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(54) **A foundation system as well as a thermally insulating layer suitable for such a foundation system**

(57) A foundation system for a building comprises a thermally insulating layer provided on a ground surface. Air passage ducts extending substantially parallel to the thermally insulating layer are provided between the thermally insulating layer and the ground surface. The air passage ducts are connected to at least one air supply duct on a first side and to at least one air discharge duct on a second side remote from the first side.

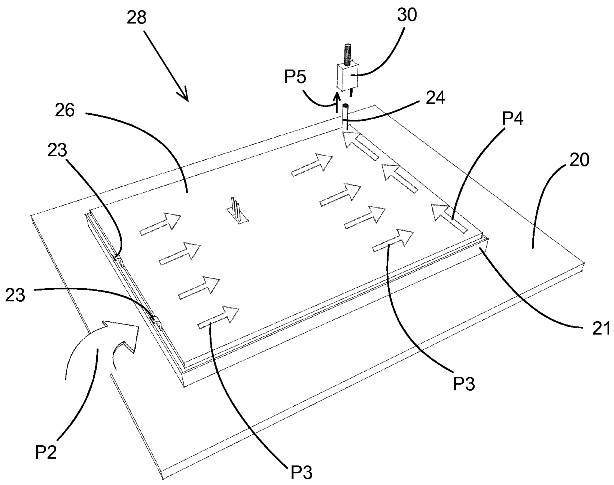

Fig. 5

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Description

[0001] The invention relates to a foundation system for a building, which foundation system comprises a thermally insulating layer provided on a ground surface.

[0002] The invention also relates to a thermally insulating layer suitable for such a foundation system.

[0003] It is generally known in the construction of buildings to first provide a thermally insulating layer on a ground surface and subsequently lay a floor, such as a concrete floor or a dry construction floor, on the thermally insulating layer. Following that, walls are placed on the foundation and/or the floor, etc. The material of the ground surface usually has a temperature of, for example, 10-15 degrees Celsius. The thermally insulating layer effectively prevents the temperature in the space above the floor in the building from undesirably and uncontrollably falling under the influence of the relatively cold ground surface.

[0004] To control the temperature in the space, heating systems can be used in the winter for increasing the temperature of the air in the space, whilst air conditioning units can be used in the summer, for example, for decreasing the temperature of the air in the space. External energy is needed for increasing or decreasing the temperature in the space in a controlled manner.

[0005] The object of the invention is to provide a foundation system by means of which energy for changing the air temperature can be obtained in a simple manner.

[0006] This object is achieved with the foundation system according to the invention in that air passage ducts extending substantially parallel to the thermally insulating layer are provided between the thermally insulating layer and the ground surface, which air passage ducts are connected to at least one air supply duct on a first side and to at least one air discharge duct on a second side remote from the first side.

[0007] Usually, a building comprises a foundation that supports walls. The thermally insulating layer lies within the foundation that supports the walls. The air supply duct and the air discharge duct may be located inside and/or outside the building.

[0008] In the winter, the outside temperature will generally be lower than the ground temperature. By carrying the air that is present outside the building into the air passage ducts via the air supply duct, the air will be heated as a result of the contact with the ground, so that the air that exits the air discharge duct will have a higher temperature than the air that enters the air supply duct. The pre-heated air can be carried directly into the building or be further heated to the desired temperature by means of a heating system. Since the air is already pre-heated, less energy will be needed for heating the outside air to the desired temperature.

[0009] In the summer, the outside temperature will generally be higher than the ground temperature. By carrying the air that is present outside the building into the air passage ducts via the air supply duct, the air will be cooled as a result of the contact with the ground, so that the air that exits the air discharge duct will have a lower temperature than the air that enters the air supply duct. The pre-cooled air can be carried directly into the building or be further cooled to the desired temperature by means of an air conditioning unit. Because the air is already pre-cooled, less energy will be needed for cooling the outside air to the desired temperature. It is also possible to carry air that is present in the space in the building directly into the air passage ducts via the air supply duct. This can be realised by means of three-way valves, for example, by means of which it is possible to determine whether or outside air or air that is present in the building is carried into the air passage ducts.

[0010] The thermally insulating layer prevents the temperature in the space present above the thermally insulating layer from being directly influenced.

[0011] Because the thermally insulating layer may extend over the entire ground area of the building, air can be pre-heated or pre-cooled over a relatively large area.

[0012] Because air passage ducts may be provided under the entire building, a relatively large amount of air can be treated without extra space outside the building being required for this purpose.

[0013] Because the air passage ducts moreover extend substantially parallel to the thermally insulating layer, practically no additional preparatory work needs to be carried out with regard to the ground surface. Said preparatory work will in particular comprise the digging up of the ground to the desired depth for placing the foundation system. Said depth only needs to be a few centimetres more than in the case of a foundation system comprising a thermally insulating layer not provided with air passage ducts. The air passage ducts have practically no thermal insulation value of their own. The dimensions of the thermally insulating layer, and in particular the thickness thereof, is so calculated or determined by experiment that the thermally insulating layer will have the desired insulation value (for example RC value). It is possible to provide an additional thermally insulating layer on the thermally insulating layer that bounds the air passage ducts, in which case the insulation value is determined by the two superposed layers. The desired insulation value determines the total layer thickness and the depth to which digging must take place. The foundation for supporting the walls that surrounds the thermally insulating layer can be provided at a different depth, depending on the supporting properties of the ground.

[0014] One embodiment of the foundation system according to the invention is characterised in that the thermally insulating layer is provided with slots which are open on the side facing the ground, which slots, together with the ground surface, form the air passage ducts.

[0015] Such slots are easy to form in any desired dimension in the thermally insulating layer. The slots can be mechanically formed in a factory, so that the slots are already present in the thermally insulating layer at the building site. It is also possible to form slots forming air passage ducts in the ground, but this can only be done on-site and strongly depends on the hardness and the stability of the ground, among other factors.

[0016] Another embodiment of the foundation system according to the invention is characterised in that the air passage ducts extend parallel to each other.

[0017] This makes it possible to provide a relatively large number of air passage ducts over the area of the thermally insulating layer, so that a good heat exchanger is obtained.

[0018] Another embodiment of the foundation system according to the invention is characterised in that the air supply duct and the air discharge duct extend substantially transversely to the air passage ducts.

[0019] In this way a compact layout of the air supply duct and the air discharge duct relative to the air passage ducts can be obtained, in which all the air passage ducts are connected to the air supply duct with their first side and to the air discharge duct with their second side.

[0020] Another embodiment of the foundation system according to the invention is characterised in that the air passage ducts are spaced from each other by a distance of 5 to 15 cm.

[0021] When such a spacing is used, a good heat transfer between the ground and the air present in the air passage ducts is obtained. The spacing can be determined in dependence on, for example, the amount of heat to be absorbed or given off, the desired amount of air through the air passage ducts or the desired air resistance.

[0022] Another embodiment of the foundation system according to the invention is characterised in that the air passage duct has a width and/or a height of 1 to 10 cm.

