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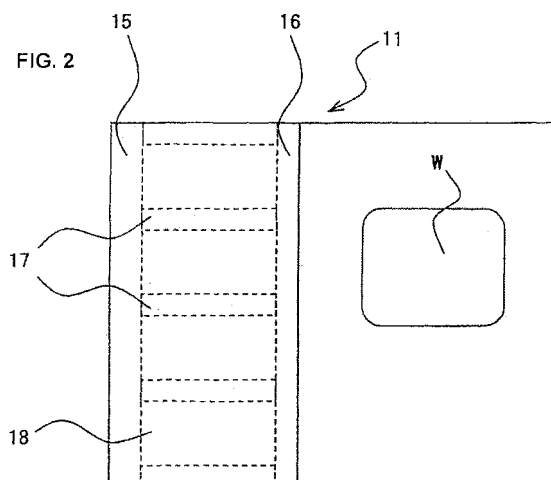
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(54) **Railway vehicle with energy absorbing structure**

(57) The invention provides a car body of a railway vehicle capable of absorbing the energy caused when collision occurs to the end of the car body. The present invention comprises a strength member 15 disposed along the circumferential direction of the car body on the end of the car body, a strength member 16 disposed along the circumferential direction at a position rearward from the member 15, rib members 17 disposed along the longitudinal direction of the car body and connecting the two strength members, and an outer panel 18 covering the same. The longitudinal direction of the rib member 17 corresponds to the longitudinal direction of the car body. The rib member 17 is composed of two flanges 17c, 17d and a web 17b connecting the two flanges, and the side having the web 17b is welded to the outer panel 18 via fillet welding. A notch 21 opened to the edge of the flange is formed on the flange at the center of the longitudinal direction of the rib member 17. When collision load is applied, the notch 21 is valley-folded, by which the rib member is bent toward the direction opposite from the side to which the outer panel 18 is attached, so that the collision load can be absorbed sufficiently

since the outer panel 18 will not interfere with the buckling of the rib member 17.



Description

BACKGROUND OF THE INVENTION

Field of the invention

[0001] The present invention relates to an energy absorbing structure of railway vehicles such as railway cars and monorail cars.

Description of the related art

[0002] A railway vehicle may collide unexpectedly with objects during normal operation. Possible objects that the vehicle may unexpectedly collide with include large objects such as road vehicles, trees and railway cars, and small objects such as rocks, snowballs and parts from oncoming vehicles. Further, the speed during collision may range from high speed to low speed.

[0003] We will now consider a case in which the railway vehicle collides with a large object at high speed. When the railway vehicle collides with a large object at high speed, a large load is applied on the railway car with a large impact. In order to protect the crew and passengers on board the transport machine from such impact, it is necessary to absorb the energy of collision by allowing a portion of the structure of the transport machine to be easily deformed.

[0004] The above concept provides in the structure of the railway vehicle a space where the crew and passengers exist and which is aimed at preventing the structure of the railway vehicle from crushing during collision with an object (hereinafter called a survival zone), and a space aimed at absorbing the energy of collision by allowing the structure of the railway vehicle to be easily deformed during collision with an object (hereinafter called a crushable zone), which are provided in a separate manner.

[0005] On the other hand, we will consider a case in which the railway vehicle collides with a large object at low speed. If the railway car collides with a large object at low speed, the impact acting on the car body is very small compared to when the railway car collides at high speed. Therefore, unlike the collision occurring at high speed, the safety of the crew and passengers can be ensured without having to intendedly absorb the energy acting on the car body during collision. On the contrary, it is preferable for the car body not to have a too rigid structure so that it will be deformed by the load acting on the car body during high speed collision.

[0006] Furthermore, when beam members are subjected to deformation, it is preferable for the direction of deformation or the starting point of deformation to be controlled.

[0007] Amar Ainoussa; A crashworthy high speed aluminum train: the west coast main line class 390 tilting train, Proc. Imech E Conf., "What can we realistically expect from crashworthiness?", (2001) (non-patent document 1) discloses an example of a structure in which an

incoming object protector panel is disposed at a front end in the longitudinal direction or the direction of the rail of a car body, and having an energy absorbing member arranged adjacent to the protector panel.

[0008] Japanese Patent Application Laid-Open Publication No. 2004-168218 (patent document 1) teaches that an energy absorbing structure having hollow extruded shape members made of aluminum alloy disposed on four sides is capable of absorbing energy efficiently.

[0009] Japanese Patent Application Laid-Open Publication No. 2002-67952, No. 2001-88698 and No. 2001-26268 (patent documents 2, 3 and 4) teach the art of absorbing energy by forming holes on the face plate of the energy absorbing member.

SUMMARY OF THE INVENTION

[0010] As described, it is desirable to provide a structure capable of absorbing the energy by allowing to be easily deformed when a load greater than a certain level is applied, while not deforming when a load smaller than a certain level is applied.

[0011] The above object can be achieved by a railway vehicle having at an end of an intermediate car or at an end of a car connected to the intermediate car of a railway car formation the following: two strength members disposed along the perpendicular direction of side walls of a crew cabin and along a roof at the end of the car, one of the strength members disposed at the leading end of the car body in the longitudinal direction thereof and the other member disposed rearward than the first member in the longitudinal direction of the car body; wherein the end of the car body is composed of the front and rear strength members of the car body, rib members welded to the strength members, and an outer panel covering the rib members and the two strength members; the longitudinal direction of the rib member is disposed along the longitudinal direction of the car body; the rib member is composed of two flanges and a web connecting the two flanges; the side of the rib member having the web is welded via fillet welding to the outer panel; the flanges are each provided with a notch that opens to the edge of the flanges at the middle in the longitudinal direction of the rib member; and the web has a hole formed between the notches and the longitudinal end of the rib member.

[0012] According to the arrangement described above, when a collision load is applied on the front end of a vehicle, the load is applied via a strength member to rib members. The rib members are buckled at the notched portions. The buckled rib members will not be bent toward the outer panel, so that the collision energy can be absorbed without having the outer panel interfere with the buckling.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a perspective view of the railway vehicle;
 FIG. 2 is a side view showing an end portion of the car body of FIG. 1;
 FIG. 3 is a perspective view of a rib member according to one embodiment of the present invention;
 FIG. 4 is a view taken from arrow IV of FIG. 3;
 FIG. 5 shows a deformed view of the rib member of FIGS. 3 and 4;
 FIG. 6 is a plan view showing a hole 21b according to another embodiment of the present invention;
 FIG. 7 is a plan view showing the rib member utilizing the hole of FIG. 6;
 FIG. 8 is a view taken from arrow IX of FIG. 7;
 FIG. 9A and 9B are side views showing a deformation example when load is applied on the car body;
 FIG. 10A and 10B are side views showing an end portion of the car body to which the present invention is applied;
 FIG. 11 is a perspective view of the rib member according to another embodiment of the present invention;
 FIG. 12 is a perspective view of the rib member according to another embodiment of the present invention;
 FIG. 13 is a perspective view of the rib member according to another embodiment of the present invention;
 FIG. 14 is a perspective view of the rib member according to another embodiment of the present invention; and
 FIG. 15 is a perspective view of the rib member according to yet another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Now, the preferred embodiments of the present invention will be described with reference to the drawings.

[Embodiment 1]

[0015] A first embodiment in which the present invention is applied to a railway vehicle is described with reference to FIGS. 1 through 6.

[0016] First, the structure of a railway vehicle is described with reference to FIG. 1. According to FIG. 1, a car body structure 1 of a railway vehicle is composed of a roof structure 2 constituting the roof thereof, end structures 3 constituting the sides closing the longitudinal ends of the car body, side structures 4 constituting the left and right side walls with respect to the longitudinal direction of the car body, and an underframe strength member 5 constituting the floor of the car body. The side structure 4 has windows Wand openings for exists.

[0017] The car body structure 1 is composed of a survival zone 10 for protecting the lives of passengers and

crews during collision, and a crushable zone 11 for absorbing the energy generated during collision. The survival zone 10 is disposed at the longitudinal center of the vehicle.

[0018] The crushable zones 11 are formed at both longitudinal ends of the vehicle, arranged so as to sandwich the survival zone.

[0019] In the present drawing, the car body structure is explained using as an example a middle car that does not have a driving device, but also in a car having a driving device, the relative arrangements of the crushable zones 11 and the survival zone 10 are the same.

[0020] FIG. 2 shows a side view of the crushable zone 11. This crushable zone 11 is disposed at the rear end of a leading car, and at longitudinal ends of a middle car of a railway car formation (or at connecting portions facing front and rear cars).

