(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 July 2013 (18.07.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/105890 A1

(51) International Patent Classification:
*B62D 1/11* (2006.01) *B60R 21/05* (2006.01)

(21) International Application Number:
PCT/SE2013/050004

(22) International Filing Date:
7 January 2013 (07.01.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
IN153/CHE/2012 13 January 2012 (13.01.2012) IN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

*[Continued on next page]*

(54) Title: IMPACT ENERGY ABSORBER FOR STEERING WHEEL

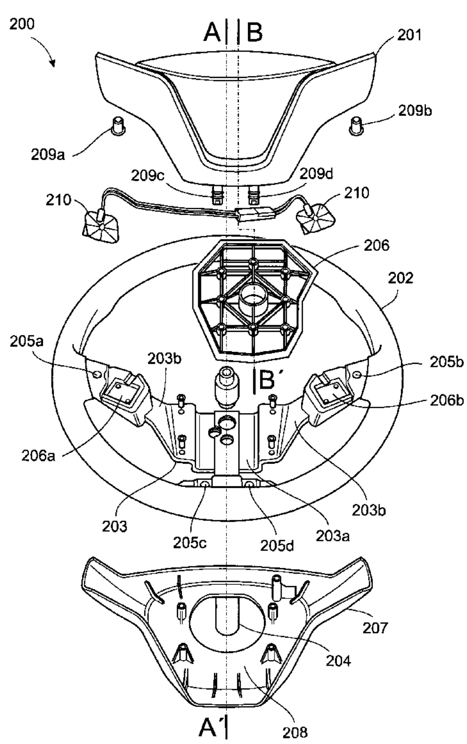



Fig.2

**(57) Abstract**: The present invention provides a steering wheel with an impact-energy absorbing movable horn pad connected to an armature. A primary impact-energy absorbing member connected to the horn pad, to absorb primary impact energy from the armature. A set of secondary impact-energy absorbing members connected to the primary impact-energy absorbing member, to absorb secondary impact energy from the primary impact-energy absorbing members. A peripheral impact-energy absorbing arrangement, connected to the primary and secondary impact-energy absorbing members, to absorb residual impact energy from the primary and secondary impact-energy absorbing members and to retain the horn pad with the armature of the steering wheel, to uniformly absorb and dissipate impact-energy. The impact-energy absorbing horn pad of the present invention renders a complete dissipation and absorption of the impact energy without causing any resultant damage to a user and it also prevents the scattering of debris of the horn pad on impact.

WO 2013/105890 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published**:

— *with international search report (Art. 21(3))*

# IMPACT ENERGY ABSORBER FOR STEERING WHEEL

## Technical Field

The present invention relates to an impact energy absorber for a steering wheel of a vehicle. The present invention specifically relates to an impact-energy absorbing movable horn pad with a network of impact-energy absorbing members to absorb and dissipate an impact-energy uniformly, resulting from an application on an external in-plane load.

## Background of the invention

In a steering wheel construction for a vehicle, a movable horn pad made of soft synthetic resin is arranged to cover a boss section of the steering wheel and an underlying armature, which is connected to a steering shaft. The horn pad is connected to a steering wheel body by means of snaps or guides arranged at the marginal portions of the back side of the horn pad. The horn pad is assembled to the steering wheel body by locking these snaps into corresponding latch portions of the steering wheel body. In its assembled state, the horn pad is urged upwards from the steering wheel body by means of a biasing arrangement provided to the horn pad from the steering wheel body. Whenever the horn pad is depressed on the application of force, it moves inwards and actuates connected horn switches mounted on an armature of the steering wheel.

An impact energy absorbing member generally made of sheet metal or polymer is disposed in a box-like pad, which is provided on top of the boss portion of the steering wheel and underneath the horn pad, to absorb an impact energy acting on the horn pad and to undergo deformation during the course of a crash or an accident.

The deformation behavior of the energy absorbing member varies due to the changes in the incident angle of the impact force on the horn pad. For instance, depending on the incident angle of the impact force, the quantity of energy absorption also varies, resulting in non-uniform deformation of the energy absorbing member. In addition, in the event of any such deformation of the energy absorbing member, at the time of a crash or accident, the risk of dispersion of debris from the broken or deformed energy absorbing member, due to its rigid construction, is also high, which may in turn cause injuries to a driver.

The intensity of the impact force acting upon the horn pad also causes dislocation of the horn pad from the steering wheel body, which also contributes to the uncontrolled or reduced dissipation of the impact energy through the energy absorbing member.

In known horn pad arrangements guide members that are used to fix the horn pad to the armature of the steering wheel, break away under the impact of the force resulting in the displacement of the horn pad from the armature causing injuries to user.

Indian Patent Application No. 589/MUM/2007 discloses a steering wheel horn pad 1 with an energy absorbing structure 2 with a through hole 3, at the center portion of the horn pad 1and ribs 4 on either side of the energy absorbing structure 2, to absorb a portion of energy and ribs 6 to accommodate horn actuating means. In this arrangement wherein the energy absorbing structure 2 is located at the center portion the horn pad is co-axial to the steering wheel fastener and impacts directly on to it at the time of impact, which by nature of its construction, exerts a piercing force on the horn pad 1 through the energy absorbing structure 2. In addition, by virtue of the arrangement of the lengthier ribs 4, the ribs 4 come into contact with armature initially and thereafter the absorbing structure 2, resulting in an inefficient absorption of energy. In this known arrangement due to the absence of a direct connectivity or network between the energy absorbing structure 2 and the ribs 2 and 6 the flow of dissipation of energy between the absorbing structure 2 and ribs 2 and 6 is discontinuous and not uniform across the horn pad 1.

In the event of an accident, normally, it will be the head portion of a person in driver’s seat comes in contact with the central portion of horn pad of steering wheel. Therefore, it is imperative to provide an impact-energy absorbing arrangement, which is optimized to possess the desired buckling and collapsing parameters, to substantially reduce the effect of the impact energy on the head portion of the person.

Accordingly, there is a need to provide a set of networked impact-energy absorption members, for a horn pad, which not only absorb and dissipate the impact-energy uniformly across the length, breadth and depth of the absorption members but also prevent the dispersion of the debris, upon the application of an impact force. In other words, the desired impact-energy absorbing members of a horn pad shall have an optimum buckling and collapsing property, in order to effectively absorb the impact-energy. It is also preferable to provide a horn pad with impact-energy absorbers, having impact-energy absorbing cum locking arrangement, which can retain the horn pad to the steering wheel assembly, even on the application of the impact force.

**Objects of the invention**

The primary object of the present invention is to provide a network of impact-energy absorbing members such as primary, secondary and peripheral impact-energy absorbing members, for a movable horn pad of a steering wheel, which can buckle and collapse (undergo deformation) under an impact and uniformly absorb and dissipate the corresponding impact-energy.

An object of the present invention is to provide a network of impact-energy absorbing members for a movable horn pad of a steering wheel, to prevent the scattering of debris of the deformed impact-energy absorbing members and the horn pad, at the time of application of impact force on the horn pad.

Another object of the present invention is to provide impact-energy absorbing members for a movable horn pad of a steering wheel, with a network of plurality of impact-energy absorbing members, which are positioned offset to central axis of the steering wheel column, to effectively absorb and uniformly dissipate the impact energy.

It is also an object of the present invention to provide a network of impact-energy absorbing members for a movable horn pad of a steering wheel, to retain the horn pad with the steering wheel body even after deformation of the horn pad on the application an external in-plane load.

It is also further object of the present invention to provide a network of impact-energy absorbing members for a movable horn pad of a steering wheel, which can effectively manage the energy absorption, provide a better deceleration profile and reduce the chance of uncontrolled buckling of the energy-absorbing members or structures.

**Summary of the present invention**

The present invention provides a steering wheel with an impact-energy absorbing movable horn pad connected to an armature. A network of impact-energy absorbing members includes a primary impact-energy absorbing member connected to a movable horn pad, to absorb the first portion of impact energy from an external in-plane load. A set of secondary impact-energy absorbing members connected to the primary impact-energy absorbing member, to disperse and absorb a second portion of the impact energy radiating from the primary-impact energy absorbing member. A peripheral impact-energy absorbing arrangement, connected to the primary and secondary impact-energy absorbing members, to absorb residual impact energy and to retain the horn pad with the armature of the steering wheel. This managed energy absorption provides a better deceleration profile and reduces the chances of uncontrolled buckling of the energy-absorbing members or structures. The use of a network of impact energy-absorbing arrangements, connected to the horn pad also substantially reduces the risk of cracking or fragmenting of the horn pad assembly during the impact thereby exposing a driver to injurious sharp edges.

