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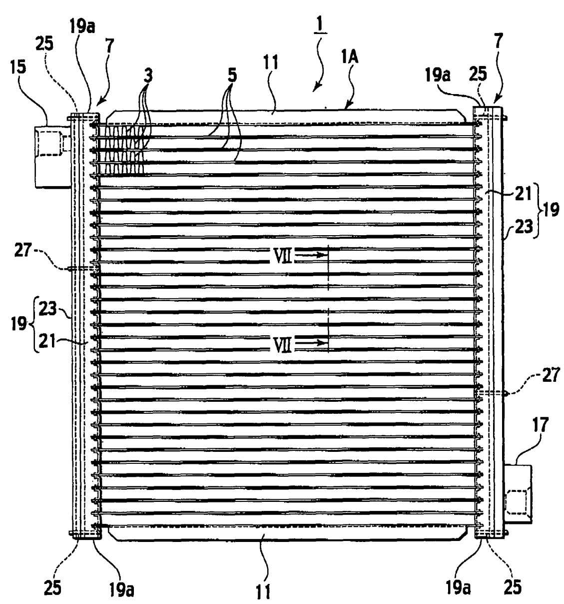
# (54) Heat exchanger

(57) A heat exchanger (1) comprises outer fins (3); a plurality of tubes (5) arranged alternately with the outer fins (3); and header tanks (7) receiving open ends of the tubes for communication with the tubes. The header tanks (7) each comprise a first member (21) and a second member (23) which are combined to each other. The first member (21) has tube insertion slots (33) into which the open ends of the tubes (5) are inserted, the second member (23) does not have the tube insertion slots. The first member (21) is either a core material having no brazing material layers on outer and inner peripheral surfaces thereof, or a core material having a brazing material layer on an outer peripheral surface thereof but having no brazing material layer on an inner peripheral surface thereof. The second member (23) is brazed to the outer or inner peripheral surface of the first member (21) having no brazing material layer thereon.

FIG.1

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## Description

CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application Is based upon and claims the benefit of priority from the prior Japanese Patent Applications Nos. 2004-011689, 2004-015959 and 2004-021566 filed on January 20, 2004, January 23, 2004 and January 29, 2004, respectively; the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

**[0002]** The present invention relates to a heat exchanger for use in automotive air-conditioning systems and the like.

2. Description of the Related Art

**[0003]** A conventional heat exchanger includes flat tubes arranged in multiple stages as heat transfer tubes, corrugated outer fins each arranged between the adjacent multistage flat tubes, and a pair of header tanks connected to opposite open ends of the flat tubes for communication. A corrugated inner fin is inserted in each tube.

**[0004]** The header tanks each include a pipe, lids closing opposite open ends of the pipe, and a partition plate partitioning a passage extending longitudinally through the pipe. The pipe has a plurality of multistage tube insertion slots into which the tubes are Inserted.

**[0005]** In this heat exchanger, a refrigerant introduced Into one of the header tanks through a refrigerant Inlet connector flows through the tubes between the header tanks in a zigzag path, and finally is discharged through a refrigerant outlet connector fixed to either of the header tanks. During that time, the refrigerant flowing through the heat exchanger exchanges heat with air passing through spaces in the outer fins between the tubes. For example, when the heat exchanger Is used as a radiator or a condenser, the refrigerant is cooled and the air is heated. When the heat exchanger is used as an evaporator, the refrigerant is heated and the air is cooled.

**[0006]** In the manufacturing method of the heat exchanger, with the tubes and the outer fins arranged alternately, the tubes are inserted Into the tube insertion slots in the header tanks to form a temporary assembly. Next, the temporary assembly is heated to a predetermined temperature to melt brazing material on a surface of each component, and then cooled. As a result, the components are bonded (joined) to each other by the cooled brazing material so as to form the heat exchanger.

**[0007]** In the above-described related art, the components constituting the heat exchanger each have a brazing material layer on a peripheral surface thereof. Therefore, during brazing, molten brazing material flows all over the heat exchanger. Much of the molten brazing material flows into joint surfaces by capillarity flow. Generally, a core of the heat exchanger, in which the tubes are joined to the outer fins, has a much greater total joint area (total contact area) than the header tanks. Therefore, brazing material of the header tanks flows out to the core of the heat exchanger during brazing. As a result, the header tanks are short of brazing material, so that (i) brazing between members constituting the header tanks have reduced stability; (II) brazing between the header tanks and the tubes has reduced stability; and (III) brazing between the header tanks and piping connectors have reduced stability.

**[0008]** In the above-described art, each tube may be formed by bending a single metal plate Into a tubular shape, or may be formed by combining two metal plates in a tubular shape. The tube in either form includes a metal plate joint (seam). With this tube structure including a seam, during brazing, a molten brazing material in a brazing material layer on the inner surface of the tube and a molten brazing material In a brazing material layer on the outer surface of the tube flow into or out of the tube through the seam of the tube. At that time, the brazing material is absorbed Into one of the Inner side and the outer side of the tube which has a larger total joint area, and the other side of the tube becomes short of brazing material. Generally, the total area of inner joint surfaces of the tube (joint surfaces between the inner peripheral surface of the tube and the inner fin) is larger than the total area of outer joint surfaces of the tube (joint surfaces between the outer peripheral surface of the tube and the outer fins). Therefore, the outer joint surfaces of the tube (joint surfaces between the outer peripheral surface of the tube and the outer fins) tend to be short of brazing material.

SUMMARY OF THE INVENTION

**[0009]** It is an object of the present invention to prevent molten brazing material from flowing between a core of a heat exchanger and header tanks during brazing. It is another object of the present invention to prevent molten brazing material from flowing from the inside of tubes to the outside of the tubes or from the outside of the tubes to the inside of the tubes during brazing.

**[0010]** The inventors of the present invention have noted that a portion of a tube having no brazing material layer thereon can prevent flow of brazing material.

**[0011]** A heat exchanger according to one aspect of the present invention comprises outer fins; a plurality of tubes arranged alternately with the outer fins; and header tanks receiving open ends of the tubes for communication with the tubes. The header tanks each comprise a first member and a second member which are combined with each other. The first member has tube Insertion slots into which the open ends of the tubes are Inserted, while the second member does not have tube insertion slots. The first member is either a core material which does not have brazing material layers on outer and inner peripheral surfaces thereof, or a core material having a brazing material layer on an outer peripheral surface thereof but not having a brazing material layer on an Inner peripheral surface thereof. The second member is brazed to the outer or inner peripheral surface of the first member which does not have brazing material layers thereon.

**[0012]** A heat exchanger according to another aspect of the present invention comprises tubes; outer fins brazed to outer surfaces of the tubes; and inner fins brazed inside the tubes. Each of the tubes has a seam and does not have a brazing material layer on an Inner peripheral surface thereof but has a brazing material layer on an outer peripheral surface thereof. Each of the inner fins has brazing material layers on both surfaces of a core material, and is brazed to the Inner peripheral surface of the tube, avoiding contact with the seam of the tube.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

**[0013]**

FIG. 1 is an elevation view of an entire configuration of a heat exchanger in a first embodiment of the present invention;
FIG. 2 is an exploded perspective view of a header tank and surrounding parts of the heat exchanger;
FIG. 3 is a cross-sectional view of the exchanger header tank at a portion where a tube insertion slot is located;
FIG. 4A is a cross-sectional view of the header tank at a portion where a lid (or partition) is located; and FIG. 4B is a cross-sectional view along line IVB-IVB In FIG. 4A;
FIG. 5 is a cross-sectional view of a tube In the heat exchanger;
FIGS. 6A to 6C are explanatory diagrams illustrating a part of a manufacturing process of the tube;
FIG. 7 is a cross-sectional vlew along tine VII--VII In FIG. 1;
FIG. 8 Is an exploded perspective view of a header tank and surrounding parts of a heat exchanger In a second embodiment of the present invention;
FIG. 9 Is a cross-sectional view of the header tank in the second embodiment at a portion where a lid (or partition) is located;
FIG. 10 Is a cross-sectional view of a header tank of a heat exchanger In a third embodiment of the present invention;
FIG. 11 is a cross-sectional view of a header tank of a heat exchanger In a fourth embodiment;
FIG. 12 is a cross-sectional view of a header tank of a heat exchanger in a fifth embodiment;
FIG. 13 is a cross-sectional view of a header tank of a heat exchanger in a sixth embodiment;
FIGS. 14A and 14B are perspective views of a header tank in a modification; FIG. 14A Illustrates the header tank before combining; and FIG. 14B Illustrates the header tank after combining;
FIGS. 15A and 15B are perspective views of a header tank In a modification; FIG. 15A illustrates the header tank before combining; and FIG. 15B Illustrates the header tank after combining;
FIG. 16 is a cross-sectional view of a header tank of a heat exchanger In a seventh embodiment at a portion where a tube insertion slot Is located;
FIG. 17A Is a cross-sectional view of the header tank at a portion where a lid (or partition) is located; and FIG. 17B is a cross-sectional view along line XVIIB-XVIIB In FIG. 17A;
FIG. 18 is a cross-sectional view of a header tank of a heat exchanger in an eighth embodiment at a portion where a tube insertion slot is located;
FIG. 19A is a cross-sectional view of the header tank at a portion where a lid (or partition) is located; and FIG. 19B is a cross-sectional view along line XIXB-XIXB In FIG. 19A;
FIG. 20 Is a cross-sectional view of a header tank of a heat exchanger in a ninth embodiment at a portion where a tube insertion slot is located;
FIG. 21 is a cross-sectional view of a header tank of a heat exchanger in a tenth embodiment at a portion where a tube Insertion slot Is located;
FIG. 22 Is a cross-sectional view of a comparative example 1 to the seventh to tenth embodiments, at a portion of a header tank where a tube insertion slot is located;
FIG. 23A is a cross-sectional view of a portion of the header tank In FIG. 22 where a lid (or partition) is located; and FIG 23B is a cross-sectional view along line B-B in FIG. 23A;
FIG. 24 is a cross-sectional view of a comparative example 2 to the seventh to tenth embodiments, at a portion of a header tank where a tube insertion slot Is located;
FIG. 25A is a cross-sectional view of a portion of the header tank In FIG. 24 where a lid (or partition) is located; and FIG. 25B is a cross-sectional view along line XXVB-XXVB in FIG. 25A;
FIGS. 26A, 26B and 26C are diagrams Illustrating modifications of the tube in the first to tenth embodiments;
FIG. 27 Is a diagram illustrating a modification of the tube in the first to tenth embodiments;
FIG. 28 Is a diagram illustrating a modification of the tube in the first to tenth embodiments;
FIG. 29 is a diagram illustrating a modification of the tube in the first to tenth embodiments;
FIG. 30 is an elevation view of an entire configuration of a heat exchanger in an eleventh embodiment;

FIG. 31 is an exploded perspectIve view of a header tank and surrounding parts of the heat exchanger;
FIG. 32 Is a cross-sectional view of the heat exchanger header tank at a portion where a tube Insertion slot is located;
FIG. 33A is a cross-sectional view of the header tank at a portion where a lid (or partition) is located; and FIG. 33B is a cross-sectional view along line XXXIIIB-XXXIIIB in FIG. 33A;
FIG. 34 is a cross-sectional view of a tube of the heat exchanger;
FIGS. 35A, 35B and 35C are explanatory views illustrating a part of a manufacturing process of the tube;
FIG. 36 is a vertical cross-sectional view of the heat exchanger In FIG. 1;
FIG. 37 is a diagram illustrating a modification 1 of the tube in the eleventh embodiment;
FIG. 38 is a diagram illustrating a modification 2 of the tube in the eleventh embodiment;
FIG. 39 is a diagram illustrating a modification 3 of the tube In the eleventh embodiment;
FIG. 40 is a diagram illustrating a modification 4 of the tube in the eleventh embodiment;
FIG. 41 is a diagram Illustrating a modification 5 of the tube In the eleventh embodiment;
FIG. 42 is a diagram illustrating a modification 6 of the tube in the eleventh embodiment;
FIG. 43 is a diagram illustrating a modification 7 of the tube In the eleventh embodiment; and
FIG. 44 is a diagram illustrating a modification 8 of the tube in the eleventh embodiment.

DETAILED DESCRIPTION OF THE INVENTION

**[0014]** An embodiment of the present invention will be described below with reference to the drawings.

[First Embodiment]

**[0015]** FIGS. 1 to 7 illustrate a heat exchanger in a first embodiment. The heat exchanger In this embodiment is used as a condenser in which a circulating vapor phase refrigerant is condensed while cooled.

Entire Configuration of the Heat Exchanger

**[0016]** As shown in FIG. 1, a heat exchanger 1 in the first embodiment includes a plurality of outer fins 3, a plurality of flat tubes 5 arranged alternately with the outer fins 3, reinforcing side plates 11 disposed at the outermost ends In the layering direction of the outer fins 3 and the tubes 5, and a pair of header tanks 7 receiving opposite open ends of each tube 5 for communication with the tubes 5.

**[0017]** A refrigerant inlet connector 15 Is attached to one of the header tanks 7 (left one in FIG. 1). A refrigerant outlet connector 17 is attached to the other header tank 7 (right one In FIG. 1). A partition 27 is fitted in each header tank 7 for partitioning the interior of the header tank 7 into a plurality of chambers.

**[0018]** When a refrigerant Is Introduced into the header tank 7 through the refrigerant Inlet connector 15, the refrigerant flows through the tubes 5 between the header tanks 7 In a zigzag path, and finally is let out through the refrigerant outlet connector 17 of the header tank 7. During that time, the refrigerant flowing through the tubes 5 exchanges heat with air passing outside the tubes 5.

Header Tank

**[0019]** The configuration of the header tanks 7 will be mainly described with reference to FIGS. 2 to 4.

**[0020]** Each header tank 7 Includes a rectangular tube pipe 19, and lids 25 closing opposite open ends 19a, 19a of the pipe 19. The pipe 19 is a combination of a first member 21 and a second member 23 divided longitudinally. The partition 27 for partitioning the interior space into a plurality of chambers is disposed In the header tank 7.

**[0021]** Both of the first member 21 and the second member 23 are formed In a C shape In a cross section. Specifically, the first member 21 includes a flat base 29 orthogonal to the longitudinal direction of the tube 5, and a pair of straight portions 31 projected from opposite sides of the base 29 in a generally orthogonal direction, forming a substantially C-shape cross section. The base 29 of the first member 21 has tube insertion slots 33 into which open ends of the tubes 5 are inserted. Like the first member 21, the second member 23 includes a flat base 35 orthogonal to the longitudinal direction of the tube 5, and a pair of straight portions 37 projected from opposite sides of the base 35 in a generally orthogonal direction, forming a substantially C-shape cross section. The base 35 of the second member 23 includes an opening (not shown) Into which a tubular portion 41 of the refrigerant Inlet connector 15 (or the refrigerant outlet connector 17) is inserted and fitted.

**[0022]** In this embodiment, the width dimension of the first member 21 (distance between the pair of straight portions 31) is set larger than the width dimension of the second member 23 (distance between the pair of straight portions 37). The first and second members 21, 23 are brazed to each other with outer peripheral surfaces of the straight portions 37 of the second member 23 fitted to Inner peripheral surfaces of the straight portions 31 of the first member 21.

**[0023]** The base 35 of the second member 23 is provided with support holes 43 for supporting projections 26a, 26a of the lids 25. Also, the straight portions 37 of the second member 23 are provided with support grooves 45 for supporting wings 26b, 26b of the lids 25. The support holes 43 and the support grooves 45 in the second member 23 allow the lids 25 to be positioned in place. In this embodiment, the partition 27 has the same shape as that of the lids 25. The partition 27 also Includes a projection 28a and wings 28b, 28b, and Is positioned in place by a support hole (43) not shown and support grooves (45) not shown formed in the second member 23.

**[0024]** The materials of the header tanks 7 will be mainly described.

**[0025]** The material of the first member 21 Is a core material 21a having no brazing material layers on either surface. The C-shaped first member 21 has no brazing material layers on its outer and inner peripheral surfaces.

**[0026]** The material of the second member 23 is a core material 23a Integrally formed with a brazing material layer 23c on an entire surface 23c on either side. The brazing material layer 23c is located on the outer peripheral surface of the C-shaped second member 23.

**[0027]** The material of each lid 25 is a core material 25a Integrally formed with brazing material layers 25b, 25c on both surfaces entirely (FIG. 4B).

**[0028]** The material of the partition 27 Is a core material 27a integrally formed with brazing material layers 27b, 27c on both surfaces entirely (FIG. 48).

**[0029]** When the members of the header tank 7 (the first member 21, the second member 23 and the lid 25) are assembled, a brazing material layer is located between joint surfaces of the members. Thus, brazing of the assembled members causes the members of the header tank 7 to be fixed in a unit.

**[0030]** Although the lid 25 and the partition 27 have no brazing material layers on their peripheries (surfaces to be brought into contact with inner peripheral surfaces of the first and second members 21, 23 constituting a pipe), the brazing material layers 25b, 25c on both surfaces of the lid 25 and the brazing material layers 27b, 27c on both surfaces of the partition 27 are melted to enter the peripheries by capillarity during brazing. Consequently, the lid 25 and the partition 27 are brazed to the first and second members 21, 23.

Tube

**[0031]** FIGS. 5 and 6A to 6C illustrate a tube 5. The tube 5 has a tubular shape, and Is brazed to the header tanks 7 with its opposite ends Inserted into the tube insertion slots 33 In the header tanks 7. The tube 5 includes a corrugated Inner fin 49.

**[0032]** With reference to FIGS. 6A to 6C, the manufacturing process of the tube 5 will be described. First, a metal plate 5M of a single elongated plate with a core material 5a integrally formed with a brazing material layer 5c on either surface entirely is prepared as a material 5M of the tube 5.

**[0033]** Then, as shown in FIG. 6A, opposite side portions of the metal plate 5M of an elongated plate material are rolled inward to form joint portions 47.

**[0034]** Then, the material 5M is folded Into two along the longitudinal center line so that the brazing material layer 5c is located at the outer peripheral side of the tube 5. The joint portions 47 at the edges of the fold are joined together to form a tube. At that time, as shown in FIG. 5, the Inner fin 49 Is Inserted In the tube 5. The material of the inner fin 49 is a core material 49a integrally formed with brazing material layers 49b, 49c on both surfaces as shown In FIG. 5.

**[0035]** Finally, when the heat exchanger 1 is brazed as a whole, the joint portions 47 of the tube 5 are brazed to each other to be a seam, and the inner surface of the tube 5 is brazed to the inner fin 49. As a result, the tube 5 is completed. At the same time, the outer surface of the tube 5 is brazed to the outer fins 3, and outer surfaces at opposite ends of the tube 5 are brazed to the inner peripheries of the tube Insertion slots 33 In the header tanks 7.

Outer Fin

**[0036]** The material of each outer fin 3 Is a core material integrally formed with brazing material layers on both surfaces.

Manufacturing Process of the Heat Exchanger

**[0037]** The manufacturing process of the heat exchanger 1 in this embodiment will be briefly described.

**[0038]** First, the outer fins 3, the tubes 5, the Inner fins 49, the members of the header tanks 7 (the first and second members 21 and 23 and the lids 25), the partitions 27, the connectors 15 and 17, and the side plates 11 and 11, which are made from predetermined materials, are prepared.

**[0039]** Then, these components are formed into their respective predetermined shapes.

**[0040]** Then, all of the components are assembled and temporarily fixed by a jig or the like to be a temporary assembly.

**[0041]** Then, the temporary assembly is heated In a furnace at a predetermined temperature to braze the components together. That is, brazing material layers of the components in the temporary assembly are melted at a predetermined temperature and then cooled, thereby to fix the components In a unit.

Functions

**[0042]** During brazing, the first member 21 having no brazing material layers on its outer and inner peripheral surfaces separates the brazing material layers 5c of the tubes 5 joined to the first member 21 from other members than the tubes 5 (the second member 23, the lids 25 and the partition 27) joined to the first member 21. in other words, the first member 21 having no brazing material layer separates the brazing material layers 5c of the tubes 5 from brazing material layers of the header tank 7 (the brazing material layer 23c of the second member 23, the brazing material layers 25b, 25c of the lids 25 and the brazing material layers 27b, 27c of the partition 27). Accordingly, during brazing, no brazing material is exchanged between the heat exchanger core 1A and the header tanks 7. As a result, the header tanks 7 are prevented from being deprived of brazing material by the heat exchanger core 1A having a large number of capillaries, and being short of brazing material.

Effects

**[0043]** The effects of the first embodiment will be explained below.

**[0044]** First, according to the first embodiment, the first member 21 having no brazing material layer separates the brazing material layers 5c of the tubes 5 from brazing material layers of the header tank 7 (the brazing material layer 23c of the second member 23, the brazing material layers 25b, 25c of the lids 25 and the brazing material layers 27b, 27c of the partition 27). Accordingly, the header tank 7 is prevented from being deprived of brazing material by the heat exchanger core 1A having a large number of capillaries, and being short of brazing material. This results In good stability in connection between a part (such as the connector 15, 17) joined to the header tank 7 and the members (the first and second members 21, 23 and the lids 25) constituting the header tank 7. Also, since brazing material of the header tank 7 does not flow to the heat exchanger core 1A, unnecessary brazing material does not accumulate on the tubes 5 and the outer fins 3 In the heat exchanger core 1A. As a result, it never happens that accumulation of brazing material reduces an airflow area between the tubes 5.

**[0045]** Second, according to the first embodiment, the material of the second member 23 Is the core material 23a integrally formed with the brazing material layer 23c entirely on either of the inner peripheral surface or the outer peripheral surface (the outer peripheral surface in this embodiment) which includes a portion joined to the first member 21. Thus, there is no need to previously apply brazing materials X to joint portions of the first member 21 and the second member 23 as shown in FIG. 10 described below. Consequently, the manufacturing process of the heat exchanger 1 Is simplified.

**[0046]** Third, according to the first embodiment, in the header tank 7 of a type including the pipe 19 and the lids 25 closing the opposite open ends 19a, 19a of the pipe 19, the materials of the lids 25 are the core materials 25a each integrally formed with the brazing material layers 25b, 25c on both surfaces entirely. Thus, there is no need to previously apply brazing material layers to joint portions of the lids 25 and the first and second members 21, 23. Consequently, the manufacturing process of the heat exchanger 1 is simplified.

**[0047]** Fourth, according to the first embodiment, In the header tank 7 of a type Including the partition 27, the material of the partition 27 is the core material 27a integrally formed with the brazing material layers 27b, 27c on both surfaces entirely. Thus, there is no need to previously apply brazing material layers to joint portions of the partition 27 and the first and second members 21, 23. Consequently, the manufacturing process of the heat exchanger 1 is simplified.

**[0048]** Fifth, according to the first embodiment, in the presented type, the first member 21 is formed wider than the second member 23, and outer peripheral surfaces of the second member 23 are fitted and brazed to inner peripheral surfaces of the first member 21. Since the material of the second member 23 Is the core material 23a integrally formed with the brazing material layer 23c on its entire outer surface, the first and second members 21 and 23 can be joined without applying brazing materials X to joint surfaces of the first and second members 21, 23 before brazing, unlike a third embodiment In FIG. 10 to be described below. Consequently, the manufacturing process of the heat exchanger 1 Is simplified (similar to the first effect). Further, since there is no need to provide brazing material layers to the connector 15 (17), a liquid tank and the like to be connected to the outer peripheral surface of the second member 23, the manufacturing process of the heat exchanger 1 is further simplified.

**[0049]** Sixth, according to the first embodiment, the material of the tube 5 includes the brazing material layer 5c integrally formed on the entire outer peripheral surface of the tube 5. Thus, there is no need to apply brazing material to a joint region between the tube 5 and the tube insertion slot 33. Also, there is no need to apply brazing material to joint regions between the tube 5 and the outer fins 3. Consequently, the manufacturing process of the heat exchanger 1 is further simplified.

**[0050]** Also, in the structure presented in the first embodiment, the tube 5 has no brazing material layer on its inner surface, and the inner fin 49 has brazing material layers on both sides. Therefore, there Is no need to apply brazing material to joint regions between the tube 5 and the inner fin 49 before brazing, and the manufacturing process of the heat exchanger 1 is further simplified.

**[0051]** Seventh, according to the heat exchanger 1 of this first embodiment, the tube 5 is configured to have the joint portions 47. In particular, the joint portions 47 are provided along the entire length of the tube 5. This configuration causes brazing material of the header tank 7 to be likely to be absorbed Into the joint portions 47 of the tube 5 during brazing. Thus, the brazing material flow cutoff function of the first member 21 (a brazing material flow cutoff portion S2) is more effective.

