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GB 2458956 A
JP 2014015002 A
WO 2013/191093 A1

(58) Field of Search:
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Other: **EPODOC, WPI**

(54) Title of the Invention: **Vehicle Chassis**
Abstract Title: **Vehicle chassis with non-ferrous tubular joint and reinforcement panel**

(57) A vehicle chassis structure comprises multiple non-ferrous tubular elements 150, 152, 154 joined to form a framework with a reinforcement panel 158 adhesively attached to at least first and second tubular elements 150, 152 which are joined to each other by a welding process. In one embodiment, panel 158 overlaps the welded join 155 between tubular elements 150, 152; alternatively the panel can be rebated so that it does not overlap welded join 155. Panel 158 is preferably a composite panel, such as a glass fibre composite or a carbon **fibre** composite. Tubular elements 150, 152, 154 are preferably of a lightweight alloy such as an aluminium, titanium or magnesium alloy, which may be reinforced to form a metal matrix composite, and the tubular elements preferably have a non-polygonal cross-section, for example circular or elliptical cross-section. Panel 158 may be a glass fibre composite or a carbon fibre composite.

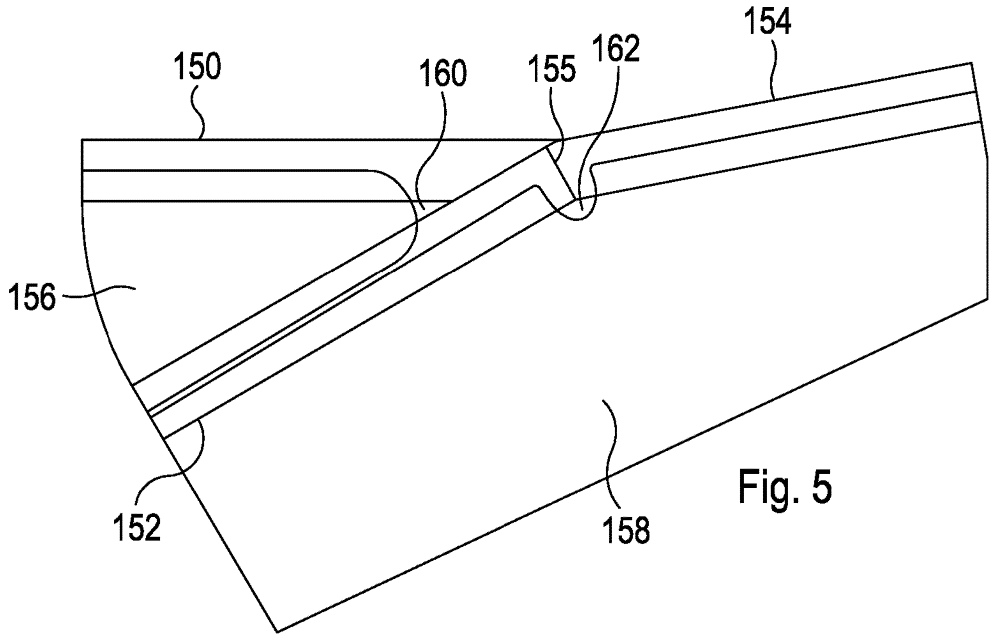

Fig. 5

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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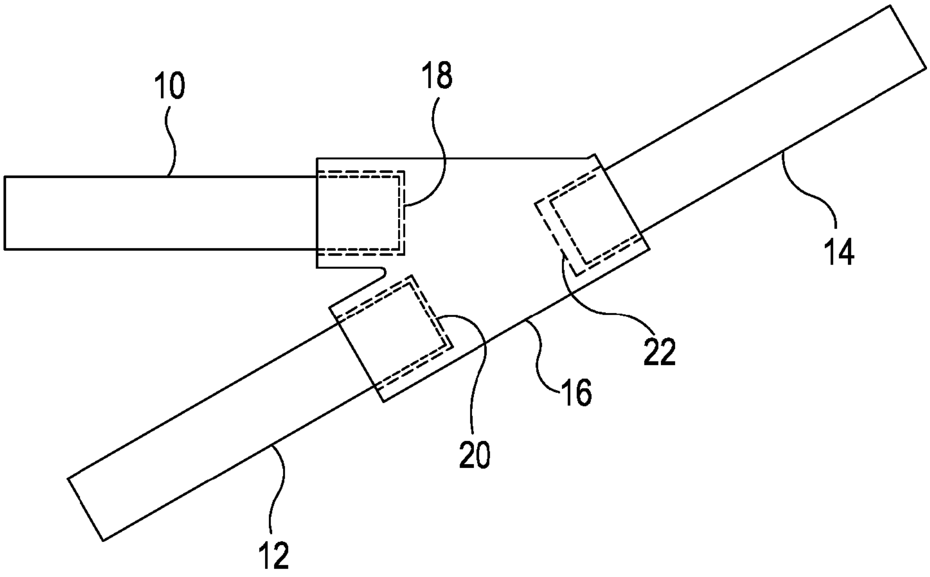

