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(54) SEISMIC DEVICE FOR ISOLATING BUILDINGS

ERDBEBEN-VORRICHTUNG ZUR ISOLIERUNG VON GEBÄUDEN

DISPOSITIF SEISMIQUE POUR L'ISOLATION DE BATIMENTS

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Description

Technical Field

[0001] The present invention finds application in the field of seismic devices and in particular relates with a seismic device for the insulation of buildings and constructions in general.

State of the art

[0002] At present the seismic isolation techniques for protecting buildings from destructive violence of an earthquake involve the use of different types of isolation devices.

[0003] Among these, the most common systems involve the use of slide systems with overlapped metal plates, systems with metal plates and rubber plates placed one over the other in an alternate way, rubber cylinders with bases fastened to the structure, rolling ball or rollers systems, simple or double pendulum systems.

[0004] WO95/23267 discloses an insulating device formed by a pair of overlapping plates having opposite faces so shaped to define channels for housing rollers for the reciprocal sliding of the plates.

[0005] The top plate is also provided with additional channels in which two further rollers are housed and rotated 90° with respect to the lower rollers and on which a third plate rests to support the construction.

[0006] In this way, the rollers can absorb the oscillations in a horizontal plane produced by an earthquake.

[0007] The whole group of plates also rests on a group of elastic elements, in particular high-strength springs, which have the task of absorbing the vertical oscillations.

[0008] The use of these cushioning systems for absorption of the vertical oscillations has, however, some drawbacks, a first of which is represented by the high cost of such systems. Furthermore, in the moment in which the absorption capacity of the loads has to be varied, it is necessary to provide different type of springs or to vary the number thereof, with possible problems of equilibrium of the device.

[0009] Moreover, in this case it is also necessary to proceed to the removal of the upper plates, which is clearly not always feasible.

Scope of the invention

[0010] The object of the present invention is to overcome the above mentioned drawbacks, by providing a seismic device for isolating buildings with high efficiency and relative cheapness.

[0011] A particular object is to provide a seismic device for isolating buildings wherein the properties of absorbing vertical loads and vertical oscillations produced by the earthquake may be easily adjusted and adapted to the specific structure which the device is applied to. Still another particular object is to provide a seismic device for isolating buildings wherein the adjustment of the capacity of absorbing vertical loads may also be obtained with the device in assembled condition.

[0012] These objects, as well others which will appear more clearly hereinafter, are achieved by a seismic device for insulating buildings that, according to claim 1, comprises a group of at least three plates mutually superimposed and having respective faces facing each other and shaped to define, between each pair of facing plates, at least one pair of channels, each of said channels housing at least one roller adapted to allow relative sliding in a horizontal plane of said plates for absorption of horizontal oscillations produced by an earthquake, the channels defined by the lower plate and the intermediate plate having the extension direction perpendicular to the channels defined between said intermediate plate and the top plate.

[0013] The device also comprises elastic damping means placed below said group of plates to isolate it from the vertical oscillations caused by an earthquake and that comprise a plurality of cushions inflatable at a predetermined controlled pressure and placed below said lower plate to raise said group from the ground and absorb the load thereof and the vertical oscillations produced by the earthquake.

[0014] In this way it will be possible to adjust the pressure of the cushions to the specific load conditions in an easy and immediate way, simply by varying the inflation pressure and without inserting or removing one or more damping elements.

[0015] Suitably, said cushions may comprise an elastomeric material inflating chamber provided with an inflation/deflation valve, so as to adjust pressure in a simple manner.

[0016] Advantageously, the damping means may comprise a plurality of spacers adapted to be disposed below said lower plate to maintain said group raised from the ground by a distance sufficient to allow insertion of said cushions in the deflated condition for their next inflation at the predetermined pressure.

[0017] In this way it will not be necessary to position the cushions already inflated but the same may be introduced below the group of plates after placing the same group and in deflated conditions so as to be gradually brought to the correct pressure value.

[0018] Advantageous embodiments of the invention are obtained in accordance with the dependent claims.

