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(54) **SEISMIC INSULATING STRUCTURE FOR EXISTING BUILDINGS**

SEISMISCHE ISOLIERSTRUKTUR FÜR BESTEHENDE GEBÄUDE

STRUCTURE D'ISOLATION SISMIQUE POUR BÂTIMENTS

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EP 2 553 176 B1

Description

TECHNICAL FIELD

[0001] The present invention relates to a seismic insulating structure for existing buildings.

BACKGROUND ART

[0002] In general, seismic insulation is based on the drastic reduction of seismic actions which challenge the structures, instead of relying on the strength of the structures themselves, thus allowing to obtain a degree of safety not achievable otherwise. Indeed, a building provided with seismic insulation at the base may withstand a violent seismic event remaining within the elastic field and consequently without being damaged.

[0003] Recent constructions in Japan (in particular the so-called "artificial ground") and China have proven the possibility of constructing complex buildings on large sized, insulated platforms. Other examples of buildings made with seismic insulation are the new school in San Giuliano di Puglia and the recent C.A.S.E. Project, built in L'Aquila after the 2009 earthquake.

[0004] Until today, seismic insulation techniques mainly concerned new constructions, above all made of reinforced concrete, for which the saving on construction cost sometimes is even competitive with respect to traditional techniques, at least in highly seismic zones.

[0005] On the contrary, the application of seismic insulating techniques to existing buildings has yet to meet with success. The reasons for this are to be sought particularly in difficulties of execution and costs, which are not always sustainable. Another matter are buildings of historical-artistic interest, for which while on one hand the economic issue is less binding, on the other, problems of execution are multiplied given the incalculable value of their historical and artistic heritage. Indeed, buildings of historical-artistic interest are often considered "untouchable" to foundation level and the presence of basements and/or crypts, decorated floors and valuable wall decorations make application of seismic insulation, for example by cutting the walls at the base, often impracticable.

[0006] It is thus understandable the need for new seismic insulating systems, which fulfill the important and often conflicting needs of structural safety and preservation of value and historic-artistic heritage. Document US0981884A1 discloses a structure according to the preamble of claim 1.

[0007] Document JP2009074272A1 discloses a seismic retrofit method, which does not foresee any two part tubes in contrast to the method of claim 6.

DISCLOSURE OF INVENTION

[0008] It is the object of the present invention to make a seismic insulating structure, the technical features of which are such to guarantee the application thereof also to existing buildings of historical-artistic interest, and which does not have exaggeratedly high implementation costs at the same time.

[0009] It is the object of the present invention a seismic insulating structure, the essential features of which are illustrated in claim 1, and the preferred and/or auxiliary features of which are illustrated in claims 2-5.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] For a better understanding of the invention, an embodiment will be described by way of non-limitative example only, with the aid of the figures of the accompanying drawing, in which:

figures 1a and 1b are two views of a first step of implementation of the seismic insulating structure according to the present invention;
figures 2a and 2b are two views of a second step of implementation of the seismic insulating structure according to the present invention;
figures 3a and 3b are two views of a third step of implementation of the seismic insulating structure according to the present invention;
figures 4a and 4b are two views of the seismic insulating structure according to a preferred embodiment of the present invention; and
figures 5a and 5b are two views of the seismic insulating structure according to a further preferred embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0011] In figures 4a and 4b, numeral 1 illustrates as a whole a preferred embodiment of the seismic insulating structure according to the present invention. The structure 1 comprises an insulating platform 2 arranged i under the foundations 3 of the building 3a to which the structure 1 is intended to be applied, and comprising, in turn, a top block 4, a bottom block 5 separated from the top block 4, a plurality of seismic insulators 6 arranged between the top block 4 and the bottom block 5. Structure 1 further comprises an inner underground wall 7 fixed on the bottom to the top block 4 of the insulating platform 2 and arranged so as to contain the ground that surrounds building 3a, and an outer underground wall 8 fixed on the bottom to the bottom block 5 and arranged about the inner underground wall 7. The inner underground wall 7 and the outer underground wall 8 combinedly define a seismic joint 9 made from a trench in the ground.

[0012] In particular, the insulating platform 2 consists of a plurality of tubes 10 arranged side by side in a horizontal position under the foundations 3. The tubes are made of concrete and have a cylindrical structure.

[0013] Each tube 10 consists of a top cap 10a and a bottom cap 10b separate from one another and between which a plurality of seismic insulators 6, of known type,

is housed. Each top cap 10a is rigidly connected to the adjacent top cap 10a, so as to form the top block 4, which thus consists of all the top caps 10a of the tubes 10.

[0014] Each bottom cap 10b is rigidly connected to the adjacent bottom cap 10b, so as to form the bottom block 5, which thus consists of all the bottom caps 10a of the tubes 10.

[0015] In particular, the connections between the various top caps 10a and the various bottom caps 10b may be made by means of a casting of reinforced concrete or other material.

[0016] Otherwise, the tubes 10 may be made of material other than concrete, and so are the connections, providing they are capable of fulfilling the proper technical requirements of their function, and may have a shape other than cylindrical, for example a square or rectangular section. Furthermore, the tubes 10 may be stiffened by metallic ribs or temporary pillars arranged on site.

[0017] The distance between the insulating platform 2 and the foundations 3 must be defined on a case by case basis according to specific needs, as well as the distance between the inner underground wall 7 and the walls of the building 3a. The distance between inner underground wall 7 and the outer inner wall 8 (seismic joint 9) depends on the seismic movement determined in design, which can reach several tens of centimeters. Furthermore, a plurality of energy dissipaters may be accommodated between the inner underground wall 7 and the outer underground wall 8.

[0018] In figures 5a and 5b, numeral 20 shows another embodiment of the seismic insulating structure according to the present invention. The parts of the structure 20 equal to those of the structure 1 will be indicated with the same numbers and will not be described again. Structure 20 differs from structure 1 in that it comprises a rigid connection 21 between the inner underground wall 7 and the building 3a. The rigid connection between the inner underground wall 7 and the building 3a has the purpose of avoiding oscillations between the same. Alternatively or additionally, the foundations 3 may be connected to the insulating structure by means of appropriate structures (micropiles or other) or ground stiffening/consolidation (injections or other).