Fig. 1

06 12 19

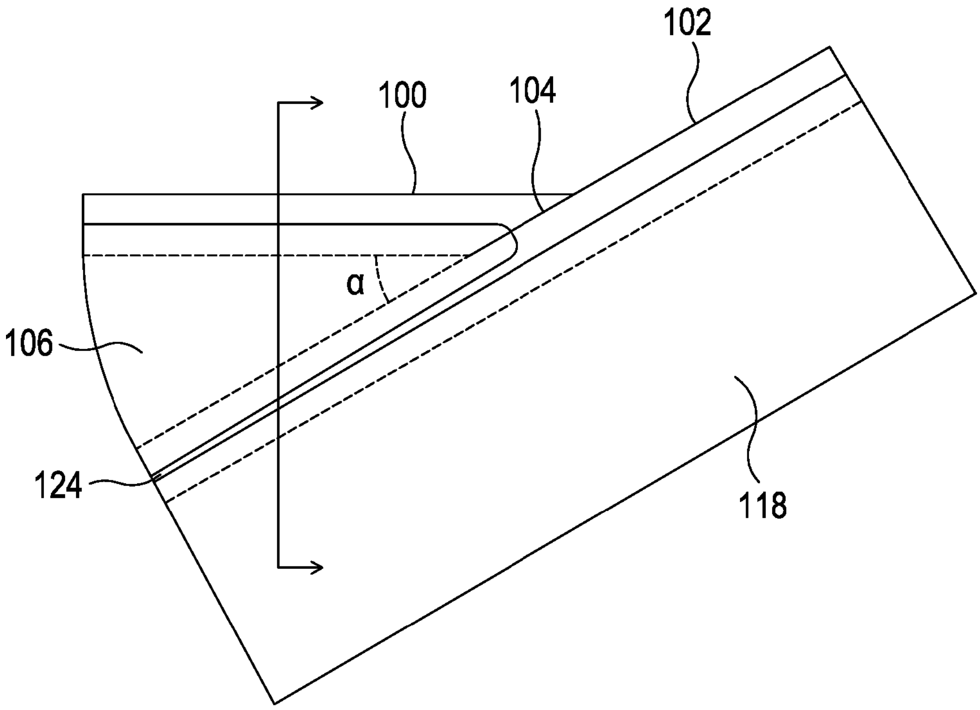

Fig. 2

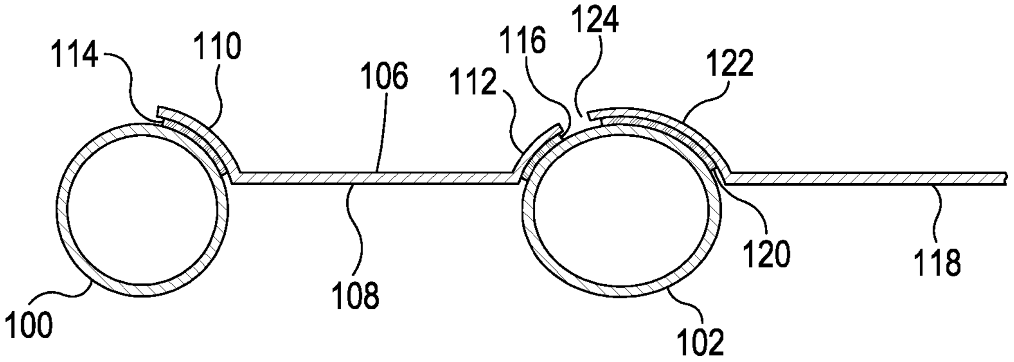
114
110
106
112
116
124
122
120
118
108
100
102