[0023] Such a width and height of the air passage duct make it possible to realise a good air flow.

[0024] Another embodiment of the foundation system according to the invention is characterised in that the thermally insulating layer comprises expanded polystyrene (EPS), polyurethane (PUR) or polyisocyanurate (PIR).

[0025] Such materials have a high thermal insulation value; they are airtight, so that the air flowing through the air passage ducts will not penetrate into the thermally insulating layer and, in addition, they are easy to work for forming the slots in the thermally insulating layer therein.

[0026] Another embodiment of the foundation system according to the invention is characterised in that the air passage ducts lie below the surface level.

[0027] This means that the ground surface lies below the surface level as well, with the ground having a relatively constant temperature. The deeper the air passage ducts lie relative to the surface level, the more constant the temperature of the ground in question will be.

[0028] Another embodiment of the foundation system according to the invention is characterised in that a foil is present between the ground and the thermally insulating layer.

[0029] The foil preferably has moisture-proof and anti-fungal properties, so that the air flowing through the air passage ducts is not humidified by the ground and there will be no fungal growth in the air passage ducts.

[0030] Another embodiment of the foundation system according to the invention is characterised in that the foil comprises polyethylene (PE), preferably provided with copper or zinc components.

[0031] In practice, the temperature difference between the air flowing through the air passage ducts at the beginning of the air passage ducts and the air at the end thereof will be relatively limited and amount to merely a few degrees, for example 1 to 10 degrees. The precipitation of moisture caused by said difference in temperature will be limited, therefore. Thus, fungal growth will be limited or hardly occur at all. The polyethylene foil is relatively easy to produce at low cost and has anti-fungal properties. The copper or zinc components further enhance the anti-fungal properties.

[0032] Another embodiment of the foundation system according to the invention is characterised in that the air supply duct is in communication with outside air from outside the building.

[0033] In this way fresh air from outside the building can be pre-heated or pre-cooled in a simple manner before being carried into the building.

[0034] In many cases it is mandatory to ensure that a building is provided with adequate ventilation, with 9 m^3 of air per m^2 per hour being replaced, for example. In the case of the foundation system according to the invention, this is combined in a simple manner with the pre-heating or precooling of the air to be replaced.

[0035] Another embodiment of the foundation system according to the invention is characterised in that the air discharge duct is connected to an air conditioning installation, a heat pump or a ventilation duct in the building.

[0036] Using such an air conditioning installation, heat pump of ventilation duct, the pre-heated or pre-cooled air can be further conditioned. The pre-heated air can be distributed over the entire building, for example, and be carried past radiators for further heating thereof.

[0037] The pre-heated air can for example be supplied to an air heat pump. A more constant and higher air temperature of the pre-heated air will lead to a higher efficiency (COP) of the air heat pump. The air heat pump can also be used for withdrawing energy from air to be discharged from the building. The pre-heated air is not carried into the building but directly outside the building in that case and is only used for increasing the efficiency of the air heat pump.

[0038] The pre-cooled air may for example be distributed over the entire building for cooling the building.

[0039] The invention will now be explained in more detail with reference to the drawings, in which:

Figures 1A - 1C show a perspective bottom view, a top view and a cross-sectional view, respectively, of a thermally insulating layer according to the invention;

Figures 2A - 2E show steps of the construction of a building that is provided with a foundation system according to the invention;

Figures 3A and 3B show a cross-sectional view and a perspective side view, respectively, of the detail III of the foundation system shown in figure 2E;

Figures 4A and 4B show a cross-sectional view and a perspective side view, respectively, of the detail IV of the foundation system shown in figure 2E;

Figure 5 shows the foundations system shown in figure 2E with airflows passing therethrough;

Figures 6A and 6B show the operation of the foundation system according to the invention in the winter and in the summer, respectively.

[0040] Like parts are indicated by the same numerals in the figures.

[0041] Figures 1A - 1C show a bottom view, a top plan view and a cross-sectional view, respectively, of a thermally insulating layer 1 according to the invention. The thermally insulating layer 1 comprises an elongate upper plate 2 and an elongate lower plate 3 that is integrally connected thereto. The upper plate 2 and the lower plate 3 are transversely staggered relative to each other, with a first longitudinal side 4 of the upper plate 2 extending beyond a first longitudinal side 5 of the lower plate 3. Similarly, a second longitudinal side 6 of the lower plate 3 extends beyond a second longitudinal side 7 of the upper plate 2. The first longitudinal side 4 of the upper plate 2 is provided with an elongate groove 8 and the first longitudinal side 5 of the lower plate 3 is provided with an elongate groove 9. The second longitudinal side 7 of the upper plate 2 is provided with an elongate rib 10 and the second longitudinal side 6 of the lower plate 3 is provided with an elongate rib 11. The ribs 10, 11 of a thermally insulating layer 1 can be connected to the grooves 8, 9 of an adjacent thermally insulating layer 1.

[0042] The upper plate 2 and the lower plate 3 are longitudinally staggered relative to each other, with a first transverse side 12 of the upper plate 2 extending beyond a first transverse side 13 of the lower plate 3. Similarly, a second transverse side 14 of the lower plate 3 extends beyond a second transverse side 15 of the upper plate 2. In the case of connected-together thermally insulating layers 1, the first transverse side 12 of the upper plate 2 of one thermally insulating layer 1 abuts against the second transverse side 14 of the lower plate 3 of the adjacent thermally insulating layer 1.

[0043] The lower plate 3 of the thermally insulating layer 1 is provided with a number of rectangular slots 16 extending parallel to the longitudinal sides 5, 6, which slots extend over the entire length of the transverse side 13 towards the transverse side 14. The slot 16 has a width B of 1 to 10 centimetres, for example 2 centimetres, and a height H of 1 to 10 centimetres, for example 5 centimetres. The slots 16 are spaced apart by a pitch distance S of 5 to 15 centimetres, for example 9 centimetres. The slots 16 are open to the bottom side. The thickness of the thermally insulating layer 1 is at least twice the height of the slot 16, for example, so that a solid thermally insulating layer 1 is obtained.

[0044] The thermally insulating layer 1 is preferably made of polystyrene (EPS), polyurethane (PU) or polyisocyanurate (PIR).

[0045] The length and the width of the thermally insulating layer 1 are 80 and 60 cm, for example, with a total thermally insulating layer having the desired dimensions being obtained by connecting a number of thermally insulating layers 1 together.

[0046] Figures 2A-2F show various steps of the construction of a building provided with the above-described thermally insulating layers 1 for forming a foundation system according to the invention.

[0047] A compacted sand package 20 is provided on the underlying ground surface in a known manner, on which sand package a concrete foundation 21 having the desired shape of the building to be constructed is laid (see figure 2A). The construction of such a foundation is known per se and will not be explained in more detail herein, therefore.

[0048] Subsequently, foil strips 22 are laid on the sand package 20 in the foundation 21, which strips are arranged to overlap, with one strip 22 overlapping the next strip 22 in the direction indicated by arrow P1, so that an air flow in the direction indicated by arrow P1 over the strips 22 will press the overlapping parts of the strips 22 together (figure 2B).

