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(54) **EARTHQUAKE-RESISTANT STRUCTURE**

(57) An earthquake protection structure, applicable in the construction sector, comprising: a trench fill foundation (1) provided with a base (11) and side walls (12); a building formwork slab (2) comprising a floating slab (21) and side walls (22) respectively spaced from the base (11) and side walls (12) of the foundation (1); damping devices (3), arranged between the foundation (1) and the formwork slab (2); comprising helical springs (31) on

which the floating slab (21) of the formwork slab is supported by a lifting mechanism (32) of said floating slab (21); and devices (4) for limiting the horizontal movements of the formwork slab (2) comprising elastic elements (41) arranged around a column (2) fixed to the foundation (1) and received in holes in the floating slab (21) of said formwork slab.

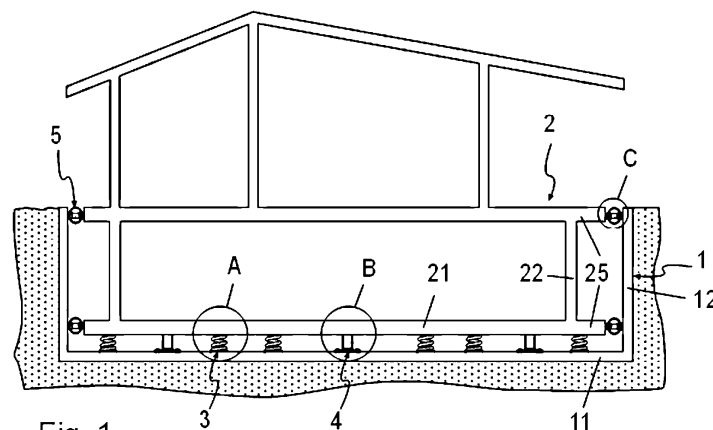


Fig. 1

Description

Technical Field

[0001] The present invention relates to an earthquake protection structure, applicable in the construction sector, and comprising: a trench fill foundation provided with a base and side walls; a formwork slab, comprising a floating slab of reinforced concrete and side walls respectively spaced from the base and side walls of the foundation, and damping devices, arranged between the foundation and the building formwork slab; said damping devices comprising helical springs, oriented vertically, on which the floating slab of the formwork slab is supported by a lifting mechanism for said floating slab.

[0002] The earthquake protection structure comprises devices for limiting the horizontal movements of the formwork slab with respect to the foundation; and possibly, in combination with said limiting devices, second elements for damping said horizontal movements.

Background Art

[0003] In the state of the art, it should be mentioned the existence of European patent EP 2 202 367, by the same applicant of the present invention, which describes a device for the placement of floating slabs of reinforced concrete, which is integrated into the reinforcement of the floating slab and which has a helical damping element, oriented vertically, for the support of said floating slab on a foundation, and a lifting mechanism that acts on the corresponding damping element.

[0004] A variable number of devices are integrated into the floating slab, suitably distributed, so that when the respective lifting mechanisms are actuated, the floating slab is raised and supported on the foundation by means of the damping elements.

[0005] This background focuses on the cube shape of the device that is integrated into the formwork slab and the arrangement, on the sides thereof, of horizontal tubes suitable for the introduction of fixing rods to the reinforcements of said floating slab.

[0006] In the position of use, that is, once the floating slab is set and raised, it is supported on the foundation by means of the helical dampers.

[0007] Other devices for the support and damping of floating slabs or floors, mentioned in said European patent EP 2 202 367, are described in documents FR 2 682 412 which has helical spring boxes and DE 4 012 493 which, instead of helical springs, uses pneumatically operated bellows.

[0008] The use of devices integrated into the floating slab and provided with damping elements constituted by helical springs, intended to support the floating slab and keep it vertically distanced from the foundation, provides a limited capacity for the damping of seismic movements with both horizontal and vertical force components.

Summary of the invention

[0009] The earthquake protection structure object of the invention is applicable in the construction sector and has technical characteristics that substantially improve the damping of seismic movements and the behaviour of the structure against said seismic movements.

[0010] This earthquake protection structure is of the type described in the preamble of the main claim and comprises a foundation, as a trench fill, provided with a base and side walls; a building formwork slab, comprising a floating slab of reinforced concrete and side walls respectively spaced from the base and side walls of the foundation; and damping devices against seismic forces, arranged between the foundation and the building formwork slab; said damping devices comprising helical springs, oriented vertically, on which the floating slab of the formwork slab is supported by a lifting mechanism for the floating slab.

