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(71) Applicant(s):
Woven Technology Ltd
14 Bardwell Court, Oxford, Oxfordshire, OX2 6SX, United Kingdom

(72) Inventor(s):
Gavin David William Palmer

(74) Agent and/or Address for Service:
Boult Wade Tennant
Verulam Gardens, 70 Gray's Inn Road, LONDON, WC1X 8BT, United Kingdom

(54) Title of the Invention: **A monocoque structure**
Abstract Title: **A composite monocoque structure for a vehicle**

(57) A vehicle comprising a monocoque or semi-monocoque body 1 formed of a composite and forming the central body of the vehicle. A first and second externally mounted support member (200 fig. 4) distributes forces around the vehicle, wherein the first externally mounted support member is attached to the second externally mounted support member and transfers forces between the externally mounted support members. The monocoque or semi-monocoque body is provided with at least one region of additional strength, and one or more of the externally mounted support members is configured to transfer forces to this region. The body may be moulded or may comprise a combination of moulding and 3D printed parts.

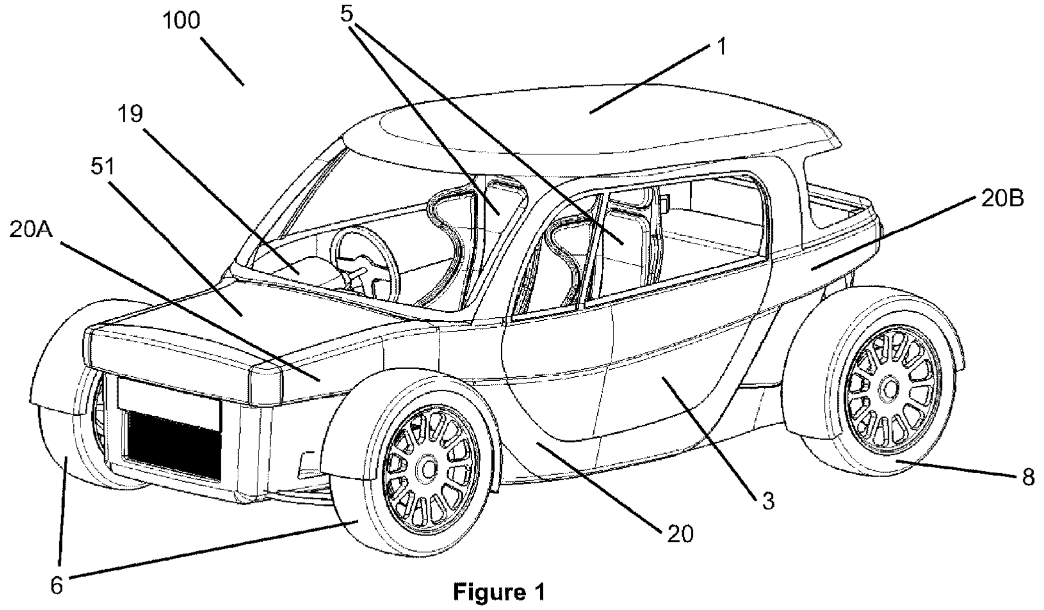

Figure 1

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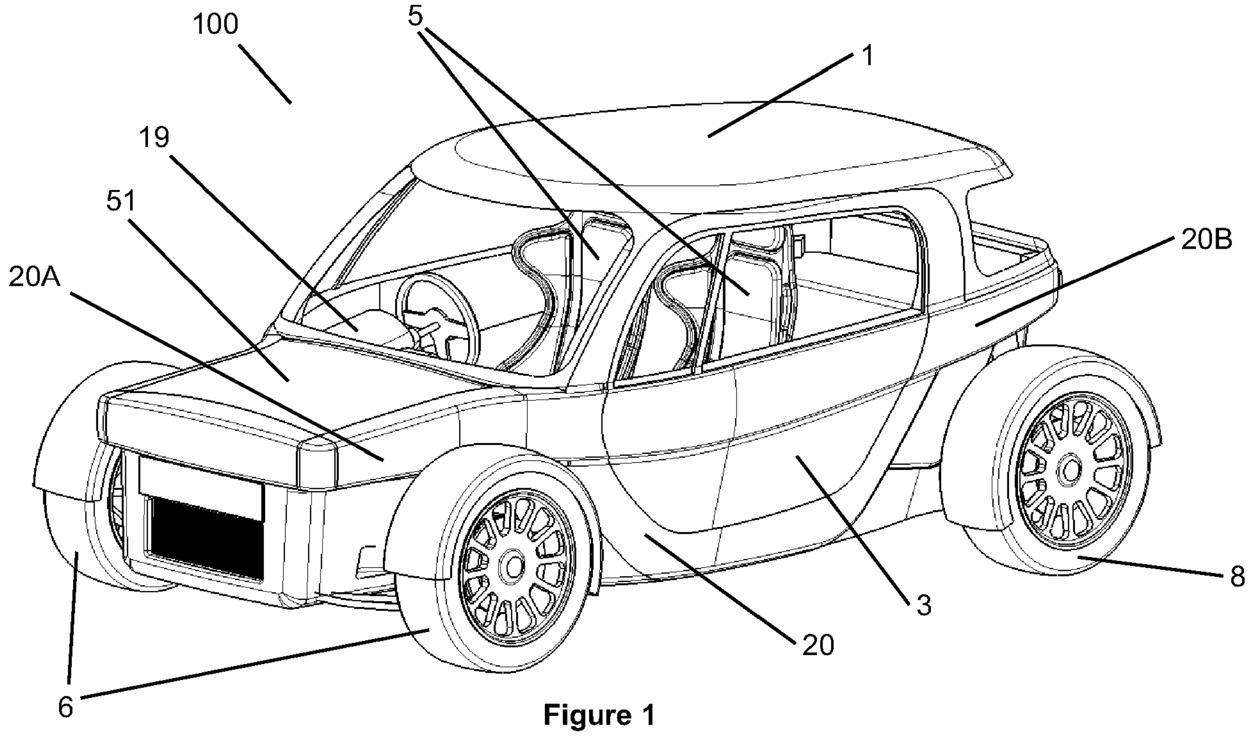

