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(54) Belly armor

(57) An add-on armor (10) adapted for protecting a belly (3) of a vehicle (1), the add-on armor (10) comprising a base plate (20) and a plurality of energy absorbing modules (30) fitted to the base plate (20). The arrangement is such that at least a majority of a surface of each energy absorbing module (30) facing the base plate (20) overlaps with the base plate (20) at an area thereof constituting a module zone (MZ). The module zones (MZ) are associated with different modules (30) being spaced from one another by vacancy zones (VZ).

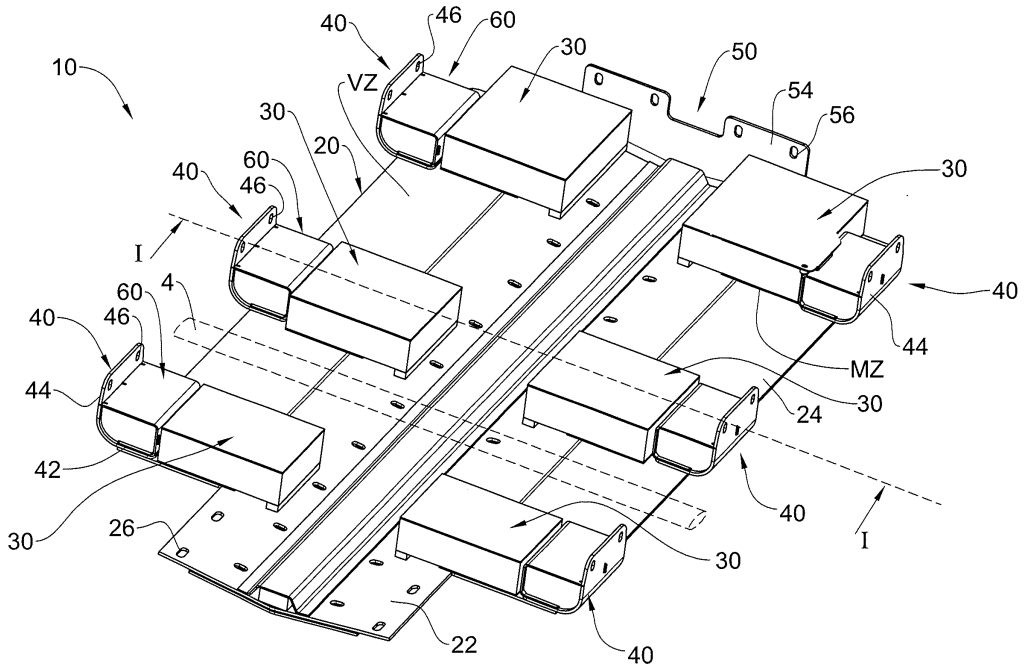

Fig. 2A

EP 2 267 400 A2

Description

FIELD OF THE INVENTION

[0001] This invention relates to add-on armors adapted for protecting a belly of a vehicle, in particular, add-on armors comprising energy absorbing mechanisms.

BACKGROUND OF THE INVENTION

[0002] Vehicles, in particular military vehicles, require armor in order to protect them from incoming threats such as projectiles, bombs, missiles, mines etc. For this purpose, a variety of armors have been contemplated adapted for covering portions of the vehicle in order to provide the desired protection.

[0003] In general, armor may be divided into two types - integral armor and add-on armor. The integral armor is integrally formed with the vehicle to be protected, while an add-on armor is usually attachable to the vehicle in a detachable manner, and may be mounted onto an existing vehicle and be removed therefrom if so desired.

[0004] Specific add-on armors have been designed for specific portions of vehicles, e.g. door armor, hull armor, belly armor etc. One such example of a belly armor is disclosed in US 5,905,225.

SUMMARY OF THE INVENTION

[0005] According to the present invention there is provided an add-on armor adapted for protecting a belly of a vehicle, said add-on armor comprising a base plate and a plurality of energy absorbing modules fitted to said base plate so that at least a majority of a surface of each energy absorbing module facing said base plate overlaps with the base plate at an area thereof constituting a module zone, the module zones associated with different modules being spaced from one another by vacancy zones.

[0006] According to a second aspect of the present invention there is provided an armored vehicle comprising a hull and an add-on armor of the first aspect of the present invention, said add-on armor being attached to the belly of the vehicle such that the energy absorbing modules are disposed between their respective module zoned and the belly of said vehicle.

[0007] Said vehicle may be driven either by wheels (conventional vehicle) or by endless traction belt (e.g. tank, armored troop carrier).

[0008] The add-on armor may be adapted to protect passengers located within the vehicle from an external force applied to the belly of the vehicle, e.g. a force caused by an explosion. Preferably, the add-on armor is adapted to absorb the majority of energy conveyed by the force of the explosion and the belly of the vehicle itself is adapted to absorb at least part of the remainder of said energy.

[0009] It should be noted that the add-on armor is designed according to the specific shape and dimensions of the vehicle. Said vehicle may comprise a plurality of automotive components, e.g. drive shaft etc., some of which are externally located beneath the belly of the vehicle. The energy absorbing modules may be arranged along the base plate at predetermined locations such that when the add-on armor is mounted onto the belly of the vehicle, the energy absorbing modules are located between the automotive components. More specifically, the arrangement may be such that no automotive component of the vehicle is disposed between the energy absorbing module and the belly of the vehicle.

[0010] Several advantages may arise from the above design, two of which are load **distribution** and **automotive protection:**

- **load distribution** - In the event of an explosion, loads applied by the explosion on the base plate at a local area (hereinafter 'explosion zone') may be distributed to all the energy absorbing modules located in the vicinity of the explosion zone. It is appreciated that in the absence of a base plate as described above, the only energy absorbing module/s to absorb the energy of the explosion would be those located at the explosion zone itself; and
- **automotive protection** - since no automotive components are located between the energy absorbing module and the belly of the vehicle, and since most of the loads are taken on by the modules, in the event of an explosion the chances of an automotive component to take on loads is reduced, making it less prone to damage due to the explosion. It should also be noted that while local structural damage to the hull of the vehicle may be acceptable, damage to one of the automotive components may cause immobilization of the entire vehicle.

[0011] It is appreciated that in the absence of a base plate as described above (i.e. in a design in which the energy absorbing modules are attached to the belly), the only energy absorbing modules to absorb the energy of the explosion would be those located at the explosion zone itself.

[0012] The energy absorbing module may have a thickness T measured between the face of the energy absorbing module facing the base plate and a face opposite thereto. Thus, the minimal distance required between the base plate and the belly of the vehicle when the add-on armor is mounted onto the belly, should be at least equal to the thickness T of the energy absorbing module.