[0011] This earthquake protection structure combines the aforementioned support and lifting damping elements for the floating slab with elements that limit the horizontal movements of the formwork slab with respect to the foundation, resulting in synergies that contribute to substantially improving the damping of the seismic movements and the behaviour of the structure against said seismic movements.

[0012] According to the invention, the floating slab of the formwork slab comprises vertical through holes that receive devices for limiting, and dampening, the horizontal movements of the formwork slab with respect to the foundation; said devices for limiting horizontal movements comprising elastic elements arranged around a column anchored to the base of the foundation, fixed to said column and facing the side walls of the corresponding vertical hole (of the formwork slab).

[0013] It should be mentioned that said elastic elements can be elastic metal cushions, springs, rubber pads or any others with elastic properties.

[0014] In the event of a seismic movement, the elastic elements initially work together with the helical springs in the absorption of the horizontal movements, compressing laterally against the columns anchored to the base of the foundation, limiting the possibility of horizontal movement of the formwork slab with respect to the foundation.

[0015] This limitation of the amplitude of horizontal movement of the formwork slab with respect to the foundation, caused by the elastic elements and the support columns thereof, in addition to contributing with the helical springs in the damping of said movements, prevents said helical springs from undergoing unlimited horizontal stress and from being damaged or allowing a lateral displacement of the formwork slab, detrimental to the whole of the earthquake protection structure.

[0016] In this invention, it has been provided that the earthquake protection structure can incorporate second elements for damping horizontal movements of the formwork slab, arranged between the side walls of the foundation and the side walls of the formwork slab.

dation and extensions that protrude laterally from the floating slab and the side walls of the slab.

Brief description of the contents of the drawings

[0017] In order to complement the description that is being carried out and with the purpose of facilitating the understanding of the characteristics of the invention, the present description is accompanied by a set of drawings wherein, by way of an illustrative and non-limiting example, the following has been represented:

- Figure 1 shows an elevational view of an exemplary embodiment of the earthquake protection structure object of the invention, with the formwork slab of a building supported on a foundation by means of devices for damping, and with devices for limiting and damping the horizontal movements of the formwork slab with respect to the foundation.
- Figure 2 shows a bottom plan view of the formwork slab, in which an example of the distribution of the devices for damping and the devices for limiting and damping the horizontal displacements of said formwork slab with respect to the foundation can be seen.
- Figure 3 shows an enlarged view sectioned by a vertical plane of the detail (A) indicated in Figure 1, and in which one of the devices for damping and supporting the formwork slab on the foundation can be seen.
- Figure 4 shows a top plan view of the damping device of Figure 3.
- Figure 5 shows an enlarged view sectioned by a vertical plane of the detail (B) indicated in Figure 1, and in which one of the devices for limiting and damping horizontal movements of the formwork slab can be seen, which are received in a vertical through hole of the floating slab of the formwork slab, provided with elastic elements, constituted in this embodiment by elastic metal cushions fixed around a column anchored to the foundation and which, in this example, has a one-piece body.
- Figures 6 and 7 respectively show a perspective view and a top plan view of the device for limiting and damping horizontal movements of Figure 5.
- Figure 8 shows a view analogous to that of Figure 5, of a variant embodiment of the device for limiting and damping horizontal movements in which the column comprises a lower section, carrying the foundation anchoring foot, and a removable upper section to which the elastic metal cushions are laterally fixed.
- Figure 9 shows an enlarged view of the detail (C)

indicated in Figure 1 and in which an exemplary embodiment of second elements for damping horizontal movements has been represented which, as shown in said Figure 1, are arranged between lateral extensions of the formwork slab and the lateral walls of the foundation.

- Figure 10 shows a plan view of the second elements for damping horizontal movements of Figure 9.

Detailed explanation of embodiments of the invention

[0018] The earthquake protection structure shown in Figure 1 comprises a trench fill foundation (1) provided with a base (11) and side walls (12), and a formwork slab (2) of the building comprising a floating slab (21) and side walls (22), respectively spaced from the base (11) and side walls (12) of the foundation (1).

[0019] The earthquake protection structure comprises damping devices (3) arranged between the foundation (1) and the formwork slab (2), responsible for supporting the weight of the building as a whole.

[0020] As shown in Figure 2, these damping devices (3), as well as the devices (4) for limiting and damping horizontal movements that will be described later, are suitably distributed on the surface of the floating slab (21).

[0021] In the embodiment shown in Figures 3 and 4, the damping devices (3) comprise a helical spring (31), oriented vertically, on which the floating slab (21) is supported by a lifting mechanism (32) of said floating slab (21).

