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(54) Method for protecting an object against traffic induced vibration

(57) A method and system for protecting an object to be protected against vibration induced by traffic and transmitted from a roadway (2) via the ground. The object to be protected (1), such as a building, is protected against the vibration induced by traffic and transmitted from a roadway (2) via the ground using an insulator wall (3), which has been driven into the ground at a distance from the roadway substantially in parallel with the road-

way between the roadway and the object to be protected to damp vibration. The insulator wall (3) has been installed with respect to the vertical direction at an inclined angle (α) so that the insulator wall is slanting downward at the aforesaid angle (α) and away from the roadway (1) to direct the vibration obliquely downward, the insulator wall (3) both damping and directing the vibration into the direction determined by the insulator wall.

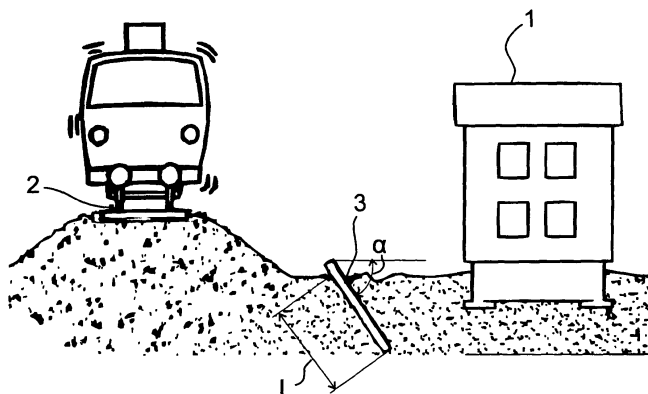


Fig. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method as defined in the preamble of claim 1. Further, the invention relates to a system as defined in claim 12.

BACKGROUND OF THE INVENTION

[0002] Vehicles travelling on roadways induce ground vibration that is transmitted via the soil into buildings close to the roadways, causing various damages and reducing the quality of life. This is a serious problem especially on roadways with heavy traffic volumes. In the long run, the vibration may also cause structural damages to the buildings. As used herein, the term "roadway" refers both to railways with train traffic and to highways with wheeled vehicles. In the case of railway traffic, in order to avoid extreme vibration levels, sometimes the maximum train speeds must be limited in such areas where the ground vibration causes problems. The problem has been understood to be so serious that new international standards are under preparation work in the European Community for stating limits to acceptable vibration levels. This is an important element leading towards environmentally friendly ground transport especially in the neighbourhood of highly populated urban towns. On the other hand, demands to increase the performance of ground transportation are forcing the expedition and railway companies to use heavy wagons with increasing speeds. It has been observed that higher speeds lead to higher structural and ground responses especially in the case of soft soil (Bahrekazemi, M & Bodare, A. Reduction of Train-induced Ground vibrations by Lime-Cement Columns, Seventh International Workshop on Railway Noise, Solving Urban Rail Noise and Vibration Problems, Portland, Maine USA, October 24-27, 2001). Because this development is in conflict with both building protection and environmental requirements one has started to examine technical solutions to reduce ground vibration close to roadways.

[0003] In the state of the art, one has introduced and used between the vibration source and object:

- stiff ground vibration isolator barriers (use of a concrete structure has been disclosed in publications [Ahmad, S. and Al-Hussaini, T.M. Simplified Design for Vibration Screening by Open and In-filled Trenches, Journal of Geotechnical Engineering (1991) 117(1) pp. 67-88]),
- soft ground vibration isolator barriers (the use of an air cushion has been disclosed in publication [Al-Hussaini, T.M. and Ahmad, S. Design of Wave Barriers for Prediction of Horizontal Ground Vibration, Journal of Geotechnical Engineering (1991) 117(4), pp. 616-636]), and
- medium hard barrier walls [Bahrekazemi, M & Bo-

dare, A. Reduction of Train-induced Ground vibrations by Lime-Cement Columns, Seventh International Workshop on Railway Noise, Solving Urban Rail Noise and Vibration Problems, Portland, Maine USA, October 24-27, 2001].

[0004] Field tests have shown that said methods and structures are relatively effective in their primary function and, therefore, it has opened the discussion on how these structural elements could be installed in a cost-effective way.

[0005] Prior-art structures are also known from patent publications PL 168171, JP11280099, US 2004091316, EP 0 913 527 A1, US 5,173,012 and JP 04-312607, in which the vibration-damping walls are vertical. Due to the verticality of the insulator wall, no doubt the ground vibration can be reduced to some extent, but not sufficiently. Furthermore, known installation methods are expensive and structures very complicated.

OBJECTIVE OF THE INVENTION

[0006] The objective of the invention is to eliminate the drawbacks referred to above.

[0007] One specific objective of the invention is to disclose an advantageous and fast installation method and system which require very little labour and damp the ground vibration transmitted into an object to be protected more efficiently than before.

SUMMARY OF THE INVENTION

[0008] The method of the invention is characterized by what has been presented in claim 1. Further, the system of the invention is characterized by what has been presented in claim 12.

[0009] According to the invention, in the method, an isolator wall is placed to an inclined angle so that the isolator wall is slanting downward at said angle and away from the roadway to direct the vibration obliquely downward, the insulator wall thus both damping and directing the vibration into the direction determined by the insulator wall.

[0010] Similarly, according to the invention, in the system, the insulator wall is with respect to the vertical direction at an inclined angle so that the insulator wall is slanting downward at said angle and away from the roadway to direct the vibration obliquely downward, the insulator wall thus both damping and directing the vibration into the direction determined by the insulator wall.

[0011] The invention has the advantage that thanks to it an object such as a building can be protected against traffic-induced vibration more efficiently than before because besides being damped, the vibration is directed downward.

[0012] In one embodiment of the method, the insulator wall is installed with respect to the horizontal direction to an angle of about $10^\circ \leq \alpha \leq 60^\circ$, preferably about 45° .

[0013] In one embodiment of the method, the depth of the insulator wall below ground level is adjusted to be about 5 m. The depth is adjusted according to the soil type into which the insulator wall is to be installed.

[0014] In one embodiment of the method, a noise barrier is attached to the insulator wall to damp the noise transmitted from the roadway via the air, the insulator wall thus acting as a foundation for the noise barrier.

[0015] In one embodiment of the method, a number of wall elements are installed into the ground and attached to one another side by side in line to form a uniform insulator wall.

[0016] In one embodiment of the method, the wall elements are driven one by one into the ground at the aforesaid angle.

[0017] In one embodiment of the method, soil material is removed from above the wall elements that were driven into the ground to expose the side surface; a soft insulator layer such as an air cushion, a layer of cellular plastic, of light gravel or the like is placed against the side surface in engagement therewith; and the excavation is filled to cover the formed insulator wall formed together by the wall elements and the insulator layer. In one alternative embodiment of the method, the wall elements are not driven into the ground, instead an excavation groove is formed in the ground having a peripheral wall disposed at the aforesaid angle and facing the roadway; the insulator wall is placed on top of the peripheral wall; the insulator layer is placed on top of the wall elements; and the excavation groove is filled.

