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(54) **EXPLOSIVE ENERGY DISSIPATING CONNECTOR**

(57) Dissipating connector for protection of structures against explosions comprising a sacrificial panel (P), connected to the structure (E) to be protected by dissipating connectors for dissipating the energy resulting from explosions. The device of the invention comprises an energy sink (D) incorporating a first body of the energy sink (D.1), a core of the energy sink (D.2), a base plate of the energy sink (D.3) and a first body of the energy sink (D.4), a fixed body (F) that incorporates a box (F.1), a crushing punch (F.2), fixing holes (F.3), grooves (F.4), retainers (F.5), a fixing plate of the fixed body (F.6) and holes of the fixing plate of the fixed body (F.7), a removable body (A) incorporating a sliding plate (A.1), bearings (A.2), a guide of the removable body (A.3), a fixing plate of the removable body (A.4), holes of the fixing plate of the removable body (A.5), a hinge (R) that incorporates a plate (R.1), a fastening element (R.2) and a rotation limiting pin (R.3).

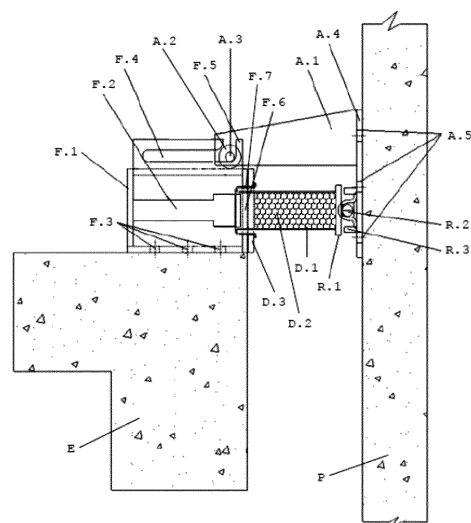


Fig. 1

Description

[0001] The present invention relates generally to the field of the construction of structures, more specifically to a device for dissipation of the energy of explosions for the protection of structures under explosions, comprising a sacrificial panel, linked to the structure to be protected through dissipating connectors with explosion energy absorption capacity, reducing and redistributing significantly the loading transmitted to the structure.

Framework of the invention

[0002] The use of precast concrete panels on building façades is not new and is itself an embodiment for fast and efficient application. The most current encapsulation embodiments use panels coupled to the existing structure through rigid elements that do not dissipate energy. In some cases, the outer structure is just juxtaposed to the existing structure, transferring all the loads imposed onto the elements in contact. This embodiment, being common in ordinary constructions, does not truly protect the critical elements or prevents the local collapse. Just adding dissipative devices to these planar elements does not solve the problem, as the maximum distance available to dissipate energy by plastic deformation is very small.

[0003] Research on the consequences of explosions in structures is vast, particularly for military purposes and for industrial facilities where there are explosive products, and also as a result of the need for states to protect their citizens from terrorist threats.

[0004] There are essentially three basic approaches for strengthening existing buildings to resist explosions:

- 1) Strengthening of structural elements and/or connections;
- 2) Allow existing elements to break and be collected by a retention system protecting the occupants of the debris projection; and
- 3) Protect a structural element from the blast loading by the addition of a new blast-resistant external element.

[0005] The first approach is the most studied, having been developed several protective embodiments based on high performance concrete, including the incorporation of fibres. There are also studies that try to solve the problem of masonry through its reinforcement, which normally focus on: adding mass to the system, increase the thickness by adding internal masonry walls, concrete walls, or walls based on metallic elements; adding metal elements in the internal side is also widespread, reducing the free span of walls. It is also well documented the use of elastomers bonded to the surface of walls to dissipate part of the energy induced by the explosion. The first ones have the disadvantage of significantly disrupting the activity of the occupants in terms of time needed for

the "hardening" process and the loss of interior space. The use of polymers offers good benefits for the strengthening of masonry, allowing a significant increase of bending ductility out of the wall plane. Most recently there were attempts to use other materials such as polymers and metallic foams, or structures with configurations that allow dissipation of energy (honeycomb).

[0006] However, despite the increased resistance obtained by the presented embodiments, none of them truly solves the instability and possible local collapse, with potential total structural collapse. In fact, for conventional explosions outside the target to be protected, the action is primarily local (e.g., in a column) and may progress into a global collapse (progressive collapse).

[0007] For this reason, it is important to protect the elements directly exposed, which leads to the third approach. Solutions have been studied that intend to adapt principles used in the automotive and aeronautical industries, using impact energy absorbing devices. The underlying idea is to convert, fully or partially, the kinetic energy in another kind of energy. Conversion can be reversible, if the device is kept in the linear elastic regime, or irreversible if a plastic deformation is imposed. The most common materials used for this purpose have been copper, aluminium and low carbon steels alloys. The lateral compression of tubular structures has inspired several investigations due to its adaptability as energy absorbing systems. A system of this type can consist of a single tube or a system of tubes. Being relatively effective, this system has some limitations and difficulties in its practical implementation, in terms of the considerable size of the device required (which becomes too intrusive), of deformable space available to absorb energy, and some randomness in the dissipation response, which makes it difficult to design.