**[0052]** Eighth, In this first embodiment, in the tube 5 with the joint portions 47, the inner fin 49 having the brazing material layers 49b, 49c on both surfaces of the core material 49a Is brazed to the inner peripheral surface of the tube 5, avoiding contact with the joint portions 47 of the tube 5. Therefore, brazing material inside the tube 5 (the brazing material layers 49b, 49c on both surfaces of the Inner fin (49) is separated from brazing material outside the tube 5 (the brazing material layer 5c on the outer surface of the tube 5) by the tube inner peripheral surface having no brazing material layer. That is, the Inner peripheral surface of the tube 5 has a brazing material flow cutoff portion S3 for preventing the flow of brazing material between the inside of the tube 5 and the outside of the tube 5. Thus, during brazing, brazing material inside the tube 5 is prevented from flowing out of the tube 5 through a joint surface between the joint portions 47, and brazing material outside the tube 5 is prevented from flowing into the tube 5 through a joint surface between the joint portions 47. Thus, either the Inside or the outside of the tube 5 never becomes short of brazing material. In the first embodiment, the total joint area Inside the tube 5 (the total area of the joint surfaces between the inner peripheral surface of the tube 5 and the Inner fin 49) is greater than the total joint area outside the tube 5 (the total area of the joint surfaces between the outer peripheral surface of the tube 5 and the outer fins 3). Thus, during brazing, the brazing material flow cutoff portion S3 prevents brazing material outside the tube 5 from flowing away into the tube 5 to cause a shortage of brazing material at the outside of the tube 5.

**[0053]** Other embodiments will be described below.

[Second Embodiment]

**[0054]** FIGS. 8 and 9 show a heat exchanger i in a second embodiment. The heat exchanger 1 In the second embodiment is different from the first embodiment In the structure of supporting a lid 25 and a partition 27 in a header tank 7. In the second embodiment, support holes 44 are additionally formed in a first member 21 In the structure of the first embodiment. Projections 26c and 28c to be supported by the support holes 44 are added to the lid 25 and the partition 27, which is different from the first embodiment.

**[0055]** According to the second embodiment, even with the structure having the holes 44 formed in the first member 21, since a core material 21a of the first member 21 has no brazing material layers on its inner and outer peripheral surfaces, the first member 21 having no brazing material layers on the Inner and outer peripheral surfaces can have a brazing material flow cutoff function, as in the first embodiment.

[Third Embodiment]

**[0056]** FIG. 10 shows a third embodiment. A header tank 100 In the third embodiment in FIG. 10 is different from that in the first embodiment In that a brazing material layer is not integrally formed on the entire outer surface of a second member 102, and a core material 102a is exposed to the entire second member 102. To ensure a brazed joint between a first member 21 and the second member 102, brazing materials X are applied to joint surfaces between the first member 21 and the second member 102 before brazing. At that time, the brazing materials X may be applied either to the first member 21 or to the second member 102 before brazing.

**[0057]** According to the third embodiment, as in the first embodiment, the first member 21 having no brazing material layers on its inner and outer peripheral surfaces can provide a brazing material flow cutoff function.

[Fourth Embodiment]

**[0058]** FIG. 11 shows a fourth embodiment.

**[0059]** The fourth embodiment in FIG. 11 is different from the third embodiment In that a header tank 110 has a second member 112 formed wider than a first member 21, and outer peripheral surfaces of the first member 21 is fitted and brazed to inner peripheral surfaces of the second member 112. The second member 112 is constituted by a core material, and brazing materials X are applied to joint surfaces between the first member 21 and the second member 112 before brazing, as In the third embodiment. At that time, the brazing materials X may be applied either to the first member 21 or to the second member 112 before brazing.

**[0060]** According to the fourth embodiment, as In the first to third embodiments, the first member 21 having no brazing material layers on Its Inner and outer peripheral surfaces can provide a brazing material flow cutoff function.

[Fifth Embodiment]

**[0061]** FIG. 12 shows a fifth embodiment. A header tank 120 in the fifth embodiment is different from that In the fourth embodiment In that a brazing material layer 121b is integrally formed on an entire inner peripheral surface of a core material 120a of a second member 121.

**[0062]** According to the fifth embodiment, unlike the fourth embodiment, the first member 21 can be joined to the second member 121 without application of brazing materials X to joint surfaces between the first member 21 and the second member 112 before brazing. Thus, the manufacturing process of a heat exchanger 1 is more simplified than in the fourth embodiment.

[Sixth Embodiment]

**[0063]** FIG. 13 shows a sixth embodiment. A header tank 130 in the sixth embodiment is different from that in the fifth embodiment in that the material of a second member 131 is a core material 131a Integrally formed with brazing material layers 131b, 131c on its entire inner and outer peripheral surfaces.

**[0064]** The sixth embodiment eliminates the need for applying or thermal spraying a brazing material to a connector 15 (17) to be connected to the outer peripheral surface of the second member 131, and thus the manufacturing process of a heat exchanger 1 is more simplified, in addition to the effect In the fifth embodiment.

**[0065]** In the first to sixth embodiments, a first member 141 and a second member 142 of a header tank 140 may be integrally formed with a lid as shown in FIGS. 14A and 14B, for example, if a material of the first member 141 is a core material with no brazing material layers integrally formed on its inner and outer peripheral surfaces. Alternatively, a first member 141 and a second member 152 of a header tank 150 may be Integrally formed with a lid as shown in FIGS. 15A and 15B, for example. That is, in the first to sixth embodiments, the header tank 140 (header tank 150) may be of a type In which It is longitudinally divided Into the box-shaped first member 141 (first member 151) and second member 142 (second member 152) which are combined in the longitudinal direction of the tubes, each member having an opening formed in the combining direction.

**[0066]** In short, according to the first to sixth embodiments, a first member constituted by a core material having no brazing materials on both surfaces separates a brazing material layer of a tube from a brazing material layer of a header tank. That is, a first member with no brazing material layer serves as a brazing material flow cutoff portion. Consequently, the header tank is prevented from being deprived of brazing material by a heat exchanger core having a large number of capillaries, and being short of brazing material. This results In a good stability In connection between the header tank and a part (such as a connector) joined to the header tank. Also, tubes and outer fins In the heat exchanger core are prevented from having an accumulation of unnecessary brazing material.

**[0067]** Seventh to tenth embodiments will be described. The seventh to tenth embodiments are different from the first to sixth embodiments in that a first member 161 is of a type having a brazing material layer 161c on Its outer surface.

[Seventh Embodiment]

**[0068]** A header tank 160 In the seventh embodiment is different from that in the first embodiment in which the first member 21 has no brazing material layers on its inner and outer peripheral surfaces, In that, as shown In FIGS. 16 to 18, a first member 161 has a brazing material layer 161c on its outer surface, and in other respects, is completely identical to that In the first embodiment.

**[0069]** When members of the header tank 160 (the first member 161, a second member 23, a lid 25) are assembled, a brazing material layer is located between joint surfaces of the members. The assembled members are brazed at a predetermined temperature, thereby to fix the members of the header tank 160 in a unit.

**[0070]** In a heat exchanger in the seventh embodiment, the first and second members 161 and 23 of the header tank 160 are brazed together with the second member 23 fitted to the inner peripheral surface of the first member 161. Thus, the inner peripheral surface and edges of the first member 161 with no brazing material layers (brazing material flow cutoff portions S2) separate a brazing material layer 23c for joining the first and second members 161 and 23 from a brazing material layer of a tube 5. Therefore, during brazing, the brazing material layer 23c for joining the first and second members 161 and 23 Is prevented from flowing away to the tube 5 through the inner and outer peripheral surfaces of the first member 161.

**[0071]** In the heat exchanger In the seventh embodiment, a lid 25 Is provided, and the lid 25 is fitted to the inner peripheral surface of a pipe 19 consisting of the first member 161 and the second member 23, with brazing material layers 25b, 25c of the lid 25 out of contact with the brazing material layer 161c on the outer peripheral surface of the first member 161. Thus, the brazing material layers 25b, 25c of the lid 25 (brazing material layers 25b, 25c for joining the lid 25 to the first and second members 161 and 23) are separated from a brazing material layer 5c of a tube 5 by the inner peripheral surface with no brazing material layer and edges 52 of the first member 161. Thus, the brazing material Is prevented from flowing away to the tube 5 during brazing. Consequently, during brazing, brazing material in the brazing material layers 23c, 25b and 25c for joining the lid 25 to the Inner peripheral surfaces of the first and second members 161 and 23 is prevented from flowing away from the inner and outer peripheral surfaces of the first member 161 to the tube 5.

**[0072]** Thus, according to the seventh embodiment, during brazing, the brazing material layer 23c for joining the first member 161 and the second member 23 and the brazing material layers 25b, 25c and 23c for joining the lid 25 to the first and second members 161 and 23 are prevented from flowing away to the tubes 5.

Effects

**[0073]** The effects of the seventh embodiment will be summarized below.

**[0074]** First, according to the seventh embodiment, the inner peripheral surface and the edges S2 with no brazing material layers of the first member 161 separates the brazing material layer 5c of the tube 5 from brazing material layers of the header tank 160 (the brazing material layer 23c of the second member 23 and the brazing material layers 25b, 25c of the lid 25). Consequently, the header tank 160 is prevented from being deprived of brazing material by a heat exchanger core 1A having a large number of capillaries, and being short of brazing material. This results in good stability In connection between a part (such as a connector 15 or 17) joined to the header tank 160 and members constituting the header tank 160 (the first and second members 161, 23 and the lid 25). Also, since brazing material of the header tank 160 does not flow to the heat exchanger core 1A, unnecessary brazing material does not accumulate on tubes 5 and outer fins 3 in the heat exchanger core 1A. As a result, accumulation of brazing material reducing an airflow area between the tubes 5 never happens.

**[0075]** Second, like the lid 25, a partition 27 is fitted in the pipe 19 comprised of the first and second members 161, 23, with Its brazing material layers 27b, 27c out of contact with the outer peripheral surface of the first member 161 and tubes 5. Thus, brazing material of the header tank 160 does not flow away to the tubes 5 (heat exchanger core 1A) through the brazing material layers 27b, 27c of the partition 27.

**[0076]** Third, In the heat exchanger 1 in the seventh embodiment, each tube 5 is longitudinally provided with joint portions 47. With this, a brazing material flow cutoff function of the first member 161 is more effective. If the first member 161 did not have the brazing material flow cutoff function in the seventh embodiment, brazing material of the header tank 160 would be further absorbed Into the joint portions 47 of the tube 5.

**[0077]** Fourth, according to the seventh embodiment, the second member 23 has the brazing material layer 23c on its outer peripheral surface. Thus, brazing material for joining the second member 23 to the inner peripheral surface of the first member 161 is provided by the brazing material layer 23c on the outer peripheral surface of the second member 23. This eliminates the need for applying brazing materials (X) for joining a second member (192) to the inner peripheral surface of a first member (161) before brazing as in the tenth embodiment described below.

**[0078]** Fifth, according to the seventh embodiment, the lid 25 is in a plate shape, and has the brazing material layer 25b, 25c on at least one surface. Thus, brazing material for joining the lid 25 to the inner peripheral surfaces of the first and second members 161 and 23 is provided by the brazing material layer 25b, 25c of the lid 25. This eliminates the need for applying brazing material for joining the lid 25 to the inner peripheral surfaces of the first and second members 161 and 23 before brazing. In this embodiment, the brazing material layer 23c on the outer peripheral surface of the second member 23 flows over the brazing material layers 25b, 25c of the lid 25, thereby also acting as brazing material for joining the inner peripheral surfaces of the first and second members 161 and 23 and the lid 25.

**[0079]** Sixth, according to the seventh embodiment, the partition 27 is In a plate shape, and has the brazing material layer 27b, 27c on at least one surface. This eliminates the need for applying brazing material for joining the partition 27 to the inner peripheral surfaces of the first and second members 161 and 23 before brazing. In this embodiment, the brazing material layer 23c on the outer peripheral surface of the second member 23 flows over the brazing material layer 27b, 27c of the partition 27, thereby also acting as brazing material for joining the partition 27 to the inner peripheral surfaces of the first and second members 161 and 23.

[Eighth Embodiment]

**[0080]** FIGS. 18 and 19 show a header tank 170 of a heat exchanger in an eighth embodiment. The header tank 170 in the eighth embodiment has the same structure as that In the seventh embodiment except that a second member 172 has brazing material layers 172c and 172b on both inner and outer peripheral surfaces of a core material 172a, respectively. Even with this structure In which the second member 172 has the brazing material layer 172b on its inner peripheral surface, the same effects as in the seventh embodiment can be provided.

[Ninth Embodiment]

**[0081]** FIG. 20 shows a header tank 180 of a heat exchanger In a ninth embodiment. The header tank 180 in the ninth embodiment is different from that in the seventh embodiment in that a first member 161 is provided with expanding portions 181 expanding In a tapered cross-section shape at edges of a pair of straight portions 31, and edge portions S2 of the first member 161 are spaced from a brazing material layer 23c on the outer peripheral surface of a second member 23.

**[0082]** According to the ninth embodiment, In addition to the effects In the seventh embodiment, even when the first member 161 Is formed thinner, the edge portions S2 of the first member 161 can reliably prevent a brazing material layer 161c on the outer peripheral surface of the first member 161 from connecting to the brazing material layer 23c on the outer peripheral surface of the second member 23. This is also effective even if the first member 161 Is not thin.

[Tenth Embodiment]

**[0083]** FIG. 21 shows a header tank 190 of a heat exchanger in a tenth embodiment. The header tank 190 in the tenth embodiment is different from those in the seventh to ninth embodiments In which the second members 23, 172 have the brazing material layers 23c, 17c on the outer surfaces, in that a second member 192 is only comprised of a core material 192 with no brazing material layer thereon. Thus, before brazing of the header tank 190 In the tenth embodiment, brazing materials X for joining a first member 161 and the second member 192 are applied to the first member 161 or the second member 192.

**[0084]** According to the tenth embodiment, similar functions and effects to those In the seventh to ninth embodiments can be provided. The manufacturing process of the heat exchanger 1 In the seventh to ninth embodiments Is simpler than in that In the tenth embodiment because the brazing material layer 23c of the second member 23 joins the first member 161 and the second member 23, thus eliminating the need for separately applying brazing materials X for joining the first member 161 and the second member 192 as in the tenth embodiment.

**[0085]** Comparative examples to the seventh to tenth embodiments will be described below. The comparative examples are Intended to clarify the structures and the functions/effects of the seventh to tenth embodiments. Comparative examples 1 and 2 are not conventional examples.

[Comparative Example 1]

**[0086]** FIGS. 22, 23A and 23B show a comparative example 1. This comparative example 1 is out of the scope of the present invention. A header tank 200 of a heat exchanger in the comparative example 1 is different from those in the seventh to tenth embodiments in which the first member 161 has the brazing material layer 161c only on its outer peripheral surface, In that a first member 201 has a brazing material layer 201b on its inner peripheral surface as well as a brazing material layer 201c on Its outer peripheral surface.

**[0087]** In this comparative example 1, since the first member 201 has the brazing material layer 201b on its Inner peripheral surface, a brazing material layer 23c on the outer peripheral surface of a second member 23 (brazing material for joining the first member 201 and the second member 23) Is In contact with the brazing material layer 21b on the inner peripheral surface of the first member 201 as shown In FIGS. 22 and 23A. The brazing material layer 201b on the inner peripheral surface of the first member 21 is in contact with a brazing material layer on the outer peripheral surface of a tube 5 projected into the pipe inner peripheral side through a tube insertion slot 33 in the first member 21. Therefore, during brazing, the brazing material layer 23c on the outer peripheral surface of the second member 23 flows out to the brazing material layer 5c on the outer peripheral surface of the tube 5 through the brazing material layer 201b on the inner peripheral surface of the first member 21.

**[0088]** In the seventh to tenth embodiments, no brazing material layer Is provided to the inner peripheral surface of the first member 161 which can be in contact with the brazing material layers 5c on the outer peripheral surfaces of the tubes 5. Thus, brazing material of the header tanks 160, 170, 180 and 190 is prevented from flowing out to the tubes 5.

[Comparative Example 2]

**[0089]** FIGS. 24, 25A and 25B show a comparative example 2. This comparative example 2 is also out of the scope of the present invention. A header tank 300 of a heat exchanger in the comparative example 2 includes a first member 21 provided with support holes 44, and a lid 25 and a partition 27 provided with projections 26c and 28c supported by the support holes 44, In addition to the components In the seventh to tenth embodiments.

**[0090]** In the comparative example 2, the projections 26c and 28c of the lid 25 and the partition 27 are In contact with a brazing material layer 301c on the outer peripheral surface of the first member 21. Therefore, as shown in FIGS. 24, 25A and 25B, a brazing material layer 23c on the outer peripheral surface of a second member 23 (brazing material for joining the first member 21 and the second member 23) flows out to tubes 5 through brazing material layers 25b, 25c, 27b and 27c of the lid 25 and the partition 27, through the projections 26c, 28c, through the brazing material layer 301c on the outer peripheral surface of the first member 21, and through brazing material layers on the outer peripheral surfaces of the tubes 5. At the same time, brazing material in the brazing material layers 25b, 25c, 27b and 27c of the lid 25 and the partition 27 flows out to the tubes 5 in the same route.

**[0091]** in the seventh to tenth embodiments, when the lid 25 and/or the partition 27 are provided, the lid 25 and/or the partition 27 are fitted in the header tank 160, 170, 180 or 190, with the brazing material layers 25b, 25c, 27b and 27c of the lid 25 and/or the partition 27 out of contact with the brazing material layer 161c on the outer peripheral surface of the first member 161. Thus, brazing material of the header tank is prevented from flowing out to the tubes 5. In the seventh to tenth embodiments, to support the lid 25 and/or the partition 27 on the first member 161, support portions can be in any shape such as a hole with a bottom or a groove formed in the inner peripheral surface of the first member, except for a hole extending from the Inner peripheral surface to the outer peripheral surface of the first member.

**[0092]** As described above, according to the seventh to tenth embodiments, a header tank includes a first member and a second member combined to each other; the first member Includes tube insertion slots, while the second member includes no tube insertion slots; the first member has no brazing material layer on its inner surface, while having a brazing material layer on Its outer surface; and the second member is fitted to the Inner peripheral surface of the first member. Therefore, brazing material of the header tank (especially brazing material for joining the second member to the first member) is prevented from flowing out to tubes through the first member.

**[0093]** In any of the seventh to tenth embodiments, a joint surface of a second member to a first member is an outer peripheral surface of the second member, A joint surface of a second member to a first member may be an inner peripheral surface of the second member, an outer peripheral surface of the second member, or an edge surface of the second member.

**[0094]** Also, In any of the seventh to tenth embodiments, a header tank is configured to include a pipe 19 comprised of a first member and a second member, and lids 25 at opposite ends of the pipe 19. However, If a first member 141 and a second member 142 are integrally formed with a lid as shown in FIG. 14, for example, the same effects as in the seventh to tenth embodiments can be obtained. That is, the header tank 140 may be of a type longitudinally divided into the box-shaped first member 141 and second member 142 which are combined in the longitudinal direction of tubes 5, each member having an opening formed in the combining direction.

**[0095]** In the structure In any of the first to tenth embodiments, a partition is provided, but it is possible not to provide a partition.

**[0096]** In the first to tenth embodiments, outer fins and side plates may be configured to be in contact with a first member. When outer fins, side plates and the like are in contact with a first member, and the outer fins and the side plates are provided with brazing material layers, brazing material of a header tank is out of contact with the brazing material layers.

**[0097]** In the first to tenth embodiments, a tube with joint portions is used. Alternatively, a tube with joint portions as In "tube modification 1" or "tube modification 2" described below may be used, or a tube with no joint portions as in "tube modification 3" described below may be used.

[Tube Modification 1]

**[0098]** Tubes in FIGS. 26A, 26B and 26C are different from the tube In FIG. 5 in the shape of a joint. The tubes in FIGS. 26A, 26B and 26C are each of a type in which a single metal plate Is folded in a tubular shape, like the tube in FIG. 5.

**[0099]** A tube 50 In FIG. 26A is identical to the tube 5 in the first embodiment in that an elongated plate-like material having a brazing material layer 50 on an entire surface to constitute the outer surface of a core material 50a is folded In a tubular shape, and joint portions 51, 52 at opposite sides are brazed to each other, but is different from the tube 5 In the first embodiment in that one of the joint portions 51, 52 at the opposite sides of the material (the upper one 51 in this embodiment) is formed longer than the other one (the lower one 52 in this embodiment), and is formed in a substantially C shape to enclose the other one. In brazing, an inner surface of the joint portion 51 is in contact with an outer surface of the joint portion 52 having a brazing material layer, whereby the joint portions 51, 52 are brazed to each other.

**[0100]** A tube 60 in FIG. 26B is identical to the tube 5 in FIG. 5 in that an elongated plate-like material having a brazing material layer 60c on an entire surface to constitute the outer surface of a core material 60a is folded In a tubular shape, and joint portions 61 at opposite sides are brazed to each other, but Is different in the shape of the joint portions 61.

**[0101]** A tube 70 in FIG. 26C is identical to the tube 5 in FIG. 5 in that an elongated plate-like material having a brazing material layer 70c on an entire surface to constitute the outer surface of a core material 70a is folded in a tubular shape, and joint portions 71 at opposite sides are brazed to each other, but is different from the tube 5 In FIG. 5 in that the joint portions 71 are brazed to each other at their inner surfaces with no brazing material layers.

[Tube Modification 2]

**[0102]** FIG. 27 shows another modified tube. A tube 80 in FIG. 27 is different from the tube 5 in FIG. 5 in that two metal plates 80A, 80B are used. The tube 80 is configured such that the two metal plates 80A, 80B are Joined In a tubular shape, and joint portions 81, 82 at opposite sides are brazed to each other. The tube 80 is similar to the tube 5 in FIG. 5 In that it has the joint portions 81, 82 along its entire length.

[Tube Modification 3]

**[0103]** Tubes in the first to tenth embodiments Include a seam, but tubes may be formed seamlessly. A tube 90A in FIG. 28 and a tube 90B In FIG. 29 are longitudinally extruded tubes, and have no seams. The tube 90A in FIG. 28 includes a separate inner fin 49; and the tube 90B in FIG. 29 Is Integrated with an inner fin.

**[0104]** In the first to tenth embodiments, each outer fin 3 is integrally formed with brazing material layers on both surfaces, but may alternatlvely be formed integrally with a brazing material layer only on one surface, or may have no brazing material layers on both surfaces.

**[0105]** In the first to tenth embodiments, each tube 5 has the brazing material layer 5c not on its Inner surface but on its outer surface, but alternatively, a brazing material layer may be provided on the inner surface of the tube 5. If a brazing material layer is provided on the Inner surface of the tube 5, an inner fin 49 with no brazing material layers on either surface can be used.

[Eleventh Embodiment]

**[0106]** An embodiment will be described which can prevent brazing material from flowing from inner surfaces of tubes to outer surfaces of the tubes or from outer surfaces of tubes to inner surfaces of the tubes through seams of the tubes during brazing.

**[0107]** FIGS. 30 to 36 Illustrate a heat exchanger in an eleventh embodiment. The heat exchanger In this embodiment is used as a condenser In which a circulating vapor phase refrigerant is condensed white cooled.

Entire Configuration of the Heat Exchanger

**[0108]** As shown in FIG. 30, a heat exchanger 501 In the eleventh embodiment includes a plurality of outer fins 503, a plurality of flat tubes 505 arranged alternately with the outer fins 503, reinforcing side plates 511 disposed at the outermost ends in the layering direction of the outer fins 503 and the tubes 505, and a pair of header tanks 507 receiving opposite open ends of each tube 505 for communication with the tubes 505.

**[0109]** A refrigerant inlet connector 515 is attached to one of the header tanks 507 (left one in FIG. 30). A refrigerant outlet connector 517 is attached to the other header tank 507 (right one in FIG. 30). A partition 527 is fitted in each header tank 507 for partitioning the interior of the header tank 507 into a plurality of chambers.

**[0110]** When a refrigerant is Introduced into the header tank 507 through the refrigerant inlet connector 515, the refrigerant flows through the tubes 505 between the header tanks 507 in a zigzag path, and finally is let out through the refrigerant outlet connector 517 of the header tank 507. During that time, the refrigerant flowing through the tubes 505 exchanges heat with air passing outside the tubes 505.