[0022] Said lifting mechanism (32) is mounted on a metal cube (33) that is fixed to the reinforcement (23) of the floating slab (21), prior to the pouring of the concrete forming said floating slab (21) so that, once the concrete has set, said metal cube (33) is embedded in said floating slab (21) delimiting therein a vertical hole where the helical spring (31) with its lifting mechanism (32) is located.

[0023] The metal cube (33) is provided, at two opposite corners at the top, with oblique stops (34) that define a gap of sufficient amplitude for the insertion therein of the helical spring (31) and the lifting mechanism (32) of the floating slab (21).

[0024] This lifting mechanism (32) of the floating slab (21) comprises a screw (35) for tightening the helical spring (31), threadedly mounted on a crosspiece (36) whose ends are arranged, by means of a horizontal rotation movement, below said oblique stops (34).

[0025] By operating the lifting mechanism (32) of the damping devices (3), lifting of the floating slab (21) is achieved, which is supported on the base (11) of the foundation (1) by means of the helical springs (31).

[0026] The floating slab (21) of the formwork slab (2) further comprises vertical through holes (24) in which the devices (4) for limiting and damping horizontal movements of the formwork slab (2) with respect to the foun-

ation (1) are received.

[0027] Said devices (4) for limiting horizontal movements comprise, as shown in Figures 5 to 8, elastic elements (41), constituted in this example by elastic metal cushions, arranged around a column (42) anchored to the base (11) of the foundation (1), fixed to said column (42) by screws, and facing the side walls of the corresponding vertical hole (24) of the floating slab (21). Preferably, as shown in the exemplary embodiment, the column will be prismatic, with an elastic element (41) being positioned on each of its sides.

[0028] In the embodiment shown in Figure 5, the side walls of the vertical holes of the floating slab (21) are constituted by a metal box (43) open at the upper and lower ends and fixed to the reinforcement (23) of said floating slab (21) prior to the pouring of the concrete forming said floating slab (21), similarly to the metal cubes (33) of the damping devices (3) so that, once the concrete has set, both the metal cubes and the metal boxes (43), which are also prismatic, are embedded in the floating slab (21).

[0029] The metal cubes (33) and the metal boxes (43) have the same height and, once fixed to the reinforcement (23), concrete is poured onto the reinforcement (23) until reaching the same height as the metal cubes and boxes; in this way, once the concrete is set, both the metal cubes (33) and the metal boxes (43) are embedded and flush with the upper and lower surfaces of the floating slab (21).

[0030] In Figure 5 to 8, one of the devices (4) for limiting horizontal movements and the corresponding metal box (43) are shown.

[0031] The columns (42) of the devices (4) for limiting horizontal movements comprise a support foot (44) on the foundation base (11) and anchoring screws (45) to the foundation (1), said anchoring screws being accessible through the interior of the vertical holes (24) of the floating slab (21) of the formwork slab, in this case of the metal box (43) that forms the side walls of said vertical holes (24).

[0032] In the exemplary embodiment shown in Figures 5 to 7, the columns (42) have a one-piece body and the elastic elements (41) are laterally fixed, by means of screws, to an area near the upper end of each side of said columns (42).

[0033] In this embodiment, the assembly and tightening of the anchoring screws (45) of the foot (44) to the base (11) of the foundation must be carried out through the spaces between the elastic elements (41), visible in Figure 7, which may involve some discomfort due to the limitation of the access space.

[0034] To facilitate this access, the invention contemplates a variant embodiment shown in Figure 8, in which the column (42) does not have a one-piece body, but comprises: a lower section (42a) carrying the foot (44), a removable upper section (42b), to which the elastic elements (41) are laterally fixed, and at least one screw or fixing element (46) of the upper section (42b) to the lower

section (42a), once the anchoring screws (45) of the foot (44) are fixed to the base of the foundation.

[0035] In the embodiment shown in Figure 1, the floating slab (21) and the side walls (22) of the formwork slab (2) comprise extensions (25) that protrude laterally from the floating slab (21) and the side walls (22) of the formwork slab (2) towards the side walls (12) of the foundation (1), and second elements (5) for damping horizontal movements of the formwork slab, arranged between the side walls (12) of the foundation and said extensions (25) of the formwork slab.

[0036] Figures 9 and 10 show an exemplary embodiment of said second elements (5) for damping horizontal movements, comprising helical cables (51), whose coils are fixed by areas diametrically opposite to parallel plates (52), forming respective contact surfaces with the side walls (12) of the foundation and with the extensions (25) of the floating slab (21) and the side walls (22) of the formwork slab.

