



**EUROPEAN PATENT SPECIFICATION**

- (12) **EUROPEAN PATENT SPECIFICATION**
- (45) Date of publication of patent specification : **04.08.93 Bulletin 93/31**
- (51) Int. Cl.<sup>5</sup> : **E04H 9/02, E01D 19/04**
- (21) Application number : **91830012.0**
- (22) Date of filing : **18.01.91**

**(54) Load dissipating and limiting element.**

- |   |  |
|---|--|
| <p>(30) Priority : <b>20.02.90 IT 1941390</b></p> <p>(43) Date of publication of application : <b>28.08.91 Bulletin 91/35</b></p> <p>(45) Publication of the grant of the patent : <b>04.08.93 Bulletin 93/31</b></p> <p>(84) Designated Contracting States : <b>AT BE CH DE DK ES FR GB LI NL SE</b></p> <p>(56) References cited :<br/><b>EP-A- 0 206 183</b><br/><b>DE-A- 3 047 762</b><br/><b>JP-A-63 219 928</b><br/><b>US-A- 4 117 637</b><br/><b>US-A- 4 901 486</b></p> | <p>(73) Proprietor : <b>FIP INDUSTRIALE S.P.A.</b><br/><b>Via Scapacchiò, 41</b><br/><b>I-35030 Selvazzano Dentro (Padova) (IT)</b></p> <p>(72) Inventor : <b>Medeot, Renzo</b><br/><b>c/o FIP Industriale S.p.A., Via Scappacchio</b><br/><b>I-35030 Selvazzano Dentro (Padova) (IT)</b></p> <p>(74) Representative : <b>Cicogna, Franco</b><br/><b>Ufficio Internazionale Brevetti Dott.Prof.</b><br/><b>Franco Cicogna Via Visconti di Modrone, 14/A</b><br/><b>I-20122 Milano (IT)</b></p> |
|---|--|

**EP 0 443 988 B1**

Note : Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid (Art. 99(1) European patent convention).

## Description

The present invention relates to a load dissipating and limiting element, which has been specifically designed for antiseismic devices and apparatus for bridges, viaducts, buildings and the like.

In prior Patent Applications in the name of the same Applicant (Italian Patent Applications No. 19538 A/86 and No. 19539 A/86 filed on February 26, 1986), there are illustrated antiseismic devices comprising specifically designed pivot pins, shown in figures 1 and 2, which are substantially provided, at one end thereof, with a cylindric portion to which there is coupled a variable cross-section portion tapering toward the opposite end where a ball shaped portion ends.

The pivot pins, restrained in the cylindric portion, are deformed so as to be bent according to a given curvature, under the action of seismic forces applied to the ball shaped portion.

These embodiments provide multiple advantages, for example a comparatively reduced cost, a simple construction, reduced size, as well as multidirectional characteristics.

On the other hand, the mentioned pivot pins allow only rather limited sliding movement to occur, which drawback can be at least partially removed by using the arrangements shown in figures 3, 4 and 5, by diagrams which are statically and dynamically equivalent.

As it should be apparent, these constructions, while being operative, are very complex and expensive.

The document IT-A-19538/86 (or 19539/86) discloses a load dissipating and limiting element for antiseismic devices having the features of the pre-characterizing portion of claim 1.

## SUMMARY OF THE INVENTION

Accordingly, the aim of the present invention is to solve the above mentioned problem by providing a dissipating element which, owing to its specifically designed construction, affords the possibility of overcoming all of the difficulties associated with the mentioned limited sliding movements.

In fact, as is known a seismic event generates abrupt displacements of the soil and, accordingly, abrupt accelerations which, as they are transmitted through foundation assemblies, will generate inertia forces because of the involved large masses forming the bridge, viaduct, building and the like construction.

Also known is that, by using suitable de-coupling devices, as properly arranged, it is possible to reduce the inertia forces.

For example, in the case of bridges and viaducts, resilient restraining means have been adopted, which define a swinging element system, practically operating has a spring for the construction mass which has

a proper resonance frequency which can be displaced away from the characteristic frequencies of the seismic events so as to greatly reduce the involved forces.

