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(54) **ENHANCED SEISMIC ISOLATION LEAD RUBBER BEARINGS**

(57) A lead rubber bearing includes a deformable body (20) comprising rubber layers (22) laminated with metal reinforcement layers (21), and at least one lead plug received in a hole (26) formed through the laminated layers of the deformable body. The deformable body (20)

has a thermally conductive interface in contact with the lead plug to provide thermal conduction between the lead plug and at least some of the metal reinforcement layers (21).

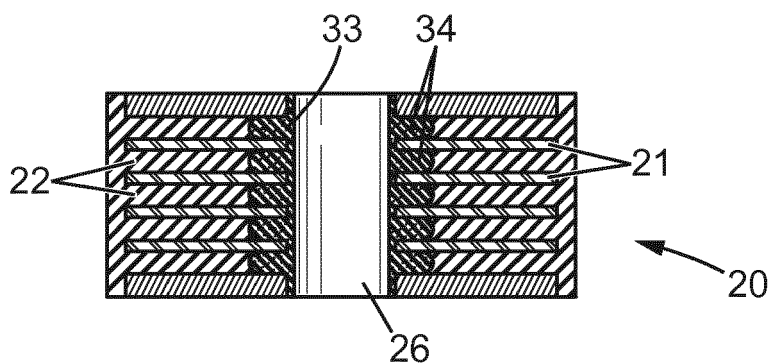


FIG. 8

Description

[0001] The present invention relates to seismic isolation bearings used in the construction industry, and more particularly to lead rubber bearings.

BACKGROUND

[0002] Elastomeric isolators are commonly used in the structure of buildings or other construction works in seismic areas, to separate the superstructure from the foundation or other supporting structure. The isolator, or bearing, must have a high vertical but low horizontal stiffness, resulting in a significant reduction of the seismic accelerations that are transmitted to the superstructure. Such bearings are specified in section 8.2 of the European Standard EN 15129, "Anti-seismic devices", November 2009.

[0003] A known design of an elastomeric isolator is referred to as a lead rubber bearing (LRB). Such an isolator has one or more holes formed in an elastomeric body to receive a lead core or plug.

[0004] Figure 1 is a view of a typical LRB. The elastomeric body 20 is usually reinforced by plate-shaped steel members 21 embedded in the rubber material 22. The reinforcement members 21 are arranged perpendicular to the direction of the main effort to which the bearing is subjected, usually horizontally. Thus, they allow absorption of some shear strain by the elastomeric body 20 in case of dynamic efforts caused, for example, by earthquakes. In the example shown, there is a central hole formed vertically through the elastomeric body and a lead plug 23 inserted in the hole. Frames plates 24, 25 are arranged on both sides of the elastomeric body 20 for connecting the bearing to the foundation and the superstructure.

[0005] To describe the behavior of a LRB in case of earthquake, a bilinear model as illustrated in figure 2 can be schematically referred to. In figure 2, the horizontal axis represents displacement while the vertical axis represents horizontal force. At first, the behavior is predominantly governed by the shear stiffness K_1 of lead. When the lead yields at the plastic limit at point (S_Y, F_Y) , the shear stiffness K_2 of rubber is involved until the maximum displacement S_D is reached.

[0006] At the end of this displacement at point (S_D, F_D) , when there is no more horizontal speed, the lead material can recrystallize and recover its shear stiffness. The lead plug can then react to the horizontal acceleration in the opposite direction, until the plastic limit is again reached, at which point, the resisting effort depends only on the stiffness of rubber.

[0007] This results in a cyclic behavior when the structure is subjected to periodic accelerations, as illustrated in figure 3. The cycle in the displacement/force relation has a surface area proportional to the energy dissipated by the isolation bearing, while the effective stiffness K_{eff} determines the natural frequency of the bearing. These two parameters determine the performance of the seismic isolation, and thus the behavior of the structure in case of earthquake.

[0008] In practice, the behavior in the first cycle, as shown in figure 3, is not maintained during subsequent cycles. This known phenomenon is taken into account in the design of LRBs. For example, the AASHTO standard (see "Guide Specifications for Seismic Isolation Design", 3rd edition, July 2010, American Association of State Highway and Transportation Officials) requires that the minimum effective stiffness measured during the three first cycles is not be less than 80% of the maximum effective stiffness. It also requires that the minimum energy dissipated per cycle (EDC) measured during the specified number of cycles is not less than 70% of the maximum EDC.

[0009] When cycles are repeated, the plastic yield limit of the lead material decreases, which causes a reduction of the effective stiffness K_{eff} and a reduction of the dissipated energy. This behavior is taken into account when computing the response of the structure to the seismic event (forces), either by considering a mean or minimum value for the plastic yield limit of the lead, or by performing iterative calculation with a variable value at each cycle.

[0010] An object of the present invention is to propose an enhanced LRB design, having a more stable dynamic behavior and thus better efficiency.

SUMMARY

[0011] The present document discloses a lead rubber bearing, comprising a deformable body comprising rubber layers laminated with metal reinforcement layers, and at least one lead plug received in a hole formed through the laminated layers of the deformable body. The deformable body has a thermally conductive interface in contact with the lead plug to provide thermal conduction between the lead plug and at least some of the metal reinforcement layers.