[0037] In this embodiment, the second elements (5) for damping horizontal movements comprise at least one elastic element (53) between the parallel plates (52). This elastic element (53) may also consist of an elastic metal cushion, a rubber plug, a spring or any other element or material with elastic properties.

[0038] Once the nature of the invention as well as a preferred exemplary embodiment have been sufficiently described, it is stated for all pertinent purposes that the materials, form, size and arrangement of the described elements are susceptible to changes, provided these do not involve an alteration of the essential features of the invention which are claimed below.

Claims

1. An earthquake protection structure, applicable in the construction sector, comprising: a trench fill foundation (1), provided with a base (11) and side walls (12); a building formwork slab (2) comprising a floating slab (21) and side walls (22) respectively spaced from the base (11) and side walls (12) of the foundation (1), and damping devices (3) against seismic forces, arranged between the foundation (1) and the building formwork slab (2); said damping devices (3) comprising helical springs (31), vertically oriented, on which the floating slab (21) of the formwork slab is supported by a lifting mechanism (32) of said floating slab (21); **characterised in that** the floating slab (21) of the formwork slab comprises vertical through holes (24) in which devices (4) for limiting and damping the horizontal movements of the formwork slab (2) with respect to the foundation (1) are received; said devices (4) for limiting horizontal movements comprising elastic elements (41) arranged around a column (42) anchored to the base (11) of the foundation (1), fixed to said column (42) and facing the side walls of the corresponding vertical gap (24) of the

formwork slab (2).

2. The earthquake protection structure according to claim 1, wherein the side walls of the vertical holes (24) of the floating slab (21) are constituted by a metal box (43) open at the upper and lower ends and fixed to a reinforcement (23) of said floating slab (21). 5

3. The earthquake protection structure according to any of claims 1 and 2, wherein the columns (42) comprise a support foot (44) on the base (11) of the foundation (1) and anchoring screws (45) of the foot (44) to the foundation (1), said anchoring screws (45) being accessible through the interior of the vertical holes (24) of the floating slab (21) of the formwork slab (2). 10 15

4. The earthquake protection structure according to claim 3, wherein the columns (42) have a one-piece body and the elastic elements (41) are laterally fixed to an area near the upper end of said columns (42). 20

5. The earthquake protection structure, according to claim 3, wherein the columns (42) comprise: a lower section (42a) carrying the foot (44), a removable upper section (42b), to which the elastic elements (41) are laterally fixed, and at least one screw or fixing element (46) of the upper section (42b) to the lower section (42a) once the anchoring screws (45) of the foot (44) are fixed to the base (11) of the foundation (1). 25 30

6. The earthquake protection structure according to claim 1, comprising second elements (5) for damping horizontal movements, arranged between the side walls (12) of the foundation and extensions (25) that protrude laterally from the floating slab and the side walls of the formwork slab. 35 40

7. The earthquake protection structure according to claim 6, wherein the second elements (5) for damping horizontal movements comprise helical cables (51), the coils of which are fixed by areas diametrically opposite to respective parallel plates (52), forming respective contact surfaces with the side walls (12) of the foundation (1) and with the extensions (25) of the floating slab (21) and the side walls (22) of the formwork slab. 45 50

8. The earthquake protection structure according to claim 7, wherein the second elements (5) for damping horizontal movements comprise at least one elastic element (53) between the parallel plates (52). 55