[0049] The foil of the strip 22, which is moisture-resistant and anti-fungal, is for example made of polyethylene (PE) with copper or zinc components.

[0050] Figure 2C shows the step in which the thermally insulating layers 1 are positioned on the foil strips 22 in stretcher bond, with the transverse sides 12-15 extending parallel to the longitudinal direction of the strips 22. In this step the air supply ducts 23 and the air discharge ducts 24 are provided as well. The orientation of said ducts and the direction in which they intend will be explained in more detail yet with reference to figures 3A - 4B.

[0051] Figure 2D shows the step in which further thermally insulating layers 25 are laid on the thermally insulating layers 1. The thermally insulating layers 25 are practically identical to the thermally insulating layers 1, but they are not provided with slots 16 and have a smooth underside. The thermally insulating layers 25 are positioned in stretcher bond, with the longitudinal sides of the thermally insulating layers 25 extending transversely to the longitudinal sides of the thermally insulating layers 1.

[0052] Figure 2E shows the step in which a concrete layer 26, such as a concrete floor or a dry construction floor is provided on the thermally insulating layers 25. The installation of the concrete layer 26 is known per se and will not be explained in more detail herein, therefore.

[0053] Figure 2F shows the step in which walls 27 of the building 28 are placed on the foundation 21 and the concrete layer 26. The walls 27 are provided with air passages 29. The building 28 is further provided with an air conditioning installation 30, which is connected to the air discharge duct 24.

[0054] Figures 3A and 3B show a cross-sectional view and a perspective side view, respectively, of the detail III of the foundation system shown in figure 2E. On the foundation 21, an inner wall 31 and, spaced therefrom, an outer wall 32 are placed. Present between the inner wall 31 and the outer wall 32 is a wall cavity 33, in which a thermally insulating layer 34 is provided. The thermally insulating layer 1 present on the foil strips 22 is cut off at right angles near the inner wall 31, so that the transverse sides 14, 15 of the upper plate 2 and the lower plate 3 are aligned. The transverse sides 14, 15 are spaced from the inner wall 31, with an elongate air supply duct 35 being formed between the transverse sides 14, 15 and the inner wall 31. The air supply duct 35 is bounded by the ground surface formed by the sand package 20 and the foil strips 22 on the bottom side and by the thermally insulating layer 25 that extends up to the inner wall 31 on the upper side. Air supply ducts 23 made up of plastic pipes are connected to the air supply duct 35. The air supply duct 23 extends through the inner wall 31, the wall cavity 33 and the outer wall 32 to outside the building 28, where it is provided with an inlet nozzle 36.

[0055] The thermally insulating layer 1 abuts against the ground surface formed by the sand package 20 and the foil strips 22. The slots 16 are closed by the foil strips 22 on the open bottom side, forming air passage ducts which are connected to the air supply duct 35 on a first side.

[0056] Figures 4A and 4B show a cross-sectional view and a perspective side view, respectively, of the detail IV of the foundation system shown in figure 2E. On the foundation 21, the inner wall 31 and, spaced therefrom, the outer wall 32 are placed. Present between the inner wall 31 and the outer wall 32 is the wall cavity 33, in which the thermally insulating layer 34 is provided. Transverse sides 12, 13 of the thermally insulating layer 1 that lies on the foil strips 22 are spaced from the inner wall 31, with an elongate air discharge duct 37 being formed between the transverse sides 12, 13 and the inner wall 31. The transverse sides 14, 15 are spaced from the inner wall 31 by a distance of 10 centimetres, for example. The air discharge duct 37 is bounded by the ground surface formed by the sand package 20 and the foil strips 22 on the bottom side and by the thermally insulating layer 25, which extends up to the inner wall 31, on the upper side. The air discharge duct 24 made of plastic pipes is connected to the air discharge duct 37. The air discharge duct 24 extends through the thermally insulating layer 25 and a concrete floor 26 to inside the building 28, where it is provided with an outlet nozzle 38. Inside the building 28, the air discharge duct 24 may be connected to an air conditioning installation 30 or directly open into a ventilation duct in the building 28. The air conditioning installation 30 may be an air conditioning installation or a heat pump.

[0057] The air passage ducts bounded by the slots 16 and the ground surface formed by the sand package 20 and the foil strips 22 are connected to the air discharge duct 37 on a second side.

[0058] As is usual with a foundation 21, the sand package 21 and at least part of the foundations lie below the surface level 39, so that also the thermally insulating layers 1 and the air passage ducts formed by the slots 16 in the thermally insulating layers 1 and the ground lie below the surface level.

[0059] Figure 5 shows a perspective view of a part of the building 28 that is provided with the foundation system according to the invention. Air is carried from outside the building 28 into the inlet nozzles 36 by means of a fan (not shown) or sucked from the outlet nozzle 38 into the building by means of a suction pump (not shown), creating an air flow in the directions indicated by arrows P_2, P_3, P_4 and P_5 through the air supply ducts 23, the air supply duct 35, the air passage ducts formed by the slots 16 in the thermally insulating layers 1 and the ground surface, the air discharge duct 37 and the air discharge ducts 24.

[0060] Figure 6A shows the air flow in the winter through the air passage ducts formed by the slots 16 in the thermally insulating layers 1 and the ground surface, with the inflowing air in the air supply duct 35 (arrow P_2) having a temperature of o degrees, for example. In the winter, the sand package 20 and the underlying earth has a temperature of 10 degrees, for example. While the air flows through the air passage ducts, heat transfer takes place in the direction indicated by arrow P6 from the ground to the air in the air passage ducts, so that the air is heated and the air in the air discharge duct 37 (arrow P_5) will have a temperature of 5 degrees, for example.

[0061] Figure 6B shows the air flow in the summer through the air passage ducts formed by the slots 16 in the thermally insulating layers 1 and the ground surface, with the inflowing air in the air supply duct 35 (arrow P_2) having a temperature of 25 degrees, for example. In the summer, the sand package 20 and the underlying earth has a temperature of 15 degrees, for example. While the air flows through the air passage ducts, heat transfer takes place in the direction indicated by arrow P_7 from the air in the air passage ducts to the ground, so that the air is cooled and the air in the air discharge duct 37 (arrow P_5) will have a temperature of 20 degrees, for example.

[0062] The pre-heated or pre-cooled air can subsequently be heated or cooled to the desired temperature, using means that are known per se.

[0063] It is also possible to form the thermally insulating layers from rock wool or glass fibres, in which case the bottom side provided with slots has been made airtight, using a foil, for example, so that the air flowing through the slots cannot find its way into the rock wool or the glass fibres.

[0064] It is also possible not to use foil strips 22 if there is no risk of moisture or fungal growth or said risk is ruled out otherwise.

[0065] If the insulation provided by the thermally insulating layers 1 is sufficient, the thermally insulating layers 25 may be left out.

