(12) UK Patent Application (19) GB (11) 2548576 (13) A

(43) Date of A Publication 27.09.2017

(21) Application No: 1604745.8

(22) Date of Filing: 21.03.2016

(71) Applicant(s):
**Composite I Ltd**
**1908 Hampton on the Hill, Warwick, Warwickshire, CV35 8QR, United Kingdom**

(72) Inventor(s):
**Roger Terrence Arthur Medwell**

(74) Agent and/or Address for Service:
**Withers & Rogers LLP**
**4 More London Riverside, LONDON, SE1 2AU, United Kingdom**

(51) INT CL:
***F41H 7/04*** (2006.01) ***B60N 2/42*** (2006.01)
***B60N 2/427*** (2006.01)

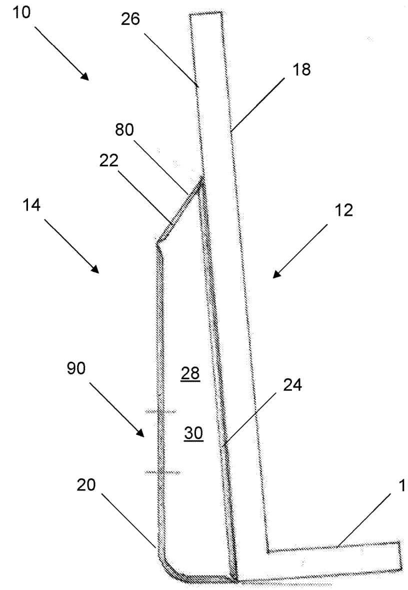
(56) Documents Cited:
**EP 2650168 A1** **WO 2010/037804 A1**
**USH1833**

(58) Field of Search:
INT CL **B60N, F41H**
Other: **WPI, EPODOC**

(54) Title of the Invention: **Blast attenuation seat**
Abstract Title: **Blast attenuation seat**

(57) A blast attenuation seat 10 for a vehicle comprises a composite material seat structure 12 having a seat base 16 and a seat back 18 and a composite material mechanism 14. The composite material mechanism 14 is configured for attachment between a sidewall of a vehicle and the seat back 18. The composite material mechanism 14 may be arranged in a loop, the loop defining an inner core region 28, the inner core region 28 having a damper 30. The damper 30 may be a closed cell foam.