**Brief description of the drawings**

FIG. **1** is a perspective view of a steering wheel with a movable horn pad.

FIG. **2** is an exploded perspective view of the steering wheel assembly with an impact-energy absorbing movable horn pad of the present invention depicting primary, secondary and peripheral impact absorbing arrangements.

FIG. **3a** is a top view of the horn pad of the present invention showing a peripheral impact-energy absorbing arrangement in a disengaged position.

FIG. **3b** is a partially exploded detail view **b** of a FIG. **3**, showing the peripheral impact-energy absorbing arrangement in a disengaged position.

FIG. **4a** is a top view of the horn pad of the present invention and FIG. **4b** and **4c** are sectional views **C-C'** and **D-D'** of FIG. **4a** depicting the arrangement of the peripheral impact-energy absorbing arrangement in an engaged position with the armature of the steering wheel.

FIG. **5** is a perspective inner view of the impact-energy absorbing horn pad of the present invention depicting a network of primary, secondary and peripheral impact-energy absorbing members.

FIGS. **6a**, **6b, 6c** and **6d** depict perspective exemplary views of network of primary and secondary impact-energy absorbing members of the horn pad of the present invention.

FIG. **7a** is a cross-sectional view of a network of primary and secondary impact-energy absorbing members of the horn pad of the present invention, in an assembled position.

FIG. **7b** is a cross-sectional view of a network of primary and secondary impact-energy absorbing members of the horn pad of the present invention, shown in deformed position, with the horn pad held together with an armature of the steering wheel.

FIG. **8** is a graphical representation of the impact energy dissipation curve of the impact-energy absorbing movable horn pad of the present invention, on application of an external in-plane load.

**Detailed description of the invention**

Accordingly, the present invention provides a horn pad with an energy absorbing member and a latch arrangement, as hereinafter described.

FIG. **1** is a plan view of an impact-energy absorbing movable horn pad **201**mounted on a steering wheel **100** and connected to an annular body **102**, through its peripheral portions.

The impact-energy absorbing arrangement of the movable horn pad **201** of the present invention is now described by initially referring to FIG. **2**, which is an exploded perspective view of the steering wheel assembly **200**.

An armature **203**, which forms a basic supporting frame work for the steering wheel assembly **200**, is made of a lightweight die-casting material, such as an aluminum alloy. The armature **203** is generally provided with a central lower portion **203a**, to which a column shaft **204** of the steering wheel **200** is connected. Collars **203b** of the armature **203** extend laterally from the central lower portion **203a** and are connected peripherally, to the annular body **202**, at different locations, as shown in FIG.**2**. The connectivity of the collars **203a** of the armature **203** to the annular body **202** of the steering wheel **200** is shown, at three different location points, in an exemplary manner, to render a substantially inverted triangular configuration to the armature **203**. In this context, it is understood that the location points of the collars **203b** on the annular body **202** can be suitably varied depending upon the desired shape and configuration of the steering wheel **200** and the horn pad **201**.

An impact-energy absorbing movable horn pad **201** is integrally connected to the armature **203** and the annular body **202**, of the steering wheel assembly **200**, through the armature collars **203b** as shown in FIG.**2**. An intervening space **G** (as shown in FIG.7**a**) is arranged between the impact-energy absorbing movable horn pad **201** and the armature **203** to facilitate the longitudinal movement of the horn pad **201** towards the armature **203**. The movable horn pad **201** is connected to the armature **203** and arranged parallel to the central axis **A-A`** of a steering wheel column shaft **204** and offset to axis **B-B`** of the steering column shaft **204**.

A plurality of impact-energy absorbing members **206**, which are networked together, are connected to the inner surface of the horn pad **201** and positioned to extend longitudinally towards the armature **203**. The arrangement of the impact-energy absorbing members **206** is more fully described *infra*.

At least a pair of locking members **209a** and **209b**with proximal and distal ends are provided on the inner peripheral surfaces of the horn pad **201** to project longitudinally towards the armature **203**, as shown in FIG.**2**. The proximal ends of the locking members **209a** and **209b** are integrally connected to the inner peripheral surface of the impact-energy absorbing movable horn pad **201** by molding or by any other suitable connecting arrangement such as thread, press-fit etc. The locking members **209a** and **209b** are positioned with an intervening space, laterally, across the inner surface of the impact-energy absorbing movable horn pad **201** and positioned substantially parallel to each other.

Collar-sockets **205a** and **205b** with a suitable inner configurations corresponding to the outer profiles of the locking members **209a** and **209b**, are provided on the armature collars **203b** and are positioned co-axial to the locking members **209a** and **209b**, respectively.

The impact-energy absorbing movable horn pad **201** is mounted on the armature **203** by urging the locking members **209a** and **209b** longitudinally towards the respective collar-sockets **205a** and **205b** by means of the distal ends of the locking members **209a** and **209b**. The locking members **209a** and **209b** are in the form of cylindrical projections having surface profiles suitable for locking with the sockets **205a** and **205b** respectively.

The impact-energy absorbing movable horn pad **201** of the present invention is provided with a network of primary, secondary and peripheral impact-energy absorbing members as hereinafter described by referring to the accompanied drawings.

A peripheral impact-energy absorbing arrangement including impact-absorbing horn pad-armature locking members **209c** and **209d** are provided on the inner surface of the horn pad **201** as shown in FIG.**2**, which are also used to connect the horn pad **201** with the armature **203**, through collar-sockets **205c** and **205d** respectively.

A shell **207** is connected to the armature collars **203b**, through the column shaft **204**, to form a holding-chamber **208** around the central cavity portion **203a** and the collars **203b** of the armature **203**. The holding chamber **208** also functions as a collector for debris, if any, arising out of the deformed horn pad **201** at the time of impact. Horn switch assemblies **210** are also mounted on the armature **203** and connected to the horn pad **201**and armature through sockets **206a** and **206b**, for their actuation, on depression of the horn pad **201**.

In one aspect of the present invention the peripheral impact-energy absorbing arrangement, as shown in FIG. **3a** and **3b** (which is a detail view of a portion of FIG. **3**), includes, at least a pair of impact-absorbing horn pad-armature locking members **309c** and **309d**, which are cylindrical protrusions extending longitudinally from the inner surface of the horn pad **201**, through their proximal ends as shown in FIG.**3a**. The impact-absorbing horn pad-armature locking members **309c** and **309d** are co-axially positioned along respective passage axes of the collar-sockets **305c** and **305d**.

Spatially-arranged protrusions **311** such as rings are arranged on the outer surfaces of distal ends of the impact-absorbing horn pad-armature locking members **309c** and **309d**, with intervening spaces between them to render multi-stage locking of the impact-absorbing horn pad-armature locking members **309c** and **309d** with the collar-sockets **305c** and **305d** of the armature **303**, both in the state of assembly and after the impact, as more fully described *infra*. The ring configuration as provided on the surfaces of impact-absorbing horn pad-armature locking members **309c** and **309d** can be suitably changed with other surface profiles such as thread, latch or any other arrangements, which can provide the desired locking with the collar-sockets **305c** and **305d** of the armature **303**.

In another aspect of the present invention, the impact-absorbing horn pad-armature locking members **309c** and **309d** are made of suitable load-bearing polymeric material, such as soft synthetic resin. The material thus chosen possesses a desired tolerance of flexural loads, a capacity to absorb impact energy and to undergo buckling and partial deformation, on the application of an external in-plane load.

The distal ends, preferably at the tip portions of the impact-absorbing horn pad-armature locking members **309c** and **309d**, are provided, optionally, with serrations, slits or perforations **309e** and **309f**, along with the spatially-arranged protrusions **311** to facilitate an easy buckling, deformation, dispersal or lateral movement of the tips of the impact-absorbing horn pad-armature locking members **309c** and **309d**, inside the collar-sockets **305c** and **305d**, application of the external in-plane load.

