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(54) **Suspended ceiling with 3 layer ceiling plates**

(57) A suspended ceiling arranged below a basic ceiling of a room, such that the basic ceiling and the suspended ceiling is forming a cavity, said suspended ceiling comprising a grid of profiles, said grid forming rectangular or substantially rectangular openings; and further comprising ceiling plates arranged in said openings of the grid, said ceiling plates having two major surfaces and four edge sections, said ceiling plate comprising a first layer comprising fibres, a second airtight sheet layer and a third layer comprising mineral fibres, said three layers

are extending parallel or substantially parallel with the two major surfaces. The suspended ceiling further comprising paint applied to the edge sections of the ceiling plates whereby the air flow resistance through the edge sections is increased. The suspended ceiling further comprising means for forming tight connections with a high air flow resistance between either, the ceiling plates and the grid profiles, or, between two adjacent ceiling plates. The invention further concerns a method for manufacturing a suspended ceiling.

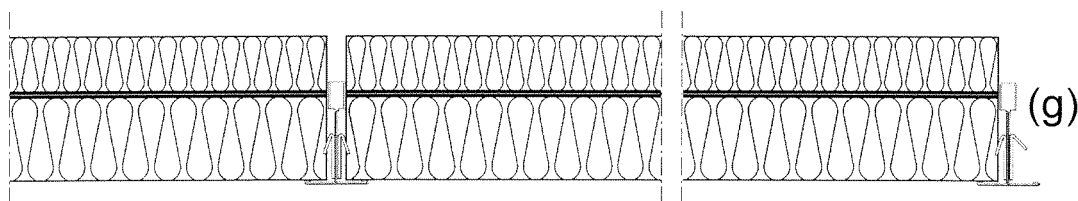


Fig. 8

Description

[0001] This invention relates to a suspended ceiling arranged below a basic ceiling of a room, such that the basic ceiling and the suspended ceiling is forming a cavity, said suspended ceiling comprising a grid of profiles, said grid forming rectangular or substantially rectangular openings. Ceiling plates are arranged in the rectangular openings.

[0002] Suspended ceilings with sound absorbing properties and manufactured from fibrous materials are well-known. Such ceilings are prepared for having optimal sound absorption in order to reduce the reverberation time in the room. The known solutions often comprise ceiling plates having one layer of a fibrous material, e.g. mineral fibre, provided with a fleece layer and a layer of paint on the major surface facing the room. These ceiling plates are typically arranged in a supporting grid of profiles.

[0003] Suspended ceilings are often used in large rooms divided into two or more smaller rooms by partition walls. The suspended ceiling is installed first and forms a cavity between the suspended ceiling and the basic ceiling. Following this the partition walls are installed. These will typically extend from the floor to the suspended ceiling

[0004] One problem with this type of construction is that sound or noise penetrating the suspended ceiling from one room will propagate in the cavity between the suspended ceiling and the basic ceiling, and may to some extent penetrate into neighbouring rooms.

[0005] EP 1 261 782 B1 describes an example of a suspended ceiling. It is known from US 4,428,454 to have ceiling plates comprising several layers.

[0006] None of the known sound absorbing suspended ceilings is solving the above mentioned problem sufficiently efficient for the demands of buildings.

[0007] It has now been found that the problem can be solved by a suspended ceiling with ceiling plates having two major surfaces and four edge sections, said ceiling plate comprising a first layer comprising mineral fibres, a second airflow restricting layer and a third layer comprising mineral fibres, said three layers are extending parallel or substantially parallel with the two major surfaces; and said suspended ceiling comprising edge sealing means applied to the edge sections of the ceiling plates whereby the air flow resistance through the edge sections is increased; and said suspended ceiling further comprising connection sealing means arranged at connections between the ceiling plates and the grid profiles, and/or between two adjacent ceiling plates.

[0008] By airflow restricting layer is meant a layer having a relatively low permeability to air, such as a permeability of 10 l/m²/s or less.

[0009] The edge sealing means may be a film, a foil or a layer of paint applied to the edges.

[0010] In a preferred embodiment of the invention the connection sealing means comprises a flexible material

attached to the profiles. In a further preferred embodiment the connection sealing means formed by a flexible material are arranged as flaps attached to said profiles. Such flaps of a flexible material will provide a reliable airflow restricting connection between the ceiling plate and the grid profile.

[0011] In a further embodiment of the invention said second airflow restricting layer is a membrane of aluminium, aluminium/paper composite, paper or polymer material. Other materials could also be used for the membrane, such as paint or water glass. Preferably a non-combustible or low-combustible material should be used in order not to deteriorate fire properties of the ceiling plates.

[0012] In a preferred embodiment of the invention said profiles are inverted T-profiles or Z-profiles, comprising a vertical base portion and a horizontal flange portion for supporting said ceiling panels. Inverted T-profiles or Z-profiles offer a mechanical stable grid, and provides a good support for the ceiling plates.

[0013] In a further embodiment of the invention said flaps of a flexible material are arranged on the base portion of said T-profiles. This gives a close and airflow restricting connection between the ceiling plates and the profiles of the grid.