Fig. 1




GB 2548576 A

Fig. 1

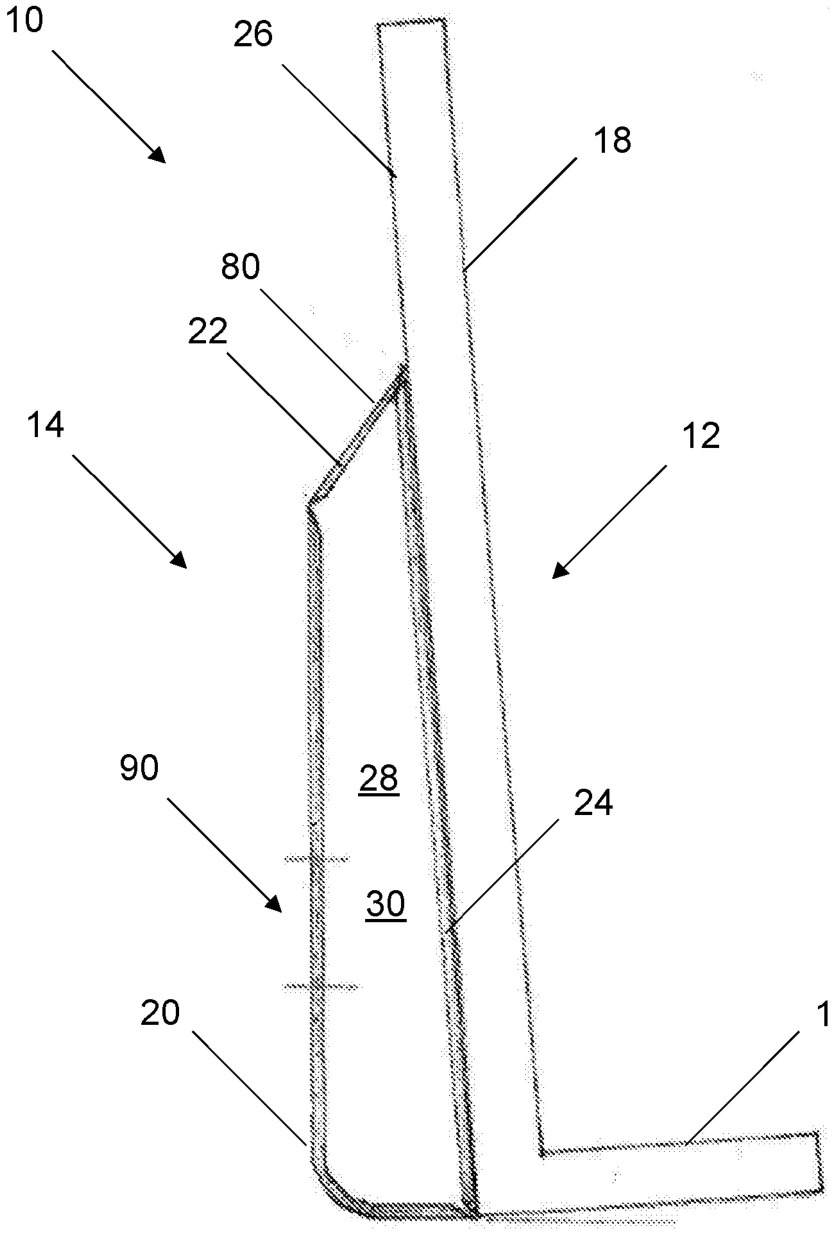


Fig. 2

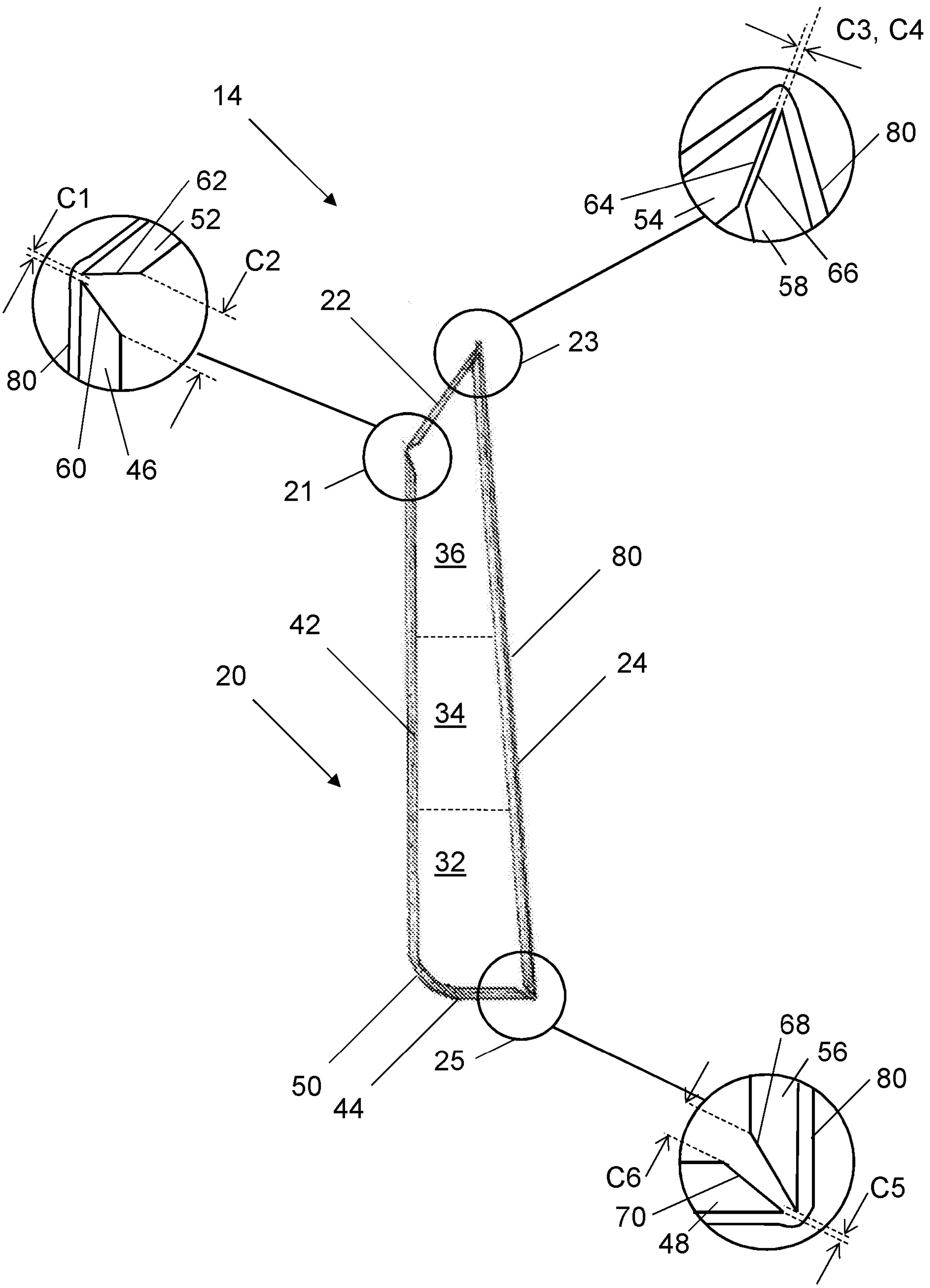

C3, C4
14
80
62