Fig. 3

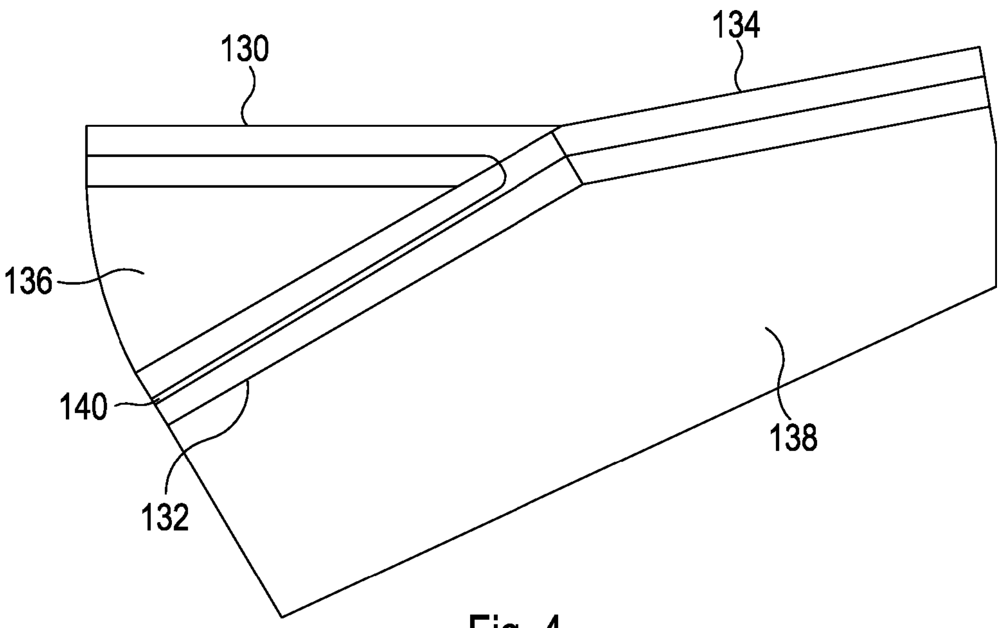
130
134
136
140
132
138

Fig. 4

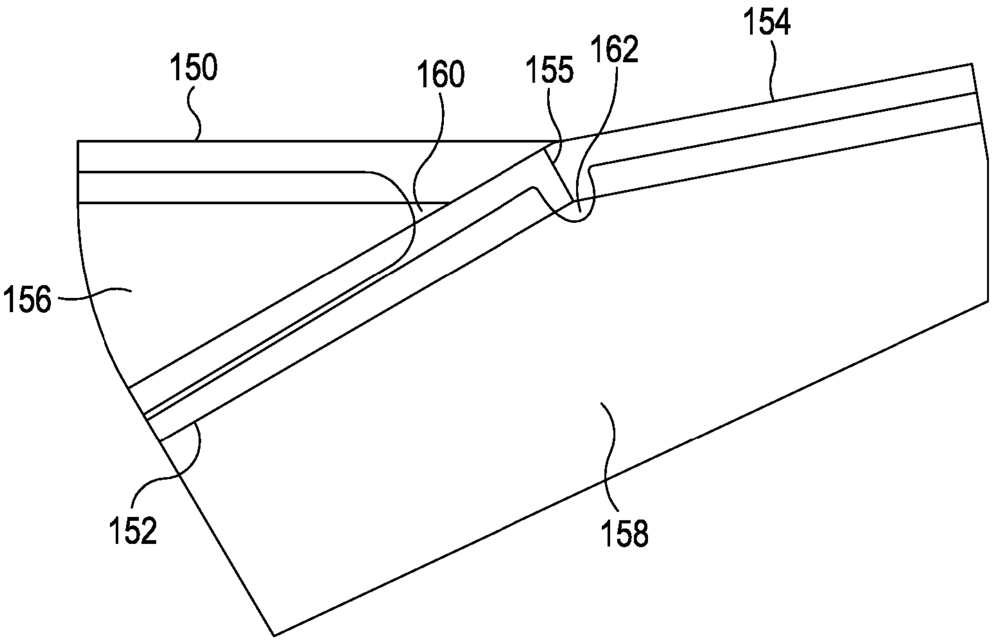

Fig. 5

06 12 19

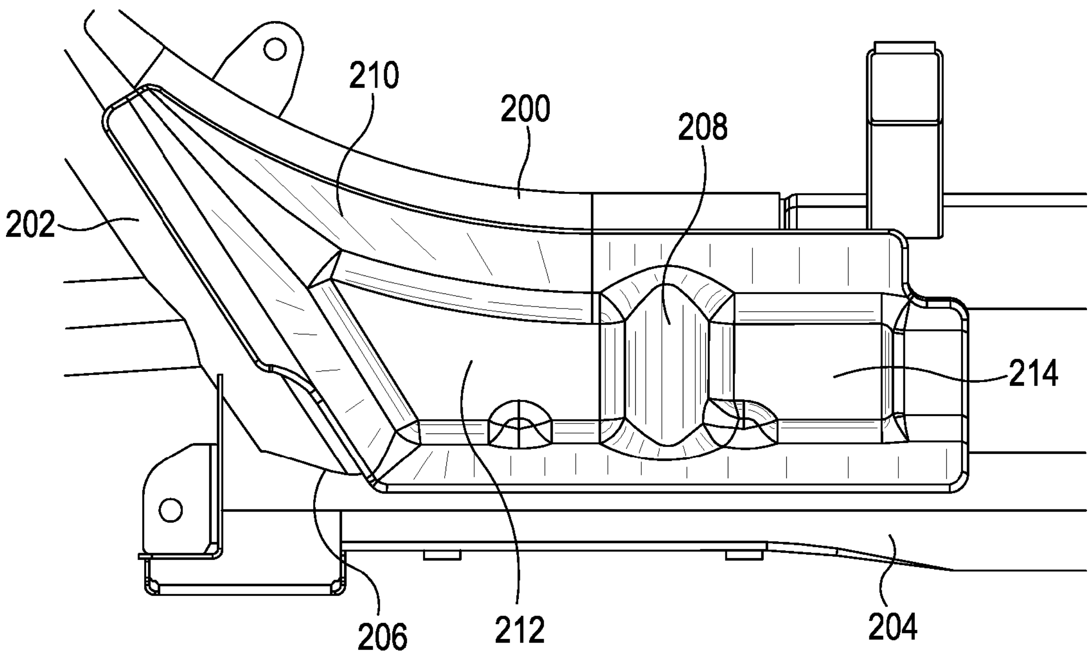

Fig. 6

Vehicle Chassis

FIELD OF THE INVENTION

The present invention relates to a chassis for a vehicle.

BACKGROUND ART

For the last 110 years or so, the chassis structures for mass production cars have been made using standard formed sheet metal. In the early 20th century, this was with a separate frame and body design, and during the last 60 years or so a unitary construction (incorporating frame and body) has been adopted.

For the greater part of high volume automobile production history, the material of choice was steel. During the last two decades there has been a move towards aluminium and composite structures in an attempt to reduce the overall vehicle weight with a lighter body-in-white ("BIW") assembly.

A challenge that arises in the design of automotive aluminium primary structures is that the joining technologies that need to be employed are much more complex, heavy and expensive relative to the simple spot welding processes that can be used to join stamped-steel BIW structures. High levels of stress in structure element joints (nodes) often require complex castings or multi-element designs to reduce the likelihood of fatigue failure, and aluminium sheet joints are normally bonded and riveted.

Another issue with aluminium BIW structures is that base aluminium is not as strong as mild steel (typically 40% the yield strength of steel). Accordingly, high strength aluminium alloys are normally specified, and this results in further issues with cost and joint selection. In high strength heat-treated alloys the heat affected zone ("HAZ") near to a welded joint can often require some form of post weld treatment in order to restore the pre-existing microstructure and maintain the mechanical properties of the alloy; this can cause further heat distortion.

Another issue with welded aluminium structures is resistance to fatigue in the welded joint and the surrounding HAZ. To overcome this, node joints are employed. These are complex, heavy and expensive, and therefore add weight and cost to the BIW structure.

Similar problems arise in relation to other non-ferrous lightweight alloys, such as Titanium and Magnesium alloys.