Figure 1

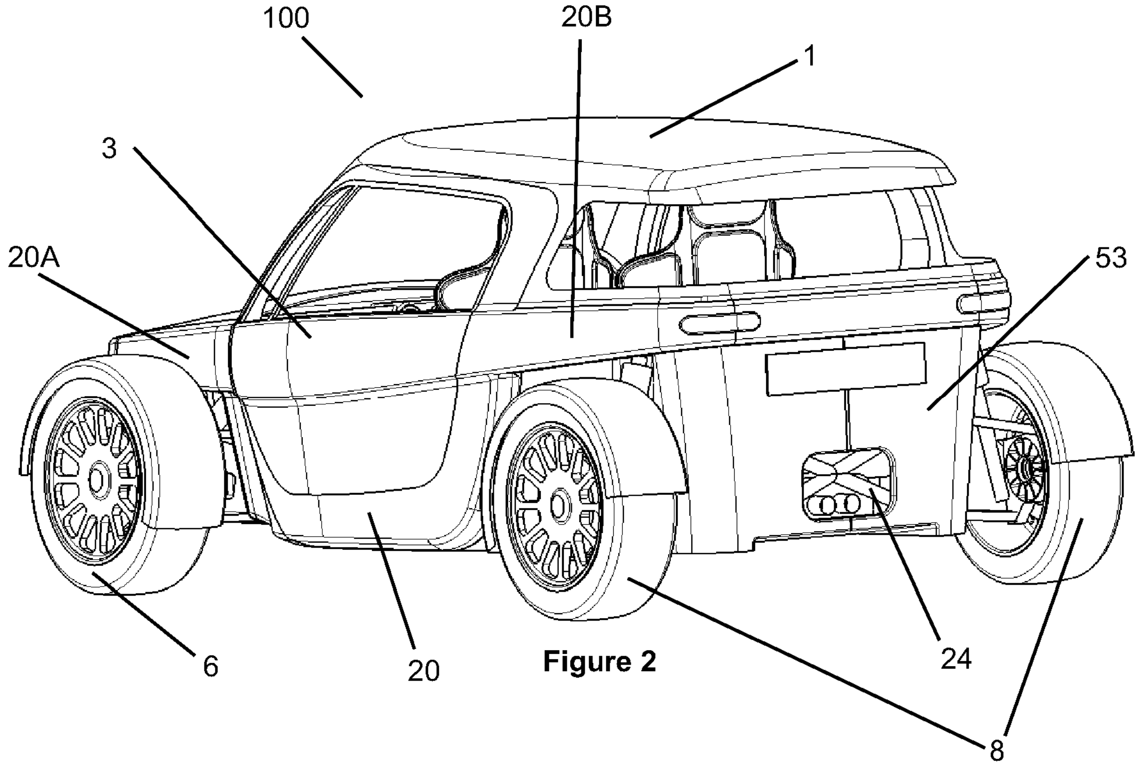

Figure 2

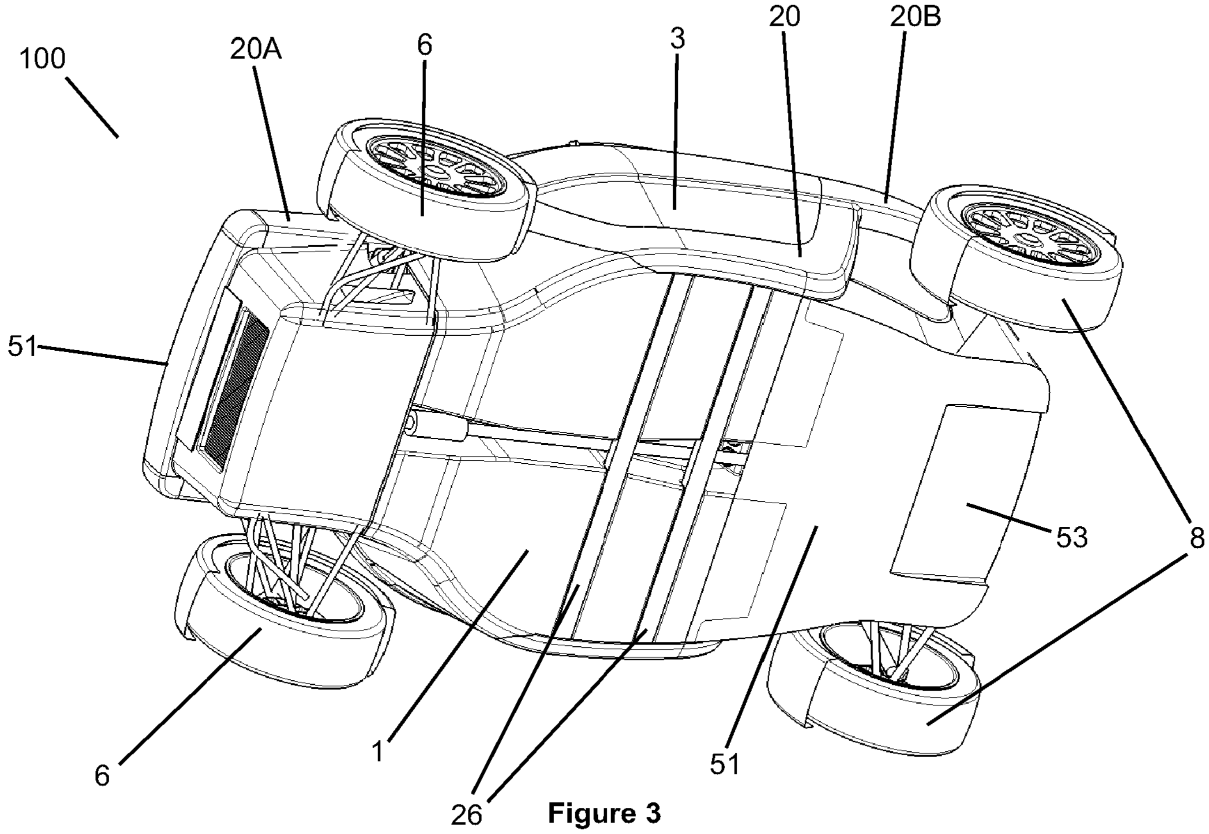

Figure 3

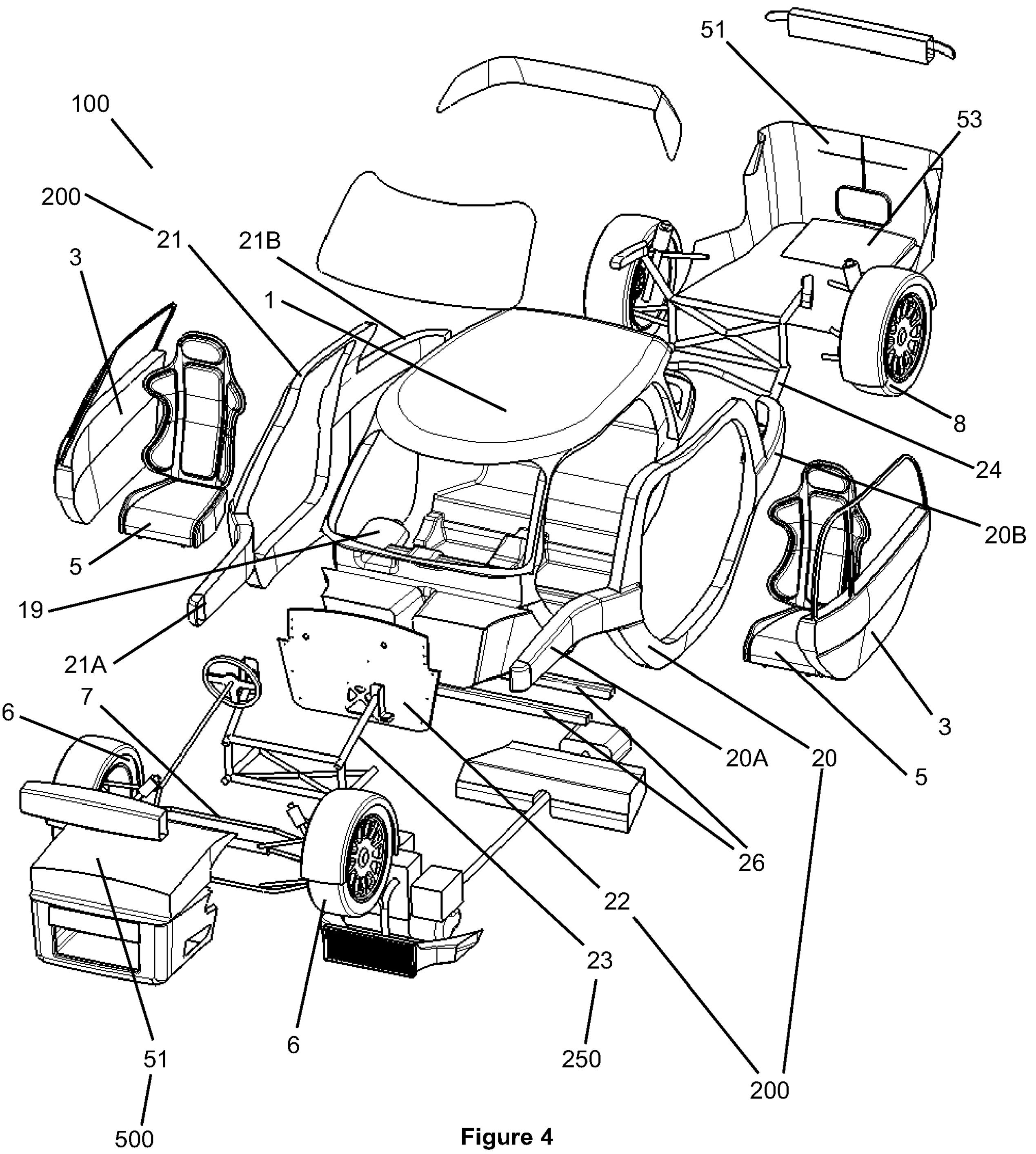
100
200
21
21B
3
1
51
53
8
24
20B
5
19
21A
7
6
20A
20
3
5
26
22
23
6
51
250
200
500