[0018] In one embodiment of the method, rails of a railway serve as the roadway, whereby

- a) a railway wagon is arranged which serves as an intermediate storage for the wall elements and/or the insulator layer material in the work site;
- b) a working machine is arranged which is equipped with an articulated boom arm having a quick clamping device at the end thereof for removable fastening of a tool, which working machine is arranged to be movable under the control of the rails;
- c) a gripping and jolting apparatus and a bucket are arranged to act as the tools for the working machine;
- d) the railway wagon and the working machine are transferred to the work site;
- e) the gripping and jolting apparatus is attached to the quick clamping device of the articulated boom arm;
- f) the gripping and jolting apparatus is used to grasp the wall element;
- g) a number of wall elements are driven side by side one after the other into the ground at the aforesaid angle,
- h) soil material is removed from above the wall elements that were driven into the ground;
- i) a soft insulator layer such as an air cushion, a layer of light gravel or the like is placed against the side surface of the wall elements; and

j) the insulator wall formed by the wall elements driven into the ground and the insulator layer is covered with soil material.

[0019] In one embodiment of the method, after step j), the wall elements are removed from inside the ground, and just one insulator layer is left inside the ground, acting as the insulator wall alone.

[0020] In one embodiment of the method, after step j), a noise barrier is attached to the wall elements.

[0021] In one embodiment of the system, the insulator wall is with respect to the horizontal direction at an angle of about $10^\circ \leq \alpha \leq 60^\circ$, preferably about 45° .

[0022] In one embodiment of the system, the depth of the insulator wall below ground level is about 5 m.

[0023] In one embodiment of the system, a noise barrier is attached to the insulator wall to damp the noise transmitted from the roadway via the air, the insulator wall thus acting as a foundation for the noise barrier.

[0024] In one embodiment of the system, the insulator wall includes a number of wall elements that have been attached to one another side by side in line to form a uniform insulator wall.

[0025] In one embodiment of the system, the wall element is a profile sheet element having connecting members in the edges thereof to consecutively attach similar profile sheet elements to one another.

[0026] In one embodiment of the system, the wall element is a so-called sheet pile profile element.

[0027] In one embodiment of the system, the wall element is a box consisting of a profile sheet element and of a sheet attached to the open flank of the profile sheet element. The profile sheet element can be e.g. a sheet pile profile element, and the sheet can be e.g. a steel sheet. A supporting plate such as a steel sheet can be further placed between the profile sheet element and the sheet attached to its open flank. The sheet can be fastened to the open flank of the profile sheet element, for example, by welding. In the same manner, the supporting plate can also be welded to the box formed by the profile sheet element and the sheet. The box can be filled with concrete, soil material and/or any other suitable medium.

[0028] In one embodiment of the system, the wall element refers to a predefined number of tubes that have been attached to one another by means of connecting members as a series of no less than two interlocked tubes. The tubes can be e.g. steel tubes. To form the wall element, two separate tubes can be e.g. welded together, and thereafter a predetermined number of parts formed by two tubes can be connected to one another by means of connecting members such as flat iron bars. In one embodiment of the system, the tubes can be filled with concrete, soil material and/or any other suitable medium.

[0029] In one embodiment of the system, the bottom end of the wall element can be provided with a tip part which facilitates installing of the wall elements into the ground.

[0030] In one embodiment of the system, the insulator wall comprises steel, concrete and/or plastic.

[0031] In one embodiment of the system, the insulator wall includes an insulator layer of substantially soft material that is arranged against that side surface of the wall elements which is facing the building to be protected.

[0032] In one embodiment of the system, the insulator layer is an air cushion, a layer of cellular plastic and/or of light gravel.

[0033] The system can be utilised in protecting buildings situated close to a railway or highway against ground vibration.

LIST OF FIGURES

[0034] In the following section, the invention will be described in detail with reference to the accompanying drawing, in which

Fig. 1 is a schematic partially sectioned view illustrating one embodiment of the system according to the invention;

Fig. 2 is a schematic partially sectioned view illustrating another embodiment of the system according to the invention;

Fig. 3 shows a working machine to be used in one embodiment of the method according to the invention; and

Fig. 4 shows a combination of a working machine and a railway wagon to be used in one embodiment of the method according to the invention;

Figs. 5 - 9 illustrate different steps of one embodiment of the method according to the invention;

Figs. 10 - 13 shows four different insulator wall structures;

Fig. 14 illustrates directing the vibration into the direction determined by the insulator wall;

Fig. 15 is a schematic sectional view showing the sheet pile profile elements to be used in one embodiment of the system according to the invention when attached to form a wall structure;

Fig. 15a is a schematic sectional view showing the wall elements to be used in another embodiment of the system according to the invention when attached to form a wall structure;

Fig. 15b schematically shows the wall structure of Fig. 15a as seen from the side; Fig. 15 c further shows a wall element according to one embodiment of the invention; and

Figs. 16 and 17 schematically show one preferred gripping and jolting apparatus and a sheet pile profile element in its grasp.

DETAILED DESCRIPTION OF THE INVENTION

[0035] Fig. 1 shows a system using which a building to be protected 1 has been protected against vibration induced by train traffic and transmitted from a railway

track 2 via the ground. The system may as well be used on highways to protect buildings nearby against ground vibration induced by heavy traffic.

[0036] The system as shown in Fig. 1 comprises an insulator wall 3, which has been buried into the ground at a distance from the roadway substantially in parallel with respect to the roadway between the roadway and the object being protected to damp vibration. The insulator wall 3 is with respect to the horizontal direction at an inclined angle α so that the insulator wall is slanting downward at the aforesaid angle α and away from the roadway 1. In that case, as shown in Fig. 14, the ground vibration is directed obliquely downward deep into the ground, where it is damped and not transmitted into the building 1. Thus, the insulator wall 3 both damps and directs the vibration into the direction determined by the insulator wall. The insulator wall is with respect to the horizontal direction at an angle α , which is $10^\circ \leq \alpha \leq 60^\circ$, preferably about 45° , as shown in Fig. 1. The depth L of the insulator wall 3 below ground level is about 5 m. The depth is adjusted according to the soil type. Preferably, the insulator wall 3 can consist of a wall formed from solid, stiff materials such as steel or concrete, of artificial gravel layers and of air cushion walls.

[0037] Fig. 2 shows a preferred embodiment of the system of Fig. 1, in which an underground insulator wall 3 has been provided with an aboveground noise barrier 4 to damp the noise transmitted from the roadway 1 via the air. In that case, the underground insulator wall 3 acts as a founding for the noise barrier 4, and no separate founding for the noise barrier is needed. The noise barrier 4 can be of any suitable prior-art type.