The surface configuration of the impact-absorbing horn pad-armature locking members **309c** and **309d** is circular or non-circular with circumferential protrusions and serrations. The non-circular surface configuration can be rectangular, hexagonal, polygon or any other suitable profiles.

The impact-absorbing horn pad-armature locking members **309c** and **309d** are provided with extended lengths to allow the transmission of the impact energy at the time of impact and further dissipation thereof. The impact-absorbing horn pad-armature locking members **309c** and **309d** are also arranged to absorb the applied external in-plane load, to great extent, and hold the horn pad **201** with the armature **303**, even after undergoing deformation.

In another aspect of the present invention a mating or locking arrangement of the impact-absorbing horn pad-armature locking members **409c** and **409d** with collar sockets **405c** and **405d** of the armature **403**, in its assembled position, is shown in FIGS. **4a** and **4b** (a detailed view of section **C-C'** of FIG.**4a**) and **4b**.

The inner surface profile of the collar sockets **405c** and **405d** are provided with suitable locking-slots corresponding to the outer profile of the horn pad-armature locking members **409c** and **409d**, as shown in FIG.**4a** and **4b**. Accordingly, in an assembled state, impact-absorbing horn pad-armature locking members **409c** and **409d**, with extended lengths **X**, when urged towards the armature **403**, engage with the collar sockets **405a** and **405d**, in a press-fit locked position, in a multi-lock mode.

The collar sockets **405c** and **405d** are provided with lengths **Y** of socket greater than the lengths **X** of the impact-absorbing horn pad-armature locking members **409c** and **409d**, as shown in FIG.**4C** (a detailed view of section **D-D'** of FIG.**4a**), to permit longitudinal travel of impact-absorbing horn pad-armature locking members **409c** and **409d**, inside the collar sockets **405c** and **405d**, in the event of the application of the impact force on the horn pad **201**. The mating of impact-absorbing horn pad-armature locking members **409c** and **409d** with the collar sockets **405c** and **405d**, is accomplished in a manner that at the time of the application of the impact force, **405c** and **405d** travel inside the free space of the collar sockets **409c** and **409d**, while absorbing the kinetic energy of the impact force and finally undergo a partial deformation owing to the corresponding tensile strength and load bearing capacity, inside the collar sockets socket **409c** and **409d**. The absorption of the kinetic energy by impact-absorbing horn pad-armature locking members **409c** and **409d**, their travel inside the collar sockets **409c** and **409d** and their partial deformation, help in holding the horn pad **201** to the armature **403** and prevent the forceful ejection of the horn pad **201** from the armature **403**, during the course of application of the impact force on the horn pad **201**. Accordingly, the impact-absorbing horn pad-armature locking members **409c** and **409d** are non-detachably disposed in the collar-sockets **409c** and **409d** even after their deformation.

In another aspect of the present invention, as shown in FIG.**5**, the impact-energy absorbing movable horn pad **201** of the present invention with the network of impact-energy absorbing arrangement **500**, to absorb and dissipate an impact-energy uniformly, resulting from an application on an external in-plane load is now described. A primary impact-absorbing member **512** is integrally connected to the inner surface of the horn pad **201**. The primary impact-absorbing member **512** is a hollow cylindrical member integrally connected to the horn pad **201**. The primary impact absorbing member **512** is arranged to extend longitudinally from the inner surface of the horn pad **201**, towards the armature. The arrangement of the primary impact-absorbing member **512** is not co-axial to the central axis **A-A'** of the steering wheel column shaft **204** (as shown in FIG. **7a**) of the steering wheel and positioned offset to the column shaft **204**(as shown in FIG. 7**a**). The primary impact-absorbing member **512** is provided with an extended length, to enable it to come into contact, first, with the armature, away from its central portion where the column shaft is connected, upon the application of the impact force on the horn pad **501**. On impact, the primary impact-absorbing member **512**, while absorbing a first portion of the impact energy generated by an in-plane load on the horn pad **201**, due to the impact of head portion of a user (driver), undergoes an initial buckling and thereafter collapsing, before transmitting the corresponding second portion of the impact energy further to other energy-absorbing members. The distal end of the primary impact-absorbing member **512** is terminated in the intervening space **G** (as shown in FIG. 7**a**) arranged between the armature and the primary impact-absorbing member **512**. The primary impact-energy absorbing member **512** is made of suitable load-bearing polymeric material, such as soft synthetic resin. The material thus chosen will have a desired tolerance of flexural loads and a capacity for partial deformation, on the application of the external in-plane load.

Secondary impact-energy absorbing members **514** and **515** are integrated to the inner surface of the horn pad **201** with their proximal ends and distributed uniformly across the length and breadth of the inner surface of the horn pad **201**. The arrangement of the secondary impact-energy absorbing members is a network of longitudinal and transverse impact-absorbing members **514** and **515**, tubular impact-energy absorbing members **513** and an inner-peripheral impact-absorbing member **51**7.

The longitudinal and transverse impact-absorbing members **514** and **515** are non-cylindrical structures, optionally provided with perforations, which are integrated to the inner surface of the horn pad **201**. The longitudinal and transverse impact-absorbing members **514** and **515** are distributed on the inner surface of the horn pad **201** and arranged to extend from the horn pad **501**, towards the armature and terminated in the intervening space between the armature and the longitudinal and transverse impact-absorbing members **514** and **515**. The longitudinal and transverse impact-absorbing members **514** and **515** are integrally connected to each other to form a network or grid of impact-absorbing members. The network of the longitudinal and transverse impact-absorbing members **514** and **515** is further integrally connected to the primary impact absorbing-member **512**, to absorb the second portion of the impact energy from the primary impact absorbing-member **512**, on the application of the impact force on the horn pad **501**. The network of the longitudinal and transverse impact-absorbing members **514** and **515** is provided with openings between the adjacent sets of longitudinal and transverse impact-absorbing members **514** and **515**, termed as apertures **516**, which are large enough to allow the absorption of the secondary impact-energy from the primary impact-absorbing member **512** and the dissipation thereof.

The secondary impact-energy absorbing members **514** and **515** are made of suitable load-bearing polymeric material, such as soft synthetic resin. The material thus chosen will have a desired tolerance of flexural loads and a capacity for partial deformation, on the application of an external in-plane load and on receiving the radiated impact energy from the primary impact-absorbing member **512**.

It is also observed that not only the longitudinal and transverse impact-absorbing members' **514** and **515** strengths are important, but also the junction strength i.e. the meeting points of the longitudinal and transverse impact-absorbing members **514** and **515**, is also significant in imparting a uniform dissipation of the impact energy across the network of longitudinal and transverse impact-absorbing members' **514** and **515**. Accordingly, the junction points where the longitudinal and transverse impact-energy absorbing members **514** and **515** meet are provided with tubular structures or nodes **513**. The nodes **513** are arranged longitudinally to extend towards the armature and their distal ends terminate in the intervening space between the armature and the nodes **513**.

The central diameters of the nodes **513** are smaller than the diameter of the primary impact-absorbing member **512**. The nodes **513** are connected to the primary impact-absorbing member **512** and the longitudinal and transverse impact-absorbing members **514** and **515** to receive the second portion of the impact or kinetic energy from the primary impact-absorbing member **512**, upon the application of the impact force on the horn pad **201**.

The nodes **513** are tubular in nature to facilitate an effective dissipation of the kinetic energy of the impact force. The nodes **513** are provided at the junction points of the longitudinal and transverse impact-absorbing members **514** and **515** to provide a desired rigidity and tensile drawing strength to the longitudinal and transverse impact-absorbing members **514** and **515**.The nodes **513** assist in the uniform dissipation of the kinetic energy, across the longitudinal and transverse impact-absorbing members **514** and **515**.

The longitudinal and transverse impact-absorbing members **514** and **515** are shorter than the primary impact-absorbing member **512**.

The longitudinal and transverse impact-absorbing members **514** and **515** that are connected to the primary impact-absorbing member **512** can be constructed in any suitable shapes and configurations as depicted in FIGS. **6a, 6b, 6c** and **6d**. The primary and secondary impact-absorbing members **612** as shown in FIGS. **6a, 6b, 6c** and **6d** are provided with perforations **618** and **619**, to facilitate an effective absorption of the kinetic energy from the armature. The perforations **618** and **619** also facilitate a controlled deformation of the primary impact-absorbing member **612**, while absorbing the first portion of the kinetic or impact energy.