[0008] The embodiments presented in this document are based on protecting a structure by using an energy absorbing device which allows flexible use in terms of physical dimensions, deformable course available (stroke) and materials used, keeping a highly stable energy dissipation behaviour during the dissipation process, allowing for adaption of its characteristics to existing or new structures, in order to absorb and redistribute the remnant energy of the explosion to the global structure, while protecting the essential supporting elements to the structural stability. In addition, it allows for mitigation of fragment propelling from fragile elements, usually present in façades, as it is an encapsulation system.

Background of the invention

[0009] Several documents were found in the state of the art referring devices for energy accommodation resulting from an explosion.

[0010] The document US2005144900A1 which presents a set of panels comprising plates with resin-impregnated fibre reinforcement layers with the objective of dampening the impact, preventing the formation of

secondary projectiles.

[0011] The document WO2014183607A1 which refers to interior wall partitions in buildings, for riot control (creating barriers) and to dissipate essentially impact energy, although explosions are also referred. It is based on a transparent panel (allowing the user to look through it) and in energy absorption through crushing of a single core system in a frame.

[0012] Reference is also made to document US5653062 which presents a device for protecting a structure against explosions which incorporates several sliding connectors, each one comprising a solid box rigidly coupled to a structural frame of the protected structure and a fixed device to a wall panel. Each box comprises a slot for the device. When the explosion occurs, the wall panel does not immediately transfer its momentum to the structure of the building but, remaining parallel to its starting position, distributes this transfer over a sequence of pendulum movements, thus considerably attenuating the impact of the explosion on vital structural elements of the building.

[0013] However, no document has been found that presents a device equal or similar to the device of the invention.

Advantages of the invention

[0014] The present invention intends to ensure that the element that receives the energy of the explosion is not in direct contact to the elements to be protected, using energy dissipating connectors at floor-level with a sufficient stroke to accommodate, by shortening, the intensity of an explosion.

[0015] The advantages of the present invention are varied, whether in terms of the protection of critical elements, or the possibility for the designer to use the space between the outer panel and the structure for filling with other absorbent materials, for example against fragmentation, or simply for placing thermal and/or acoustic insulation.

[0016] Ordinary structures are not designed to support charges due to explosions, so the collapse of certain vulnerable elements or in the vicinity of the explosion has high probability of occurring, with a high potential to form progressive collapse mechanisms, which can lead to the partial or complete collapse of the structure.

[0017] In contrast, the equipment of the present invention allows for the absorption of most of the loading generated by the explosion and redistribution of the remaining energy at the floor levels of the structure, thus endowing it with the capacity to resist the action of the explosion shock wave.

[0018] When the outer panel is actuated, it actuates the installed dissipating connector, which due to the compression begin to produce an external inversion of the tubular element(s) and simultaneously crushing the energy sink material contained internally. This process allows the partial absorption of the explosion transmitted

energy, depending on its magnitude and on the sizing of the dissipating connector, without direct energy transmission of the exterior panel to the remaining bearing structure through contact. The residual energy will be transmitted to the structure at the floor levels, mobilizing the resistance of the structure to horizontal actions. The energy dissipation achieved simultaneously through the two mechanisms presented (tube inversion and core crushing) allows an optimization of the dissipation with respect to dimension, allowing its use in multiple situations, beyond structural protection.

Brief description of the figures

[0019] These and other characteristics can be easily understood by means of the attached drawings, which are to be considered as mere examples and in no way restrictive of the scope of the invention. In the drawings, and for illustrative purposes, the measurements of some of the elements may be exaggerated and not drawn to scale. The absolute and relative dimensions do not correspond to the real ratios for the embodiments of the invention.

[0020] In a preferred embodiment:

Figure 1 shows a side sectional view of the dissipating connector of the invention.

Figure 2 shows details of the fixed body, with figure 2a showing a side view, figure 2b a plant view and figure 2c a front view.

Figure 3 shows a detail of the dissipating connector.

Figure 4 shows a detail of the removable body, with figure 4a showing a side view and figure 4b a front view.

Figure 5a presents a schematic representation of a first embodiment of the dissipating connector, before of an explosion.

Figure 5b presents a schematic representation of a first embodiment of the dissipating connector, after an explosion.

Figure 6a presents a schematic representation of a second embodiment of the dissipating connector, before of an explosion.

Figure 6b presents a schematic representation of a second embodiment of the dissipating connector, after an explosion.

Figure 7a presents a schematic representation of the dissipating connector, in a third embodiment, whose core is replaced by a tubular element (double inversion), before an explosion.

Figure 7b presents a schematic representation of the dissipating connector, in a third embodiment, whose core is replaced by a tubular element (double inversion), after an explosion.

[0021] In the figures are marked the elements and components of the equipment of the present invention:

- F. fixed body
 - F.1 - box
 - F.2 - crushing punch
 - F.3 - fixing holes
 - F.4 - grooves
 - F.5 - retainer
 - F.6 - fixing plate of the fixed body
 - F.7 - holes of the fixing plate of the fixed body
- A. removable body
 - A.1 - sliding plate
 - A.2 - bearing
 - A.3 - guide of the removable body
 - A.4 - fixing plate of the removable body
 - A.5 - holes of the fixing plate of the removable body
- D. energy sink
 - D.1 - first body of the energy sink
 - D.2 - core of the energy sink
 - D.3 - base plate of the energy sink
 - D.4 - second body of the energy sink
- R. hinge
 - R.1 - plate
 - R.2 - fastening element
 - R.3 - rotation limiting pin
- E. structure
- P. sacrificial panel

Detailed description of the invention

[0022] The present invention relates to an explosion energy dissipating connector.