[0013] Said energy absorbing module may me adapted for undergoing progressive deformation under the application of the load of the explosion. By progressive deformation, a deformation is meant which, contrary to regular plastic deformation, does not lead to simultaneous crushing of the entire mechanism, but rather successively compresses it, such that uncompressed portions of the mechanism maintain their integrity until they are com-

pressed.

[0014] The arrangement may be such that under the application of the above mentioned force, the energy absorbing module is pressed upon from one side by the base plate and from the other side by the belly, applying a load to the module which entails its deformation.

[0015] According to a third aspect of the present invention there is provided an add-on armor for a vehicle comprising a hull having sidewalls and a belly extending therebetween at a bottom side of said vehicle, said add-on armor comprising a base plate adapted for being externally mounted onto said belly and at least one energy absorbing module, which, when the base plate is mounted onto said belly is located between said base plate and belly said, wherein said energy absorbing module is adapted for undergoing progressive deformation under application of a load thereto.

[0016] One advantage of an energy absorbing module which is adapted for undergoing progressive deformation is that during this deformation, loads applied to the energy absorbing module are not immediately transferred to the belly of the vehicle located above it. Thus, the energy absorbing module may absorb a considerable amount of energy before loads are transferred to the belly of the vehicle.

[0017] The energy absorbing module may comprise at least any one of the following:

- a structure adapted for progressive deformation; and
- at least one layer of energy absorbing material adapted for progressive deformation, e.g. metallic foam, for example, Aluminum foam.

[0018] In the latter case, said energy absorbing module may comprise a plurality of layers, at least one of which is made of said energy absorbing material. In particular, said energy absorbing material may constitute an intermediate layer and be positioned between two cover layers. The cover layers and the energy absorbing material may be attached to one another to form the energy absorbing module by gluing, pressing and the like. **1.** The cover layers may be made of a material which is, on the one hand, adapted for undergoing local fracture under application of a predetermined load and on the other hand, is relatively light-weight and high durability to environmental conditions (wind, water etc.). Such a material may be chosen from a family of fibrous materials capable of undergoing deformation when a load is applied thereto, which is localized to an area essentially less than the area of said surface of the module, without influencing the remainder of the cover layer. Examples of such a material may be fiberglass or basalt sheets. It is noted that for the present invention, fibrous materials such as Aramid will not suffice due to their lack of durability to environmental conditions, and lack of ability to undergo localized deformation as defined above.

[0019] The tendency of the energy absorbing material to undergo local deformation, demonstrates another advantage of the add-one armor, which is uniform application of load. More particularly, in the event of an explosion, in the absence of a base plate, the loads applied to the energy absorbing module may be very local, and thus entail only local deformation in the module, leading to a low absorption of energy. To the contrary, in the present invention, the explosion applies loads first to the base plate, which then uniformly transfers the loads through the module zone to the entire face of the energy absorbing module, thereby increasing its ability to absorb energy.

[0020] The base plate may be formed with a plurality of attachment ports, associated with corresponding attachment ports of the belly of the vehicle. In particular, the base plate may have belly portions extending generally parallel to the belly of the vehicle and side portions extending generally parallel to the side walls of the vehicle such that the attachment ports located on the belly portions are associated with attachment ports located on the belly of the vehicle, and the attachment ports located on the side portions are associated with attachment ports located on the side walls of the vehicle. Attachment between the attachment ports of the base plate and the attachment ports of the belly may be performed by bolts, welding etc.

[0021] The add-on armor may also comprise securing elements adapted for preventing the side portions of the base plate from detaching from the side walls of the vehicle under the impact of the force of the explosion on the belly portion of the base plate. Such securing elements may be adapted to be fitted between the base plate and the belly of the vehicle. According to a particular example, such a securing element may be a metal box having side faces attached to the vehicle belly and to a side portion and a belly portion of the base plate.

[0022] The base plate itself may be in the form of ballistic armor (referred herein as *'belly armor*'), e.g. having a construction and/or made of a material providing ballistic protection against the expected force of the explosion against which protection of the passengers of the vehicle is sought.

[0023] According to a particular example, the belly armor may extend generally parallel to the belly of the vehicle and adapted for providing additional ballistic protection to the belly of the vehicle. The belly armor may be made of a material providing ballistic protection, e.g. steel.

[0024] In order to increase its ballistic protection, the belly armor may have a special anti-ballistic design, for example, a V-shaped design. The base plate may be mounted onto the vehicle such that the apex of the V shape is the most remote point of the belly armor from the belly of the vehicle. Hereinafter, the term *'central portion'* will refer to the area of the apex of the belly armor, while the term *'peripheral portion'* will refer to areas of the belly armor surrounding the central portion. Such a V-shaped design may be adapted for diverting the energy of an explosion from the central portion towards the pe-

ripheral portion of the belly armor, and consequently towards the portions of the belly of the vehicle adjacent the side walls thereof.

[0025] The belly armor may be designed so as to have an increased ballistic protection at the central portion thereof than at the peripheral portion. Such an increase may be provided, for example, by the belly armor having an increased thickness at the central portion. According to a particular design, the central portion may be provided with an auxiliary armor sheet attached thereto at an external side thereof, i.e. such that, when the add-on armor is mounted onto the belly, the belly armor is disposed between the auxiliary sheet and the vehicle belly.

[0026] The auxiliary armor sheet may be made of a material similar to the material of the belly armor in its ballistic characteristics. According to a particular example, the belly armor and the auxiliary armor sheet may be separated therebetween by an intermediate layer adapted for interrupting energy dissipation between the auxiliary armor sheet and the belly armor itself. Such a material may be, for example, ballistic fabric, fiberglass, basalt sheet etc.

[0027] The belly armor may further be fitted with an internal energy absorbing member which is attached to an inner side of the belly armor and extending along the ridge formed by the V-shaped design of the base plate. Such an energy absorbing member may be generally similar in construction to the previously described energy absorbing module, i.e. it may also be adapted for performing progressive deformation. However, it should be noted that it is not restricted to the exact construction previously described, i.e. an intermediate layer and two cover layers.

[0028] The above described arrangement and manner of operation may allow the majority of energy of the explosion to be absorbed by the add-on armor (i.e. the belly armor and the energy absorbing modules), leaving only a minor amount of energy to be absorbed by the belly of the vehicle itself. Thus, passengers located within the vehicle are not subjected to considerable loads due to an explosion and remain generally protected.