The longitudinal and transverse impact-absorbing members **514** and **515** are suspended in the central cavity of the armature of the steering wheel, by providing an intervening gap **G** (as shown in **FIG. 7a**) between the armature surface and the bottom portion of the longitudinal and transverse impact-absorbing members **514** and **515**.

In another embodiment of the present invention, the longitudinal and transverse impact-absorbing members **514** and **515** and the primary impact-absorbing member **512** are covered peripherally with an inner-peripheral impact-energy absorbing member **517** to envelope the network of the impact-energy absorbing members.

The inner-peripheral impact-energy absorbing member **517** is of desired density, preferably of a polymer material with a higher density than that of the material of the other impact-energy absorbing members, to act as an enclosure or envelope for the primary impact-energy absorbing member **512** and the secondary impact-energy absorbing members **514** and **515** to prevent the scattering of the debris arising out of the deformation of the impact-absorbing members during the course of the impact.

The impact-energy absorbing members of the horn pad of the present invention are positioned to uniformly absorb kinetic energy by buckling and collapsing and to dissipate the kinetic or impact energy applied on the horn pad, which is in the form of an external in-plane load in a pre-designated and controlled manner, irrespective of the angle of incidence of the longitudinal force acting upon the horn pad at the time of the impact or accident.

As shown in FIGS. **7a** and **7b** in view of the offset arrangement of the horn pad along with its impact-energy absorbing members **712** and **715** to the axis of the steering wheel column shaft, the collision of the primary impact-energy absorbing member **712** is avoided on the column shaft **704** and the impact energy is uniformly dissipated across the impact-energy absorbing members. The deformation of the impact-energy absorption is also uniform as shown in FIG. **7b**, where the first portion of the impact energy is absorbed by the primary impact-energy absorbing member**712**, which deforms substantially and thereafter the second portion of the impact energy is absorbed by the secondary and peripheral absorbing members. It can also be seen from FIG. **7b** that even after the deformation of the horn pad under the impact force, the horn pad is prevented from ejecting from the steering wheel assembly and retained to the armature of the steering wheel.

The impact-energy absorbing horn pad of the present invention also meets the desired parameters of the impact-energy dissipation, such as slow dissipation for the first 10msec under the process of buckling and thereafter collapsing for next 10 to 15 msec. This controlled dissipation of the impact-energy facilitates maximum energy absorption so that when the head portion of a person in a driver's seat of a vehicle touches the horn pad **201**, no hard contact with any rigid part of the assembly is made by the head portion. This aspect of impact-energy dissipation is graphically represented in FIG. **8**, by plotting the parameters of a simulated impactor test using the horn pad **201** of the present invention the parameters of velocity, time and acceleration inverse, to show an impactor's deceleration and absorption of the impact-energy, under standard test conditions.

The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description arid not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the appended claims.

Although the embodiments herein are described with various specific embodiments, it will be obvious for a person skilled in the art to practice the embodiments herein with modifications. However, all such modifications are deemed to be within the scope of the claims. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the embodiments described herein and all the statements of the scope of the embodiments which as a matter of language might be said to fall there between.

**Claims**

1. A steering wheel comprising:
   (i) an impact-energy absorbing movable horn pad connected to an armature with an intervening space and disposed parallel and offset to a steering column shaft axis A-A`;
   (ii) a primary impact-energy absorbing member extending from an inner surface of the horn pad, disposed to absorb a first portion of an impact energy arising from an application of an in-plane load on the horn pad and radiate a second portion of the impact energy,
   (iii) a plurality of secondary impact-energy absorbing members operably connected to the primary impact-energy absorbing member, to absorb the radiated second portion of the impact energy from the primary impact-energy absorbing members; and
   (iv) a peripheral impact-energy absorbing arrangement, operably connected to the primary and secondary impact-energy absorbing members and to the armature, to absorb a residual impact energy from the primary and secondary impact-energy absorbing members and to retain the horn pad with the armature.

2. The steering wheel according to claim 1, wherein the secondary impact-energy absorbing member comprises:
   (i) a network of longitudinal and transverse impact-absorbing members with apertures integrally connected to each other;
   (ii) a network of tubular impact-absorbing members, operably connected to the longitudinal and transverse impact-absorbing members; and
   (iii) an inner-peripheral impact-absorbing member disposed to envelope the network of longitudinal and transverse impact-absorbing members and the tubular impact-absorbing members.

3. The steering wheel according to claim 1, wherein the peripheral impact-energy absorbing arrangement, comprises:
   (i) impact-absorbing horn pad-armature locking members;

(ii) collar sockets disposed on the armature and arranged co-axial to the impact-absorbing horn pad-armature locking members, and

wherein the impact-absorbing horn pad-armature locking members disposed to movably engage the collar sockets.

4. The steering wheel according to claim 1, wherein the primary impact-absorbing member is perforated.

5. The steering wheel according to claim 1, wherein the primary impact-energy absorbing member is not co-axial to the steering column shaft axis A-A`.

6. The steering wheel according to claim 2, wherein the longitudinal and transverse impact-absorbing members are non-cylindrical.

7. The steering wheel according to claims 1 and 2, wherein the diameter and length of the primary impact-absorbing member are greater than the diameter of the tubular impact-absorbing members.

8. The steering wheel according to claims 1 and 2, wherein the length of the primary impact-absorbing member is greater than the length of the longitudinal and transverse impact-absorbing members.

9. The steering wheel according to claims 1 and 2, wherein the longitudinal and transverse impact-absorbing are perforated.

10. The steering wheel according to claim 3, wherein the impact-absorbing horn pad-armature locking members are longitudinal.

11. The steering wheel according to claim 3, wherein the surface configuration of the impact-absorbing horn pad-armature locking members is circular or non-circular with circumferential protrusions and serrations.

12. The steering wheel according to claim 3, wherein the lengths of the collar-sockets are greater than the corresponding length of the impact-absorbing horn pad-armature locking members.

13. The steering wheel according to claim 3, wherein the collar-sockets are provided with locking-slots.

14. The steering wheel according to claim 3, wherein the impact-absorbing horn pad-armature locking members are non-detachably disposed in the collar-sockets.