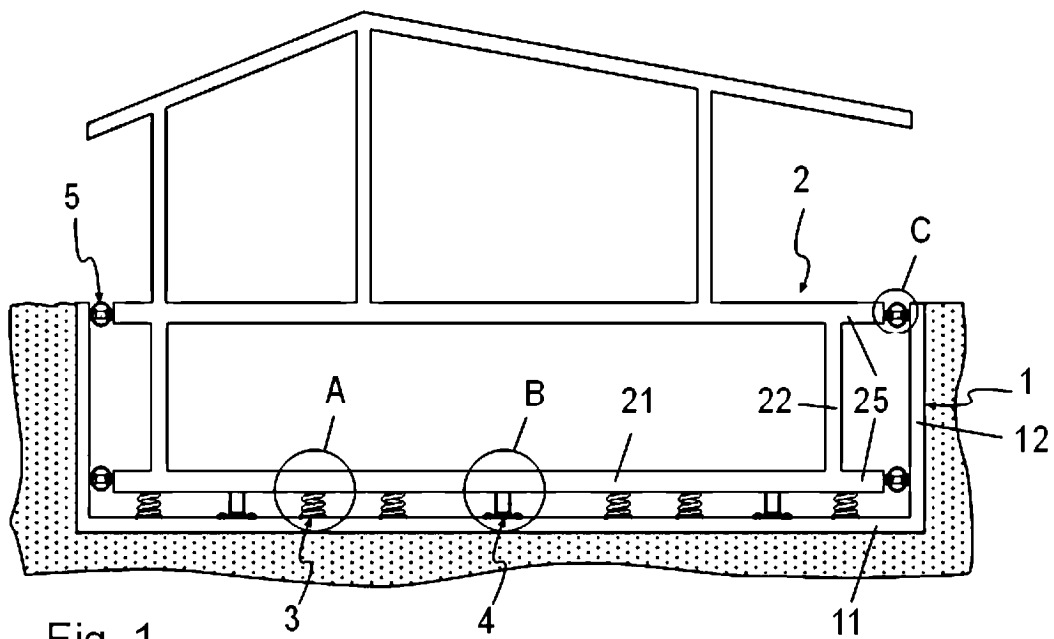


Fig. 1

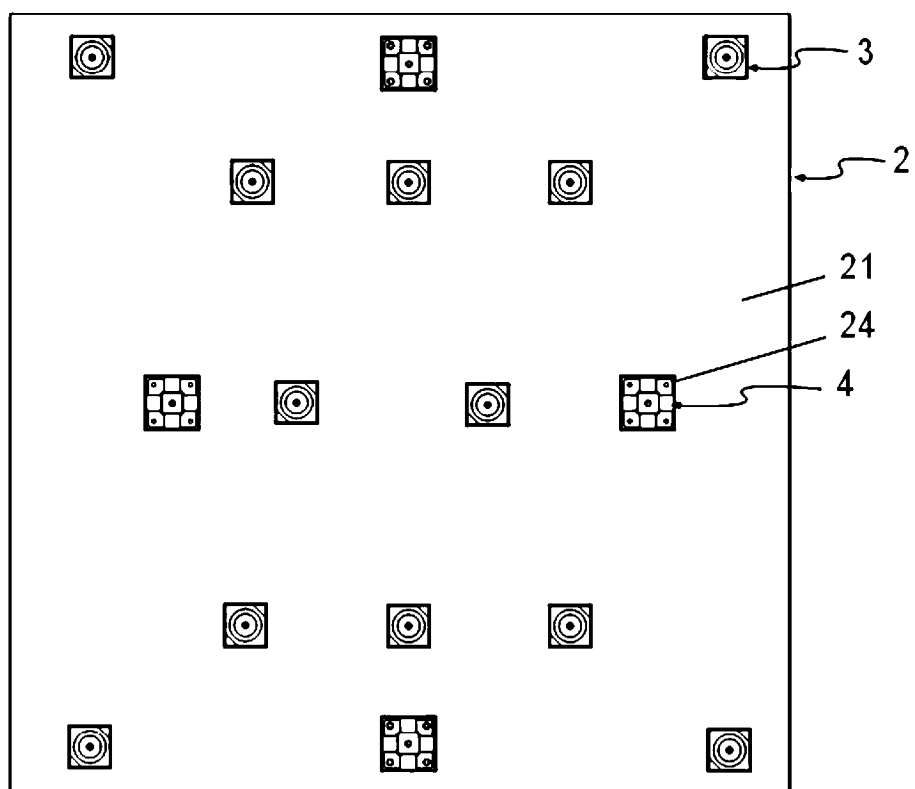