[0029] The add-on armor according to the present invention may be particularly useful for vehicles having a low ground clearance. By *'ground clearance'* a vertical distance is meant which, when the vehicle is positioned on a reference surface, is measured between the lowermost point of the belly of the vehicle and the reference surface. In general, for energy conveyed by the same explosion, an armor of a vehicle having a low ground clearance will require to absorb substantially more energy than an armor of a vehicle with high ground clearance for providing a similar level of protection to the vehicle. The term 'low' with respect to ground clearance refers to a ground clearance which is not greater than 50mm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic cross-sectional view of a vehicle adapted for mounting thereon the add-on armor of the present invention, the cross-section being taken along a plane extending between side walls of the vehicle;

Fig. 2A is a schematic front isometric view of an add-on armor according to the present invention;

Fig. 2B is a schematic cross-section view of the add-on armor shown in Fig. 2A, taken along a plane perpendicular to a base plate of the add-on armor as shown by line I-I Fig. 2A;

Fig. 2C is a schematic enlarged view of the detail A shown in Fig. 2B;

Fig. 2D is a schematic rear isometric view of the add-on armor shown in Fig. 2A;

Fig. 2E is a schematic bottom isometric view of the add-on armor shown in Fig. 2A; and

Fig. 3 is a schematic isometric view of an energy absorbing module used in the add-on armor shown in Fig. 2A.

DETAILED DESCRIPTION OF EMBODIMENTS

[0031] With reference to Fig. 1, a vehicle, generally designated as **1** is shown comprising a hull having side walls **2** extending in a generally vertical direction and a belly **3** extending between the side walls **2** at the bottom of the vehicle **1** (i.e. generally parallel to the ground). The vehicle **1** further comprises a wheel base having an axle **4** with two wheels **5** mounted thereon. Inside the hull of the vehicle there are positioned two seats **6.**

[0032] The vehicle **1** may be a military vehicle, in which case protection thereof against various threats may be sought. For this purpose, attention is drawn to Figs. 2A to 2E in which an add-on armor generally designated **10** is shown comprising a base plate **20** and six energy absorbing modules **30.**

[0033] The energy absorbing modules **30** are disposed along predetermined locations of the base plate **20** (hereinafter referred to as *'module zones'* MZ) leaving vacant spaces between the modules **30** (hereinafter referred to as *'vacant zones'* VZ). The modules **30** are oriented so with respect to the base plate **20** that a face thereof facing the base plate **20** is almost fully covered by it.

[0034] In assembly, the add-on armor **10** is adapted to be mounted onto the belly **3** of the vehicle **1** as seen in Fig. 2B. The add-on armor is adapted to protect passengers located within the vehicle **1** (e.g. sitting on the seats **6)** from an external force applied to the belly **3** of the vehicle **1,** e.g. a force caused by an explosion. The add-on armor **10** is designed to absorb the majority of energy conveyed by the force of the explosion so that the belly **3** of the vehicle **1** itself absorbs only a part of the remainder of this energy.

[0035] It should be noted that the add-on armor **10** is designed according to the specific shape and dimensions of the vehicle **1.** Thus, the module zones MZ are chosen such that when the add-on armor **10** is mounted onto the vehicle **1**, no automotive components of the vehicle **1,** e.g. the axle **4,** are disposed between the energy absorbing modules **30** and the belly **3,** i.e. passing only above the vacant zones VZ of the base plate **20.**

[0036] Several advantages may arise from the above design, two of which are **load distribution** and **automotive protection:**

- **load distribution** - In the event of an explosion, loads applied by the explosion on the base plate **20** at a local area (hereinafter 'explosion zone' EZ) will be distributed to all the energy absorbing modules **30** located in the vicinity of the explosion zone EZ. It is appreciated that in the absence of a base plate **20** as described above, the only energy absorbing modules **30** to absorb the energy of the explosion would be those located at the explosion zone itself; and
- **automotive protection** - since no automotive components are located between the energy absorbing module **30** and the belly **3** of the vehicle **1,** and since most of the loads are taken on by the modules **30,** in the event of an explosion the chances of the automotive component/s to take on loads is reduced, making it less prone to damage. It should also be noted that while local structural damage to the hull of the vehicle **1** may be acceptable, damage to one of the automotive components may cause immobilization of the entire vehicle **1.**

[0037] The energy absorbing module **30** has a thickness **T** measured between the face of the energy absorbing module **30** facing the base plate **20** and a face opposite thereto. Thus, the minimal distance required between the base plate **20** and the belly **3** of the vehicle **1** when the add-on armor **10** is mounted onto the belly **3,** should be at least equal to the thickness **T** of the energy absorbing module **30.**

[0038] The energy absorbing module **30** is adapted for undergoing progressive deformation under the application of the load of the explosion. By progressive deformation, a deformation is meant which, contrary to regular plastic deformation, does not lead to simultaneous crushing of the entire mechanism, but rather successively compresses it, such that uncompressed portions of the mechanism maintain their integrity until they are compressed.

[0039] The arrangement is such that under the application of the above mentioned force, the energy absorbing module **30** is pressed upon from one side by the base plate **20** and from the other side by the belly **3,** applying a load to the module **30** which entails its deformation.

[0040] One advantage of such an energy absorbing module is that loads applied to the energy absorbing module **30** are not immediately transferred to the belly **3** of the vehicle **1** located above it. Rather, the energy absorbing module **30** absorbs a considerable amount of energy before loads are transferred to the belly **3** of the vehicle **1.**

[0041] With particular reference to Fig. 3, the energy absorbing module **30** comprises an intermediate layer **32** and two cover layers **34** confining the intermediate layer **32** from opposite sides thereof. The cover layers **34** and the intermediate layer **32** can be attached to one another by any conventional means such as gluing, pressing and the like. Reverting momentarily to Figs. 2A to 2E, the modules **30** are mounted on the base plate **20** such that one cover layer **34** faces the base plate **20** and the other cover layer **34** faces the belly **3** of the vehicle **1.** Due to a curved shape of the base plate **20,** the energy absorbing module **30** is provided with a support **36** located between a bottom cover layer **34** thereof and the base plate **20,** adapted for firmer positioning thereof on the base plate **20.**

[0042] The intermediate layer is made of a material adapted for performing progressive deformation, e.g. Aluminum foam. Such a material is adapted, under the application of a load, to become compressed (on account of its porous structure) and thereby absorb energy. Upon complete compression thereof, the material continues to absorb energy in a manner similar to regular metal (in this case Aluminum).

[0043] The cover layers **34** may be made of fibrous brittle materials, having the advantage, on the one hand, of being adapted for undergoing local fracture under application of a predetermined load and on the other hand, being light-weight and high durability to external conditions (wind, water etc.). In the present example, the cover layers are made of fiberglass. However, other materials chosen from a family of fibrous brittle materials may be used as cover layers, e.g. basalt sheet.

[0044] The tendency of the energy absorbing material to undergo local deformation, demonstrates another advantage of the add-one armor **10,** which is uniform application of load. More particularly, in the event of an explosion, in the absence of a base plate **20,** the loads applied to the energy absorbing module **30** may be very local, and thus entail only local deformation in the module, leading to a low absorption of energy. To the contrary, when using a base plate **20,** the explosion applies loads first to the base plate **20,** which then uniformly transfers the loads through the module zone MZ to the entire face (cover layer **34)** of the energy absorbing module **30,** thereby increasing its ability to absorb energy.