[0066] It is also possible to provide an air supply duct inside the building, so that in the summer the relatively hot air in the building can be directly carried into the air passage ducts between the thermally insulating layer and the ground surface for cooling.

[0067] Instead of having a rectangular cross-section, the slots may also have a different cross-section, for example a triangular or a round cross-section. Usually, EPS is cut by means of hot wires, and from a mechanical point of view it is easiest to cut rectangular slots. The shape of the slots is not essential to the function of the slots, however. The thickness of the thermally insulating layer provided with slots is preferably selected so that the thermally insulating layer will be relatively stiff, so that it will be easy to transport and install.

[0068] The building may be a house, an office, a shop or an apartment.

[0069] It is possible to provide the air supply duct with a filter or a device for disinfecting the inflowing air, using ozone, for example, or scenting or purifying said air.

List of numerals

[0070]

1	thermally insulating layer
2	upper plate
3	lower plate
4	longitudinal side
5	longitudinal side
6	longitudinal side
7	longitudinal side
8	groove
9	groove
10	rib
11	rib
12	transverse side
13	transverse side
14	transverse side
15	transverse side
16	slot
20	sand package
21	foundation
22	foil strip
23	air supply duct
24	air discharge duct
25	thermally insulating layer
26	concrete layer
27	wall
28	building
29	air passage
30	air conditioning installation
31	inner wall
32	outer wall
33	wall cavity
34	thermally insulating layer
35	air supply duct
36	inlet nozzle
37	air discharge duct
38	outlet nozzle
39	surface level
B	width
H	height
P_1-P_7	arrow
S	pitch distance

Claims

1. A foundation system for a building (28), which foundation system comprises a thermally insulating layer (1) provided on a ground surface, **characterised in that** air passage ducts extending substantially parallel to the thermally insulating layer (1) are provided between the thermally insulating layer (1) and the ground surface, which air passage ducts are connected to at least one air supply duct (35) on a first side and to at least one air discharge duct (37) on a second side remote from the first side.

2. A foundation system according to claim 1, **characterised in that** the thermally insulating layer (1) is provided with slots (16) which are open on the side facing the ground surface, which slots, together with the ground surface (20), form the air passage ducts.

3. A foundation system according to claim 1 or 2, **characterised in that** the air passage ducts extend parallel to each other.

4. A foundation system according to claim 2, **characterised in that** the air supply duct (35) and the air discharge duct (37) extend substantially transversely to the air passage ducts.

5. A foundation system according to claim 3 or 4, **characterised in that** the air passage ducts are spaced from each other by a distance of 5 to 15 cm.

6. A foundation system according to any one of the preceding claims **characterised in that** the air passage duct has a width and/or a height of 1 to 10 cm.

7. A foundation system according to any one of the preceding claims, **characterised in that** the thermally insulating layer (1) comprises expanded polystyrene (EPS), polyurethane (PUR) or polyisocyanurate (PIR).

8. A foundation system according to any one of the preceding claims, **characterised in that** the air passage ducts lie below the surface level (39).

9. A foundation system according to any one of the pre-

ceding claims **characterised in that** a foil (22) is present between the ground (20) and the thermally insulating layer (1).

10. A foundation system according to claim 9, **characterised in that** the foil (22) comprises polyethylene (PE), preferably provided with copper or zinc components.

11. A foundation system according to any one of the preceding claims, **characterised in that** the air supply duct is in communication with outside air from outside the building.

12. A foundation system according to any one of the preceding claims, **characterised in that** the air discharge duct is connected to an air conditioning installation, a heat pump or a ventilation duct in the building (28).

13. A thermally insulating layer (1) suitable for a foundation system according to any one of the preceding claims, **characterised in that** the thermally insulating layer (1) is provided with open slots (16) to be directed toward a ground surface, which slots, together with the ground surface, form air passage ducts.