However, in the characteristic curve of the above mentioned restraining elements, after a first portion of proportionality between the stresses and strains, follows an abruptly raising portion thereby it is not possible to "control" the maximum force involved.

For solving this problem there have been designed further antiseismic restraining elements in which the above mentioned proportional portion is followed by a curve portion in which the force is independent from the strain, that is these elements have a substantially "plastic" performance.

In particular, these elastic-plastic performance devices allow the possibility of reducing as well as controlling the maximum inertia forces transmitted by the restrained masses (such as a viaduct mass) to the supporting constructions (for example the pile and shoulder construction), with self-evident advantages in the case of a high intensity seismic event.

From a dynamic standpoint, the use of horizontal restraining elements, with substantially elastic-plastic characteristics, corresponds to the introduction, near a series type of "spring", of a power dissipating element provided with a very high power dissipating capability and which, owing to its plastic deformations, provides a very advantageous ductile performance.

Accordingly, by the above mentioned dissipation, it is possible to obtain a great reduction, under a high intensity seismic event, of the spectrum response, with respect to the accelerations of the overall construction system, with a consequent great reduction of the stresses on the supporting structures.

In this connection it should be pointed out that the antiseismic devices have been mainly used in the road and railway bridges since the present technique is to made the latter with a continuous truss type of construction.

To the foregoing it is to be added that it is not possible to define the main direction of the seismic movements, thereby it will be necessary to design multidirectional antiseismic devices.

Within the scope of the above mentioned aim, a main object of the present invention is to provide a load dissipating and limiting element which can be directly associated with the supporting structures and which allows to easily make antiseismic devices, differentiated from the supporting structures or apparatus, and adapted to provide an efficient restraining system exclusively on a horizontal plane.

Another object of the present invention is to provide such a load dissipating and limiting element which is very simple construction-wise and can be easily made and assembled with a comparatively reduced cost.

According to the present invention, the above

mentioned aim and objects, as well as yet other objects, which will become more apparent hereinafter, are achieved by a load dissipating and limiting element, for antiseismic devices and apparatus for bridges, viaducts, buildings and the like, having the features of claim 1. Further advantageous features are claimed in the dependent claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the present invention will become more apparent hereafter from the following detailed description of a preferred, though not exclusive, embodiment of a load dissipating and limiting element, according to the invention, which is illustrated, by way of an indicative but not limitative example, in the accompanying drawings, where:

Figures 1 and 2 show prior art pivot pins by a perspective view and an elevation view respectively; Figures 3, 4 and 5 show prior art applications which afford satisfactory mutual sliding movements;

Figure 6 is a perspective view showing the load dissipating or absorbing and limiting element according to the invention;

Figure 7 shows an elevation view of the load dissipating and limiting element according to the present invention;

Figure 8 shows the load dissipating and limiting element of the invention in an assembled condition which is conceptually analogous to those shown for the prior art;

Figure 9 is a schematic view showing a possible embodiment of an antiseismic device using the load dissipating and limiting element according to the present invention; and

Figure 10 is a cross-sectional view taken along the line X-X of Figure 9.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to the figures of the accompanying drawings, the load dissipating and limiting element, which has been particularly designed for antiseismic devices and apparatus for bridges, viaducts, buildings and the like according to the invention, comprises an elongated body, overallly indicated at the reference number 1, which, advantageously, is made of a steel material having a high ultimate elongation characteristic (elongation at rupture).

At the end portions thereof, the body 1 is provided with restraining elements which, preferably though not necessarily, comprise cylindrical portions 2.

At the central portion thereof, each load dissipating and limiting element, which will be more simply

called "spindle" is provided with a double tapering region 3 converging from the ends toward the central portion thereof.

Each spindle will be designed so as to provide the desired displacements and reactions, and its shape is so designed as to use, under plastic deformations, the main portions of the material forming the stem thereof, that is the tapering region thereof, so as to provide the desired ductile performance.