[0012] In conventional LRBs, the reason for the change in the mechanical behavior of the lead plug lies in the increase of its temperature. The absorbed seismic energy is transformed into heat, first in the lead and then by conduction in the adjacent materials which mainly consist of rubber having a low thermal conductivity. The characteristics of the lead material, in particular its yield limit, are impacted by the temperature increase. For example, the temperature of a lead cylinder with a diameter of 75 mm and a length of 177.5 mm, used as an LRB plug, increases by 15 °C if the LRB is subjected to a lateral deformation cycle of ± 98 mm (100% shear strain), assuming a shear yield limit of 10 MPa. If no

heat diffusion take place, such heating of the lead plug gives rise to a ~15% drop of the yield limit for the second cycle. In conventional LRBs, the lead plug is in contact with flexible rubber material that is not thermally conductive.

[0013] The LRB proposed herein allows quicker diffusion of the heat generated in the lead plug, through the thermally conductive interface and the metal reinforcement layers.

[0014] Given that the heat generated in the lead plug can be evacuated more efficiently, its performance will not be degraded as much as in conventional LRBs. The metallic reinforcement layers can act like radiator fins to evacuate the heat promptly (due to their high thermal conductivity) and massively (due to the high specific heat of the surrounding rubber) away from the lead plug.

[0015] In an embodiment, the thermally conductive interface includes at least one thermally conductive deformable portion in contact with at least one of the metal reinforcement layers, and exposed at an inner surface of the hole to be in contact with the lead plug.

[0016] The thermally conductive deformable portion may consist of rubber material loaded with thermally conductive particles, for example graphite particles.

[0017] In an embodiment, the thermally conductive deformable portion have an inner part forming at least part of a wall of the hole receiving the lead plug, and radial extensions belonging to the rubber layers of the deformable body laminated with the metal reinforcement layers. The rubber layers of the deformable body may include thermally non-conductive portions surrounding the radial extensions of the thermally conductive deformable portion.

[0018] Typically, the thermally conductive deformable portion has a thermal conductivity of more than $0.5 \text{ W.m}^{-1}.\text{K}^{-1}$. Preferably, that thermal conductivity is more than $5 \text{ W.m}^{-1}.\text{K}^{-1}$.

[0019] In another embodiment, the thermally conductive interface includes edges of the metal reinforcement layers that are exposed at an inner surface of the hole to be in contact with the lead plug.

[0020] In another aspect, there is proposed a method of manufacturing a lead rubber bearing. The method comprises stacking rubber layers alternating with metal reinforcement layers, the stacked layers having at least one hole therethrough, forming a deformable body with the rubber layers, the metal reinforcement layers and the hole therethrough, wherein forming a deformable body comprises curing the rubber layers, and inserting a lead plug in the hole of the deformable body. The deformable body is formed to have a thermally conductive interface in contact with the lead plug to provide thermal conduction between the lead plug and at least some of the metal reinforcement layers.

[0021] In another embodiment of the method, at least some of the stacked rubber layers include a first ring of rubber material loaded with thermally conductive particles, disposed adjacent to the hole, and a second ring of rubber material not loaded with thermally conductive particles, disposed around the first ring. Curing the rubber layers may be performed by allowing part of the rubber material of the first ring to flow and cover edges of the metal reinforcement layers, so as to form a wall of the hole receiving the lead plug. After curing, the rubber material loaded with thermally conductive particles may have a thermal conductivity of more than $0.5 \text{ W.m}^{-1}.\text{K}^{-1}$, preferably more than $5 \text{ W.m}^{-1}.\text{K}^{-1}$.

[0022] When the thermally conductive interface includes edges of the metal reinforcement layers exposed at an inner surface of the hole to be in contact with the lead plug, forming the deformable body may comprise, after curing the rubber layers, removing rubber material at the inner surface of the hole to expose the edges of the metal reinforcement layers. Alternatively, forming the deformable body comprises, before curing the rubber layers, disposing a removable molding plug in the hole, in contact with the edges of the metal reinforcement layers.

BRIEF DESCRIPTION THE DRAWINGS

[0023] Other features and advantages of the Lead Rubber Bearing or LRB disclosed herein will become apparent from the following description of non-limiting embodiments, with reference to the appended drawings, in which:

- figure 1 is a schematic perspective view of an LRB for seismic isolation;
- figure 2 illustrates graphically a simplified force/displacement model for the LRB;
- figure 3 is a graph showing a force/displacement cycle of an LRB under seismic conditions;
- figure 4 is a schematic cross-sectional view of the deformable body of a conventional LRB;
- figure 5 is a schematic cross-sectional view of a deformable body similar to that of figure 4 but modified to be part of an LRB modified in accordance with an embodiment of the present invention;
- figure 6 is a schematic perspective view illustrating the formation of a stack of alternated rubber and steel layers which may be used in the manufacture of an LRB according to an embodiment;

- figure 7 is a schematic cross-sectional view of the stack shown in figure 6;
- figure 8 is a schematic cross-sectional view of an LRB formed with a stack as shown in figures 6 and 7; and
- 5 - figures 9-11 are partial cross-sectional views of three LRBs.