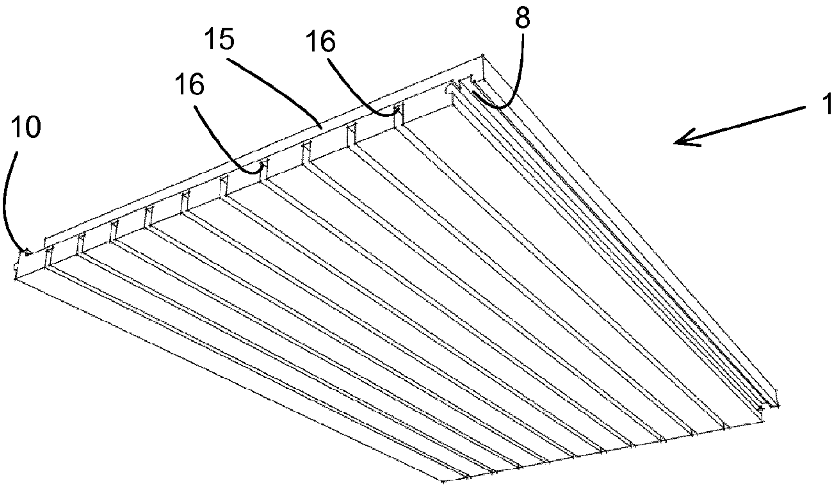

Fig. 1A

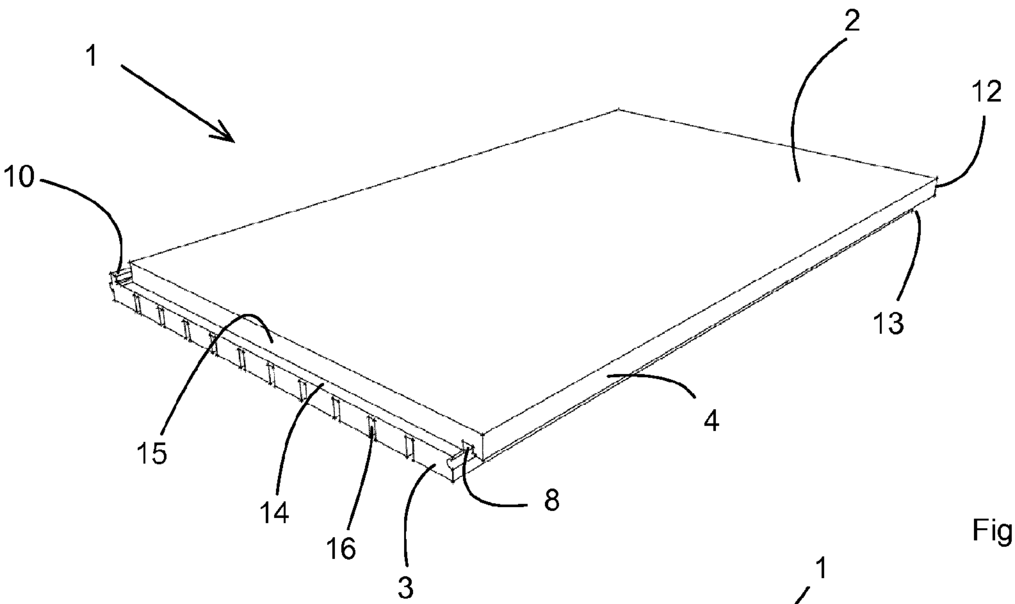

Fig. 1B

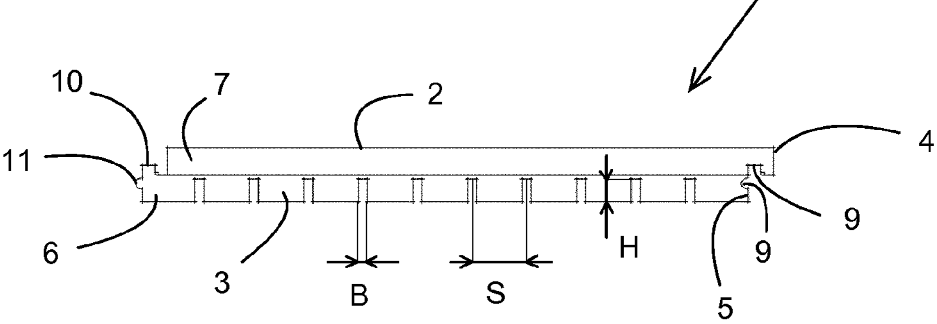

Fig. 1C

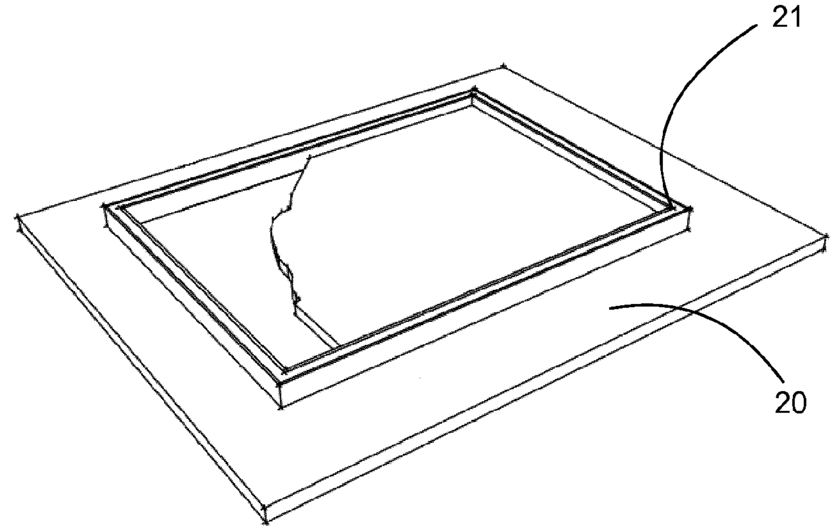