The "spindles" are restrained by means of the end restraining elements 2 to the elements or plates 10 of the antiseismic devices or supporting constructions subjected to a relative displacements during the seismic event.

One of the two restraining elements can be withdrawn in order to allow the above mentioned relative displacements of the plates, without causing the spindle stem to be elongated.

The cross-sectional shape of the stem can be circular, in which case an isotropic performance will be obtained with respect to the displacements and reactions, or any desired shapes (for example an elliptical shape) in which case it will be obtained an anisotropic type of performance, while preserving the important features of a multi-directional characteristic.

Figures 9 and 10 show an antiseismic device made by using the above disclosed spindles, and comprising two end plates 10 restraining said spindles.

More specifically, the bottom plate is anchored to the understructure by means of restraining elements 11, whereas the top plate is coupled to the overstructure through a cup element 12 in turn anchored by restraining elements 13.

The mutual movement under the structure and above it will deform the spindles 1 and the provision of the cup element 12 allows to absorb the displacements toward one another of the end plates, which displacements is produced by second order effects deriving from the spindle deformations, without subjecting the latter to any tension stresses.

As stated, the same effect can also be obtained by using sleeve removable restraining elements.

In the embodiments shown in figures 9 and 10 there is provided a circular geometry; of course any arrangements of the spindles will be possible, for example a square geometry, rectangular geometry and the like.

The use of the above disclosed spindle provides a solution equivalent to that of the prior art shown in figures 3 to 5 with much simpler constructional means.

In fact, in the prior art diagram, the top and bottom hinges will rotate, by symmetry, for the same amount, under the effect of the displacements of the two end plates; likewise, the load dissipating and limiting element according to the invention provides the same effect since it is adapted to increase the mutual

displacements, the length being the same, with respect to the pins and with the same stiffness of the system.

To the foregoing it is to be added that the device according to the present invention can be also provided with other means, such as set-breakage small keys, in order to remove from the characteristic curve the resilient portion, as well as with plungers or other hydraulic means for absorbing the slow movement (for example due to thermal effects) without stressing the spindles.

The spindle elements according to the present invention can be applied to any supporting apparatus (for example made of neoprene, steel, polytetrafluoroethylene and so on) in a like way to that shown in the above mentioned patent applications IT-A-19538/86 and 19539/86.

The invention as disclosed is susceptible to several modifications and variations all of which will come within the scope of the invention as defined in the appended claims.

In practicing the invention, the used material, as well as the specific size and shapes can be any according to requirements within the scope of the claims.

## Claims

1. A load dissipating and limiting element for an antiseismic supporting apparatus for bridges, viaducts, buildings and the like, said element comprising an elongated body (1) of a material suitable to absorb elastic-plastic deformations having restraining elements (2) at the end portions thereof for connecting said body with said apparatus by insertion of said restraining elements into apertures provided in opposite elements (10) of the supporting apparatus, characterized in that the body is provided at an intermediate portion thereof with regions (3) tapering from said end portions toward the centre thereof and that said restraining elements have a substantially cylindrical shape.
2. A load dissipating and limiting element according to Claim 1, characterized in that said tapering regions (2) have a circular shape cross section, in order to provide an isotropic performance with respect to the displacements.
3. A load dissipating and limiting element according to one or more of the preceding claims, characterized in that said tapering regions (3) have cross sections differing from the circular shape in order to provide an anisotropic performance with respect to the displacements.

4. An antiseismic apparatus comprising a load dissipating and limiting element according to one or more of the preceding claims, characterized in that at least one of the end portions of the body (1) is coupled to end plates (10) by a removable restraining coupling of the sleeve type.
5. An antiseismic apparatus comprising a load dissipating and limiting element according to one or more of the preceding claims, characterized in that said body (1) is arranged between movable portions of said supporting apparatus, so as to cause said apparatus to follow a set antiseismic stress-strain characteristic curve.
6. An antiseismic apparatus comprising a load dissipating and limiting apparatus according to claim 4, characterized in that said apparatus comprises a plurality of bodies (4) connecting said plates (10) which are subjected to mutual displacements during a seismic event, so as to provide a set performance with respect to displacements and reactions.
7. An antiseismic support apparatus including at least a load dissipating and limiting element according to any preceding claims, characterized in that said apparatus further comprises an element for compensating second order effects, so as to allow the end plates coupling a plurality of load dissipating and limiting elements to move towards one another without subjecting said load dissipating and limiting elements to any elongations or tension stresses.