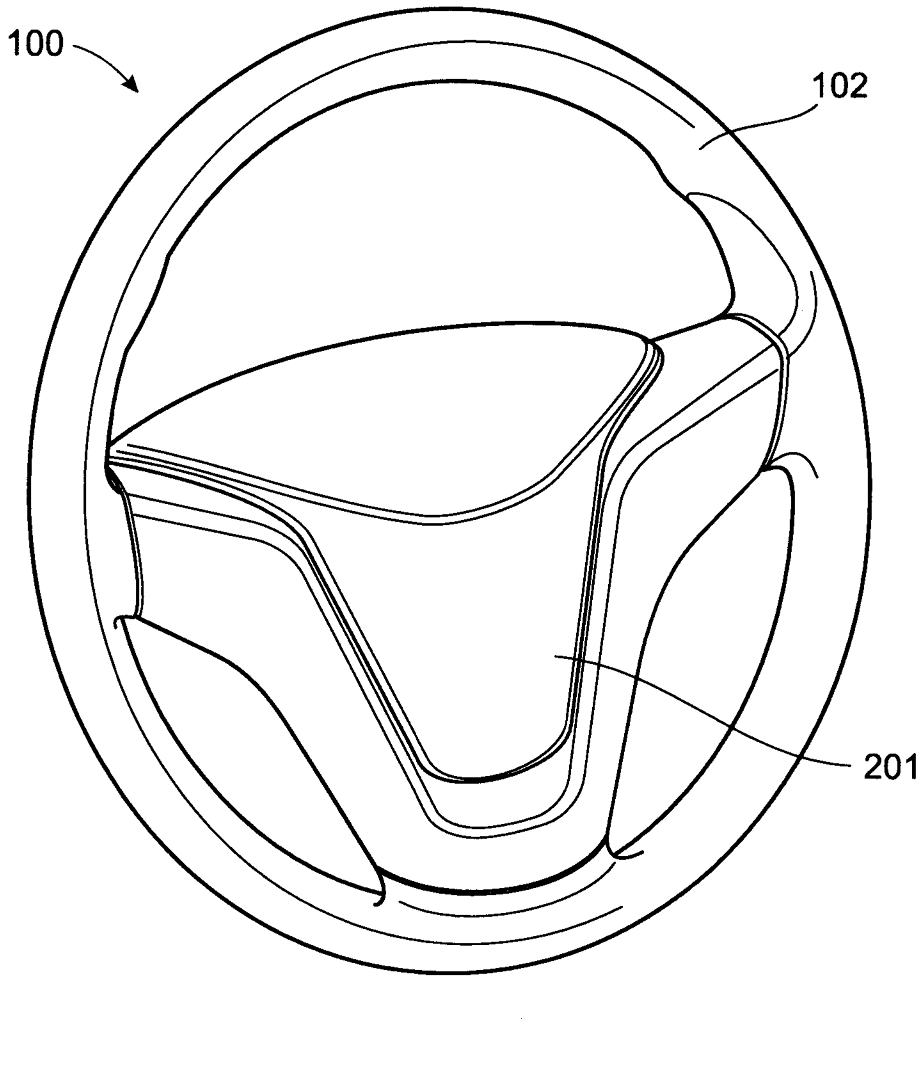
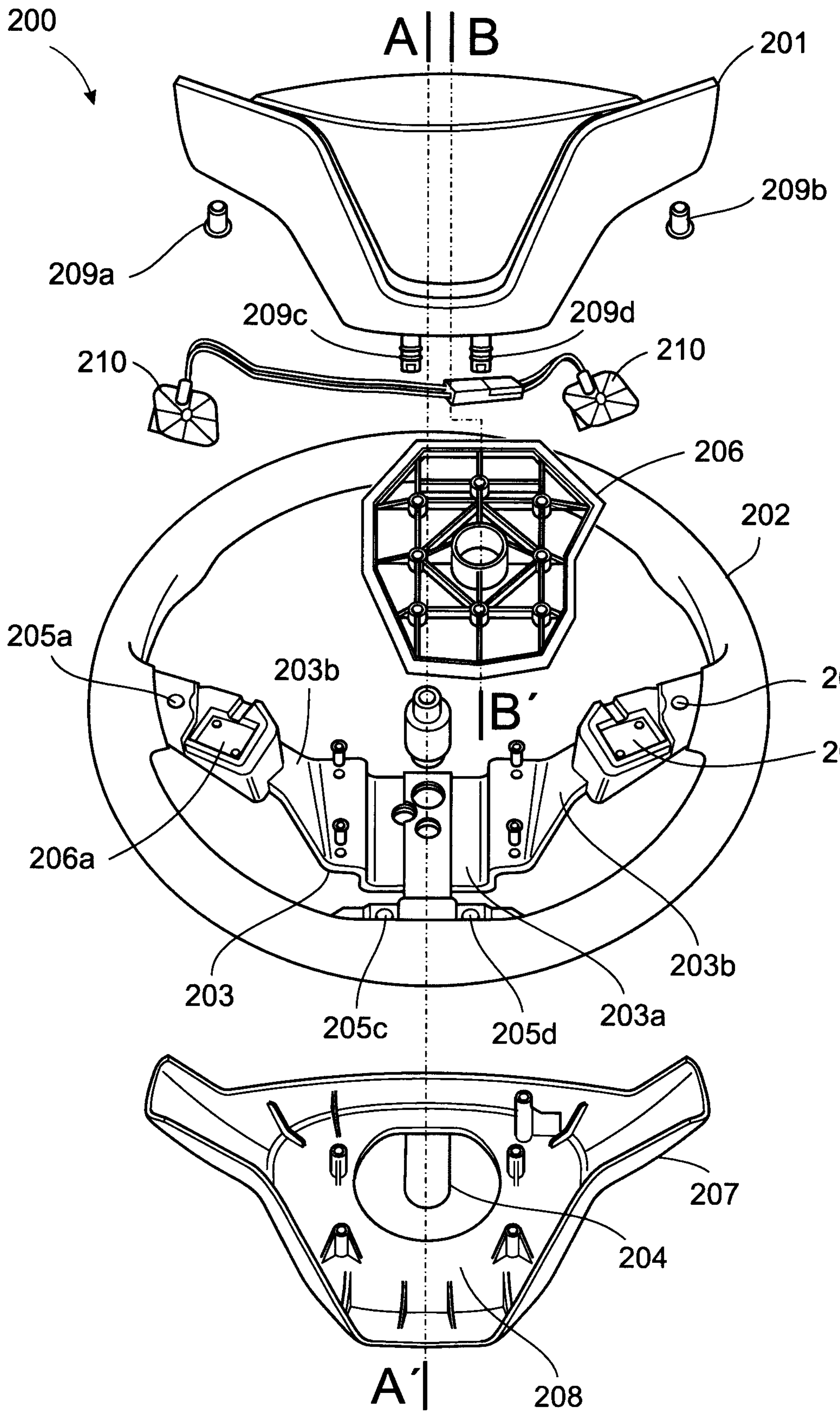



Fig.1


200
A
B
201
209b
209a
209c
209d
210
210
206
202
205a
203b
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B´
206b
206a
203
205c
205d
203a
203b
207
204
208
A´