[0023] The application of the principles described herein is not limited to the specific embodiments mentioned.

[0024] In addition, although certain embodiments presented incorporate multiple new features, these features can be independent and do not need to be all used together in a single embodiment.

[0025] Systems for protecting structures in accordance with the principles described in this document may comprise any number of the features shown.

[0026] By "design force" is meant the dimensioning effort of the dissipating connector that depends on the intensity of the considered blast loading.

[0027] With reference to the figures, the invention relates to an explosion energy dissipating connector for protection of structures (E) against explosions comprising:

- an energy sink (D) for absorbing the energy of the explosion by plastic deformation (tubular inversion

and crushing of a core);

- two bodies (A) (F) each positioned at one of the opposite ends of the energy sink (D) comprising:

- 5 - a fixed body (F) with one or more lateral surfaces that contains the energy sink (D) when the plastic deformation occurs;
- a removable body (A) that slides linearly over the fixed body (F) through a guide of the removable body (A.3) which slides over grooves (F.4) and is locked to the fixed body (F) by a retainer (F.5).

[0028] In a preferred embodiment:

- 15 - the explosion energy dissipating connector comprises a guide of the removable body (A.3) that slides over grooves (F.4) that control the linear shortening of the removable body (A) and the fixed body (F), each positioned at one of the opposite ends of the energy sink (D). The guide of the removable body (A.3), mounted on bearings (A.2), slides over grooves (F.4) which allows the system to be shortened by linear slide conditioned by the guide of the removable body (A.3) and by the grooves (F.4), preventing simultaneously the separation of the fixed body (F) and of the removable body (A);
- 20 - the dissipating connector comprises a fixing plate of the removable body (A.4) comprising holes of the fixing plate of the removable body (A.5) for passing of fasteners to fix the removable body (A) to the sacrificial panel (P);
- 25 - the dissipating connector comprises a fixing plate of the fixed body (F.6) including holes of the fixing plate of the fixed body (F.7) for fasteners to fix the fixed body (F) to the energy sink (D) through the base plate of the energy sink (D.3);
- 30 - the fixing plate of the fixed body (F.6) has a central hole that allows the inversion of the tubular element to its interior;
- the energy sink (D) comprises a tubular structure arranged axially in relation to the linear sliding movement between the fixed body (F) and the removable body (A);
- 35 - the first body of the energy sink (D.1) is made of metal or other ductile material, namely but not exclusively, in copper, aluminium or low carbon steel alloys;
- the first body of the energy sink (D.1) comprises several thin-walled tubes with circular section that invert externally;
- 40 - the mentioned thin-walled tubes are subjected to a process expansion and pre-inversion at one end;
- the first body of the energy sink (D.1) is filled with a core of the energy sink (D.2) being comprised of, namely, but not exclusively, metal or rock or cork high density foams or polymeric mortar, polymers, aramid, metallic, honeycomb structures, which ex-
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exploit simultaneously the inversion and crushing mechanism;

- the fixed body (F) includes a crushing punch (F.2) that penetrates inside the energy sink (D) during the inversion, crushing the core of the energy sink (D.2);
- the removable body (A) includes a unidirectional hinge (R) which is adjusted to the face of the energy sink (D) avoiding the introduction of moments in the first body of the energy sink (D.1).

[0029] Additionally, the explosion energy dissipating connector comprises a rigid sacrificial panel (P) to which a plurality of dissipating connectors are coupled to support said sacrifice panel (P).

[0030] In a preferred embodiment, the sacrificial panel (P) is made, namely, but not exclusively, in steel, reinforced concrete or mixed.

[0031] In a preferred embodiment, the dissipating connectors are formed by two independent bodies:

- a fixed body (F) comprising a box (F.1) that presents a substantially parallelepiped shape, which incorporates a crushing punch (F.2) inside for crushing the core of the energy sink (D.2), fixing holes (F.3) for passing of fasteners for fixing the fixed body (F) to the structure (E), two grooves (F.4) placed above the side walls of the box (F.1) on which the guide of the removable body (A.3) slides, a retainer (F.5) that prevents separation of the fixed body (F) and of the removable body (A), a fixing plate of the fixed body (F.6) that incorporates holes of the fixing plate of the fixed body (F.7) for fixing the fixed body (F) to the energy sink (D), and
- a removable body (A) which includes:
 - a sliding plate (A.1) that slides on bearings (A.2) supported by the guide of the removable body (A.3), fixed to the fixing plate of the removable body (A.4) that is connected to the sacrificial panel (P) through fasteners that pass through the holes of the fixing plate of the removable body (A.5).

[0032] In a first embodiment:

- an energy sink (D) fixed to the fixing plate of the fixed body (F.6) through fasteners that pass through holes of the fixing plate of the fixed body (F.7), which integrates:
 - a first body of the energy sink (D.1) that has a substantially thin-walled cylindrical shape, made of metal or other ductile material, and which is coupled to the base plate of the energy sink (D.3), and
 - a core of the energy sink (D.2) composed of material with cellular characteristics;

- a unidirectional hinge (R) that avoids deviating forces in the energy sink (D), comprising a plate (R.1), a fastening element (R.2) and a plate rotation limiting pin (R.3).