[0014] In a further embodiment of the invention the density of said first layer (facing the basic ceiling) comprising mineral fibre is in the range 80 - 200 kg/m³

[0015] In a further embodiment of the invention the density of said third layer (facing the room) comprising mineral fibre is in the range 80 - 300 kg/m³. These density ranges for both the first and the third layers have been found to give optimal acoustic properties with respect to absorption and reduced sound transmission. Again layers of mineral fibres have a high sound absorption coefficient compared to e.g. a wetfelt or gypsum material.

[0016] In a further embodiment of the invention the edge sealing means is one or more layers of paint applied to the edge sections of the ceiling plates. Preferably the layer(s) of paint is minimum 1500 g/m² of wet paint having a dry matter content of 60%, i.e. 900 g/m² applied to the edge sections of the ceiling plates. This will result in an improved airflow restriction and an improved strength of the edge sections. This is a very cost efficient way of providing edge sealing means, but other choices are open to the skilled person, e.g. applying a film, foil or coating to the edge.

[0017] The invention also concerns a method for manufacturing a suspended ceiling according to the above mentioned embodiments. The method comprises the steps of forming a three layer ceiling plate by gluing two layers of mineral wool together with an intermediate airflow restricting layer, said plate having two major surfaces and four edge sections, said three layers of the ceiling plates are extending parallel or substantially parallel with the two major surfaces. The method further comprise the step of applying edge sealing means to the edge sections of the ceiling plates whereby the air flow resistance

through the edge sections is increased. The method further comprise the step of arranging suspended grid of profiles below the basic ceiling of a room, said grid forming rectangular or substantially rectangular openings. The method further comprise the step of arranging said three layers ceiling plates in said openings of the grid with connection sealing means such that tight connections with high air flow resistance are formed between either the ceiling plates and the grid profiles, and/or between two adjacent ceiling plates.

[0018] In a further embodiment of the method said profiles are selected to be inverted T-profiles or Z-profiles, comprising a vertical base portion and a horizontal supporting portion for supporting said ceiling panels.

[0019] In a further embodiment of the method tight connections between the ceiling plates and the T-profiles are provided and formed by a flexible material arranged as flaps attached to the T-profiles.

[0020] Embodiments of the invention will now be described in further details with reference to the figures, where

Figure 1 illustrates a suspended ceiling seen from below.

Figure 2 illustrates a suspended ceiling seen from below with some of the ceiling plates removed.

Figure 3 illustrates a suspended ceiling seen from above, with some ceiling plates removed.

Figure 4 illustrates a ceiling plate comprising 3 layers.

Figure 5 illustrates a cross sectional view of a suspended ceiling with one embodiment of the three layer ceiling plate.

Figure 6 as figure 5 but with a different embodiment of the three layer ceiling panel.

Figure 7 illustrates a construction of a suspended ceiling with a partition wall.

Figure 8 illustrates different examples of a cross sectional view of a suspended ceiling.

Figure 9 illustrates perspective views of examples of T-beams for a grid for a suspended ceiling provided with one set of means for obtaining tight connections.

Figure 10 illustrates perspective views of examples of T-beams for a grid for a suspended ceiling provided with two set of means for obtaining tight connections.

Figure 11 illustrates cross sectional views of the ex-

amples of T-beams in figure 9.

Figure 12 illustrates cross sectional views of the examples of T-beams in figure 10.

[0021] Figure 1 shows a suspended ceiling with ceiling plates 1 or ceiling panels arranged in a supporting grid 2. The supporting grid is made from carrier beams 3, extending along several rectangles for ceiling plates. Supporting beams 4 are arranged between two neighbouring carrier beams 3 in order to fix the distance between these and to form rectangles where one or more ceiling plate can be arranged. Both the carrier beams and the supporting beams are often formed as inverted T-profiles made from a metal, such as aluminium or steel.

[0022] The inverted T-profiles have a flange part for supporting the ceiling plates. The carrier beams 3 are attached to the basic ceiling (not shown) e.g. by hangers or wires 5. Adjustment means (not shown) for adjusting the height and flatness of the suspended ceiling are usually cooperating with the wires 5.

[0023] In figure 2 the same suspended ceiling as in figure 1 is shown with some of the ceiling plates removed, thereby showing the open rectangles of the supporting grid.

[0024] Figure 3 shows a suspended ceiling from above. It is seen that in this example the thickness of the ceiling plates 1 exceeds the height of the inverted T-profiles 3, 4.

[0025] Figure 4 shows an exploded view of an example of a ceiling plate 1 for a suspended ceiling according to the invention. It is seen that this ceiling plate 1 comprises three layers: A first upper layer 10 comprising mineral fibres, a second airflow restricting layer 11, and a third lower layer 12 comprising mineral fibres. The application of such a ceiling plate as compared to the standard type of ceiling plate with one single layer comprising mineral fibres has the advantage that the airflow restricting layer 11 will reduce the noise transmission through the ceiling plate 1. Good results have been obtained with a paper membrane constituting the airflow restricting layer 11. The paper membrane of the test had a permeability of 5 l/m²/s.

[0026] The ceiling plate shown in figure 4 has three purposes when it is installed in a suspended ceiling.