## Patentansprüche

1. Lastdissipations- und Begrenzungselement für eine, zur Brücke, Viaduckte, Gebäude und dergleichen vorgesehene erdbebensichere Lageeinrichtung, wobei dies Element mit einem verlängerten Körper (1) versehen ist, das aus einem solchen Material besteht, das zum Auffangen der elastischen-plastischen Verformungen geeignet ist und auf seinen Endportionen mit Aushalteelemente (2) versehen ist, die zur Verbindung des obengenannten Körpers mit der obengenannten Einrichtung durch Einfügung der obengenannten Aushalteelemente in der Öffnungen dient, die auf entgegengesetzten Elemente (10) der Lageeinrichtung gemacht werden, dadurch gekennzeichnet, dass der Körper auf eine mittlere Portion mit solchen Zonen (3) versehen sind, die von der obengenannten Endportionen nach ihren Mittelpunkt verjungen sich, und dass die obengenannten Aushalteelemente wesentliche zylinderförmig sind.

2. Lastdissipations- und Begrenzungselement nach Anspruch 1, dadurch gekennzeichnet, dass die obengenannten sich verjüngenden Zonen (2) um einen isotropische Effekt mit bezug auf Verschiebungen zu bilden, einen Ireisförmige Querschnitt weisen auf. 5
3. Lastdissipations- und Begrenzungselement nach einem oder mehreren vorigen Ansprüchen, dadurch gekennzeichnet, dass die obengenannten sich verjüngenden Zonen (3) einen solche Querschnitt weisen auf, der aus dem kreisförmigen Querschnitt unterscheiden sich, um so einen mit bezug auf den Verschiebungen nicht isotropische Effekt bilden. 10 15
4. Erdbebensichere Einrichtung mit einem Lastdissipations- und Begrenzungselement nach einem oder mehreren vorigen Ansprüchen, dadurch gekennzeichnet, dass wenigstens eine der Endportionen des Körpers (1) durch eine abnehmbare muffenartige Aushalteverbindung mit Endplatten (10) verbunden ist. 20
5. Erdbebensichere Einrichtung mit einem Lastdissipations- und Begrenzungselement nach einem oder mehreren vorigen Ansprüchen, dadurch gekennzeichnet, dass der obengenannte Körper (1) zwischen verschiebbaren Portionen der obengenannten Einrichtung angeordnet sind, somit diese Einrichtung eine bestimmte Last-Dehnungs-Kennlinie der Erdbebensicherheit folgen kann. 25 30
6. Erdbebensichere Einrichtung mit einem Lastdissipations- und Begrenzungselement nach Anspruch 4, dadurch gekennzeichnet, dass diese Einrichtung mit mehreren Körpern (4) versehen ist, die den obengenannten Platten (10) verbinden, die zur gegenseitigen Verschiebungen während einem Erdbebenereignis untergeworfen werden, somit einen bestimmte Effekt mit bezug auf Verschiebungen und Reaktionen gebildet wird. 35 40 45
7. Erdbebensichere Lagereinrichtung mit wenigstens ein Lastdissipations- und Begrenzungselement nach jeder einem vorhergehenden Anspruch, dadurch gekennzeichnet, dass diese Einrichtung, ausserdem, mit einem Element zum Ausgleichen der sekundären Effekte versehen ist, um so die Verschiebung der mit mehreren Lastdissipations- und Begrenzungselemente verbundenen Endplatten aneinander zu ermöglichen, ohne die obengenannten Lastdissipations- und Begrenzungselemente jener Verlängerungs- oder Spannungsbelastung zu unterwerfen. 50 55