[0033] In a second embodiment (as illustrated in figures 6a and 6b), as an alternative to the core of the energy sink (D.2), the first body of the energy sink (D.1) is formed by an inner tubular element that inverts in the direction opposite of the main direction, being inside of said first body of the energy sink (D.1) a second body of the energy sink (D.4) whose energy absorption process runs simultaneously with the first body of the energy sink (D.1). The sacrificial panel (P) contains a hole in the area where the removable body (A) is attached. For this purpose, the fixing plate of the removable body (A.4) that attaches to the sacrificial panel (P) is provided with a hole that allows the development of the inversion process through it.

[0034] In a third embodiment (as illustrated in figures 7a and 7b), a second body of the energy sink (D.4), smaller in diameter, is placed sequentially and not inside the first body of the energy sink (D.1). In this configuration, the smallest diameter element works as a system trigger, which may be relevant for far explosions, where the pressures are very low, but the total impulse transmitted to the system is significant.

[0035] In a preferred embodiment, the alignment of the two bodies, that is, of the fixed body (F) and of the removable body (A) and the shortening of the energy sink (D) without deviations in the orthogonal directions are guaranteed by the guide of the removable body (A.3), by the grooves (F.4), and by the crushing punch (F.2). The available course for energy dissipation is defined by the linear dimension of the energy sink (D), which is variable depending on the total energy intended for dissipation. Thus, the shortening of the dissipating connector exploits the plastic deformation capacity by external inversion of the circular tubular elements, as well as the dissipative capacity of the core of the energy sink (D.2) due to crushing. The guide system comprises the guide of the removable body (A.3) and the grooves (F.4) that also have the particularity of limiting the maximum extension of the system, preventing the panel affected by the explosion from being dragged out of the structure by the action of the negative phase of the shock wave (suction).

Operating method

[0036] In the resting position, the guide of the removable body (A.3), which supports the bearings (A.2) at the end of the sliding plate (A.1) of the removable body (A), is fitted in the grooves (F.4), in the farthest apart position, guaranteed by placing the energy sink (D) between the two bodies (A) (F), but prevented from separation by the retainer (F.5).

[0037] In a first embodiment, when the shock wave reaches the sacrificial panel (P) which is connected to the fixing plate of the removable body (A.4), the sacrificial

panel (P) transmits the forces resulting from the explosion to the energy sink (D) which, if the design force is reached, starts the process of inversion into the fixed body (F), through the hole in one of its faces. If the core of the energy sink (D.2) is filled with some kind of material, it is crushed by the action of the crushing punch (F.2) as the shortening of the energy sink (D) occurs.

[0038] The correct functioning of the system is guaranteed by the linear shortening movement through the guide of the removable body (A.3) and grooves (F.4) that prevent the uncoupling or the occurrence of significant deviations in the movement of the system that can cause differential forces between supports. Still, the unidirectional hinge (R) with plate (R.1) or simple hinge joint prevents the introduction of moments in the first body of the energy sink (D.1) that would reduce the efficiency of energy absorption. The required inversion length depends on the energy that needs to be absorbed.

[0039] In a second embodiment when the shock wave reaches the sacrificial panel (P) that is connected to the removable body (A), the removable body (A) transmits the forces resulting from the explosion to the energy sink (D) which, if the design force is reached, starts the inversion process to the inside of the fixed body (F), through the existing hole on one of its faces. After a certain shortening, the crushing punch (F.2) touches the second tube of inversion whose process develops in the opposite direction, through a hole in the fixing plate of the removable body (A.4), to the interior of the existing hole in the sacrifice panel (P) that receives the explosion.

[0040] As before, the correct operation of the system is guaranteed by the linear movement of shortening through the guide of the removable body (A.3) and the grooves (F.4), which prevent the decoupling or the occurrence of significant deviations in the movement of the system, which can cause the introduction of differential forces between supports. In this configuration, the connector has two charge levels that allow an increase in the capacity of dissipated energy for the same available inversion length.

[0041] In a third embodiment when the shock wave reaches the sacrificial panel (P) that is connected to the removable body (A), the removable body (A) transmits the forces resulting from the explosion to the energy sink (D) which, if the design force is reached, starts the inversion process of the smaller diameter tube, into the larger diameter (telescopic inversion mechanism). When the available length is reached, the end plates of the two tubes come into contact and the inversion of the larger diameter tube starts to inside of the fixed body (F) through the orifice in one of its sides.

[0042] As before, the correct behaviour of the system is assured by the linear movement of shortening through the guide of the removable body (A.3) and the grooves (F.4) that prevent the decoupling or the occurrence of significant deviations in the movement of the system that can cause differential forces between supports. Still, the unidirectional hinge (R) comprises one solid circular or

semi-circular element coupled to the fixing plate of the removable body (A.4) that prevents the introduction of moments in the first body of the energy sink (D.1), which would cause the reduction efficiency in energy absorption. In this configuration, the device features two charge levels that allow an increase of the capacity of dissipated energy for the same available inversion length.