[0045] The base plate **20** has a central portion **22** and two peripheral portions **24,** arranged such that when mounted onto the vehicle **1,** the portions **22, 24** extend along the longitudinal direction of the vehicle **1,** i.e. between a front end thereof and a rear end thereof. Each portion **22, 24** has a respective top face **22**T, **24**T and a respective bottom face **22**B, **24**B, such that the energy absorbing modules **30** are mounted on the top faces **22**T, **24T**, and when the add-on armor **10** is mounted onto the

vehicle **1,** the top faces **22**T, **24**T face the belly **3** of the vehicle **1** and the bottom faces **22**B, **24**B face the ground (assuming the vehicle **1** is positioned on the ground it in its upright position). Thus, the energy absorbing modules **30** are confined between the top faces **22**T, **24**T of the base plate **20** and the belly **3** of the vehicle **1.**

[0046] The central portion **22** of the base plate **20** is formed with several attachment ports **26** adapted for attachment of the add-on armor **10** to the belly **3** of the vehicle **1.** In addition, the peripheral portions **24** of the base plate **20** are each fitted with three side extensions **40** and the central portion is fitted at one side thereof with a rear extension. The extensions **40, 50** are each formed with a respective base portion **42, 52** adapted for attachment to their respective central/peripheral portion **22, 24** (e.g. by welding), and a respective vehicle portion **44, 54** extending generally perpendicular to the base portion **43, 52** and formed with respective attachment ports **46, 56** adapted for attachment to the side walls **2** and rear wall (not shown) of the vehicle **1.**

[0047] The base plate **20** is further fitted with six structural integrity devices **60** located on the peripheral portions **24** of the base plate **20** adjacent the side extensions **40.** Each structural integrity device **60** comprises a bottom face **62** attached to the base portion **42** of the extension **40,** a side face extending perpendicularly thereto, and a top face **66** extending along the belly **3** of the vehicle **1.** The purpose of the structural integrity devices **60** will be explained in detail later with respect to the operation of the add-on armor **10.**

[0048] The base plate **20** is designed to function as a ballistic armor, and as such, has a construction and/or is made of a material providing ballistic protection against the expected force of the explosion against which protection of the passengers of the vehicle is sought.

[0049] In particular, both central portion **22** and peripheral portion **24** of the base plate **20** are made of High Hardness (HH) steel about 10mm thick, thus being adapted to protect the belly of the vehicle against various ballistic threats. In addition, the central portion **22** of the base plate **20** has a V-shaped, such that the apex **27** of the V-shape is the remote most point from the belly **3** when the add-on armor **10** is mounted onto the vehicle **1.** Such a V-shaped design is adapted for diverting the energy of an explosion from the central portion **22** towards the peripheral portions **24** of the base plate **20,** and consequently towards portions of the belly **3** of the vehicle **1** adjacent the side walls **2** thereof.

[0050] The central portion **22** of the base plate **20** is formed fitted with an auxiliary sheet **70** adapted to provide the central portion with increased thickness, and consequently with increased ballistic characteristics. The auxiliary sheet **70** is made of HH steel about 8mm thick. The auxiliary sheet **70** may be attached to the central portion **22** by bolts **73.** The auxiliary sheet **70** is separated from the central portion **22** by a buffer sheet **72** adapted for interrupting energy dissipation between the auxiliary sheet **70** and the central portion **22.** It is appreciated that were the auxiliary sheet **70** be attached directly to the central portion **22,** the energy dissipation therethrough would be almost equivalent to dissipation through 18mm of steel. The buffer sheet **72** is made of fiberglass material and is about 5mm thick.

[0051] In addition, the central portion **22** is fitted with an internal energy absorbing member **76** attached to the top face **22T** of the central portion **22** and extending along the ridge formed by the V-shaped of the central portion **22.** The energy absorbing member **76** is also adapted for progressive deformation, and is also made of Aluminum foam adapted for progressive deformation. The energy absorbing member **76** is held in place by a curved frame **74** attached to the central portion **22** on both sides **75** of the member **76.** The energy absorbing member is adapted to further absorb energy in the event of an explosion as will now be described.

[0052] In operation of the add-on armor **10,** in the event of an explosion in the vicinity of the belly of the vehicle, the energy of the explosion will first be absorbed by the base plate **20,** in particular by the central portion **22** thereof. Such absorption may cause deformation of the central portion **22** towards the belly **3** of the vehicle **1.** In this case, upward deformation of the central portion **22** will urge the V-shape to straighten, entailing pressing on the energy absorbing member **76** by the central portion **22** on one side and by the curved frame **74** on the other side. The energy absorbing member **76** will then progressively deform, absorbing some of the energy of the explosion.

[0053] Simultaneously, energy is diverted by the V-shape design of the central portion **22** to the peripheral portions **24,** also urging them to deform in an upward direction towards the belly **3** of the vehicle **1.**

[0054] Upon sufficient deformation of the central portion **22** and peripheral portions **24,** i.e. when the they reach a distance from the belly **3** of the vehicle **1** which is equal to thickness **T** of the energy absorbing module **30,** a load will be applied to the energy absorbing module **30,** due to it being pressed upon by the belly **3** of the vehicle **1** on one side and by the base plate **20** on the other side. Due to this load, the intermediate layer **32** of the energy absorbing module **30,** will begin to progressively deform, thereby absorbing and additional amount of energy of the explosion.

[0055] It should be understood that the upwards deformation of the central portion **22** of the base plate **20** causes a moment M to be applied to the vehicle portions **44** of the extensions **40,** causing them to detach from the side walls **2** of the vehicle **1.** However, due to the presence of the integrity devices **60,** the vehicle portion **44** of the extension **40** is prevented from detaching from the side wall **2** of the vehicle **1.**

[0056] Those skilled in the art to which this invention pertains will readily appreciate that numerous changes, variations, and modification can be made without departing from the scope of the invention, *mutatis mutandis.*

Claims

1. An add-on armor adapted for protecting a belly of a vehicle, said add-on armor comprising a base plate and a plurality of energy absorbing modules fitted to said base plate so that at least a majority of a surface of each energy absorbing module facing said base plate overlaps with the base plate at an area thereof constituting a module zone, the module zones associated with different modules being spaced from one another by vacancy zones.

2. An add-on armor according to Claim 1, wherein the vacancy zones of the base plate are disposed at locations corresponding to locations of automotive components of the vehicle, such that when the add-on armor is mounted onto the belly of the vehicle, the energy absorbing modules are located between the automotive components, and optionally such that no automotive component of the vehicle is disposed between each of said energy absorbing modules and the belly of the vehicle.