Header Tank Configuration

**[0111]** The header tanks 507 will be mainly described with reference to FIGS. 31 to 33.

**[0112]** Each header tank 507 includes a rectangular tube pipe 519, and lids 525 closing opposite open ends 519a, 519a of the pipe 519. The pipe 519 Is a combination of a first member 521 and a second member 523 divided longitudinally. The partition 527 for partitioning the interior space into a plurality of chambers Is disposed in the header tank 507.

**[0113]** Both of the first member 521 and the second member 523 are formed in a C shape In cross section. Specifically, the first member 521 includes a flat base 529 orthogonal to the longitudinal direction of the tube 505, and a pair of straight portions 531 projected from opposite sides of the base 529 In a generally orthogonal direction, forming a substantially C-shape cross section. The base 529 of the first member 521 has tube insertion slots 533 into which open ends of the tubes 505 are inserted. Like the first member 521, the second member 523 Includes a flat base 535 orthogonal to the longitudinal direction of the tube 505, and a pair of straight portions 537 projected from opposite sides of the base 535 In a generally orthogonal direction, forming a substantially C-shape cross section. The base 535 of the second member 523 includes an opening (not shown) into which a tubular portion 541 of the refrigerant inlet connector 515 (or the refrigerant outlet connector 517) is Inserted and fitted.

**[0114]** In this embodiment, the width dimension of the first member 521 (distance between the pair of straight portions 531) is set larger than the width dimension of the second member 523 (distance between the pair of straight portions 537). The first and second members 521, 523 are brazed to each other with outer peripheral surfaces of the straight portions 537 of the second member 523 fitted to inner peripheral surfaces of the straight portions 531 of the first member 521.

**[0115]** The base 535 of the second member 523 is provided with support holes 543 for supporting projections 526a of the lids 525. Also, the straight portions 537 of the second member 523 are provided with support grooves 545 for supporting wings 526b, 526b of the lids 525. The support holes 543, 543 and the support grooves 545 in the second member 523 allow the lids 525 to be positioned In place. In this embodiment, the partition 527 has the same shape as that of the lids 525. The partition 527 also Includes a projection 528a and wings 528b, and is positioned In place by a support hole not shown and support grooves not shown formed in the second member 523.

**[0116]** The materials of the header tanks 507 will be mainly described.

**[0117]** The material of the first member 521 is a core material 521a having a brazing material layer on either surface. The first member 521 formed In a predetermined shape (in a C shape) has a brazing material layer 521c on an outer peripheral surface of the core material 521a, but has no brazing material layer on an Inner peripheral surface.

**[0118]** The material of the second member 523 is a core material 523a integrally formed with a brazing material layer 523c on an entire surface 523c on either surface. The second member 523 formed in a predetermined shape (in a C shape) has the brazing material layer 523c on the outer peripheral surface of the core material 523a.

**[0119]** The material of each lid 525 Is a core material 525a integrally formed with brazing material layers 525b, 525c on both surfaces entirely (FIG. 33B).

**[0120]** The material of the partition 527 Is a core material 527a integrally formed with brazing material layers 527b, 527c on both surfaces entirely (FIG. 33B).

**[0121]** When the members of the header tank 507 (the first member 521, the second member 523 and the rid 525) are assembled, a brazing material layer is located between joint surfaces of the members. Thus, brazing of the assembled members at a predetermined temperature causes the members of the header tank 507 to be fixed in a unit.

**[0122]** Although the rids 525 and the partition 527 have no brazing material layers on their peripheries (surfaces to be brought into contact with inner peripheral surfaces of the first and second members 521, 523 constituting a pipe), the brazing material layers 525b, 52Sc on both surfaces of the rids 525 and the brazing material layers 527b, 527c on both surfaces of the partition 527 are melted to enter the peripheries by capillarity during brazing. Consequently, the lids 525 and the partition 527 are brazed to the first and second members 521, 523.

Tube Configuration

**[0123]** FIGS. 34 and 35A to 35C frustrate a tube 505. The tube 505 has a tubular shape, and is brazed to the header tanks 507 with its opposite ends inserted Into the tube insertion slots 533 in the header tanks 507. The tube 505 includes a corrugated Inner fin 549.

**[0124]** With reference to FIGS. 35A to 35C, the manufacturing process of the tube 505 will be described. First, a metal plate M of a single elongated plate with a core material 505a integrally formed with a brazing material layer 505c on either surface is prepared as a material M of the tube 505.

**[0125]** Then, as shown in FIG. 35A, opposite side portions of the metal plate M of an elongated plate material are rolled inward to form joint portions 547.

**[0126]** Then, the material M Is folded into two along the longitudinal centerline so that the brazing material layer 505c is located at the outer peripheral side of the tube 505. The joint portions 547 at the edges of the fold are joined together to form a tube. At that time, as shown in FIG. 34, the Inner fin 549 is inserted In the tube 505. The material of the inner fin 549 is a core material 549a integrally formed with brazing material layers 549b, 549c on both surfaces as shown in FIG. 34.

**[0127]** Finally, when the heat exchanger 1 is brazed as a whole, the joint portions 547 of the tube 505 are brazed to each other, and the inner surface of the tube 505 is brazed to the inner fin 549. As a result, the tube 505 Is completed. At the same time, the outer surface of the tube 505 is brazed to the outer fins 503, and outer surfaces at opposite ends of the tube 505 are brazed to the inner peripheries of the tube insertion slots 533 in the header tanks 507. Also, the members of the header tank are brazed to each other.

**[0128]** In the eleventh embodiment, the Inner fin 549 has the brazing material layers 549b, 549c on both surfaces of the core material 549a, and is brazed to the Inner peripheral surface of the tube 505, avoiding contact with the joint portions 547 of the tube 505.

Outer Fin

**[0129]** The material of the outer fin 503 is only a core material with no brazing material.

Manufacturing Process of the Heat Exchanger

**[0130]** The process of manufacturing the heat exchanger 501 in this embodiment will be briefly described.

**[0131]** First, the outer fins 503, the tubes 505, the inner fins 49, the members of the header tanks 507 (the first and second members 521 and 523 and the rids 525), the partitions 527, the connectors 515 and 517, and the side plates 511 and 511, which are made from predetermined materials, are prepared.

**[0132]** Then, these components are formed into their respective predetermined shapes.

**[0133]** Then, all of the components are assembled and temporarily fixed by a jig or the like to be a temporary assembly.

**[0134]** Then, the temporary assembly is sintered in a furnace at a predetermined temperature to braze the components together. That is, brazing material layers of the components In the temporary assembly are melted at a predetermined temperature and then cooled, thereby to fix the components in a unit.

Functions

**[0135]** According to the eleventh embodiment, no brazing material layer is provided to the inner surface of the tube 505, while the brazing material layers 549b, 594c are provided to both surfaces of the Inner fin 549 to join the tube 505 and the inner fin 549. The inner fin 549 is brazed to the inner peripheral surface of the tube 505, avoiding contact with the joint portions 547. Therefore, as shown in FIG. 34, a brazing material flow cutoff portion S3 for separating brazing material inside the tube 505 (the brazing material layers 549b, 549c on both surfaces of the inner fin 549) from brazing material outside the tube 505 (the brazing material layer 505c on the outer surface of the tube 5) is formed on the inner surface of the tube 505 near the joint portions 547. The brazing material flow cutoff portion 53 separates flow of the brazing material inside the tube 505 from flow of the brazing material outside the tube 505 during brazing.

Effects

**[0136]** The effects of the eleventh embodiment will be summarized below.

**[0137]** First, according to the eleventh embodiment, as described above, since the brazing material flow cutoff portion S3 Is provided for separating the brazing material Inside the tube 505 (the brazing material layers 549b, 549c on the two sides of the Inner fin 549) from the brazing material outside the tube 505 (the brazing material layer 505c on the outer surface of the tube 505) so as to prevent flow of the brazing material between the inside of the tube 505 and the outside of the tube 505, the brazing material inside the tube 505 is prevented from flowing away to the outside of the tube 505 through a joint surface between the joint portions 547, and the brazing material outside the tube 505 Is prevented from flowing away into the tube 505 through a joint surface between the joint portions 547, during brazing.

**[0138]** Accordingly, no shortage of brazing material occurs inside the tube 505 or outside the tube 505.

**[0139]** In the eleventh embodiment, the total joint area inside the tube 505 (the total area of joint surfaces between the inner peripheral surface of the tube 505 and the inner fin 549) is larger than the total joint area outside the tube 505 (the total area of joint surfaces between the outer peripheral surface of the tube 505 and the outer fins 503). Thus, the brazing material flow cutoff portion S3 prevents brazing material outside the tube 505 from flowing away into the tube 505 and causing shortage of brazing material outside the tube 505.

**[0140]** Second, according to the eleventh embodiment, the tubes 505 and the outer fins 503 are arranged alternately, and the header tanks 507 to which the open ends of the tubes 505 are brazed and connected are provided. Thus, the brazing material flow cutoff portions S3 act more effectively. Specifically, during brazing, brazing material of each header tank 507 (brazing material in the brazing material layer 521c on the outer surface of the first member 521 in this embodiment) can be prevented from being absorbed into the tubes 505 together with brazing material In the brazing material layer 505c on the outer surface of the tube 505, and running short. This is because, in the structure In which the tubes 505 are connected to the header tanks 507, during brazing, brazing material of the header tanks 507 can also flow Into the tubes 505 through joint surfaces between the joint portions 547 of the tubes 505 together with brazing material In the brazing material layers 505c on the outer surfaces of the tubes 505.

**[0141]** Third, according to the eleventh embodiment, each outer fin 503 is comprised of a core material having no brazing material layer on either side, so that no exchange of brazing materlal Is made between the tubes 505. Therefore, even a structure in which one of the tubes 505 improperly has a larger joint area than the other tubes 505 can prevent brazing material from flowing in volume to and accumulating on that particular tube 505.

[Tube Modifications]

**[0142]** In the eleventh embodiment, tubes may be modified as described below as long as each tube separates brazing material inside the tube (brazing material layers on both surfaces of an inner fin) from brazing material outside the tube (a brazing material layer on the outer surface of the tube) so as to prevent flow of brazing material between the inside of the tube and the outside of the tube. In the description below, identical or like components are given like reference numerals, and those components and their functions/effects will not be described.

[Tube Modification 1]

**[0143]** A tube 610 in a modification 1 shown In FIG. 37 is similar to the tube 505 In the eleventh embodiment in FIG. 34 in that an elongated plate-like material having a brazing material layer 610c on an entire surface to be the outer surface of a core material 610a is folded longltudlnally, and joint portions 611, 612 at opposite sides are brazed to each other, but is different from the tube 505 in the eleventh embodiment in the configurations of the joint portions 611, 612. The tube 610 in the modification 1 also includes a brazing material flow cutoff portion S3 for preventing the flow of brazing material between the inside of the tube 610 and the outside of the tube 610, and thus provides the same effects as in the eleventh embodiment.

[Tube Modification 2]

**[0144]** A tube 620 In a modification 2 shown in FIG. 38 Is also different from the tube 505 in the eleventh embodiment in FIG. 34 in the configuration of joint portions 621. The tube 620 in the modification 2 also Includes a brazing material flow cutoff portion 53 for preventing the flow of brazing material between the inside of the tube 620 and the outside of the tube 620, and thus provides the same effects as In the eleventh embodiment.

[Tube Modification 3]

**[0145]** A tube 630 In a modification 3 shown In FIG. 39 Is also different from the tube 505 in the eleventh embodiment in FIG. 34 in the configurations of joint portions 631, 632. The tube 630 in the modification 3 also Includes a brazing material flow cutoff portion S3 for preventing the flow of brazing material between the inside of the tube 630 and the outside of the tube 630, and thus provides the same effects as In the eleventh embodiment. The tube 630 in the modification 3 is different from the tube 505 in the eleventh embodiment In that a surface of the joint portion 632 having a brazing material layer 505c is joined to a surface of the joint portion 631 having no brazing material layer.

[Tube Modification 4]

**[0146]** A tube 640 in a modification 4 shown in FIG. 40 is also different from the tube 505 in the eleventh embodiment in FIG. 34 in the configurations of joint portions 641, 642. The tube 640 also includes a brazing material flow cutoff portion S3 for preventing the flow of brazing material between the inside of the tube 640 and the outside of the tube 640, and thus provides the same effects as In the eleventh embodiment. The tube 640 in the modification 4 is different from the tube 505 In the eleventh embodiment and the tubes 610, 620, 630 In the modifications 1 to 3 in that one of the joint portions 641, 642 at opposite sides of the material (the upper one 641 in this modification) is formed longer than the other joint portion (the lower one 642 in this modification), and the Joint portion 641 Is bent In a substantially C shape to enclose the joint portion 642. In brazing, the joint portions 641, 642 are brazed to each other with an Inner surface of the joint portion 641 in contact with an outer surface of the joint portion 642 with a brazing material layer.

[Tube Modification 5]

**[0147]** A tube 650 in a modification 5 shown in FIG. 41 Is also different from the tube 505 In the eleventh embodiment in FIG. 34 in the configuration of Joint portions 651. The tube 650 in the modification 5 also includes a brazing material flow cutoff portion S3 for preventing the flow of brazing material between the inside of the tube 650 and the outside of the tube 650, and thus provides the same effects as in the eleventh embodiment.

**[0148]** The tube 650 in the modification 5 is different from the tube 505 in the eleventh embodiment and modifications 1 to 4 in that the joint portions 651 are brazed at their inner surfaces having no brazing material layers. Generally, configuration with a brazing material layer provided to at least one joint portion like the tube 505 in FIG. 34 and the tubes 610 to 640 in the modifications 1 to 4 will have better stability in a joint. However, in the configuration of the tube 650 shown in the modification 5, brazing material layers 650c on the outer surfaces of the joint portions 651 will come around Into the inner surfaces of the joint portions 651 through the edges, thereby ensuring the joint between the joint portions 651.

**[0149]** Tubes 660 to 680 In modifications 6 to 8 to be described below are different from the tubes 610 to 640 in the modifications 1 to 5 in that they are formed by combining a plurality of (two in those modifications) metal plates as materials.

[Tube Modification 6]

**[0150]** The tube 660 in the modification 6 shown in FIG. 42 is different from the tube 610 in the modification 1 in FIG. 37 in that two metal plates M1, M2 are used as materials, and joint portions 661, 662 at opposite sides of the metal plates M1, M2 are joined to one another, but otherwise is the same. Therefore, the same effects as those of the tube 610 In the modification 1 in FIG. 37 can be provided.

[Tube Modification 7]

**[0151]** The tube 670 In the modification 7 shown in FIG. 43 Is different from the tube 620 in the modification 2 In FIG. 38 in that two metal plates M1, M2 are used as materials, and joint portions 671 at opposite sides of the metal plates M1, M2 are joined to one another, but otherwise is the same. Therefore, the same effects as those of the tube 620 in the modification 2 in FIG. 38 can be provided.

[Tube Modification 8]

**[0152]** The tube 680 In the modification 8 shown In FIG. 44 is different from the tube 630 In the modification 3 in FIG. 39 in that two metal plates M1, M2 are used as materials, and joint portions 681, 682 at opposite sides of the metal plates M1, M2 are joined to one another, but otherwise Is the same. Therefore, the same effects as those of the tube 630 in the modification 3 in FIG. 39 can be provided.

**[0153]** In summary, according to the eleventh embodiment, no brazing material layer Is provided to the inner surface of a tube and brazing material layers are provided to both surfaces of an Inner fin to join the tube and the Inner fin. Since the inner fin is brazed to the Inner peripheral surface of the tube, avoiding contact with tube joint portions, brazing material inside the tube (the brazing material layers on both sides of the inner fin) is separated from brazing material outside the tube (the brazing material layer on the outer surface of the tube). Therefore, flow of molten brazing material during brazing is separated into flow of brazing material Inside the tube and flow of brazing material outside the tube. As a result, during brazing, brazing material is prevented from flowing away from the Inside of the tube to the outside of the tube and causing a shortage of brazing material inside the tube, or brazing material is prevented from flowing away from the outside of the tube to the Inside of the tube and causing a shortage of brazing material outside the tube.

**[0154]** The heat exchanger In the eleventh embodiment is a heat exchanger in which tubes and header tanks are brazed together with the tubes inserted into tube Insertion slots in the header tanks. Alternatively, It may be a heat exchanger in which tubular tank portions are formed at longitudinal ends of tubes in such a manner as to project in a layering direction of the tubes, and the tank portions of the adjacent tubes in the layering direction are brazed and connected to each other to form header tanks. The eleventh embodiment may be a heat exchanger with no header tanks like a serpentine-type one.

**[0155]** Although the invention has been described above by reference to certain embodiments of the invention, the invention Is not limited to the embodiments described above. Modification and variation of the embodiments can be made without departing from scope of the appended claims. Therefore, the embodiments are only for Illustrative purpose and do not limit the Invention.

## Claims

**1.** A heat exchanger (1) comprising:

outer fins (3);
a plurality of tubes (5), (50), (60), (70), (80), (90A), (90B) having open ends and arranged alternately with the outer fins; and
header tanks (7), (100), (110), (120), (130), (140), (150), (160), (170), (180), (190) receiving the open ends of the tubes for communication with the tubes, the header tanks each comprising a first member (21), (141), (151), (161) and a second member (23), (102), (112), (122), (132), (142), (152), (172), (192) which are combined to each other;

wherein the first member includes tube insertion slots (33) into which the open ends of the tubes are inserted, the second member lacking the tube insertion slots (33);

the first member (21), (141), (151), (161) is either a core material (21a) having no brazing material layers on outer and Inner peripheral surfaces thereof, or a core material (161a) having a brazing material layer (161c) on an outer peripheral surface thereof which does not have brazing material layer on an inner peripheral surface thereof; and

the second member (23), (102), (112), (122), (132), (142), (152), (172), (192) is brazed to the outer or inner peripheral surface of the first member which does not have brazing material layer thereon.

**2.** A heat exchanger (1) as set forth In claim 1, wherein the first member (21), (141), (151) is the core material (21a) which does not have brazing material layers on the outer and Inner peripheral surfaces thereof.

**3.** A heat exchanger (1) as set forth in claim 2, wherein the second member (23), (123), (133), (142), (152) has a brazing material layer (23), (123c), (133c) on the Inner or outer peripheral surface thereof to be joined to the first member (21).

**4.** A heat exchanger (1) as set forth in claim 3, wherein:

the second member (23), (142) Is provided with the brazing material layer (23c) on the outer surface of a core material (23a); and

the first and second members are brazed together with an outer peripheral surface of the second member (23), (142) connected to an inner peripheral surface of the first member (21), (141).

**5.** A heat exchanger (1) as set forth in claim 3, wherein:

the second member (123), (133) is provided with the brazing material layer (123b), (133b) on the inner peripheral surface of a core material (123a), (133a); and

the first and second members are brazed together with an outer peripheral surface of the first member (21), (151) connected to an inner peripheral surface of the second member (112), (123), (133), (152).

**6.** A heat exchanger (1) as set forth in claim 5, wherein the second member (133) is provided with the brazing material layers (133b, 133c) on the inner and outer peripheral surfaces of a core material (133a).

**7.** A heat exchanger (1) as set forth in one of claims 2 to 6, wherein the first member (141), (151) and the second member (142), (152) of the header tank (140), (150) each have a box shape with an opening formed in a combining direction.

**8.** A heat exchanger (1) as set forth in claim 7, wherein:

the header tank (7) includes a partition (27) for partitioning an interior thereof into a plurality of chambers; and

the partition (27) is provided with the brazing material layer (27b, 27c) on at least one surface of a core material (27a) having two surfaces.

**9.** A heat exchanger (1) as set forth in one of claims 2 to 6, wherein:

the header tank (7), (100), (120), (130) Includes a pipe (19) comprising the first member (21) and the second member (23), (102), (112), (123), (133), and lids (25, 2S) for closing opposite open ends of the pipe (19); and

the lids (25, 25) each have a brazing material layer (25b, 25c) on at least one surface of a core material (25a) having two surfaces.

**10.** A heat exchanger (1) as set forth in claim 9, wherein:

the header tank (7), (100), (110), (120) includes a partition (27) for partitioning an Interior thereof into a plurality of chambers; and

the partition (27) has a brazing material layer (27b, 27c) on at least one surface of a core material (27a) having two surfaces.

**11.** A heat exchanger (1) as set forth in claims 2 to 10, wherein the tubes (5), (50), (60), (70), (80) each have a brazing material layer (5c), (50c), (60c), (70c), (80c) on the outer peripheral surface thereof.

**12.** A heat exchanger (1) as set forth In one of claims 2 to 10, wherein the tubes (80) each comprise two metal plates (80A, 80B) joined in a tubular shape.

**13.** A heat exchanger (1) as set forth in claim 12, wherein joint portions (81, 82) of the two metal plates (80A, 80B) are provided along the length of the tube (80).

**14.** A heat exchanger (1) as set forth in one of claims 2 to 10, wherein the tubes (5), (50), (60), (70) each comprise a single metal plate folded in a tubular shape.

**15.** A heat exchanger (1) as set forth In claim 14, wherein the tubes (5), (50), (60), (70) each have joint portions (47, 47), (51, 52), (61, 61), (71, 71) provided along the length of the tube.

**16.** A heat exchanger (1) as set forth in claim 1, wherein:

the first member (141), (161) does not have the brazing material layer on the Inner peripheral surface thereof and has a brazing material layer (16ic) on the outer peripheral surface thereof; and
the second member (23), (142), (172), (192) is connected to an inner peripheral surface of the first member (141), (161) and brazed to the first member.

**17.** A heat exchanger (1) as set forth in clalm 16, wherein the first member (141) and the second member (142) of the header tank (140) each have a box-like shape with an opening formed In a combining direction to each other.

**18.** A heat exchanger (1) as set forth in claim 17, wherein the second member (142) has the brazing material layer (23c), (172c) thereon.

**19.** A heat exchanger (1) as set forth in claim 16, wherein:

the header tank (160), (170), (180), (190) Includes a pipe (19) comprising the first member (161) and the second member (23), (172), (192), and lids (25, 25) for closing opposite open ends of the pipe (19); and
the lids (25) are connected in the pipe (19).

**20.** A heat exchanger (1) as set forth in claim 19, wherein the second member (23), (172) includes the brazing material layer (23c), (172c) thereon.

**21.** A heat exchanger (1) as set forth in claim 19 or 20, wherein the lids (25) each have a plate-like shape, and have a brazing material layer (25b, 25c) on at least one surface thereof.

**22.** A heat exchanger (1) as set forth in one of claims 16 to 21, further comprising a partition (27) fitted in each header tank (140), (160), (170), (180), (190) for partitioning an Interior space of the header tank into a plurality of chambers, the partition (27) being connected to the inner peripheral surfaces of the first and second members.

**23.** A heat exchanger (1) as set forth in claim 22, wherein the partition (27) has a plate-like shape, and the brazing material layer (27b, 27c) on at least one surface thereof.

**24.** A heat exchanger (1) as set forth In one of claims 16 to 23, wherein an edge (181) of the first member (161) is spaced from the outer peripheral surface of the second member (23).

**25.** A heat exchanger (501) comprising:

heat transfer tubes (505), (610), (620), (630), (640), (650), (660), (670), (680) provided as heat transfer tubes;
outer fins (503) brazed to outer surfaces of the tubes; and Inner fins (549) brazed inside the tubes;

wherein each of the tubes has joint portions (547, 547), (611, 6ii), (621, 621), (631, 632), (641, 642), (651, 651), (661, 662), (671, 671), (681, 682), and does not have a brazing material layer on an inner peripheral surface thereof but has a brazing material layer on an outer peripheral surface thereof; and

each of the inner fins has brazing material layers (549b, 549c) on both surfaces of a core material (549a), and is brazed to the Inner peripheral surface of the tube, without contact with the joint portions of the tube.

**26.** A heat exchanger (501) as set forth in claim 25, wherein the tubes (505), (610), (620), (630), (640), (650) are each comprise a single bent metal plate (M) in a tubular shape, with a brazing material layer (505c) located at the outer peripheral side.

**27.** A heat exchanger (501) as set forth in claim 25, wherein the tubes (660), (670), (680) each comprise a plurality of metal plates (M1, M2) In a tubular shape, with a brazing material layers (505c) located at the outer peripheral side.