In our earlier application WO2009/122178 we proposed a three-dimensional framework of metallic tubular members, with composite panel members affixed to the framework to provide shear stability. The resulting chassis provided excellent stiffness due to the triangulation, with a very low overall weight and a low energy cost of production. In practice, the designs that were based on the invention of WO2009/122178 used steel tubes in order to provide the necessary strength and in view of the above issues.

SUMMARY OF THE INVENTION

The present invention therefore provides a vehicle chassis structure, comprising a plurality of non-ferrous tubular elements joined to form a framework, the framework being reinforced with a panel element adhesively attached to at least a first tubular element and a second tubular element, the first and second tubular elements being joined to each other by a welding or other fusion process (hereinafter referred to as "welding").

This allows simple lightweight welded structures of non-ferrous alloys to be constructed, avoiding complex and heavy cast joints. By adhering the panel element directly to the first and second tubular elements, i.e. the tubes that are joined at the weld, the panel assists in conveying loads across the welded joint and reducing the stress that needs to be borne by the weld.

The edges of the panel element are preferably shaped to conform to an outer profile of the tubular members. This allows the panel element to be adhesively attached to the first and second tubular elements via a layer of adhesive applied at the shaped edge, giving a secure connection between the panel and the tubular member.

The panel member can overlap the welded join between the first and second tubular elements, or it can be rebated so that it does not overlap the welded join. An overlapping arrangement allows for a simple shape for the panel, but a rebated design allows sight of the weld for QA and inspection purposes.

The arrangement is especially useful if the first and second tubular elements are joined at an acute angle. Such angles create a greater risk of fatigue failure at the weld, as any component of the forces borne by the structure that tends to open up the angle of the two elements will assist with crack initiation and growth. The present invention, however, provides a load path across the gap between the two elements which reduces the stress imposed on the weld material.

The panel element is preferably a composite panel, such as a glass fibre composite or a carbon fibre composite. The panel may be wholly composite, or may be a sandwich construction consisting of a composite skin and a lightweight interior structure such as a honeycomb. The non-ferrous tubular elements are preferably a lightweight alloy, such as an Aluminium alloy, a Titanium alloy, or a magnesium alloy. The alloy may be reinforced, i.e. a metallic matrix composite including silicon carbide or other forms of reinforcement.

The tubular elements can have any suitable cross-section, as required by the particular design in question. A non-polygonal cross-section such as a circular or an elliptical cross-section is usually convenient, though.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the present invention will now be described by way of example, with reference to the accompanying figures in which;

Figure 1 diagrammatically illustrates a conventional arrangement for connecting tubular non-ferrous members;

Figure 2 diagrammatically illustrates a chassis node according to a first embodiment of the present invention;

Figure 3 is a cross-section on III-III of figure 2;

Figure 4 diagrammatically illustrates a chassis node according to a second embodiment of the present invention;

Figure 5 diagrammatically illustrates a chassis node according to a third embodiment of the present invention; and

Figure 6 shows a portion of a chassis according to the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Figure 1 shows the known arrangement for joining tubular frameworks of non-ferrous alloys such as Aluminium alloys, Titanium alloys, or Magnesium alloys, where high loads need to be carried by the joints (such as in a vehicle chassis). The tubes 10, 12, 14 each need to terminate near to the join and are received in a cast connector piece 16. This is generally solid but has recesses 18, 20, 22 that are sized to receive an end of each of the tubes 10, 12, 14 and positioned so as to locate the tubes in their intended relative positions. The tubes 10, 12, 14 are secured in place in the connector piece 16 by welding, adhesive bonding, electromagnetic pulse technology, interference fit, or like processes.

This provides a secure mechanical connection between the tubes, which is resistant to fatigue failure as there are no obvious flaws or stress concentrators. However, this is achieved at the expense of including an additional part for example cast, machined or additive manufactured node, which adds weight, inventory and complexity to the structure, additional welds and higher costs of fabrication. To date, welded joins of lightweight (non-ferrous) alloys have been avoided in vehicle chassis structures as they are susceptible to loss of strength in heat-affected zones ("HAZ") – an area adjacent to a weld that has had its microstructure and properties altered by welding (or other heat intensive cutting operations). As high-strength lightweight alloys often depend on their microstructure for their mechanical properties, an HAZ will likely be of inadequate strength and hence prone to fatigue or other failure. This can be rectified after welding by a suitable heat-treatment, but this introduces an additional production step and may be impractical depending on the overall size of the structure and the location of the weld and could cause further distortion of the structure. Thus, simple welded joints of lightweight non-ferrous alloys have been avoided in favour of arrangements such as figure 1, or cast, forged or milled bulk structures that require machining to obtaining adequate accuracy.