[0027] First it must absorb noise from the room below the suspended ceiling. This means that sound waves approaching the surface of the ceiling plate must be able to penetrate the surface to some degree and to enter into the fibrous material where it is absorbed. For this purpose the surface must be porous to some extent. Therefore, any fleece and paint layer, applied e.g. for aesthetic purposes and/or for durability, should also be open to air diffusion.

[0028] A second purpose of the ceiling plate is to reduce the transmission of noise from the side of the ceiling plate facing the room to the side of the ceiling plate facing the basic ceiling, i.e. to the space formed between the

suspended ceiling and the basic ceiling. One problem with noise entering this space is that e.g. large office areas in buildings are often arranged as illustrated in figure 7 with a suspended ceiling and one or more partition walls extending between the floor and the suspended ceiling. Thereby, the space between the basic ceiling and the suspended ceiling (often called the plenum) over one office will be in open connection with the equivalent space over a neighbouring office. There will be nothing preventing sound and noise from propagating in this space, and this space will therefore often be the major route of transmitting noise from one office to a neighbouring office. By having an airflow restricting layer in the ceiling panel the transmission of noise or sound through the ceiling plate will be reduced.

[0029] A third purpose of the ceiling panel is to absorb sound waves approaching the surface facing the basic ceiling (absorption in the plenum), thereby reducing the noise level in the space between the basic ceiling and the suspended ceiling. This will also contribute to a reduction in the noise level transmitted from one room to a neighbour room.

[0030] The first upper layer facing the plenum is often made from mineral wool, such as stone wool, with a density of between 80 - 200 kg/m³. The density should normally be chosen as low as possible, as low density mineral wool gives a better sound absorption in the plenum. However the density of the first layer may be chosen higher for other reasons, e.g. depending on the density of the third layer or the airflow restricting capabilities of the second layer. Higher densities, such as 300 kg/m³ may be chosen for specific reasons, but it will normally increase the weight and price of the plate, which is a disadvantage. In specific embodiments the density may be chosen lower, e.g. 50 kg/m³, but often this will mean more difficult handling of the plates. The thickness of the first upper layer is below 30 mm, preferably below 25, and even more preferably below 20 mm.

[0031] The second airflow restricting layer 11 is often made from a plastic sheet material or from a metal foil such as aluminium. It may also be a metal foil provided with a paper layer in order to strengthen it.

[0032] The third lower layer 12 is often made from mineral wool with a density of between 80 - 300 kg/m³. The density may be chosen to fit the needs. Again the choice of density is a balance of the properties of the three layers of the plate, the price and the ease of handling which is influenced by the weight, strength and stiffness of the plate. Often a higher density will be suitable for the third layer compared to the first layer. The thickness of the first upper layer is below 40 mm, preferably below 35, and even more preferably below 30 mm.

[0033] The edge portions of the panels may be provided with shapes or profiles making them fit with different types of grid profiles, or into suspended ceilings where the grid beams are covered by the ceiling plates, i.e. so-called concealed edges.

[0034] Further, the ceiling plate in figure 4 is often pro-

vided with a fleece layer. The fleece layer is preferably a standard glass fibre fleece, comprising glass fibres and a binder. The amount of binder will often be 10 - 30 %. The fleece will preferably not comprise any oil, which is typically added to the mineral fibre material. The surface weight of the fleece will be in the range 60 - 200 g/m². Example of an applicable fleece materials of glass fibres is the product A75 from Owens Corning in US having a binder content of 25 %, and a calorie value of 5.3 MJ/kg.

[0035] Usually, such a fleece layer is provided on the surface visible from the room, i.e. on the surface of the third lower layer 12. However, often a fleece layer is also provided on the surface facing the basic ceiling, i.e. on the surface of the first upper layer 10. This has the purpose of reducing the emission of mineral fibres e.g. during installation of the suspended ceiling.

[0036] The fleece layer is often provided with a paint layer also on the major surface visible from the room below the suspended ceiling. An example of a useful paint is a water based paint with approximately 50 % dry material and approximately 10 % binder, e.g. known under the trade name Rofa 8 which is manufactured by Soframap in France. The amount of wet paint applied will preferably be in the range 50-300 g/m².

[0037] In order to be sufficiently sound absorbing the sound absorbing panel should be open to air diffusion. This means that the applied paint layer on the major surface also must be open to air diffusion. This will be the case if e.g. small holes are formed in the paint during application or drying up. Contrary, the paint layer applied to the edge portions should, preferably, be relatively closed to air diffusion in order to limit the transmission of sound or noise through the edge portions into the space between the basic ceiling and the suspended ceiling.

[0038] Examples of ceiling plates for the suspended ceiling will now be described.

[0039] In a first example the first upper layer 10 is made from stone wool with a density of 150 kg/m³. The thickness of this layer is 20 mm. The mineral wool is manufactured according to WO 2005/095727. The second airtight sheet layer 11 is an aluminium foil. The third lower layer 12 is made from stone wool with a density of 150 kg/m³. The thickness of this layer is 30 mm. The mineral wool is manufactured according to WO 2005/095727. A suspended ceiling in an embodiment of the invention with this type of ceiling plate will have a room to room sound insulation $D_{nfw} = 44$ dB. This value has been measured according to standard ISO 10848-2 and calculated as a weighted suspended ceiling normalized level according to ISO 717-1, and gives the reduction of noise transmitted from a room into a neighbouring room. The sound absorption coefficient for such a suspended ceiling is $\alpha_w = 0.90$ measured according to standard EN ISO 354. This value gives the fraction of incident noise to the suspended ceiling absorbed by the ceiling.