Fig. 2A

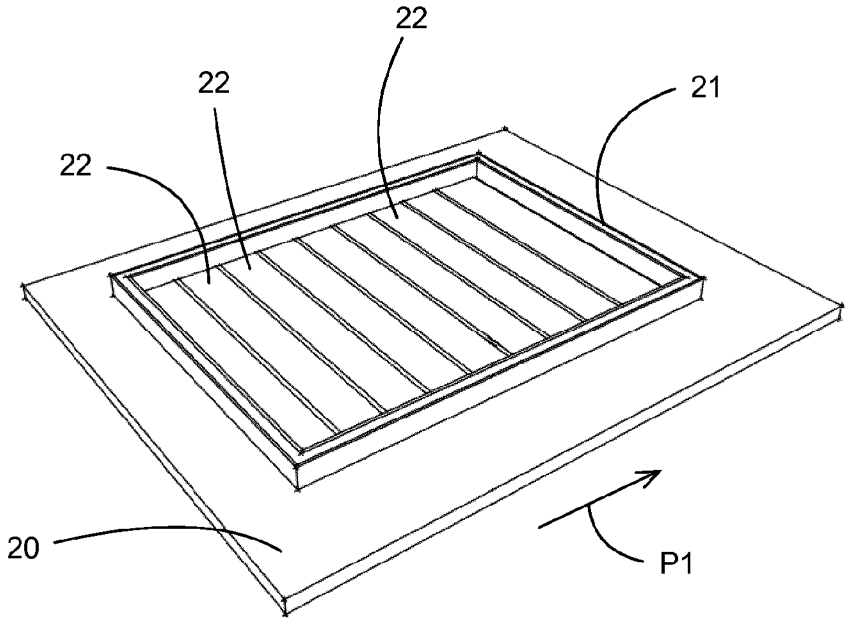

Fig. 2B

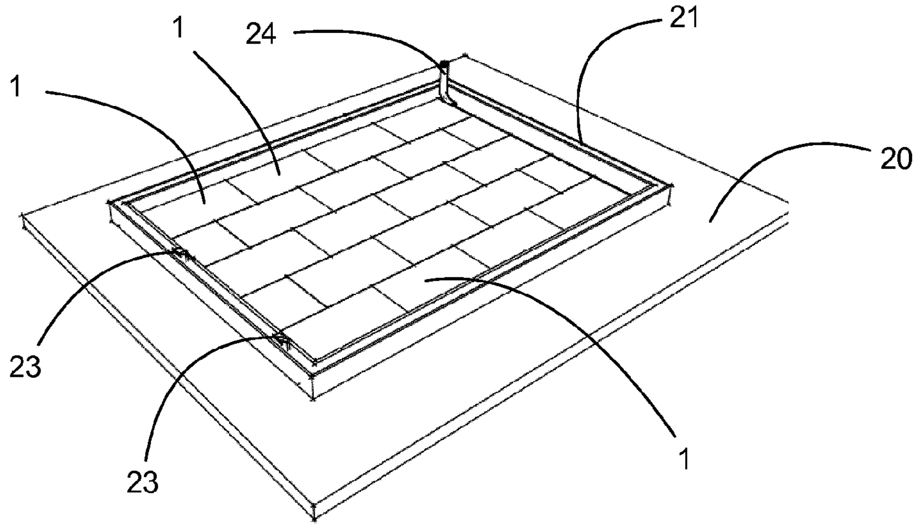

Fig. 2C

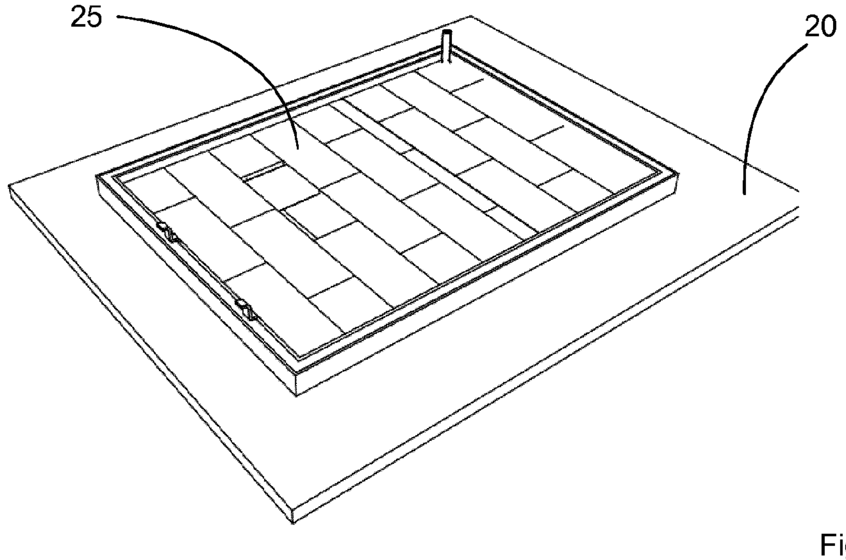

Fig. 2D

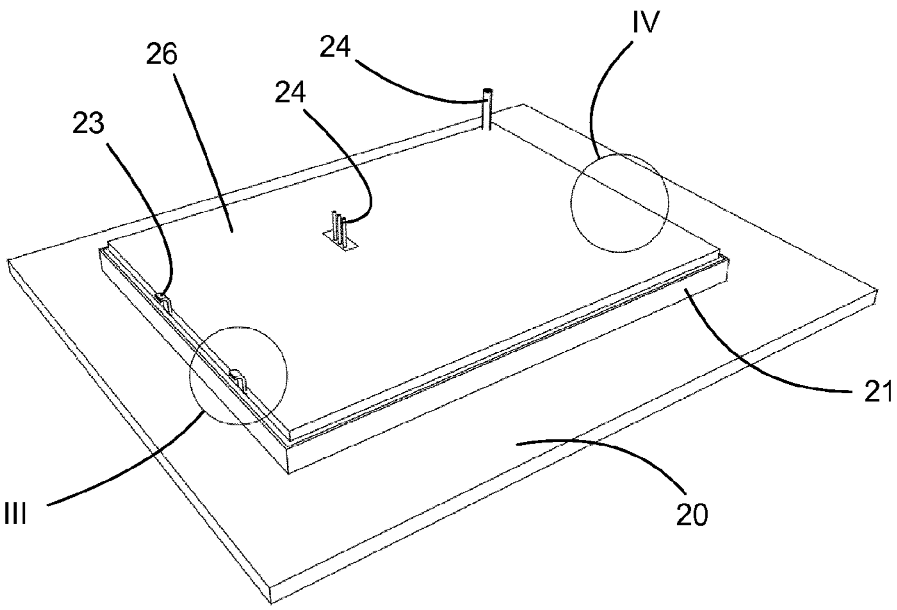