[0021] The main components constituting the crushable zone 11 include front and rear strength members 15 and 16 constituting the crew cabin of the crushable zone 11 (so-called a corner strut, a post or the like), rib members 17 connecting the front and rear strength members 15 and 16, and an outer panel 18 covering the outer side of the strength members 15, 16 and rib members 17.

[0022] The rib members 17 are disposed along the longitudinal direction of the car body. They are not slanted. The strength members 15 and 16 are disposed along the perpendicular direction on the sides of the car body, and also disposed along the roof.

[0023] In FIGS. 3, 4 and 5, the rib member 17 has a U-shaped cross-section, and an outer panel 18 is attached via fillet welding to the web 17b of the U-shaped cross-section. The fillet welding can be performed either continuously or discontinuously. Flanges 17c and 17d are disposed on both sides of the web 17b. Notches 21 are provided on flanges 17c and 17d at the longitudinal center area of the rib member 17. The notches 21 are formed to open on the ends of the flanges 17c and 17d.

[0024] Further, holes 22, 22 are formed near the longitudinal ends of the web 17b (on the surface facing the outer panel).

[0025] According to such configuration, when a load greater than a certain level (impact load) is applied on the strength member 15 along the longitudinal direction of the car, the strength member 15 and the outer panel 18 on the outer side thereof are deformed to absorb the energy, but on the other hand, when a load smaller than the certain level is applied, they are not deformed.

[0026] When a load greater than a certain level (hereinafter referred to as excessive load) is applied, the rib members 17 start to deform from the portion having the notches 21 provided at the longitudinal center thereof. As illustrated in FIG. 5, the deformation is progressed so that the side having the notches 21 is valley-folded. Since the outer panel 18 is disposed on the opposite side from the valley-folded side, the outer panel will not interfere with the valley-fold even if the notches 21 are folded, so that the deformation results in absorbing the energy.

[0027] Since openings 22 and 23 are provided on the web 17b near the longitudinal ends of the U-shaped rib member 17, the whole rib member 17 deforms so that the web 17b is gabled, as shown in FIG. 5. Therefore, the outer panel 18 deforms in a protruded shape with respect to the outer side of the car. If such deformation does not occur and local buckling occurs continuously, according to which the deformation direction cannot be controlled, a large uncrushed area may remain, and it will not be possible to ensure an effective crush. Even further, if the car deforms toward the inner side of the car body, it may affect the crew and passengers. Therefore, it is very effective to control the deformation so that the deformed portion projects toward the outer side of the car body.

[Embodiment 2]

[0028] According to the first embodiment, the web 17b of the rib member 17 having a U-shaped cross-section is welded to the outer panel 18, but as illustrated in FIGS. 6, 7 and 8, it is also possible to weld the outer panel 18 onto the ends of the flanges 17c and 17d. This way, the welding can be performed easily.

[0029] In this case, a long hole 21b corresponding to the notch 21 provided at the longitudinal center area of the rib member 17 is formed at the connecting portion between the web 17b and the flange 17c (17d). This is because the connecting portion has intense strength.

[0030] In FIG. 6, the rib member 17 is formed by bending the member at the width-direction center of the long hole 21b, so as to create the web 17b and the flange 17c or the flange 17d. For example, the width of the long hole 21b is approximately 40 mm.

[0031] FIGS. 7 and 8 illustrate the rib member 17 formed by the above method. The holes 21b correspond to the notches 21 of FIG. 3. The notches 22b and 23b correspond to the holes 22 and 23 of FIG. 3. The notches 22b and 23b are formed to open from the end of flanges 17c and 17d.

[Embodiment 3]

[0032] FIG. 9 illustrates a prior art example that corresponds to the present invention (illustrated in FIG. 10). As shown in FIG. 9A, when load is applied to the strength member 15, the rib member 17 disposed at the corresponding height mainly supports the load. In that case, if bending deformation does not occur to the rib member 17 or the strength member 16, the stress occurring to the rib member 17 or the strength member 16 will be small.

[0033] On the other hand, as illustrated in FIG. 9B, if load is applied on the area of the strength member 15 where there is no rib member 17 (17c or 17d) arranged, (that is, when the load is applied to the intermediate position between the rib members 17c and 17d), the load is supported by the rib members 17c and 17d disposed near that area.

[0034] In that case, a bending momentum occurs in proportion to the distance between the rib members 17c and 17d and the point of load. That is, when the distance between the rib members 17c and 17d and the point of load becomes longer, the bending momentum is increased. Therefore, the rib members 17c and 17d and the strength member 15 are subjected to bending deformation, and the stress occurring to the rib members 17c and 17d and the strength member 15 is increased.

[0035] At this time, if the rib members 17 are sparsely disposed, the generated stress becomes necessarily high. On the other hand, if the distance between the rib members 17c and 17d is too small, the load occurring when the rib members 17 start to deform becomes too high.

[0036] Therefore, when a high load is applied, the momentum acting on the strength member 15 and the rib members 17 become excessive, and high stress occurs to the members.

[0037] The second embodiment of the present invention will be described with reference to FIG. 10. The rib member 117 is expanded in a Y-shape at the connection between the rib member 117 and the strength member 15. The end of the rib member 117 connected to the strength member 16 is not expanded.

[0038] Therefore, the number of points where the rib members 117 are supported by the strength member 15 is increased. Thus, when load is applied to the height where there is no rib member 117 disposed, the distance from the point of load to the supporting point of the rib member 117 is short. Accordingly, the generated momentum is reduced compared to the prior art example.

[0039] In other words, as shown in FIG. 10B, when load is applied to a height where there are no rib members 117c or 117d disposed, the leading ends expanded from the rib members 117c and 117d disposed close to the height mainly support the load. In that case, bending deformation occurs in proportion to the distance between the expanded ends of the rib members 117c and 117d and the point of load, but the length (distance) branched toward the strength member 15 is not longer than the interval at which the rib members 117 are arranged. Therefore, the bending deformation occurring to the strength member 15 and rib members 117 is small, and thus the stress occurring to the rib members 117 and the strength member 15 is small.

[0040] If the applied load is so large that it becomes necessary to absorb the energy caused thereby, the weakest point of strength of the rib member 117 will be the connection between the area expanded into a Y-shape and the unbranched area. Since the number of rib members 117 and the cross-section of the weakest point of strength are the same as those of the prior art, the load occurring during buckling will be the same as that of the prior art.

[Embodiment 4]

[0041] FIG. 11 is an enlarged view of the rib member 117 having the leading end of the rib members 117 of FIG. 10 expanded into a Y-shape. A web 117g is formed between the flanges 117c, 117d and the expanded flanges 117e and 117f. The outer panel 18 can be disposed either on the side of the web 117b or on the side of the flanges 117c, 117d, 117e and 117f.

[Embodiment 5]

[0042] FIG. 12 illustrates an example in which flanges 117c and 117d and a web 117b of a rib member 117 having a U-shaped cross-section are arranged between expanded flanges 117e and 117f. The webs 117b and 117g between the expanded flanges 117e and 117f can be overlapped. The outer panel 18 can be disposed either on the side of the web 117b or the side of the flanges 117c, 117d, 117e and 117f.

[Embodiment 6]

[0043] In FIG. 13, the rib member 20 is formed by branching the side of the rib member 117 of FIG. 3 attached to the strength member 15 into a Y-shape. Holes 24 and 24 corresponding to the notches 21 are provided on the flanges at an area closer to the strength member 16 than a connecting portion 117i and 117j of the flanges 117e and 117f and flanges 117g and 117f branched into a Y-shape. Thereby, the area having the holes 24 and 24 formed thereto becomes the weakest point of strength. The holes 24 are vertically long.

[0044] The flanges 117e, 117f, 117g and 117h branched into a Y-shape are disposed on both sides of webs 117k and 117m.

[0045] The outer panel 18 can be disposed on either side, as described in the embodiment of FIGS. 11 and 12.

[0046] According to this arrangement, when excessive load is applied, the deformation progresses from the holes 24 and 24 constituting the weakest point of strength, so it becomes possible to control the deformation.

[Embodiment 7]

[0047] In FIG. 14, notches 24b and 24b are formed on flanges 117c and 117d where holes 24 had been formed in the former example. According to this arrangement, the portion having the notches 24b and 24b become the weakest point of strength. A hole 26 is formed on the web 117b and holes 25 are formed on webs 117k and 117m close to the connection with strength members 15 and 16.

[0048] The outer panel 18 is disposed on the side having the web 117b.