Figure 4

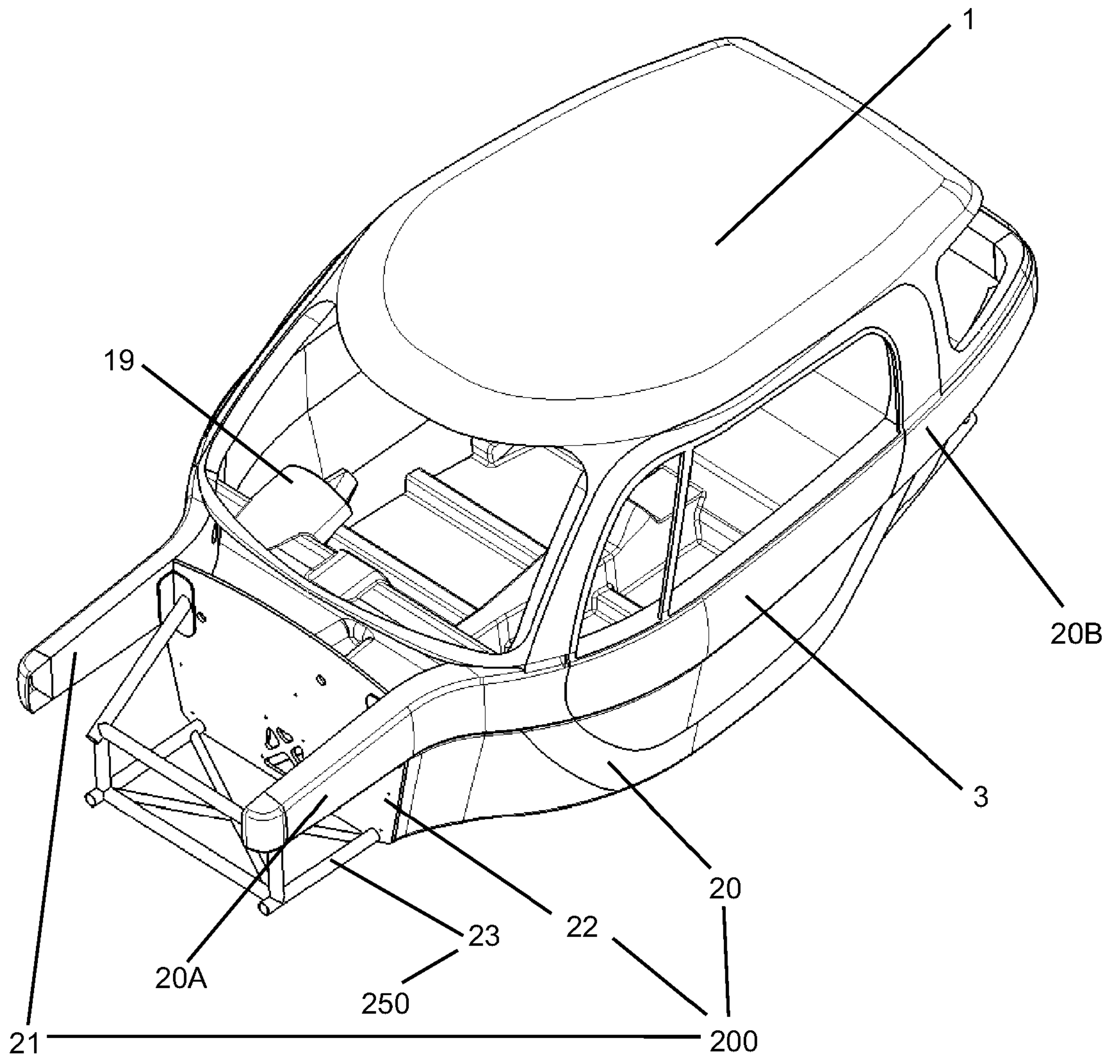

Figure 5

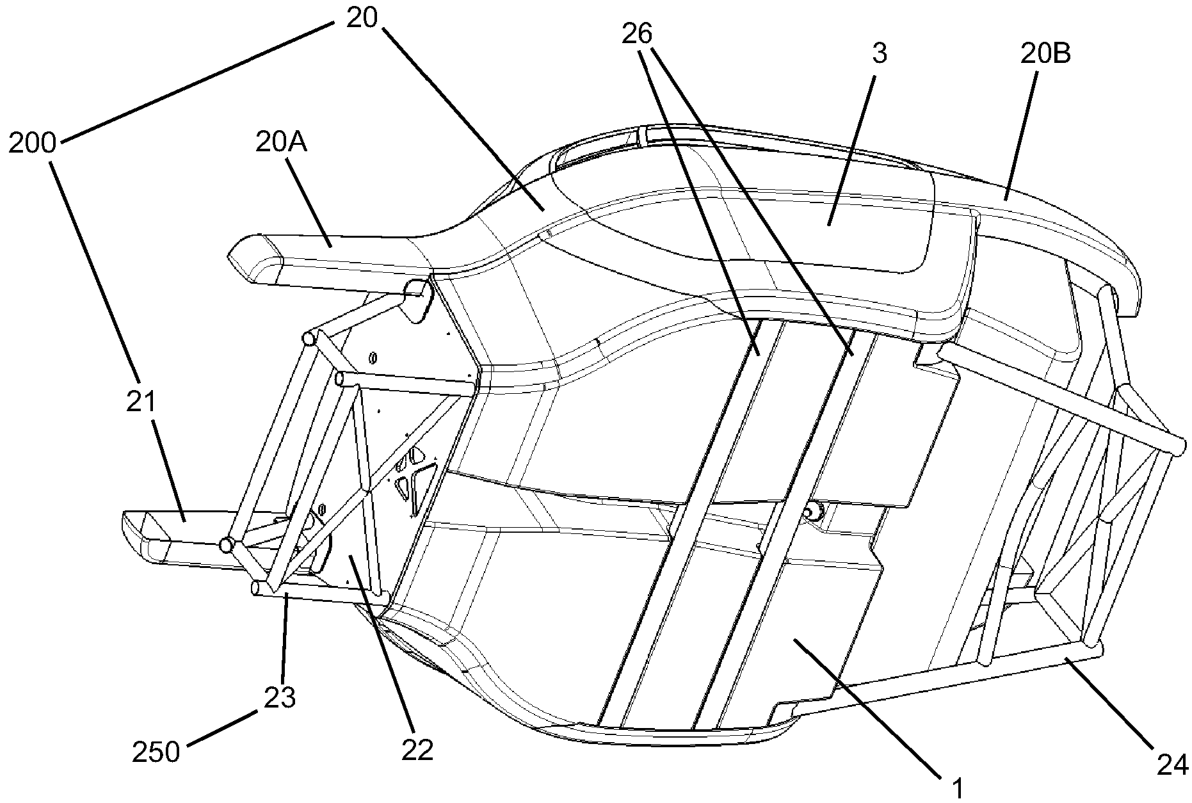

Figure 6

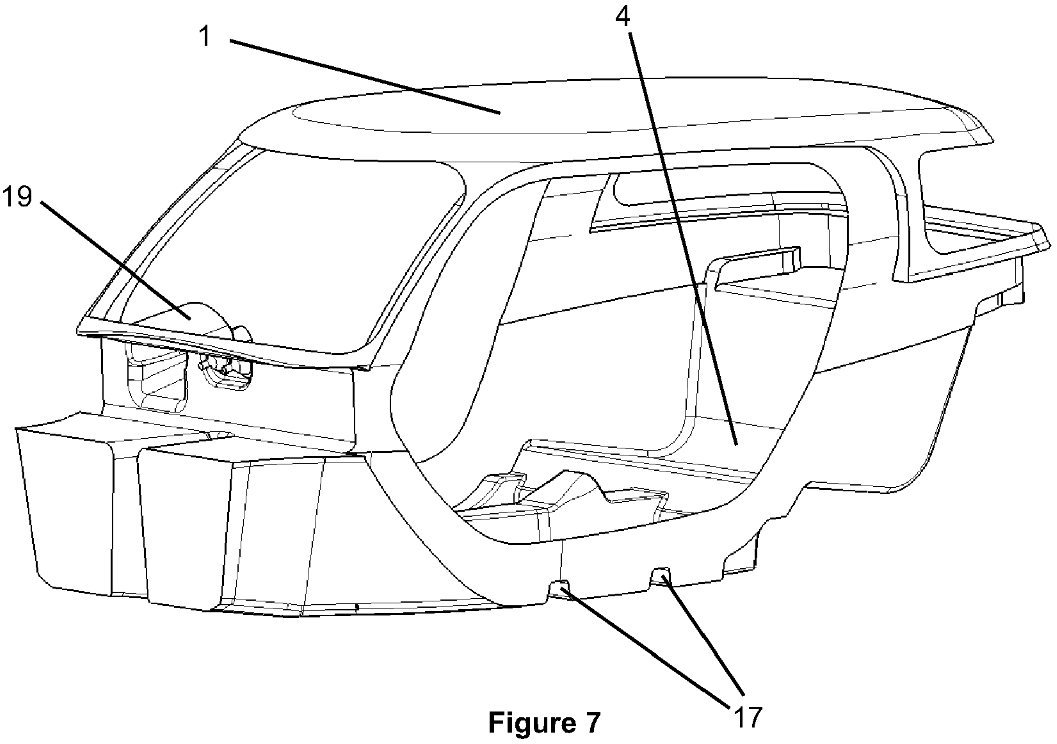

Figure 7

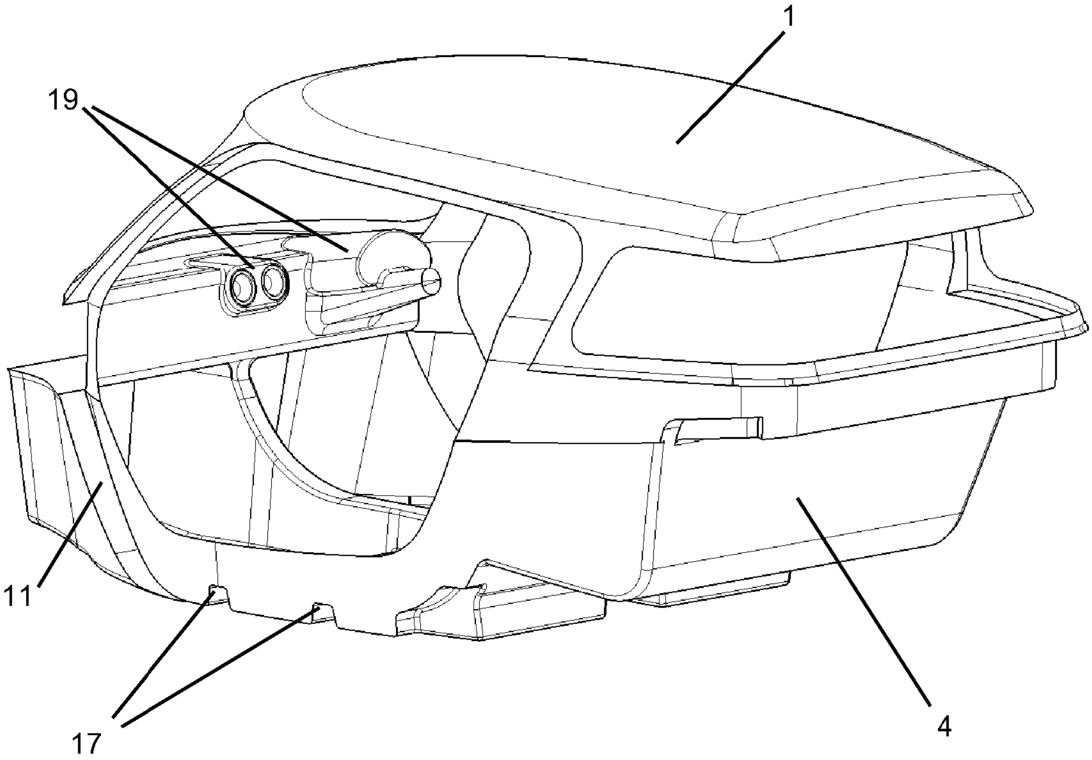

Figure 8

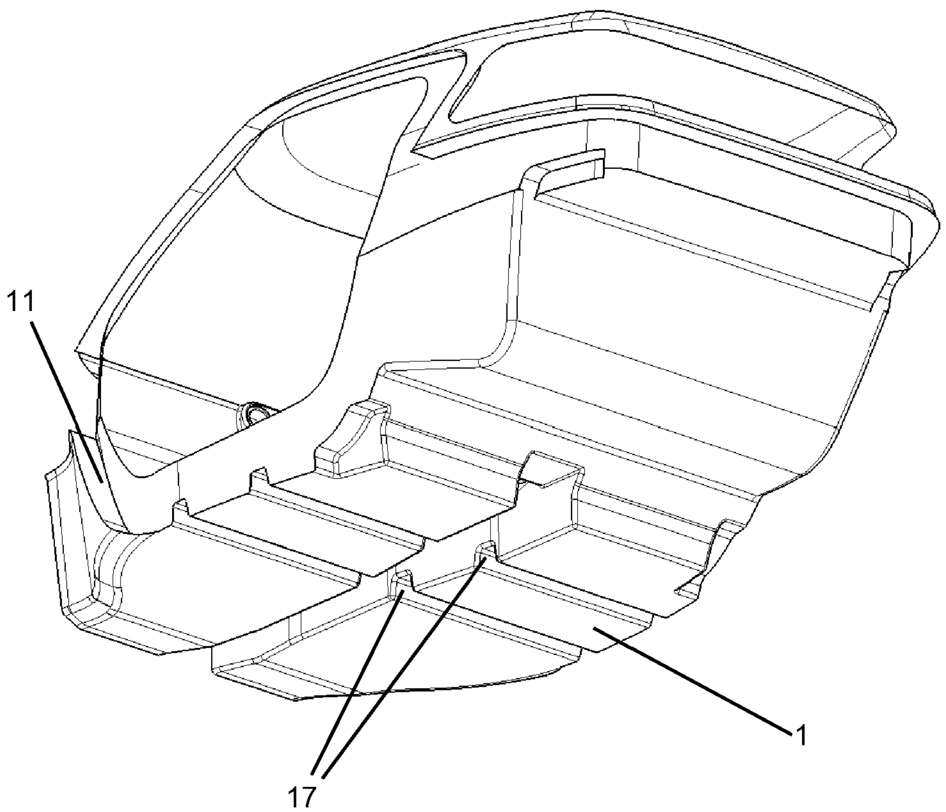

Figure 9

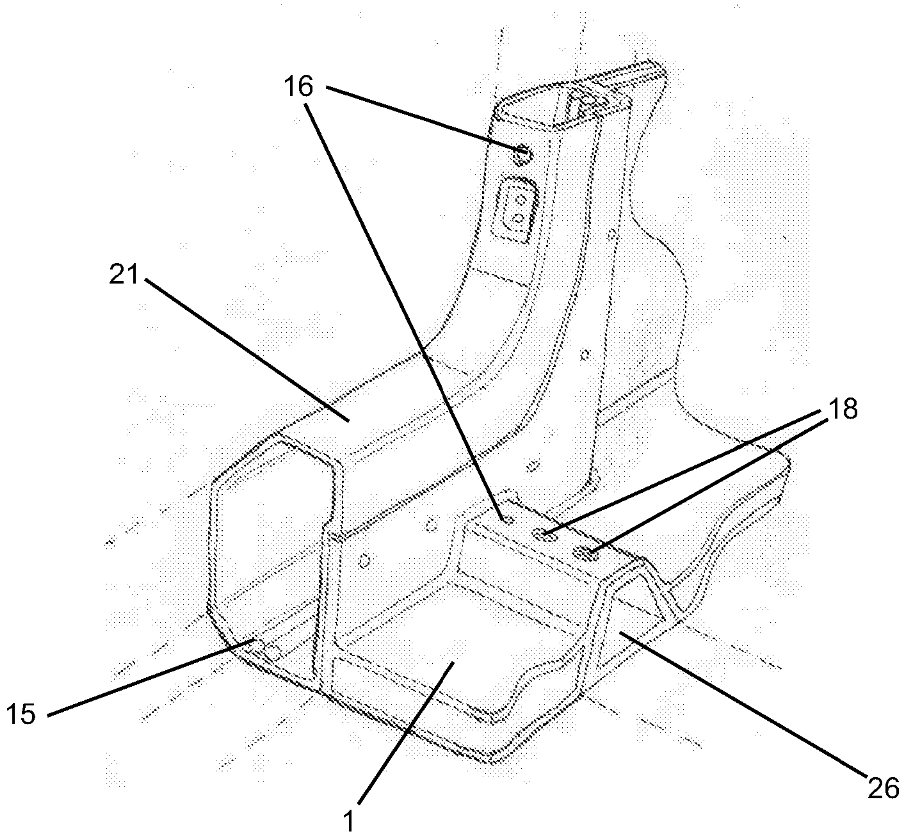