Fig. 2E

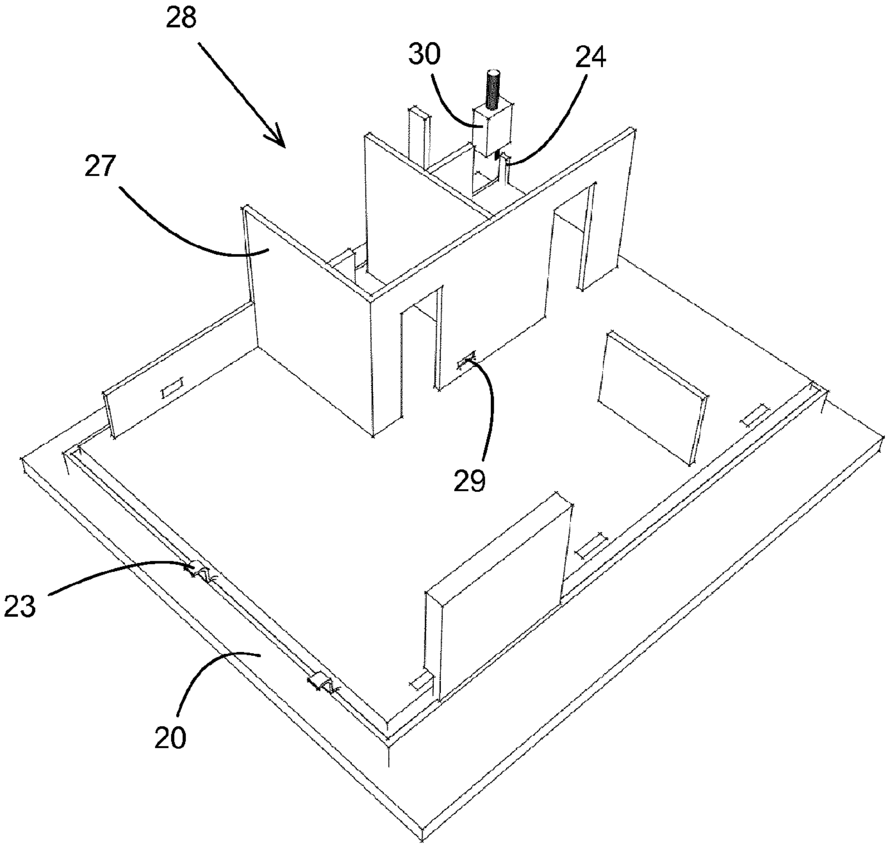

Fig. 2F

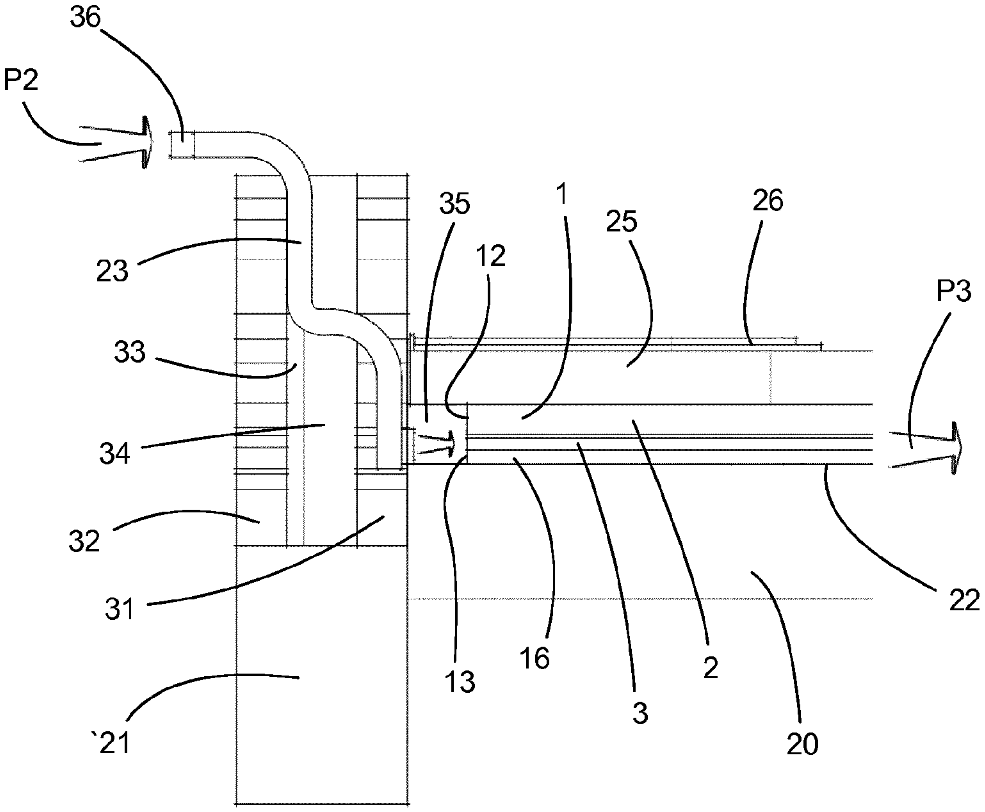

Fig. 3A

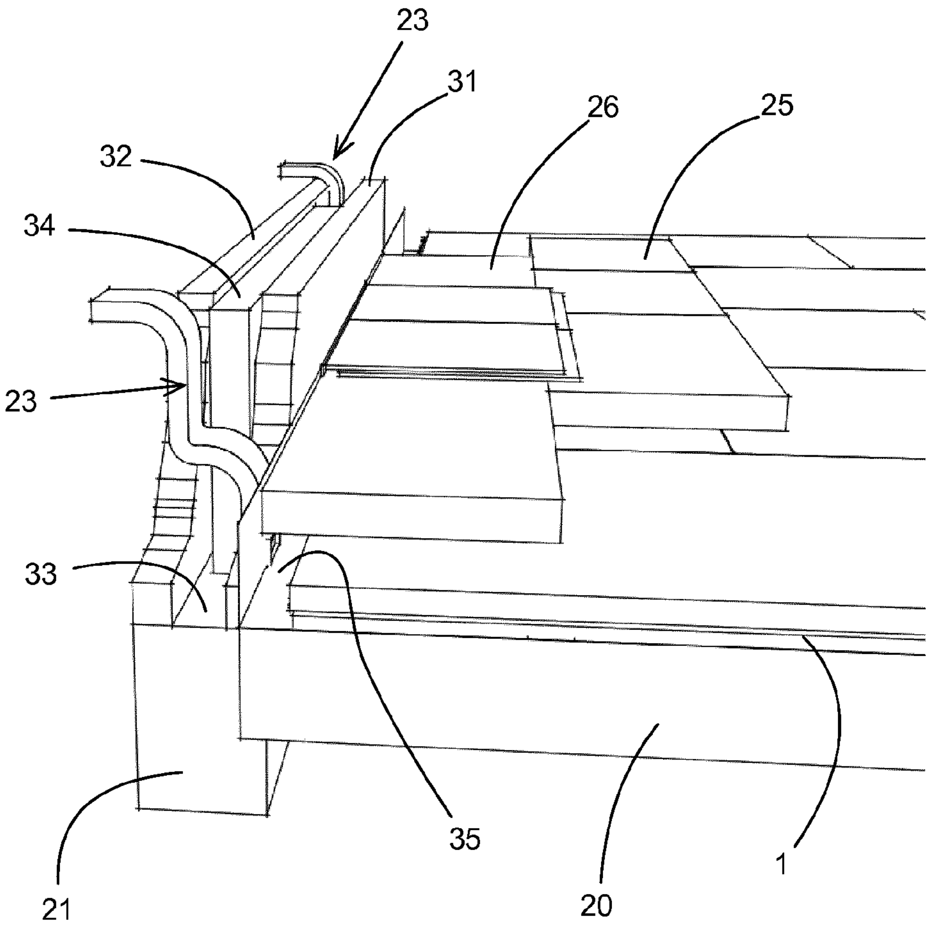

Fig. 3B