## Revendications

1. Élément de dissipation et de limitation de la charge pour un appareil de support à l'abri des tremblements de terre, pour les ponts, les viaducs, les bâtiments et similaires, ledit élément comprenant un corps allongé (1) fait d'un matériel adapté pour absorber les déformations élastiques-plastiques présentant des éléments pour restreindre (2) sur leur portions d'extrémité, en vue de connecter ledit corps avec ledit appareil par insertion desdits éléments pour restreindre dans des ouvertures qui sont prévues dans des éléments opposés (10) de l'appareil de support, caractérisé en ce que le corps est muni, sur l'une de ses régions intermédiaires, de régions (3) s'effilant à partir desdites portions d'extrémité envers le centre et en ce que lesdits éléments pour restreindre ont une forme essentiellement cylindrique.
2. Élément de dissipation et de limitation de la charge selon la revendication 1, caractérisé en ce que lesdites régions (2) s'effilant présentent une section transversale d'une forme circulaire, en vue de créer un effet isotropique par rapport aux déplacements.
3. Élément de dissipation et de limitation de la charge selon l'une ou plusieurs des revendications précédentes, caractérisé en ce que lesdites régions (3) s'effilant présentent des sections transversaux qui sont différentes de la forme circulaire en vue de créer un effet non-isotropique par rapport aux déplacements.
4. Appareil à l'abri des tremblements de terre comprenant un élément de dissipation et de limitation de la charge selon l'une ou plusieurs des revendications précédentes, caractérisé en ce qu'au moins l'une des régions d'extrémité du corps (1) es accouplée aux plaques d'extrémité (10) par des accouplements pour restreindre d'une manière amovible du type en forme de manchon.
5. Appareil à l'abri des tremblements de terre comprenant un élément de dissipation et de limitation de la charge selon l'une ou plusieurs des revendications précédentes, caractérisé en ce que ledit corps (1) est arrangé entre des portions mobiles dudit appareil de support, de façon que ledit appareil suive une courbe caractéristique de déclin antisismique prédéterminée.
6. Appareil antisismique comprenant un dispositif de dissipation et de limitation de la charge selon la revendication 4, caractérisé en ce que ledit ap-

pareil comprend une pluralité de corps (4) connectant lesdites plaques (10) qui sont assujetties à des déplacements mutuels pendant un événement sismique, de façon de créer un effet prédéterminé par rapport aux déplacements et aux réactions. 5

7. Appareil de support antisismique comprenant au moins un élément de dissipation et de limitation de la charge selon l'une quelconque des revendications précédentes, caractérisé en ce que ledit appareil comprend en outre un élément pour compenser des effets d'ordre secondaire, de façon de permettre que les plaques d'extrémité s'accouplant avec une pluralité d'éléments de dissipation et de limitation de la charge, se déplacent l'un vers l'autre sans assujettir lesdits éléments de limitation et de dissipation de la charge à aucune sollicitation de tension ou d'élongation. 10  
15  
20

25

30

35

40

45

50

55

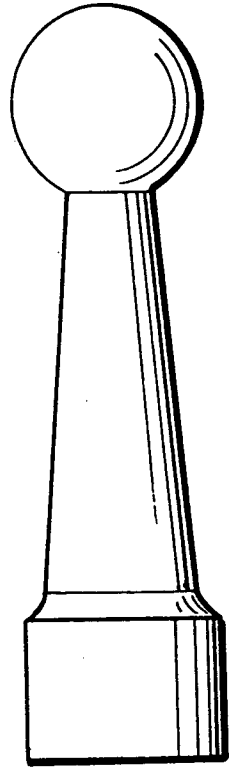
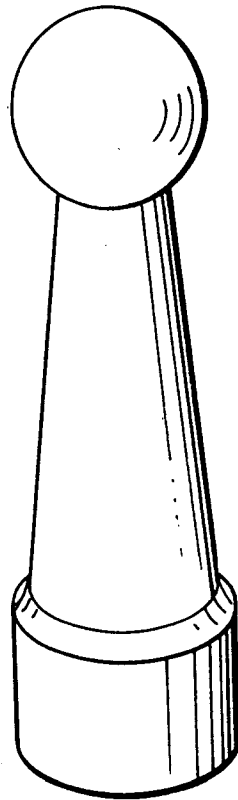