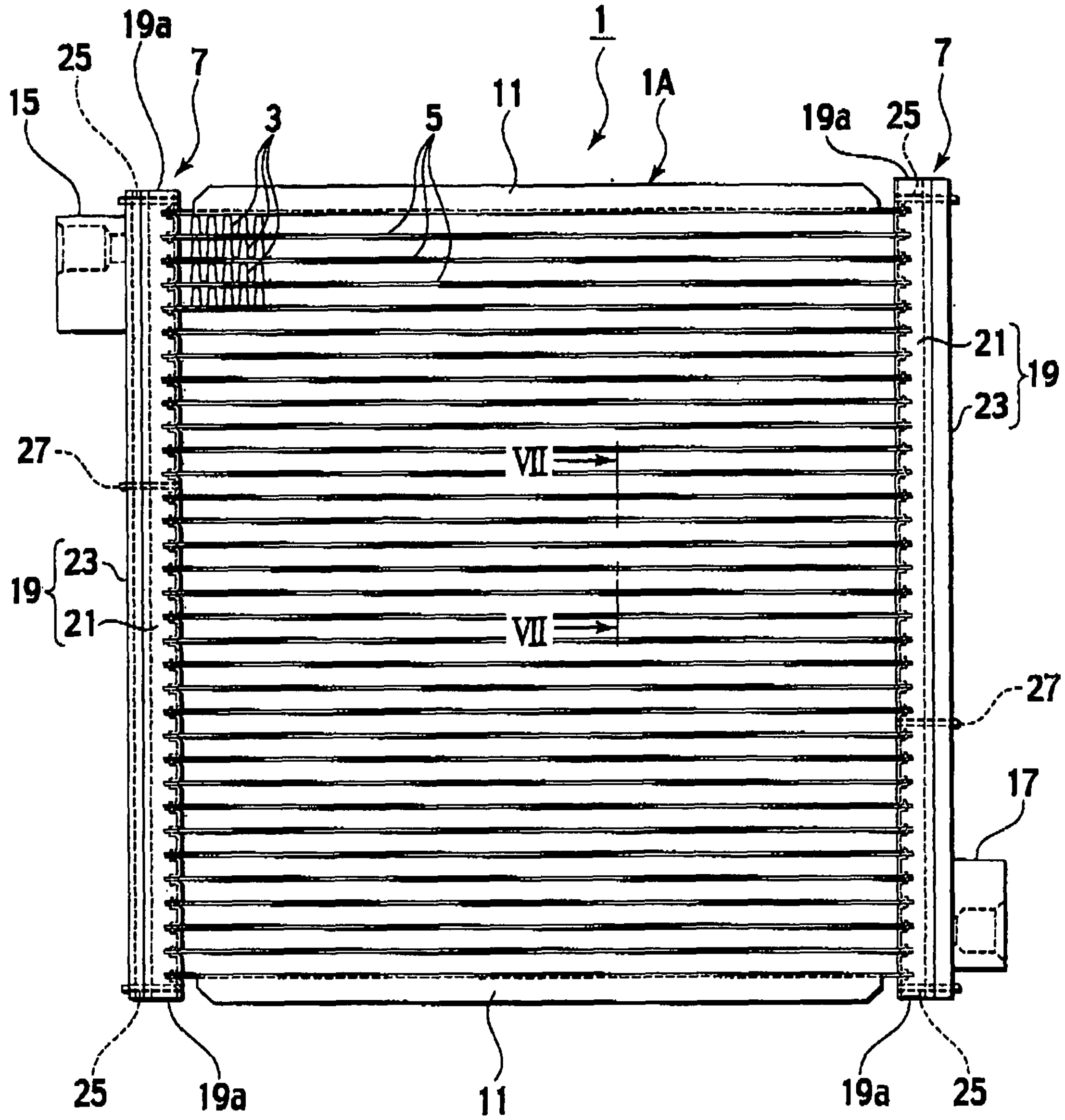
**28.** A heat exchanger (501) as set forth In one of claims 25 to 27, further comprising:

header tanks (507) to which open ends of the tubes are brazed;

wherein the tubes and the outer fins are arranged alternately.

**29.** A heat exchanger (501) as set forth in one of claims 25 to 28, wherein the outer fins (503) each comprise a core material which does not have the brazing material layers on either surface thereof.

FIG.1



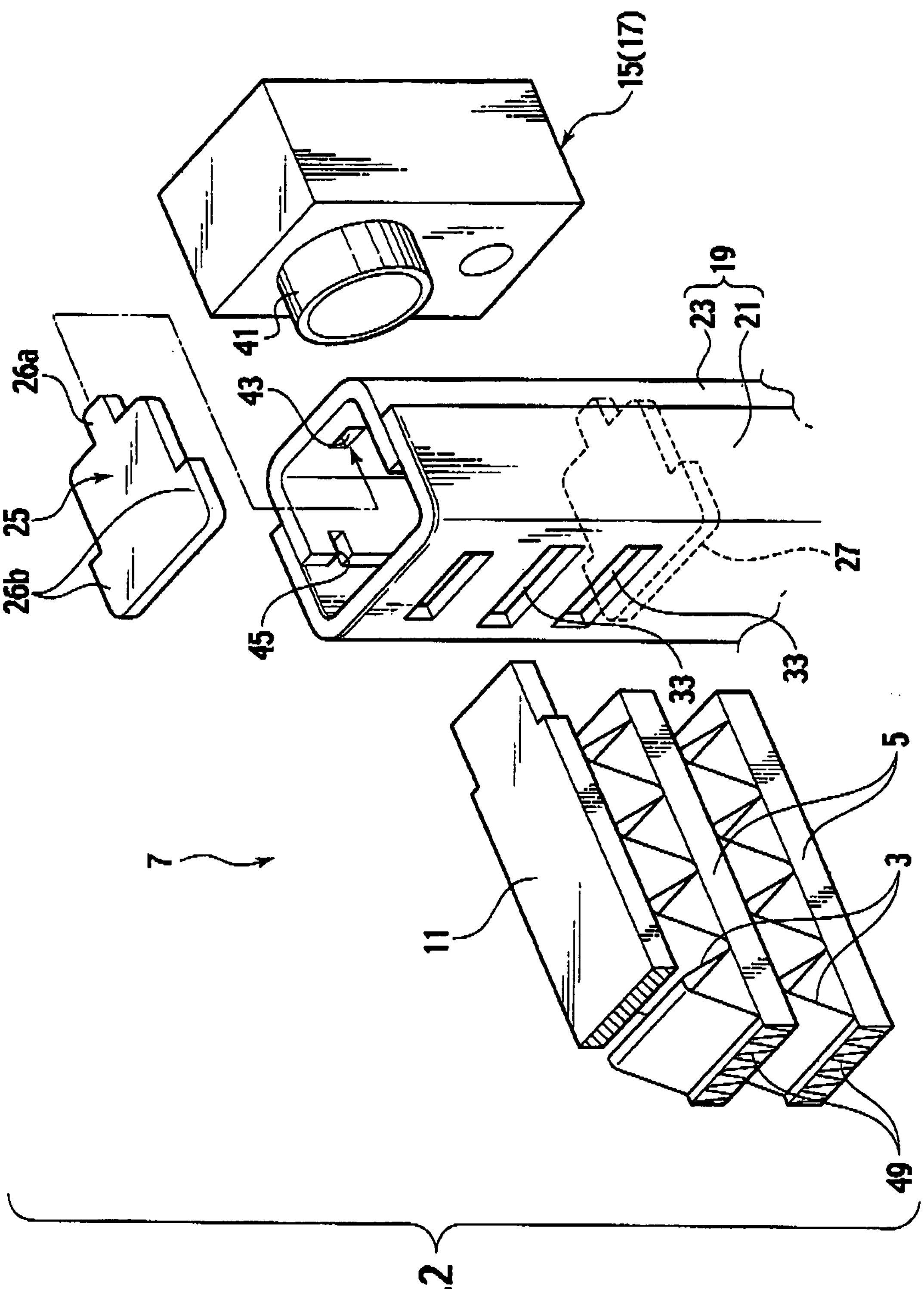



FIG.2

FIG.3

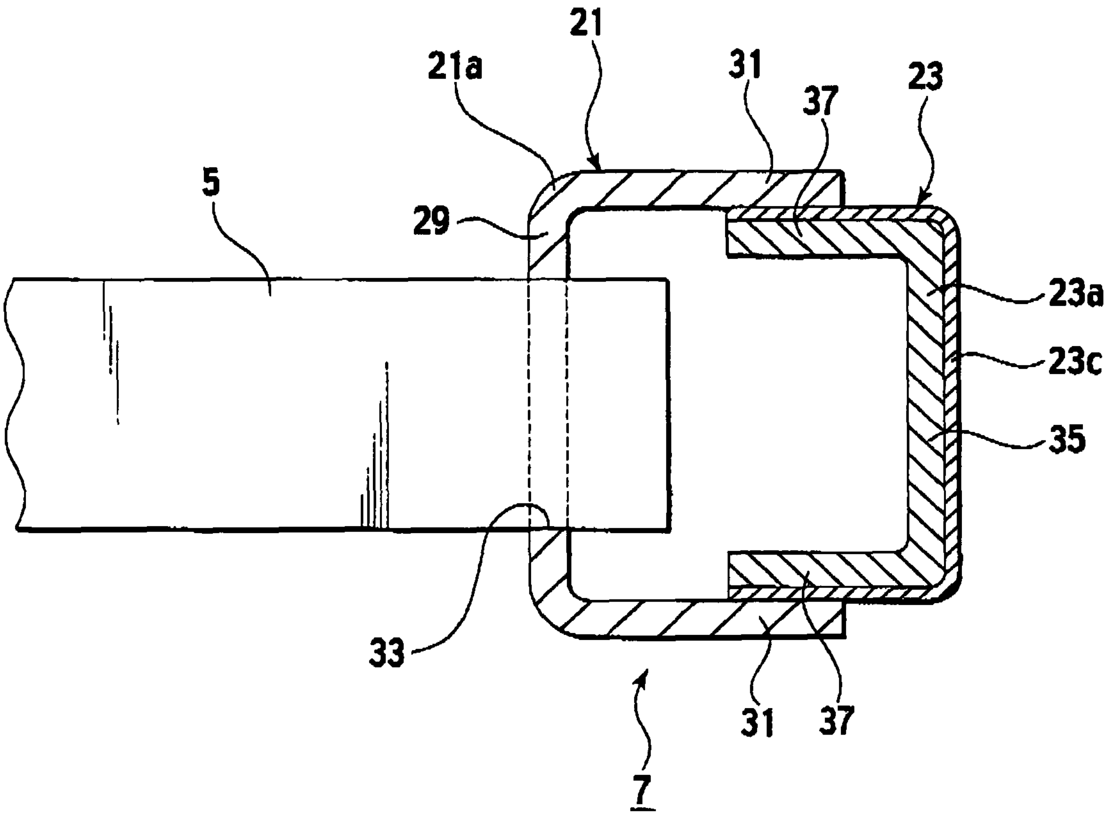


FIG.4A

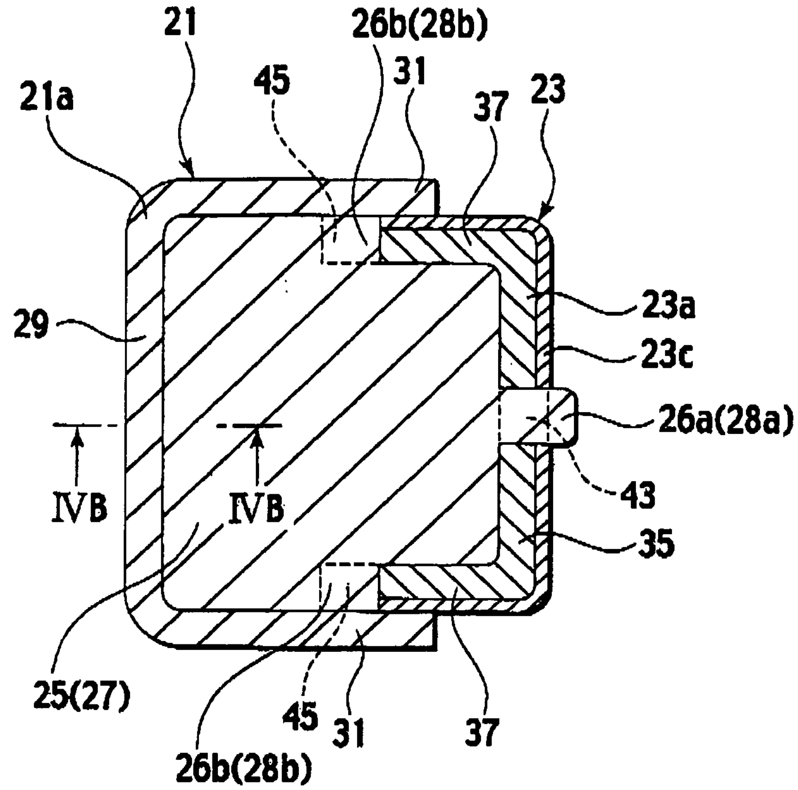

21
26b(28b)
21a
45
31
37
23
23a
29
23c
26a(28a)
IVB
IVB
43
35
25(27)
45
31
37
26b(28b)

FIG.4B

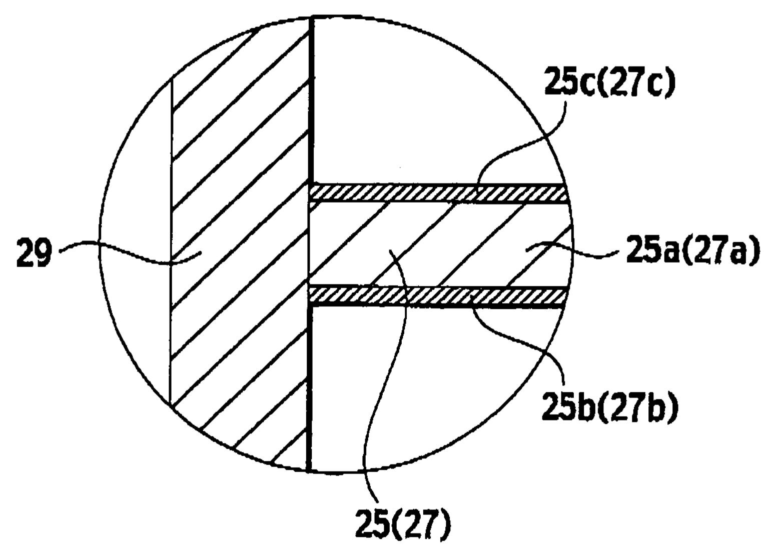

25c(27c)
29
25a(27a)
25b(27b)
25(27)

FIG.5

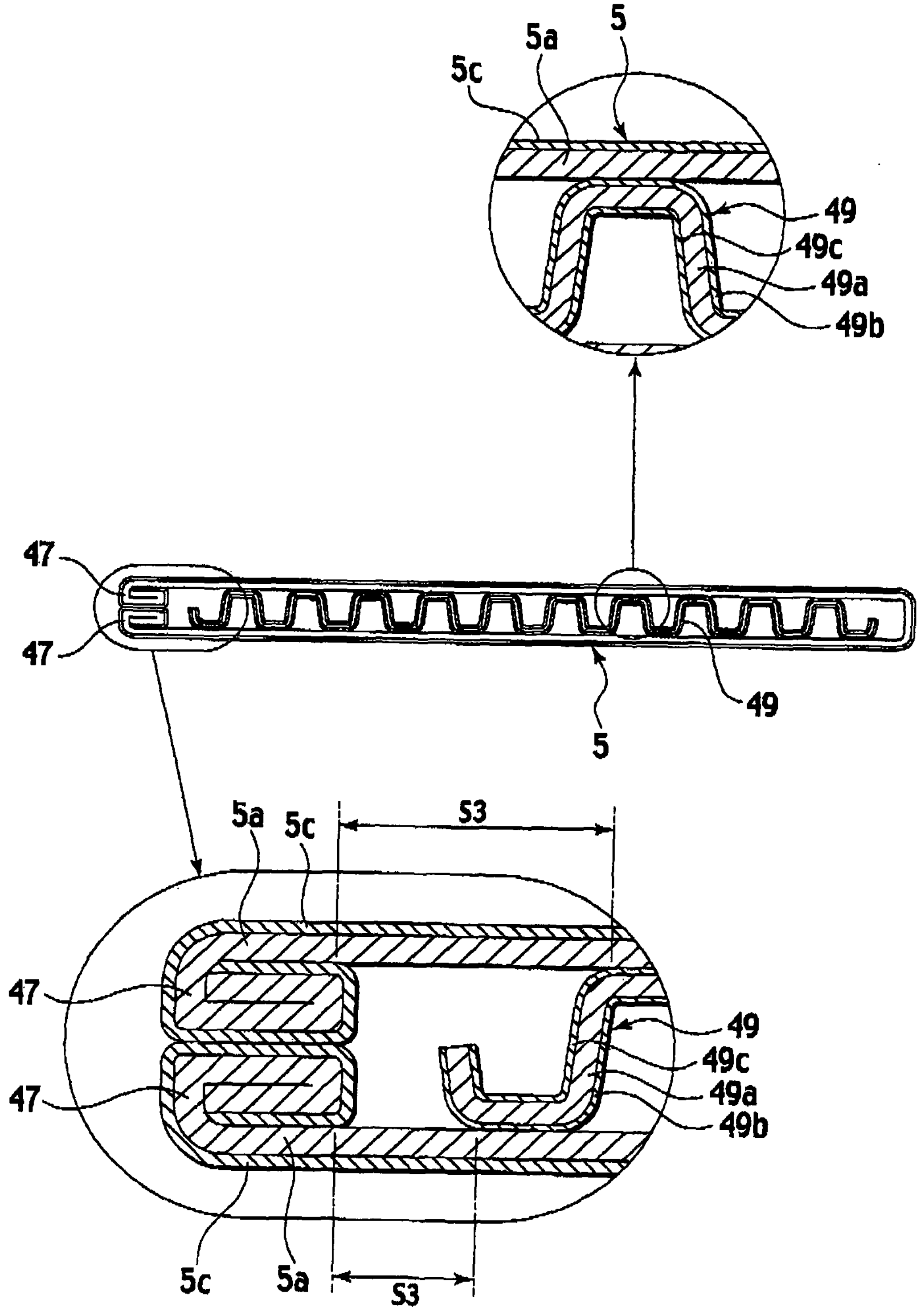

5
5a
5c
49
49c
49a
49b
47
47
49
5
5a
5c
S3
47
47
49
49c
49a
49b
5c
5a
S3

FIG.6A

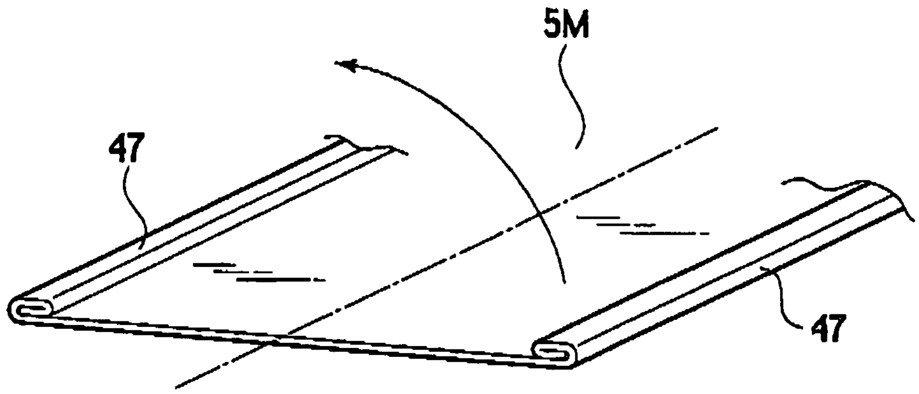



FIG.6B

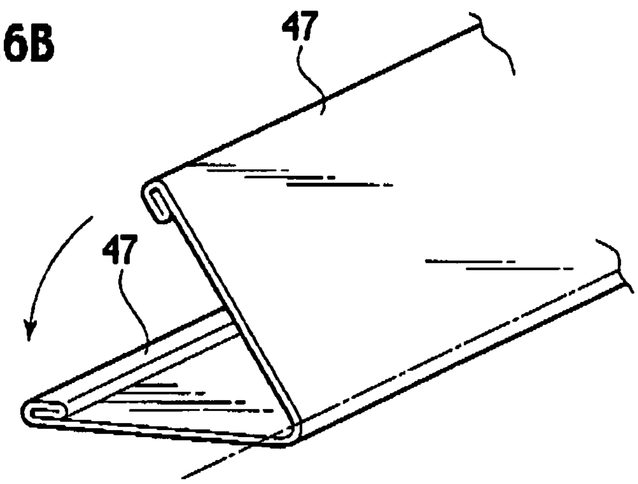



FIG.6C

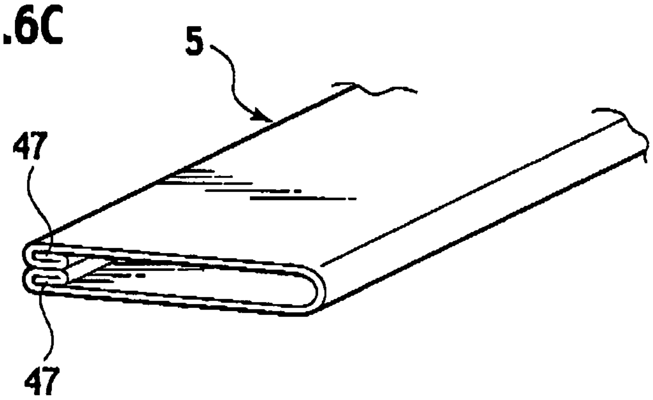
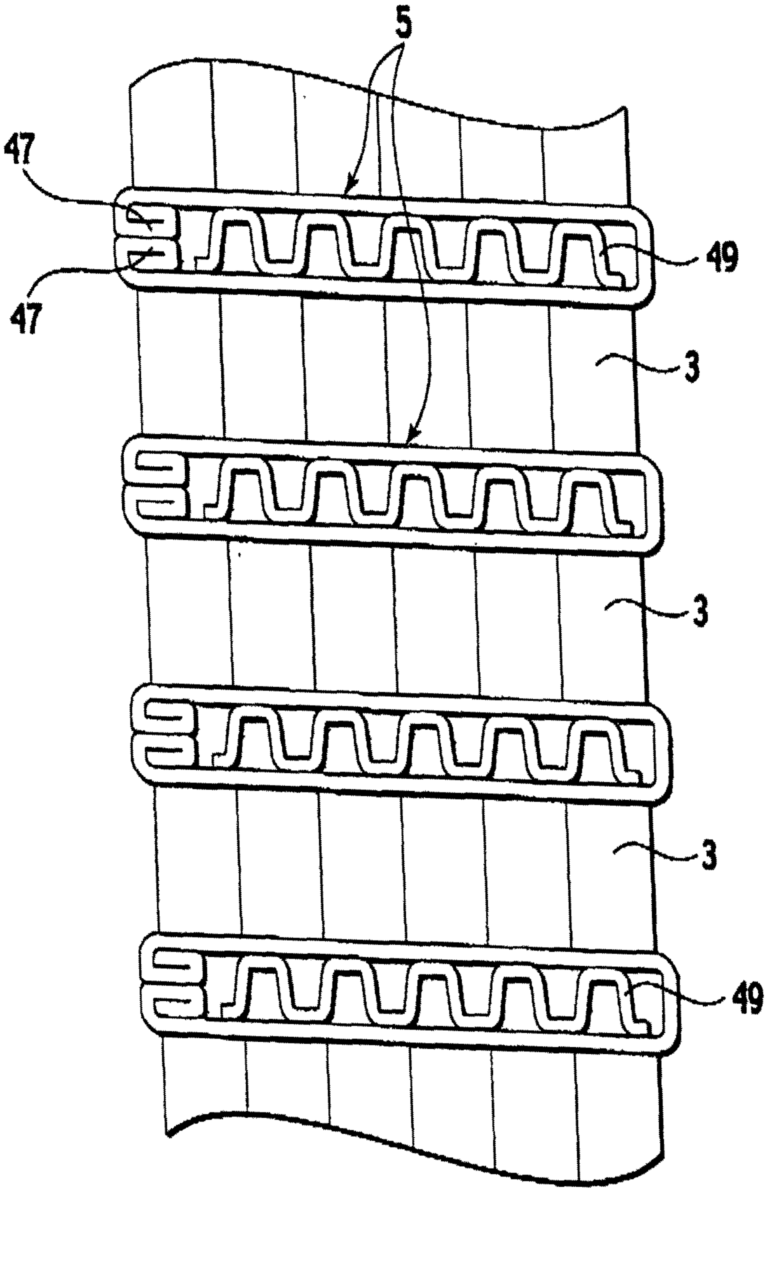