[0049] According to this arrangement, deformation progresses from the portion of notches 24b and 24b when excessive load is applied. The deformation progresses

so that the side having the notches is valley-folded. Further, when considering the rib member 117 as a whole, the rib member 117 is deformed so that the side having the notches 24b and 24b are valley-folded and the side having the holes 25 and 26 are gabled.

[Embodiment 8]

[0050] In FIG. 15, the notches 24b and 24b are similar to the aforementioned embodiment. In addition, notches 25b and 25b corresponding to the holes 25 are formed on flanges 117e, 117f, 117g and 117h. Notches 26b corresponding to the hole 26 is formed on flanges 117c and 117d. It is also possible to provide the notches 25b and 26b on the web 117b and flanges 117c, 117d, 117e, 117f, 117g and 117h similarly as the holes provided on the flanges 17c, 17d and the web 17b of the example illustrated in FIGS. 6, 7 and 8.

[0051] The outer panel 18 is provided on the side having the web 117b.

Claims

1. A railway vehicle having at an end of an intermediate car or at an end of a car connected to the intermediate car of a railway car formation the following:

two strength members disposed along the perpendicular direction of side walls of a crew cabin and along a roof at the end of the car, one of the strength members disposed at the leading end of the car body in the longitudinal direction thereof and the other member disposed rearward than the first member in the longitudinal direction of the car body; wherein

the end of the car body is composed of the front and rear strength members of the car body, rib members welded to the strength members, and an outer panel covering the rib members and the two strength members;

the longitudinal direction of the rib member is disposed along the longitudinal direction of the car body;

the rib member is composed of two flanges and a web connecting the two flanges;

the web of the rib member is welded via fillet welding to the outer panel;

the flanges are each provided with a notch that opens to the edge of the flanges at the middle in the longitudinal direction of the rib member; and

the web has a hole formed between the notches and the longitudinal end of the rib member.

2. A railway vehicle having at an end of an intermediate car or at an end of a car connected to the intermediate car of a railway car formation the following:

two strength members disposed along the perpendicular direction of side walls of a crew cabin and along a roof at the end of the car, one of the strength members disposed at the leading end of the car body in the longitudinal direction thereof and the other member disposed rearward than the first member in the longitudinal direction of the car body; wherein

the end of the car body is composed of the front and rear strength members of the car body, rib members welded to the strength members, and an outer panel covering the rib members and the two strength members;

the longitudinal direction of the rib member is disposed along the longitudinal direction of the car body;

the rib member is composed of two flanges and a web connecting the two flanges;

the ends of the flanges are welded via fillet welding to the outer panel;

the flanges and the web are provided with a notch formed so that the center of the notch corresponds to a bent portion between the web and the flange; and

the web has a hole formed between the notches and the longitudinal end of the rib member.

3. A railway vehicle having at an end of an intermediate car or at an end of a car connected to the intermediate car of a railway car formation the following:

two strength members disposed along the perpendicular direction of side walls of a crew cabin and along a roof at the end of the car, one of the strength members disposed at the leading end of the car body in the longitudinal direction thereof and the other member disposed rearward than the first member in the longitudinal direction of the car body; wherein

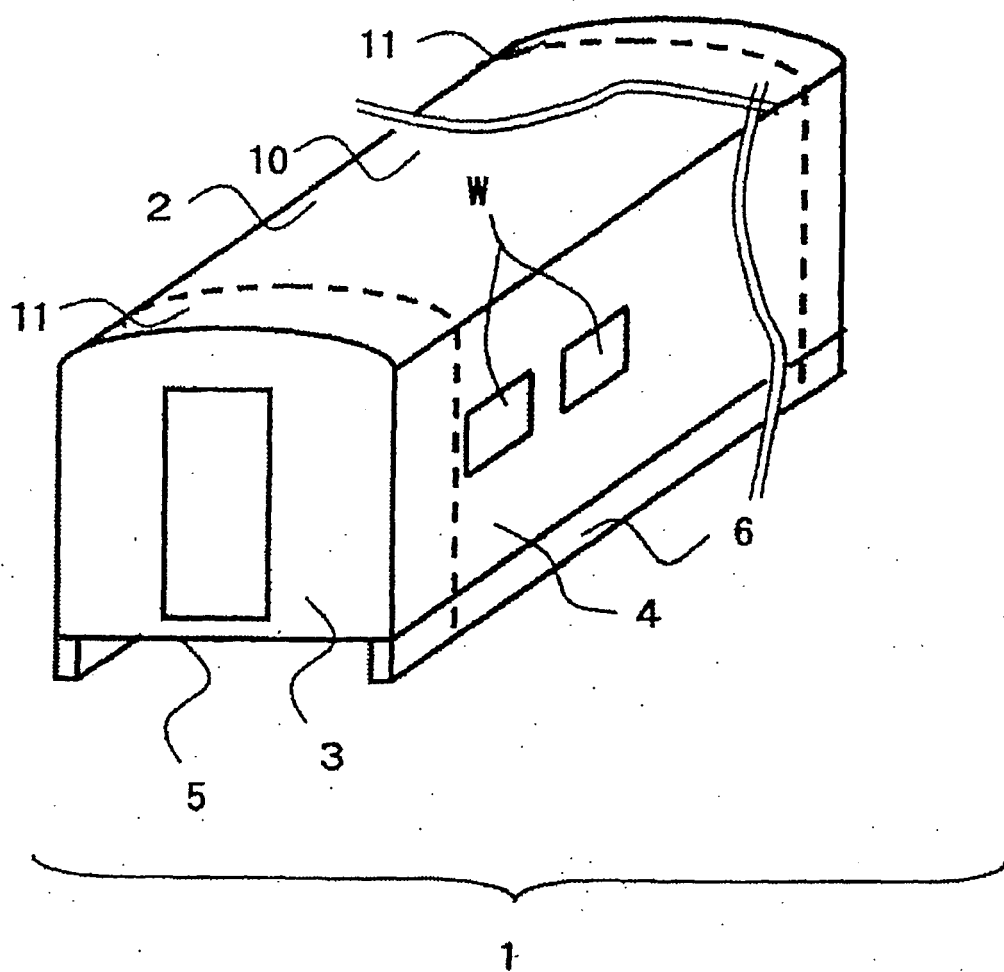
the end of the car body is composed of the front and rear strength members of the car body, a plurality of rib members welded to the strength members, and an outer panel covering the rib member and the two strength members;

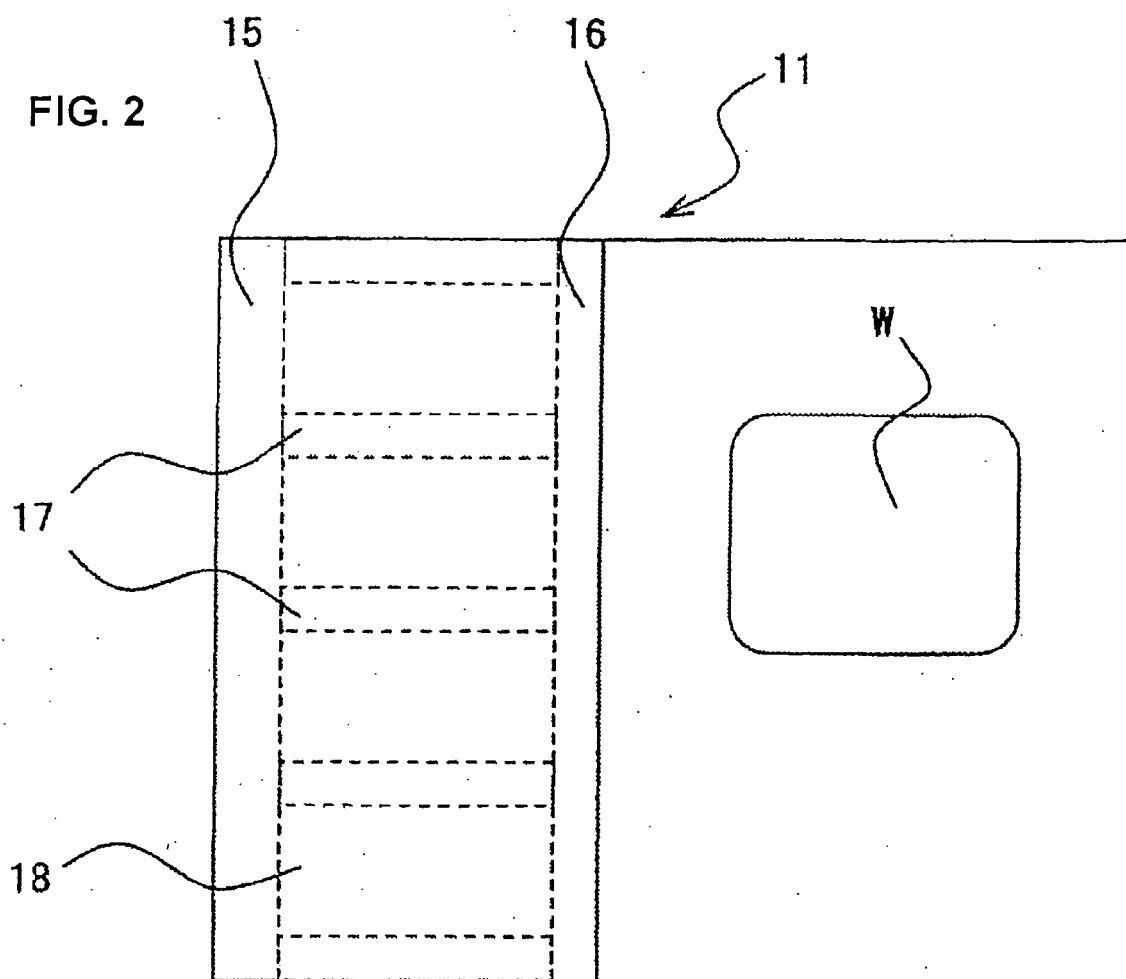
the longitudinal direction of the rib member is disposed along the longitudinal direction of the car body;