FIG. 1

FIG. 2



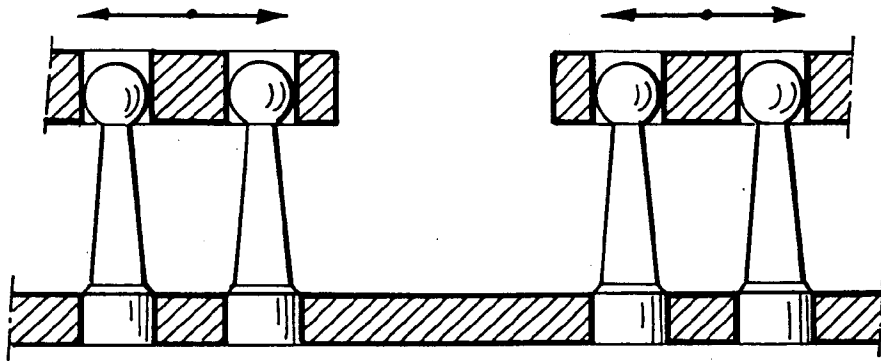


FIG. 3

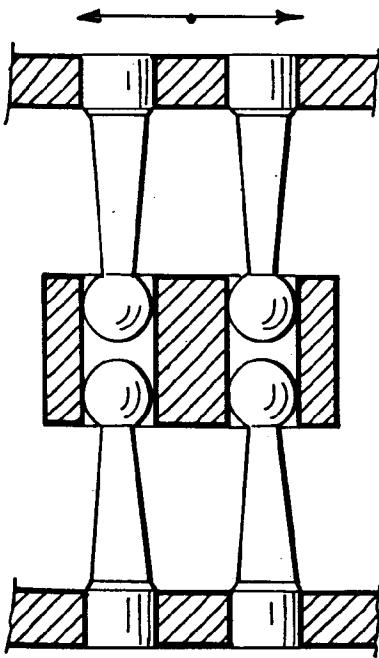


FIG. 4