Brief description of the drawings

[0019] Further features and advantages of the invention will become more apparent from the detailed description of some preferred but not exclusive embodiments of a seismic device for isolating buildings, illustrated by way of non-limiting example with the aid of the accompanying drawing in which:

FIG. 1 is a front view of the lower plate of the group

of the invention and of two sides views of the same plate;

FIG. 2 is a front view of the intermediate plate of the group of the invention and of two sides views of the same plate;

FIG. 3 is a front view of the top plate of the group of the invention and of two sides views of the same plate;

FIG. 4 is a perspective view of the device of the invention in a first preferred embodiment;

FIGs. 5 and 6 are two front views of the device of Fig. 4 rotated of 90° with each other;

FIGs. 7 and 8 are two front views of a device in a second preferred embodiment rotated of 90° with each other;

FIG. 9 shows two possible embodiments of the rollers;

FIG. 10 shows an inflatable cushion in an inflated condition and in a deflated condition;

FIGs. 11 and 12 are two front views of the device in a third preferred embodiment rotated of 90° with each other;

FIGs. 13 and 14 are two front views of the device in a fourth preferred embodiment rotated of 90° with each other;

FIG. 15 shows a detail of the devices of Figs. 11 to 14;

FIG. 16 shows the lower spacers of the device according a top view and side views.

Best modes of carrying out the invention

[0020] With reference to the attached figures, there are illustrated some preferred but not exclusive embodiments of a seismic device for isolating building structures, such as buildings, bridges and infrastructure in general, designed to be arranged in correspondence of the supporting structures of a building in order to absorb the horizontal and vertical oscillations produced by a possible earthquake.

[0021] In its most basic configuration, the device, shown assembled in the operating configuration of **Fig. 4,** comprises a group of three plates **1, 2, 3** overlapping each other and having respective faces facing each other shaped to define, between each pair of facing plates, at least one pair of channels **12.**

[0022] Each channel **12** houses one or more rollers **5** adapted to allow the relative sliding of the plates **1, 2, 3** in a horizontal plane for the absorption of horizontal oscillations produced by the earthquake.

[0023] In particular, the channels **12** between the lower plate **1** and the intermediate plate **2** have a direction of development perpendicular to the channels **12** between the intermediate plate **2** and the top plate **3** of the group.

[0024] Elastic damping means are arranged below the lower plate **1** for absorbing the upper load and isolating the group of plates **1, 2, 3,** and consequently the upper construction, from the vertical oscillations caused by the earthquake.

[0025] The elastic damping means comprise a plurality of cushions **9** adapted to be inflated to a controlled predetermined pressure to raise the group from the ground and absorb the load and the vertical oscillations produced by the earthquake.

[0026] The number and the capacity of the cushions **9** may vary depending on the load and the size of the whole device, without particular theoretical limitations.

[0027] The cushions **9** will comprise an inflation chamber made of elastomeric material, for example rubber, provided with an inflation/deflation valve.

[0028] As shown from **Fig. 10,** the inflation chambers may have an annular shape. In this figure, the chamber **8** is in the deflated configuration while the chamber **9** is in inflated condition.

[0029] The damping means also comprise a plurality of spacers **11** adapted to be arranged below the lower plate **1** to keep the group raised from the ground for a distance sufficient to allow insertion of the cushions **8** in deflated condition for subsequently inflating them to the predetermined pressure.

[0030] In this way, through the introduction of hydraulic jacks or similar means it will be also possible to temporarily bypass the device, for example in a maintenance phase.

[0031] The spacers **11** may be arranged directly on the ground or on a support **10** adapted to support the whole group of plates, as shown in **Fig. 16.**

[0032] The spacers **11** are arranged along the perimeter of the lower plate **1,** in a variable number according to the dimensional requirements, with heights that can be selected in function of the dimensional features of the cushions **9,** i.e. the height of the latter in the inflated condition, so that with inflated cushions **9** the lower plate **1** is raised with respect of the spacers **11.**

[0033] From **Fig. 1,** wherein the lower plate **1** of the group is shown, it is visible that the plate **1** has a flat lower face and a shaped upper face on which two concavities identical with each other in shape and mutually parallel are realized, in relief or recessed.

[0034] Each concavity will define a rolling track for one or more rollers **5** and will face a corresponding concavity made in the lower face of the intermediate plate **2,** so as to define two channels **12** for housing respective rollers **5.**

[0035] The channels **12** defined between the lower plate **1** and the intermediate plate **2** will be parallel to each other to confer to the rollers **5** a same direction of rolling, allowing the horizontal relative sliding between the lower plate **1** and the intermediate plate **2** in a direction orthogonal to the axis of rotation of the rollers **5** for absorbing the respective horizontal components of the oscillations produced by the earthquake.

[0036] The upper face of the intermediate plate **2** is also shaped with a pair of concavities or rolling tracks facing upwards and which develop in a direction orthogonal to the concavities or tracks of the lower face.