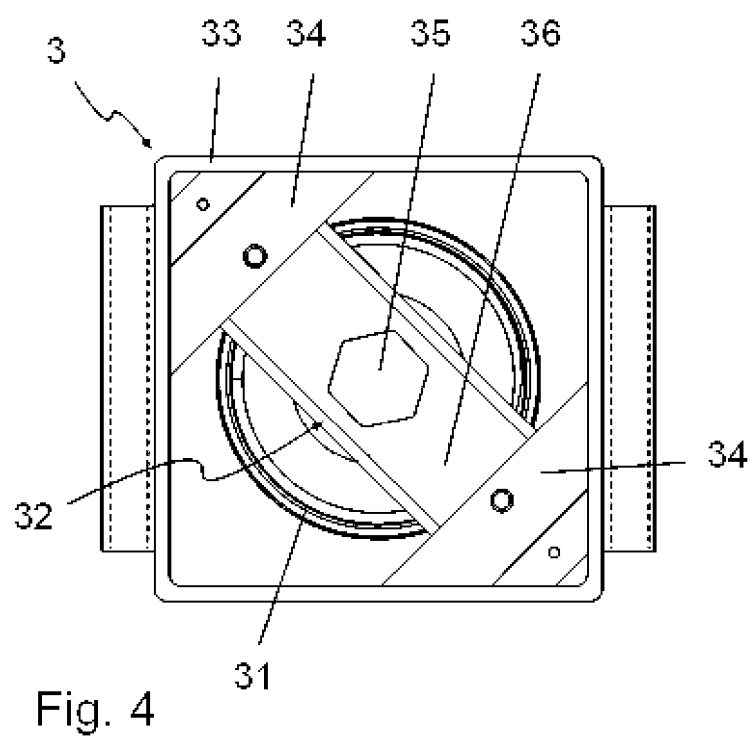
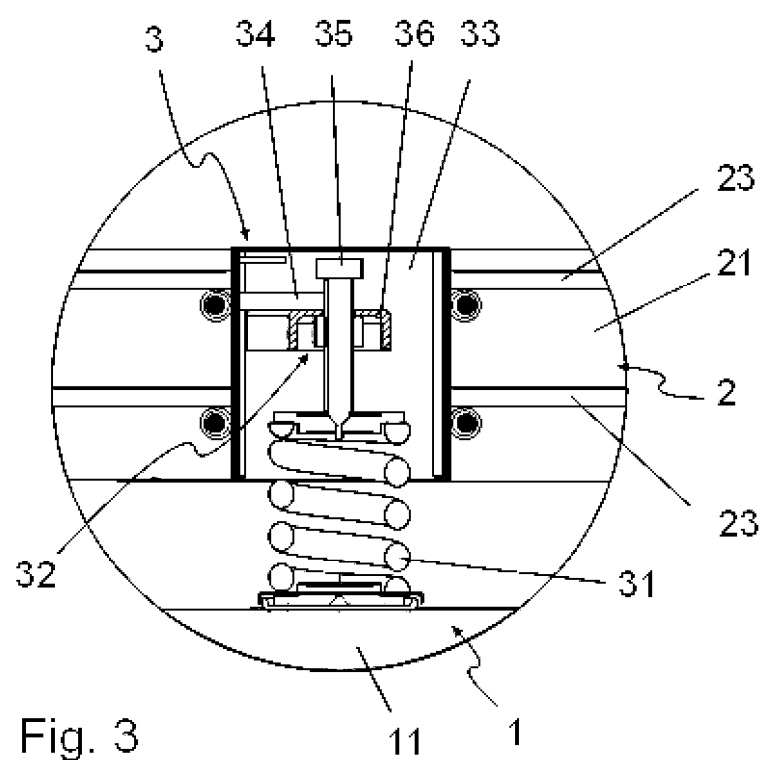