FIG.7



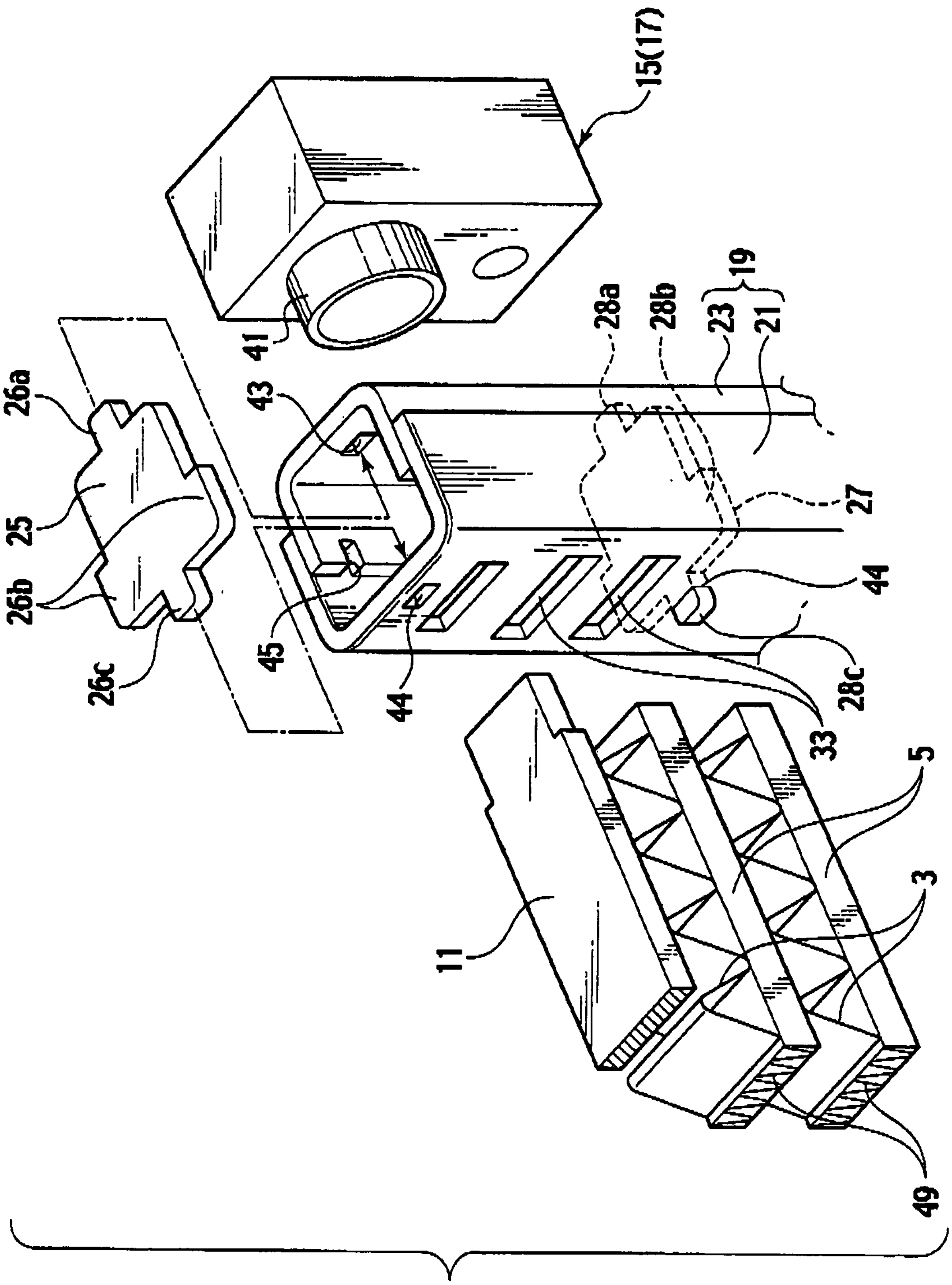

15(17)
41
19
23
21
28a
28b
27
43
44
28c
26a
25
26b
26c
45
44
33
5
3
11
49

FIG.8

FIG.9

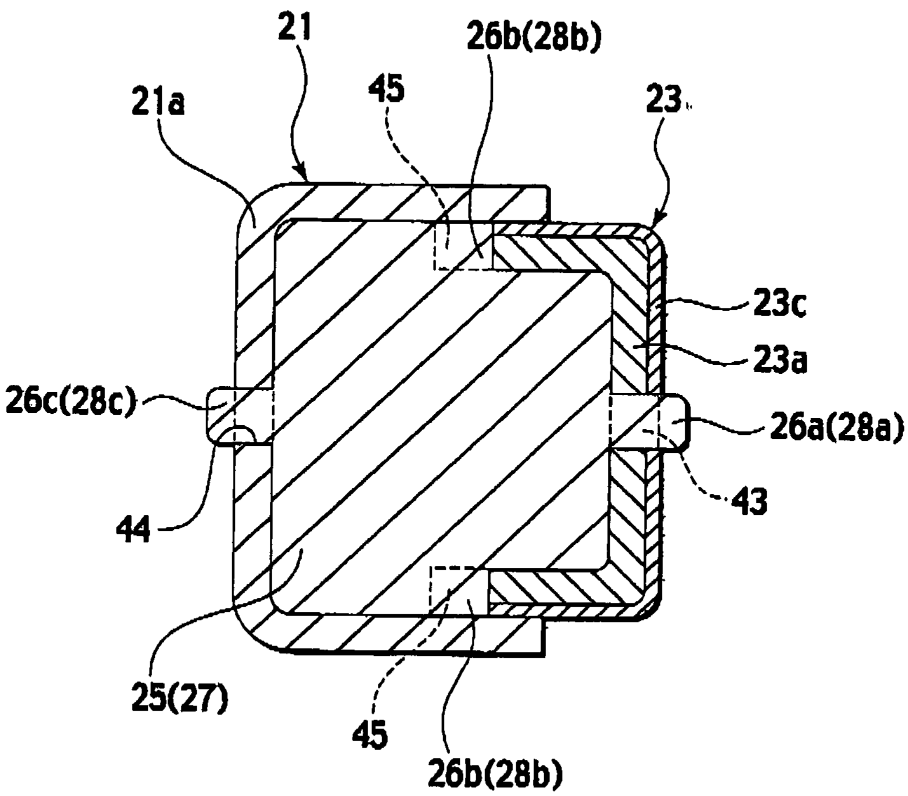


FIG.10

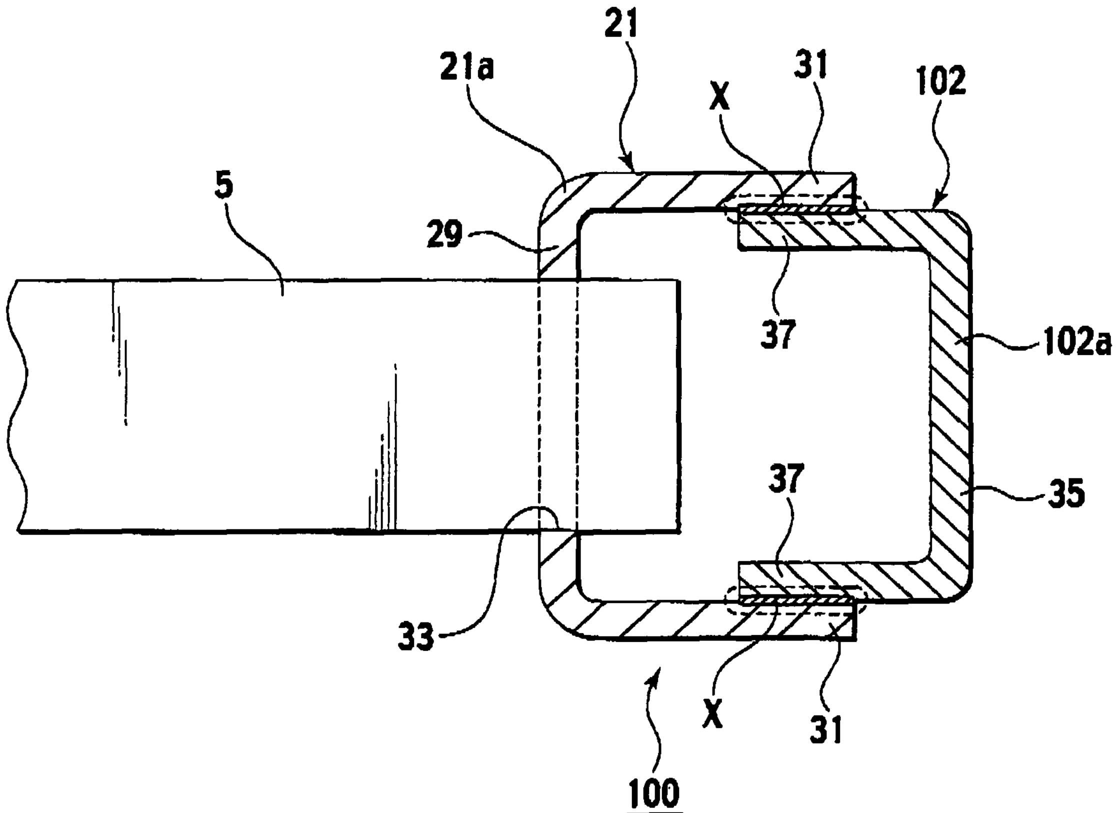


FIG.11

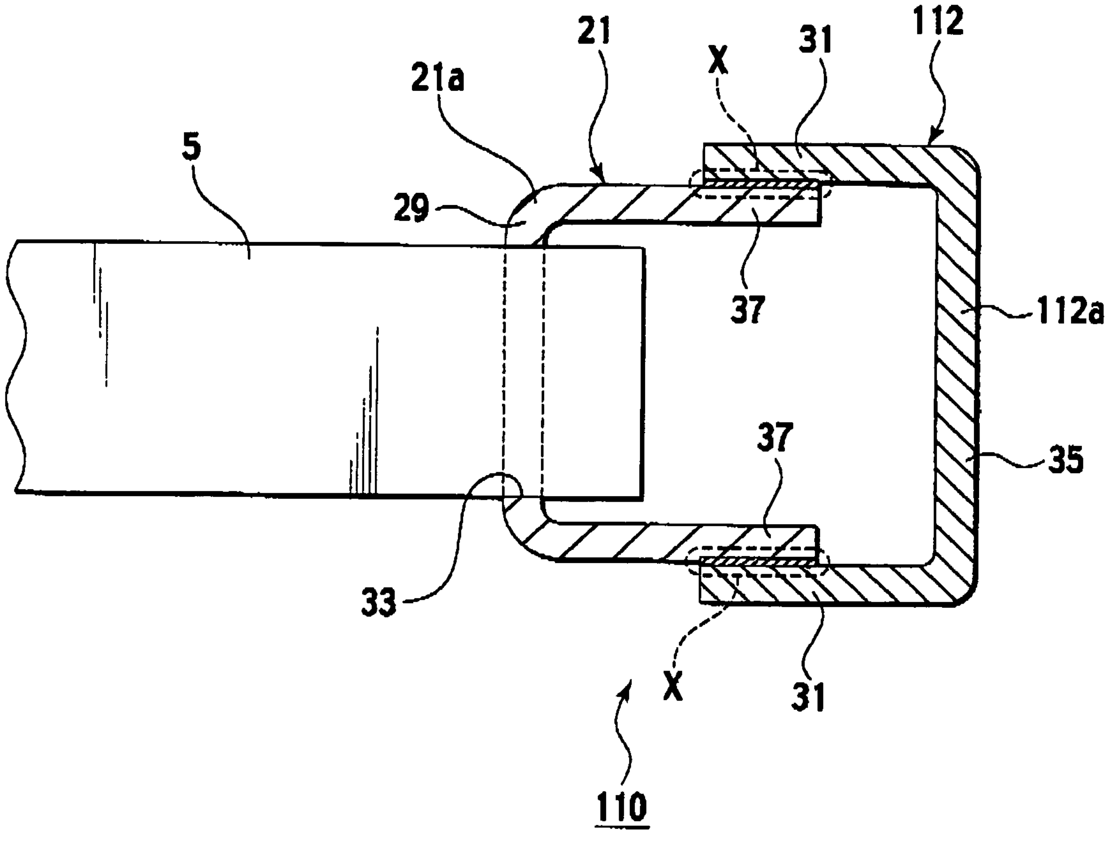


FIG.12

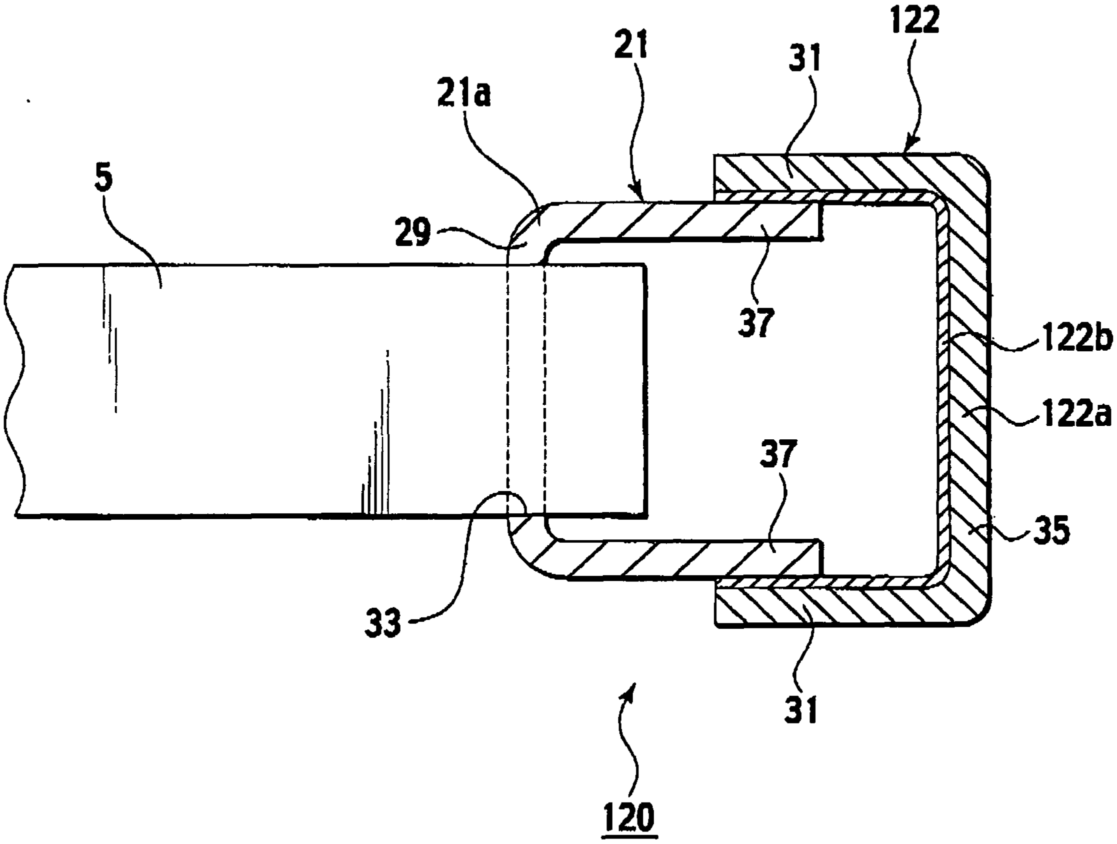


FIG.13

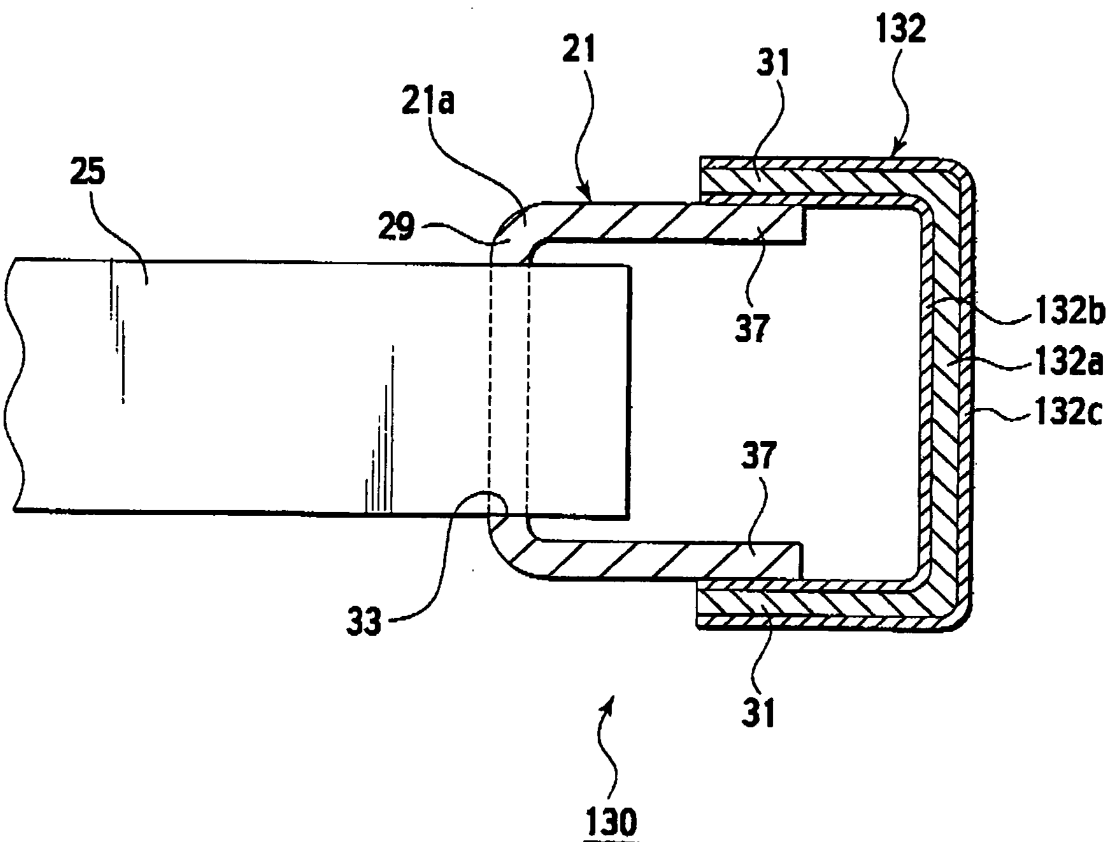


FIG.14A

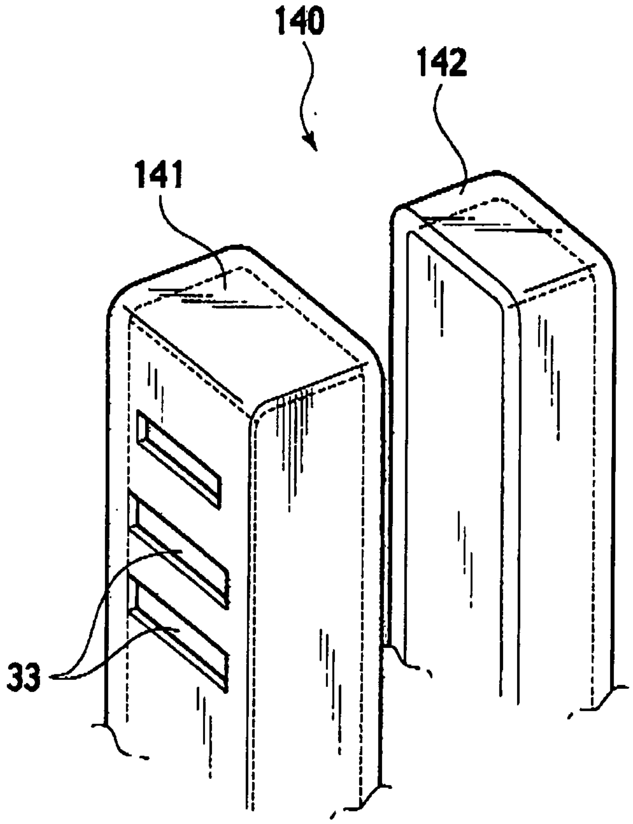



FIG.14B

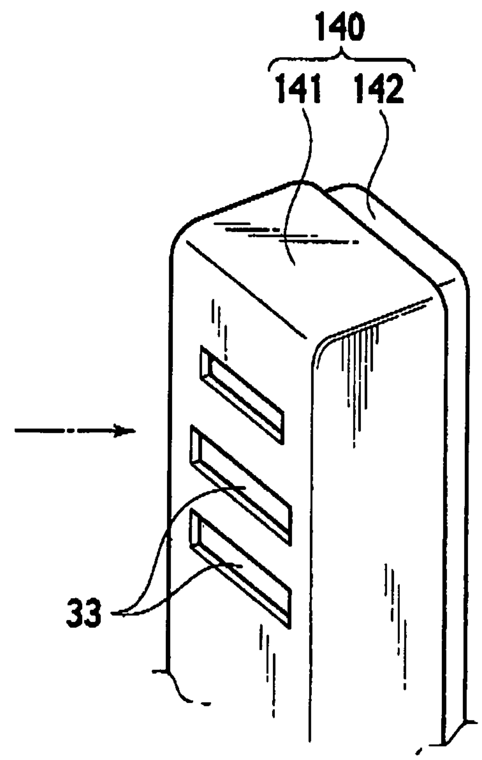


FIG.15A

FIG.15B

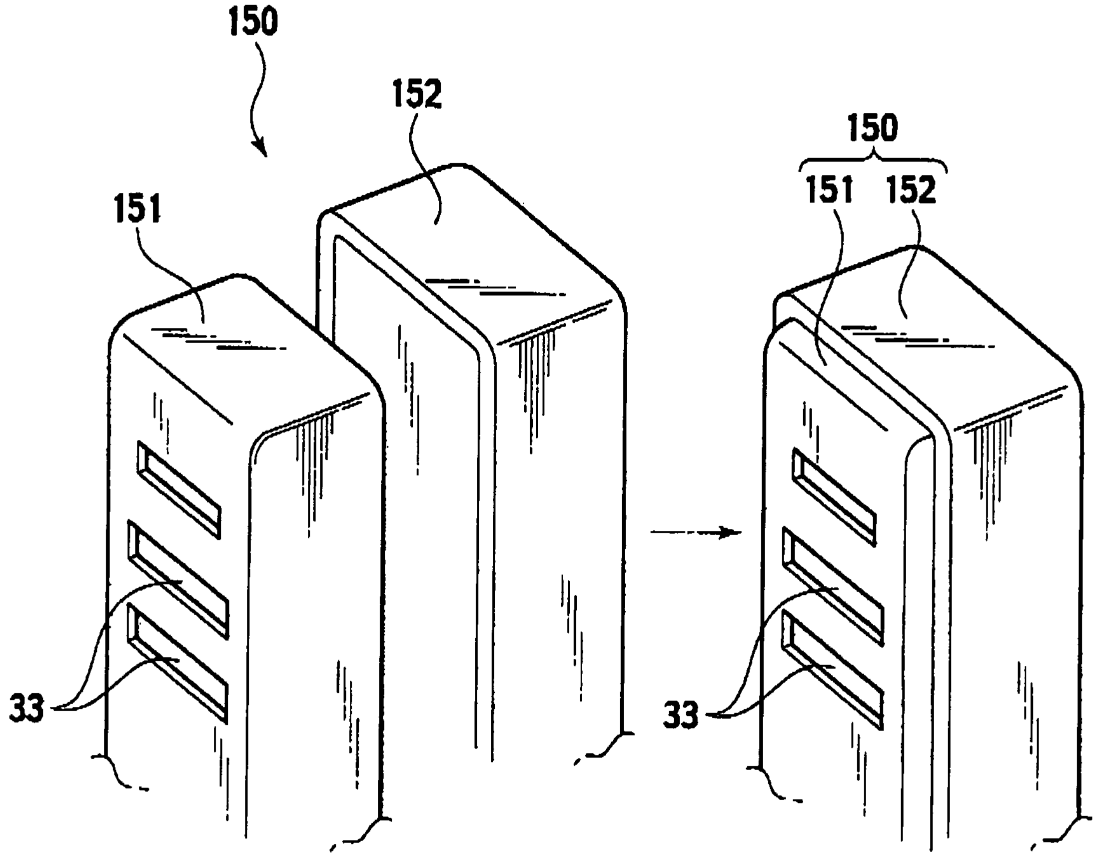


FIG.16

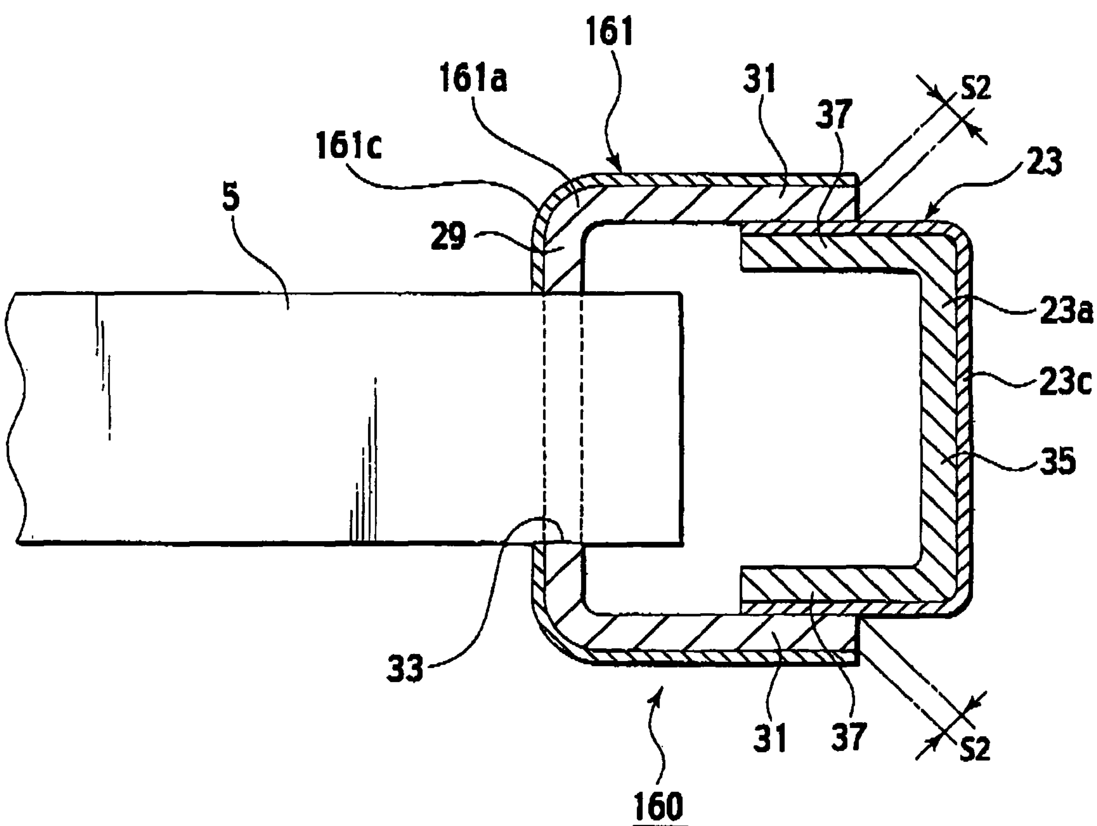


FIG.17A

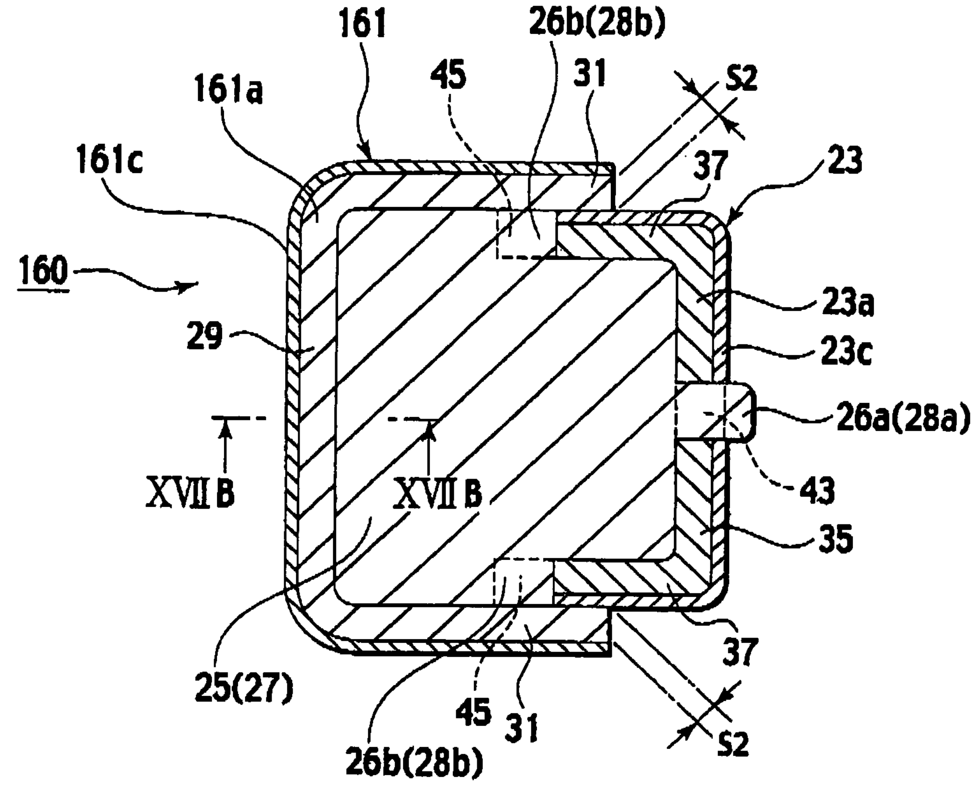