Figures 2 and 3 show a joint according to the present invention. Aluminium tube 100 is required (by the design of the vehicle chassis structure of which it forms a part) to butt joint to aluminium tube 102. Both tubes are of a suitable engineering grade high-strength lightweight Aluminium alloy such as 2xxx, 6xxx or 7xxx series alloys. Tube 100 is formed with a chamfered end 104 which is then butt-welded to the side of tube 102 at the required angle, in this case an acute angle α. A composite glass-fibre-reinforced panel 106 is attached to the tubes 100, 102 so as to provide an additional load path between the two; this both triangulates the framework that tubes 100, 102 form part of and also removes stress loading from the welded join at 104. As can be seen in figure 3, the panel 106 comprises a generally flat central portion 108 sitting between the tubes 100, 102, and profiled edges 110, 112 that match the external profile of the circular-section tubes 100, 102 (note that tube 102 appears slightly elliptic in figure 3 as the cross-section line is not perpendicular to the tube). These profiled edges are adhered to the tubes 100, 102 using engineering-grade adhesive in layers 114 , 116 as (for example) disclosed in our earlier application WO2015/197761.

A further panel 118 is attached to the tube 102, again via a layer 120 of adhesive between the tube 102 and a profiled edge 122 of the panel 118. This is connected to other tubes of the framework (not shown) in order to provide a three-dimensional structure making up a vehicle chassis. A small clearance 124 is provided between the panels 106, 118 to allow for tolerances.

In this embodiment, the panel 106 extends over and covers the weld region 104, and is adhered to the tubes 100, 102 in this region also.

Figure 4 shows an alternative arrangement, joining three non-colinear tubes 130, 132, 134. In this case, all three tubes have been formed with an end profile that matches the surface of the tubes they will butt against; tubes 132 and 134 meeting at a small angle and tube 130 meeting tube 132 at an acute angle. The three Aluminium alloy tubes are then butt-welded to each other to form the join. Titanium or Magnesium alloys are alternative options. A panel 136 is then attached to tubes 130, 132 in the same manner as panel 106 and provides similar reinforcement, triangulating the framework and transferring load between the tubes without passing through the welded join. A further panel 138 is attached to the tubes 132 and 134, and to other tubes of the framework (not shown) in order to provide a three-dimensional structure making up a vehicle chassis. This panel also supports the welded join between tubes 132 and 134. As before, a small clearance 140 is provided between the panels 136, 138 to allow for tolerances.

Figure 5 shows an alternative arrangement. Based on the layout of figure 4, three non-colinear lightweight-alloy tubes 150, 152, 154 are butt-welded together at a join 155. All three tubes have again been formed with an end profile that matches the surface of the tubes they will butt against; tubes 152 and 154 meeting at a small angle and tube 150 meeting tube 152 at an acute angle. A panel 156 is attached to tubes 150, 152 as before, and a further panel 158 is attached to the tubes 152 and 154, and to other tubes of the framework (not shown) in order to provide a three-dimensional vehicle chassis.

In this arrangement, the two panels 156, 158 each have a rebated section 160, 162 (compared with panels 106, 118, 136, 138) so that the panels do not extend over the welded join 155. For panel 156 which extends into the acute angle between tubes 150, 152, this is achieved by shaping the panel 156 so that it ends with a smooth radius short of the welded join 155. For panel 158, covering an obtuse angle between tubes 152, 154, this is achieved by providing a notch-shaped rebate 162 on the edge of the panel 158 at the location of the welded join 155; this allows the panel edges to be adhered to the tubes 152, 154 as before and for the panel 158 to avoid the join 155.

In this way, potential tolerances around the join 155 resulting from the uneven surface profile of the weld do not affect the positioning of the panels 156, 158. Other advantages include less adhesive and smaller panel tooling, resulting in lower weight and costs and better access for repair.