C1
52
64
54
C2
66
58
22
23
80
60
46
21
36
80
42
24
20
34
32
68
50
44
25
56
80
C6
70
48
C5

Fig. 3

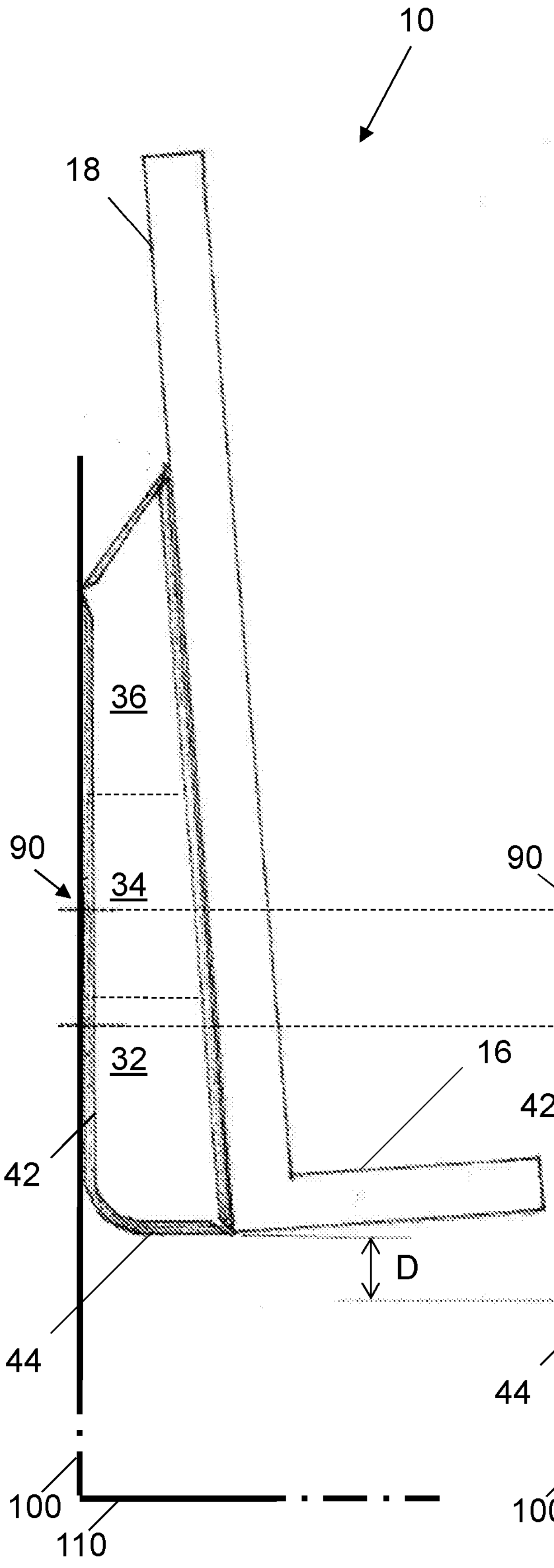