Figure 10

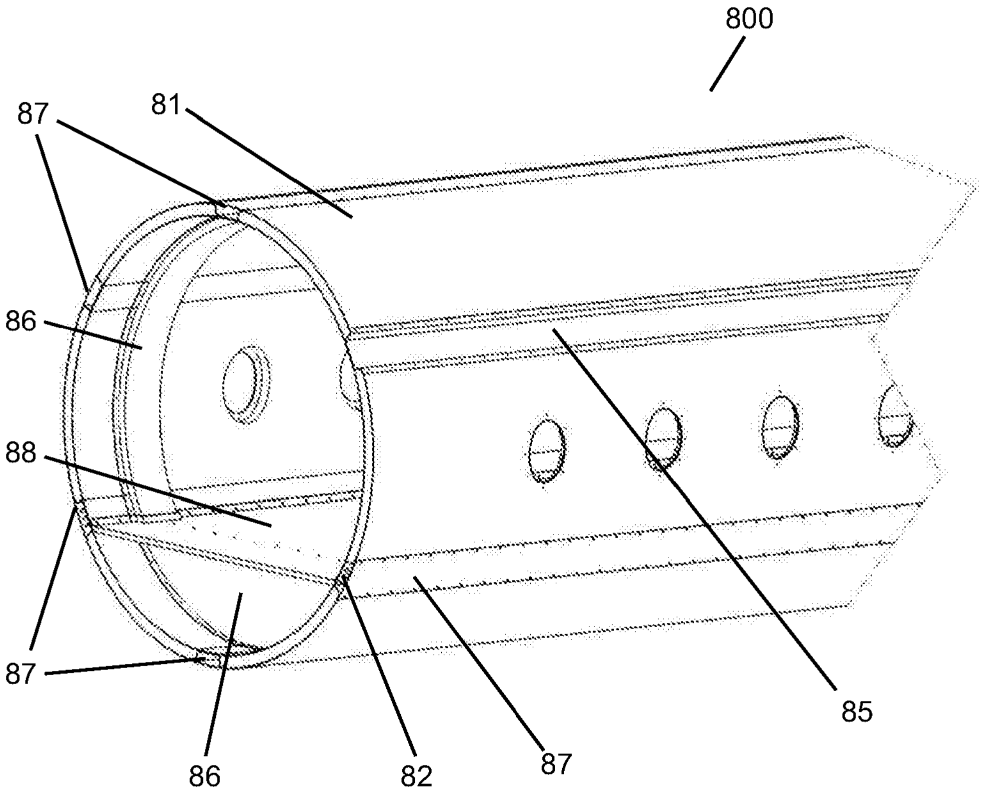

Figure 11

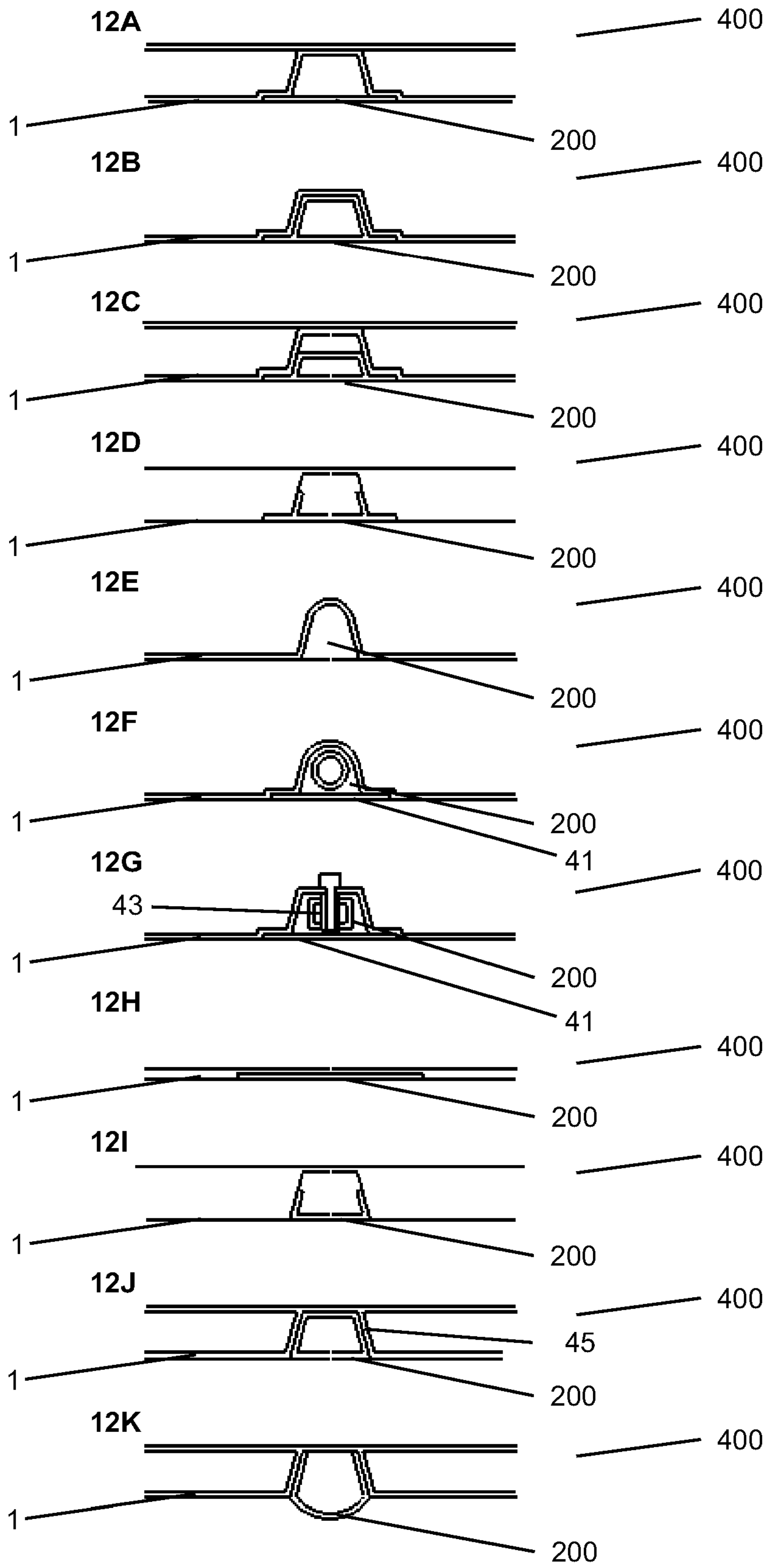
12A
400
1
200
12B
400
1
200
12C
400
1
200
12D
400
1
200
12E
400
1
200
12F
400
1
200
41
12G
400
43
1
200
41
12H
400
1
200
12I
400
1
200
12J
400
45
1
200
12K
400
1
200