[0038] Preferably, the insulator wall 3 includes a wall structure consisting of a number of wall elements 5, which have been attached to one another in line side by side to form a uniform insulator wall. Fig. 15 shows a portion of the wall in which the wall elements 5 are profile sheet elements, that is sheet pile profiles. The edges of the elements 5 are provided with connecting members 16 for connecting similar profile sheet elements 5 successively to one another. The connecting members 16 form together a tongue-and-groove joint. Fig. 15a shows a portion of the wall in which the wall elements 5 are boxes, filled e.g. with concrete 23, formed from profile sheet elements, that is so-called sheet pile profile elements, and from sheets 20 attached to the open flanks of the profile sheet elements. Fig. 15a further shows a supporting plate 21 attached to the middle portion of the box. Fig. 15b shows the aforesaid portion of the wall as seen from the side. Fig. 15b further shows the tip part 22 disposed at the lower end of the wall element 5. Fig. 15c shows an example of a part of the wall element, formed from a predetermined number of tubes 24, which have been connected to one another by means of connecting members 25 as a series of no less than two interlocked tubes. In one embodiment of the invention, the tubes 24 can be so-called RHS tubes (e.g. 100x200x6). As the connecting members 25, e.g. PL flat iron bars (e.g. 100x8) can be

used. The tubes can be filled e.g. with concrete 23 or with any other suitable medium.

[0039] Fig. 10 shows an embodiment in which the insulator wall 3 consists of just a wall formed from sheet pile profiles 5.

[0040] Fig. 11 shows an embodiment in which the insulator wall 3 consists of a wall formed from sheet pile profiles 5 and from an insulator layer 7, disposed against that side surface 6 of the wall which is facing the building to be protected, which insulator layer is herein, for example, a layer of light gravel (artificial gravel).

[0041] Fig. 12 shows an embodiment in which the insulator wall 3 consists of a wall formed from sheet pile profiles 5 and from an insulator layer 7, disposed against that side surface 6 of the wall which is facing the building to be protected, which insulator layer is herein an air cushion.

[0042] Fig. 13 shows an embodiment in which the insulator wall 3 consists of a sheer insulator layer 7, which is herein an air cushion.

[0043] The wall that is formed from sheet pile profiles to be driven into the ground can be used mainly in soft soil.

[0044] Figs. 3 - 9 illustrate a method by which the insulator wall 3 is installed into the ground.

[0045] Fig. 3 shows a working machine 11, which is an excavator equipped with an articulated boom arm 12 having a standard quick clamping device 13 at the end thereof for removable fastening of a tool 14, 15, which working machine is equipped with railway wheels 17 as it is designed to be movable under the control of railway rails 2. Preferably, the railway track 2 is used as a mechanical guide element in order to keep the distance between the insulator wall 3 and the railway substantially constant. As the tools of the working machine 11 act a gripping and jolting apparatus 14 (see Figs. 3, 5, 9, 16) and a bucket 15 (see Figs. 6, 7 and 8), which one uses in the quick clamping device 13 by turns according to each work phase.

[0046] The gripping and jolting apparatus 14 to be used in the method is preferably the device schematically shown in Figs. 16 and 17 engaging with the sheet pile profile 5 from the side and provided with a jolting tool 18 and a gripper 19 as a single small-sized complex that flexibly performs all the necessary material handling, manipulation, adjusting, automatic steering and piling operations. This kind of excavator accessory is sold under the trade name Movax (manufacturer Unisto Oy, Finland).

[0047] Fig. 4 shows another preferred complex to be used in a railway embodiment, in which a railway wagon 10 acts as an intermediate storage of the wall elements 5 and/or the insulator layer material 7 (not shown in the figure) in the work site. The working machine 11 can also be connected to the railway wagon 10. Also herein the working machine 11 is an excavator which is equipped with an articulated boom arm 12 having at the end thereof a quick clamping device 13 for removable fastening of the tool 14, 15. Also in this embodiment, the railway track 2 is used as a mechanical guide element in order to keep

the distance between the insulator wall 3 and the railway substantially constant. As the tools of the working machine 11 act a gripping and jolting apparatus 14 and a bucket 15, which one uses in the quick clamping device 13 by turns according to each work phase. When the one is not used, the other can be kept in the railway wagon 10, enabling one to carry the necessary tools at all times as the work proceeds.

[0048] With the aforementioned arrangements, the method can be made fast, enabling one to avoid long traffic breaks. Furthermore, the method requires very little labour because the installation work can be performed by a single person, who operates an installation device 13 and a bucket 14 installed into the excavator 11.

[0049] Fig. 4 shows a phase in which the railway wagon 10 and the working machine 11 have been transferred to the working site and the gripping and jolting apparatus 14 has been attached to the quick clamping device of the articulated boom arm, and in which the gripping and jolting apparatus 14 is used to grasp the wall element 5 with a side grip.

[0050] In Fig. 5, the wall element 5 has been conveyed to a desired place and to a suitable angle position α , and is being driven into the ground. Once one element 5 has been driven into the ground, the wagon 10 or the excavator 11 is driven along the railway track about the width of the element 5, and the next wall element 5 is driven next to the previous one and so that the connecting members 16 are connected to one another as shown in Fig. 15. The aforementioned steps are repeated until there are in the ground wall elements 5 driven side by side one after the other and having a common width corresponding to the width of the air cushion 7 to be used as the insulator layer.

[0051] Fig. 6 shows a situation in which the articulated boom arm 12 has a bucket 15 attached to the end thereof to the quick clamping device 13. Soil material is removed from above the wall elements 5 that were driven into the ground to show their side surface 6. The removed soil material is used for filling the adjacent dig place.

[0052] In Fig. 7, by using the articulated boom of the excavator 11 as the hoisting device, a soft insulator layer 7 such as an air cushion or the like is placed against the inclined side surface 6 of the wall formed by the wall elements 5.

[0053] In Fig. 8, the insulator wall 3 formed by the wall elements and insulator layer 7 is covered with soil material.

[0054] In Fig. 9, the bucket 15 has been replaced with the gripping and jolting apparatus 14. If the sheet pile wall is a temporary one and is only used as an installation aid of the insulator layer 7, then the wall elements 5 can be removed from inside the ground, leaving just the insulator layer 7 therein, arriving at the result as shown in Fig. 13. Alternatively, when using a sheet pile wall to be permanently left inside the ground, one arrives at the result shown 11 or 12.

[0055] The method can propagate as some kind of a

window which propagates along the railway track according to the aforementioned steps. One can flexibly proceed with the method as long as the terrain and the soil material are suitable for driving wall elements into the ground.

[0056] The invention is not limited merely to the embodiment examples referred to above; instead many variations are possible within the scope of the inventive idea defined by the claims.