3. An add-on armor according to Claim 1 or 2, wherein the energy absorbing module is adapted for undergoing progressive deformation at least under the application of a load in a direction perpendicular to its surface facing said base plate.

4. An add-on armor according to Claim 3, wherein said energy absorbing module is in the form of at least one of the following:

   - an energy absorbing structure collapsible for providing said progressive deformation; and
   - a material capable of undergoing said progressive deformation.

5. An add-on armor according to Claim 4, wherein said material is a metallic foam, optionally aluminum foam.

6. An add-on armor according to Claim 4 or 5, wherein said energy absorbing module comprises several layers, one of which is constituted by said energy absorbing material.

7. An add-on armor according to Claim 6, wherein said energy absorbing module comprises an intermediate layer constituted by said material and two cover layers disposed on opposite sides thereof, optionally at least one of said cover layers being made of fibrous material capable of undergoing deformation when a load is applied thereto, which is localized to an area essentially less than the area of said surface of the module, without influencing the remainder of the cover layer.

8. An add-on armor according to Claim 7, wherein at least one of said cover layers is made of at least one of the following:

   - Fiberglass; and
   - Basalt sheet.

9. An add-on armor according to any one of the preceding Claims, wherein the base plate has side portions adapted to extend generally parallel to the side walls of the vehicle, when the armor is mounted thereon, and formed with attachment ports associated with attachment ports located on the side walls of the vehicle, and optionally the base plate is fitted with securing elements adapted for preventing the side portions from detaching from the side walls of the vehicle under application of corresponding moment thereto.

10. An add-on armor according to any one of the preceding Claims, wherein said base plate comprises a central portion and two peripheral portions, the central portion having a ballistic resistance greater than the peripheral portions.

11. An add-on armor according to Claim 10, wherein said central portion:

    - has a greater thickness than the peripheral portions; and/or
    - is fitted with an auxiliary armor sheet.

12. An add-on armor according to Claim 11, wherein said auxiliary armor sheet is separated from the central portion by an intermediate layer, optionally, said layer is made of fiberglass.

13. An add-on armor according to any one of the preceding Claims, wherein said base plate is fitted with an internal energy absorbing member which is attached to an inner side thereof and having a similar design to said energy absorbing module.

14. An armored vehicle comprising a hull and an add-on armor according to any one of Claims 1 to 13, said add-on armor being attached to said hull such that the energy absorbing modules are disposed between the base plate of said add-on armor and said hull.

15. An armored vehicle according to Claim 14, having a ground clearance which does not exceed 50cm.

16. An add-on armor for a vehicle comprising a hull having sidewalls and a belly extending therebetween at a bottom side of said vehicle, said add-on armor comprising a base plate adapted for being externally mounted onto said belly and at least one energy ab-

sorbing module adapted for undergoing progressive deformation under application of a load thereto, and for being disposed between said base plate and said belly, when the add-one armor is mounted onto said vehicle.