DESCRIPTION OF EMBODIMENTS

10 **[0024]** The description which follows is illustrated with schematic drawings where the same reference numerals are used to designate similar parts. Figures 4-11 show LRBs having a general configuration similar to that of figure 1, with a cylindrical lead plug 23 inserted into a hole formed centrally in a generally cylindrical deformable body 20. It will be appreciated that the teachings of the present invention are applicable to LRBs having a variety of other geometries, with any number of lead plugs.

15 **[0025]** Figure 4 is a schematic cross-sectional view of the deformable body of the conventional LRB of figure 1, where the arrangement of the rubber layers 22 laminated with the metal reinforcement layers 21 of the deformable body 20 is better seen. The metal reinforcement layers 21 are fully embedded in the rubber material. The thermal conduction between them and the lead plug 23 is poor because the hole 26 that receives the lead plug 23 is lined with a thickness of rubber material 27.

20 **[0026]** The situation is improved when the wall of the hole 26 that receives the lead plug 23 is processed to expose the inner edges 28 of the metal reinforcement layers 21 as shown in figure 5.

25 **[0027]** The lead plug 23 is then in direct contact with the metal reinforcement layers 21. The thermal conduction to take away the heat generated in the lead plug 23 is then governed by the thermal conductivity of lead and stainless steel, namely $35.3 \text{ W.m}^{-1}\text{.K}^{-1}$ and $50.2 \text{ W.m}^{-1}\text{.K}^{-1}$, respectively. In contrast, the thermal conductivity of rubber (such as the rubber layer 27 present at the wall on the hole 26 in figure 4) is $0.16 \text{ W.m}^{-1}\text{.K}^{-1}$, while its specific heat is $2000 \text{ J.kg}^{-1}\text{.K}^{-1}$. Therefore, an embodiment as shown in figure 5 avoids excessive heating of the lead plug 23. This results in a more stable behavior on the LRB, in terms of displacement/force cycle, and thus in better isolation performance under seismic forces.

30 **[0028]** To manufacture an LRB as shown in figure 5, alternating rubber and metal layers having a central hole there-through are conventionally stacked, and then the rubber layers 22 are cured to form the deformable body 20. Afterwards, the lead plug 23 is forcibly inserted into the hole 2. The hole in each metal reinforcement layers 21 has substantially the same diameter as the lead plug 23, so that an intimate contact between the lead and the stainless steel is obtained when the plug is inserted.

35 **[0029]** In a possible manufacturing method, a molding core having a diameter slightly smaller than that of the lead plug 23 is inserted in the central hole 26 of the stack of rubber and metal layers 22, 21 when the rubber material is cured, so that a deformable body 20 as shown in figure 4 is obtained, with a layer 27 of rubber material at the inner surface of the hole 26. After curing, that layer 27 is removed, e.g. by abrasion, to expose the inner edges 28 of the metal reinforcement layers 21.

40 **[0030]** Alternatively, a molding core having the same diameter as the lead plug 23 can be used. When the molding core is removed after curing of rubber material, the inner edges 28 the metal reinforcement layers 21 are exposed at the inner surface of the hole 26.

[0031] Figures 6-8 illustrate another embodiment of a LRB in accordance with the invention. In that embodiment, part of the usual rubber used in the layers 22 is replaced by a ring of rubber material modified to have a much higher thermal conduction and located adjacent to the lead plug 23 and in contact with the metal reinforcement layers 21.

45 **[0032]** Thermally conductive rubber materials can be obtained, for example, by replacing, in the mixture, part of the carbon black by expanded graphite that has a thermal conductivity 18 times larger.

[0033] Alternatively, other kinds of thermally conductive particles are added to the rubber composition, such as small fibers or flakes of highly conductive materials, e.g. copper. The present invention is not limited to any particular way of making a rubber material thermally conductive.

50 **[0034]** Figures 6 and 7 show the layers of metal 21 and of rubber 22 that are stacked around a molding core 30 that has a diameter equal to or slightly smaller than that of the lead plug 23. The diameter of the molding core 30 is smaller than that of the central hole formed in the metal reinforcement layers 21, for example 2 to 5 mm smaller. Each rubber layer 22 includes a ring 31 of thermally conductive rubber disposed around the molding core 30 and surrounded by another ring 32 of conventional thermally non-conductive rubber.

55 **[0035]** Figure 8 illustrates the configuration of the deformable body 20 after curing of the rubber material under pressure, which provides strong adherence between the rubber and the stainless steel of the reinforcement layers 21.

[0036] The rubber material of the inner rings 31 is transformed into a thermally conductive deformable portion that includes an inner part 33 forming the wall of the hole 26 that will receive the lead plug 23 and radial extensions 34 belonging to the rubber layers 22 of the deformable body 20. The inner part 33 is formed by the rubber material that

flows from the inner rings 31 during the heat treatment and migrates to the surface of the molding core 30. Its outer surface is in contact with the inner edges of the metal reinforcement layers 21. The radial extensions 34 of the thermally conductive deformable portion are also in contact with the metal reinforcement layers 21 on their upper and lower sides. Around the radial extensions 34, the rubber material from the rings 32 remains as thermally non-conductive portions to provide the required deformability and the shear stiffness K_2 .

[0037] The embodiment of figure 8 does not alter the flexibility and elasticity of the rubber layers 22. It also ensures a durable contact of the metal reinforcement layers 21 with the conductive material that conveys the heat generated in the lead plug 23.