Claims

1. A method for protecting an object to be protected (1), such as a building, from vibration induced by traffic and transmitted from a roadway (2) via the ground, in which method an insulator wall (3), which is substantially parallel with respect to the roadway, is driven into the ground at a distance from the roadway between it and the object to be protected to damp vibration, **characterised in that** the insulator wall (3) is installed so as to be at an inclined angle α so that the insulator wall is slanting downward at the aforesaid angle α and away from the roadway (2) to direct the vibration obliquely downward, the insulator wall both damping and directing the vibration into the direction determined by the insulator wall.
2. The method as defined in claim 1, **characterised in that** the insulator wall (3) is installed with respect to the horizontal direction so as to be at an angle (α), which is $10^\circ \leq \alpha \leq 60^\circ$, preferably about 45° .
3. The method as defined in claim 1 or 2, **characterised in that** the depth (L) of the insulator wall (3) below ground level is adjusted to be about 5 m.
4. The method as defined in any one of claims 1 - 3, **characterised in that** a noise barrier (4) is attached to the insulator wall (3) to damp the noise transmitted from the roadway (1) via the air, the insulator wall (2) thus acting as a foundation for the noise barrier (4).
5. The method as defined in any one of claims 1 - 4, **characterised in that** a number of wall elements (5) are driven into the ground and attached to one another side by side in line to form a uniform insulator wall (3).
6. The method as defined in claim 4, **characterised in that** the wall elements (5) are driven one by one into the ground at the aforesaid angle (α).
7. The method as defined in claim 6, **characterised in that** soil material is removed from above the wall elements (5) that were driven into ground to expose

the side surface (6); a soft insulator layer (7), for example an air cushion, a layer of cellular plastic, of light gravel or the like, is placed against the side surface in engagement therewith; and the excavation is filled to cover the formed insulator wall (3) formed together by the wall elements (5) and the insulator layer (7).

8. The method as defined in any one of claims 1 - 6, **characterised in that** an excavation groove (8) is formed in the ground having a peripheral wall (9) disposed at the aforesaid angle (α) and facing the roadway (1); the insulator wall (3) is placed on top of the peripheral wall; the insulator layer (7) is placed on top of the wall elements (5); and the excavation groove is filled.
9. The method as defined in any one of claims 5 - 7, **characterised in that** the rails of a railway serve as the roadway, and that
 - a) a railway wagon (10) is arranged acting as an intermediate storage of the wall elements (5) and/or the insulator layer material in the work site,
 - b) a working machine (11) is arranged which is equipped with an articulated boom arm (12) having at the end thereof a quick clamping device (13) for removable fastening of a tool (14, 15), which working machine is arranged to be movable under the control of the railway rails,
 - c) a gripping and jolting apparatus (14) and a bucket (15) are arranged to act as the tools for the working machine (11);
 - d) the railway wagon (10) and the working machine (11) are transferred to the work site;
 - e) the gripping and jolting apparatus (14) is attached to the quick clamping device of the articulated boom arm;
 - f) the gripping and jolting apparatus (14) is used to grasp the wall element (5);
 - g) a number of wall elements (5) are driven side by side one after the other into the ground at the aforesaid angle (α);
 - h) soil material is removed from above the wall elements (5) that were driven into the ground;
 - i) a soft insulator layer (7) such as an air cushion, a layer of light gravel or the like is placed against the side surface (6) of the wall elements; and
 - j) the insulator wall (3) formed by the wall elements (5) driven into the ground and the insulator layer (7) is filled with soil material.
10. The method as defined in claim 9, **characterised in that** after step j) the wall elements are removed from inside the ground, and just the insulator layer (7), acting as the insulator wall (3) alone, is left inside the ground.

11. The method as defined in claim 9, **characterised in that** after step j) a noise barrier (4) is attached to the wall elements (5).
12. A system for protecting an object to be protected (1), such as a building, from vibration induced by traffic and transmitted from a roadway (2) via the ground, which system includes an insulator wall (3), which is driven into the ground at a distance from the roadway substantially in parallel with respect to the roadway between the roadway and the object to be protected to damp vibration, **characterised in that** the insulator wall (3) is with respect to the vertical direction at an inclined angle α so that the insulator wall is slanting downward at the aforesaid angle α and away from the roadway (1) to direct the vibration obliquely downward, the insulator wall (3) both damping and directing the vibration into the direction determined by the insulator wall.
13. The system as defined in claim 12, **characterised in that** the insulator wall (3) is with respect to the horizontal direction at an angle (α), which is $10^\circ \leq \alpha \leq 60^\circ$, preferably about 45° .
14. The system as defined in claim 12 or 13, **characterised in that** the depth (L) of the insulator wall (3) below ground level is about 5 m.
15. The system as defined in any one of claims 12 - 14, **characterised in that** a noise barrier (4) is attached to the insulator wall (3) to damp the noise transmitted from the roadway (1) via the air, the insulator wall (3) thus acting as a foundation for the noise barrier (4).
16. The system as defined in claim 12 - 14, **characterised in that** the insulator wall (3) includes a number of wall elements (5) that have been attached to one another side by side in line to form a uniform insulator wall.
17. The system as defined in claim 16, **characterised in that** the wall element (5) is a profile sheet element having at the edges thereof connecting members (16) for connecting similar profile sheet elements consecutively to one another.
18. The system as defined in claim 16, **characterised in that** the wall element (5) is a so-called sheet pile profile element.
19. The system as defined in claim 16, **characterised in that** the wall element (5) is a box formed from a profile sheet element and a sheet (20) attached to the open flank of the profile sheet element.
20. The system as defined in claim 16, **characterised in that** the wall element (5) refers to a predetermined number of tubes (24) that have been attached to one another by means of connecting members (25) as a series of no less than two interlocked tubes.
21. The system as defined in claim 19 or 20, **characterised in that** the box/tubes have been filled with concrete, soil material and/or some other medium.
22. The system as defined in any one of claims 16 - 21, **characterised in that** the wall element (5) has at the lower end thereof a tip part (22).
23. The system as defined in any one of claims 12 - 22, **characterised in that** the insulator wall (3) includes steel, concrete and/or plastic.
24. The system as defined in any one of claims 12 - 23, **characterised in that** the insulator wall (3) includes an insulator layer (7) of substantially soft material, arranged against that side surface (6) of the wall elements (5) which is facing the building to be protected.
25. The system as defined in claim 18, **characterised in that** the insulator layer (7) is an air cushion, a layer of cellular plastic and/or of light gravel.
26. The use of a system as defined in any one of claims 12 - 25 for protecting buildings close to railways and highways against ground vibration.