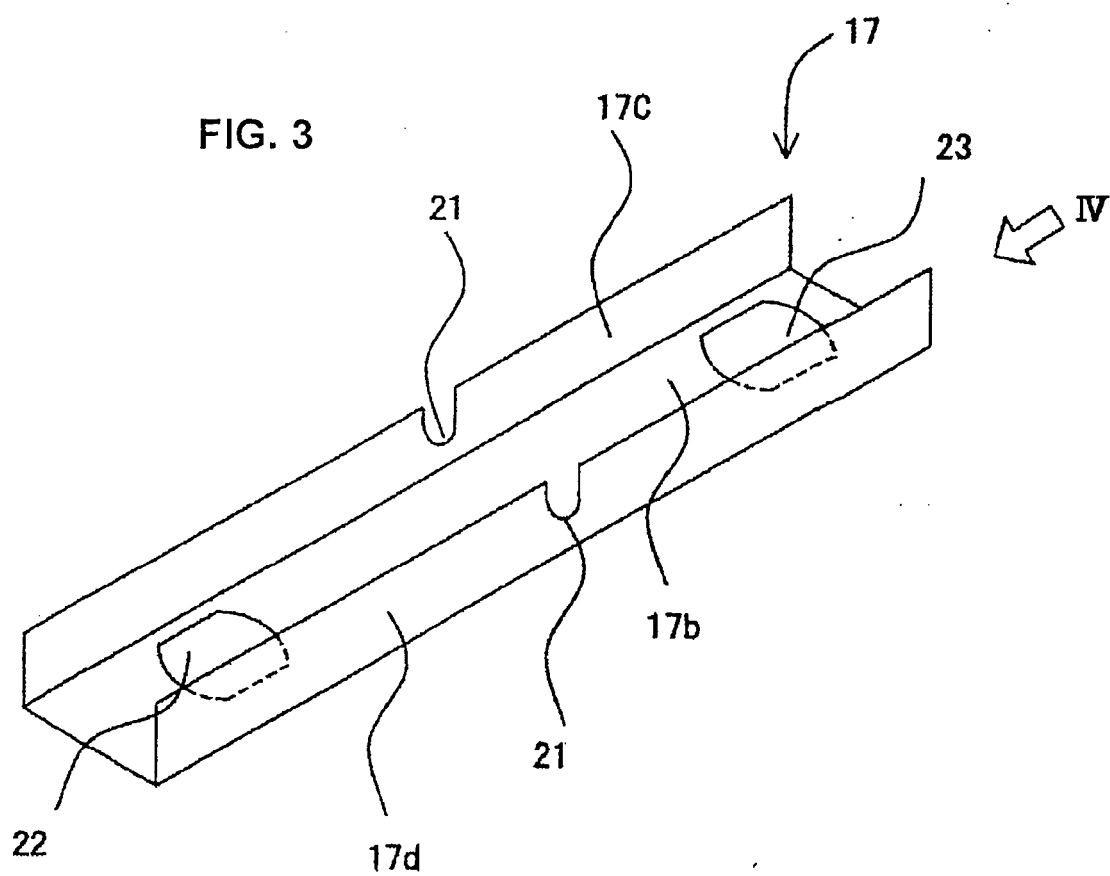
the rib member is composed of two flanges and a web connecting the two flanges; and

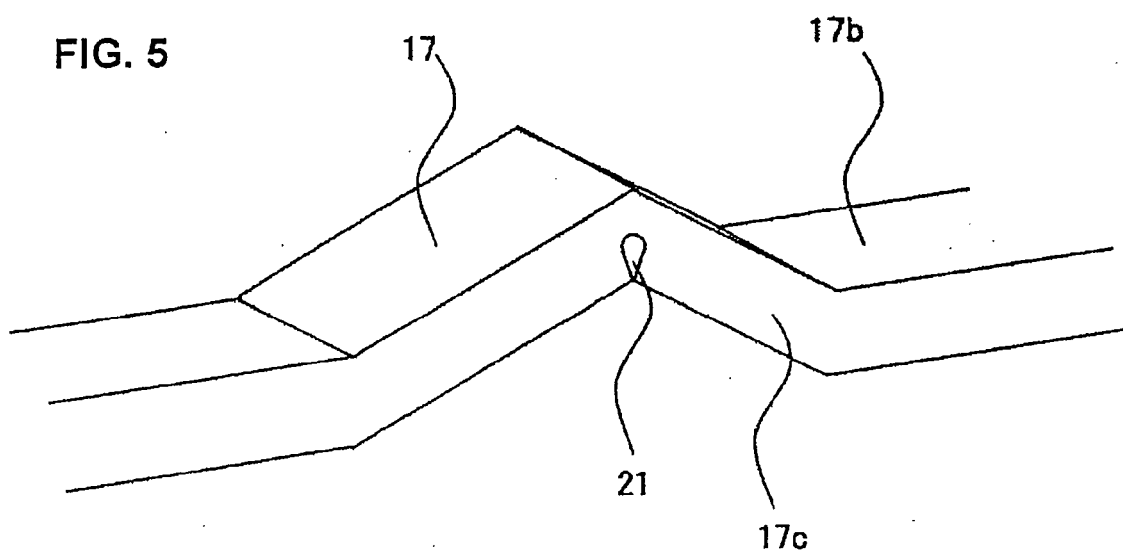
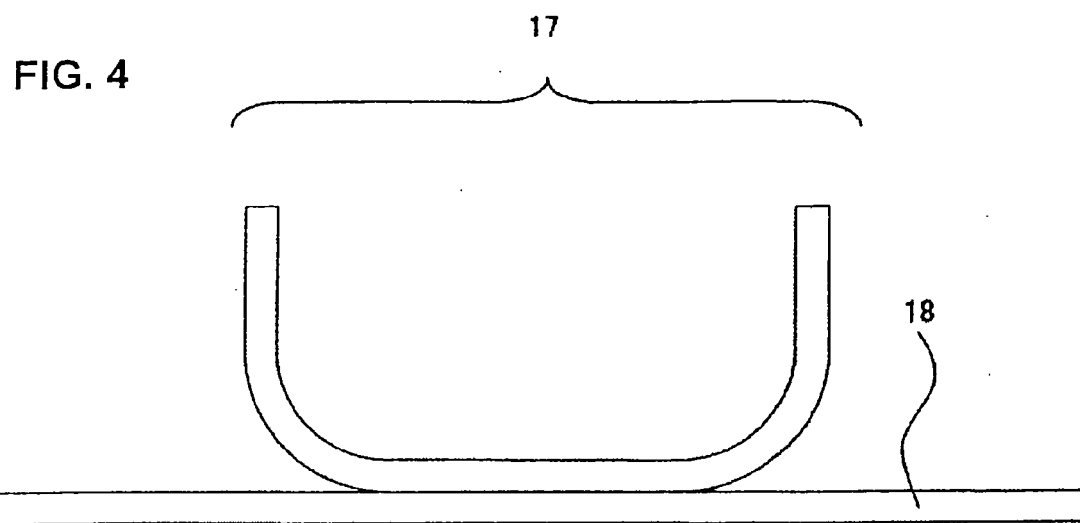
one end of the rib member in the longitudinal direction of the car body is branched into a Y-shape, whereas the other end thereof is not branched.