Fig. 4

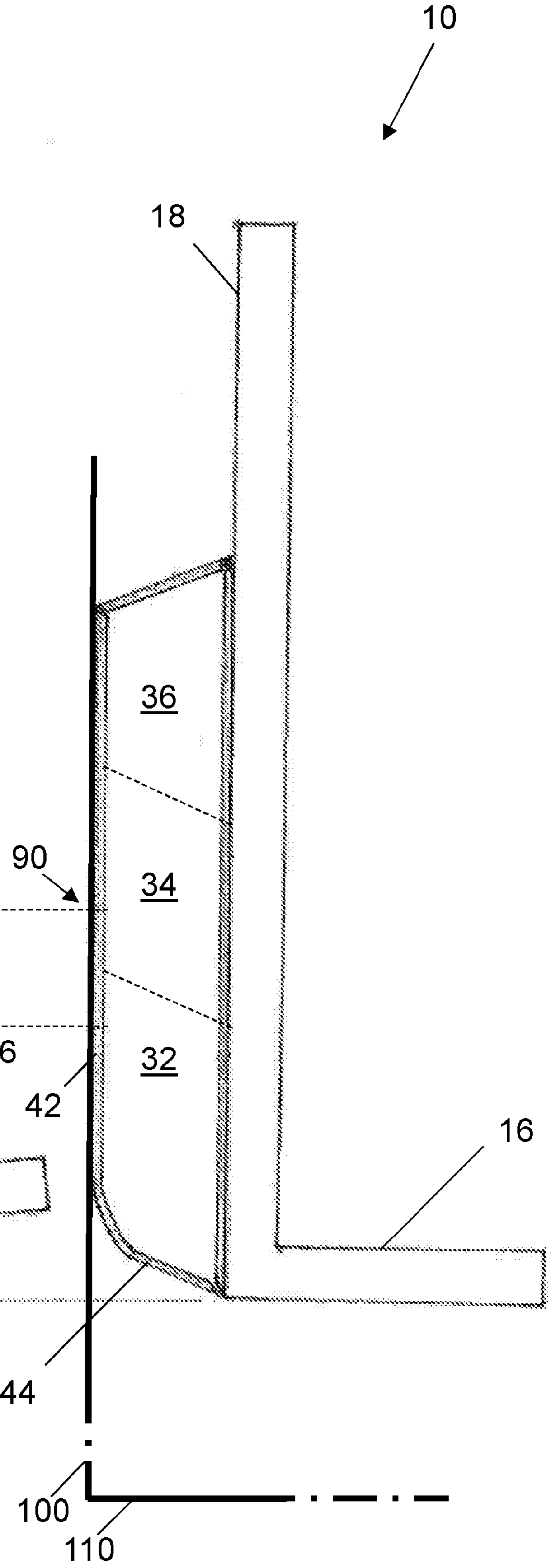


Fig. 5

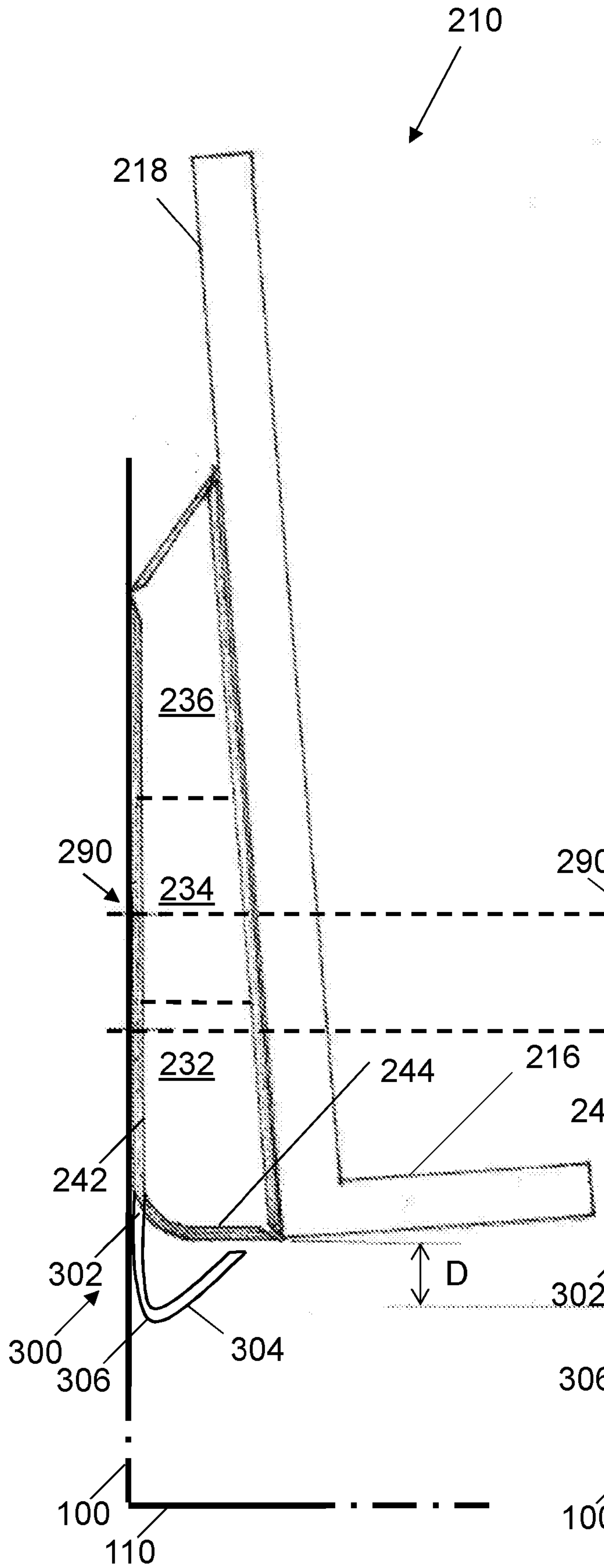
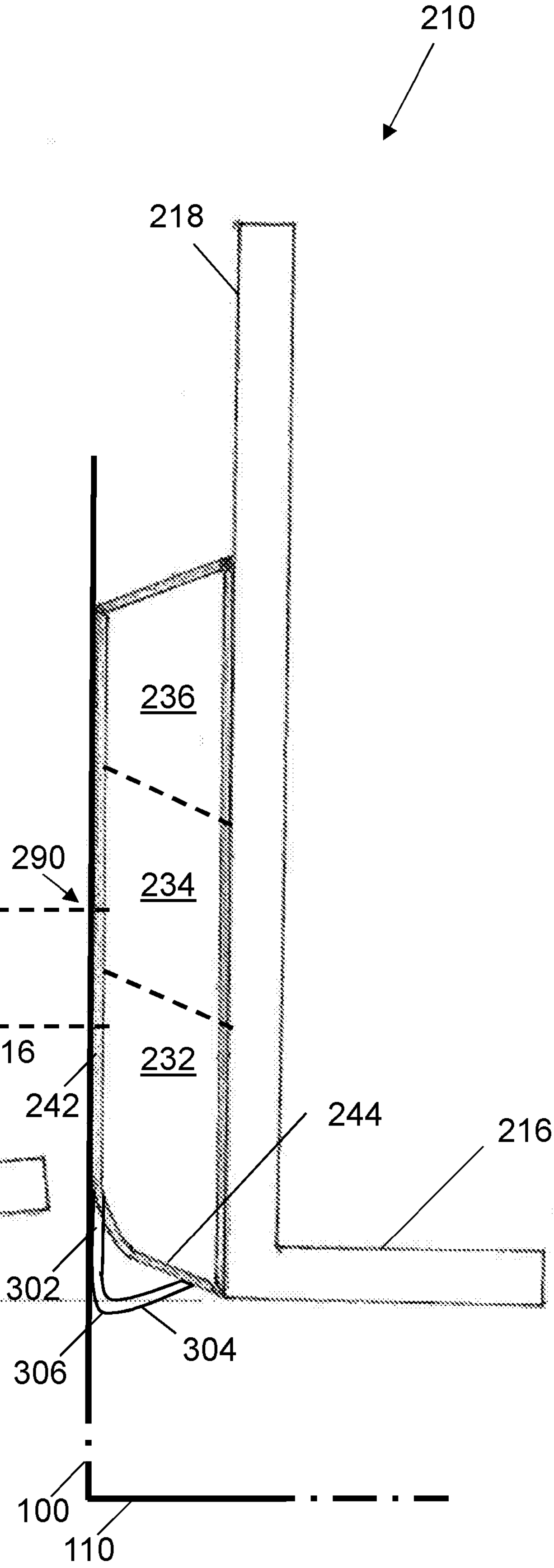