[0038] For comparison purposes, we consider the example of a lead rubber bearing having a generally cylindrical deformable body 20 with an outer diameter of 500 mm, made of fourteen rubber layers 22 having a thickness of 7 mm with 4 mm-thick stainless steel reinforcement plates 21 between them. The deformable body 20 has a central hole where a cylindrical lead plug with a diameter of 75 mm is inserted.

Comparative Example 1:

[0039] Figure 9 shows such an LRB in a conventional configuration where there is a 2.5 mm-thick rubber layer 27 lining the inner wall of the hole 26 that receives the lead plug 23.

[0040] If 45 kJ are dissipated in the lead plug 23 of that LRB, the temperature increase of the lead material after 45 s is 28.1 °C. The energy of 45 kJ corresponds to that of two cycles of horizontal deformation of $\pm 100\%$ (± 98 mm) of the bearing with the usual value of 13 MPa as the yield limit of lead under shear stress.

Example 2:

[0041] Figure 10 shows an illustrative LRB according to an embodiment of the invention, which has geometry similar to that of figure 9, except that the inner edges 28 of the metal reinforcement layers 21 are in contact with the lead plug 23.

[0042] Here, if the same amount of seismic energy (45 kJ) is dissipated in the lead plug 23, the temperature increase of the lead material after 45 s is only 12.8 °C.

Example 3:

[0043] Figure 11 shows an illustrative LRB according to another embodiment of the invention, which again has geometry similar to that of figure 9, except that there is a thermally conductive deformable portion with an inner part 33 and radial extensions 34 as discussed with reference to figures 6-8. The inner part 33 has a thickness of 2.5 mm along the radial direction, while the radial extensions 34 have a length of 5 mm.

[0044] In example 3, the thermal conductivity of the rubber material of the thermally conductive deformable portion 33, 34 is six times larger than that ($0.16 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$) of the rubber of the outer ring 32, i.e. $0.96 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$.

[0045] Here, if the same amount of seismic energy (45 kJ) is dissipated in the lead plug 23, the temperature increase of the lead material after 45 s is 22.9 °C.

Example 4:

[0046] In example 4, the configuration of the LRB is the same as in example 3, but the thermal conductivity of the rubber material of the thermally conductive deformable portion 33, 34 is sixty times larger than that of the rubber of the outer ring 32, i.e. $9.6 \text{ W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$.

[0047] Here, if the same amount of seismic energy (45 kJ) is dissipated in the lead plug 23, the temperature increase of the lead material after 45 s is only 13.1 °C.

[0048] The examples show that constructive measures as proposed by the present invention significantly reduce the temperature increase of the lead plug 23 of the LRB in case of earthquake. This results in an improved dynamic behavior of the LRB.

[0049] If variations of the shear yield limit of lead as a function of temperature according to the literature are taken into account (about $0.1 \text{ MPa}/^\circ\text{C}$), the gain afforded by the improved thermal contact with the lead plug 23 is as indicated in Table 1 below.

Table 1

Example No.	Temperature increase	Loss in shear yield limit	Relative loss	Gain
1	28.1 °C	-2.81 MPa	-22%	0%

(continued)

Example No.	Temperature increase	Loss in shear yield limit	Relative loss	Gain
2	12.8 °C	-1.28 MPa	-10%	54%
3	22.9 °C	-2.29 MPa	-18%	19%
4	13.1 °C	-1.31 MPa	-10%	53%

[0050] The comparison shows that a thermally conductive deformable portion 33, 34 of $9.6 \text{ W.m}^{-1}\text{K}^{-1}$ to form the thermally conductive interface between the lead plug 23 and the metal reinforcement layers 21 (example 4) achieves performances almost as good as direct lead-steel contact (example 2), while it provides a more durable contact with the lead plug.

[0051] The thermal conductivity at the thermally conductive interface is preferably more than $5 \text{ W.m}^{-1}\text{K}^{-1}$. Still a significant improvement over conventional LRBs is obtained in example 3, where the thermally conductive deformable portion 33, 34 is only $0.96 \text{ W.m}^{-1}\text{K}^{-1}$. Generally, the behavior of the LRB is improved when the thermal conductivity of the thermally conductive deformable portion 33, 34 is more than $0.5 \text{ W.m}^{-1}\text{K}^{-1}$.

[0052] It will be appreciated that the embodiments described above are illustrative of the invention disclosed herein and that various modifications can be made without departing from the scope as defined in the appended claims.

Claims

1. A lead rubber bearing, comprising:

a deformable body (20) comprising rubber layers (22) laminated with metal reinforcement layers (21); and at least one lead plug (23) received in a hole (26) formed through the laminated layers of the deformable body, wherein the deformable body (20) has a thermally conductive interface in contact with the lead plug (23) to provide thermal conduction between the lead plug and at least some of the metal reinforcement layers (21).

2. The lead rubber bearing as claimed in claim 1, wherein the thermally conductive interface includes at least one thermally conductive deformable portion (33, 34) in contact with at least one of the metal reinforcement layers (21), and exposed at an inner surface of the hole (26) to be in contact with the lead plug (23).

3. The lead rubber bearing as claimed in claim 2, wherein the thermally conductive deformable portion (33, 34) consists of rubber material loaded with thermally conductive particles.