[0040] In a third example the first upper layer 10 is made from stone wool with a density of 150 kg/m³. The thickness of this layer is 20 mm. The mineral wool is

manufactured according to WO 2005/095727. The second airtight sheet layer 11 is an aluminium foil. The third lower layer 12 is made from stone wool with a density of 300 kg/m³. The thickness of this layer is 30 mm. A suspended ceiling in an embodiment of the invention with this type of ceiling plate will have a room to room sound insulation $D_{nfw} = 49$ dB. The sound absorption coefficient for the suspended ceiling in this example is $\alpha_w = 0.60$. The lower value is caused by the higher density of the mineral wool facing the room below the suspended ceiling.

[0041] The adhesive applied for gluing the three layers of the ceiling plate 1 together is often a hot melt adhesive or powder glue of e.g. polyamide. The adhesive should preferably be able to function even though the temperature is raised to approximately 140 degree Celsius or more, before the adhesive has dried up. This temperature is often necessary in order to dry the paint applied to the fleece and to the edge sections, and in order to have an efficient production line, drying of this paint may be necessary before the adhesive has dried completely. The adhesive could be a hot melt adhesive based on a block copolymer with a viscosity (according to ASTM D-3236) of 1500 - 2100 mPa s at a temperature of 177 degree Celsius, and a softening point (according to ASTM E-28) of 94 - 104 degree Celcius.

[0042] Figure 5 shows a cross sectional view of a suspended ceiling in which the first upper layer 10 together with the second airflow restricting layer 11 of the ceiling plate 1 is extending over the edge of the third lower layer 12. The purpose of this embodiment is that this extending portion can establish an airflow restricted connection with the inverted T-profile, and/or with the neighbouring ceiling plate.

[0043] Figure 6 shows a cross sectional view of a suspended ceiling in which a notch is provided in the first upper layer 10 such that only an upper part of this first upper layer 10 is extending over the edge of the third lower layer 12. This means that it will be possible to let two neighbouring ceiling plates abutting each other over the inverted T-profile. The second airflow restricting layer 11 will, in this embodiment, often extend to the edge of the third lower layer 12, which will also be the edge of the first upper layer 10 where the notch is made. The second airflow restricting layer may also follow the side walls of the notch, and thereby extend to a position where it may abut the profile. However, an airflow restricting layer of paint covering the edge section 15 and being in contact with the airflow restricting layer will provide the same result concerning the edge section 15 being sealed.

[0044] As mentioned, figure 7 shows a suspended ceiling and a partition wall extending between the floor (not shown) and the suspended ceiling. In this typical construction there is no partition in the space between the basic ceiling 8 and the suspended ceiling.

[0045] Figure 8 shows seven different embodiments for arranging the inverted T-profile 3 with the edge sec-

tions of the ceiling plate 1 or panel. The difference between 8a, 8b, 8c and 8d lies within the shape of the edge sections of the ceiling plates 1. Figure 8a shows a simple straight cut off edge section, Figure 8b shows the principle also illustrated in figure 6, where two neighbouring ceiling plates abuts over the inverted T-profile in order to reduce sound transmission through the suspended ceiling. Figure 8c illustrates the design of having the flange portion of the inverted T-profile in an indent of the two abutting ceiling plates. Figure 8d shows an example where the grid profiles of the suspended ceiling is concealed. Such a suspended ceiling is described in EP 1 261 782 B1.

[0046] Figure 9 shows perspective examples of inverted T-profiles 3 provided with flaps for obtaining a sealed connection with restricted airflow between the T-profile and the ceiling plates. The flaps can be arranged either on the base part or on the upward facing part of the flange portion of the inverted T-profile.

[0047] Figure 10 shows in perspective that flaps 20, 21 can be arranged on both the base part and on the flange portion, such that the ceiling plate will be in contact with two flaps on each inverted T-profile 3. It has been found that the extra effect of two flaps 20, 21 is relatively limited. Also, it has been found that a flap 20 on the flange portion of the inverted T-profile may have the effect that a small visible gap occurs between the ceiling plate and the Inverted T-profile. A flap 21 on the base portion has in some tests been found to result in the best reduction of sound transmission. This may be caused by the compression of the ceiling plate against the flap.

[0048] Figure 11 and 12 shows in cross sectional the same embodiments as figure 9 and 10 of the inverted T-profiles 3 with flaps 20, 21 for providing sealed connections between the inverted T-profiles 3 and the ceiling plates 1.