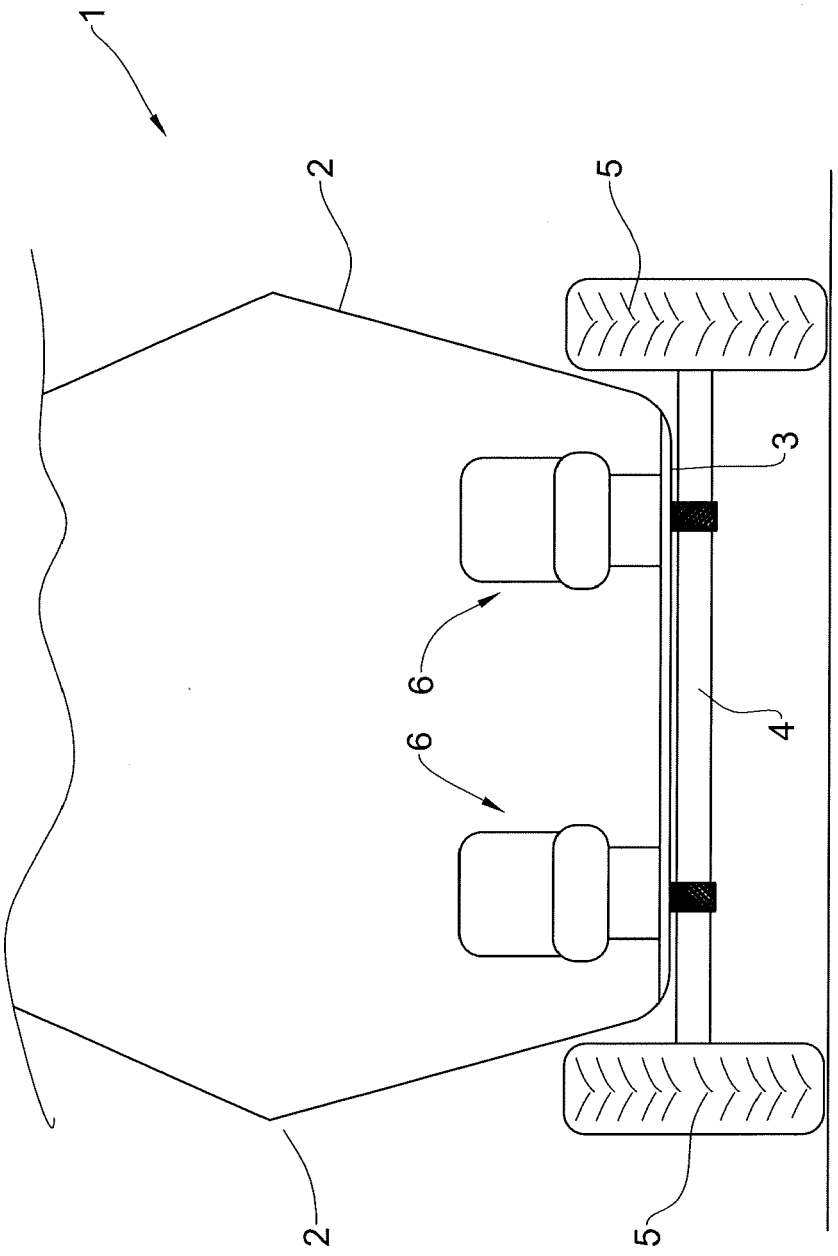

Fig. 1

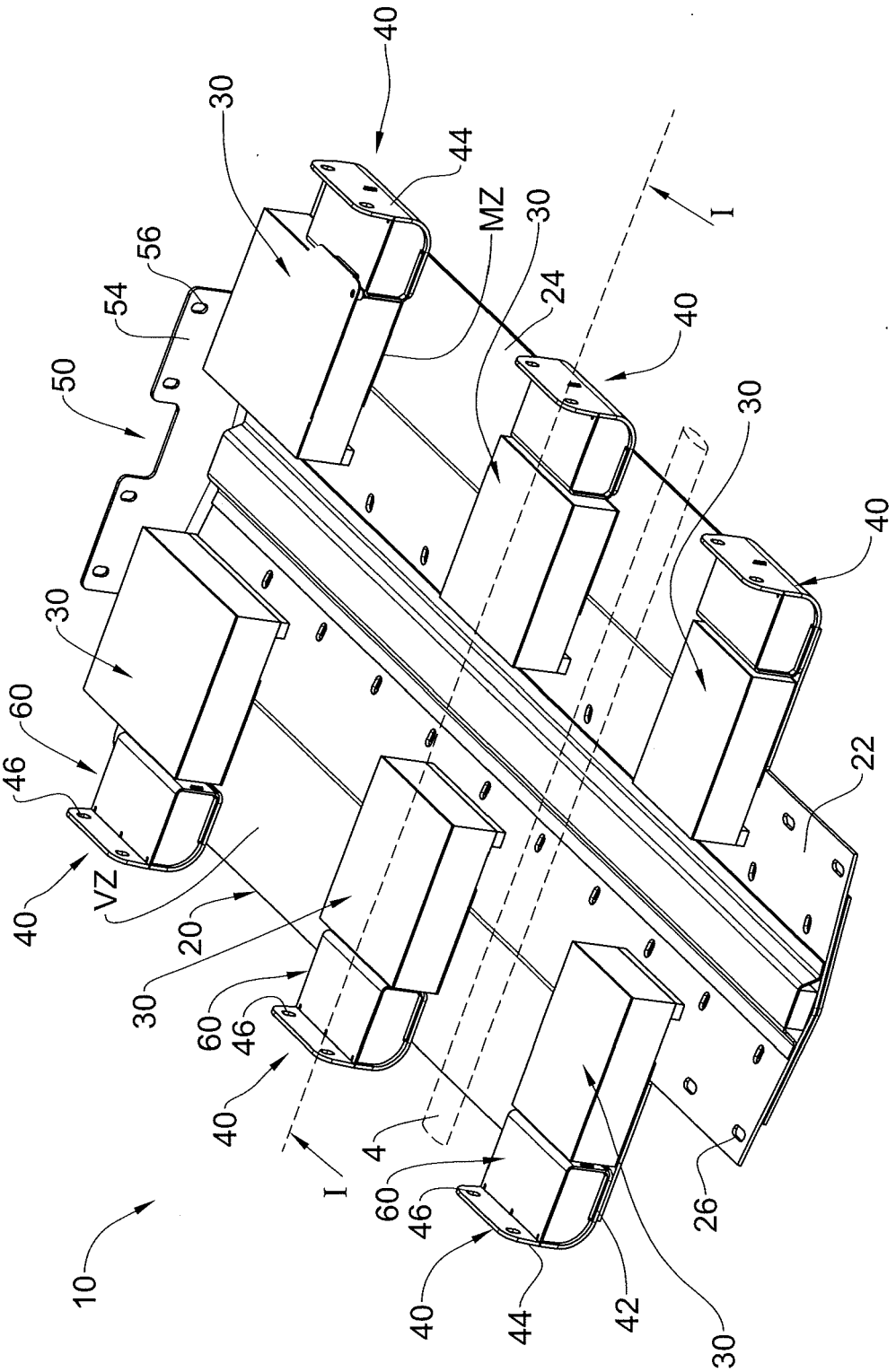
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Fig. 2A