10 Claims

1. Explosion energy dissipating connector **characterized by** comprising:

- at least one energy sink (D), including a first body of the energy sink (D.1) and a base plate of the energy sink (D.3);
- a fixed body (F) comprising grooves (F.4) and a retainer (F.5) that prevents separation of a removable body (A) from the fixed body (F);
- the removable body (A) that comprises a guide of the removable body (A.3) that fits in the grooves (F.4) and allows linear sliding of the removable body (A) over the grooves (F.4); and
- the fixed body (F) and the removable body (A) placed each one at opposite ends of the at least one energy sink (D).

2. Connector according to claim 1, wherein the at least one energy sink (D) further comprises a core of a energy sink (D.2).

3. Connector according to the preceding claim, wherein the first body of the energy sink (D.1) is filled with the core of the energy sink (D.2).

4. Connector according to any of the claim 2 or 3, wherein the core of the energy sink (D.2) is comprised of metal or rock foams or high-density cork or polymeric mortar, polymers, aramid, metallic, honeycomb structures.

5. Connector according to claim 1, wherein the at least one energy sink (D) further comprises a second body of the energy sink (D.4).

6. Connector according to claim 5, wherein the second body of the energy sink (D.4) is inside the first body of the energy sink (D.1).

7. Connector according to claim 5, wherein the second body of the energy sink (D.4) is placed sequentially to the first body of the energy sink (D.1).

8. Connector according to any of the preceding claims, wherein the energy sink (D) comprises a tubular structure arranged axially in relation to the sliding linear movement between the fixed body (F) and the

removable body (A).

9. Connector according to any of the preceding claims, wherein the first body of the energy sink (D.1) is made of a ductile material. 5
10. Connector according to the preceding claim, wherein the ductile material is selected from: copper, aluminium and low carbon steel alloys. 10
11. Connector according to any of the preceding claims, wherein the first body of the energy sink (D.1) is comprised of several thin wall tubes with circular section. 15
12. Connector according to any of the preceding claims, wherein the dissipating connector further comprises a sacrificial panel (P). 20
13. Connector according to any of the preceding claims, wherein the sacrificial panel (P) is made of steel, reinforced concrete or mixed. 25
14. Connector according to any of the preceding claims, wherein the removable body (A) further comprises: a sliding plate (A.1), bearings (A.2), a fixing plate of the removable body (A.4) and holes of the fixing plate of the removable body (A.5), and by:
 - the sliding plate (A.1) sliding on bearings (A.2) supported by the guide of the removable body (A.3), 30
 - the sliding plate (A.1) being fixed to the fixing plate of the removable body (A.4),
 - the fixing plate of the removable body (A.4) being connected to the sacrificial panel (P) through fasteners that pass through the holes of the fixing plate of the removable body (A.5). 35
15. Connector according to any of the preceding claims, wherein the fixed body (F) comprises a box (F.1), a crushing punch (F.2), fixing holes (F.3) for passing of fasteners to fix the fixed body (F) to a structure (E) and a fixing plate of the fixed body (F.6) comprising holes of the fixing plate of the fixed body (F.7) to fix the fixed body (F) to the energy sink (D). 40 45
16. Connector according to any of the preceding claims, wherein the removable body (A) comprising a unidirectional hinge (R) that adjusts to the face of the energy sink (D). 50

Amended claims under Art. 19.1 PCT

1. Explosion energy dissipating connector comprising: 55
 - at least one energy sink (D), including a first body of the energy sink (D.1) and a base plate

of the energy sink (D.3);

- a fixed body (F) comprising grooves (F.4) and a retainer (F.5) that prevents separation of a removable body (A) from the fixed body (F);
- the removable body (A) that comprises a guide of the removable body (A.3) that fits in the grooves (F.4) and allows linear sliding of the removable body (A) over the grooves (F.4); and
- the fixed body (F) and the removable body (A) placed each one at opposite ends of the at least one energy sink (D), wherein the energy sink (D) comprises a tubular structure arranged axially in relation to the sliding linear movement between the fixed body (F) and the removable body (A).

2. Connector according to claim 1, wherein the at least one energy sink (D) further comprises a core of an energy sink (D.2).
3. Connector according to the preceding claim, wherein the first body of the energy sink (D.1) is filled with the core of the energy sink (D.2).
4. Connector according to any of the claim 2 or 3, wherein the core of the energy sink (D.2) is comprised of metal or rock foams or high-density cork or polymeric mortar, polymers, aramid, metallic, honeycomb structures.
5. Connector according to claim 1, wherein the at least one energy sink (D) further comprises a second body of the energy sink (D.4).
6. Connector according to claim 5, wherein the second body of the energy sink (D.4) is inside the first body of the energy sink (D.1).
7. Connector according to claim 5, wherein the second body of the energy sink (D.4) is placed sequentially to the first body of the energy sink (D.1).
8. Connector according to any of the preceding claims, wherein the first body of the energy sink (D.1) is made of a ductile material.
9. Connector according to the preceding claim, wherein the ductile material is selected from: copper, aluminium and low carbon steel alloys.
10. Connector according to any of the preceding claims, wherein the first body of the energy sink (D.1) is comprised of several thin wall tubes with circular section.
11. Connector according to any of the preceding claims, wherein the dissipating connector further comprises a sacrificial panel (P).