[0037] Such concavities will face respective specular concavities of the lower face of the top plate **3,** so as to

define two further channels **12** for housing and rolling the rollers **5,** always parallel to each other to have a same direction of rolling.

[0038] These further channels **12** will develop orthogonally to the channels **12** defined between the lower plate **1** and the intermediate one **2** to allow the relative horizontal sliding between the top plate **3** and the intermediate plate **2** in a direction orthogonal to the axis of rotation of the respective rollers **5** and allow the absorption of the respective horizontal components of oscillations produced by the earthquake.

[0039] In this way, the combined action of the rollers **5** arranged between the lower plate **1** and the intermediate plate **2** and of the rollers **5** between the intermediate plate **2** and the top one **3** will make it possible to absorb all the horizontal components of the stresses produced by the earthquake.

[0040] The lower plate **1** and the top plate **3** will be substantially similar to each other and be mutually rotated by 180° on the vertical plane and of 90° on the horizontal plane.

[0041] The rollers **5,** of free-rolling type, self-centering, permanent and instantaneous for gravity will be substantially cylindrical with a circular or elliptical base, with axial extension close to that of the respective channels **12** and minimum diameter so to maintain the plates **1, 2, 3** mutually spaced apart in the vertical direction to prevent their mutual contact and the consequent friction.

[0042] The rollers **5** will present a hard and smooth outer surface with low friction coefficient, possibly mirror-polished, and may either be manufactured without guides or with removable guides, as shown in **Fig. 9** wherein the rollers with guides are indicated by **6.**

[0043] In turn, the concavities will be machined so as to have a hard and smooth outer surface with low friction coefficient, possibly mirror-polished.

[0044] In this way the device will be highly effective in the absorption of oscillations since the friction will be substantially null.

[0045] By contrast, the faces of the lower plate **1** and of the top plate **3** not provided with the concavities may be rough, with the top plate **3** having the upper face facing upwards that will constitute a single block with the above structure, while its lower face will isolate the structure from the ground.

[0046] More than one roller **5** having axes of rotation parallel with each other may also be housed in each channel **12.**

[0047] For example, **Figs. 7** and **8** show a device having two rollers **5** for each channel **12.** In **Figs. 11** and **12** three rollers **5** are instead present in each channel **12,** while in **Figs. 13** and **14** every channel **12** houses four rollers **5.**

[0048] In the case of three or more rollers **5** for each channel **12,** the side rollers will have diameter smaller than the one of the central rollers to allow their insertion inside the channels **12** with a circular arc section.

[0049] Moreover, in case of more rollers **5** in the same channel **12,** these rollers **5** will have the respective axes of rotation mutually coupled by connecting rods, struts with bushings, ball bearings or other equivalent chain-mounted mechanisms, as shown in **Fig. 15** wherein such means are indicated by **7,** to maintain fixed the transverse distance of the rollers **5** and at the same time allow the rolling thereof, but preventing the rollers **5** to roll by gravity towards the center of the tracks, both in static conditions and during an earthquake.

[0050] The dimensions of the various parts of the device are not limiting nor significant for the present invention, as will be selected in function of the construction which the device is designed for.

[0051] From above it appears evident that the device according to the invention achieves the intended objects.

[0052] The device according to the invention is susceptible of numerous modifications and variations, all falling within the scope of the present invention as defined by the accompanying claims. All the details may be also replaced with other technically equivalent elements, and the materials may be different according to requirements, without departing from the scope of protection of the present invention defined by the appended claims.

Claims

1. A seismic device for isolating buildings, comprising:

- a group of at least three plates **(1, 2, 3)** overlapping each other and having respective faces facing each other shaped to define, between each pair **(1, 2; 2, 3)** of facing plates, at least one pair of channels **(12),** each of said channels **(12)** housing at least one roller **(5, 6)** adapted to allow relative sliding in a horizontal plane of said plates **(1, 2, 3)** for the absorption of horizontal oscillations produced by an earthquake, the channels **(12)** between the lower plate **(1)** and the intermediate plate **(2)** having a development direction orthogonal with respect to the channels **(12)** defined between said intermediate plate **(2)** and top plate **(3)** of said group;
- elastic damping means arranged below said group of plates **(1, 2, 3)** to isolate it from the vertical oscillations caused by an earthquake;

characterized in that said elastic damping means comprise a plurality of cushions **(9)** inflated to a predetermined controlled pressure and arranged below said lower plate **(1)** to raise said group from the ground and absorb the load and the vertical oscillations produced by the earthquake.