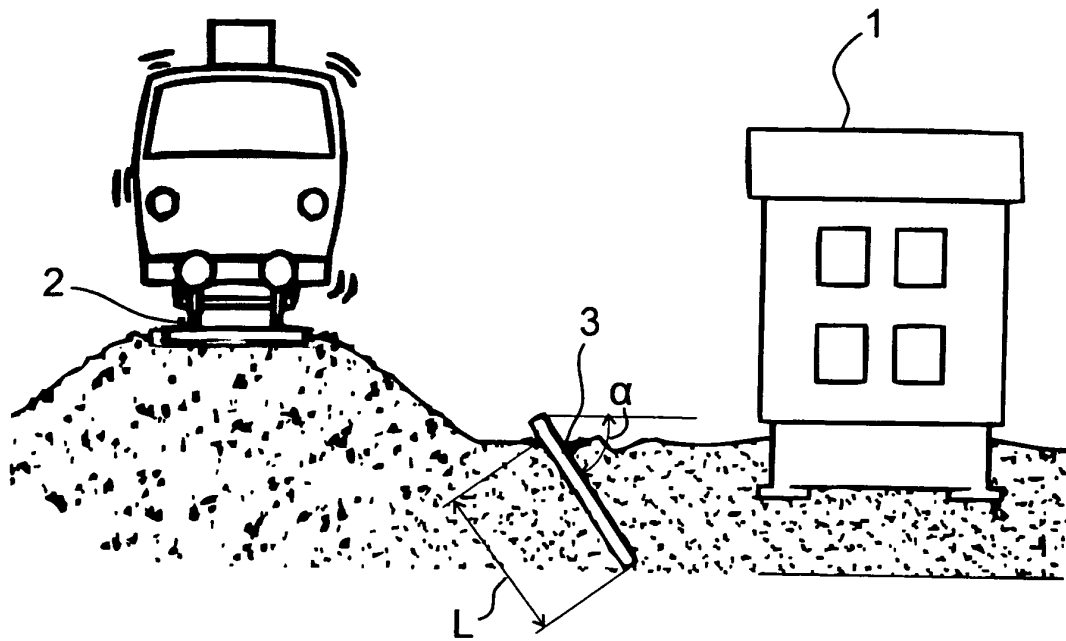


Fig. 1

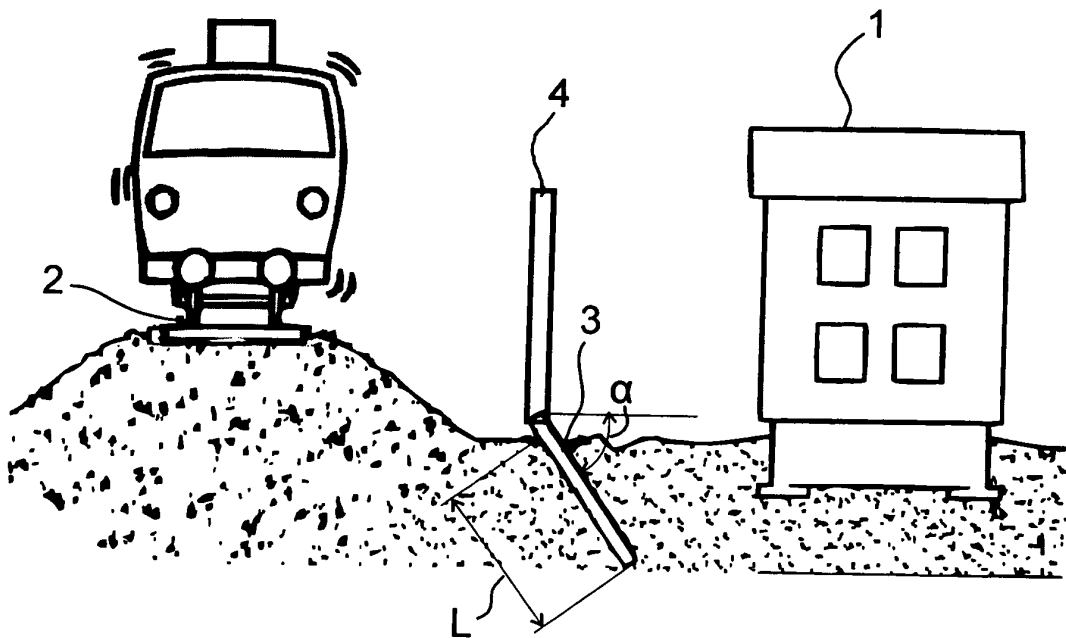


Fig. 2

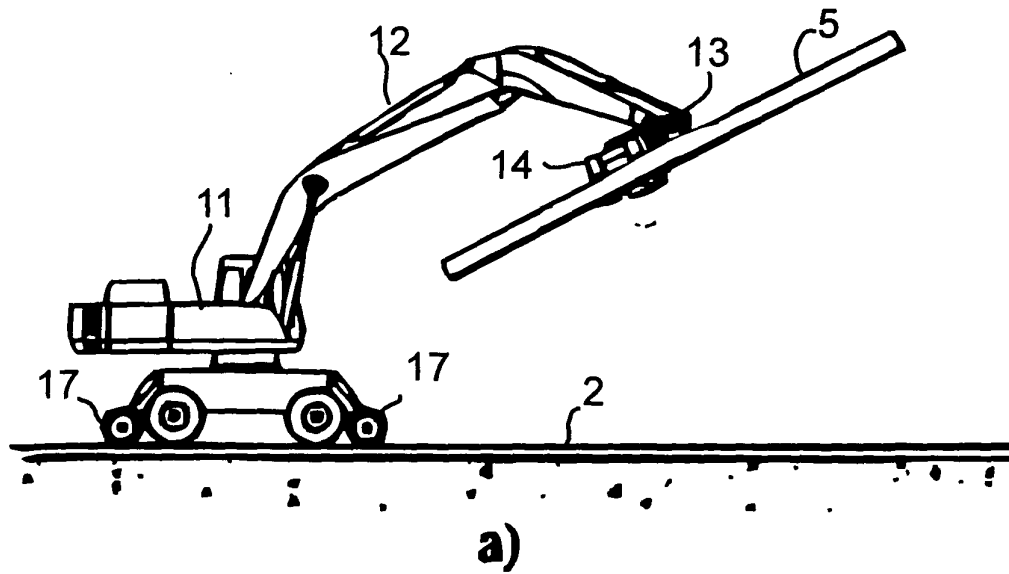


Fig. 3

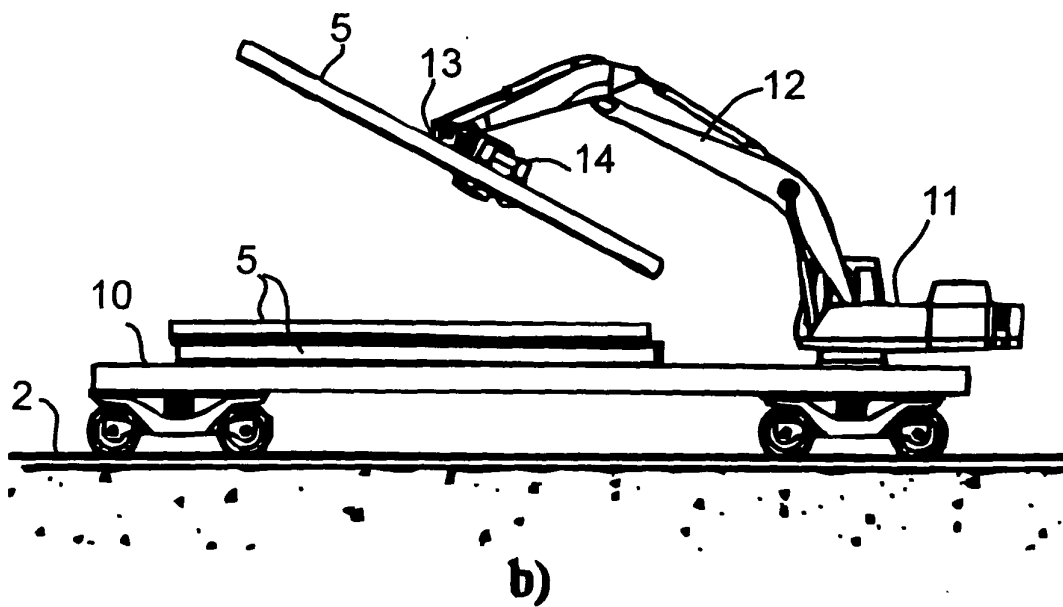


Fig. 4

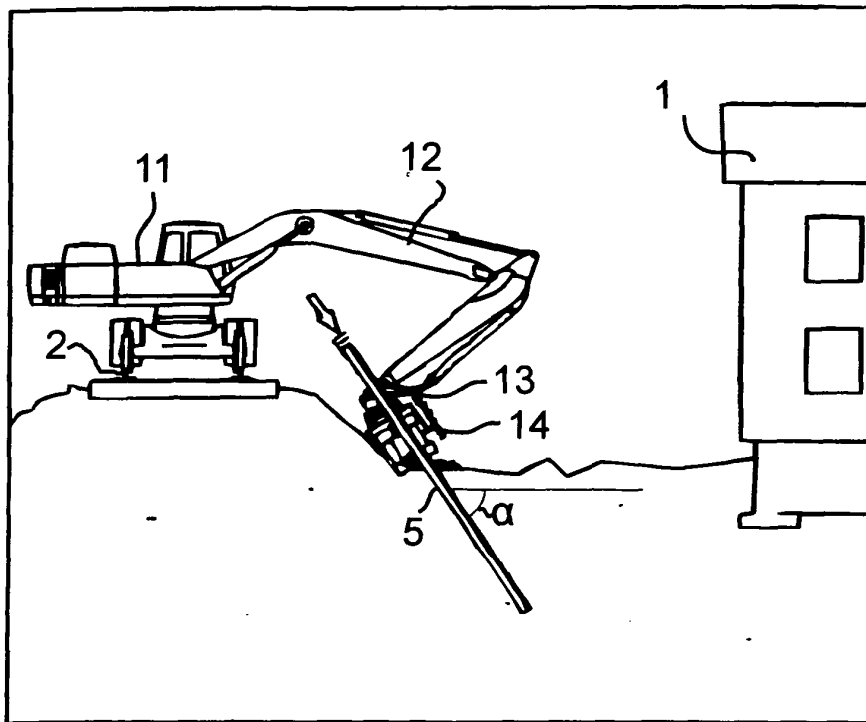


Fig. 5