Fig.2

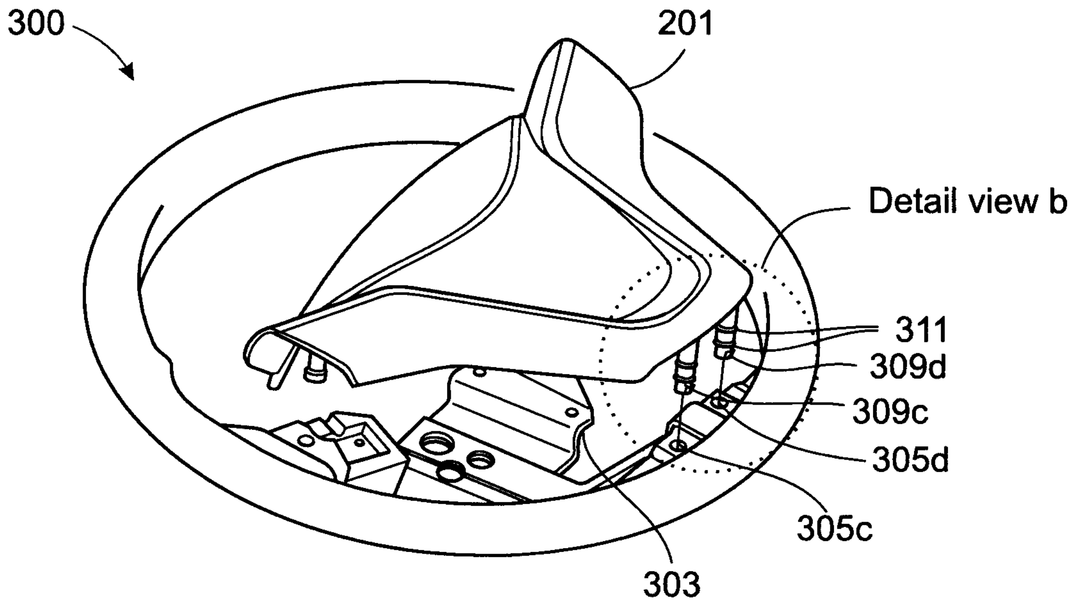

300
201
Detail view b
311
309d
309c
305d
305c
303

Fig.3a

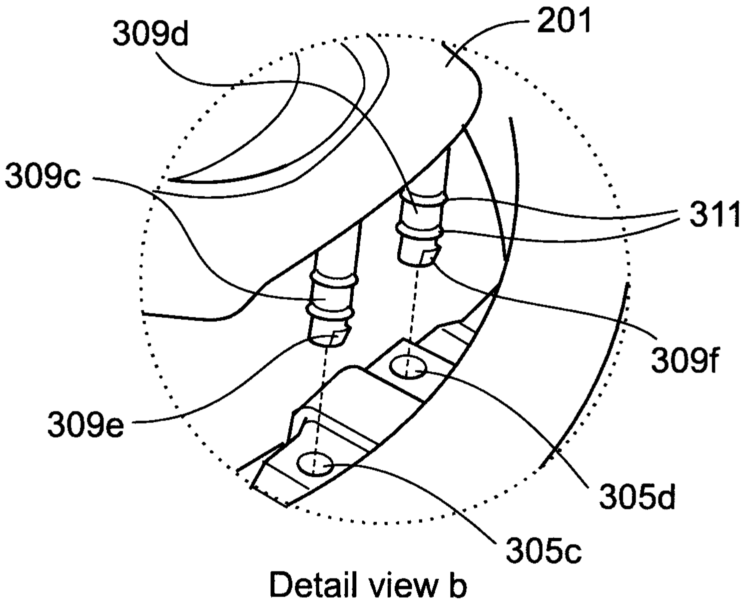

309d
201
309c
311
309f
309e
305d
305c
Detail view b

Fig.3b

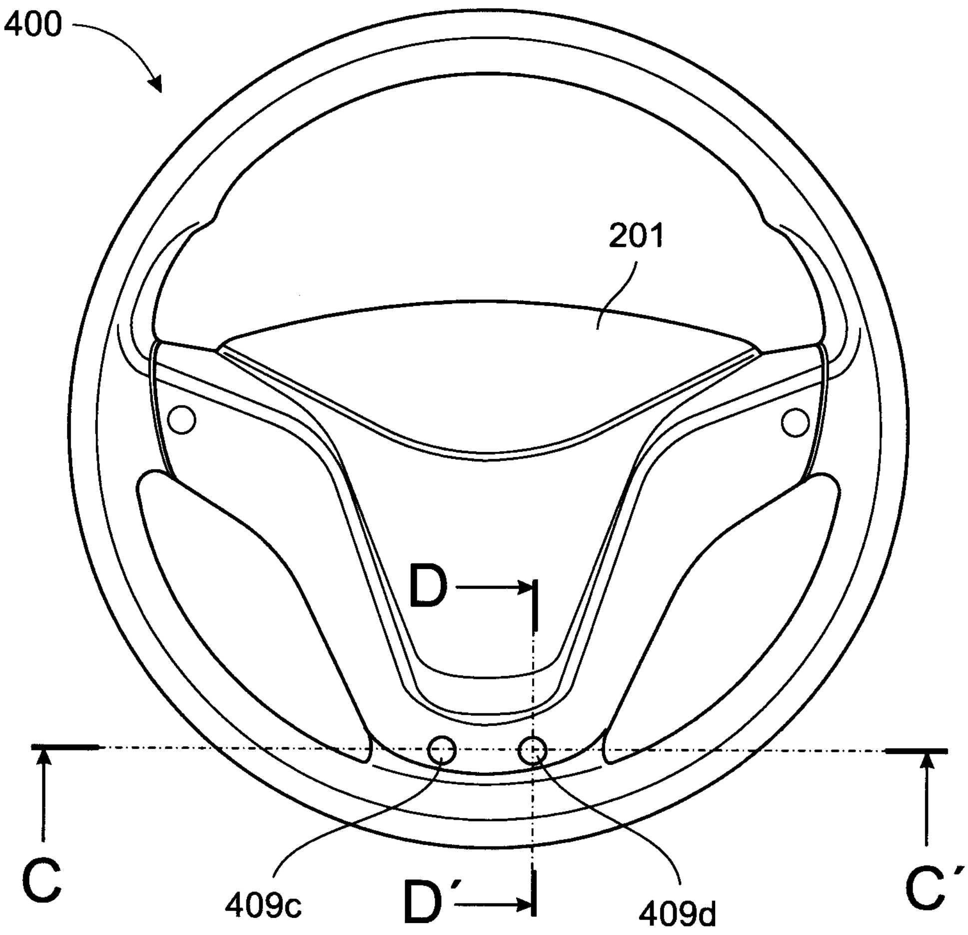
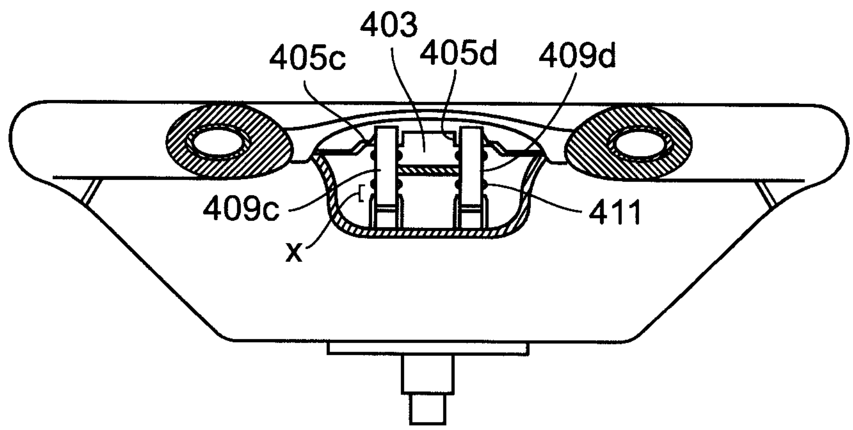