2. Seismic device as claimed in claim 1, **characterized in that** said cushions **(9)** comprise an inflation chamber made of elastomeric material and provided with an inflation/deflation valve.

3. Seismic device as claimed in claim 1 or 2, **characterized in that** said damping means comprise a plurality of spacers **(11)** adapted to be disposed below said lower plate **(1)** for maintaining said group raised from the ground by a distance sufficient to allow the insertion of the deflated cushions **(8)** for their subsequent inflation to the predetermined pressure.

4. Seismic device as claimed in any preceding claim, **characterized in that** each shaped face of said plates **(1, 2, 3)** has a pair of identical and mutually parallel concavities, said concavities being specular to the concavities of the shaped face facing it and having a circular arc-shaped section.

5. Seismic device as claimed in claim 4, **characterized in that** said lower plate **(1)** and said top plate (3) have respective shaped faces identical to each other and are arranged in positions rotated 90° with each other.

6. Seismic device as claimed in claim 5, **characterized in that** said intermediate plate **(2)** has two mutually opposite shaped faces each having a pair of concavities defining the rolling tracks for said rollers **(5, 6).**

7. Seismic device as claimed in claim 6, **characterized in that** said concavities extend along mutually orthogonal directions parallel to the directions of development of the concavities formed in the shaped faces facing thereto to define respective housing channels **(12)** for said rollers **(5, 6).**

8. Seismic device as claimed in any preceding claim, **characterized in that** said rollers **(5, 6)** are sized with such a diameter as to hold said plates **(1, 2, 3)** mutually spaced apart and prevent the mutual contact.

9. Seismic device as claimed in any preceding claim, **characterized in that** each of said channels **(12)** houses at least two rollers **(5, 6)** having axes of rotation parallel with each other.

10. Seismic device as claimed in claim 9, **characterized in that** the rollers **(5, 6)** inserted in a same channel have respective axes of rotation mutually coupled by connecting rod or bearing means **(7)** so as to maintain fixed the transverse distance and to allow the rolling.

11. Seismic device as claimed in claim 9 or 10, **characterized in that** said rollers **(5, 6)** have a decreasing diameter from the center of said channels **(12)** towards the side edges thereof.

Patentansprüche

1. Seismische Vorrichtung zum Isolieren von Gebäuden, umfassend:

   - eine Gruppe von mindestens drei Platten **(1, 2, 3),** die einander überlappen und die jeweiligen einander zugewandten Flächen so geformt sind, dass sie zwischen jedem Paar **(1, 2; 2, 3)** einander gegenüberliegender Platten mindestens ein Paar bilden Kanäle **(12),** wobei jeder der Kanäle **(12)** mindestens eine Rolle **(5, 6)** aufnimmt, die dafür ausgelegt ist, ein relatives Gleiten in einer horizontalen Ebene der Platten **(1, 2, 3)** zur Absorption von horizontalen Schwingungen zu ermöglichen, die von einem erzeugt werden Erdbeben, wobei die Kanäle **(12)** zwischen der unteren Platte **(1)** und der Zwischenplatte **(2)** eine Entwicklungsrichtung haben, die orthogonal zu den Kanälen **(12)** ist, die zwischen der Zwischenplatte (2) und der oberen Platte (3) der genannten Platte definiert sind Gruppe;
   - elastische Dämpfungsmittel, die unter der Gruppe von Platten (1, 2, 3) angeordnet sind, um sie vor den durch ein Erdbeben verursachten vertikalen Schwingungen zu isolieren;

   dadurch gekennzeichnet, dass die elastischen Dämpfungsmittel eine Vielzahl von Kissen (9) aufweisen, die auf einen vorbestimmten gesteuerten Druck aufgeblasen sind und unter der unteren Platte (1) angeordnet sind, um die Gruppe vom Boden anzuheben und die Last und die durch das Erdbeben erzeugten vertikalen Schwingungen zu absorbieren.

2. Seismische Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Kissen (9) eine Aufblaskammer aus einem elastomeren Material aufweisen und mit einem Aufblas- / Ablassventil versehen sind.

3. Seismische Vorrichtung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Dämpfungsmittel eine Vielzahl von Abstandshaltern (11) umfassen, die so angeordnet sind, dass sie unter der unteren Platte (1) angeordnet sind, um die Gruppe um einen ausreichenden Abstand vom Boden zu halten ermöglichen das Einsetzen der entleerten Kissen (8) für ihr nachfolgendes Aufblasen auf den vorbestimmten Druck.