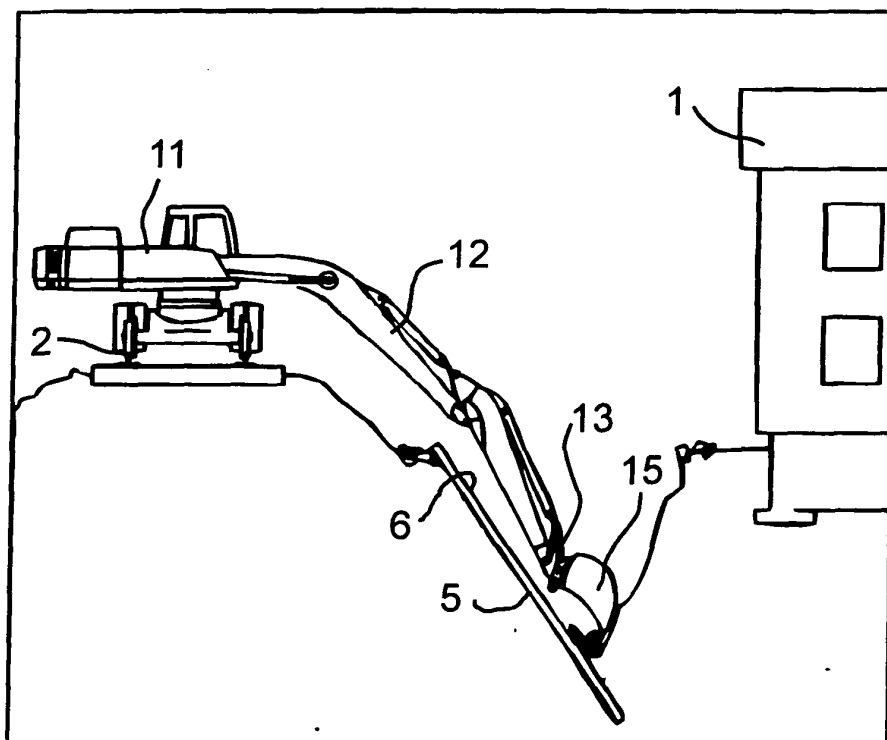


Fig. 6

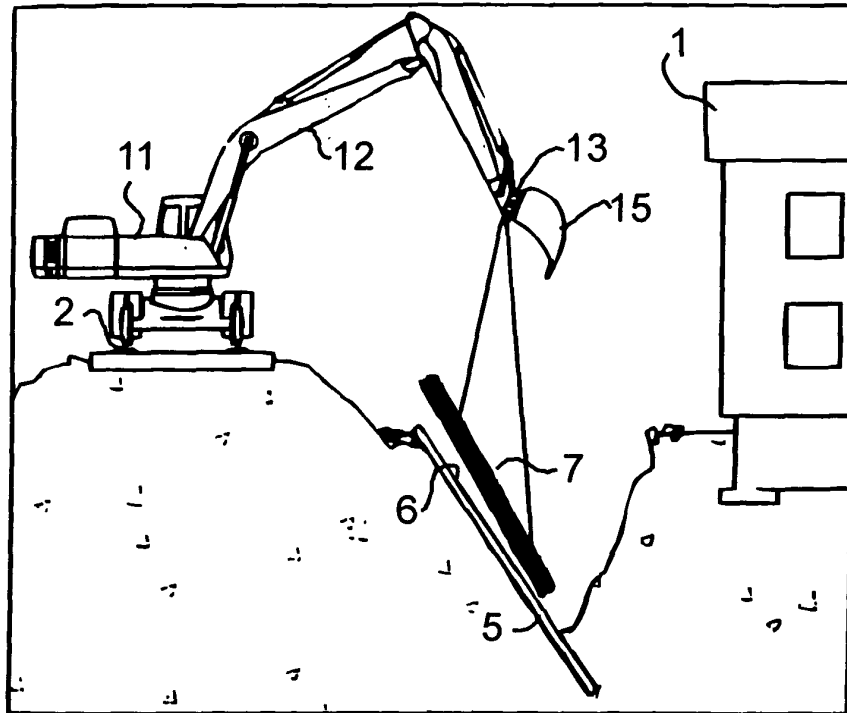


Fig. 7

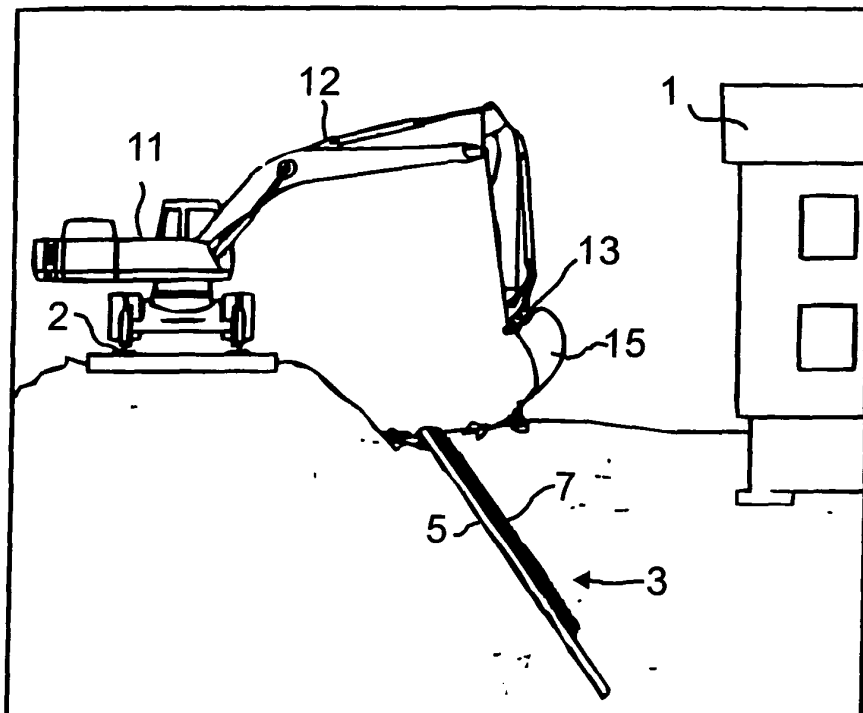


Fig. 8

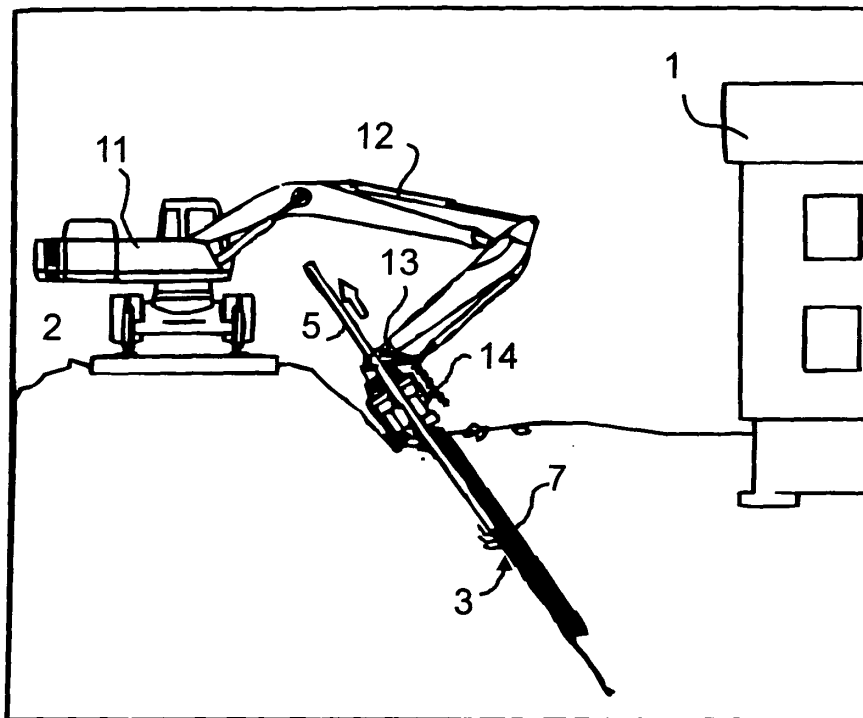


Fig. 9

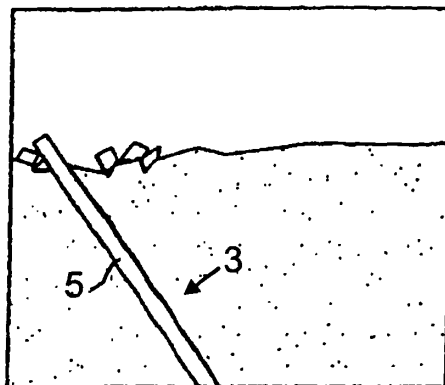


Fig. 10