[0019] An underground volume, which can be used in various manners, or vehicle transit ways may be obtained between the foundations 3 and the insulating platform 2.

[0020] The size of the tubes guarantees accessibility and consequently possibility of inspecting and replacing the elements, such as the seismic insulators 6.

[0021] Figures 1a, 1b, 2a, 2b, 3a, 3c show the various steps of implementation of the structure 1 as described below.

[0022] Figures 1a, 1b, 2a, 2b show the insertion by means of the "auger boring" or "guided auger boring" technique of the concrete tubes 10 having an inner diameter sufficient to allow the installation and subsequent inspection of the insulators.

[0023] Insertion is carried out after digging a trench along a side of the concerned area. Choosing the most suitable technique depends on the features of the subsoil. The tubes 10, arranged side by side or at an appropriate distance for the subsequent insertion of the seismic insulators 6, must be inserted at a depth to be defined on a case by case basis so as to leave the entire structure unchanged and to allow, when needed, to make an effective connection between foundation and the tubes 10 themselves to possibly obtain a basement. The tubes 10 consist of two caps, top 10a and bottom 10b, connected to one another by means of removable elements 11, appropriately anchored to the caps at two springing lines.

[0024] Such removable elements 11 must consist of parts which are easy to separate and remove so as to facilitate both the housing of the seismic insulators 6 and the discontinuity between the two caps themselves, after inserting the seismic insulators themselves 6.

[0025] Figures 3a 3b show the insertion of the seismic insulators 6 and the disconnection between top 10a and bottom 10b caps.

[0026] At the positions of the seismic insulators 6, the removable elements 11 between the caps 10a and 10b are removed and connections of concrete or other material are made between the adjacent bottom caps 10b, being careful to arrange the housings for the brackets of the insulators.

[0027] Connections of concrete or other material are made between the adjacent top caps 10a in which the top brackets of the insulators 6 are embedded after having arranged the seismic insulators 6.

[0028] Finally, the removable elements 11 are removed, creating the discontinuity between top caps 10a and bottom caps 10b, which remain connected only by the insulators 6.

[0029] Figures 4a and 4b show the structure 1 with the inner 7 and outer 8 underground walls.

[0030] The inner 7 and outer 8 underground walls are built along the perimeter of the building 3a, at an appropriate distance therefrom to be evaluated on a case by case basis. The inner underground wall 7 must be rigidly connected to the upper block 4, constituted by the top caps 10a, which constitute a "tank" containing the underground part of the building 3a seismically insulated at the base. The outer underground wall 8 is rigidly connected to the bottom block 5, constituted by the bottom caps 10b.

[0031] As inferred from the description above, the structure of the present invention allows to seismically insulate existing buildings, guaranteeing that the structure and architecture of the building are not damaged in any manner, also with regards to possible underground rooms, which are part of the insulated substructure.

[0032] Furthermore, between the foundations 3 of the building 3a and the upper caps 10a of the tubes 10, an underground volume usable in various manner, or vehicle transit ways, can be obtained, while the dimensions of the tube guarantee possibility of access and consequently of inspecting and maintaining the structure as a whole, with particular reference to the seismic insulators

6.

[0033] Finally, the structure of the present invention allows to make large insulated platforms, particularly suitable for structural aggregates of even considerable size.

Claims

1. A seismic insulating structure (1) for buildings **characterized by** comprising an insulating platform (2) arranged under the foundations (3) of a building (3a) and comprising a top block (4), a bottom block (5) separated from the top block (4), a plurality of seismic insulators (6) arranged between the top block (4) and the bottom block (5), an inner underground wall (7) fixed on the bottom to the top block (4) and an outer underground wall (8) fixed on the bottom to the bottom block (5) and arranged about said inner underground wall (7); said inner underground wall (7) and said outer underground wall (8) defining a seismic joint for their entire height (9, **characterized in that** the inner underground wall (7) is arranged so as to contain the ground that surrounds said building (3a).

2. The seismic insulating structure according to claim 1, **characterized in that** said insulating platform (2) comprises a plurality of tubes (10) arranged side by side in a horizontal position; each of said tubes (10) consisting of a top cap (10a) and a bottom cap (10b) separate from one another and between which a plurality of seismic insulators (6) is housed; each of the top caps (10a) being rigidly connected to the adjacent top caps (10a), so as to form said top block (4) and each of the bottom caps (10b) being rigidly connected to the adjacent bottom caps (10b), so as to form said bottom block (5).

3. The seismic insulating structure according to claim 2, **characterized in that** said tubes (10) are made of concrete and have a cylindrical structure.

4. The seismic insulating structure according to claim 3, **characterized by** comprising concrete connections between the different top caps (10a) and between the different bottom caps (10b).

5. The seismic insulating structure according to any of the preceding claims, **characterized by** comprising a rigid connection (21) between the inner underground wall (7) and said building (3a).

6. A process for making a seismic insulating structure; said process being **characterized by** comprising in a sequence:

   - a step of introducing a plurality of tubes (10) under the foundations (3) of a building (3a) to be seismically insulated; said tubes (10) being formed by a top portion (10a) and a bottom portion (10b) connected to one another by means of a plurality of removable elements (11);
   - a first step of connecting the different bottom portions (10b) to form a single bottom block (5);
   - a step of positioning a plurality of seismic insulators (6) between the top portions (10a) and the bottom portions (10b);
   - a second step of connecting the different top portions (10a) to form a single top block (4);
   - a step of removing the removable elements (11);
   - a step of forming both an inner underground wall (7) arranged to contain the ground that surrounds the building (3a) and rigidly connected to the top block (4), and an outer underground wall (8) arranged externally to said inner wall (7) and rigidly connected to the lower block (5).

7. The process according to claim 6, **characterized in that** said tubes (10) are made of concrete.

8. The process according to claim 7, **characterized in that** said steps of connecting the different bottom portions (10b) and the different top portions (10a) take place by means of concrete.