4. Seismische Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** jede geformte Fläche der Platten (1, 2, 3) ein Paar identischer und zueinander paralleler Konkavitäten aufweist, wobei die Konkavitäten zu den Konkavitäten der ihr zugewandten geformten Fläche spiegelnd sind und einen kreisbogenförmigen Abschnitt aufweist.

5. Seismische Vorrichtung nach Anspruch 4, **dadurch gekennzeichnet, dass** die untere Platte (1) und die obere Platte (3) jeweils identische Formflächen haben und in zueinander um 90 ° gedrehten Positionen angeordnet sind.

6. Seismische Vorrichtung nach Anspruch 5, **dadurch gekennzeichnet, dass** die Zwischenplatte (2) zwei einander gegenüberliegende geformte Flächen aufweist, von denen jede ein Paar Konkavitäten aufweist, die die Rollbahnen für die Rollen (5, 6) definieren.

7. Seismische Vorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** sich die Konkavitäten entlang zueinander orthogonaler Richtungen parallel zu den Entwicklungsrichtungen der Konkavitäten erstrecken, die in den dazu zugewandten Formflächen ausgebildet sind, um jeweilige Gehäusekanäle (12) für die Rollen (5, 5) zu bilden. 6).

8. Seismische Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Rollen (5, 6) einen solchen Durchmesser haben, dass die Platten (1, 2, 3) voneinander beabstandet gehalten werden und der gegenseitige Kontakt verhindert wird.

9. Seismische Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** jeder der Kanäle (12) mindestens zwei Rollen (5, 6) mit zueinander parallelen Drehachsen enthält.

10. Seismische Vorrichtung nach Anspruch 9, **dadurch gekennzeichnet, dass** die Rollen (5, 6), die in einem gleichen Kanal eingesetzt sind, jeweilige Drehachsen aufweisen, die durch Verbindungsstangen oder Lagermittel (7) miteinander gekoppelt sind, um den Querabstand fest zu halten das Rollen zulassen.

11. Seismische Vorrichtung nach Anspruch 9 oder 10, **dadurch gekennzeichnet, dass** die Rollen (5, 6) von der Mitte der Kanäle (12) zu deren Seitenkanten hin einen abnehmenden Durchmesser aufweisen.

Revendications

1. Un dispositif sismique pour isoler les bâtiments, comprenant:

   - un groupe d'au moins trois plaques (1, 2, 3) qui se chevauchent et dont les faces respectives se font face de manière à définir, entre chaque paire (1, 2; 2, 3) de plaques opposées, au moins une paire de des canaux (12), chacun desdits canaux (12) logeant au moins un rouleau (5, 6) adapté pour permettre un glissement relatif dans un plan horizontal desdites plaques (1, 2, 3) pour l'absorption des oscillations horizontales produites par tremblement de terre, les canaux (12) entre la plaque inférieure (1) et la plaque intermédiaire (2) ayant une direction de développement orthogonale par rapport aux canaux (12) définis entre ladite plaque intermédiaire (2) et la plaque supérieure (3) de ladite groupe;
   - des moyens d'amortissement élastiques agencés sous ledit groupe de plaques (1, 2, 3) pour l'isoler des oscillations verticales provoquées par un séisme;

   caractérisé en ce que lesdits moyens d'amortissement élastiques comprennent une pluralité de coussins (9) gonflés à une pression contrôlée prédéterminée et agencés sous ladite plaque inférieure (1) pour relever ledit groupe du sol et absorber la charge et les oscillations verticales produites par le séisme.

2. Dispositif sismique selon la revendication 1, **caractérisé en ce que** lesdits coussins (9) comprennent une chambre de gonflage en matériau élastomère et munie d'une valve de gonflage / dégonflage.

3. Dispositif sismique selon la revendication 1 ou 2, **caractérisé en ce que** lesdits moyens d'amortissement comprennent une pluralité d'entretoises (11) aptes à être disposées en dessous dudit plateau inférieur (1) pour maintenir ledit groupe surélevé du sol d'une distance suffisante pour permettre l'insertion des coussins dégonflés (8) pour leur gonflage ultérieur à la pression prédéterminée.

4. Dispositif sismique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** chaque face profilée desdites plaques (1, 2, 3) présente une paire de concavités identiques et parallèles entre elles, lesdites concavités étant spéculaires aux concavités de la face profilée qui lui fait face. et ayant une section en forme d'arc de cercle.

5. Dispositif sismique selon la revendication 4, **caractérisé en ce que** ladite plaque inférieure (1) et ladite plaque supérieure (3) ont des faces conformées respectives identiques l'une à l'autre et sont disposées dans des positions tournées à 90 ° l'une par rapport à l'autre.