FIG.17B

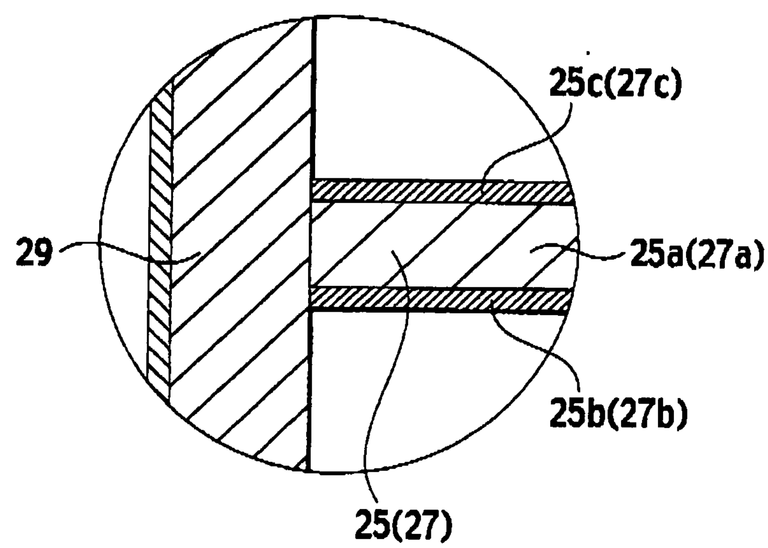


FIG.18

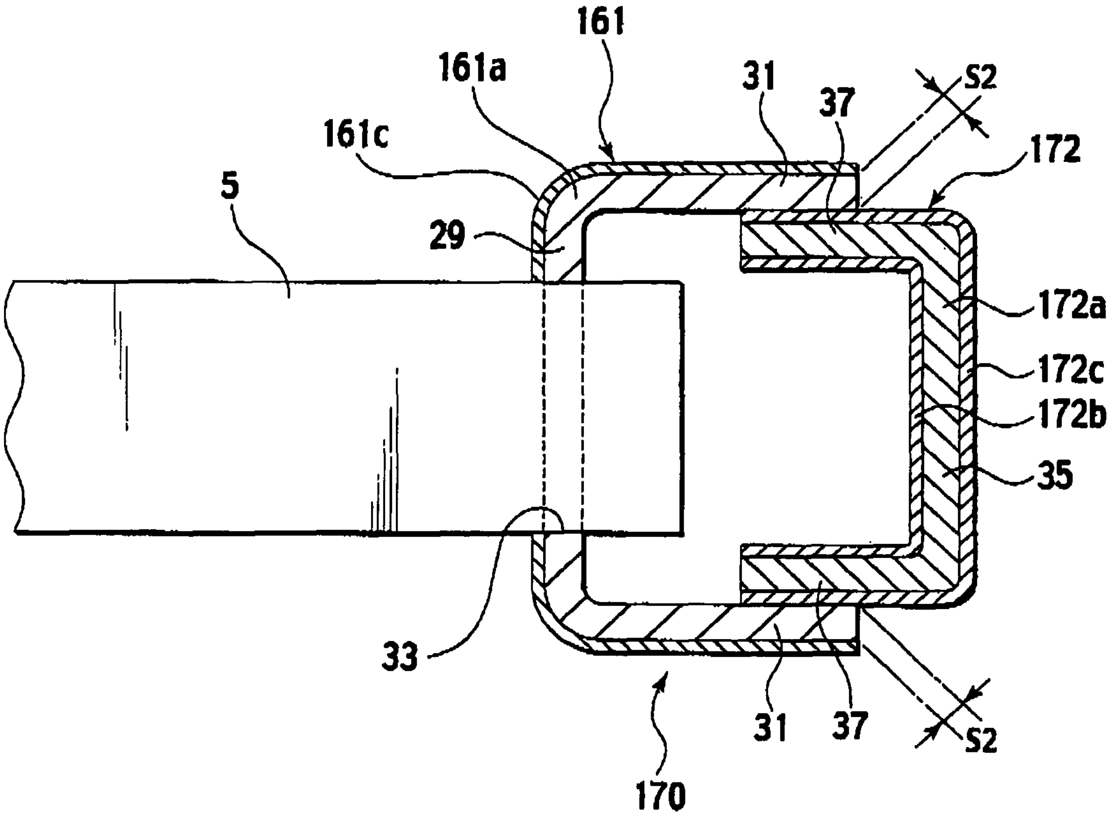


FIG.19A

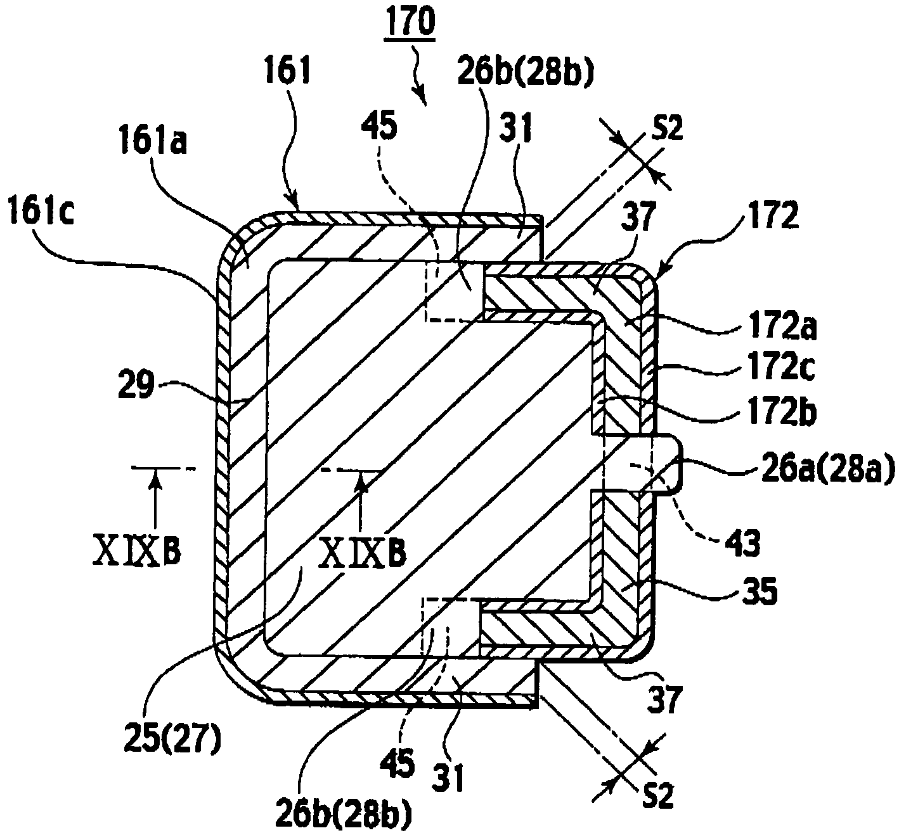



FIG.19B

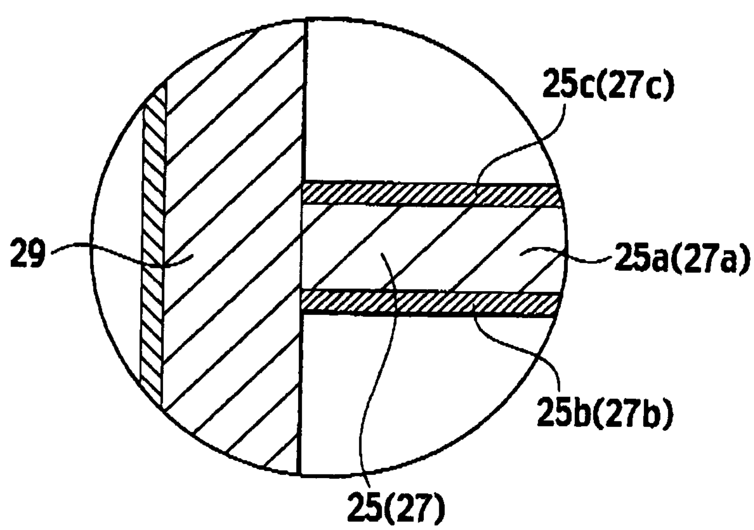


FIG.20

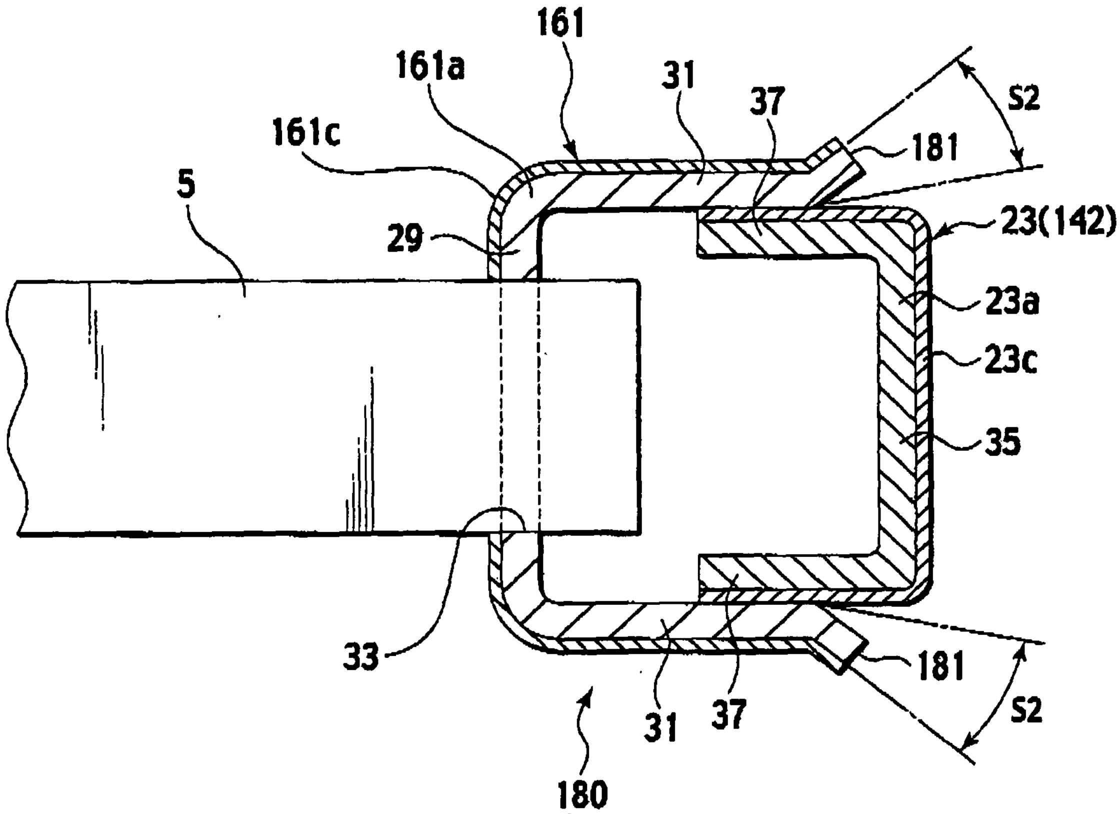

161
161a
161c
5
29
31
37
181
S2
23(142)
23a
23c
35
33
31
37
181
S2
180

FIG.21

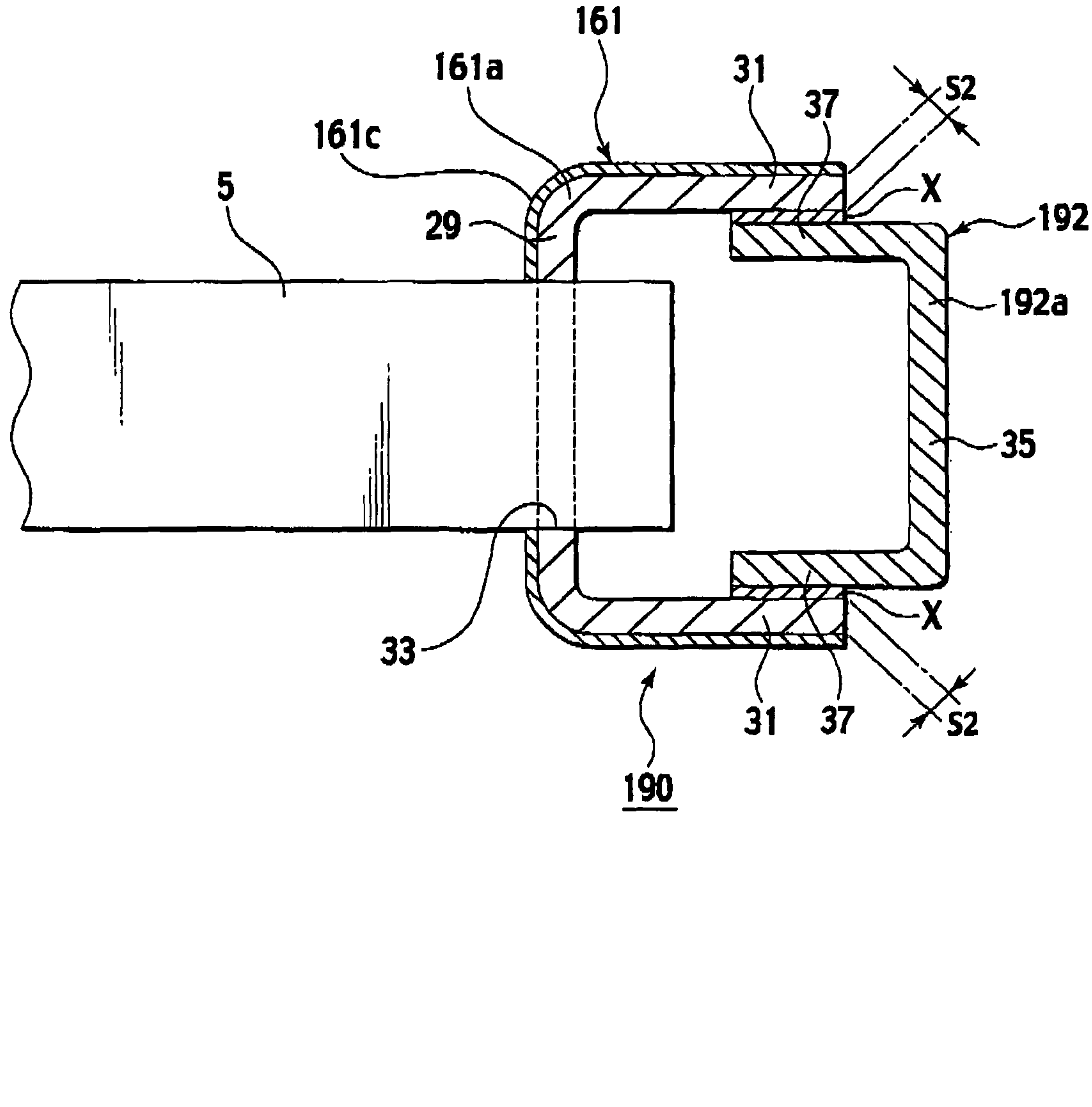


FIG.22

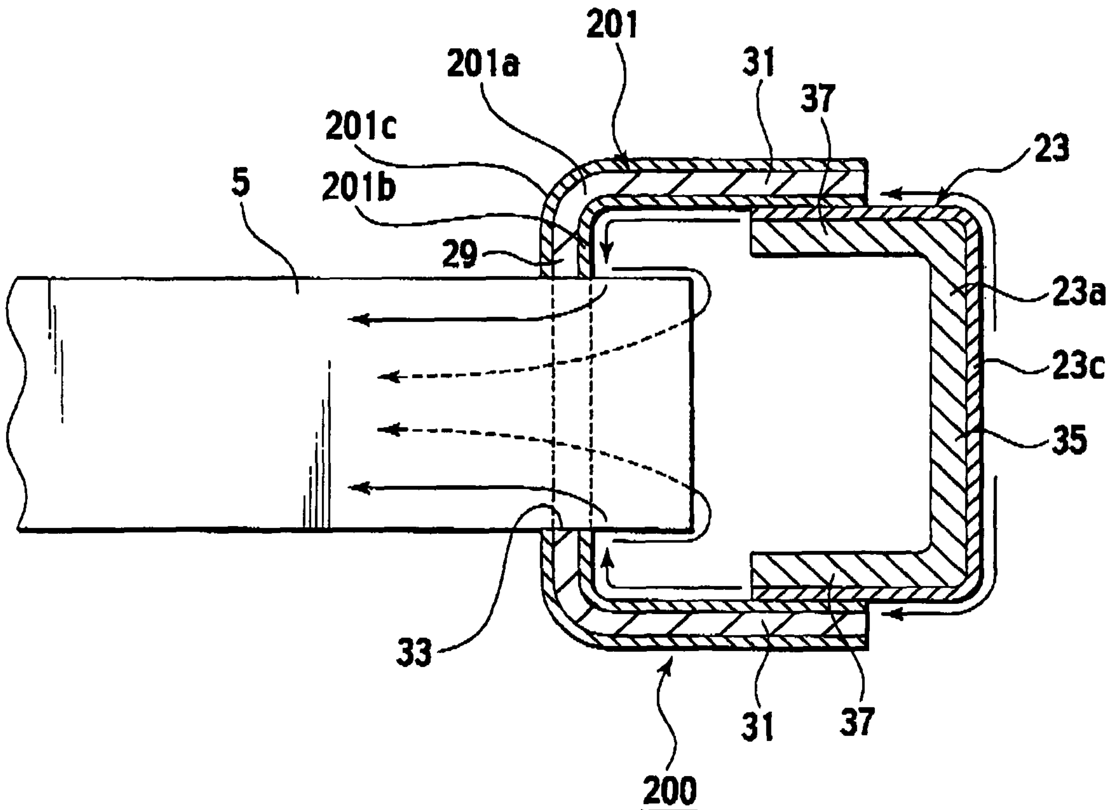


FIG.23A

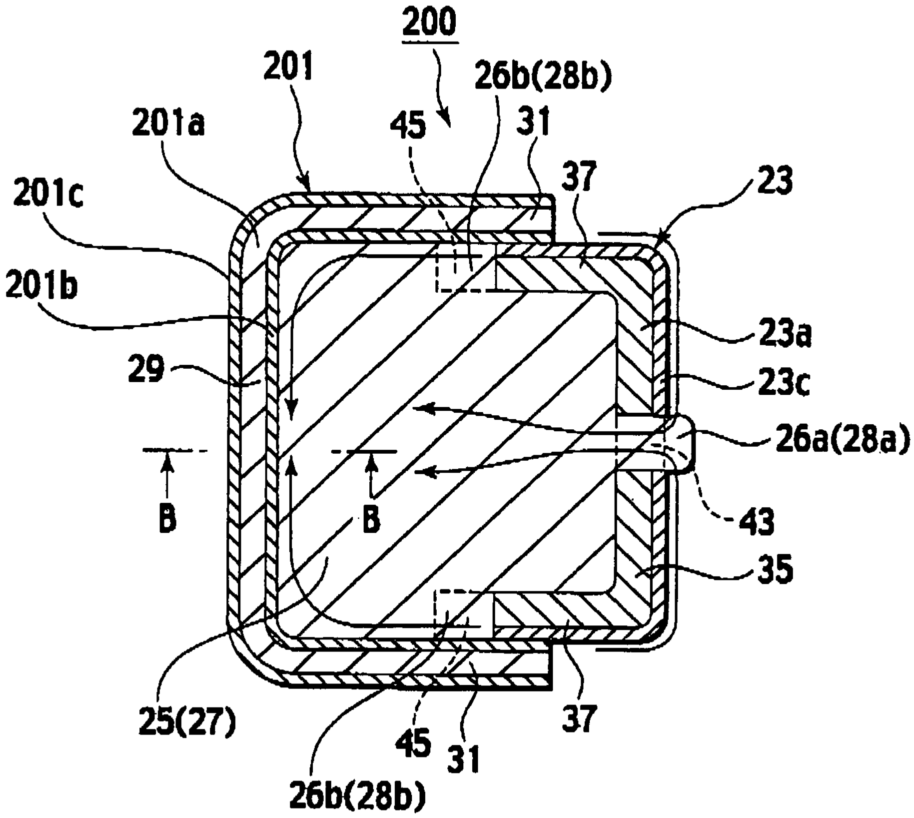



FIG.23B

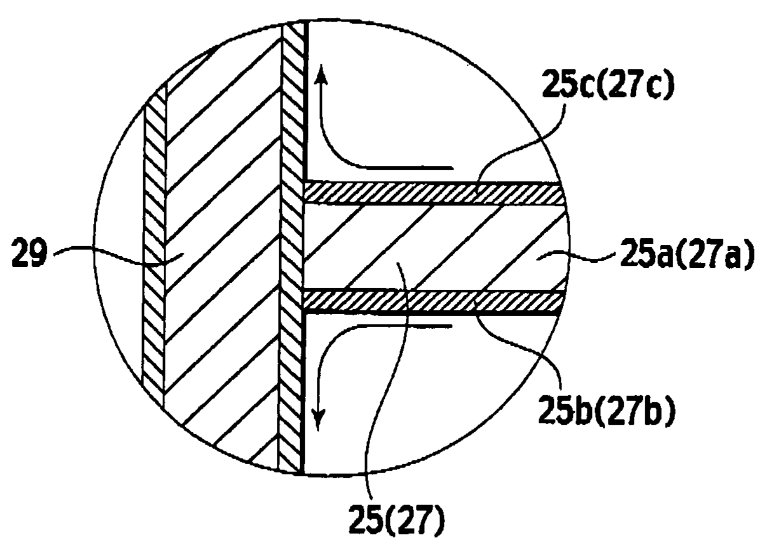


FIG.24

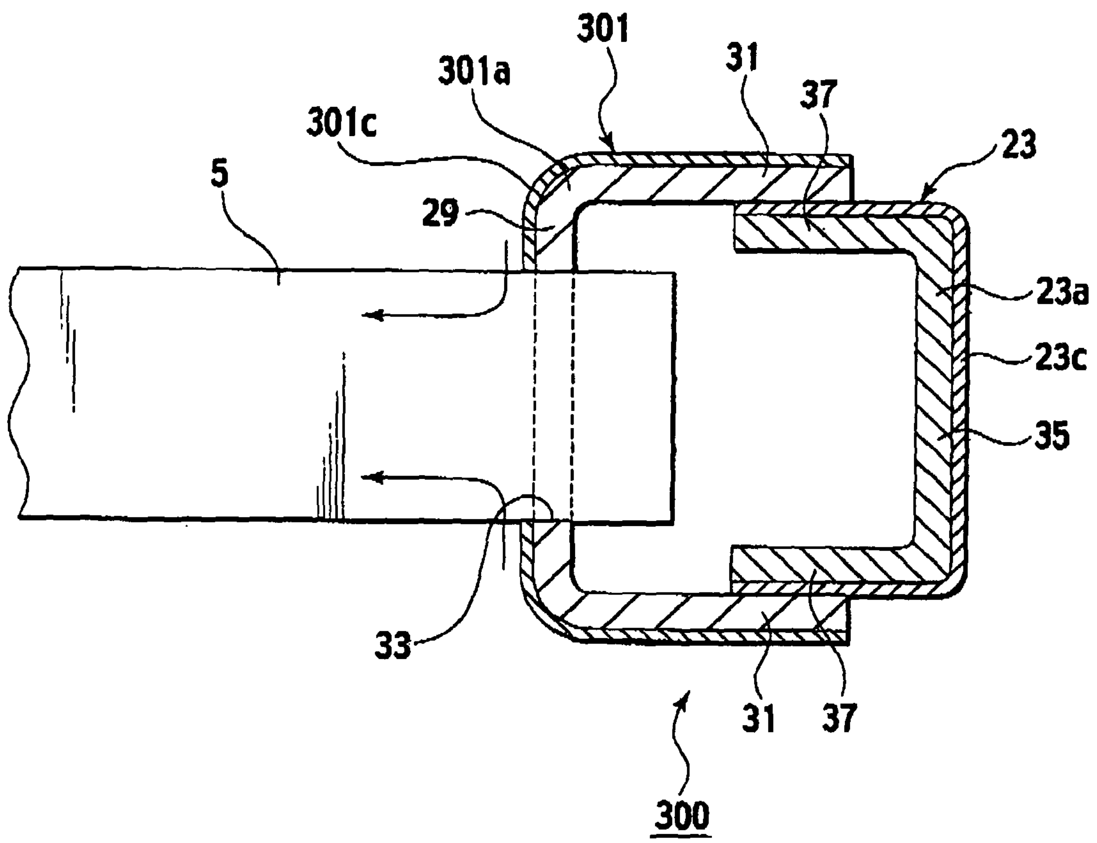


FIG.25A

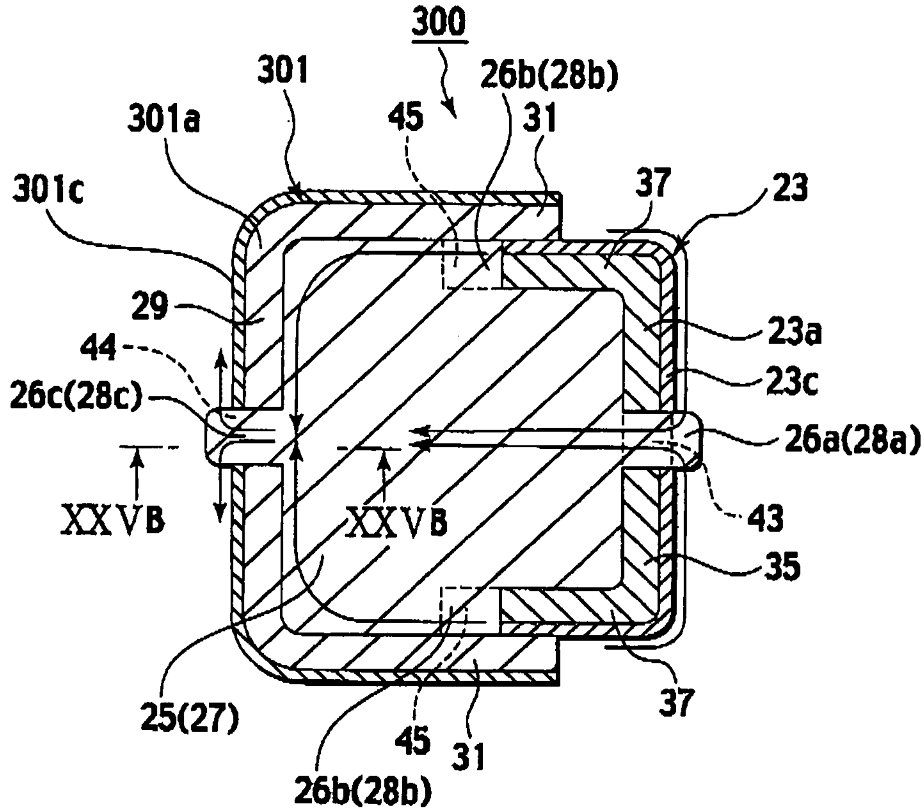