Fig.4a




C - C´

Fig.4b

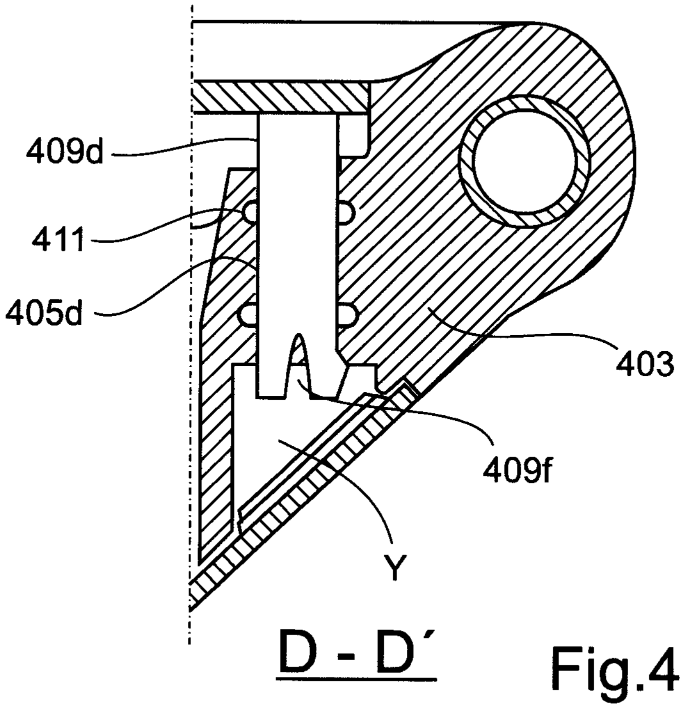



Fig.4c

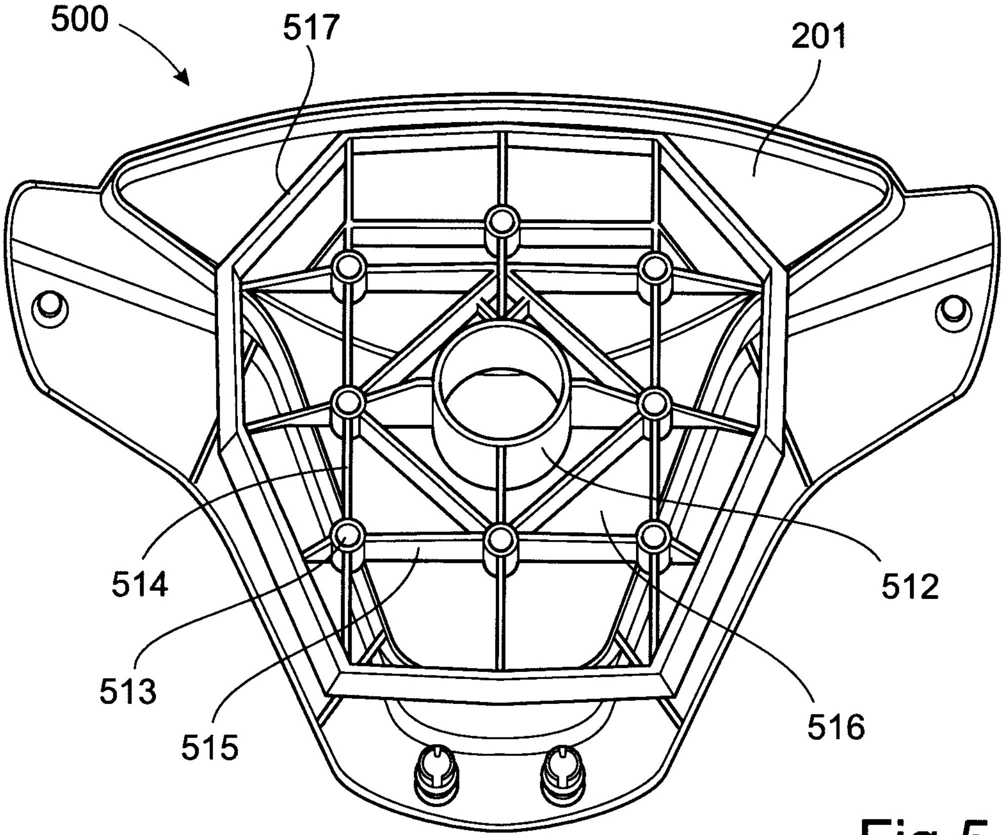



Fig.5

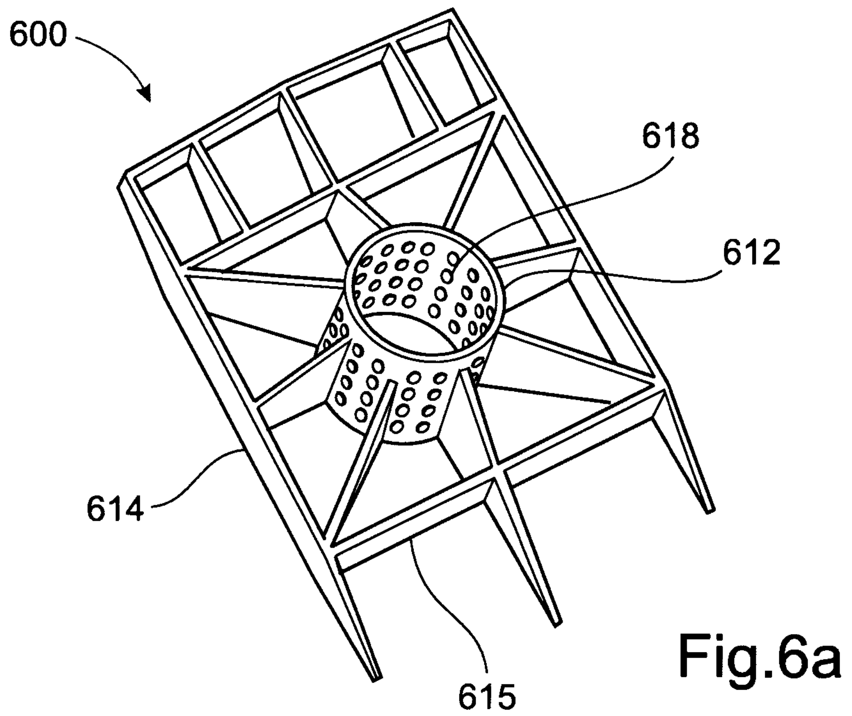



Fig.6a

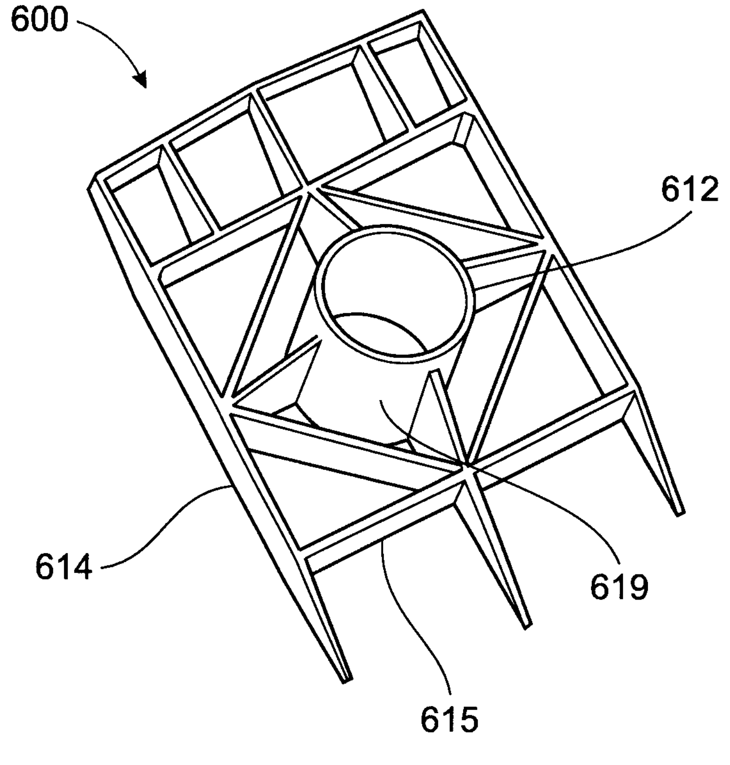



Fig.6b

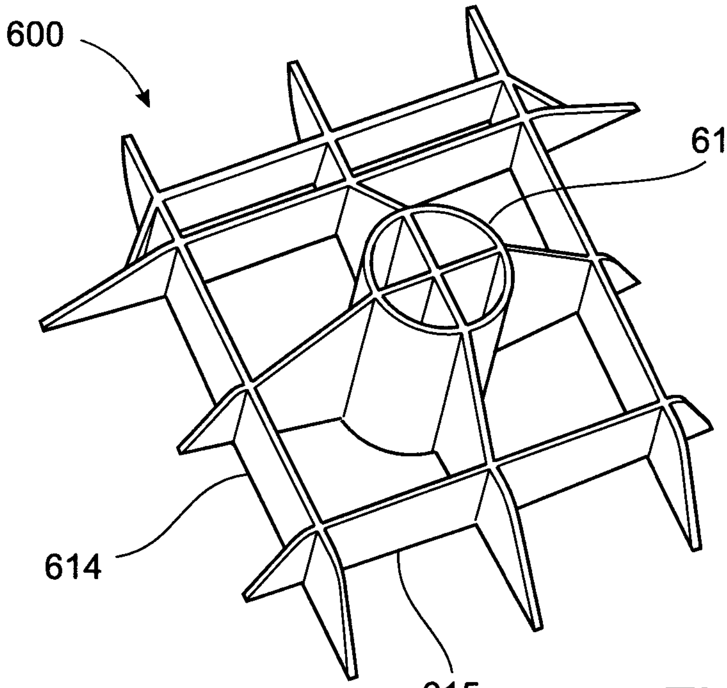



Fig.6c

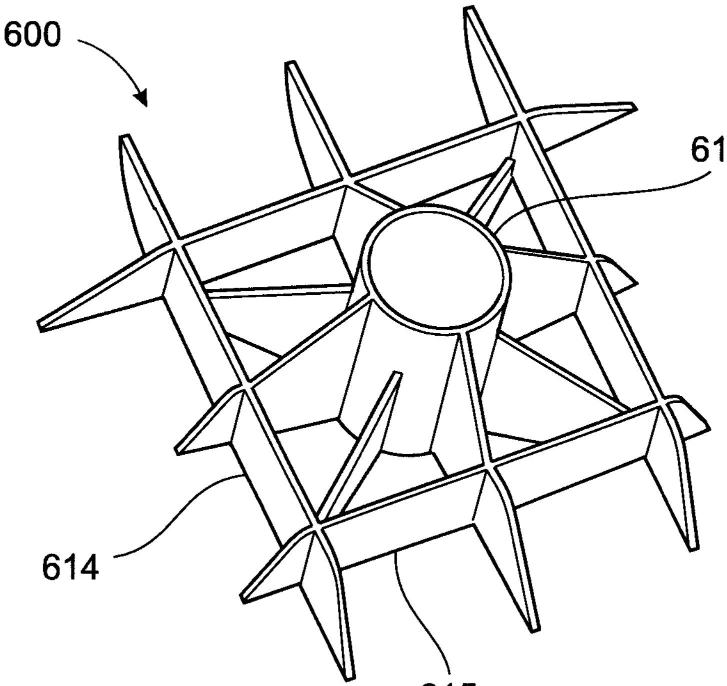



Fig.6d

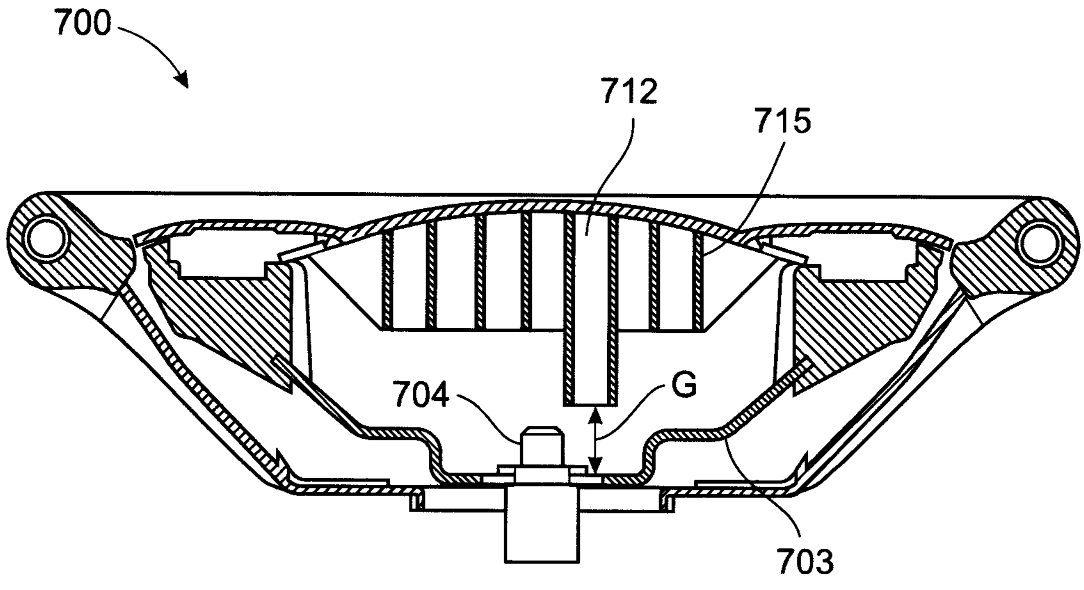



Fig.7a

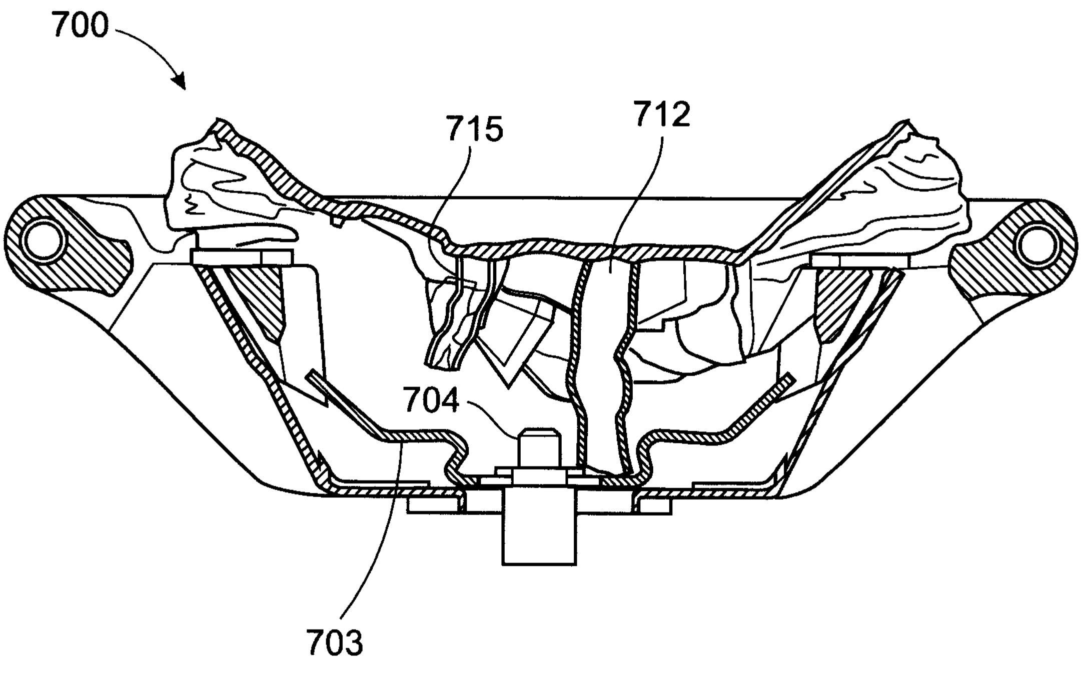
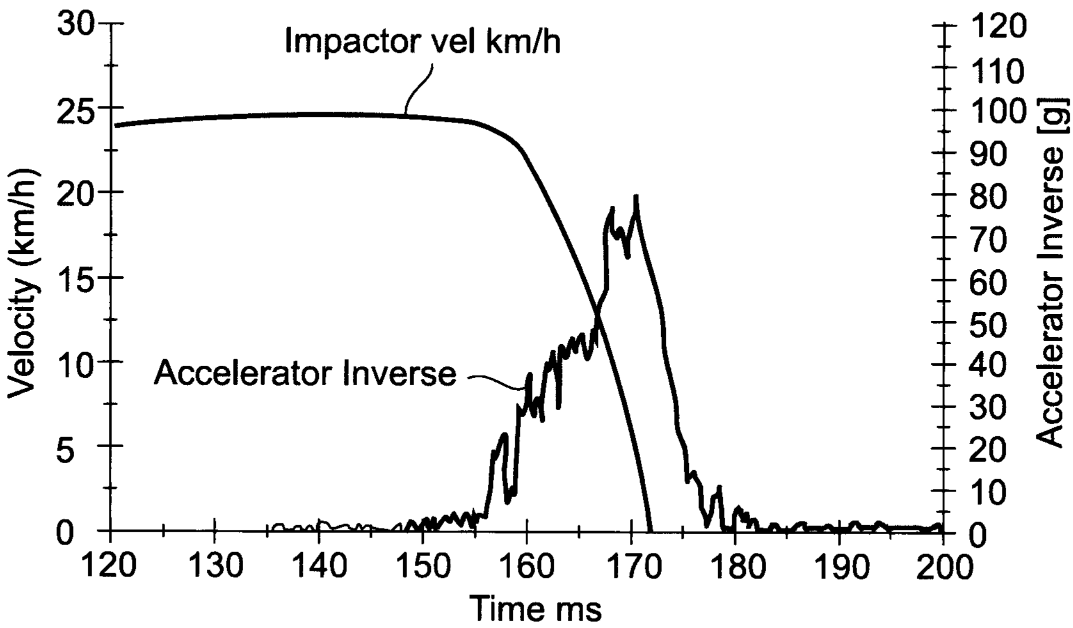



Fig.7b



Impactor vel km/h
Accelerator Inverse
Velocity (km/h)
Accelerator Inverse [g]
Time ms
30
25
20
15
10
5
0
120
110
100
90
80
70
60
50
40
30
20
10
0
120
130
140
150
160
170
180
190
200


Fig.8

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/050004

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B60R, B62D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| A | US 4657121 A (UCHIDA SADAO ET AL), 14 April 1987 (1987-04-14); abstract; figures 5-7<br>-- | 1-14 |
| A | US 3493244 A (BOZICH DANIEL J), 3 February 1970 (1970-02-03); column 1, line 10 - line 27; figures 1-3<br>-- | 1-14 |

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 30-04-2013 | 02-05-2013 |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/SE2013/050004

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| A | US 6168206 B1 (GREIB GARY R ET AL), 2 January 2001 (2001-01-02); abstract; figures 1,4,6<br>-- | 1-14 |
| A | US 5934730 A (YAGISHITA FUMIO ET AL), 10 August 1999 (1999-08-10); column 10, line 33 - column 11, line 8; figures 22-24<br>-- | 1-14 |
| A | EP 1352791 A1 (NISSAN MOTOR), 15 October 2003 (2003-10-15); abstract; figures<br>--<br>-------- | 1-14 |

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**International Patent Classification (IPC)**

***B62D 1/11*** (2006.01)
***B60R 21/05*** (2006.01)

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