6. Dispositif sismique selon la revendication 5, **caractérisé en ce que** ladite plaque intermédiaire (2) présente deux faces de forme opposées ayant chacune une paire de concavités définissant les pistes de roulement desdits rouleaux (5, 6).

7. Dispositif sismique selon la revendication 6, **caractérisé en ce que** lesdites concavités s'étendent suivant des directions orthogonales mutuellement pa-

rallèles aux directions de développement des concavités formées dans les faces profilées qui leur font face pour définir des canaux de logement respectifs (12) pour lesdits rouleaux (5, 6)

8. Dispositif sismique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** lesdits rouleaux (5, 6) sont dimensionnés avec un diamètre tel qu'ils maintiennent lesdites plaques (1, 2, 3) espacées les unes des autres et empêchent le contact mutuel.

9. Dispositif sismique selon l'une quelconque des revendications précédentes, **caractérisé en ce que** chacun desdits canaux (12) loge au moins deux rouleaux (5, 6) ayant des axes de rotation parallèles l'un à l'autre.

10. Dispositif sismique selon la revendication 9, **caractérisé en ce que** les galets (5, 6) insérés dans un même canal ont des axes de rotation respectifs couplés mutuellement par des biellettes ou des moyens de support (7) de manière à maintenir fixe la distance transversale et pour permettre le roulement.

11. Dispositif sismique selon la revendication 9 ou 10, **caractérisé en ce que** lesdits rouleaux (5, 6) ont un diamètre décroissant à partir du centre desdits canaux (12) vers leurs bords latéraux.