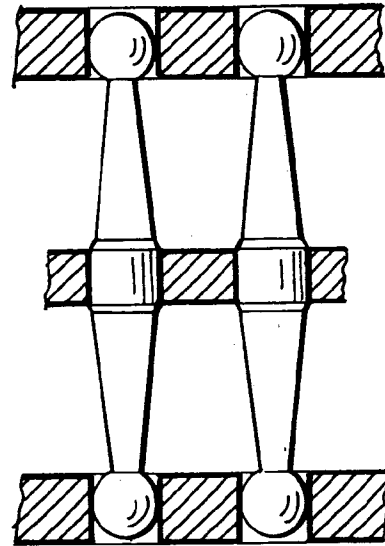


FIG. 5

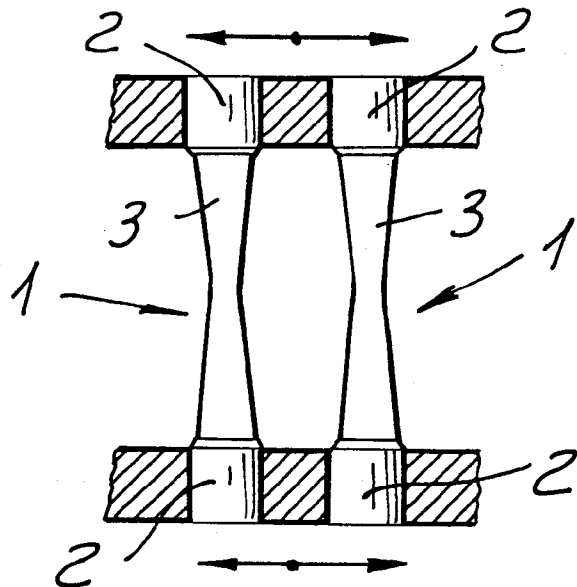


FIG. 8

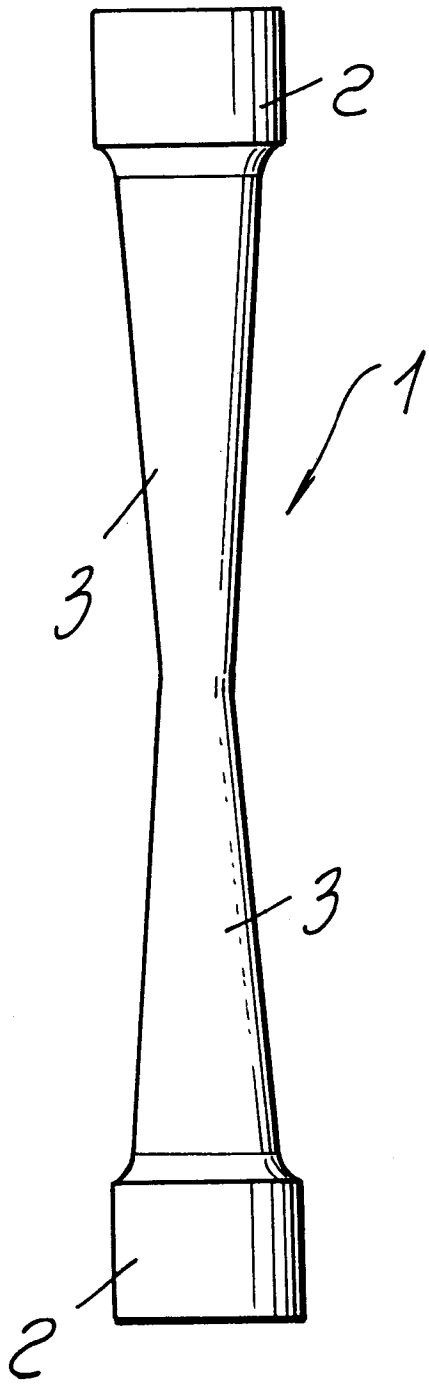