FIG.25B

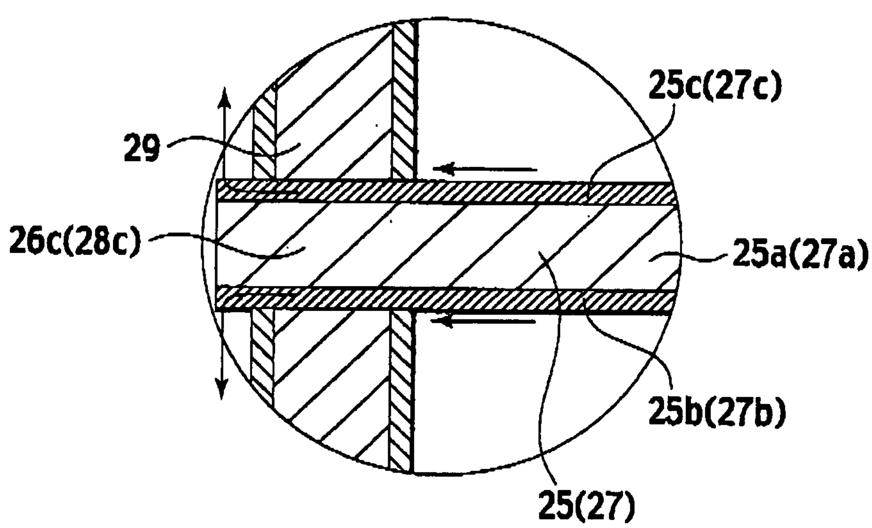


FIG.26A

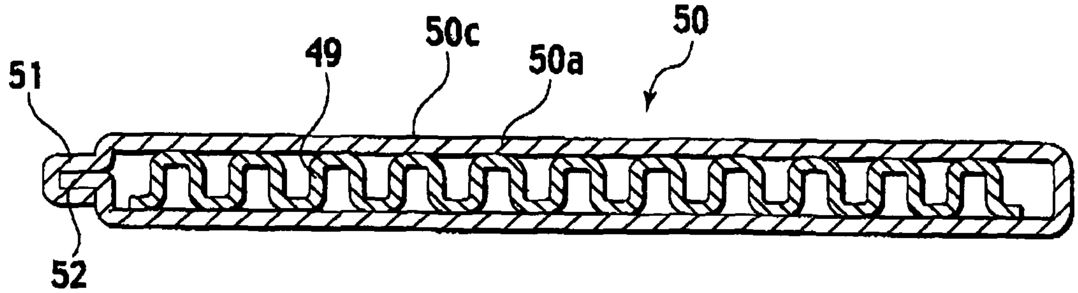



FIG.26B

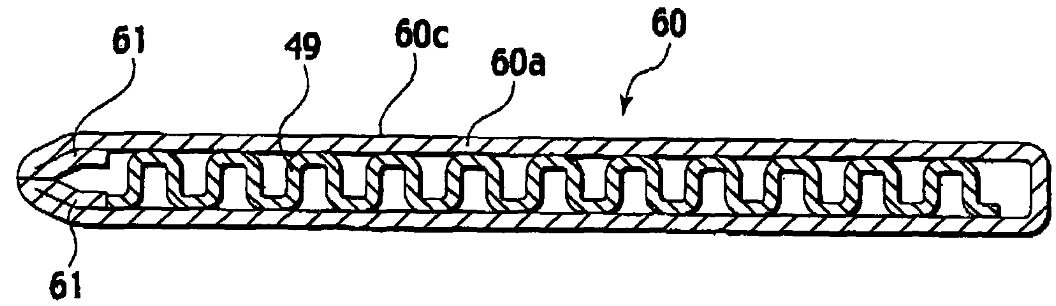



FIG.26C

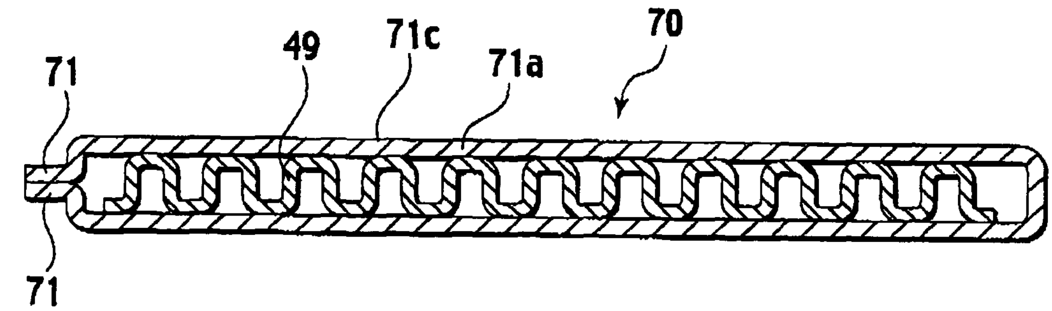


FIG.27

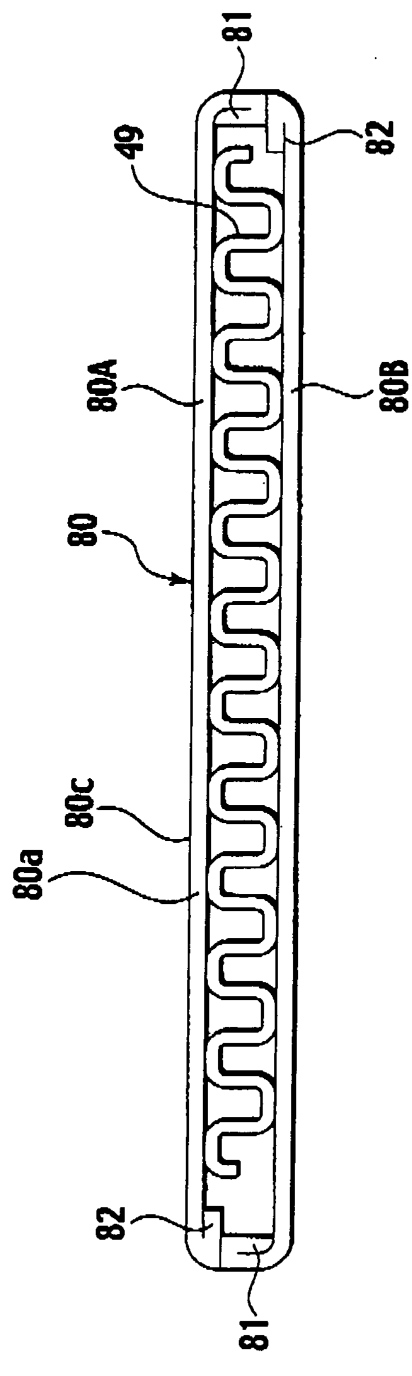


FIG.28

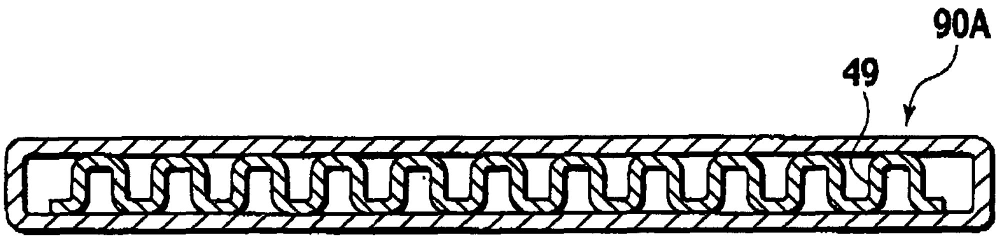



FIG.29

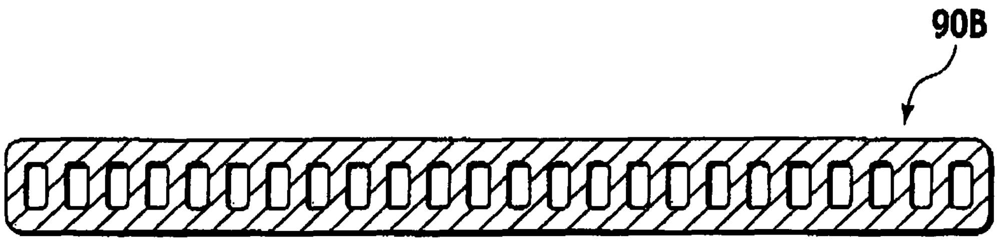
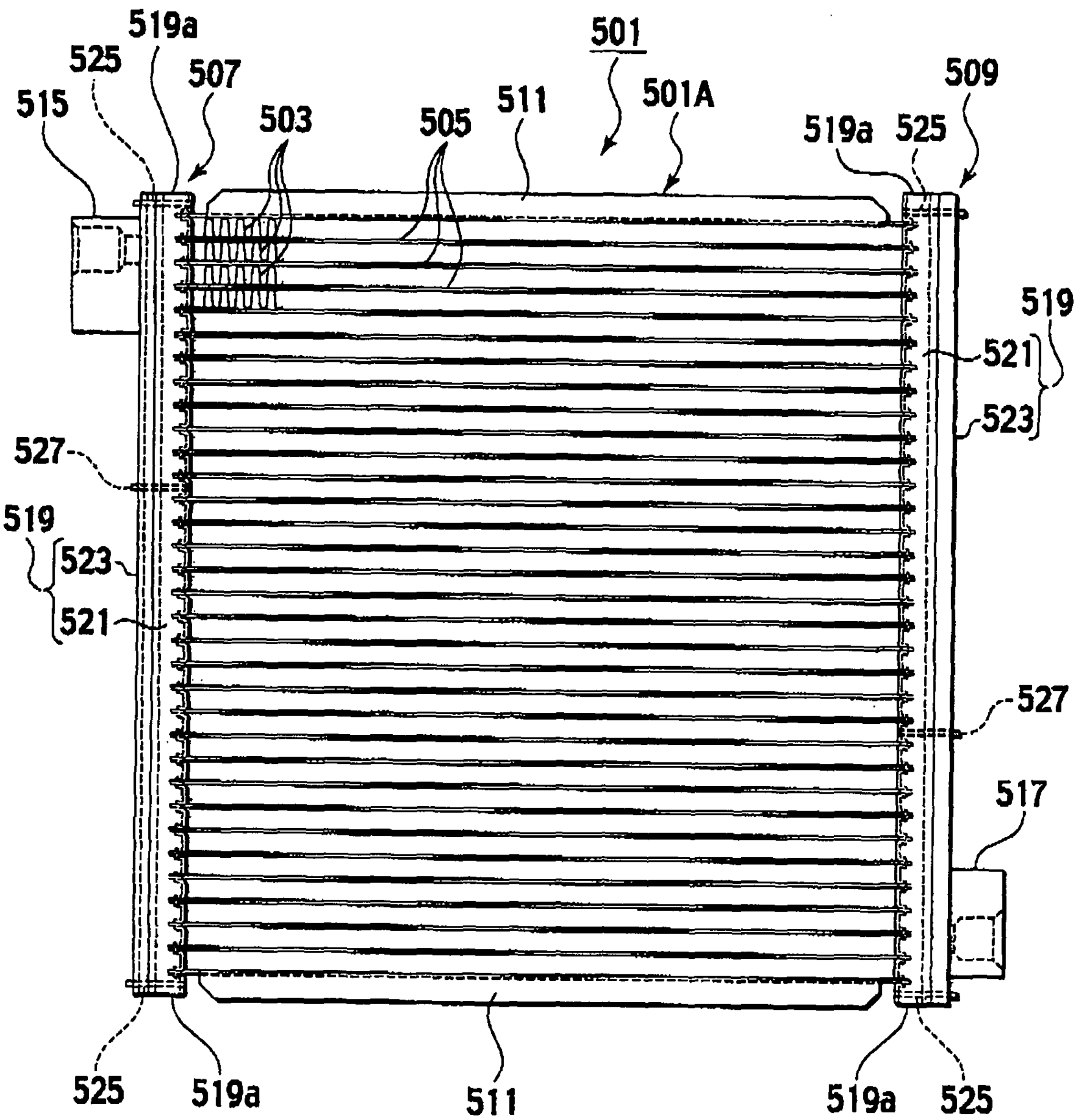


FIG.30


519a
525
507
515
503
505
511
501
501A
509
519a
525
519
521
523
527
519
523
521
527
517
525
519a
511
519a
525

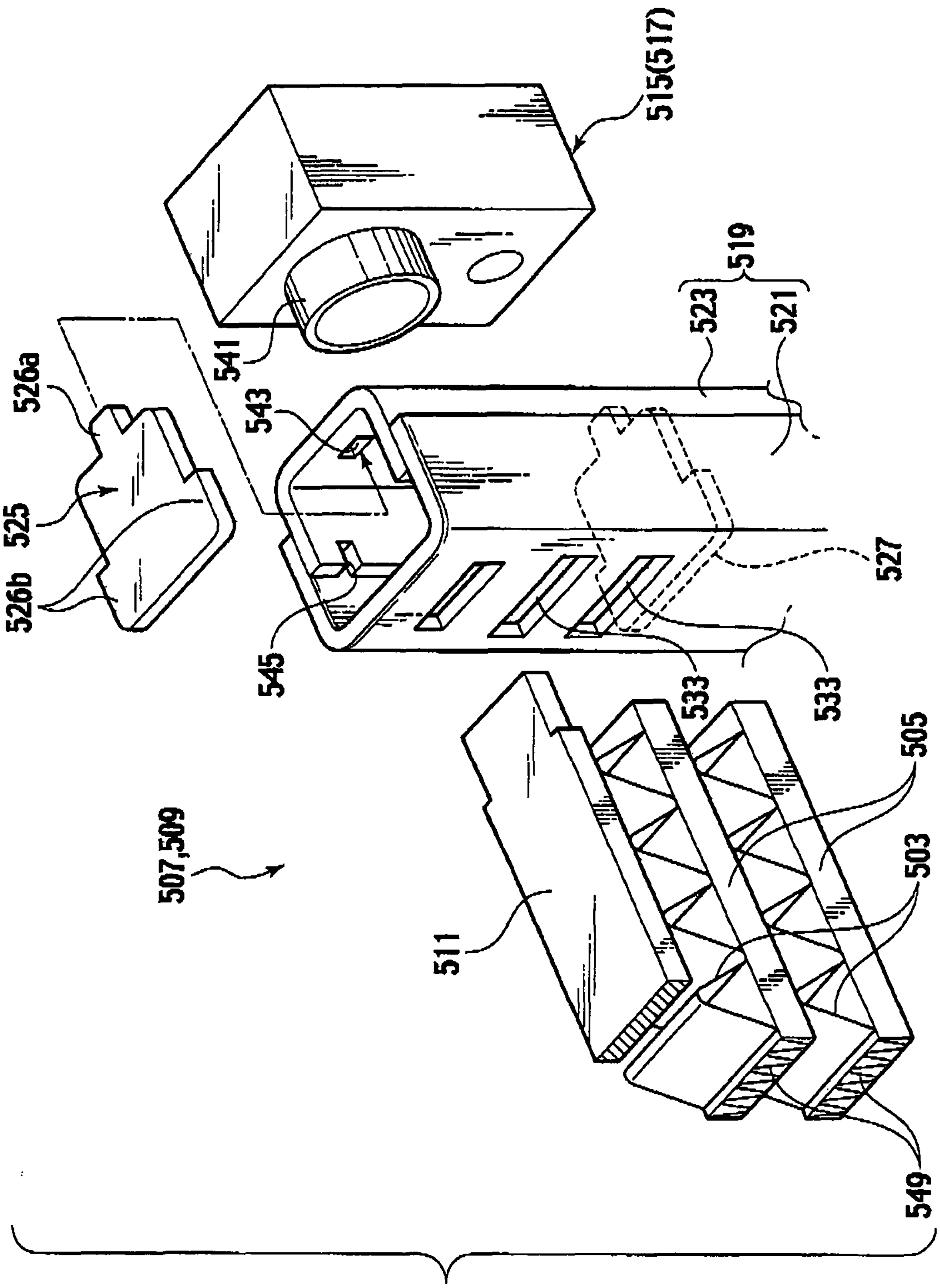

515(517)
519
523
521
541
543
526a
525
526b
545
533
533
527
505
503
507,509
511
549