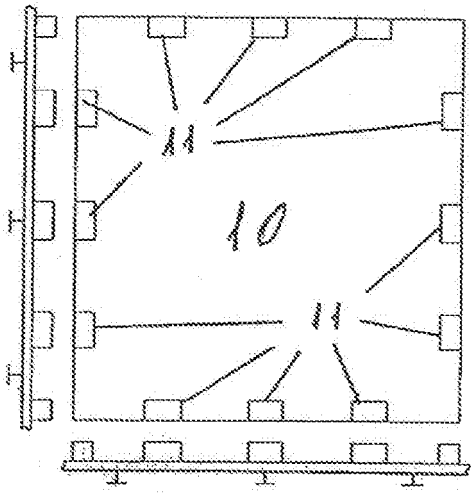

FIG. 1G

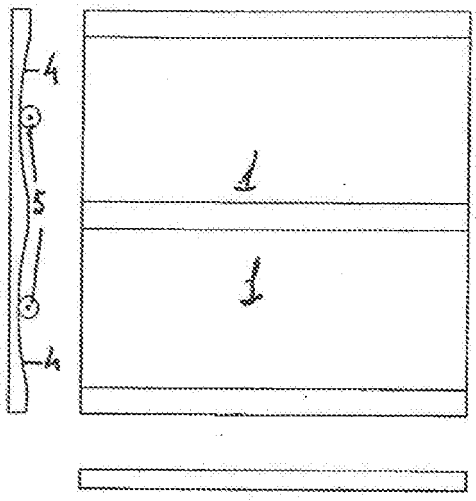

FIG. 1

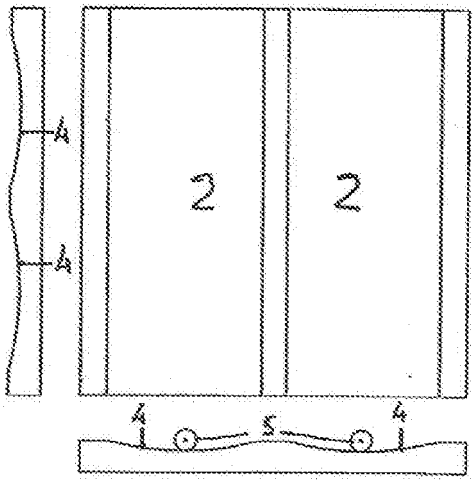

FIG. 2

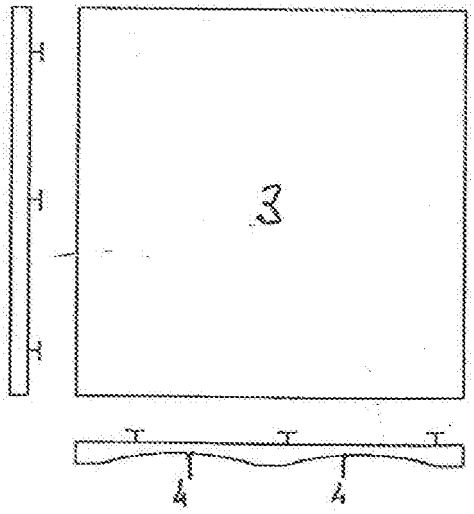

FIG. 3

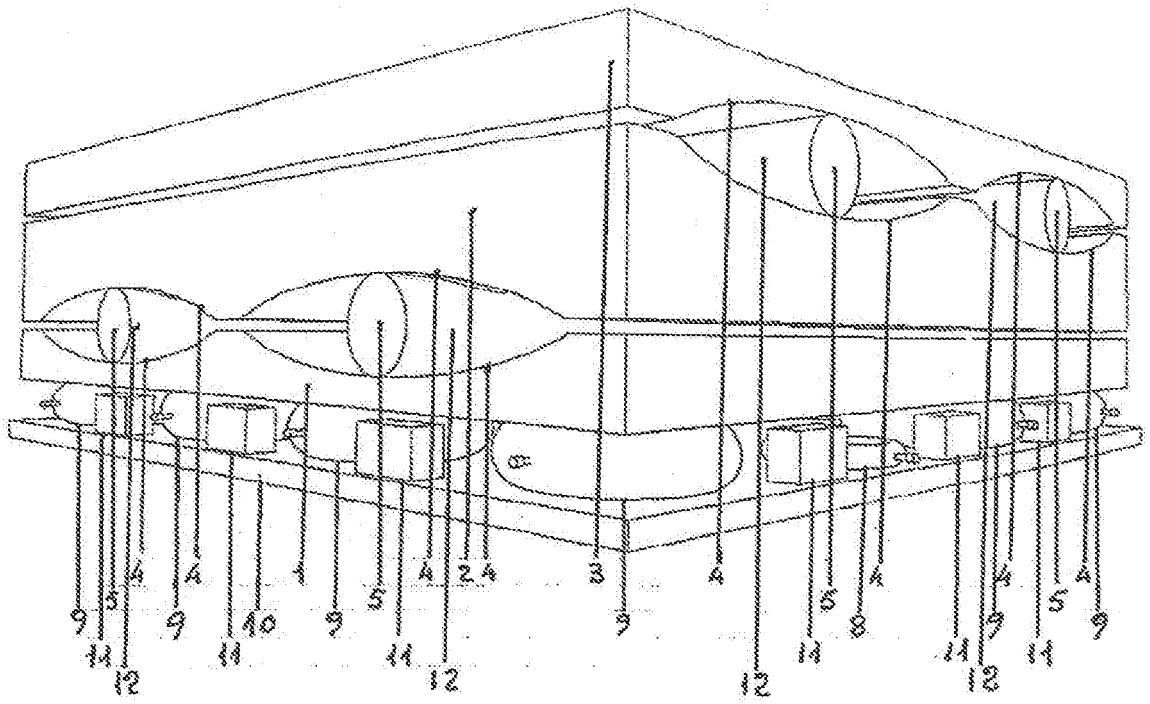

FIG. 4

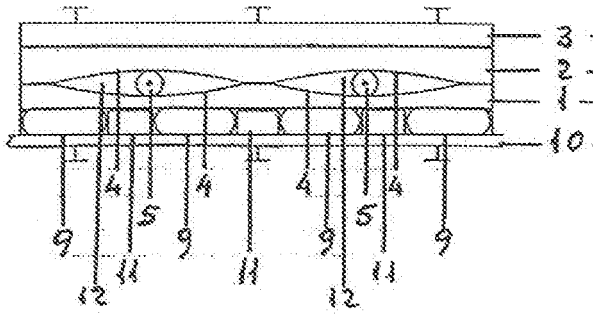

FIG. 5

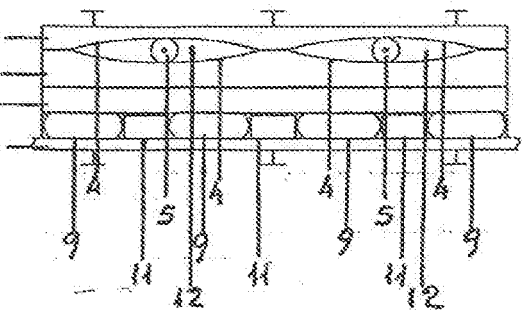

FIG. 6

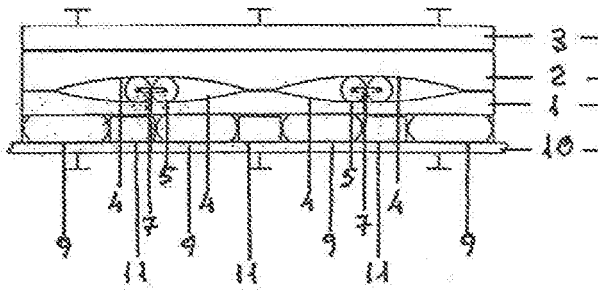

FIG. 7

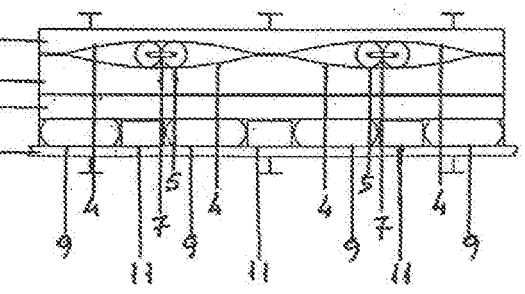