Figure 6 shows the invention in use in a section of an actual vehicle chassis design. Tubes 200, 202, 204 are circular-section light-alloy tubes that form part of a vehicle chassis. Tubes 200, 204 are parallel for part of their length, tube 200 directly above tube 204 to form a side sill of the vehicle; at their rearward end the sill tubes 202, 204 meet a descending tube 202; the lower tube 204 ends at a welded join 206 with the descending tube 202, and the upper tube 200 curves upwards to a smooth join with the descending tube 202. A bracing tube 208 extends vertically downward from the upper sill tube 200 to the lower sill tube 204, and is welded at each end to the respective sill tube.

The framework thus formed is covered with a panel member 210 which is shaped to provide a generally flat portion in the gaps 212, 214 between the tubular members and to conform to the outer profile of the tubular members at its edges and where is overlaps a tube (such as the bracing tube 208). This allows the panel member to be adhered to the tubes in a like manner to that described with reference to figure 3.

The panel 210 thus provides shear stabilisation of the framework of tubes, and also reinforces the welded joins between them. In this way, a lightweight alloy composition such as an Aluminium, Titanium or Magnesium alloy can be used, welded together quickly and easily, and processed further without the need for complex and time-consuming post-weld treatment. The tubes themselves may be of a conventional circular cross-section, or may be polygonal (such as hexagonal or octagonal), or may be an other non-polygonal section such as elliptical. The tubes can be hollow, or they may include internal bracing structures. Such shapes are usually formed by extrusion, although other methods are possible.

It will of course be understood that many variations may be made to the above-described embodiment without departing from the scope of the present invention.

CLAIMS

1. A vehicle chassis structure comprising a plurality of non-ferrous tubular elements joined to form a framework, the framework being reinforced with a panel element adhesively attached to at least a first tubular element and a second tubular element, the first and second tubular elements being joined to each other by a welding process.

2. A vehicle chassis structure according to claim 1 in which edges of the panel element are shaped to conform to an outer profile of the tubular members.

3. A vehicle chassis structure according to claim 2 in which the panel element is adhesively attached to the first and second tubular elements via a layer of adhesive applied at the shaped edge.

4. A vehicle chassis structure according to any one of the preceding claims in which the panel member overlaps the welded join between the first and second tubular elements.

5. A vehicle chassis structure according to any one of claims 1 to 4 in which the panel member does not overlap the welded join between the first and second tubular elements.

6. A vehicle chassis structure according to any one of the preceding claims in which the first and second tubular elements are joined at an acute angle.

7. A vehicle chassis structure according to any one of the preceding claims in which the panel element is a composite panel.

8. A vehicle chassis structure according to claim 7 in which the composite panel is a glass fibre composite.

9. A vehicle chassis structure according to claim 7 in which the composite panel is a carbon fibre composite.

10. A vehicle chassis structure according to any one of the preceding claims in which the non-ferrous tubular elements are an Aluminium alloy.

11. A vehicle chassis structure according to any one of claims 1 to 9 in which the non-ferrous tubular elements are a Titanium alloy.

12. A vehicle chassis structure according to any one of claims 1 to 9 in which the non-ferrous tubular elements are a Magnesium alloy.

13. A vehicle chassis structure according to any one of claims 10 to 12 in which the alloy is reinforced with a second phase to form a metal matrix composite.

14. A vehicle chassis structure according to any one of the preceding claims in which the tubular elements have a non-polygonal cross-section.

15. A vehicle chassis structure according to any one of the preceding claims in which the tubular elements have a circular cross-section.

16. A vehicle chassis structure according to any one of claims 1 to 14 in which the tubular elements have an elliptical cross-section.

Application No:	GB1814564.9	**Examiner:**	Simon Rose
Claims searched:	1-16	**Date of search:**	30 January 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-16	WO 2013/191093 A1 (TORAY) See particularly Figures 17, 28-30 and 40 and abstract
X	1-16	JP 2014015002 A (TORAY) See particularly Figure 1 and WPI abstract accession number 2013-X43567
X	1-16	GB 2458956 A (GORDON MURRAY) See particularly Figures 1 and 13, sheet 50, and abstract

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B62D

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B62D	0023/00	01/01/2006
B62D	0029/00	01/01/2006