4. The lead rubber bearing as claimed in claim 3, wherein the thermally conductive particles include graphite particles.

5. The lead rubber bearing as claimed in any one of claims 2-4, wherein the thermally conductive deformable portion has:

an inner part (33) forming at least part of a wall of the hole (26) receiving the lead plug (23); and radial extensions (34) belonging to the rubber layers (22) of the deformable body (20) laminated with the metal reinforcement layers (21).

6. The lead rubber bearing as claimed in claim 5, wherein the rubber layers (22) of the deformable body (20) include thermally non-conductive portions (32) surrounding the radial extensions (34) of the thermally conductive deformable portion.

7. The lead rubber bearing as claimed in any one of claims 2-6, wherein the thermally conductive deformable portion (33, 34) has a thermal conductivity of more than $0.5 \text{ W.m}^{-1}\text{K}^{-1}$, and preferably more than $5 \text{ W.m}^{-1}\text{K}^{-1}$.

8. The lead rubber bearing as claimed in any one of the preceding claims, wherein the thermally conductive interface includes edges (28) of the metal reinforcement layers (21) that are exposed at an inner surface of the hole (26) to be in contact with the lead plug (23).

9. A method of manufacturing a lead rubber bearing, the method comprising:

stacking rubber layers (22) alternating with metal reinforcement layers (21), wherein the stacked layers have at least one hole (26) therethrough;
forming a deformable body (20) with the rubber layers, the metal reinforcement layers and the hole therethrough, wherein forming a deformable body comprises curing the rubber layers; and
inserting a lead plug (23) in the hole of the deformable body,
wherein the deformable body (20) is formed to have a thermally conductive interface in contact with the lead plug (23) to provide thermal conduction between the lead plug and at least some of the metal reinforcement layers (21).

10. The method as claimed in claim 9, wherein at least some of the stacked rubber layers (22) include:

a first ring (31) of rubber material loaded with thermally conductive particles, disposed adjacent to the hole (26);
and
a second ring (32) of rubber material not loaded with thermally conductive particles, disposed around the first ring.

11. The method as claimed in claim 10, wherein curing the rubber layers (22) is performed by allowing part of the rubber material of the first ring (31) to flow and cover edges of the metal reinforcement layers (21), so as to form a wall of the hole (26) receiving the lead plug (23).

12. The method as claimed in any one of claims 10-11, wherein the thermally conductive particles include graphite particles.

13. The method as claimed in any one of claims 10-12, wherein the rubber material loaded with thermally conductive particles has, after curing, a thermal conductivity of more than $0.5 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$, and preferably more than $5 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$.

14. The method as claimed in any one of claims 9-13, wherein the thermally conductive interface includes edges (28) of the metal reinforcement layers (21) that are exposed at an inner surface of the hole (26) to be in contact with the lead plug (23).

15. The method as claimed in claim 14, wherein forming the deformable body (20) comprises, after curing the rubber layers (22), removing rubber material at the inner surface of the hole (26) to expose the edges (28) of the metal reinforcement layers (21).

16. The method as claimed in claim 14, wherein forming the deformable body (20) comprises, before curing the rubber layers (22), disposing a removable molding plug in the hole (26), in contact with the edges (28) of the metal reinforcement layers (21).