FIG. 1









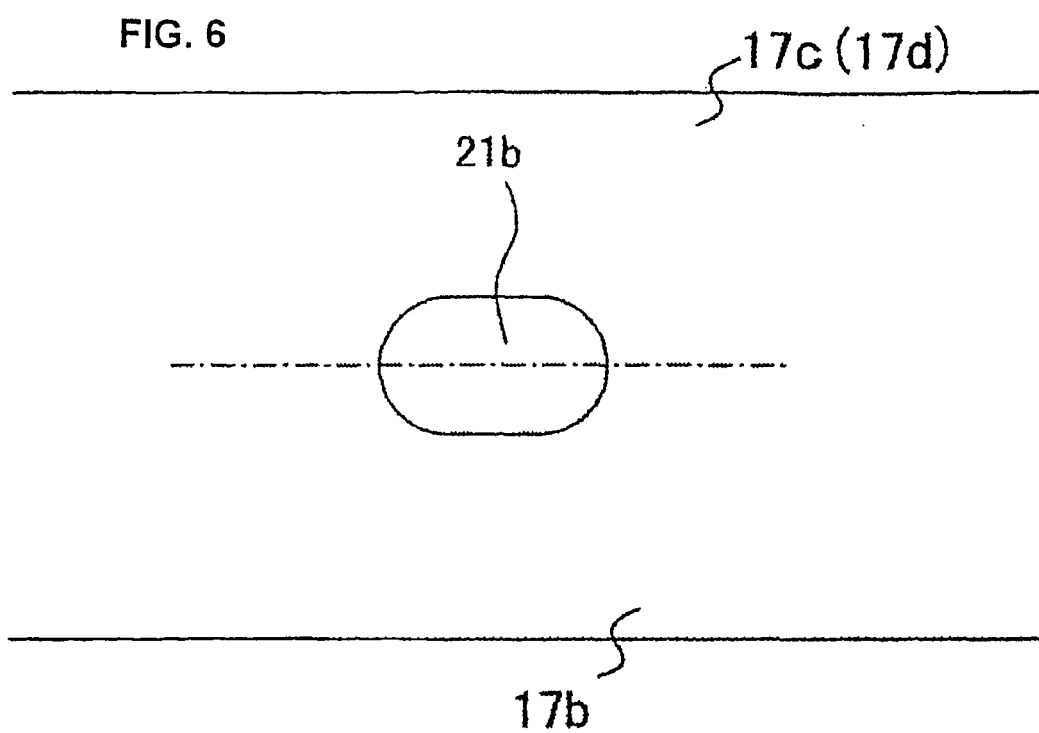


FIG. 7

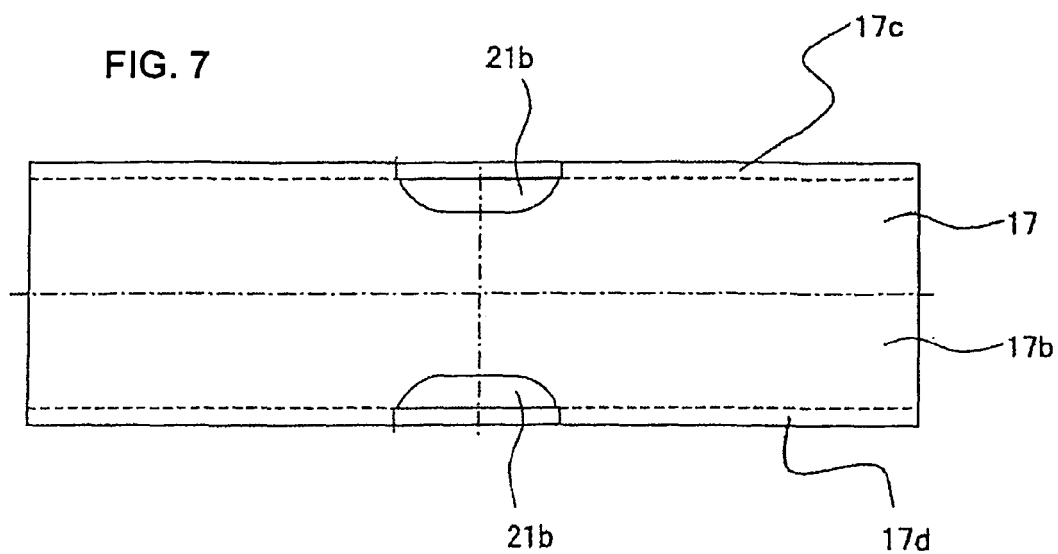


FIG. 8

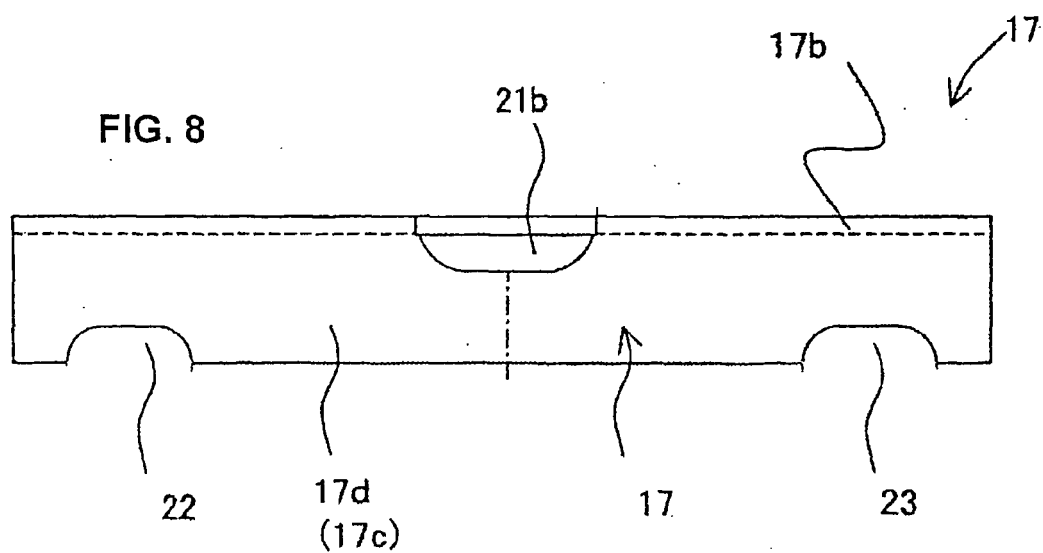


FIG. 9A

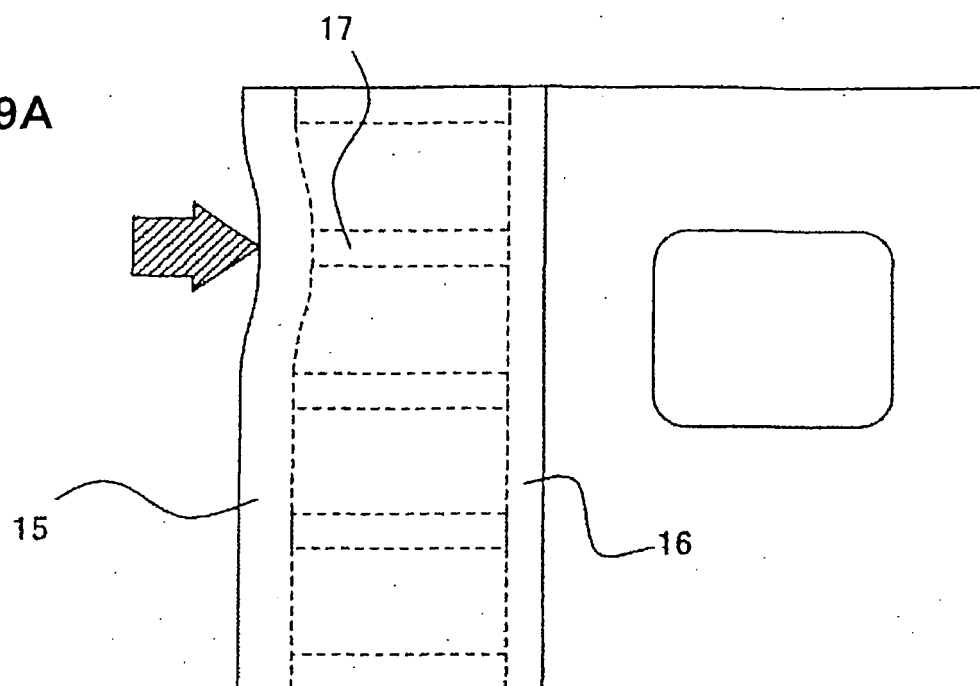