Figure 12

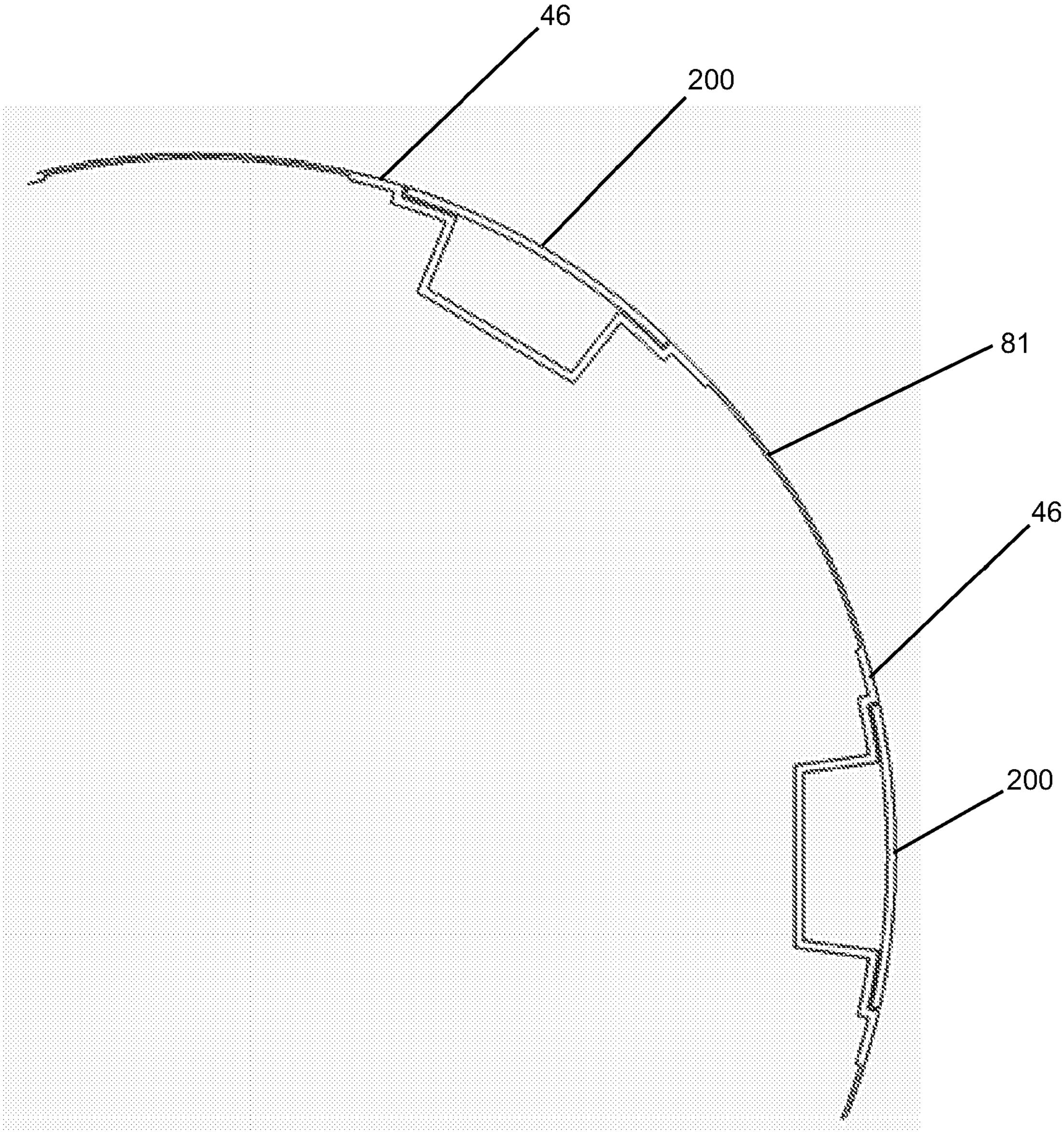

Figure 13A

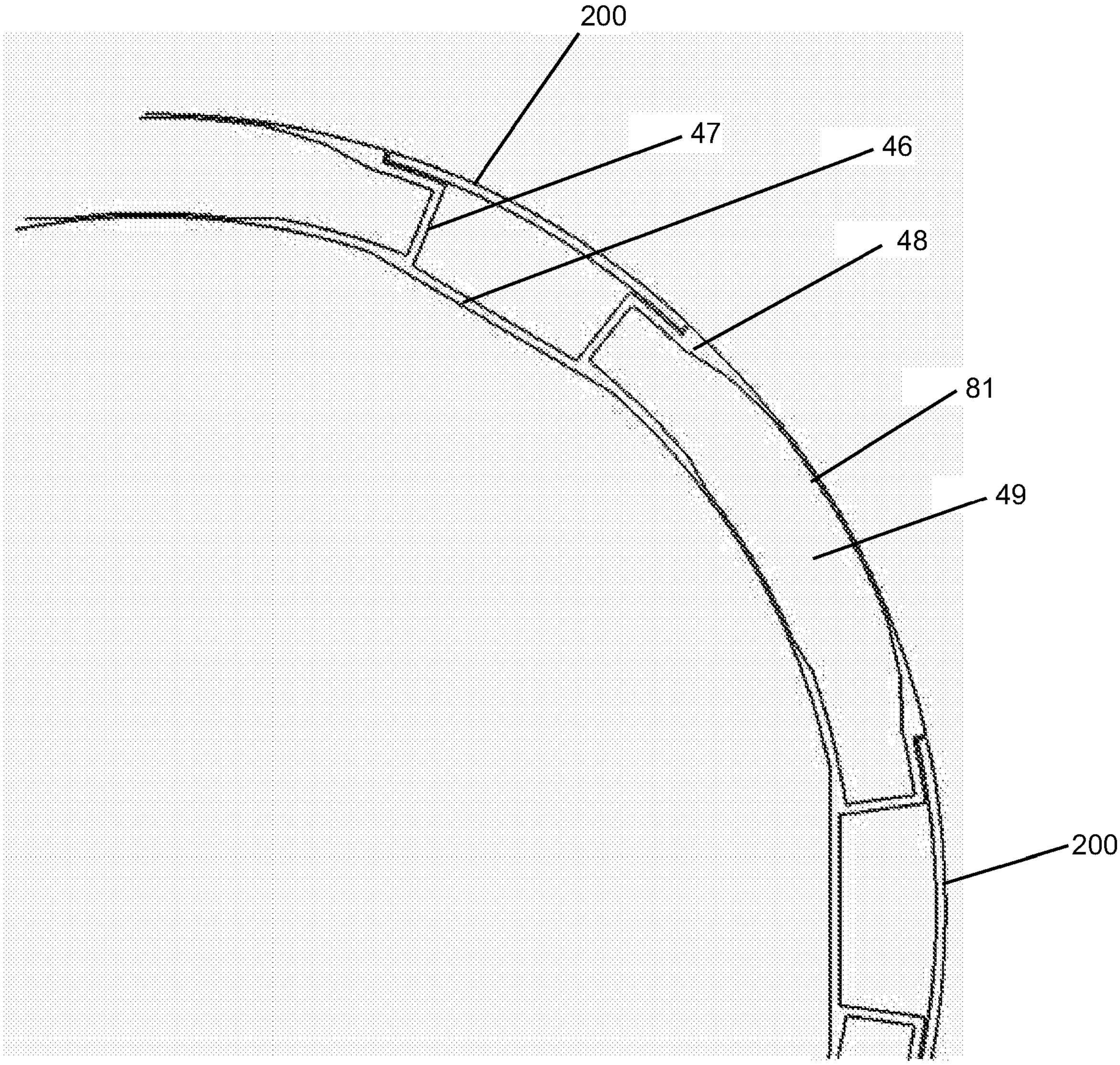

Figure 13B

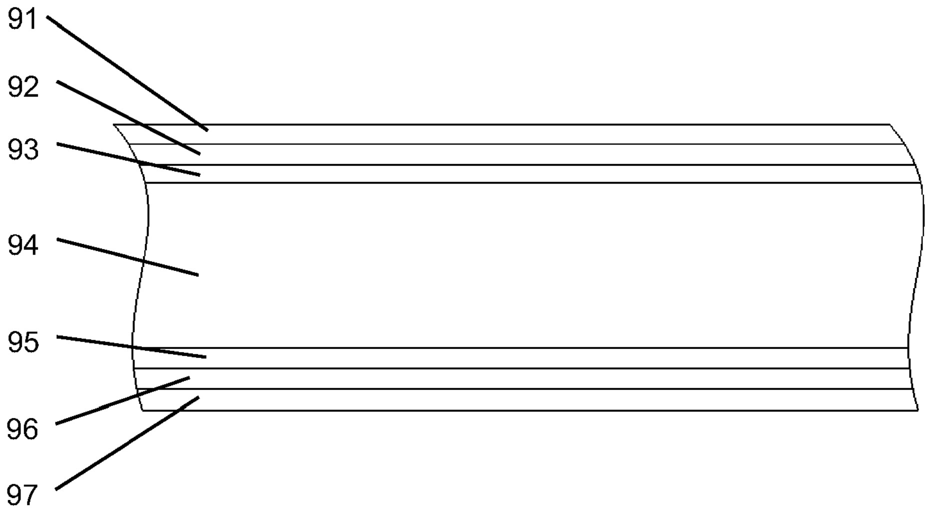

Figure 14

A MONOCOQUE STRUCTURE

The present invention relates to a vehicle comprising a monocoque or semi-monocoque body formed of a fibre resin composite, and a method of producing such a vehicle.

A monocoque is a structural system where loads are supported through the external skin of the structure. Typically this skin is stressed in order to achieve this. A semi-monocoque refers to a stressed shell structure that is similar to a true monocoque, but which derives at least some of its strength from additional reinforcement. In the field of vehicles, this differs from conventional unibody construction, which has a structural chassis, to which all other components are attached.