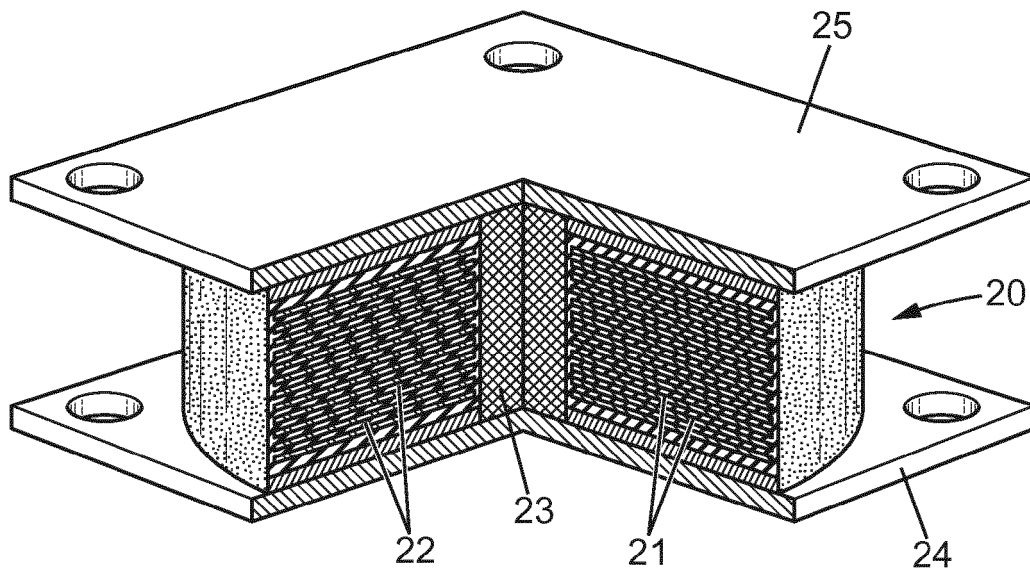


FIG. 1

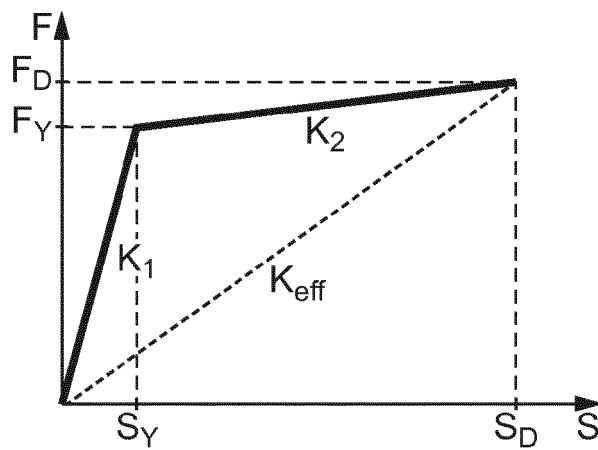


FIG. 2

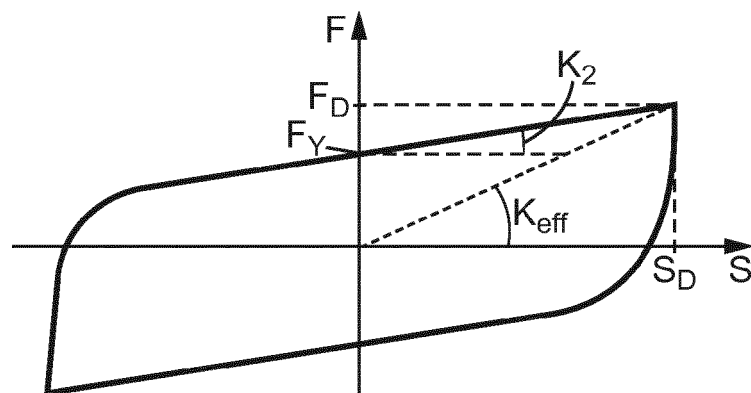


FIG. 3

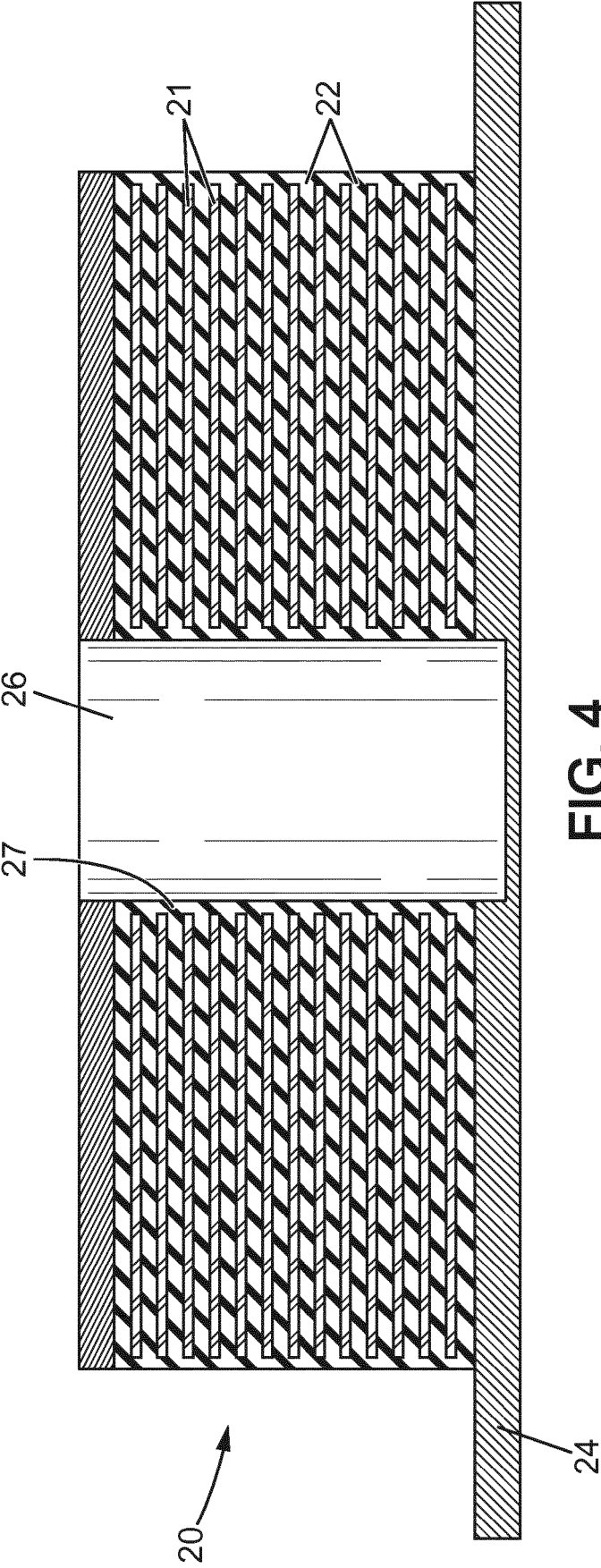


FIG. 4

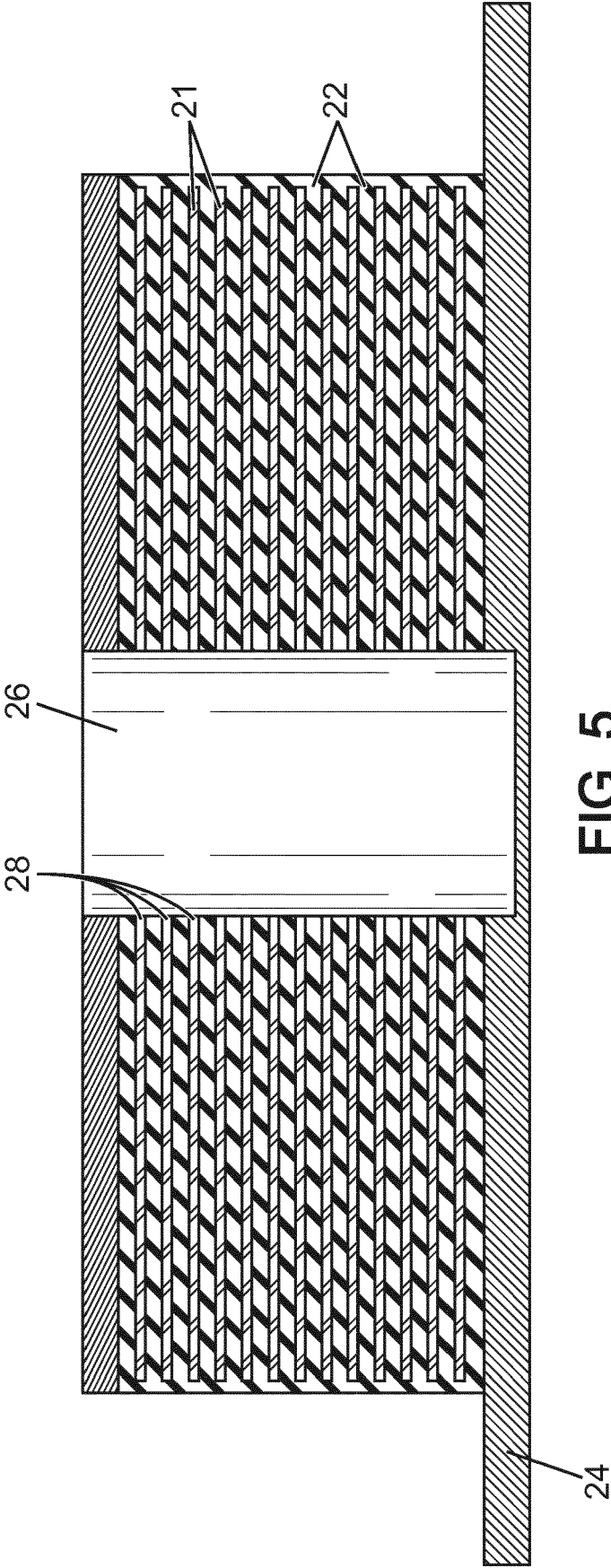


FIG. 5

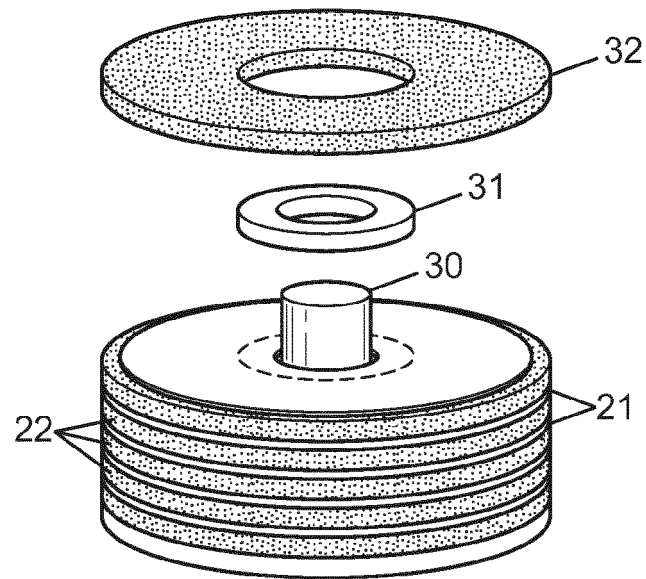


FIG. 6

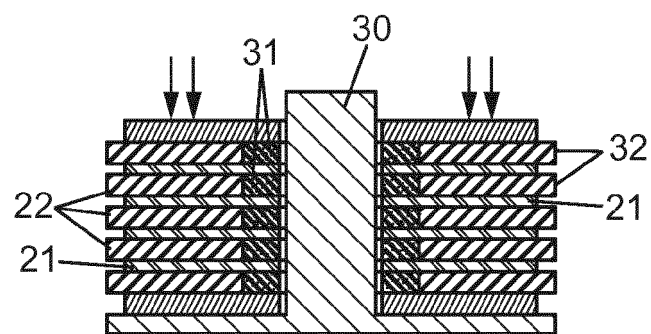


FIG. 7

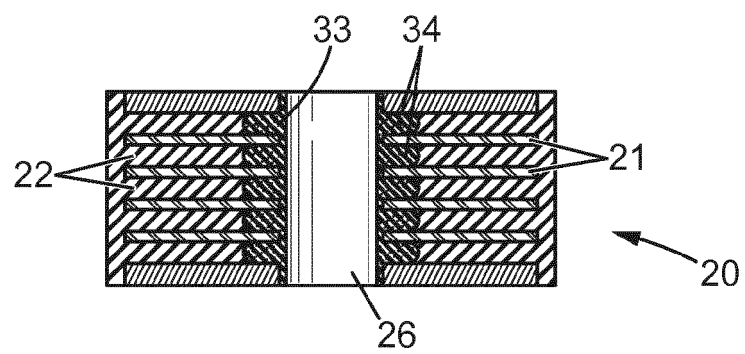


FIG. 8

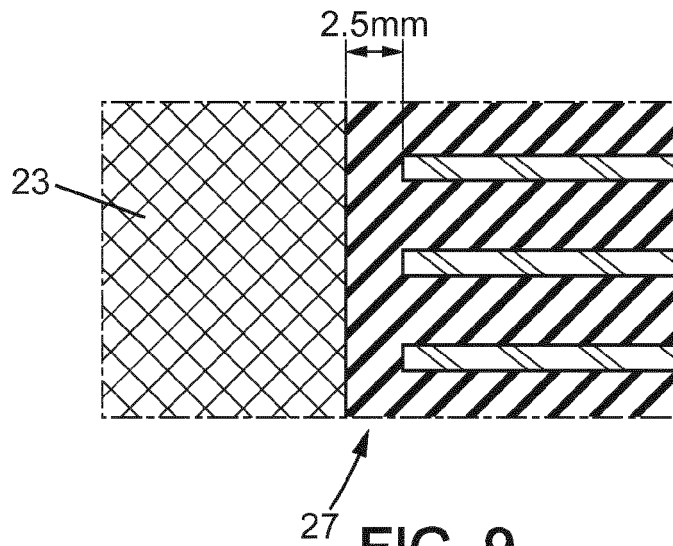


FIG. 9

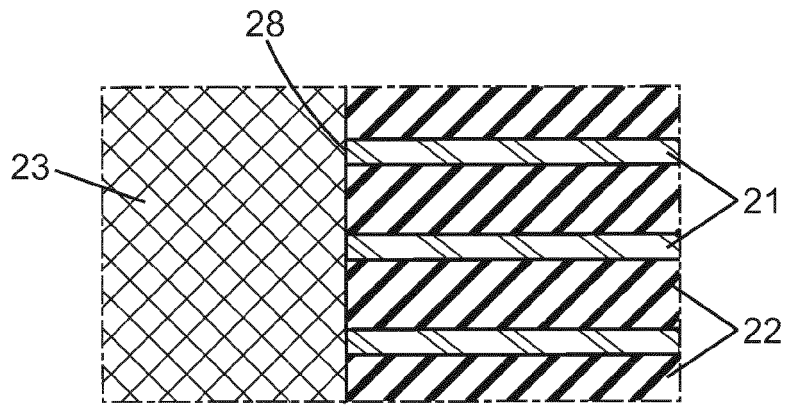


FIG. 10

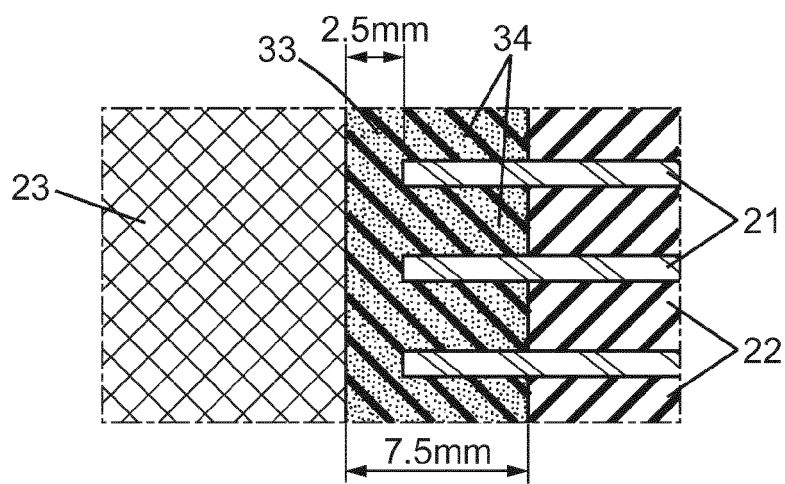


FIG. 11



EUROPEAN SEARCH REPORT

Application Number
EP 18 30 5284

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 255 303 A1 (OILES INDUSTRY CO LTD [JP]) 13 December 2017 (2017-12-13)	1-7,9-13	INV. E04H9/02
A	* page 6, line 8 - page 7, line 18 * * page 8, line 13 - line 48 * * page 9, line 16 - page 12, line 30; figures 1-4 *	15,16	

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A	* page 6, line 23 - page 9, line 18 * * page 9, line 40 - page 11, line 33; figures 1-5 *	11-13, 15,16	

A	JP 2000 145884 A (SHOWA ELECTRIC WIRE & CABLE CO) 26 May 2000 (2000-05-26)	1,2,5,6, 8-11, 14-16	
	* paragraph [0012] - paragraph [0022]; figures 1-5 *		

The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			E04H E01D
Place of search		Date of completion of the search	Examiner
Munich		21 September 2018	Stefanescu, Radu
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 30 5284

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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21-09-2018

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