FIG. 9B

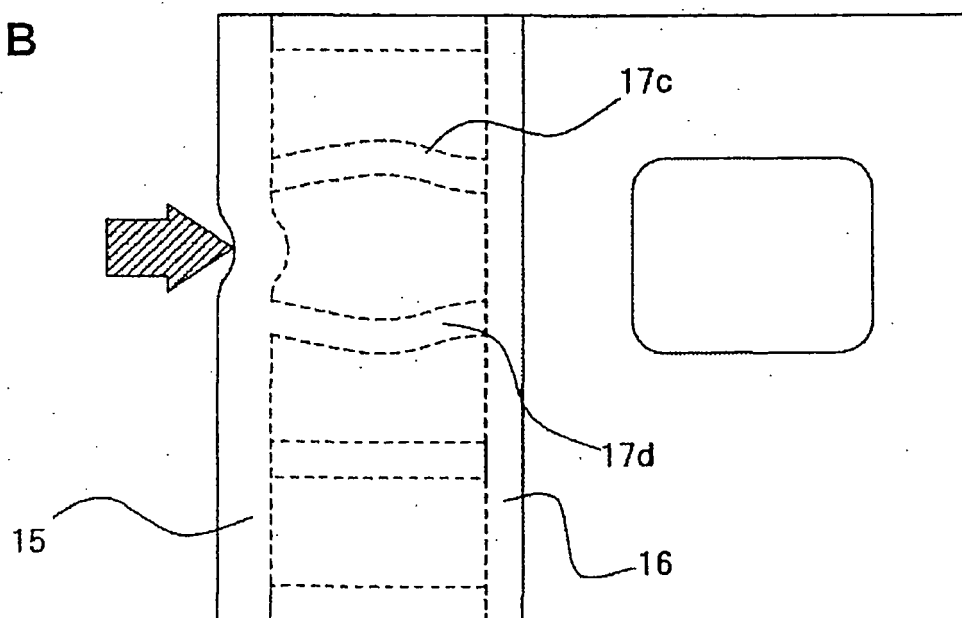


FIG. 10A

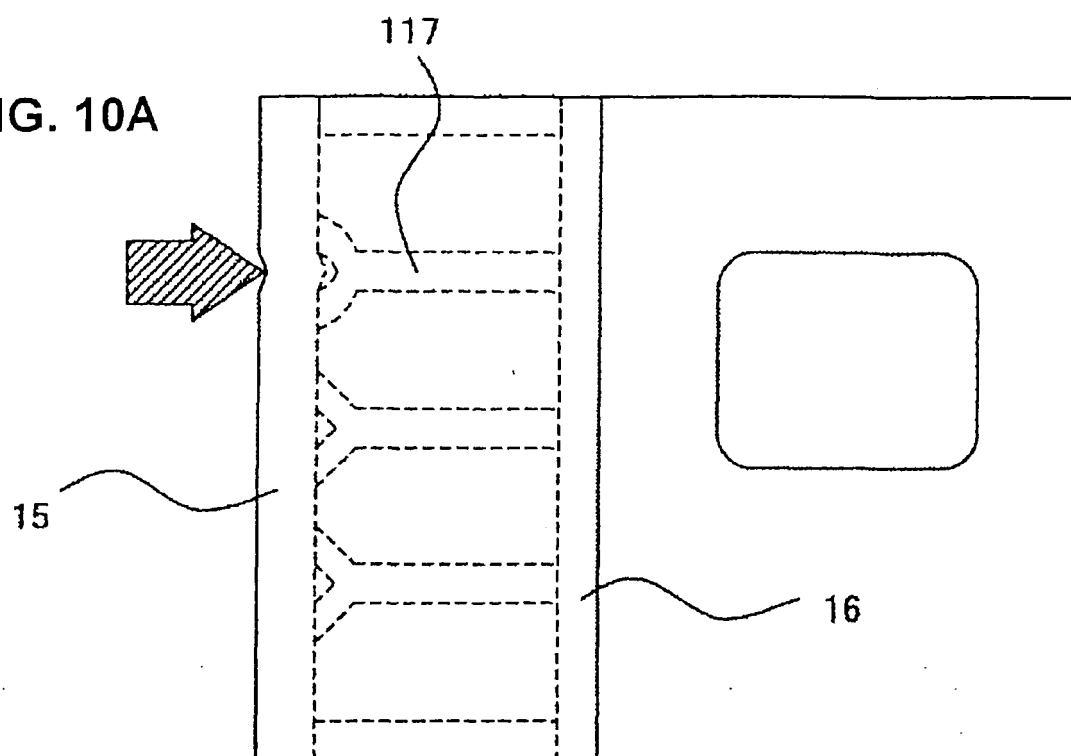


FIG. 10B

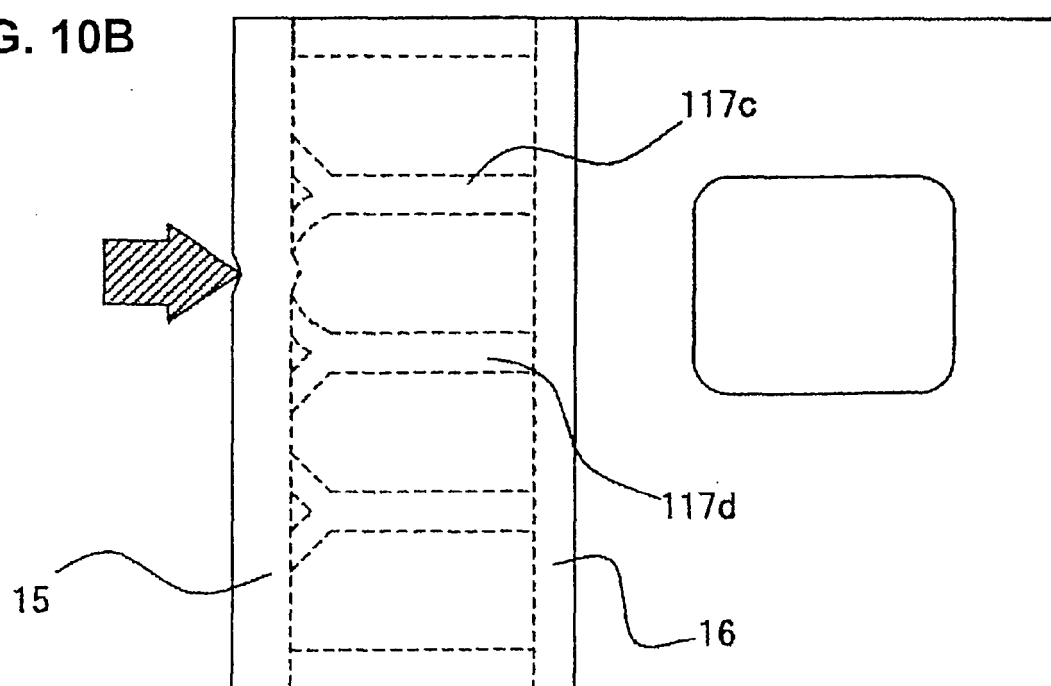
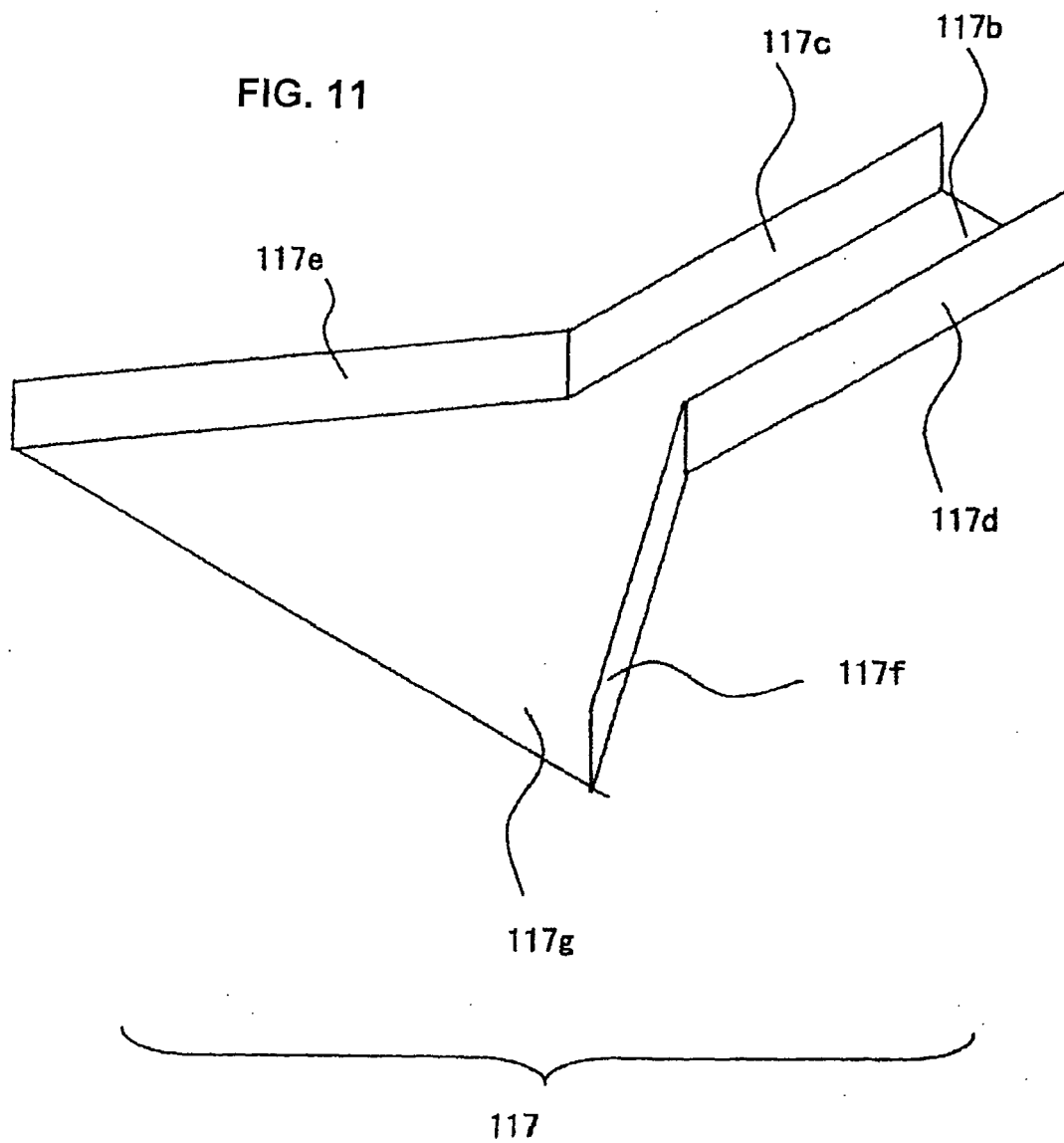