210
218
236
290
234
232
244
216
242
302
D
300
306
304
100
110

Fig. 6


210
218
236
290
234
232
242
244
216
302
304
306
100
110

# Blast Attenuation Seat

The invention relates to a blast attenuation seat and particularly, but not exclusively to a blast attenuation seat for a vehicle.

## Background of Invention

Blast attenuation seats are provided on vehicles that operate in hazardous environments. For example, defence force armoured patrol vehicles operating where mines or improvised explosive devices (IEDs) are known to present a risk. Known blast attenuation seats are constructed of steel and have metallic strips to absorb energy and to reduce the impact force on the occupant. Typically the blast attenuation seat allows the occupant to experience the blast as an acceleration to 3 m/s over 1.5 hundredths of a second rather than instantaneously.

However known blast attenuation seats are extremely heavy. An armoured patrol vehicle may carry as many as twelve blast attenuation seats. Therefore the overall mass of the vehicle is sensitive to changes in the individual blast attenuation seat weight.

Whilst the known blast attenuation seats, constructed of steel, have metallic strips to absorb an initial impact, these metallic strips are narrow and fail during the first blast. The blast seat occupant therefore does not have sufficient protection from subsequent blasts below the same vehicle.

Furthermore, using metal within an armoured vehicle provides a secondary hazard for personnel within the vehicle as metal spalls when it fails.

The present invention aims to address one or more of the aforementioned problems.

## Summary of Invention

According to the first aspect of the present invention there is provided a blast attenuation seat for a vehicle, the blast attenuation seat comprising: a composite material seat structure having a seat base and a seat back, and a composite material mechanism, wherein the mechanism is configured for attachment between a sidewall of a vehicle and the seat back.

The composite material mechanism decouples the occupant from a blast incident. However the composite mechanism is sufficiently strong to support the seat structure during normal use (i.e. non-blast incident). The composite material seat provides enhanced blast protection from blast incidents to the side of the vehicle. The elimination of steel inside vehicles both reduces the spall risk and reduces the overall weight of the blast attenuation seat substantially.

The composite material mechanism may define an inner core region, and a damper may at least partially fill the inner core region. The damper provides protection from recoil following a blast incident, subsequent blast incidents and/or other impacts.

The damper may be made of foam, preferably a closed cell foam. Preferably still, the damper is made of a plurality of closed cell foams having different densities designed to assist the composite material mechanism decoupling the seat from the vehicle.

The composite material mechanism may comprise a first member and a second member, connected via a first hinge joint.

The first hinge joint may be configured to decouple the seat structure from the vehicle during a blast event.

The first and second members may be provided as a single body.

The composite material mechanism may further comprise a third member, wherein the first member and third member are connected via a second hinge joint.

The second hinge joint may be configured to limit the relative movement of the first and third members.

The composite material mechanism may further comprise a fourth member, wherein the second member and fourth member are connected via a third hinge joint. The third hinge joint may be configured to limit the relative movement of the second and fourth members.

The third member and fourth member may be connected by a fourth hinge joint.

The first hinge joint and/or the second hinge joint and/or the third hinge joint, and/or the fourth hinge joint may comprise a flexible wrapping. The flexible wrapping allows members of the composite mechanism to move relative to one another and further provides a further means of decoupling the seat from the vehicle, as the flexible wrapping may deform plastically during the blast incident.

The first, second, third and fourth members may be arranged in a loop. The flexible wrapping may be provided as a continuous loop surrounding the composite material mechanism.

The composite material mechanism may be bonded to the seat back.

The seat structure may be made of composite, preferably the seat structure is made of glass woven fabric.

The flexible wrapping may be a unidirectional or cross woven fibre. Such an arrangement allows for plastic deformation under a pre-determined load.

The composite material mechanism may be made of at least one of carbon fibres, glass fibres, polythene fibres, and/or aramid fibres. Such man-made fibres provide a high performance under the stress of the blast event.

The blast attenuation seat may include a flexible stop mechanism. The flexible stop mechanism supports the decoupling of the occupant from a blast incident and further limits travel of the occupant relative to the vehicle.

According to a second aspect of the present invention there is provided a vehicle having a blast attenuation seat according to the first aspect of the invention.

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

Figure 1 is a side elevation of the blast attenuation seat of the present invention;
Figure 2 is a side elevation of the composite spring arrangement of the blast attenuation seat of Figure 1;
Figure 3 is a side elevation of the blast attenuation seat of Figure 1 installed on a vehicle, the blast attenuation seat is shown in a seat normal condition;
Figure 4 is a side elevation of the blast attenuation seat of Figure 1 installed on a vehicle, the blast attenuation seat is shown in a seat maximum travel condition;
Figure 5 is a side elevation of an alternate blast attenuation seat installed on a vehicle, the alternate blast attenuation seat is shown in a seat normal condition; and
Figure 6 is a side elevation of the alternate blast attenuation seat of Figure 5, the alternate blast attenuation seat is shown in a maximum travel condition.