9. The process according to one of claims 6 to 8, **characterized in that** said step of introducing the plurality of tubes (10) takes place by means of the "auger boring" or "guided auger boring" technique.

Patentansprüche

1. Eine seismische Isolierstruktur (1) für Gebäude, **dadurch gekennzeichnet, dass** die Isolierstruktur eine unter den Fundamenten (3) eines Gebäudes (3a) angeordnete Isolierplattform (2) aufweist, welche einen oberen Block (4) und einen von dem oberen Block getrennten Bodenblock (5), eine Mehrzahl von seismischen Isolatoren (6), die zwischen dem oberen Block (4) und dem Bodenblock (5) angeordnet sind, eine innere unterirdische Wand (7), die an dem Boden mit dem oberen Block (4) verbunden ist, und eine äußere unterirdische Wand (8), die an dem Boden mit dem oberen Block (4) verbunden ist, und eine äußere unterirdischen Wand (8), die an dem Boden mit dem Bodenblock (5) verbunden und um die innere unterirdische Wand (7) angeordnet ist, aufweist; wobei die innere unterirdische Wand (7) und die äußere unterirdische Wand (8) über ihre gesamte Höhe eine seismische Verbindung (9) ausbilden,
   dadurch gekennzeichnet, dass die innere unterirdische Wand (7) derart angeordnet ist, dass diese den das Gebäude (3a) umgebenden Boden umfasst.

2. Die seismische Isolierstruktur nach Anspruch 1, **dadurch gekennzeichnet, dass** die Isolierplattform (2) eine Mehrzahl von Leitungen (10) aufweist, die in einer horizontalen Ausrichtung nebeneinander angeordnet sind; wobei jede Leitung (10) aus einer oberen Kappe (10a) und einer Bodenkappe (10b) besteht, die voneinander getrennt sind und zwischen denen eine Mehrzahl von seismischen Isolatoren (6) eingeschlossen sind; jede der oberen Kappen (10a) mit den benachbarten oberen Kappen (10a) derart fest verbunden sind, dass diese den oberen Block (4) ausbilden und jede der Bodenkappen (10b) derart fest mit den benachbarten Bodenkappen (10b) verbunden sind, dass diese den Bodenblock (5) bilden.

3. Die seismische Isolierstruktur nach Anspruch 2, **dadurch gekennzeichnet, dass** die Leitungen (10) aus Beton hergestellt sind und eine zylindrische Struktur haben.

4. Die seismische Isolierstruktur nach Anspruch 3, **dadurch gekennzeichnet, dass** die Isolierstruktur Betonverbindungen zwischen den einzelnen oberen Kappen (10a) und zwischen den einzelnen Bodenkappen (10b) aufweist.

5. Die seismische Isolierstruktur nach einem der vorausgehenden Ansprüche, **dadurch gekennzeichnet, dass** die Isolierstruktur zwischen der inneren unterirdischen Wand (7) und dem Gebäude (3a) eine feste Verbindung (21) aufweist.

6. Ein Verfahren zur Herstellung einer seismischen Isolierstruktur; wobei das Verfahren durch folgende Verfahrensschritte gekennzeichnet ist:

   - ein Schritt des Einsetzens einer Mehrzahl von Leitungen (10) unter die Fundamente des Gebäudes (3a), so dass die Leitungen seismisch isoliert sind; wobei die Leitungen (10) von einem oberen Teil (10a) und einem Bodenteil (10b) gebildet werden, die durch eine Mehrzahl von entfernbaren Elementen (11) miteinander verbunden sind;
   - ein erster Schritt des Verbindens der einzelnen Bodenteile (10b), um einen einzelnen Bodenblock (5) auszubilden;
   - ein Schritt des Positionierens einer Mehrzahl von seismischen Isolatoren (6) zwischen den oberen Teilen (10a) und den Bodenteilen (10b);
   - ein zweiter Schritt des Verbindens der einzelnen oberen Teile (10a), um einen einzelnen oberen Block (4) auszubilden;
   - ein Schritt des Entfernens der entfernbaren Elemente (11);
   - ein Schritt des Ausbildens sowohl einer inneren unterirdischen Wand (7), die angeordnet ist, um den das Gebäude (3a) umgebenden Boden zu umfassen, und die fest mit dem oberen Block (4) verbunden ist, als auch einer äußeren unterirdischen Wand (8), die außen an der inneren Wand (7) angeordnet ist und fest mit dem unteren Block (5) verbunden ist.

7. Das Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** die Leitungen (10) aus Beton hergestellt sind.

8. Das Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** die Schritte des Verbindens der einzelnen Bodenteile (1 Ob) und der einzelnen oberen Teile (10) mittels Beton erfolgt.

9. Das Verfahren nach einem der Ansprüche 6 bis 8, **dadurch gekennzeichnet, dass** der Schritt des Einsetzens der Mehrzahl der Leitungen (10) mittels der Technik des "Erdbohrens " oder "des geführten Erdbohrens" erfolgt.

Revendications

1. Structure d'isolation sismique (1) pour des bâtiments **caractérisée en ce qu'**elle comprend une plateforme d'isolation (2) agencée sous les fondations (3) d'un bâtiment (3a) et comprenant un bloc de dessus (4), un bloc de fond (5) séparé du bloc de dessus (4), une pluralité d'isolants sismiques (6) agencés entre le bloc de dessus (4) et le bloc de fond (5), une paroi souterraine interne (7) fixée sur le fond au bloc de dessus (4) et une paroi souterraine externe (8) fixée sur le fond au bloc de fond (5) et agencée autour de ladite paroi souterraine interne (7) ; ladite paroi souterraine interne (7) et ladite paroi souterraine externe (8) définissant une jointure sismique sur la totalité de leur hauteur (9), **caractérisée en ce que** la paroi souterraine interne (7) est agencée de façon à contenir le sol qui entoure ledit bâtiment (3a).