Modern vehicles are typically built with a unibody structure where the car body is unified with the chassis.

This sheet metal method of production can be energy intensive. The raw material is processed from ore and then rolled to a desired gauge thickness. The panels are often formed in large presses at high pressure, using heavy press tools. Unibody structures are often assembled by robots that weld a series of pressed sheets of metal together. As panel thicknesses are uniform and metals are required to be compatible for welding, these vehicles are limited in their ability to save weight. The welded joints are often complex and require concealing behind further trim for aerodynamic and aesthetic reasons. This results in heavy, inefficient panel joints made from a multitude of components.

Additionally, unibody vehicles that have experienced an impact can take a lot of time and skill to repair and may require reinforcements that further add weight.

Composite materials are well known, these are made from two or more constituent materials with different physical or chemical properties that when combined, produce a composite material with different characteristics to the individual components. This offers the ability to vary stiffness and strength to suit desired load requirements of the material. This is much more efficient than methods which can be applied to single thickness pressed metallic panels. Combinations of fibres, reinforcements and resins are configured to provide a light weight, efficient structure.

Composite impact structures can offer higher energy absorption than steel or aluminium for a lower weight. The present invention offers a more desirable system that reduces weight and increases ease of vehicle repair and assembly.

Vehicles with composite components and structures have been produced in low volume. However, current methods are unsuitable for producing efficient monocoque structures in a higher volume.

Often, these composite vehicle structures are formed from a number of parts which are each hand-laminated and cured separately in multiple stages. The parts must then be bonded together which may require additional fitting and curing processes. As such, a large amounts of raw material is required, along with high tooling costs for each component.

Racing vehicles made of composite monocoques have been explored and often comprise sandwich structure shells comprising an outer skin and an inner skin separated by a lightweight aluminium honeycomb core. However, these have inserts and reinforcements within the laminate to accommodate force transfer fittings. The inserts are usually hard points that are often made from metal or composite material. A laminate such as this would typically require curing in multiple stages. The outer skin would firstly be laminated and cured. The inserts would need then machining, then fitting and bonding to the outer skin along with the honeycomb core. The inner skin would then be laminated prior to final curing. Further bonding and post machining operations may also be necessary. These monocoques often require complex machined components, skilled labour and multiple stages of production consuming a significant amount of energy and resources. As such, this is expensive and they do not present a system which is viable to automate and/or mass produce.

A vehicle is provided according to the present invention comprising: a monocoque or semi-monocoque body formed of a composite and forming the central body of the vehicle; and a first and a second externally mounted support member for distributing forces around the vehicle, wherein the first externally mounted support member is attached to the second externally mounted support member for transferring forces between the externally mounted support members.

Such a vehicle is easier to manufacture than conventional vehicles as discussed above. In particular, mass manufacturing is easier as the number of separate parts which must be attached and manufacturing processes are kept to a minimum. The load attachment points are moved to the external support members in order to reduce the number of processes required to manufacture the central monocoque, as further processing would be necessary to integrate these into the monocoque. If the external support members are also made of composite then the attachment points can be processed in small easily accessible mould tools.

Additionally, such a vehicle is easier to recycle due to the modular nature of the construction. Whilst recycling of thermoset composites is currently energy intensive and presents difficulties with processing, thermoplastic composites are more easily recycled as thermoplastic resin can be turned to liquid by heating past its melting point. Often aircraft and automotive vehicles use a large proportion of thermoset composites, which are often slightly higher strength than thermoplastic composites. This invention offers the ability to increase the use of thermoplastic composites for elements such as the monocoque, whilst using thermoset composites for the external members that bear higher compressive and tensile loads.

A method of producing a vehicle according to the present invention comprises: forming a monocoque or semi-monocoque body from a composite in order to form the central body of the vehicle; attaching a first and a second externally mounted support member to the body so as to distribute forces around the vehicle; and attaching the first externally mounted support member to the second externally mounted support member for transferring forces between the externally mounted support members.

This manufacturing process is easier than conventional manufacturing and ensures the benefits as described above.

The invention will now be described in detail, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a vehicle constructed according to one embodiment of the invention;

Figure 2 is a rear perspective view of the vehicle of Figure 1;

Figure 3 is an underneath perspective view of the vehicle of Figure 1;

Figure 4 is an exploded perspective view of the vehicle of Figure 1;

Figure 5 is a perspective view of a partially constructed vehicle of Figure 1;

Figure 6 is an underneath perspective view of the partially constructed vehicle of Figure 5;

Figure 7 is a perspective view of a further partially constructed vehicle of Figure 1;

Figure 8 is a rear perspective view of the partially constructed vehicle of Figure 7;

Figure 9 is an underneath perspective view of the partially constructed vehicle of Figure 7;

Figure 10 is a close-up sectional perspective view of a monocoque and external stiffener arrangement of the vehicle of Figure 1;

Figure 11 is a partially sectional perspective view of an alternative vehicle constructed according to a further embodiment of the invention;

Figures 12A to 12K are schematic sectional views of different configurations for attaching a central body and external stiffener for use in any embodiment of the invention;

Figures 13A and 13B are schematic sectional views of configurations for attaching a central body and external stiffener for use in any embodiment of the invention, in particular to an aircraft; and

Figure 14 is a schematic sectional view of a laminate for use in any embodiment of the invention.

An embodiment of the present invention is shown as the vehicle 100 in Figures 1 to 10. The vehicle 100 comprises a central monocoque or semi-monocoque body 1. This body 1 is formed of a fibre resin composite. The body 1 is described as being the central part of the vehicle 100. This means that a substantial part of the vehicle's roof, floor and sides are formed by the body 1. While the body 1 may be formed of a single component, it may also be formed of multiple composite parts joined together.

As shown in Figures 7 and 8, in order to reduce the number of separate parts required for the vehicle 100, the body 1 may have a number of internal components formed integrally therewith. For example, in Figures 7 and 8 the major dashboard components 19 and the rear seat 4 are pre-formed as a part of the body 1. In further embodiments, the seats 5 and/or the exhaust tunnels may likewise be integral components of the body 1. The ducting for heating, ventilation systems and cable management may also be integrally formed within the body 1. Recesses for the windows or doors of the body 1 may also be integrally formed therewith. Additionally, vehicle systems or components may be formed integrally with the body 1 or external stiffeners 200. For example, a fuel tank may be moulded integrally with an external stiffener 200.

Certain regions of the central body 1 may be treated to handle increased loads, such as via pre-stressing. In particular, this may be the case in regions where it is expected to encounter a particularly strong force. There may also be semi-stressed or unstressed regions of the vehicle 100.

As best seen in Figure 4, attached to the body 1 is at least one externally mounted support member 200. Typically, these support members 200 are stiffeners which are arranged to enhance the overall stiffness of the body 1. Recesses 11 may be formed in the body for attaching the externally mounted support members. These externally mounted support members 200 are configured to transfer forces around the body 1 and hence the vehicle 100. These externally mounted support members are best shown in Figure 4 and include, but are not limited to, left flank and right flank support members 20, 21, the front bulkhead 22 and the lateral support beams 26. These externally mounted support members 200 are attached to the vehicle via joint connections 400. Example joint connections 400 for use in the present invention are set out in detail later with respect to Figures 12A to 12F.

Load bearing members 250 may be attached to the support members 200. Examples of such load bearing members 250 include front sub-frame 23 which is attached to the front bulkhead 22. The support members 200 may be provided with attachment points for these load bearing members 250 which have been strengthened and/or reinforced. Likewise, the attachment points where the support members 200 attach to the central body 1 may be strengthened and/or reinforced on both the support members 200 and/or the central body 1.

The support members 200 are arranged so that the external forces which are applied to the vehicle 100 in regular use are normally transmitted via the support members 200. These forces include, but are not limited to, braking and acceleration forces of the vehicle 100. Typically, the braking and acceleration forces are transferred from the front tyres 6 via the front suspension assembly 7 through the front sub-frame 23 to the front bulkhead 22. In the present embodiment, the front suspension assembly 7 includes the steering assembly, but this is not necessary. The front suspension assembly 7 could be connected directly to the front bulkhead 22 without the use of an additional sub-frame 23. Additionally, the front suspension assembly 7 could have attachment points that connect through the body 1 and support members 200.

With regard to the left and right flank support members 20, 21 these are provided along the respective flanks of the body 1 including the region where the doors 3 of the vehicle 100 are mounted. As such, the left and right flank support members 20, 21 must be provided with an opening to receive the doors 3 and an attachment region for attaching the doors 3. The doors 3 seal against the left and right flank support members 20, 21.

The lateral support beams 26 assist in improving the strength of the vehicle 100 to withstand side impacts, as well as improving the torsional stiffness of the vehicle 100. The support beams 26 also help reduce the attachment requirements for the body 1. For example, large components such as the seats 5 may be attached through the body 1 to the support beams 26. As shown in Figure 10, the body 1 is provided with a recess 17 for receiving a support beam 26. The recess 17 is provided with holes 18 for attaching the seats 5 directly to the body 1. This reduces the stresses transmitted directly to the body 1.

While in the embodiment shown in Figures 1 to 10, there are multiple separate externally mounted support members 200, it is preferable to minimise the number of support members 200. This in turn minimises the number of joint connections 400 required which is beneficial for the strength of the body 1 and the weight of the vehicle 100.

It is understood that the support members 200 should be configured to transfer both compressive and tensile forces. However, specific support members 200 may be individually designed to transfer compressive or tensile forces. Likewise, particular regions of specific support members 200 may be designed to transfer specific compressive or tensile forces.

The support members 200 may be provided with energy absorbing portions, which assist in dissipating forces applied to the vehicle 100 in the event of a collision. The front and rear extremities 20A, 20B, 21A, 21B of the side portions 20, 21 are examples of such energy absorbing portions. Indeed, the support members 200 may be hollow and contain crush tubes or impact structures to assist with this. The energy absorbing portions may be removable and replaceable. They may also assist in supporting additional structure, bodywork or vehicle systems. The energy absorbing portions may be formed of a shape that initiates crush, or provides additional crush initiators to encourage a progressive behaviour during energy absorption.