FIG.31

FIG.32

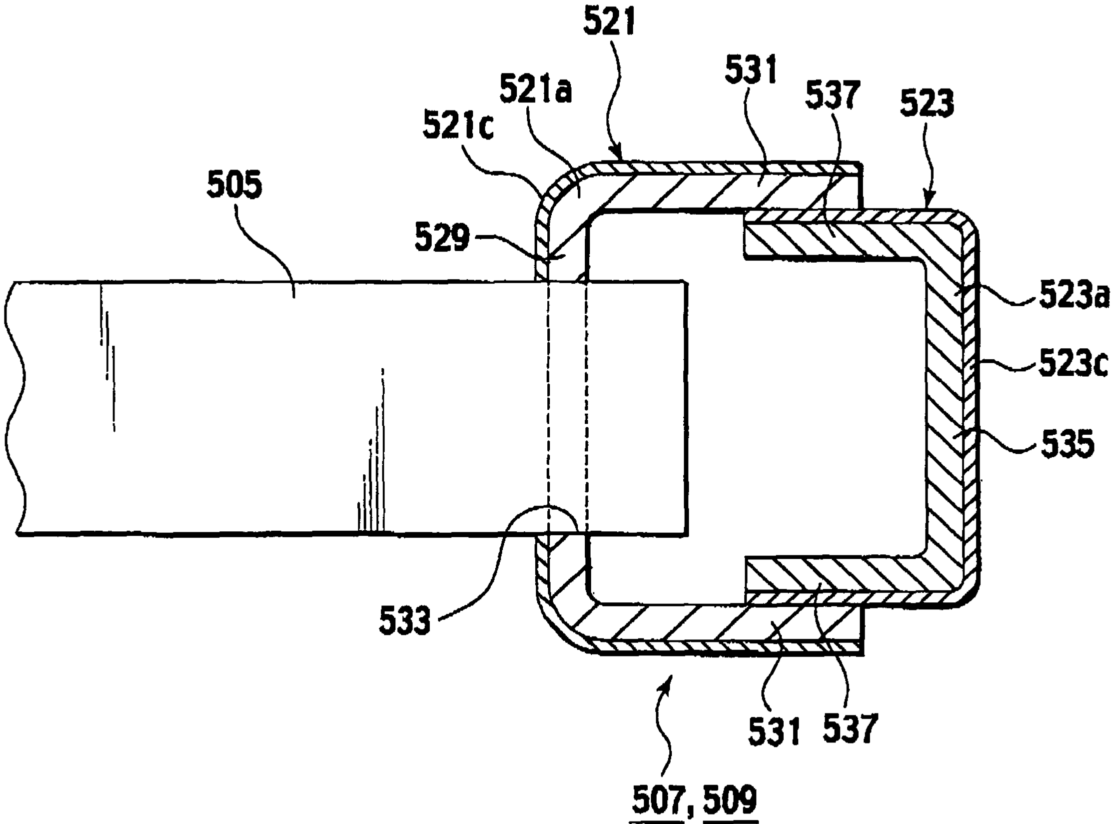

521
521a
531
537
523
521c
505
529
523a
523c
535
533
531
537
507, 509

FIG.33A

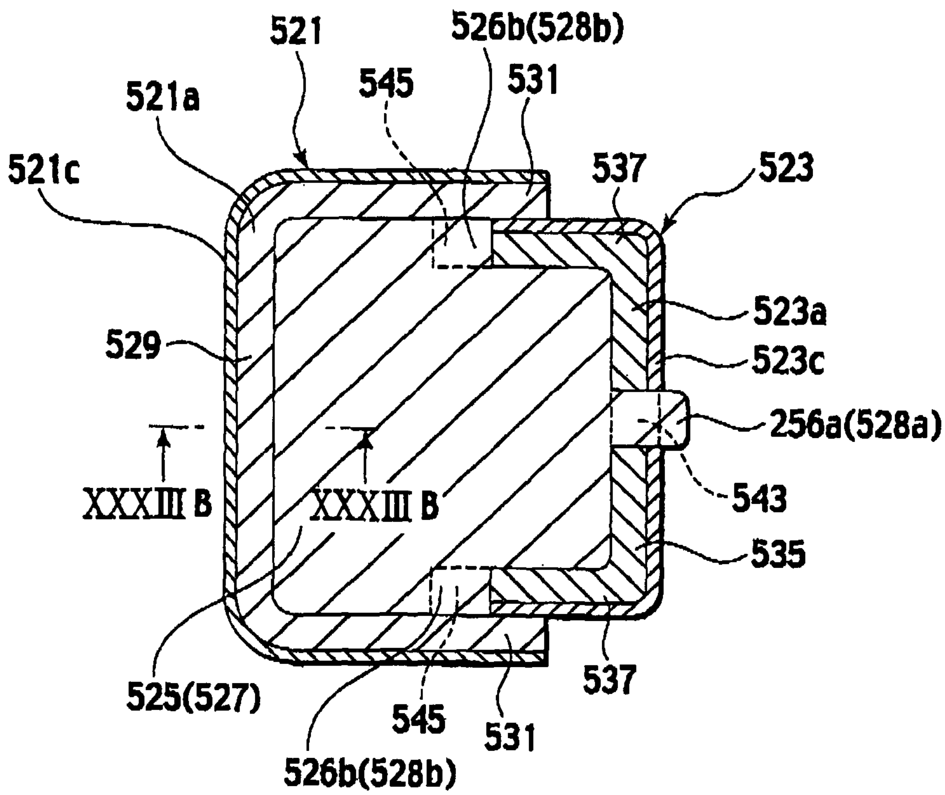



FIG.33B

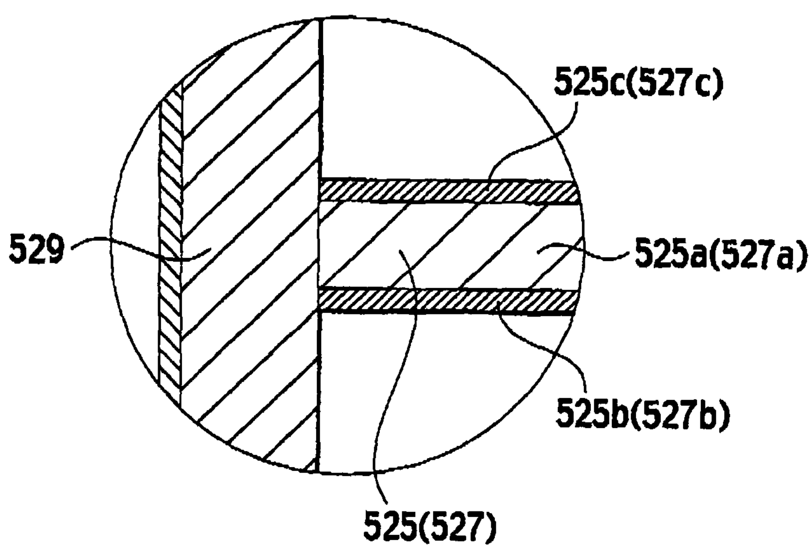


FIG.34

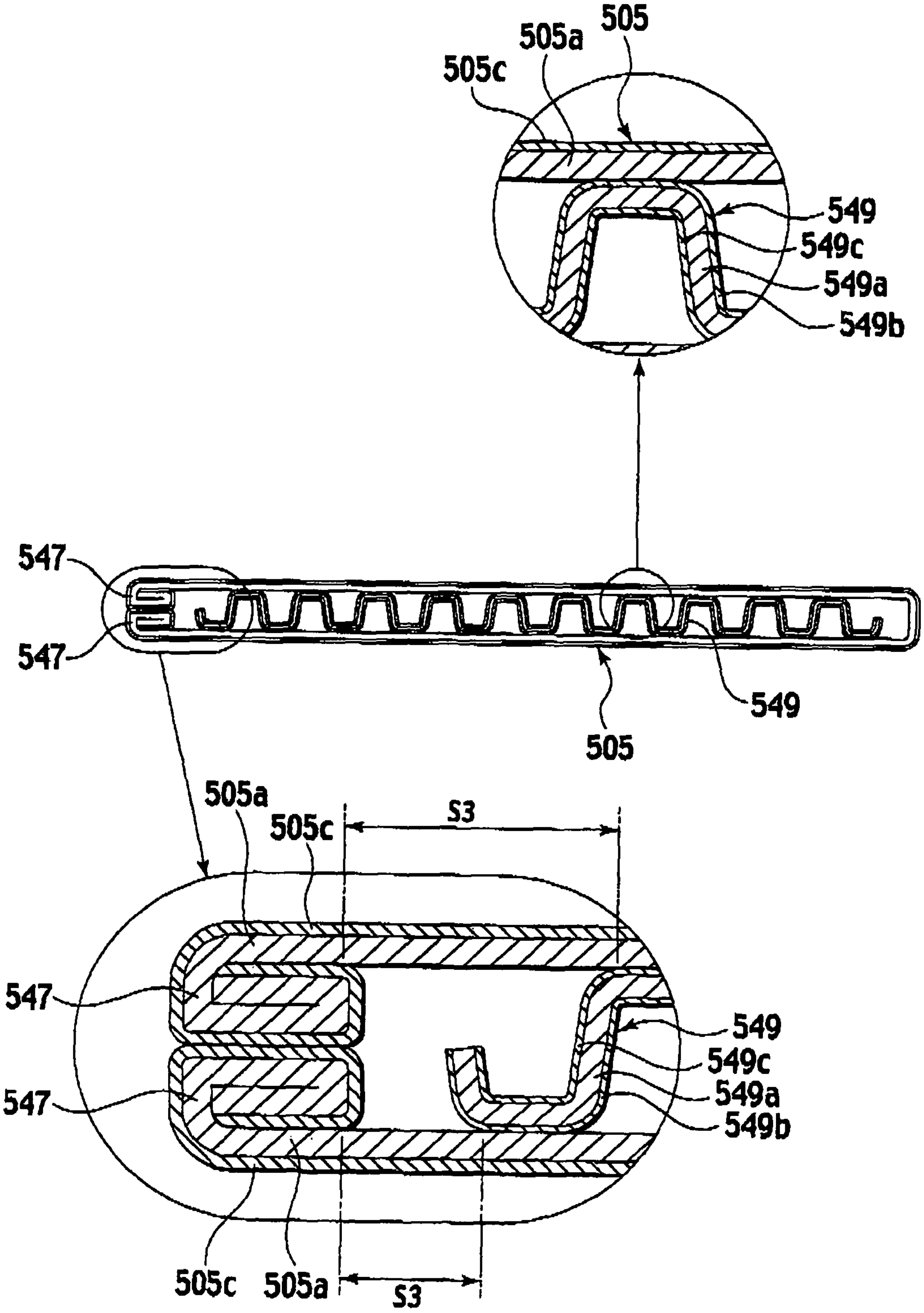

505
505a
505c
549
549c
549a
549b
547
547
549
505
505a
505c
S3
547
549
549c
547
549a
549b
505c
505a
S3

FIG.35A

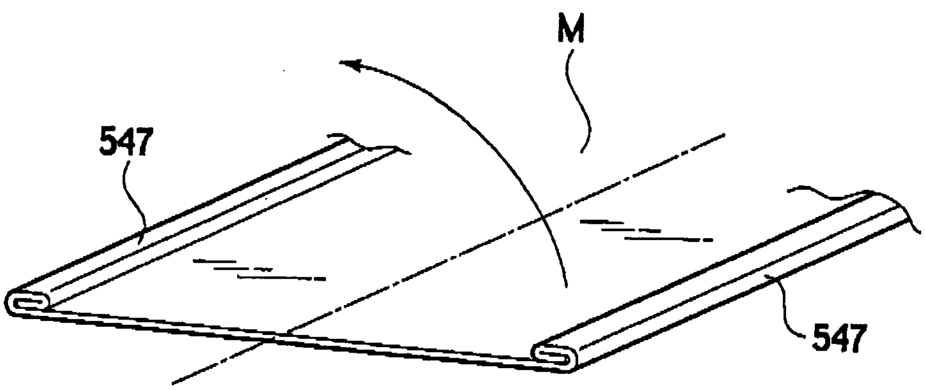



FIG.35B

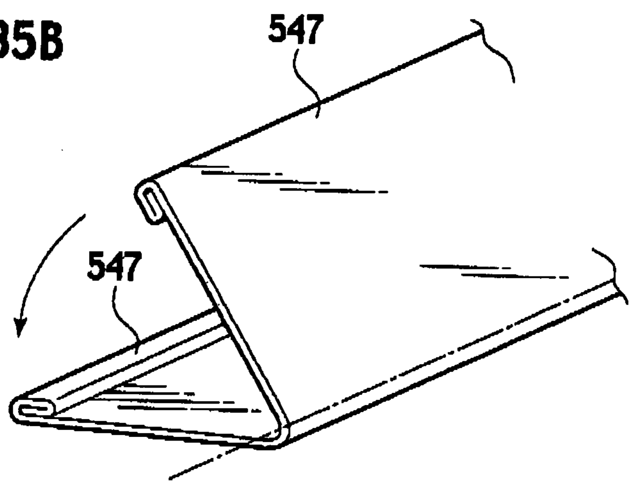



FIG.35C

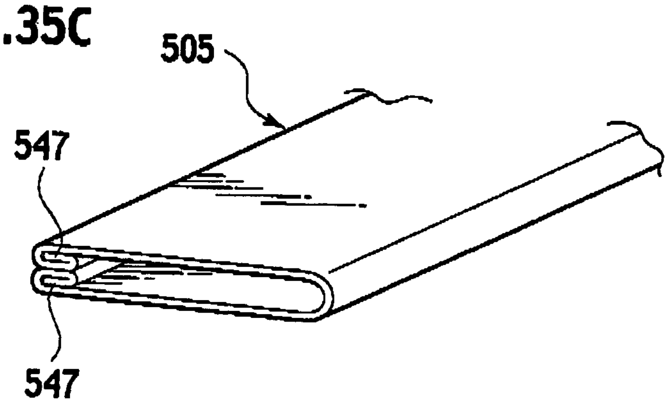


FIG.36

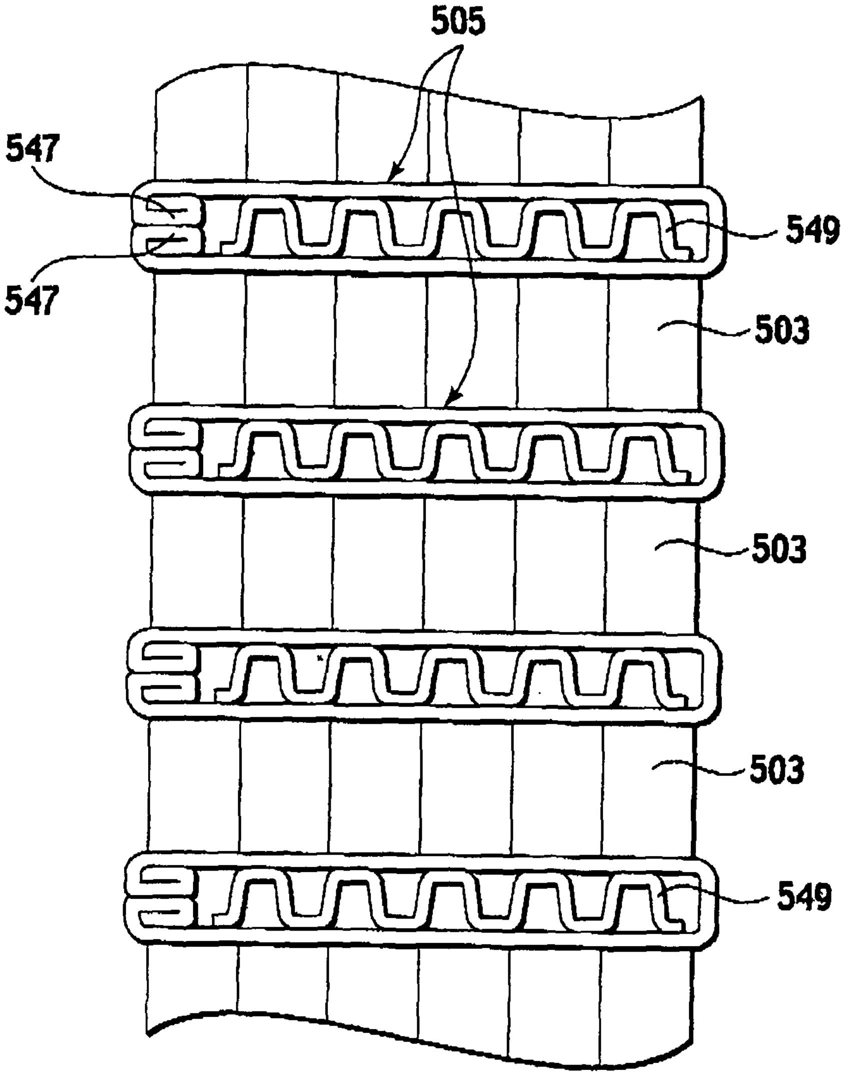


FIG.37

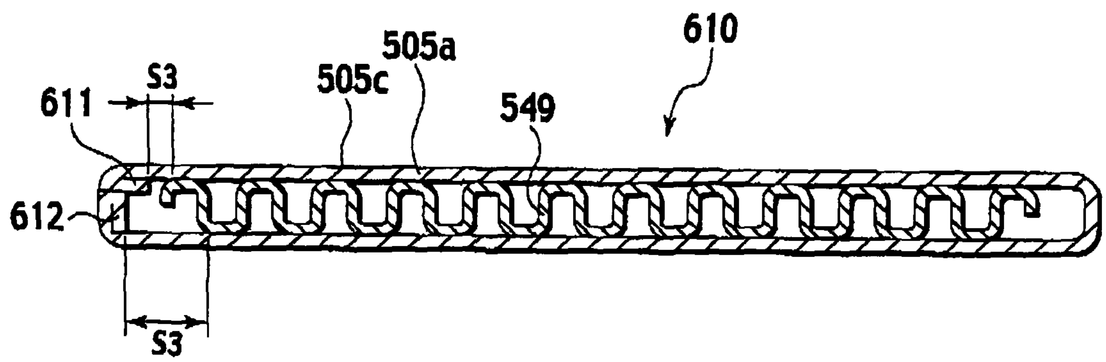



FIG.38

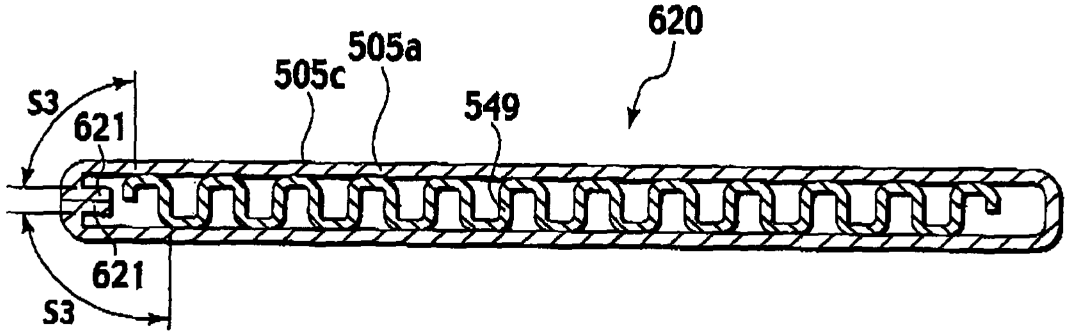



FIG.39

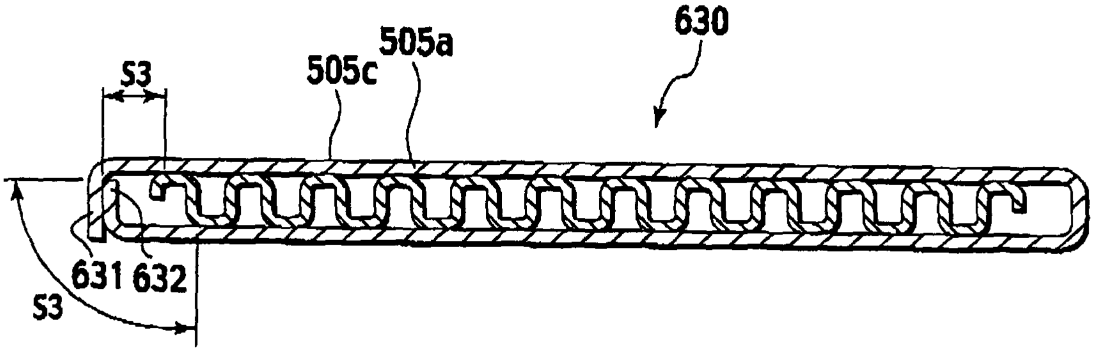


FIG.40

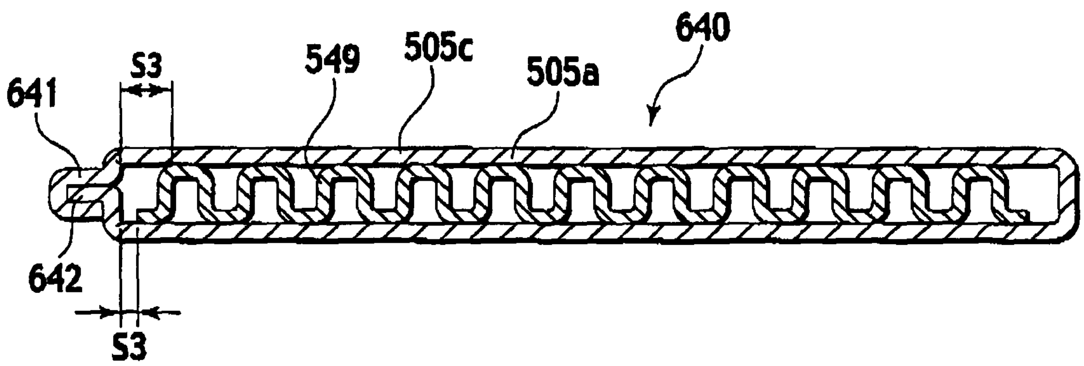



FIG.41

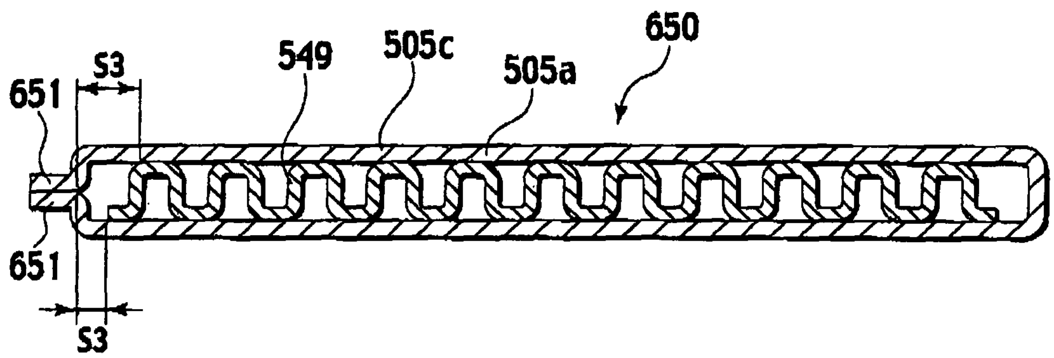


FIG.42

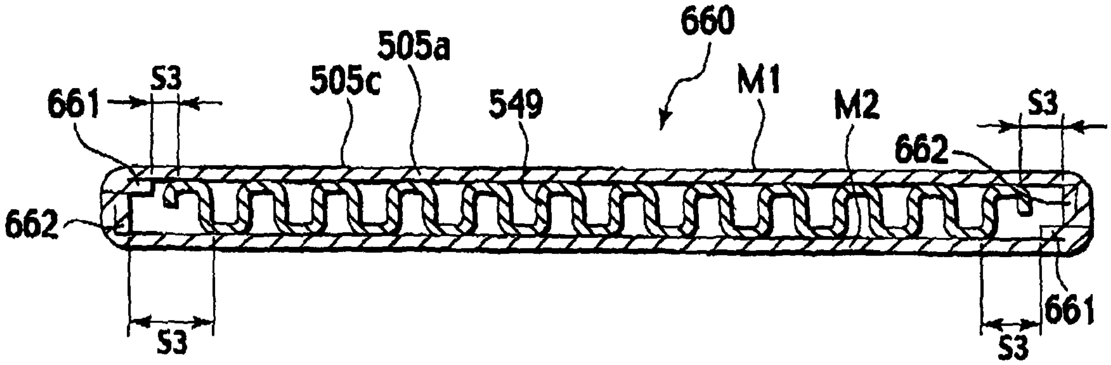



FIG.43

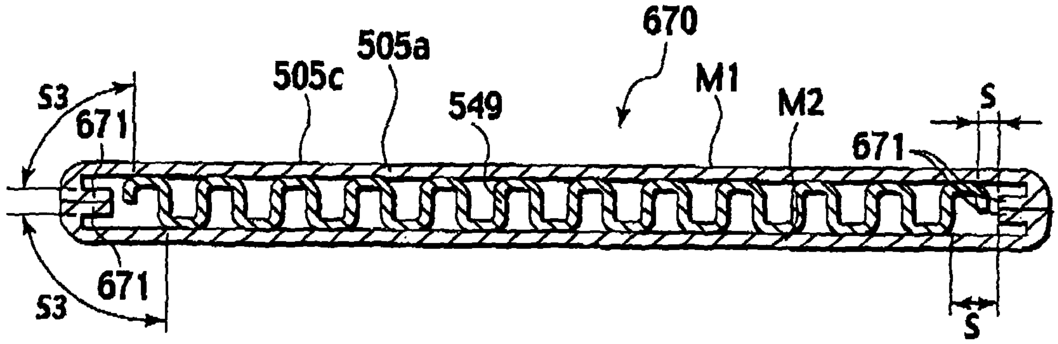



FIG.44