Claims

1. A suspended ceiling arranged below a basic ceiling of a room, such that the basic ceiling and the suspended ceiling is forming a cavity, said suspended ceiling comprising

- a grid of profiles, said grid forming rectangular or substantially rectangular openings,
- ceiling plates arranged in said openings of the grid, said ceiling plates having two major surfaces and four edge sections, said ceiling plate comprising a first layer comprising mineral fibres, a second airflow restricting layer and a third layer comprising mineral fibres, said three layers are extending parallel or substantially parallel with the two major surfaces,
- edge sealing means applied to the edge sections of the ceiling plates, whereby the air flow resistance through the edge sections is in-

- creased,
 • connection sealing means arranged at connections between the ceiling plates and the grid profiles, and/or, between two adjacent ceiling plates. 5
2. A suspended ceiling according to claim 1, wherein said connection sealing means comprises a flexible material attached to said grid profiles. 10
3. A suspended ceiling according to claim 2, wherein said flexible material is arranged as flaps attached to said grid profiles.
4. A suspended ceiling according to any one of the previous claims, wherein said second airflow restricting layer is a metal foil. 15
5. A suspended ceiling according to any one of the previous claims, wherein said profiles are inverted T-profiles, comprising a vertical base portion and a horizontal flange portion for supporting said ceiling panels. 20
6. A suspended ceiling according to claims 6, wherein said connection sealing means are arranged on the base portion of said T-profiles. 25
7. A suspended ceiling according to any one of the previous claims, wherein the density of said first layer comprising mineral fibre is in the range 80 - 200 kg/m³. 30
8. A suspended ceiling according to any one of the previous claims, wherein the density of said third layer comprising mineral fibre is in the range 80 - 300 kg/m³. 35
9. A suspended ceiling according to any one of the previous claims, wherein said edge sealing means is one or more layers of paint applied to the edge sections of the ceiling plates. 40
10. Method for manufacturing a suspended ceiling according to any one of the previous claims, said method comprising the steps 45
- forming a three layer ceiling plate by gluing two layers of mineral wool together with an intermediate airflow restricting layer, said plate having two major surfaces and four edge sections, said three layers of the ceiling plates extending parallel or substantially parallel with the two major surfaces, 50
 - applying edge sealing means to the edge sections of the ceiling plates whereby the air flow resistance through the edge sections is increased, 55
- arranging a suspended grid of profiles below the basic ceiling of a room, said grid forming rectangular or substantially rectangular openings,
 - arranging said ceiling plates in said openings of the grid with connection sealing means such that tight connections with high air flow resistance are formed between either the ceiling plates and the grid profiles, and/or between two adjacent ceiling plates.
11. A method according to claim 11, wherein said profiles are selected to be inverted T-profiles, comprising a vertical base portion and a horizontal supporting portion for supporting said ceiling panels.
12. A method according to claim 12, wherein tight connections between the ceiling plates and the T-profiles are provided and formed by a flexible material arranged as flaps attached to the T-profiles.