While the support members 200 are generally arranged to improve the aerodynamic performance of the body 1, there may be additional bodywork elements 500 mounted alongside or above the support members 200. For example, the vehicle 100 shown in the first embodiment in Figure 4 comprises a front bodywork member 51 which is attached over the front bulkhead 22. These bodywork elements 500 may be to improve the aesthetics and/or aerodynamic performance of the vehicle 100. For example, the rear bodywork member 53 has a rear diffuser ramp 55 moulded into it for improving underbody aerodynamic performance. Additionally, the front and rear bodywork components 51, 53 or any other components may wrap around the wheels 6, 8 to reduce the drag or alter the downforce characteristics of the vehicle. Additionally, there may be moveable aerodynamic devices such as retractable spoilers, ailerons, rudders and/or flaps. These components may be mounted to the external stiffeners 200 or central body 1 and may be partially recessed into these.

The support members 200 are generally hollow tubular components. They may be made as integral one-piece components or they may comprise multiple elements which are attached to one another.

When the support members 200 are hollow, they may comprise additional reinforcing members located within the hollow such as load spreaders, moulded inserts or hard pads. These allow loads to be transferred around the support members to the desired locations. The support members 200 may also comprise attachments that are assembled after curing.

These reinforcing members may be formed of a thermoset pre-preg material. A pre-preg material is a composite material that consists of fibres that may be woven or uni-directional and where the resin is already pre-impregnated into the material. Such materials offer benefits in handling and production as the resin is already in the material and not added separately to the fibre reinforcement.

When the support members 200 are hollow, wiring, hydraulic lines and the like 15 can be run through the support members 200 as shown in Figure 10. Access points 16, seen for example in Figure 10, may be provided for these lines 15 running inside the support members.

The central body 1 is formed of a fibre resin composite. This may be moulded as a single component, or comprise a number of components joined together. The central body may comprise parts that are 3D printed. The central body 1 may be hand laminated or manufactured using resin transfer moulding, infusion moulding, injection moulding, over moulding, over-braiding or various combinations of these techniques.

Thermoplastic or thermoset resins may be used to form the central body 1. A thermoset resin contains polymers that are cross-linked during curing in an irreversible manner. This means that they cannot be reshaped. Examples include polyester, vinyl ester and epoxy. A thermoplastic resin undergoes a reversible curing process, which allows the final product to be reshaped during manufacturing. Examples include PET, polypropylene, polycarbonate, nylon and PVC. The central body may also comprise materials which are metallic, composite, polymeric or a combination of these materials.

The material for the central body preferably includes fibre reinforced thermoplastic. The fibres are preferably continuous. However, the fibres may be long or in the form of a mat. The fibres may be stitched, woven or in a 3-dimensional form. In certain embodiments, the fibres may additionally be bio-degradable to enhance the recyclability of the vehicle 100. Examples of bio-degradable fibres include flax and hemp.

Once the central body 1 has been formed, it may be necessary to paint the vehicle 100. As such, the final outer finish of the moulding may be configured to allow easy painting. Paint may be applied to the mould cavity prior to laminating in order to paint and cure the central body 1 during the manufacturing process. A dye pigment may also be added to the resin prior to curing to remove the need for painting.

Additionally, for certain interior components it may be desirable to ensure a smooth finish (such as for aesthetic reasons). When closed moulding, the finish all over is smooth. However, with open moulding, additional sub-moulds may be provided to achieve the smooth finish.

The moulded central body 1 may be provided with jig locations for the purpose of assembling other components. For example, skin pins may be used to attach components together prior to bonding. Additionally, if the central body 1 is made of thermoplastic, further components such as thermoplastic 3D printed ducting could be attached to the central body via skin pins prior to thermoplastic welding or adhesive bonding.

The moulded central body 1 may be formed with all the necessary holes and recesses already formed therein. This reduces the complexity of later manufacturing. Alternatively, the central body 1 may be machined to form the necessary holes and recesses. This machining could take place within the mould after curing or it could take place on a jig or on a machine after being removed from the mould.

The complexity of manufacture may be further reduced by curing the central body 1 laminate in a single heating and cooling system. Alternatively, there may be multiple curing stages at different temperatures.

As discussed in detail later with regard to Figure 14, the material for the central body 1 may also comprise a material with insulating properties. Likewise, the material for the central body may be co-cured with a protective material layer in order to protect the body from elevated or lowered temperatures, gases, fluids or stone damage.

Exemplary materials for the support members 200 include fibre reinforced plastics or carbon fibre reinforced plastics. However, metals, plastics or other materials may be used provided that they can be formed into the correct shape. This may take the form of moulding or 3D printing for example. The support members 200 may be hand laminated, infusion moulded, injection moulded, over moulded, or manufactured using resin transfer moulding, over-braiding or various combinations of these techniques.

The support members 200 are preferably formed by moulding fibre reinforced composites. In particular, composites which have a large proportion of fibres which are uni-directional that can be aligned with the direction of forces applied are beneficial.

Additionally, in areas of the support members 200 which are intended to absorb energy, localised high fracture toughness materials may be used.

Furthermore, the support members 200 may have a cavity in which a foam core is inserted. The foam core provides consolidation pressure on laminates when they are being moulded in a closed mould. These foam cores may be left in place after manufacture and may provide additional insulating properties and/or energy absorbing propoerties, or may be removed. Closed moulds are preferred in order to give an externally moulded finish to the components. Inflatable tooling can be used and inflated internally during curing in order to provide internal pressure on the component. This method is used to produce a hollow component.

The support members 200 may be attached to the central body 1 via a number of methods, which are set out in detail in relation to Figures 12A to 12F later. In brief, they may be attached via bonding, mechanical fasteners, co-curing, or any combination thereof. Mechanical fasteners increase fatigue life while bonded joints improve the distribution of applied loads. Additionally, torsional and bending stiffness of the vehicle 100 may be increased with bonded connections. Accordingly, different support members 200 may be provided with different attachment means depending upon their use. Preferably, the connections are detachable to simplify support member 200 replacement in use, and disassembly at the end of the vehicle's life.

In certain embodiments, the support members 200 may be attached to the central body 1 via a co-curing process. This involves the support members 200 and the central body 1 being partially cured (typically at a lower temperature and/or for less time than a full cure) separately in an A stage process. The partially cured members are then brought together and assembled. The final assembly is then cured integrally in a B stage process. This removes the requirement for any additional bonding or attachment processes and hence keeps the weight of the vehicle 100 down.

When bonding components together it may be desirable to use spacers to ensure a consistent glue gap between the components to be bonded. In order to disbond components, such as in the event of a crash repair, it is necessary to apply heat to the glue above the melting point of the glue.

Figure 11 depicts an alternative embodiment of the invention, focused on an aircraft 800. This is provided with a monocoque or semi-monocoque body 81 formed of a fibre resin composite. This body 81 is substantially cylindrical and is provided with a plurality of recesses 85 for receiving external support members 87 therein. The external support members 87 act to distribute forces around the aircraft 800. These support members 87 may have any of the features as described above and as can be seen in Figure 11 they are hollow in this embodiment and comprise internal wiring 82. The aircraft 800 is further provided with an internal bulkhead 86 placed beneath the floor 88 which also acts to stiffen the body 81.

Figures 12A to 12K depict a number of methods via which an external support member 200 may be attached to a central body 1. It may be desirable to utilise a joint that accommodates differences in tolerances between welded assemblies, which can spring out of intended position after welding, with more accurate moulded attachment positions on the monocoque. It may also be desirable to use bushes to damp vibration across the joint. It may also be desirable to insulate the joint to prevent the flow of electricity or heat or consequently it may be desirable to promote the transfer of electricity or heat through a conductive joint.

Figure 12A shows a monocoque 1 that is constructed as a sandwich panel with a formed recess that is closed by an external member 200 that is a thin panel. The resulting box section is able to support the majority of compressive and tensile forces and may house systems related to the vehicle. The connection between the external member 200 and the outer skin of the monocoque is able to transfer the shear forces in the outer skin.

Figure 12B shows a thin-walled monocoque 1 with a recess in which a tubular external member with mounting flanges 200 is recessed. The mounting flanges may be used for the purpose of attaching the external member to the monocoque via fixings or for the purpose of increasing bond area between the components or a combination of the two.

Figure 12C shows a monocoque 1 that is constructed using a sandwich panel with a formed recess in which a tubular external member 200 with mounting flanges is attached. A space exists between the monocoque 1 and the external member 200 for the purpose of integrating vehicle systems into the structure.

Figure 12D shows a monocoque 1 of solid construction with an open-section external stiffener 200 with internal and externally mounted flanges.

Figure 12E shows a thin-walled monocoque 1 with a solid section external member 200 that completely fills the recess in the monocoque 1.

Figure 12F shows a thin-walled monocoque 1 with a tubular external member 200 that may be part of an external space frame with a thin walled cover panel recessed into the monocoque 1. The tubular member may be attached to the monocoque 1 with the cover panel 41 separately attached. Alternatively, the cover panel 41 may be attached to the tubular external member that is additionally attached to the monocoque, or it may be attached to both the tubular external member and the monocoque simultaneously.

Figure 12G shows a thin-walled monocoque 1 with an external member 200 constructed of a metallic tubular box section with a welded lug 43 that is attached through the monocoque 1, with an external cover panel 41 recessed into the monocoque 1. The external cover panel 41 may or may not be necessary.

Figure 12H shows a thin walled monocoque 1, into which a thin-walled external member 200 is recessed. This construction may achieve a thin-walled joint where there is a deficiency of space.

Figure 12I shows a monocoque 1 of solid construction with an open section external member 200 that is fitted with no external mounting flanges.

Figure 12J shows a monocoque 1 that is constructed as a sandwich panel with a formed recess into which a tubular-section external stiffener 200, with draft angles 45 for the purpose of mould removal, is mounted.