2. Structure d'isolation sismique selon la revendication 1, **caractérisée en ce que** ladite plateforme d'isolation (2) comprend une pluralité de tubes (10) agencés côte à côte dans une position horizontale ; chacun desdits tubes (10) étant constitué d'un bouchon de dessus (10a) et d'un bouchon de fond (10b) séparés l'un de l'autre et entre lesquels est logée une pluralité d'isolants sismiques (6) ; chacun des bouchons de dessus (10a) étant raccordé de manière rigide aux bouchons de dessus adjacents (10a), de façon à former ledit bloc de dessus (4) et chacun des bouchons de fond (10b) étant raccordé de manière rigide aux bouchons de fond adjacents (10b), de façon à former ledit bloc de fond (5).

3. Structure d'isolation sismique selon la revendication

2, **caractérisée en ce que** lesdits tubes (10) sont réalisés en béton et ont une structure cylindrique.

4. Structure d'isolation sismique selon la revendication 3, **caractérisée en ce qu'**elle comprend des raccordements en béton entre les différents bouchons de dessus (10a) et entre les différents bouchons de fond (10b).

5. Structure d'isolation sismique selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'**elle comprend un raccordement rigide (21) entre la paroi souterraine interne (7) et ledit bâtiment (3a).

6. Procédé de fabrication d'une structure d'isolation sismique ; ledit procédé étant **caractérisé en ce qu'**il comprend dans une séquence :

- une étape d'introduction d'une pluralité de tubes (10) sous les fondations (3) d'un bâtiment (3a) à isoler sismiquement ; lesdits tubes (10) étant formés par une portion de dessus (10a) et une portion de fond (10b) raccordées l'une à l'autre au moyen d'une pluralité d'éléments amovibles (11) ;
- une première étape de raccordement des différentes portions de fond (10b) pour former un seul bloc de fond (5) ;
- une étape de positionnement d'une pluralité d'isolants sismiques (6) entre les portions de dessus (10a) et les portions de fond (10b) ;
- une seconde étape de raccordement des différentes portions de dessus (10a) pour former un seul bloc de dessus (4) ;
- une étape d'enlèvement des éléments amovibles (11) ;
- une étape de formation à la fois d'une paroi souterraine interne (7) agencée pour contenir le sol qui entoure le bâtiment (3a) et raccordée de manière rigide au bloc de dessus (4) et d'une paroi souterraine externe (8) agencée à l'extérieur de ladite paroi interne (7) et raccordée de manière rigide audit bloc inférieur (5).

7. Procédé selon la revendication 6, **caractérisé en ce que** lesdits tubes (10) sont réalisés en béton.

8. Procédé selon la revendication 7, **caractérisé en ce que** lesdites étapes de raccordement des différentes portions de fond (10b) et des différentes portions de dessus (10a) ont lieu au moyen de béton.

9. Procédé selon l'une des revendications 6 à 8, **caractérisé en ce que** ladite étape d'introduction de la pluralité de tubes (10) a lieu au moyen de la technique de « forage à la tarière » ou de « forage à la tarière dirigé ».