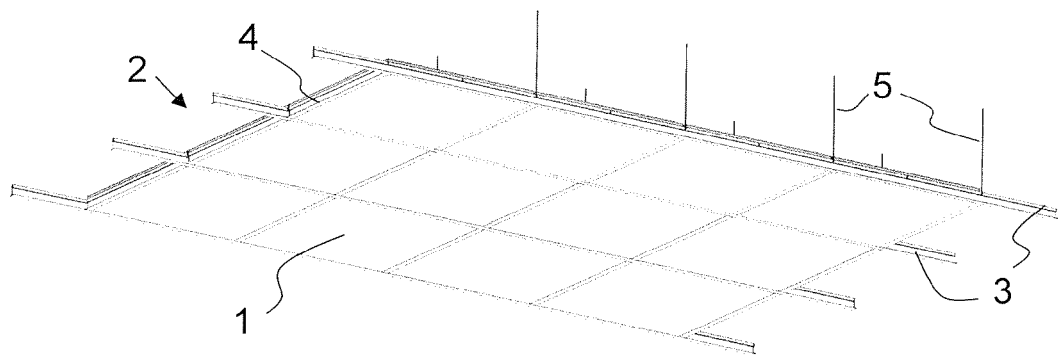


Fig. 1

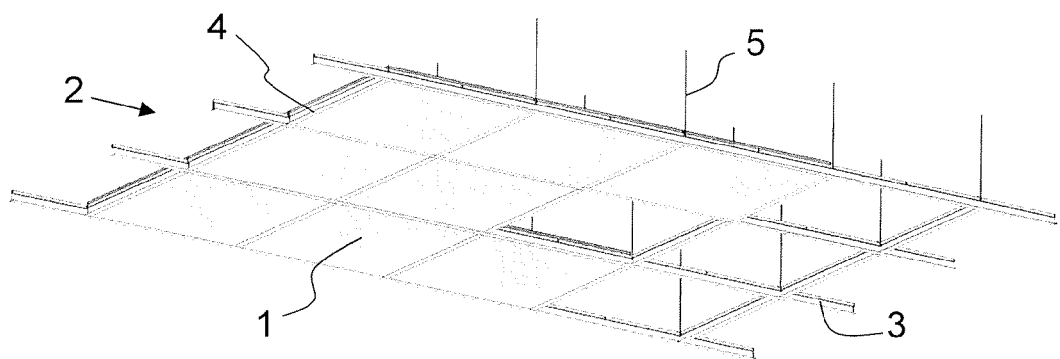


Fig. 2

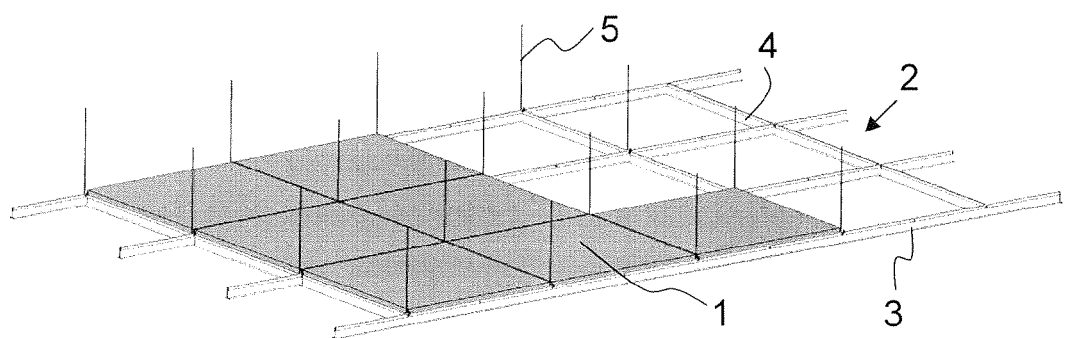


Fig. 3

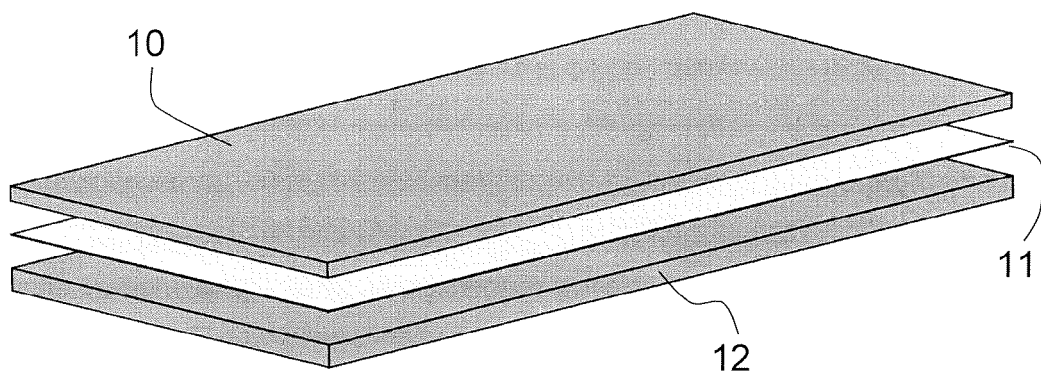


Fig. 4

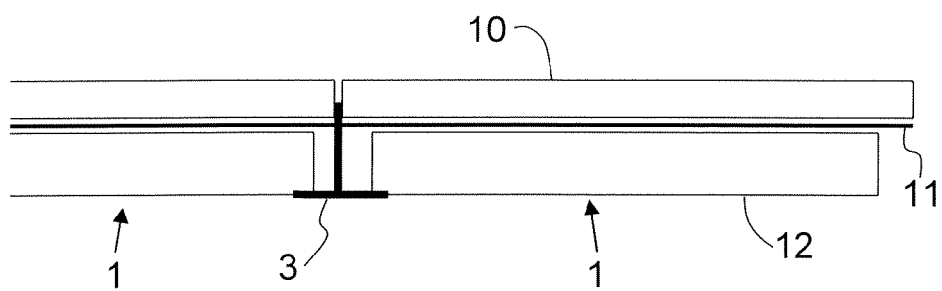


Fig. 5

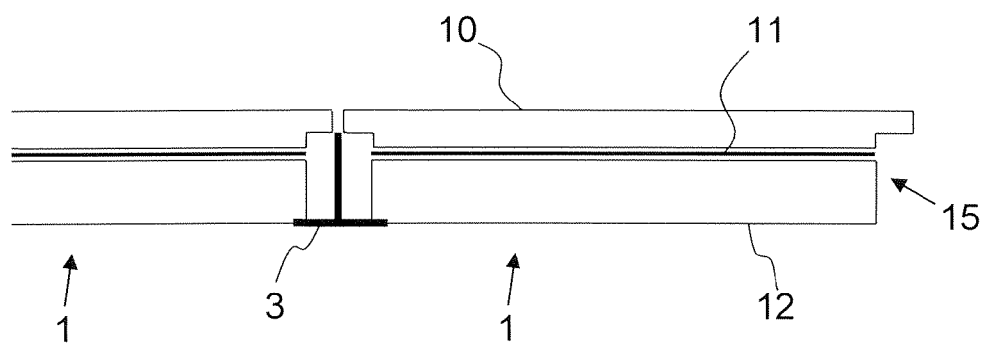


Fig. 6

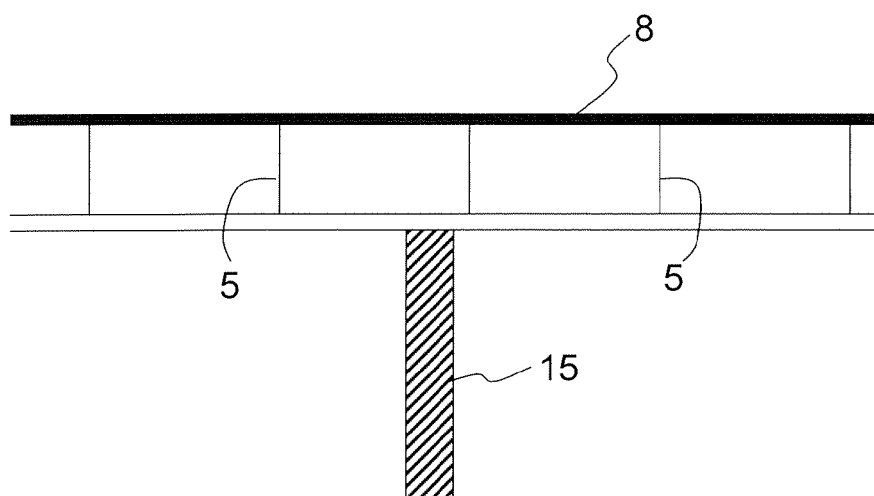


Fig. 7