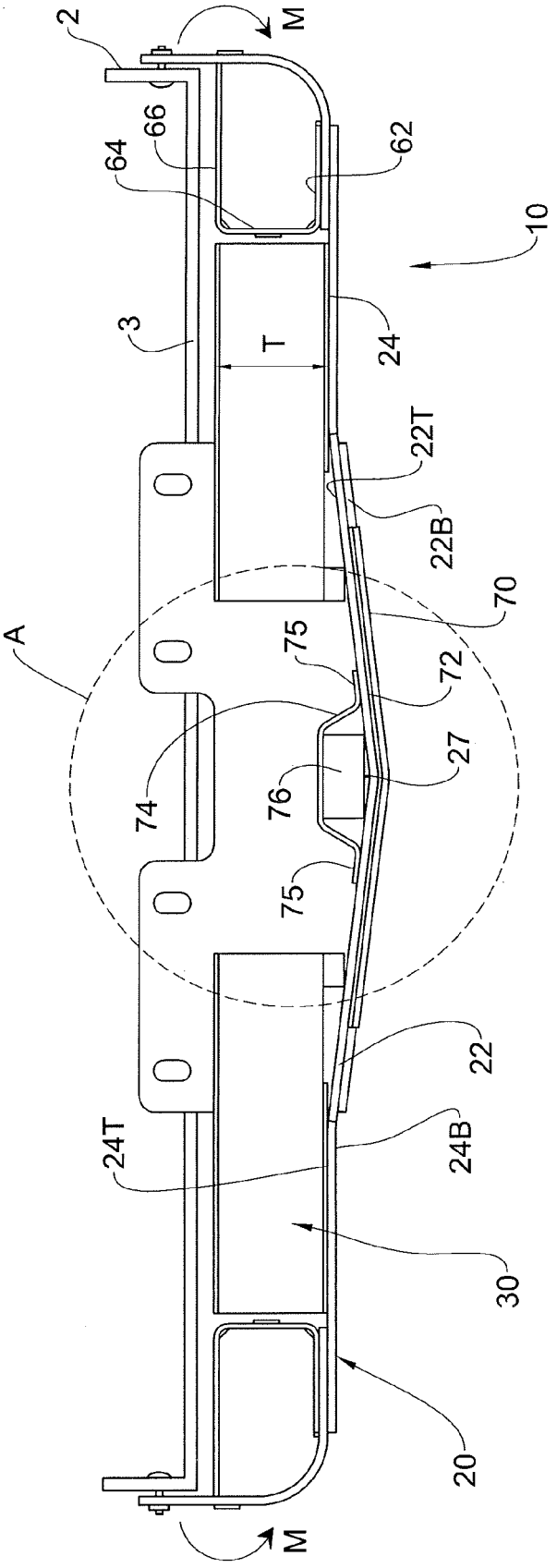

Fig. 2B

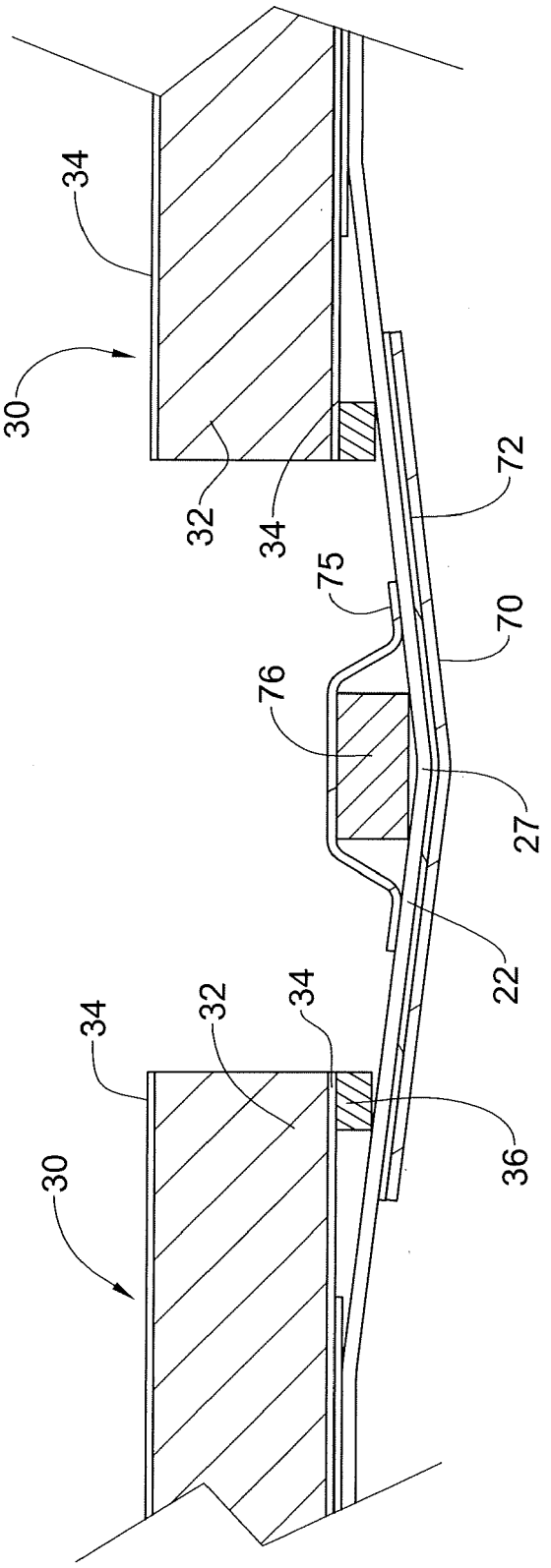

Fig. 2C

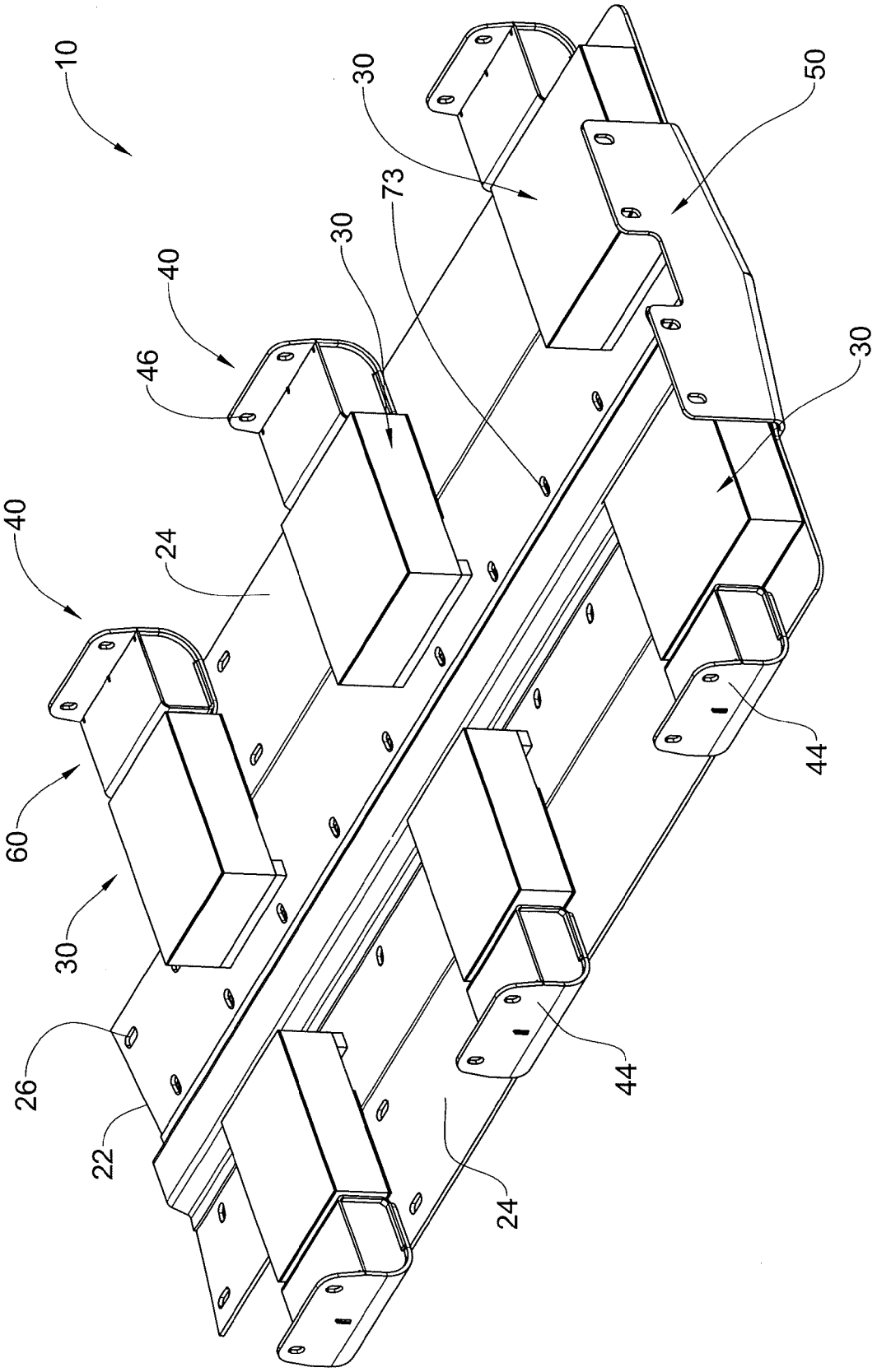

Fig. 2D