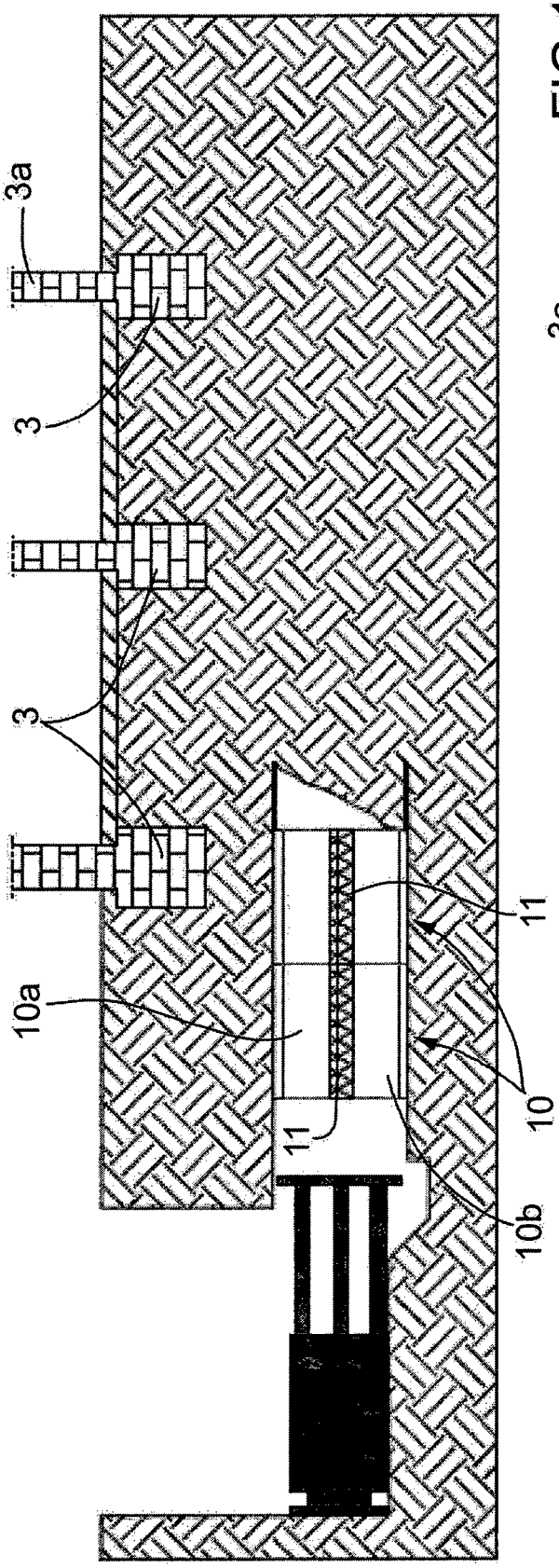


FIG.1a

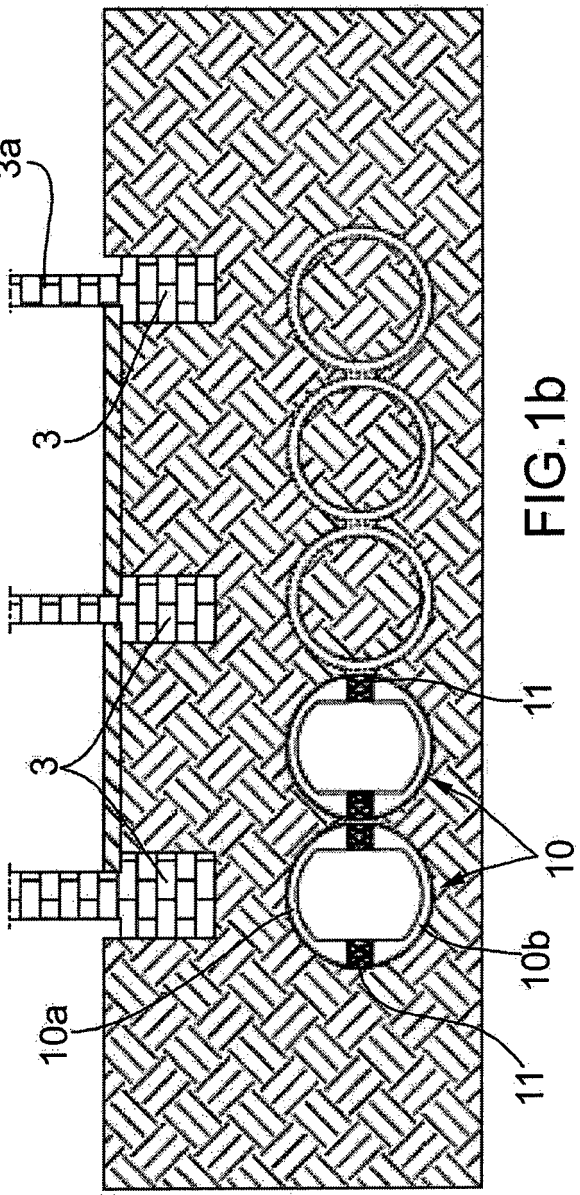


FIG.1b

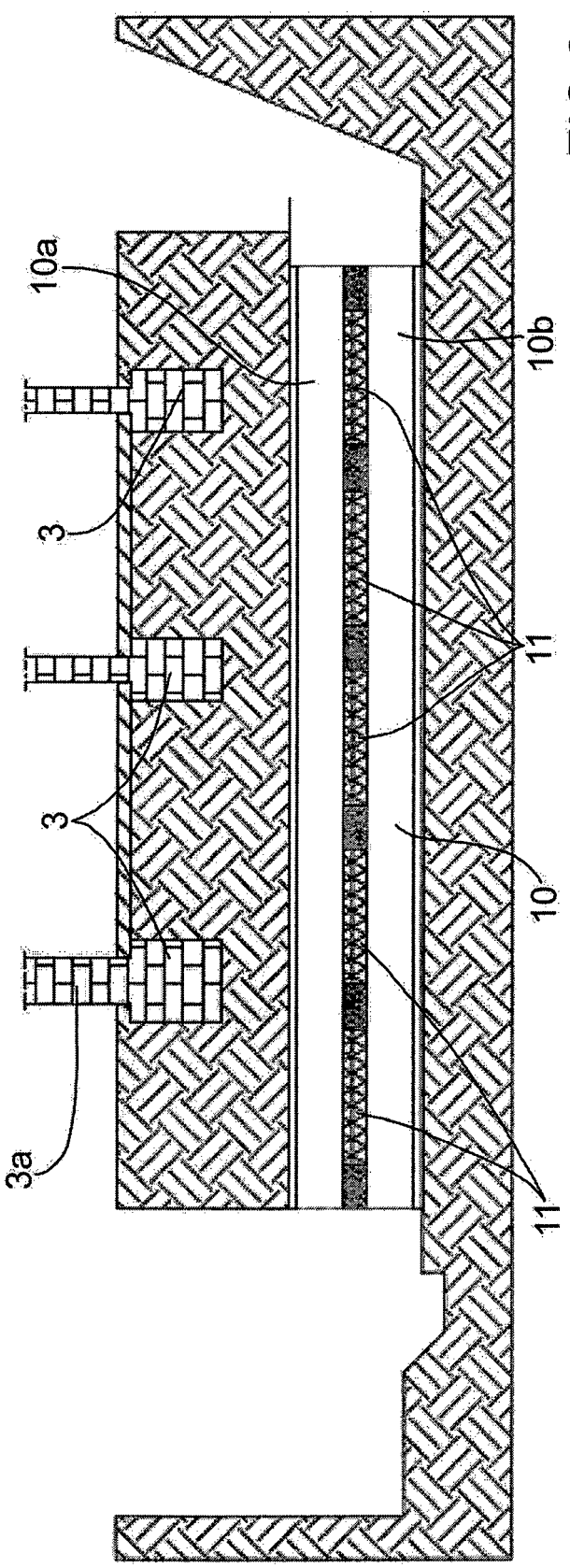


FIG.2a

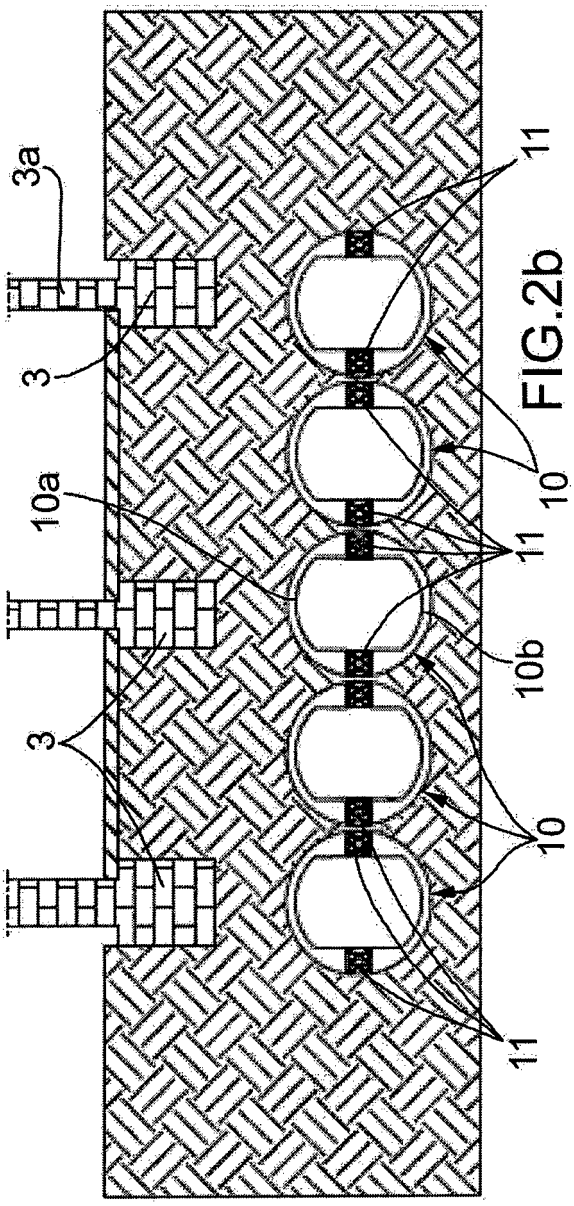