FIG. 8

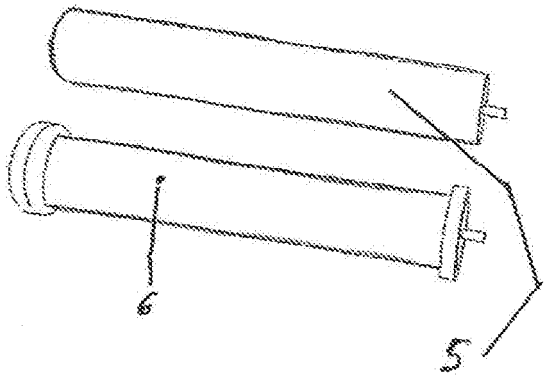

FIG. 9

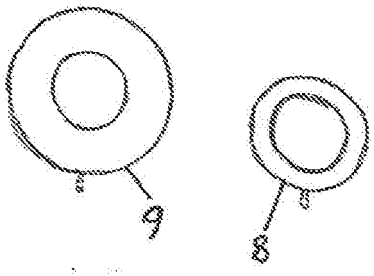

FIG. 10

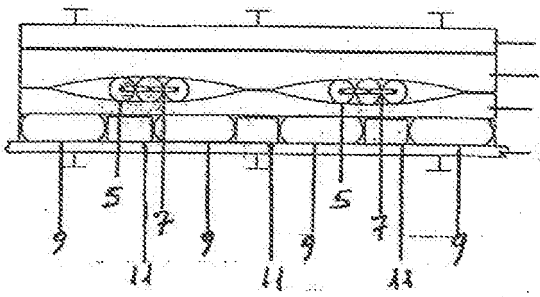

FIG. 11

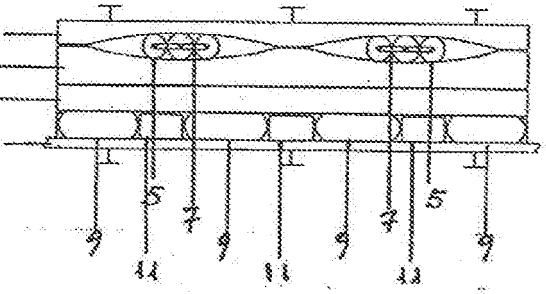

FIG. 12

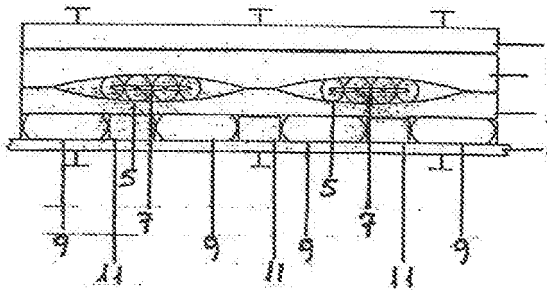

FIG. 13

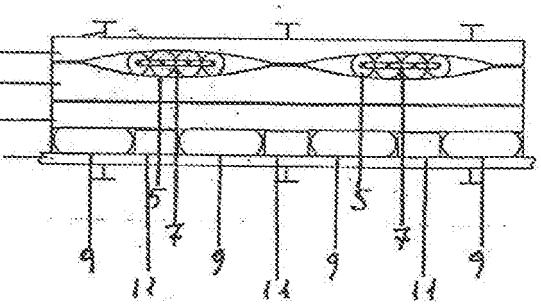

FIG. 14

FIG. 15

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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