12. Connector according to any of the preceding claims,
wherein the sacrificial panel (P) is made of steel,
reinforced concrete or mixed.
13. Connector according to any of the preceding claims, 5
wherein the removable body (A) further comprises:
a sliding plate (A.1), bearings (A.2), a fixing plate of
the removable body (A.4) and holes of the fixing plate
of the removable body (A.5), and by:
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- the sliding plate (A.1) sliding on bearings (A.2)
supported by the guide of the removable body
(A.3),
 - the sliding plate (A.1) being fixed to the fixing
plate of the removable body (A.4), 15
 - the fixing plate of the removable body (A.4)
being connected to the sacrificial panel (P)
through fasteners that pass through the holes
of the fixing plate of the removable body (A.5).
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14. Connector according to any of the preceding claims,
wherein the fixed body (F) comprises a box (F.1), a
crushing punch (F.2), fixing holes (F.3) for passing
of fasteners to fix the fixed body (F) to a structure
(E) and a fixing plate of the fixed body (F.6) compris- 25
ing holes of the fixing plate of the fixed body (F.7) to
fix the fixed body (F) to the energy sink (D).
- 30
15. Connector according to any of the preceding claims,
wherein the removable body (A) comprises a unidi-
rectional hinge (R) that adjusts to the face of the en-
ergy sink (D).

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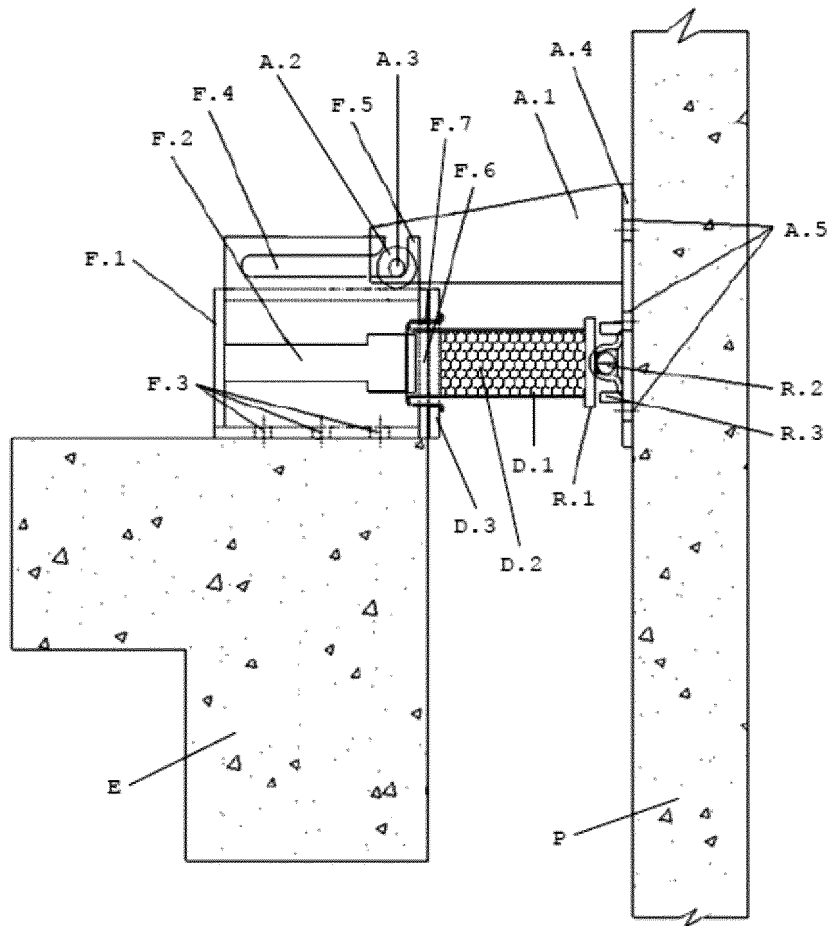