FIG.2b

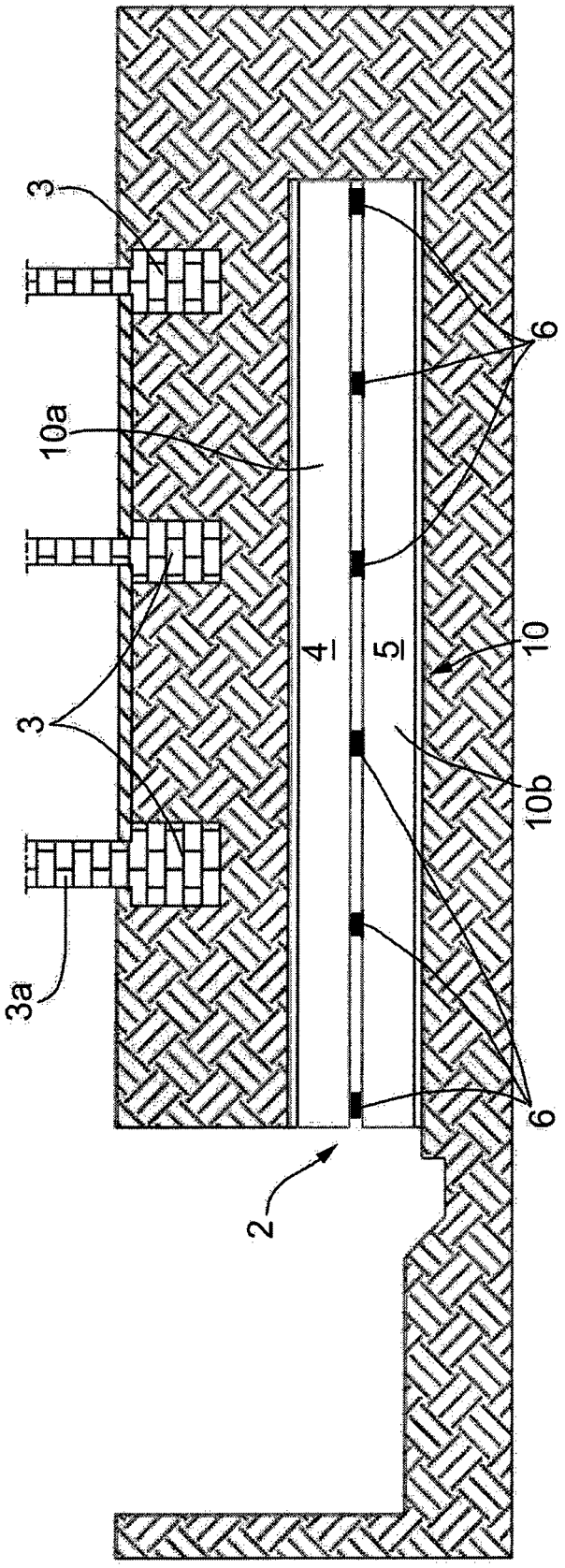


FIG.3a

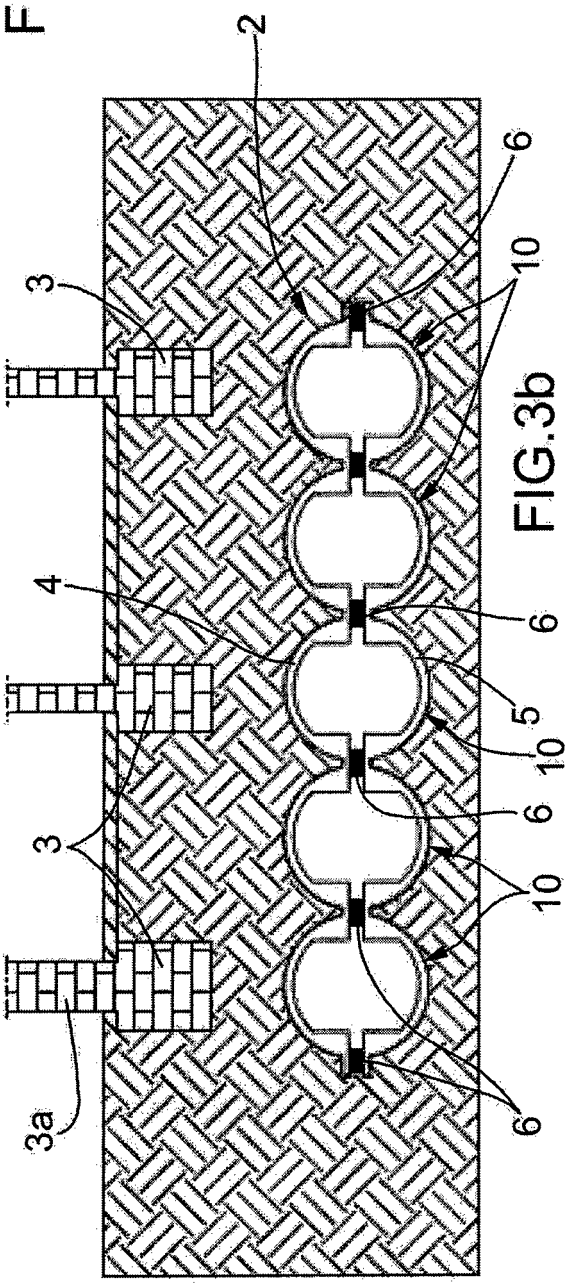


FIG.3b

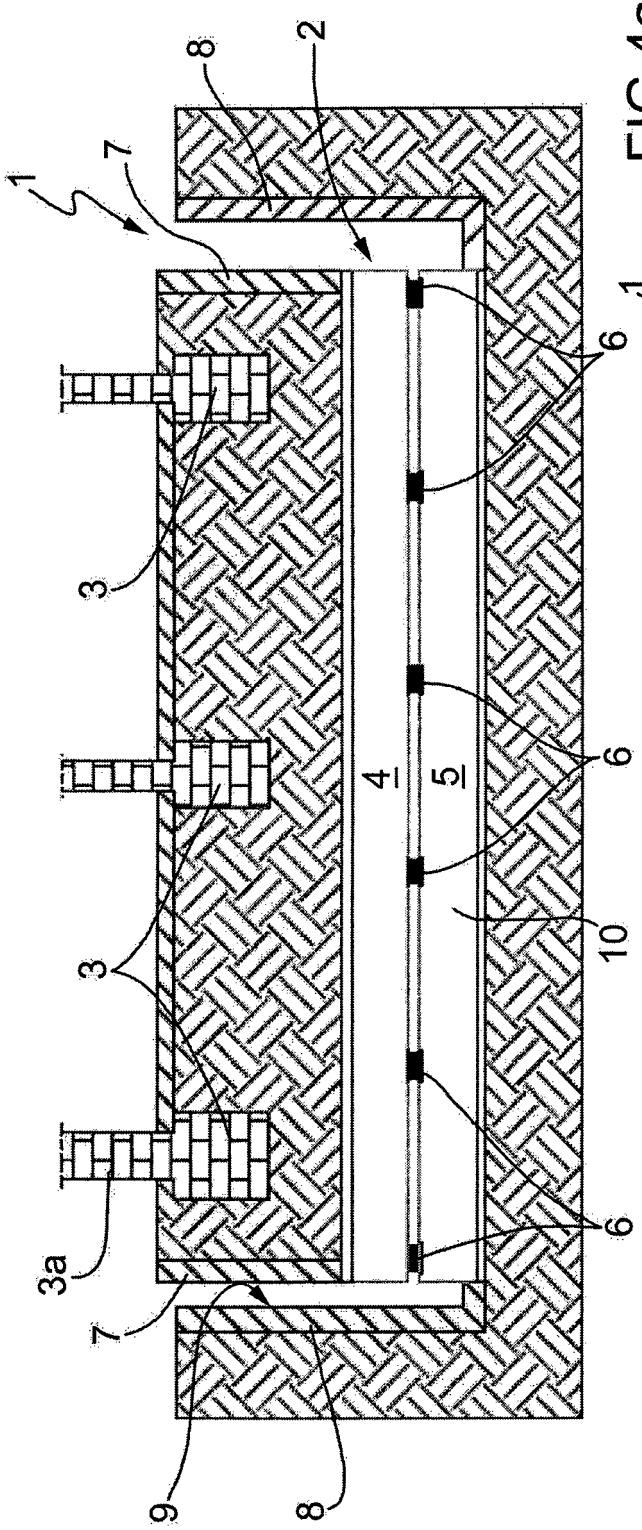


FIG.4a