Figure 12K shows a monocoque 1 that is constructed as a sandwich panel with a formed recess into which a tubular-section external member 200 is recessed and where part of the external member 200 protrudes outside the monocoque 1. The external member 200 may require an area moment of inertia that cannot easily be absorbed into the monocoque 1.

Figure 13A shows a part section through a monocoque aircraft fuselage according to the present invention with a thin-walled, monolithic external skin. The external support member 200 is attached to a stiffened region of the body 81 and recessed therein. The body 81 is configured to receive compression or tension loads in a stiffened region 46 that generally corresponds to the recess for the external support members 200. Typically, the stiffened region 46 is thicker than the skin provided between the stiffened regions 46. This thinner skin transfers shear loads between the external support members 200.

Figure 13B shows a part section through a monocoque aircraft fuselage according to the present invention. The body 81 has an internal skin and an external skin, each of which transfers shear forces between the externally mounted support members 200. The body 81 has one or more connectors 47 that connect the stiffener 200 to a stiffened region 46 of the inner skin. Again, this stiffened region is thicker than the skin provided around it. A region of graduated thicknesses 48 is provided to transition between thicker and thinner areas in order to reduce the local stresses in the skins. The outer skin and inner skin are spaced apart with a foam core 49. Spacing the skins apart in this manner provides an increase in torsional stiffness of the overall structure as well as an increase in local bending stiffness. Different types of core such as foam or metallic honeycomb may be used to space the skins apart. The body 81 is locally stiffened with additional composite material in areas that generally correspond with the recess for the external members 200. The cross-sectional shape of the stiffened region of the body and the external members 200 provides a second moment of area that contributes to stiffness for carrying compressive or tensile loads where the external members 200 are located. The resulting closed section provides an integral torsion box within the inner and outer skin that is effective for transferring compressive and tensile loads. It is likely that unidirectional fibres in the body and the external members 200 would be aligned generally along the length of the external members 200.

Figure 14 depicts an exemplary cross-section of a laminate which may be used in a central body 1. The laminate comprises inner and outer fibre reinforced skins 92, 96. Within these skins are inner and outer resin films 93, 95. Finally at the centre is an insulating material 94. As discussed previously, this may be a core material around which the body 1 has been moulded. Alternatively, this may be an air gap or any other insulating material.

Preferably, inner and outer protective coatings 91, 97 are provided for protecting the laminate. These coatings 91, 97 are provided wrapped around the inner and outer reinforced skins 92, 96. These protective coatings 91, 97 may be required to protect from elevated or lowered temperatures, gases, fluids, ultra violet (UV) light or stone damage to the vehicle.

These laminates can be manufactured by providing the insulated material encapsulated within adhesive, laying up a fibre reinforced composite skin around the insulating material and curing the laminate. In embodiments with a protective coating 91, 97, this is applied after the curing of the laminate.

While in the present application a land vehicle 100 and an aircraft 800 have been described in detail, it is acknowledged that the present invention may be applied to any vehicle. This includes, but is not limited to, a land vehicle, an aircraft, a motorbike, a trailer, a caravan, a boat, a hovercraft, an all-terrain vehicle or any other vehicle.

In this manner, a vehicle may be made with a monocoque or semi-monocoque body that is able to be mass-produced.

CLAIMS:

1. A vehicle comprising:

a monocoque or semi-monocoque body formed of a composite and forming the central body of the vehicle; and

a first and a second externally mounted support member for distributing forces around the vehicle, wherein the first externally mounted support member is attached to the second externally mounted support member for transferring forces between the externally mounted support members.

2. A vehicle according to claim 1, wherein the body is moulded or comprises a combination of moulded and 3D printed parts.

3. A vehicle according to any preceding claim, further comprising an additional structure for receiving and distributing external forces.

4. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members comprises an energy absorbing portion.

5. A vehicle according to any preceding claim, wherein at least a portion of one or more of the externally mounted support members is recessed into the monocoque or semi-monocoque body.

6. A vehicle according to any preceding claim, further comprising at least one cover panel for attaching over at least one of the externally mounted support members.

7. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are configured to distribute the forces over the entirety of the monocoque body.

8. A vehicle according to any preceding claim, wherein the monocoque body is provided with at least one region of additional strength, and one or more of the externally mounted support members is configured to transfer forces to this region.

9. A vehicle according to any preceding claim, wherein the externally mounted support members and/or monocoque or semi-monocoque body comprise integral vehicle systems.

10. A vehicle according to any preceding claim, wherein the composite for the body is a moulded composite.

11. A vehicle according to any preceding claim, wherein the composite for the body is a resin composite.

12. A vehicle according to any preceding claim, wherein the composite for the body is a fibre resin composite.

13. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are formed of a composite.

14. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are formed of a resin composite.

15. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are formed of a fibre resin composite.

16. A vehicle according to any of claims 13 to 15, wherein the composite of the one or more externally mounted support members is different to the composite of the monocoque or semi-monocoque body.

17. A method of producing a vehicle according to any preceding claim comprising:

forming a monocoque or semi-monocoque body from a composite in order to form the central body of the vehicle;

attaching a first and a second externally mounted support member to the body so as to distribute forces around the vehicle; and

attaching the first externally mounted support member to the second externally mounted support member for transferring forces between the externally mounted support members.

18. The method of claim 17, wherein the step of forming the monocoque or semi monocoque body comprises moulding or 3D printing one or more parts that may be joined together to form the body.

19. The method of claim 17 or 18, further comprising the step of attaching an additional structure for receiving and distributing external forces.

20. The method of any of claims 17 to 19, wherein the step of attaching the at least one externally mounted support member includes recessing the support member into the central body.

21. The method of any of claims 17 to 20, further comprising the step of attaching a cover panel over at least one of the externally mounted support members.

22. The method of any of claims 17 to 21, wherein the step of forming the monocoque or semi-monocoque body includes providing the body with at least one region of additional strength.

23. The method of any of claims 17 to 22, comprising the steps of:

partially curing the monocoque or semi-monocoque body and one or more of the externally mounted support members separately in a first process;

bringing the monocoque or semi-monocoque body and the externally mounted support members together and assembling them; and

curing the assembled structure.

24. The method of any of claims 17 to 23, comprising the step of inserting a vehicle system or component into the monocoque or semi-monocoque body or externally mounted support member while forming these components.

25. The method of any of claims 17 to 24, wherein the body is formed in multiple stages.

AMENDED CLAIMS HAVE BEEN FILED AS FOLLOWS:-

CLAIMS:

1. A vehicle comprising:

a monocoque or semi-monocoque body formed of a composite and forming the central body of the vehicle; and

a first and a second externally mounted support member for distributing forces around the vehicle, wherein the first externally mounted support member is attached to the second externally mounted support member for transferring forces between the externally mounted support members,

wherein the monocoque or semi-monocoque body is provided with at least one region of additional strength, and one or more of the externally mounted support members is configured to transfer forces to this region.

2. A vehicle according to claim 1, wherein the body is moulded or comprises a combination of moulded and 3D printed parts.

3. A vehicle according to any preceding claim, further comprising an additional structure for receiving and distributing external forces.

4. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members comprises an energy absorbing portion.

5. A vehicle according to any preceding claim, wherein at least a portion of one or more of the externally mounted support members is recessed into the monocoque or semi-monocoque body.

6. A vehicle according to any preceding claim, further comprising at least one cover panel for attaching over at least one of the externally mounted support members.

7. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are configured to distribute the forces over the entirety of the monocoque body.

8. A vehicle according to any preceding claim, wherein the externally mounted support members and/or monocoque or semi-monocoque body comprise integral vehicle systems.

9. A vehicle according to any preceding claim, wherein the composite for the body is a moulded composite.

10. A vehicle according to any preceding claim, wherein the composite for the body is a resin composite.

11. A vehicle according to any preceding claim, wherein the composite for the body is a fibre resin composite.

12. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are formed of a composite.

13. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are formed of a resin composite.

14. A vehicle according to any preceding claim, wherein one or more of the externally mounted support members are formed of a fibre resin composite.

15. A vehicle according to any of claims 12 to 14, wherein the composite of the one or more externally mounted support members is different to the composite of the monocoque or semi-monocoque body.

16. A method of producing a vehicle according to any preceding claim comprising:

forming a monocoque or semi-monocoque body from a composite in order to form the central body of the vehicle and providing the monocoque or semi-monocoque body with at least one region of additional strength;

attaching a first and a second externally mounted support member to the body so as to distribute forces around the vehicle; and

attaching the first externally mounted support member to the second externally mounted support member for transferring forces between the externally mounted support members.

17. The method of claim 16, wherein the step of forming the monocoque or semi monocoque body comprises moulding or 3D printing one or more parts that may be joined together to form the body.

18. The method of claim 16 or 17, further comprising the step of attaching an additional structure for receiving and distributing external forces.

19. The method of any of claims 16 to 18, wherein the step of attaching the at least one externally mounted support member includes recessing the support member into the central body.

20. The method of any of claims 16 to 19, further comprising the step of attaching a cover panel over at least one of the externally mounted support members.

21. The method of any of claims 16 to 20, comprising the steps of:

partially curing the monocoque or semi-monocoque body and one or more of the externally mounted support members separately in a first process;

bringing the monocoque or semi-monocoque body and the externally mounted support members together and assembling them; and

curing the assembled structure.

22. The method of any of claims 16 to 21, comprising the step of inserting a vehicle system or component into the monocoque or semi-monocoque body or externally mounted support member while forming these components.

23. The method of any of claims 16 to 22, wherein the body is formed in multiple stages.

Intellectual Property Office

Application No:	GB1622043.6	**Examiner:**	Mr Michael Bate
Claims searched:	1-25	**Date of search:**	22 June 2017

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	1-6, 9-15, 17-21 & 24	WO2011/128081 A1 (KAESMEIER) See particularly the figures.
X	1-7, 10-15, 17-21 & 25	US2016/0059904 A1 (KERSCHER et al.) See particularly the figures and paragraph [0016] of the description.

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	0029/04	01/01/2006
B62D	0029/00	01/01/2006
B62D	0063/02	01/01/2006