Fig. 1

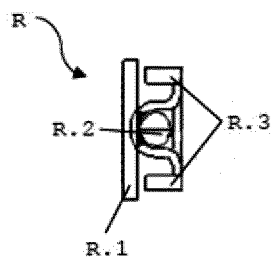


Fig. 1a

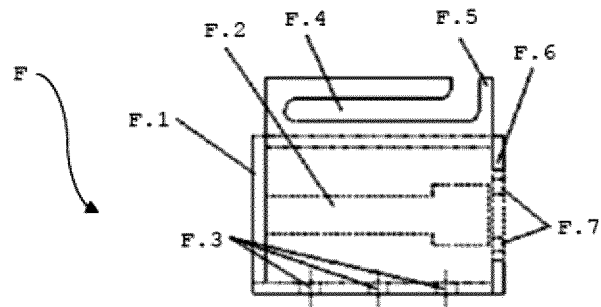


Fig. 2a

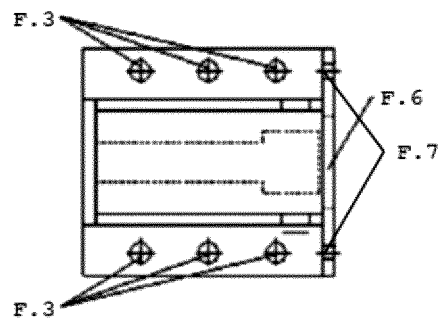


Fig. 2b

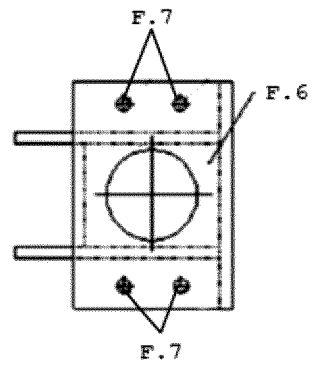


Fig. 2c

Fig. 2

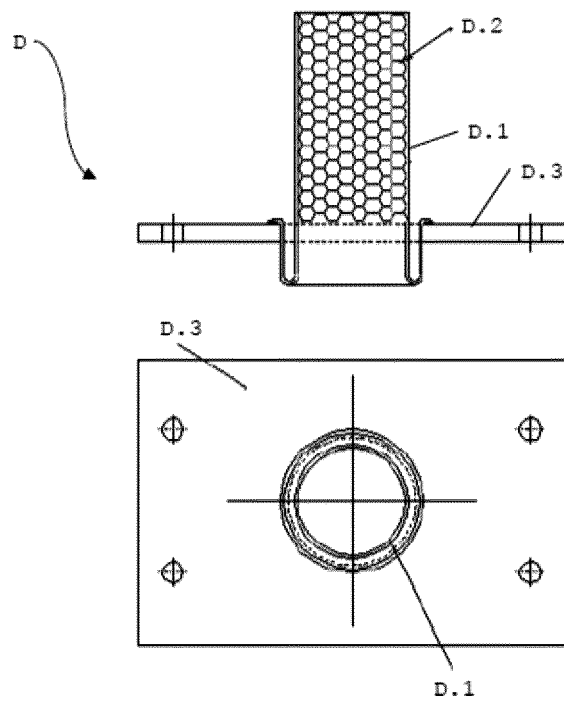


Fig. 3

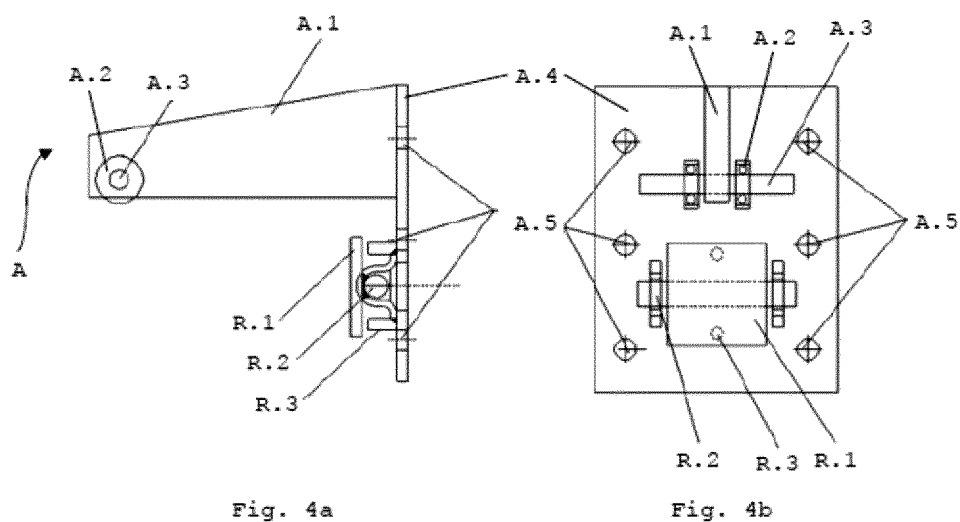


Fig. 4

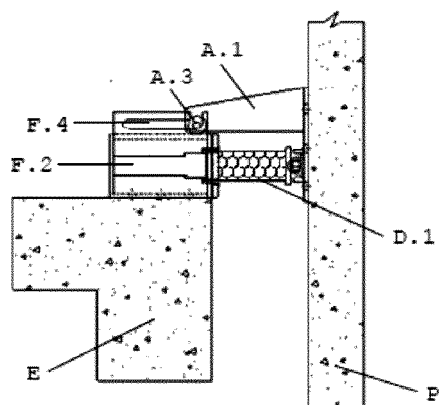


Fig. 5a

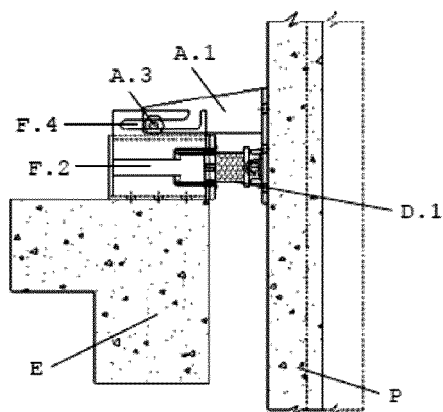


Fig. 5b

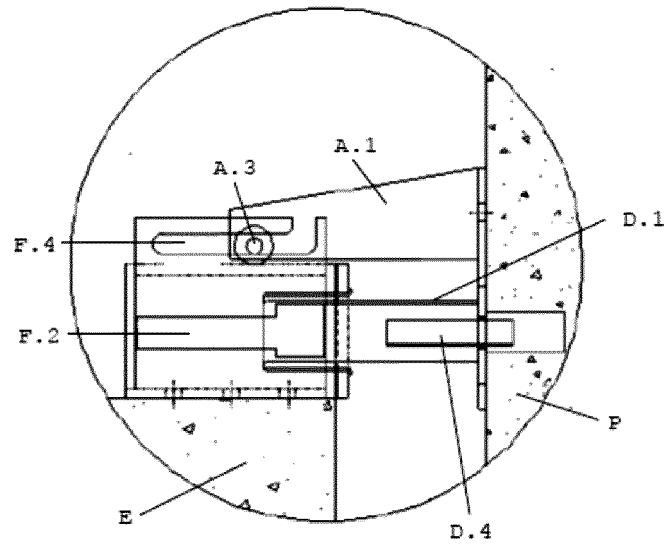


Fig. 6a

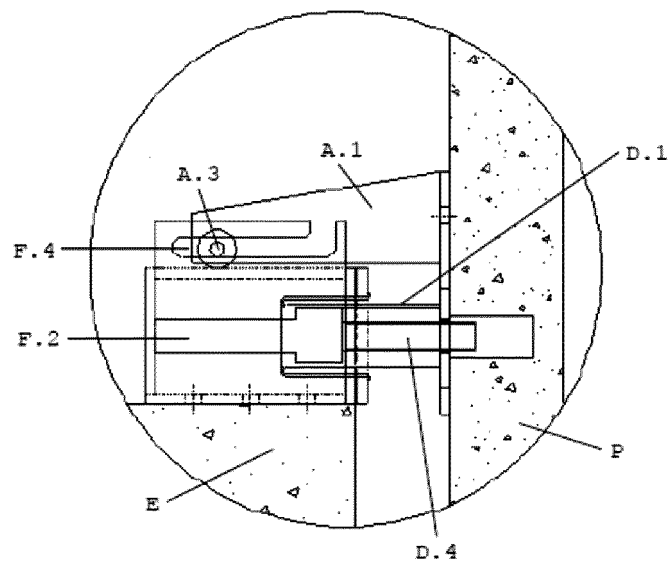


Fig. 6b

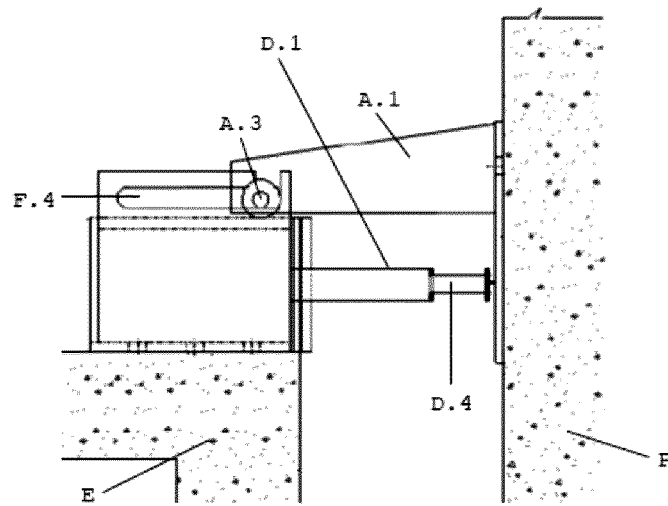


Fig. 7a

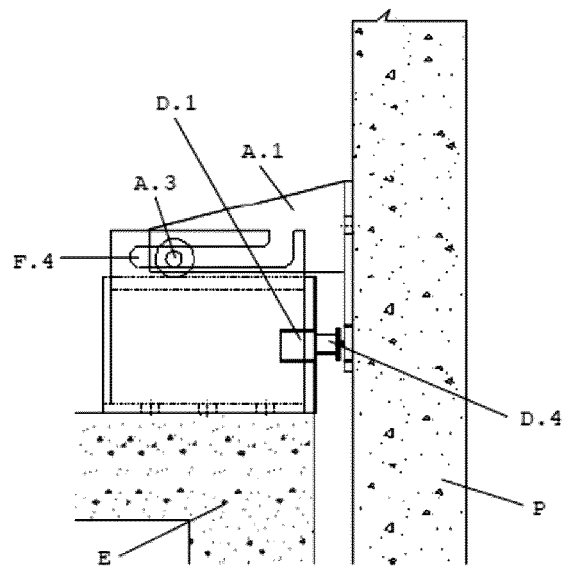


Fig. 7b

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2021/057723

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F41H5/013 F41H5/24
 ADD.

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)

F41H E04B E04H F42D

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2020/096473 A1 (INST SUPERIOR TECNICO [PT]; ACAD MILITAR [PT]) 14 May 2020 (2020-05-14)	1-7
A	abstract paragraph [0023] claims 1-6 figures	8-16
A	----- WO 2019/224853 A1 (PERMASTEELISA S P A [IT]) 28 November 2019 (2019-11-28) abstract page 6, line 4 - line 26 figures	1-16
A	----- KR 101 697 753 B1 (HILL ENG CO LTD [KR]) 18 January 2017 (2017-01-18) abstract; claim 1 figures	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

19 November 2021

Date of mailing of the international search report

26/11/2021

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Authorized officer

Vermander, Wim

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2021/057723

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KR 101697753 B1	18-01-2017	NONE	

REFERENCES CITED IN THE DESCRIPTION

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- WO 2014183607 A1 [0011]
- US 5653062 A [0012]