FIG. 7

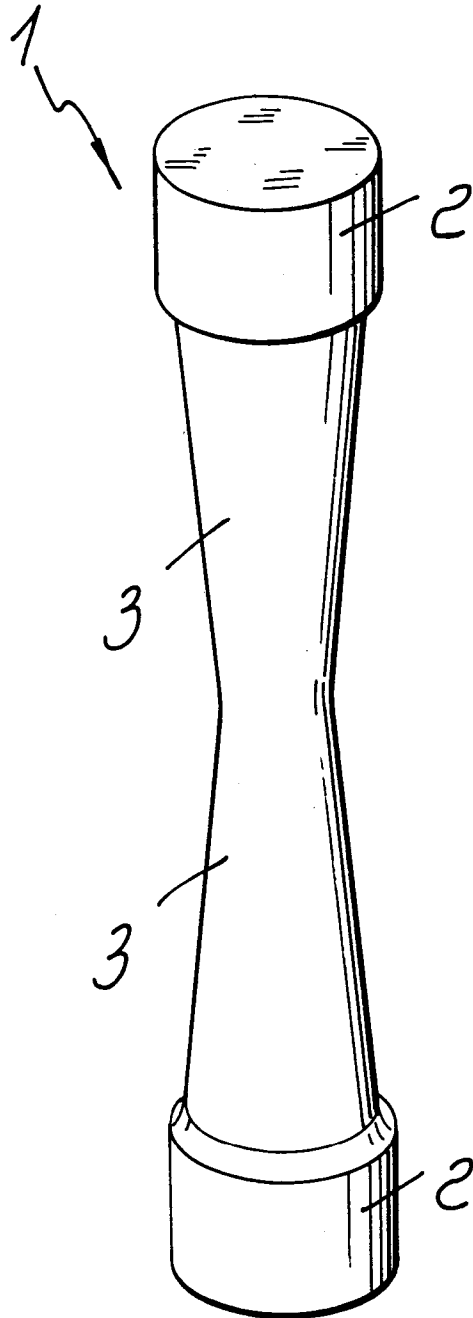


FIG. 6

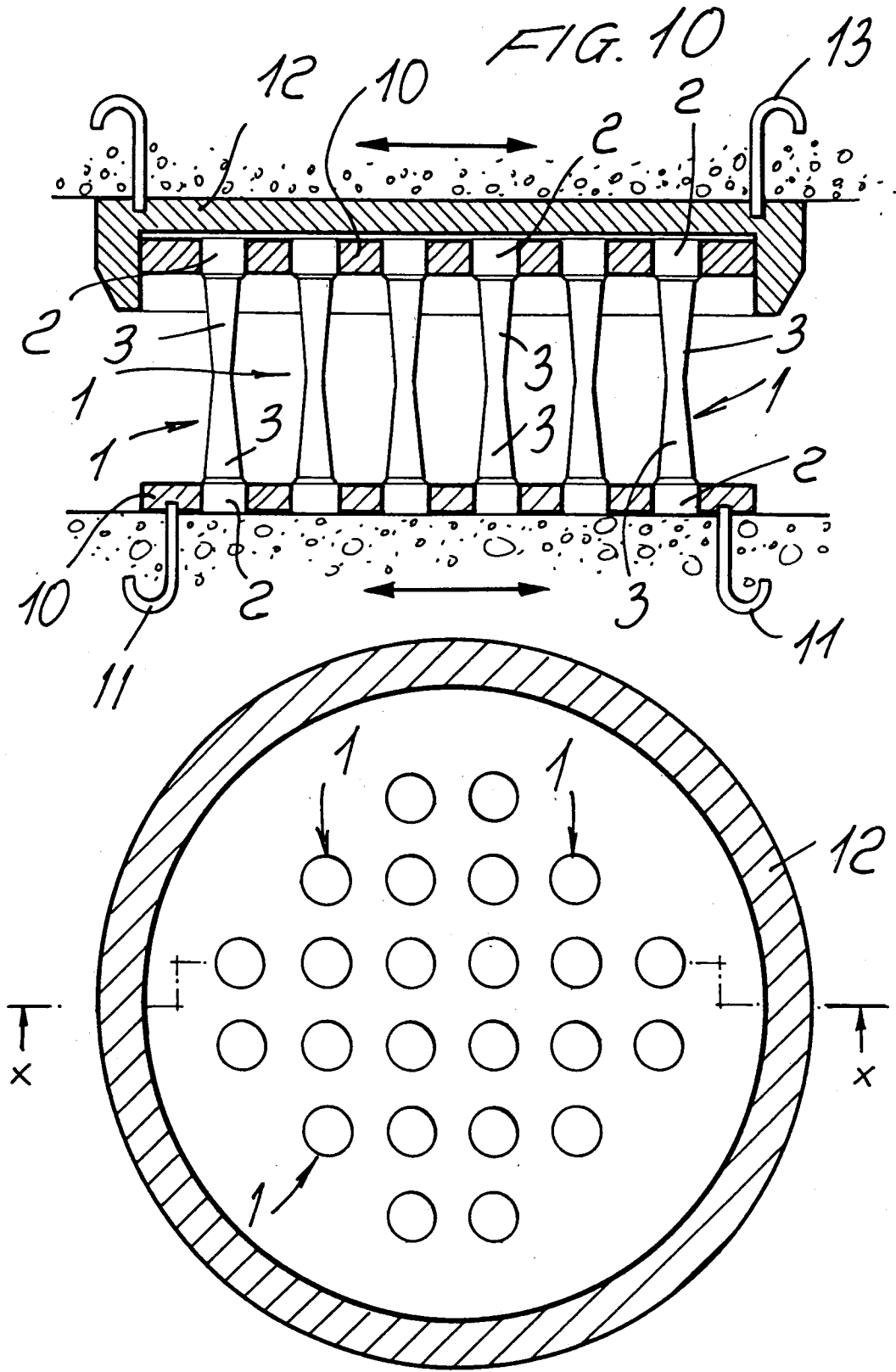


FIG. 9