Fig. 2



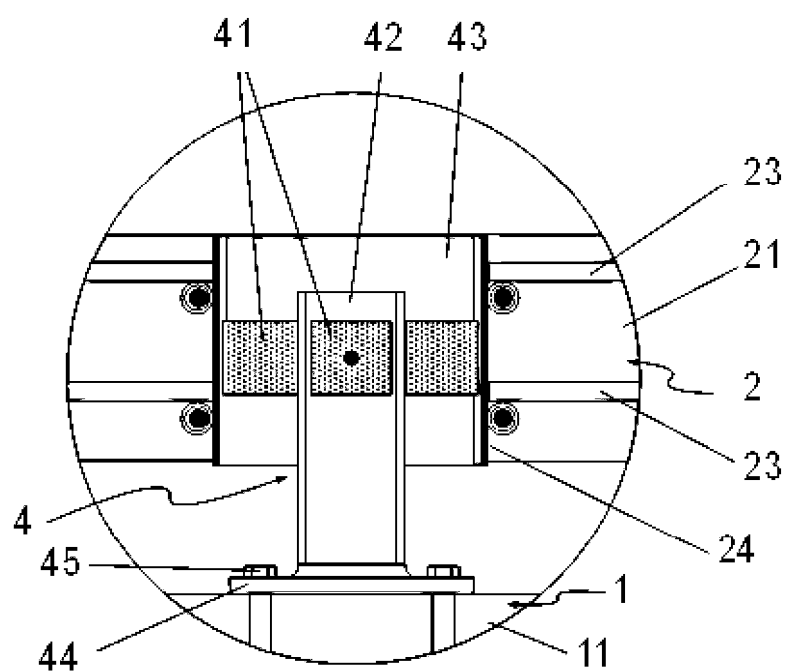


Fig. 5

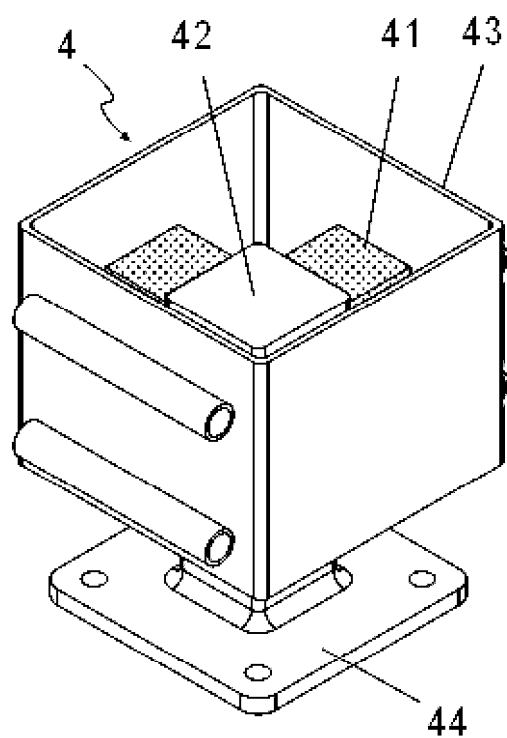


Fig. 6

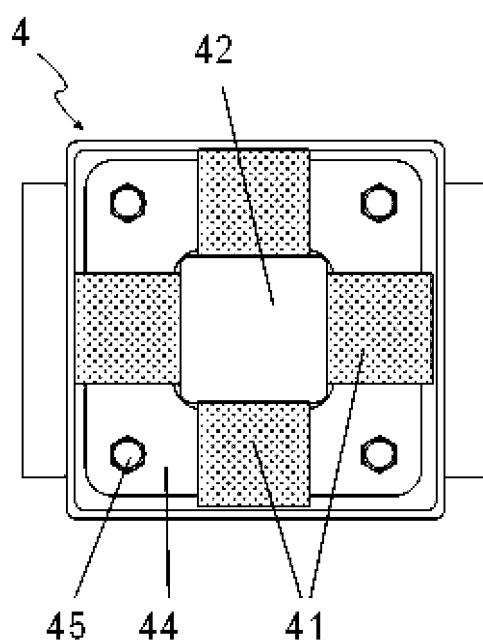


Fig. 7

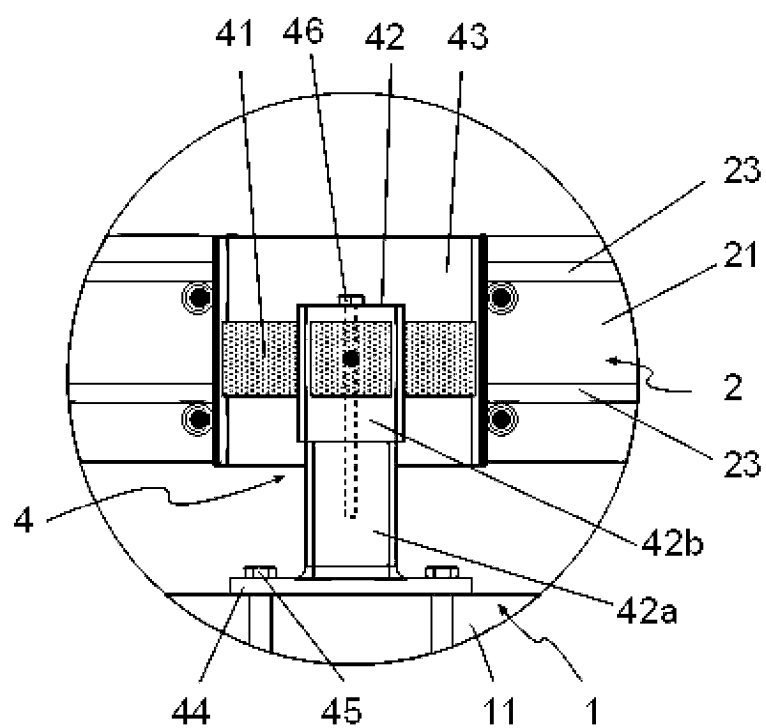


Fig. 8

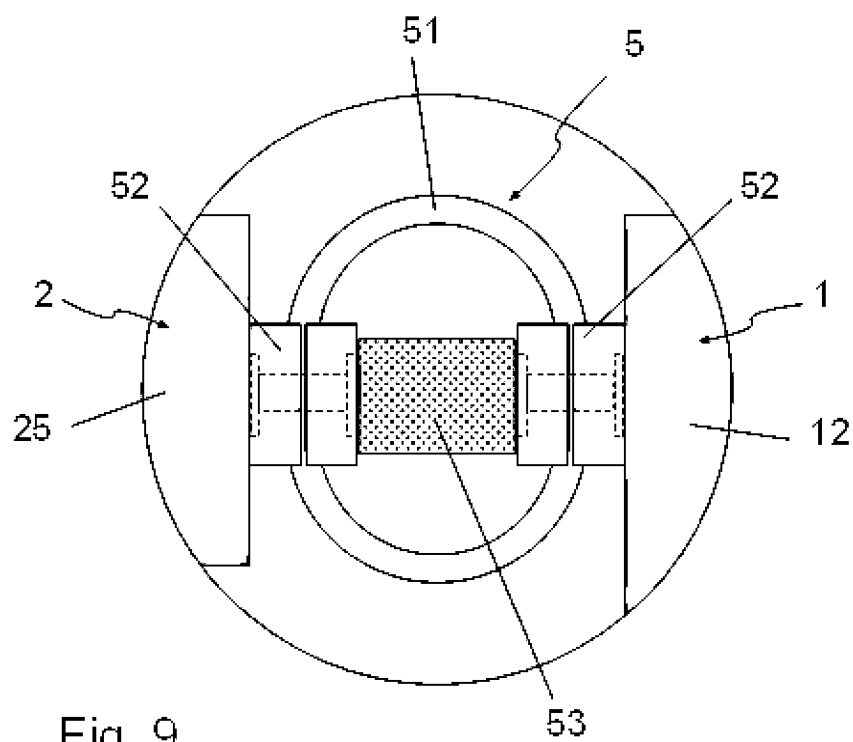


Fig. 9

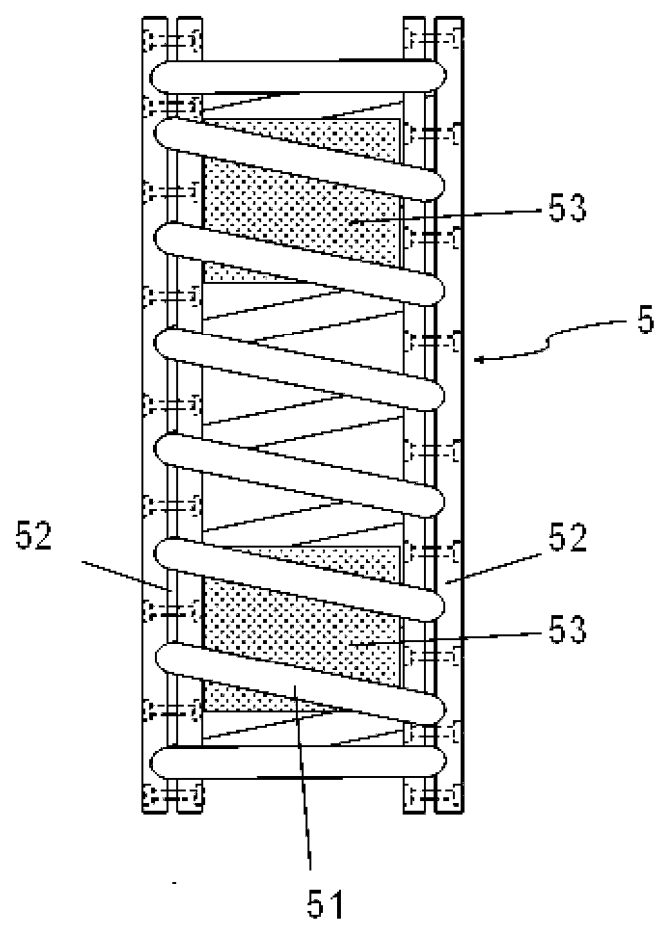


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/ES2024/070348

A. CLASSIFICATION OF SUBJECT MATTER
INV. E04H9/02
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)
E04H E02D

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

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A	JP 2013 234451 A (HAYASHI BUSSAN HATSUMEI KENKYUSHO KK) 21 November 2013 (2013-11-21) the whole document -----	1 - 8
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☒ 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

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INTERNATIONAL SEARCH REPORT

International application No
PCT/ES2024/070348

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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INTERNATIONAL SEARCH REPORT

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International application No

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- DE 4012493 [0007]