With reference to the drawings, the blast attenuation seat 10 has a seat structure 12 and a composite material mechanism 14.

The seat structure 12 comprises a seat base 16 and a seat back 18.

The composite material mechanism 14 has a first composite member 20, a second composite member 22, and a third composite member 24.

Turning to Figure 2, the first composite member 20, second composite member 22, and third composite member 24 are arranged to approximate a loop. The first composite member 20, second composite member 22, and third composite member 24 are joined by a flexible wrapping 80 which overlies the outer surfaces of the respective composite members 20, 22, 24. The flexible wrapping 80 is provided as a continuous loop surrounding the composite material mechanism 14.

The first composite member 20 is "L"-shaped in cross-section. The first composite member 20 has an upper planar arm 42 and a lower planar arm 44. The upper planar arm 42 terminates in an upper end 46 and the lower planar arm 44 terminates in a lower end 48. The upper planar arm 42 and lower planar arm 44 connect at a radiused corner 50. The radiused corner 50 acts as a living hinge joint when under a predetermined load, as will be explained in more detail below.

The second composite member 22 is a single plate-like member having a lower end 52 and an upper end 54.

The third composite member 24 is also single plate-like member having a lower end 56 and an upper end 58.

The first composite member 20, second composite member 22, and third composite member 24 are joined as follows:

The upper end 46 of the first composite member 20 defines a chamfered edge 60 to an inside surface of the upper planar arm 42. The lower end 52 of the second composite member 22 also defines a chamfered edge 62 to an inside surface of the second composite member 22. The upper end 46 of the first composite member 20 is joined to the lower end 52 of the second composite member 22 by the flexible wrapping 80.

The upper end 54 of the second composite member 22 defines a chamfered edge 64 to an inside surface thereof. The upper end 58 of the third composite member 24 also defines a chamfered edge 66 to an inside surface thereof. The upper end 54 of the second composite member 22 is joined to the upper end 58 of the third composite member 24 by the flexible wrapping 80.

The lower end 56 of the third composite member 24 defines a chamfered edge 68 to an inside surface thereof. The lower end 48 of the lower planar arm 44 of the first composite member 20 also defines a chamfered edge 70 to an inside surface thereof. The lower end 56 of the third composite member 24 is joined to the lower end 48 of lower planar arm 44 by the flexible wrapping 80.

Referring back to Figure 1, the loop of the composite material mechanism 14 defines an inner region 28. The inner region is filled with a damper 30.

The damper 30 comprises three regions, a lower region 32, a mid-region 34 and an upper region 36, (see Figure 2). The three regions are each filled with a closed cell foam. The density of the closed cell foam increases from the upper region 36 to the mid-region 34 and increases further to the lower region 32.

The third composite member 24 is arranged against a rear surface 26 of the seat back 18, sandwiching the flexible wrapping 80 therebetween. The third composite member 24 extends from level with the seat base 16 for approximately 3/4 of the seat back 18 height. The third composite member 24 and flexible wrapping 80 are bonded to the rear surface 26 of the seat back 18.

A fixing arrangement 90 is provided on an outer surface of the upper planar arm 42 of the first composite member 20 for attaching the blast attenuation seat 10 to a wall 100 of a vehicle.

**Seat Normal Condition**

In use the blast attenuation seat 10 is arranged a shown in Figure 3, in a so called seat normal condition. The seat structure 12 is presented with a slight rearwards inclination of the seat base 16 relative to a floor 110 of the vehicle and a slight rearwards inclination of the seat back 18 relative to the wall 100 of the vehicle. The lower planar arm 44 is substantially parallel to the vehicle floor 110 whilst the upper planar arm 42 is substantially parallel to the vehicle wall 100.

In the seat normal condition, the second composite member 22 extends from the upper planar arm 42 at an internal angle of approximately 120°. In the seat normal condition, the third composite member 24 extends from the second composite member 22 at an internal angle of approximately 30°. In the seat normal condition, the third composite member 24 extends from the lower planar arm 44 at an internal angle approximately 80°.

In the seat normal condition, the upper end 46 of the first composite member 20 is joined at first hinge 21 to the lower end 52 of the second composite member 22 with a clearance C1. The chamfered edges 60, 62 provide larger clearance C2 towards the respective inside surfaces of the upper planar arm 42 of the first composite member 20 and the second composite member 22.

In a seat normal condition, the upper end 54 of the second composite member 22 is joined at second hinge 23 to the upper end 58 of the third composite member 24 with a clearance C3. The chamfered edges 64, 66 provide a similar clearance C4 towards the respective inside surfaces of second and third composite members 22, 24, allowing for the relatively small 30° internal angle and the thickness of the second and third composite members 22, 24.

In a seat normal condition, the lower end 56 of the third composite member 24 is joined at third hinge 25 to the lower end 48 of the lower planar arm 44 with a clearance C5. The chamfered edges 68, 70 provide larger clearance C6 towards the respective inside surfaces of the third composite member 24 and the lower planar arm 44 of the first composite member 20.