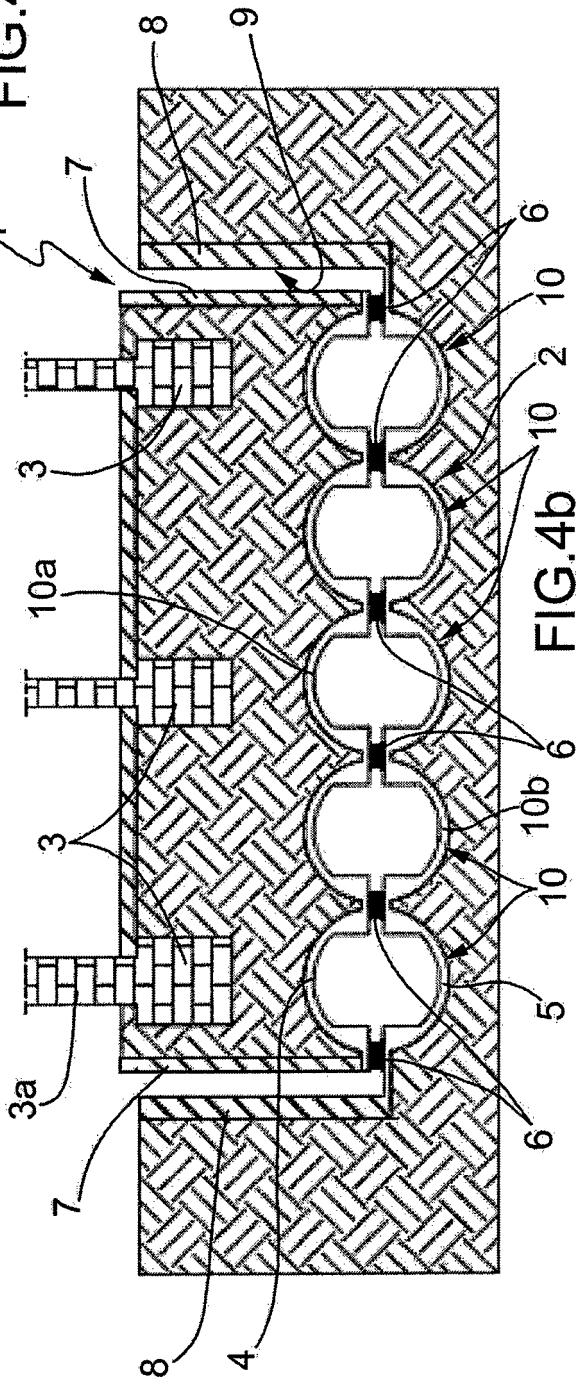


FIG.4b

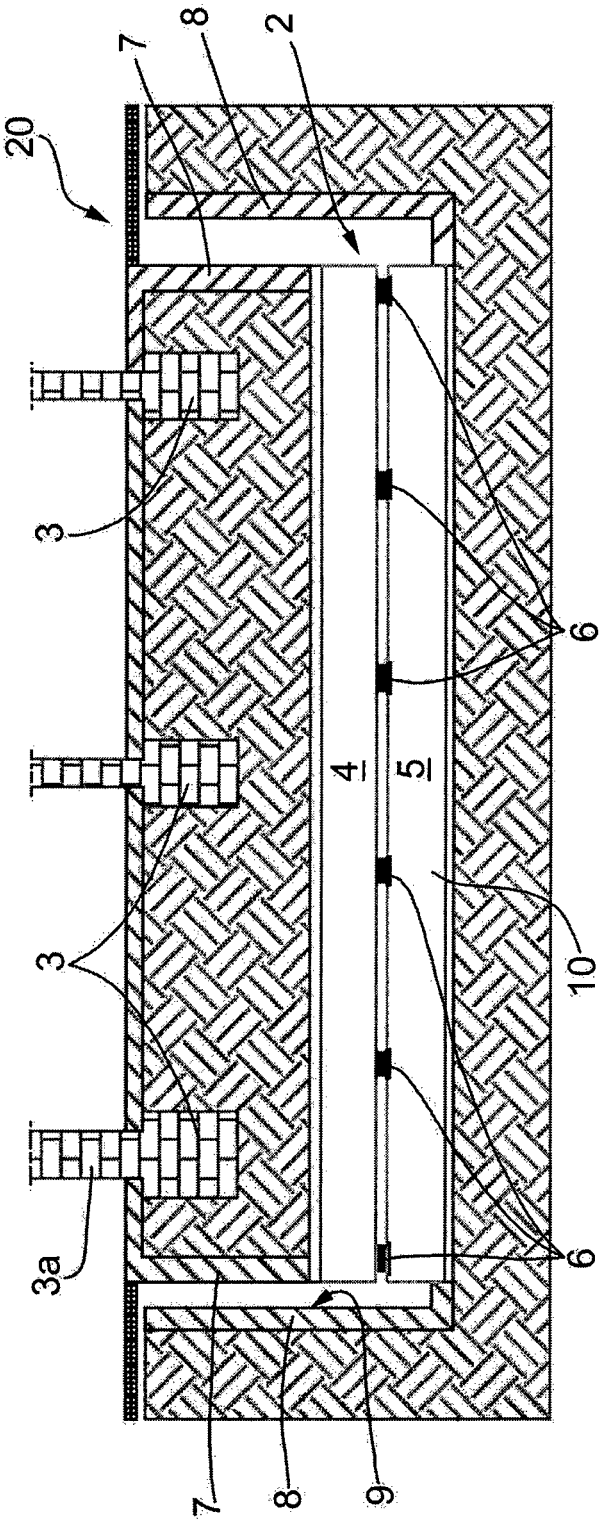
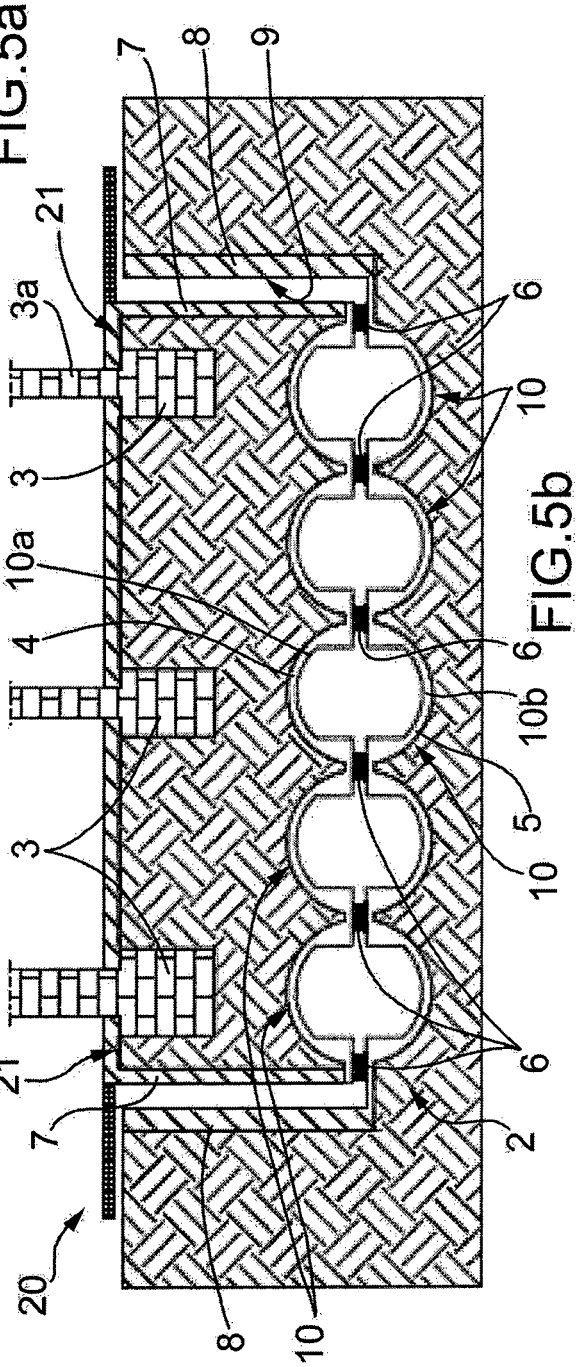

20
7
8
2
3
6
4
5
10
3
3a
7
8
9

FIG.5a


7
8
9
21
3a
6
10
3
10a
4
6
10b
5
10
3
21
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7
2
20
8
10

FIG.5b

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 0981884 A1 **[0006]**
- JP 2009074272 A **[0007]**