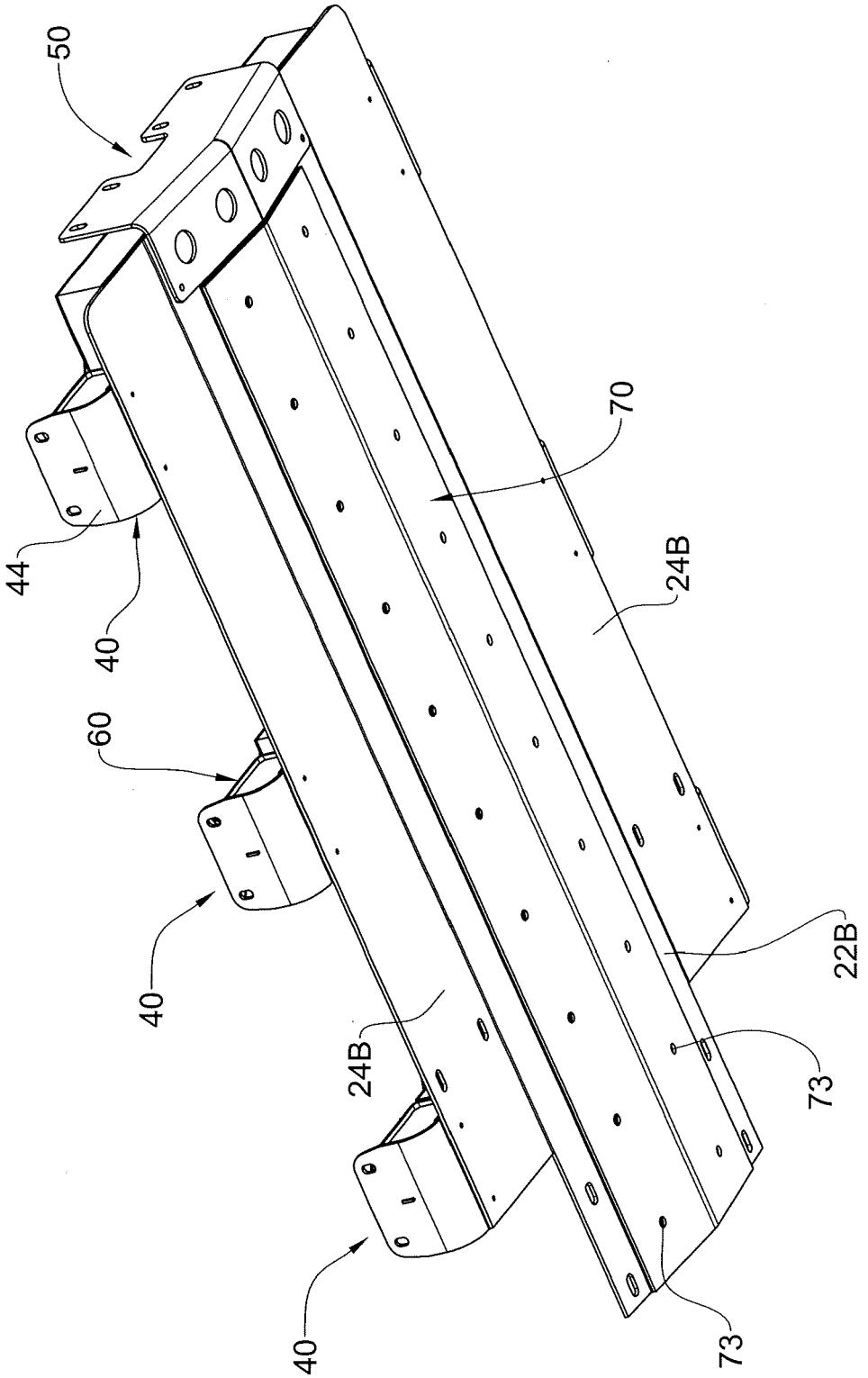

Fig. 2E

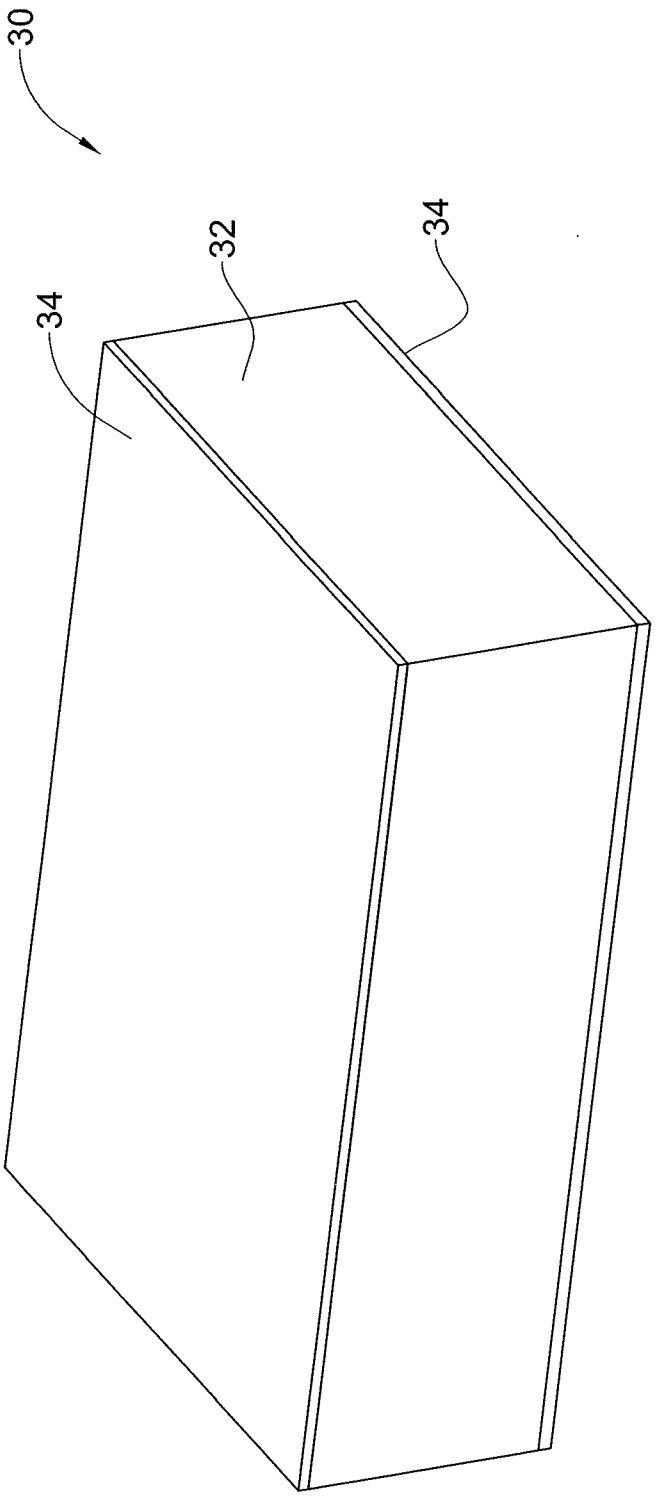

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5905225 A **[0004]**