FIG. 11



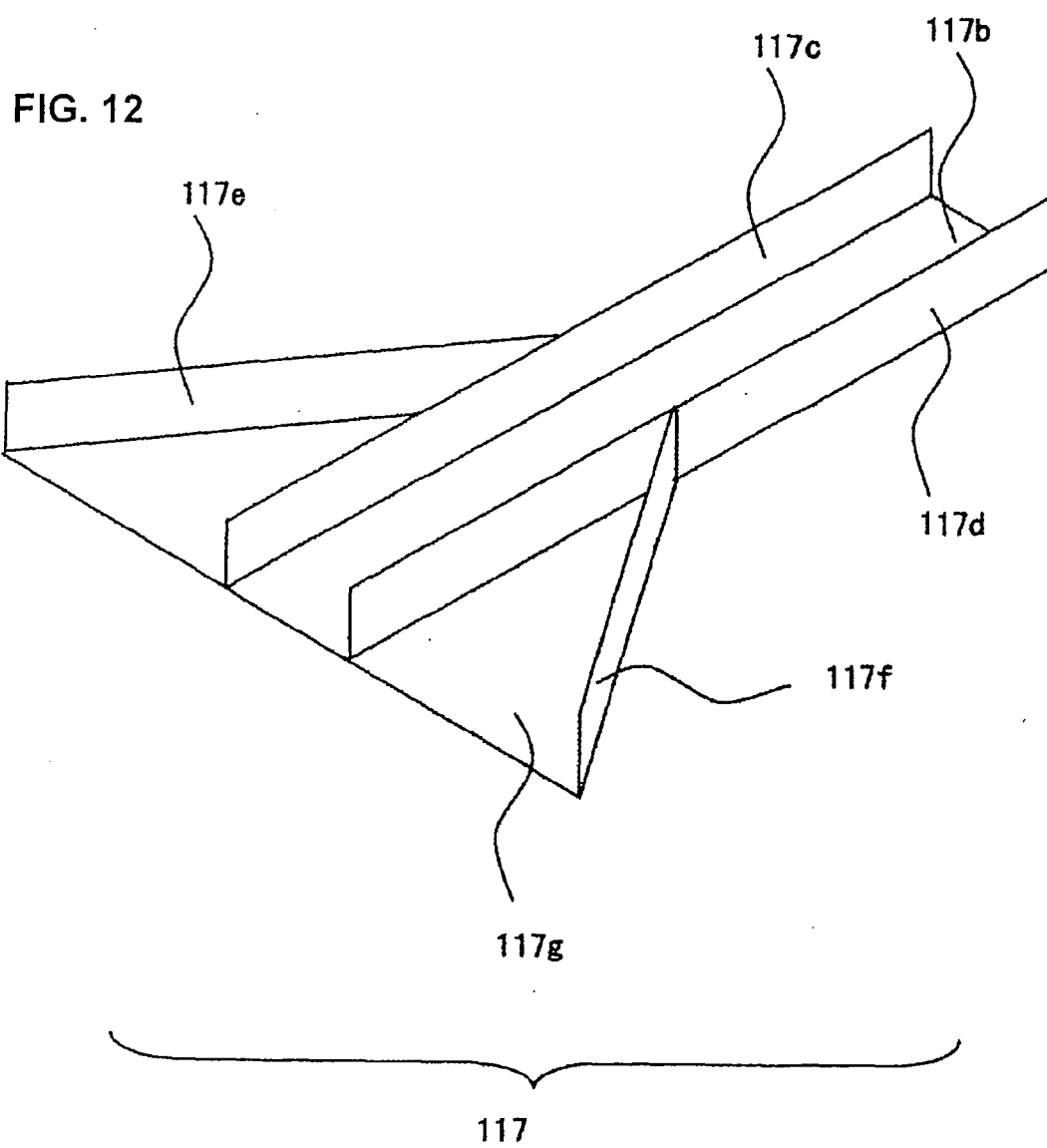


FIG. 13

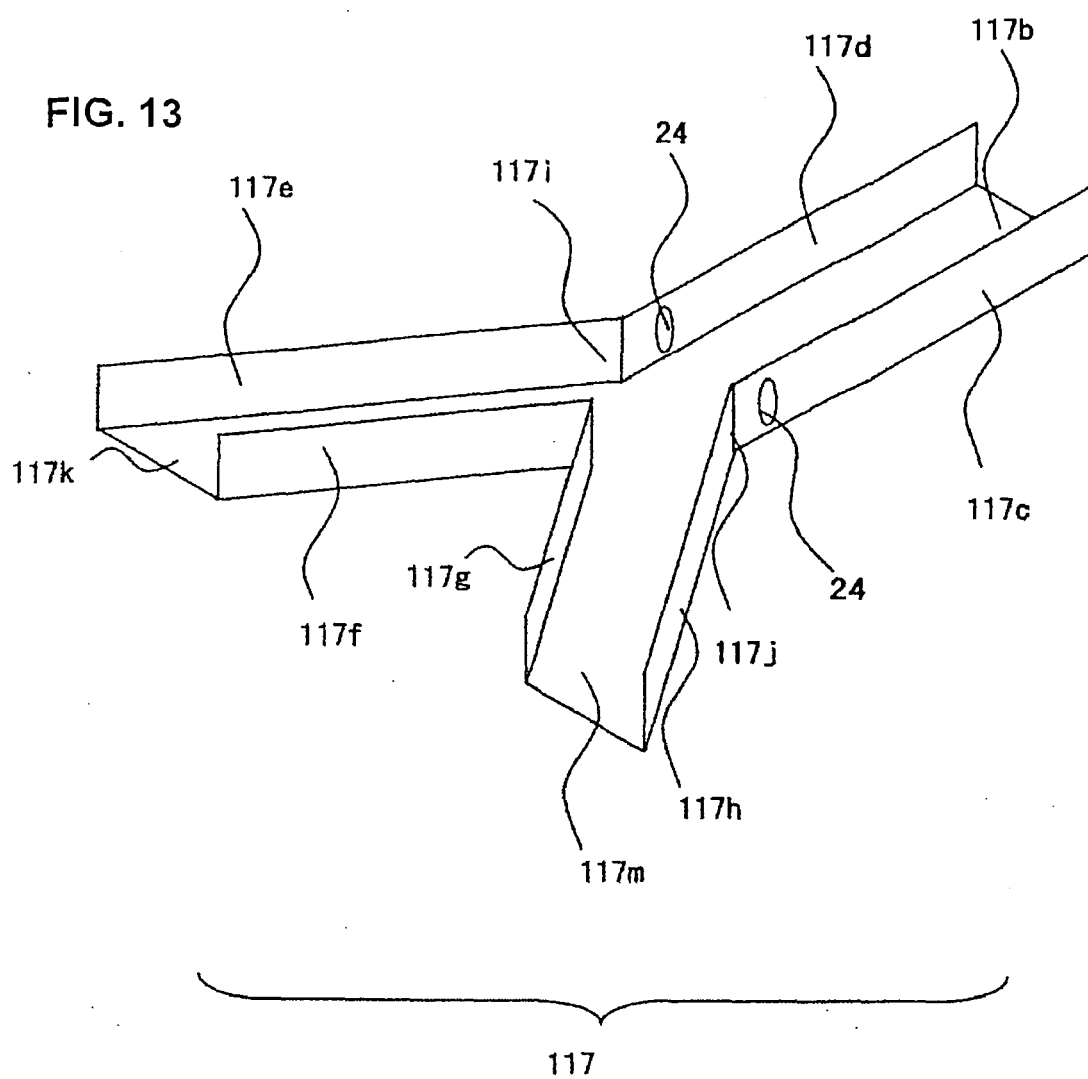


FIG. 14

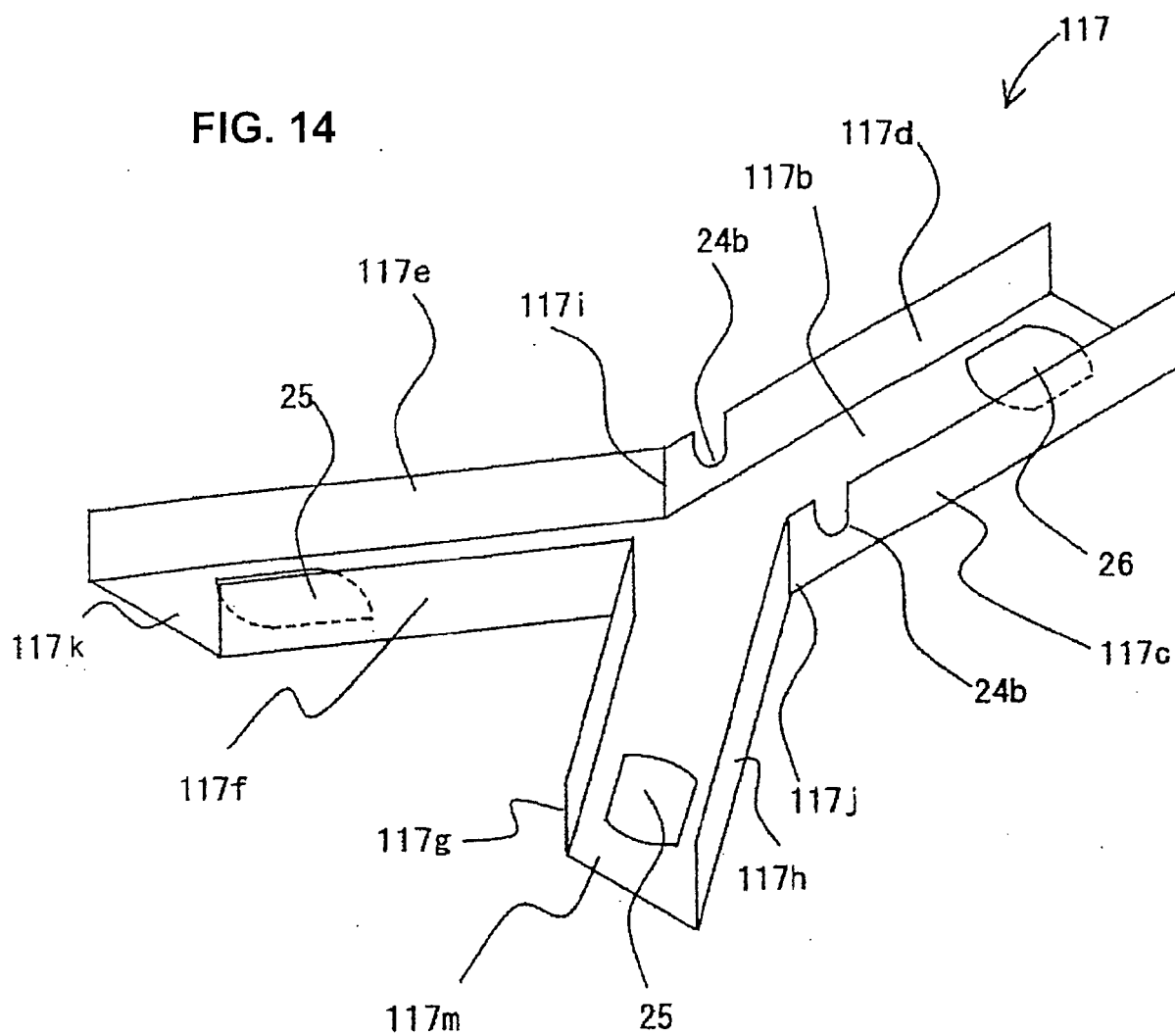
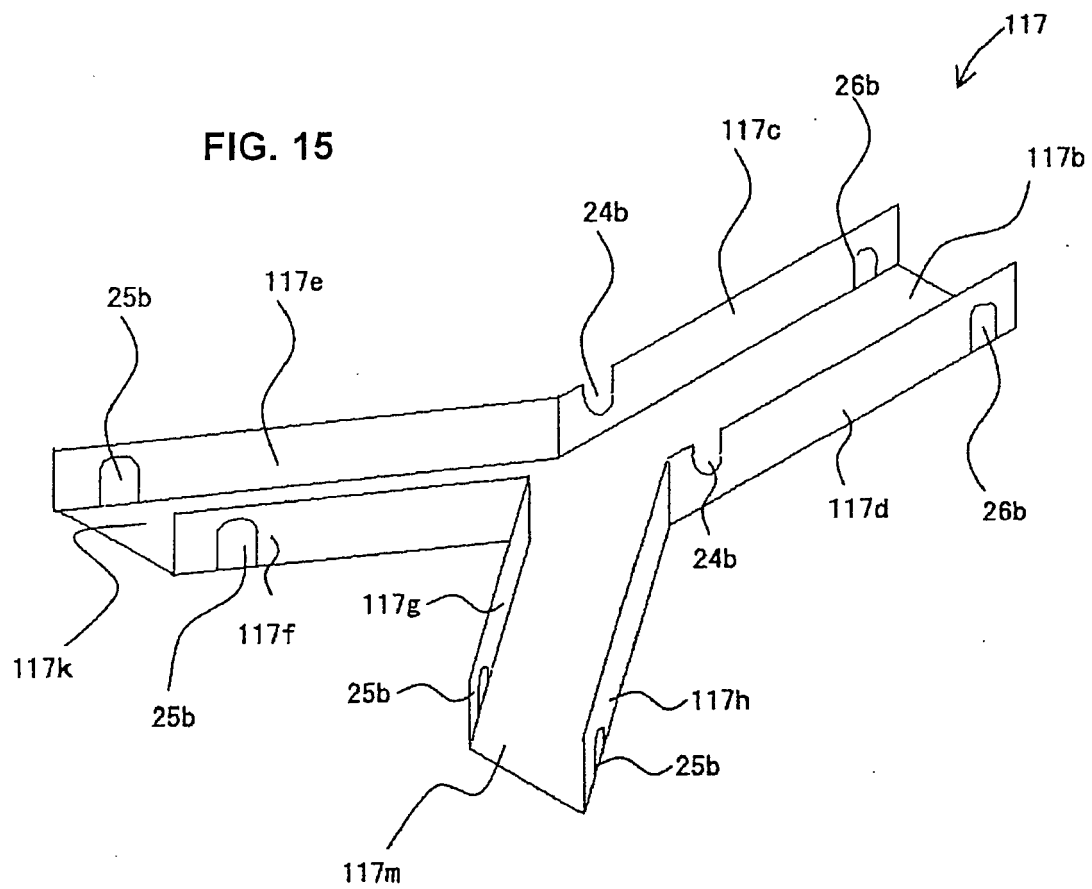


FIG. 15





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 17 January 2008	Examiner Wojski, Guadalupe
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 25 0099

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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