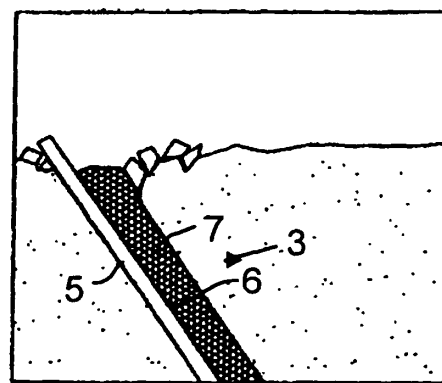


Fig. 11

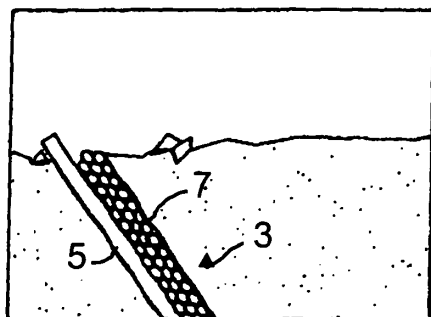


Fig. 12

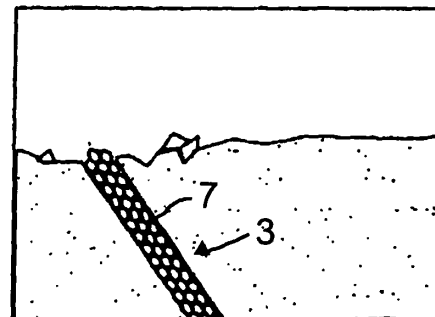


Fig. 13

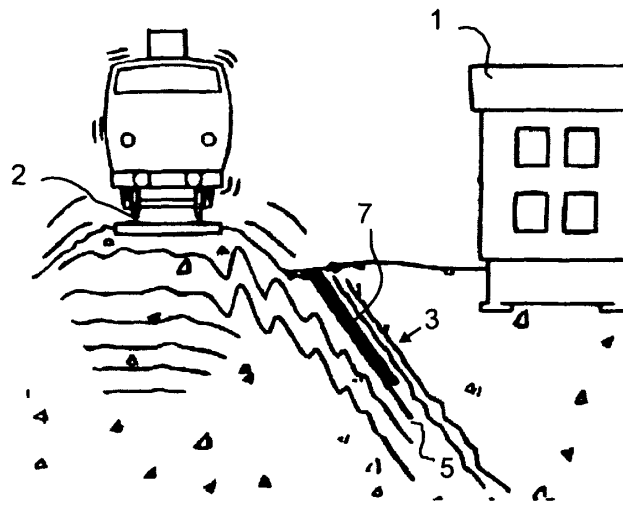


Fig. 14

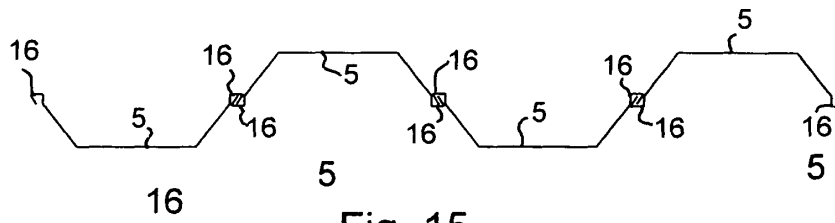


Fig. 15