The first and third hinges 21,25 provided between the first composite member 20, second composite member 22, and third composite member 24 are such that C2 > C1 and C6 > C5.

**Seat Maximum Travel Condition**

In the event of a blast occurring underneath the vehicle floor 110, the blast attenuation seat 10 is configured to absorb a proportion of the blast energy and reduce the acceleration of the blast attenuation seat 10 occupant. Nominally, the blast attenuation seat 10 is configured to allow the seat occupant to experience the blast as an acceleration to 3 m/s over 1.5 hundredths of a second rather than instantaneously.

Figure 4 shows the blast attenuation seat 10 at a maximum travel condition, 1.5 hundredths of a second following a blast event. Figure 4 and Figure 3 are drawn with the fixing arrangement 90 to the vehicle wall 100 shown aligned. It must be noted that the blast event causes the vehicle to be raised into the air. It is the primary objective of the blast attenuation seat 10 to reduce the acceleration felt by the occupant of the blast attenuation seat 10. Thus the relative "downwards" position of the blast attenuation seat 10 of Figure 4 equates to a reduction in the upwards acceleration of the blast attenuation seat 10 occupant as the vehicle is raised into the air.

Relative to the seat normal condition, in the seat maximum travel condition the seat base 16 is displaced a distance D. Distance D is approximately 50mm.

In the seat maximum travel condition, the connection of the upper planar arm 42 and the lower planar arm 44 at the radiused corner 50 has opened up so that the whilst the upper planar arm 42 remains substantially parallel to the vehicle wall 100, the lower planar arm 44 extends from the upper planar arm 42 at an angle of approximately 110° such that the lower planar arm 44 is no longer substantially parallel to the vehicle floor 110. In this movement, the living hinge joint has decoupled the acceleration of the vehicle from the seat occupant. The radiused corner 50 will open up as the angle between the upper planar arm 42 and inner planer arm 44 increases. The living hinge may eventually fail during the blast incident.

In the seat maximum travel condition, the relative positions of the first composite member 20, second composite member 22, and third composite member 24 of the composite spring arrangement 14 are also altered relative to the seat normal condition. In the maximum travel condition, the second composite member 22 extends from the upper planar arm 42 at an internal angle of approximately 95°. In the seat maximum travel condition, the third composite member 24 extends from the second composite member 22 at an internal angle of approximately 80°. In the seat maximum travel condition, the third composite member 24 extends from the lower planar arm 44 at an internal angle approximately 60°.

The relative movement of the first, second and third composite members 20, 22, 24 is possible thanks to the resilient hinges 21, 23, 25 provided by the flexible wrapping 80. In the seat maximum travel condition the first hinge 21 is closed such that clearance C2 is approximately equal to clearance C1. In the seat maximum travel condition the second hinge 23 is opened such that C4 > C3. In the seat maximum travel condition the third hinge 25 is closed such that clearance C6 is approximately equal to clearance C5.

Travel of the seat is limited by the first hinge 21, as the chamfered edge 60 of the upper end 46 of the first composite member 20 abuts the chamfered edge 62 of the lower end 52 of the second composite member 22. Travel of the seat is further limited by the third hinge 25, as the chamfered edge 68 of the lower end 56 of the third composite member 24 abuts the chamfered edge 70 of the the lower end 48 of the lower planar arm 44. The clearances C1, C2, C5 and C6 are effectively zero.

**Seat at vehicle "Slamdown"**

Following a blast event, the vehicle is raised into the air and brought back down to the ground rapidly. The vehicle impacts the ground in a so-called slam-down. At this point the blast attenuation seat 10 is configured to reduce the effect of the rapid deceleration of the vehicle on the blast attenuation seat 10 occupant.

The combination of the radiused corner 50 and damper 30 limits the speed at which the blast attenuation seat 10 is returned to the seat normal condition. Such a seat motion is often termed "recoil".

The varying densities of the lower region 32, mid-region 34 and upper region 36 of the damper 30 protect the occupant of the blast attenuation seat 10. As the seat structure 12 is returned to having a slight rearwards inclination, (i.e. moving from Figure 4 to Figure 3), there is a greater damping force from the higher density foam towards the seat base 16 than there is from the lower density foam toward the top of the composite material mechanism 14.

The recoil of the seat is also limited by the second hinge 23, as the chamfered edge 64 of the upper end 54 of the second composite member 22 abuts the chamfered edge 66 of the upper end 58 of the third composite member 24.

**Seat Construction and Materials Selection**

The seat structure 12 is made of fibre composite. This provides a higher level of spall protection relative to the use of metal. An equivalent metal e.g. steel seat structure spall when it fails, which within the closed space of the vehicle presents a secondary hazard. The seat structure may be made of glass woven fabric. The seat structure 12 also provides additional ballistic shield from explosion outside the vehicle wall 110.

The seat back 18 extends towards a vehicle ceiling to protect head of the blast attenuation seat 10 occupant against impact with the vehicle ceiling.

In an alternate embodiment, the first composite member comprises two separate arms, connected by a hinge. The hinge may be arranged in a similar manner to the second hinge 23.

**Alternate Blast Attenuation Seat**

Figures 5 and 6 show an alternate blast attenuation seat 210. Similar reference numerals have been used with respect to blast attenuation seat 10, prefixed by a "2" to indicate those features relating to the alternate blast attenuation seat 210.