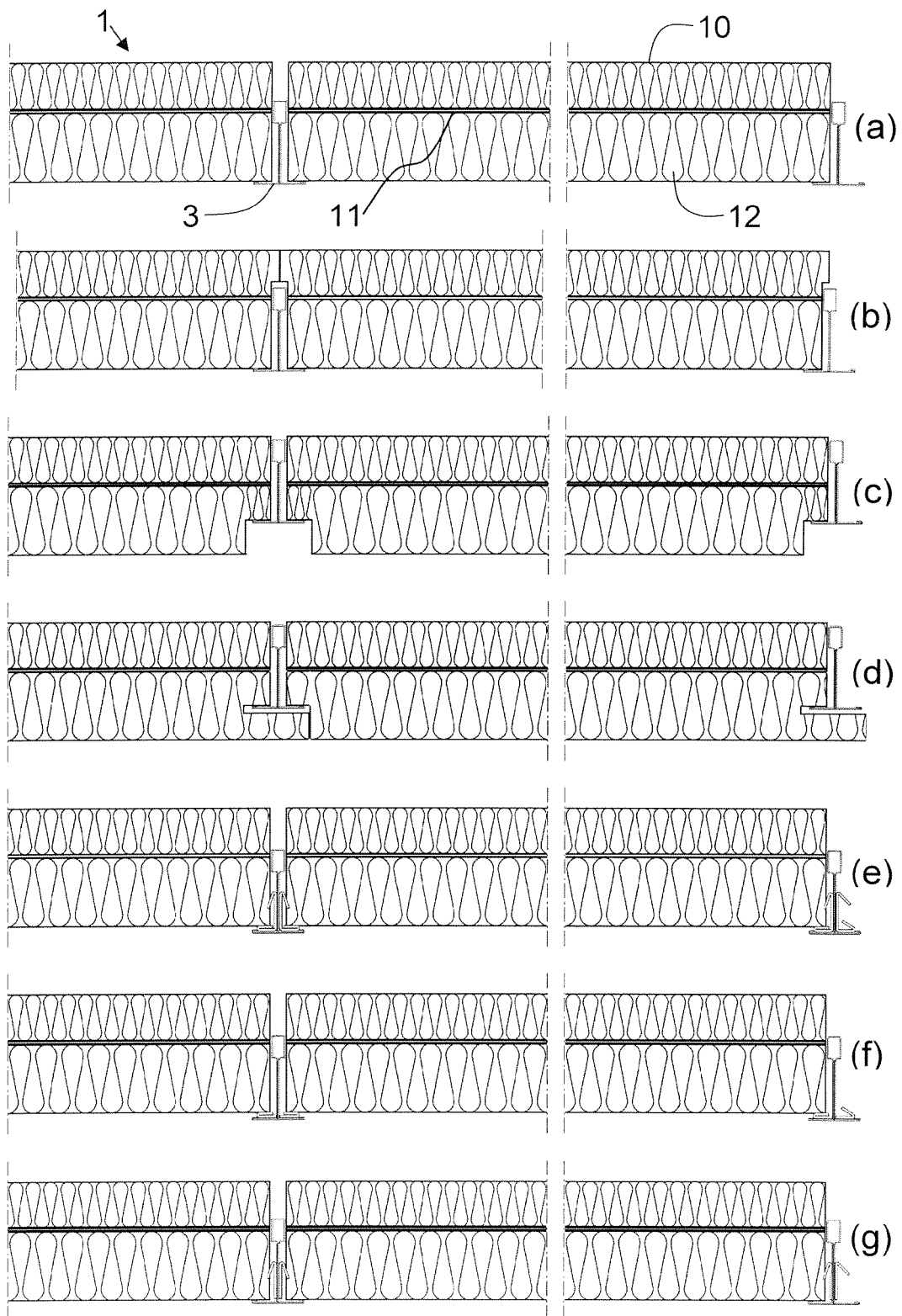


Fig. 8

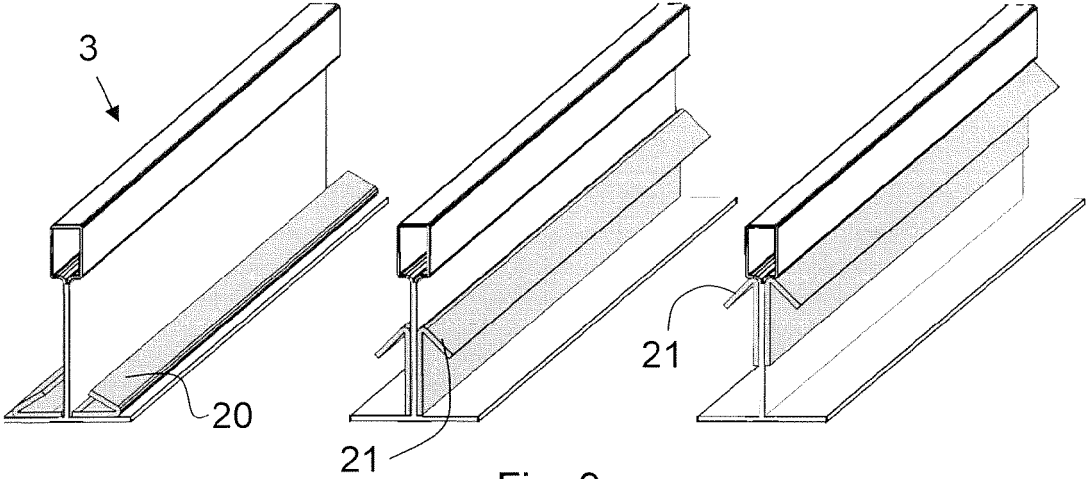


Fig. 9

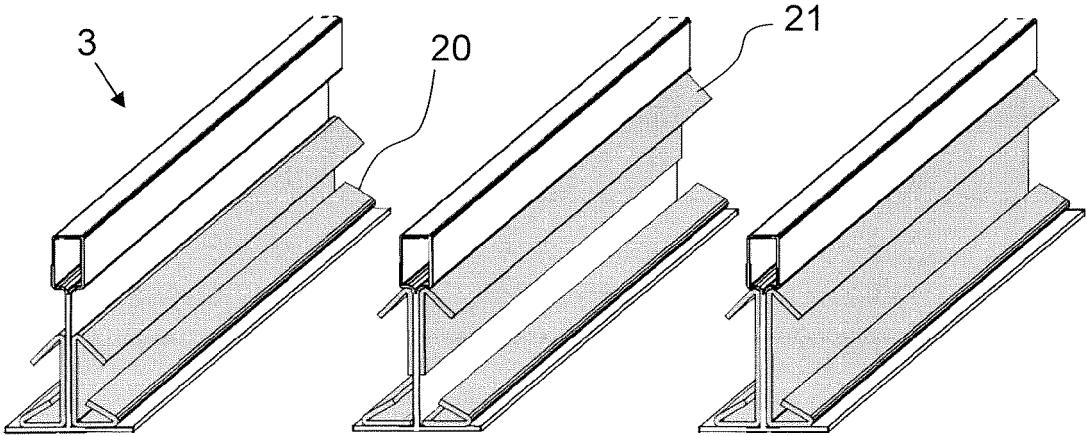


Fig. 10

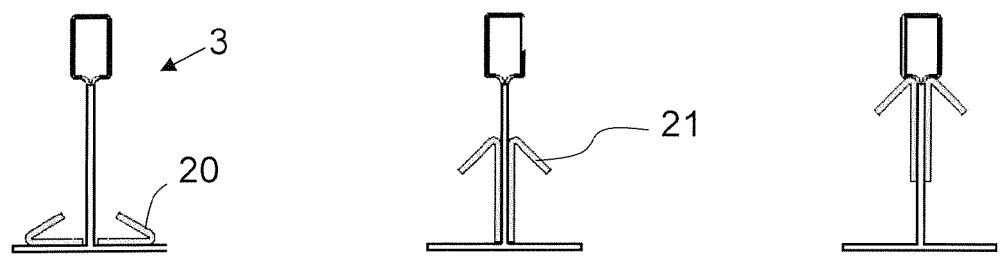


Fig. 11

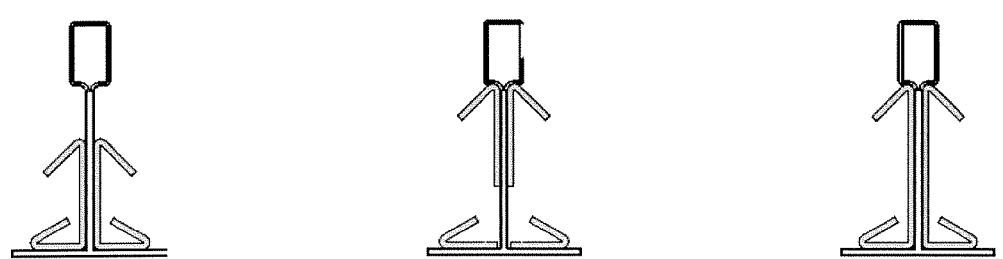


Fig. 12



EUROPEAN SEARCH REPORT

Application Number
EP 08 15 5716

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		16 October 2008	Righetti, Roberto
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			

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EPO FORM 1503 03 82 (P04C01)

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

EP 08 15 5716

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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