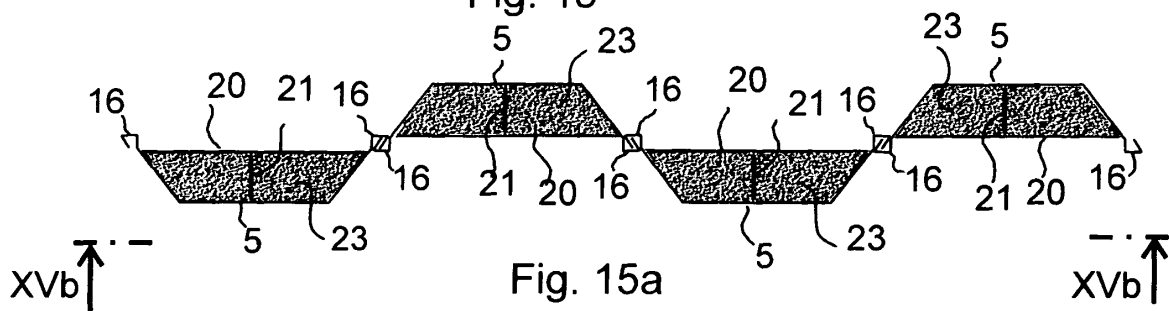


Fig. 15a

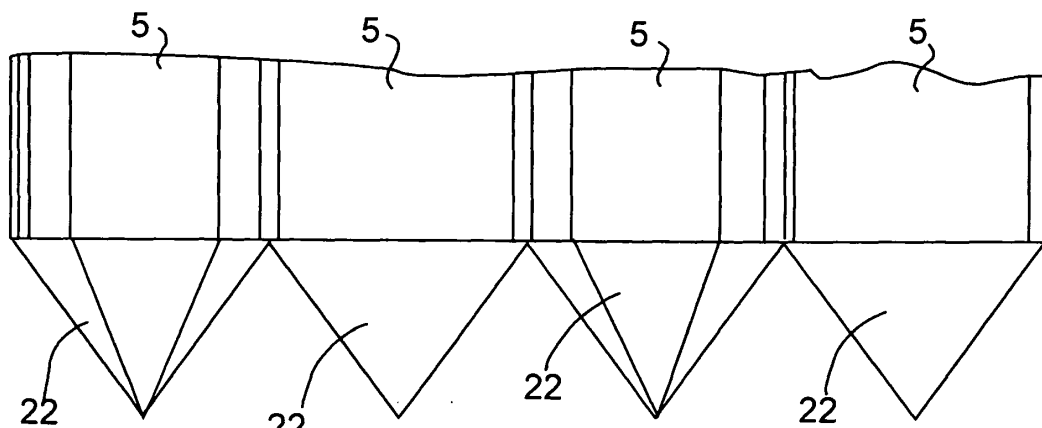


Fig. 15b

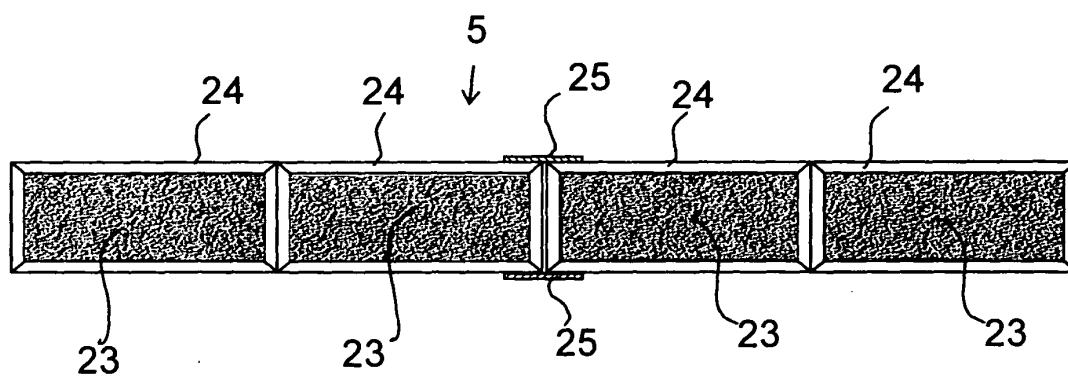


Fig. 15c

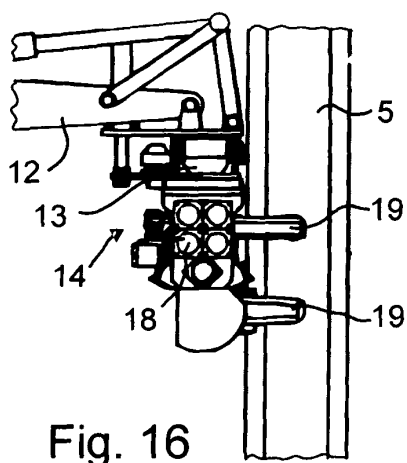


Fig. 16

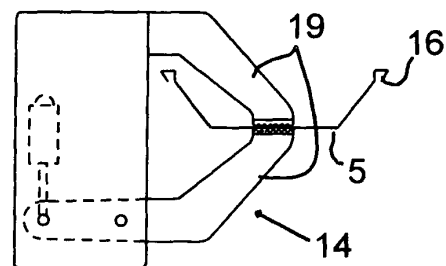


Fig. 17