Only the principal differences shall be described in detail. Blast attenuation seat 210 is provided with a further flexible stop mechanism 300. The further flexible stop mechanism 300 comprises a composite member that is "L"-shaped in cross-section. The composite member has an upper planar arm 302 and a lower planar arm 304. The upper planar arm 302 and lower planar arm 304 connect at a radiused corner 306. The radiused corner 306 acts as a living hinge joint when under a predetermined load. In an alternate embodiment, the upper and lower planar arms 302,304 are connected by a hinge arranged in a similar manner to the second hinge 23.

The upper planar arm 302 may be a continuation of upper planar arm 242 of the first composite member 220.

In the seat normal condition (see Figure 5), the lower planar arm 304 terminates clear of the lower planar arm 244 of the first composite member 220.

In the event of a blast occurring underneath the vehicle floor 110, the flexible stop mechanism is configured to absorb a proportion of the blast energy and reduce the acceleration of the blast seat 10 occupant.

This is achieved by contact between a lower surface of the lower planar arm 244 against an end of the lower planar arm 304 (see Figure 6). Thus relative "downward" movement of the seat 210 is restricted, flexibly, by opening of the radiused corner 306. The flexible stop mechanism 300 may or may not include flexible wrapping 280.

## CLAIMS

1. A blast attenuation seat for a vehicle, the blast attenuation seat comprising: a composite material seat structure having a seat base and a seat back; and a composite material mechanism, wherein the mechanism is configured for attachment between a sidewall of a vehicle and the seat back.

2. A blast attenuation seat according to claim 1, wherein the composite material mechanism defines an inner core region, and wherein a damper at least partially fill the inner core region.

3. A blast attenuation seat according to claim 2, wherein the damper is made of a foam, preferably a closed cell foam.

4. A blast attenuation seat according to claim 2, wherein the damper is made of a plurality of closed cell foams having different densities.

5. A blast attenuation seat according to any preceding claim, wherein the composite material mechanism comprises a first member and a second member, connected via a first hinge joint.

6. A blast attenuation seat according to claim 5, wherein the first hinge joint is configured to decouple the seat structure from the vehicle during a blast event.

7. A blast attenuation seat according to claim 5 or 6, wherein the first and second members are provided as a single body.

8. A blast attenuation seat according to any one of claims 5 to 7, wherein the composite material mechanism further comprises a third member, and wherein the first member and third member are connected via a second hinge joint.

9. A blast attenuation seat according to claim 8, wherein the second hinge joint is configured to limit the relative movement of the first and third members.

10. A blast attenuation seat according to claim 8 or claim 9, wherein the composite material mechanism comprises a fourth member, and wherein the second member and fourth member are connected via a third hinge joint.

11. A blast attenuation seat according to claim 10, wherein the third hinge joint is configured to limit relative movement of the second and fourth members.

12. A blast attenuation seat according to claim 10 or claim 11, wherein the third member and fourth member are connected via a fourth hinge joint.

13. A blast attenuation seat according to any of claims 5 to 8, wherein the first hinge joint and/or the second hinge joint and/or the third hinge joint and/or the fourth hinge joint comprises a flexible wrapping.

14. A blast attenuation seat according to any of claims 10 to 13, wherein the first, second, third and fourth members are arranged in a loop.

15. A blast attenuation seat according to claim 14, wherein the flexible wrapping is provided as a continuous loop surrounding the composite material mechanism.

16. A blast attenuation seat according to any preceding claim, wherein the composite material mechanism is bonded to the seat back.

17. A blast attenuation seat according to any preceding claim, wherein the seat structure is made of composite, preferably the seat structure is made of glass woven fabric.

18. A blast attenuation seat according to any of claims 13 to 17, the flexible wrapping is a unidirectional or cross woven fibre.

19. A blast attenuation seat according to any preceding claim, wherein the composite material mechanism is made of at least one of carbon fibres, glass fibres, polythene fibres, aramid fibres.

20. A blast attenuation seat according to any preceding claim, further comprising a flexible stop mechanism.

21. A vehicle having a blast attenuation seat according to any of claims 1 to 20.

22. A blast attenuation seat substantially as hereinbefore described with reference to Figures 1 to 6.

Intellectual Property Office

| | | | |
|---|---|---|---|
| **Application No:** | GB1604745.8 | **Examiner:** | Peter Macey |
| **Claims searched:** | 1 - 22 | **Date of search:** | 26 April 2016 |

## 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 |
|---|---|---|
| Y | 1 - 3, 17, 19 | USH1833 H1 (HOPPEL) see crush tubes 16 in figure 11 |
| Y | 1, 17, 19 | WO 2010/037804 A1 (WOLFF) see abstract and figures |
| Y | 2, 3 | EP 2650168 A1 (KRAUSS-MAFFEI WEGMANN) see especially figure 5. |

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

B60N; F41H

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

WPI, EPODOC

**International Classification:**

| Subclass | Subgroup | Valid From |
|---|---|---|
| F41H | 0007/04 | 01/01/2006 |
| B60N | 0002/42 | 01/01/2006 |
| B60N | 0002/427 | 01/01/2006 |