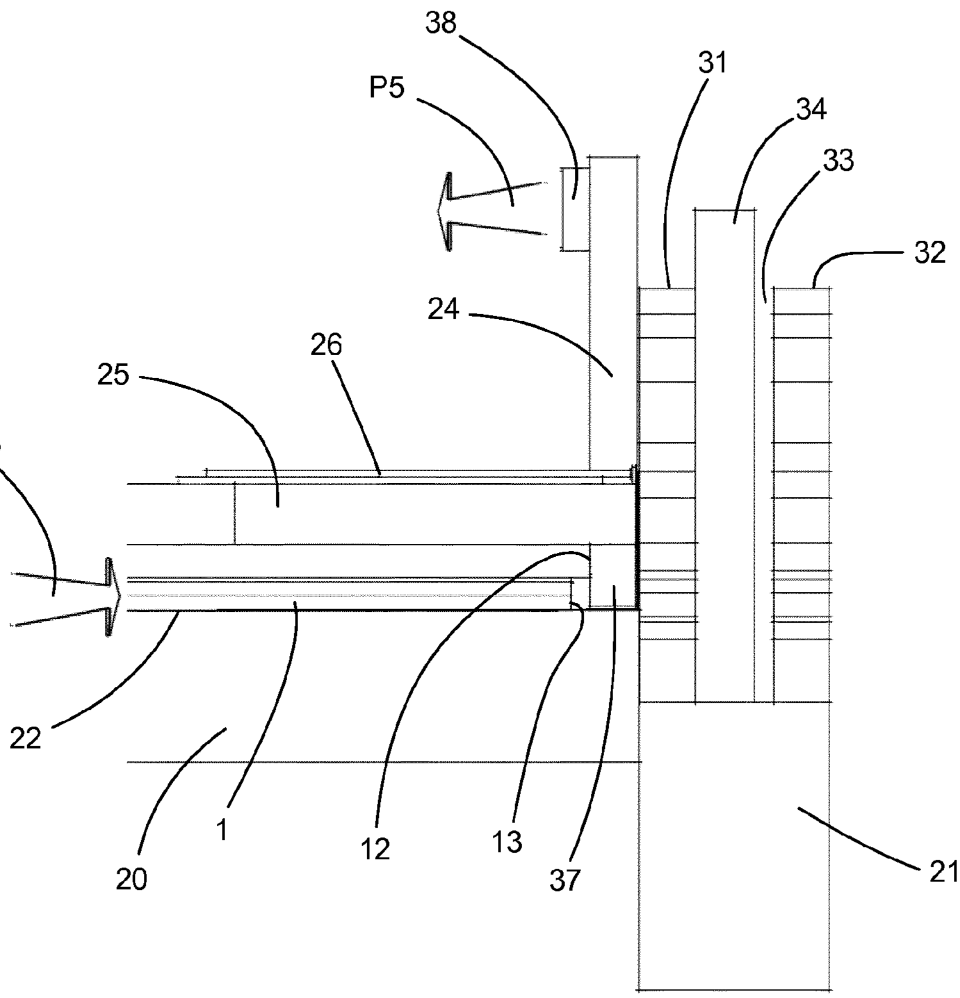

Fig. 4A

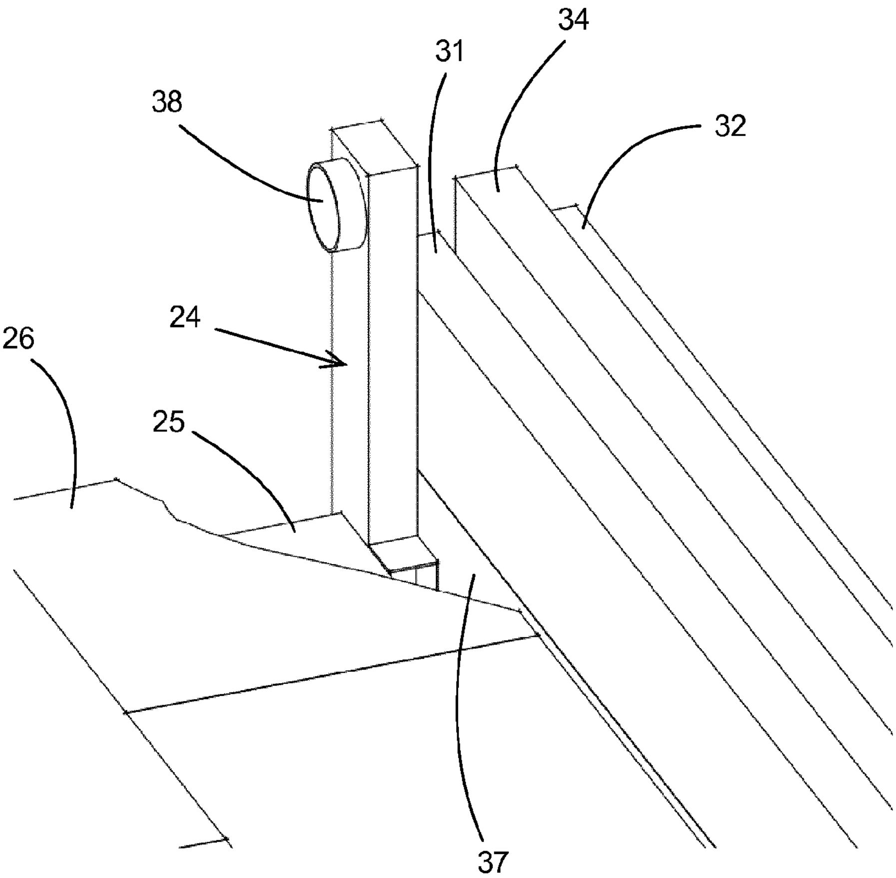

Fig. 4B

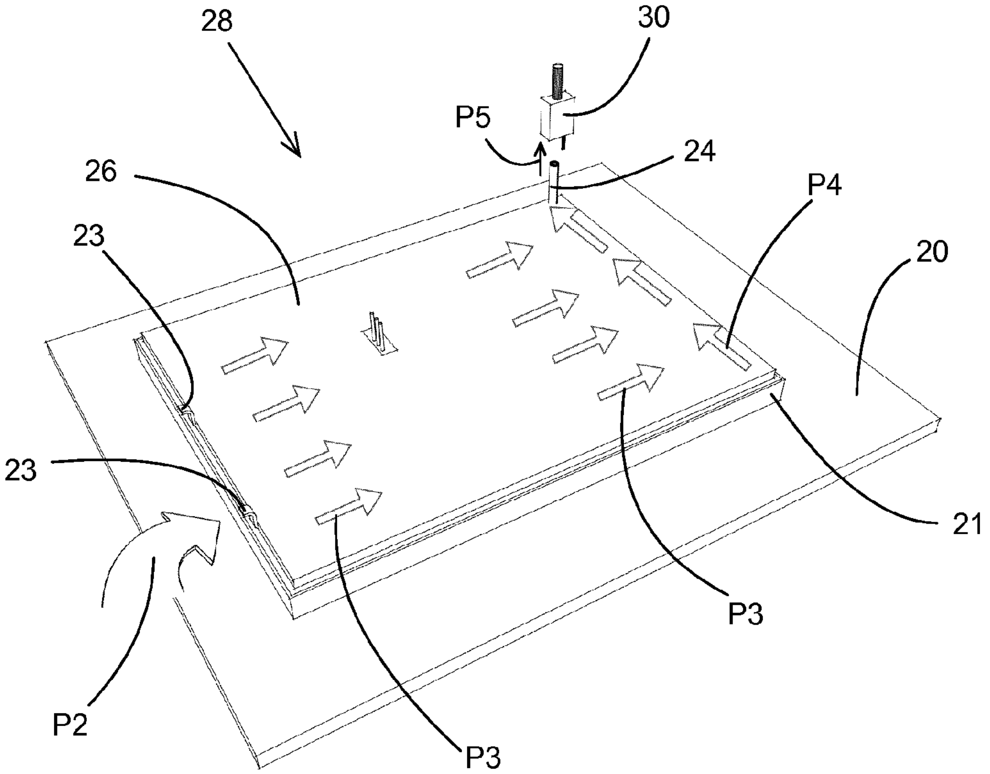

Fig. 5

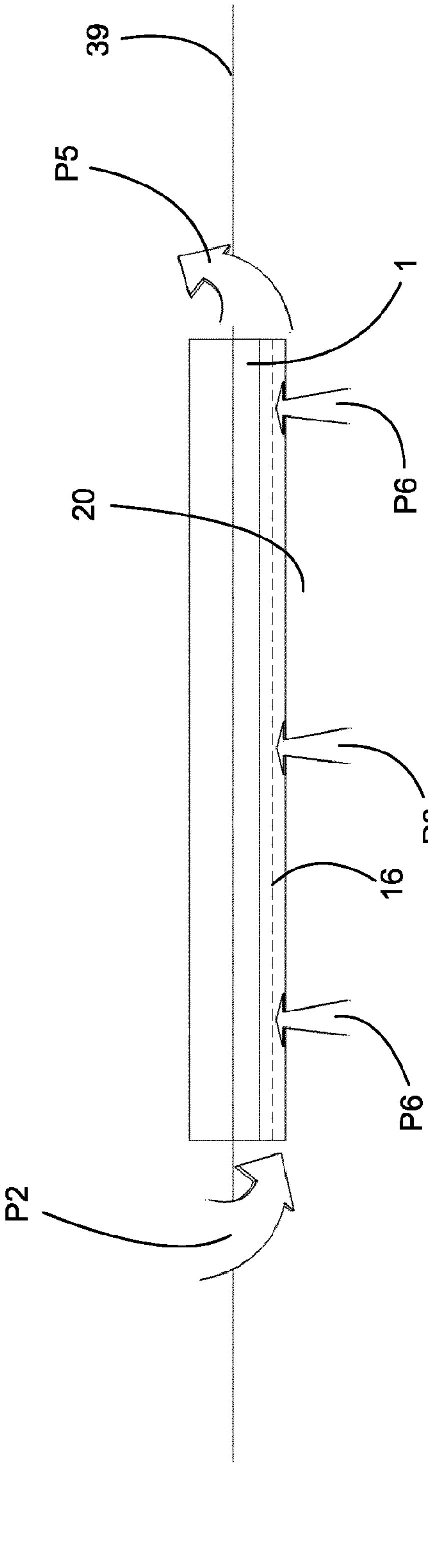

Fig. 6A

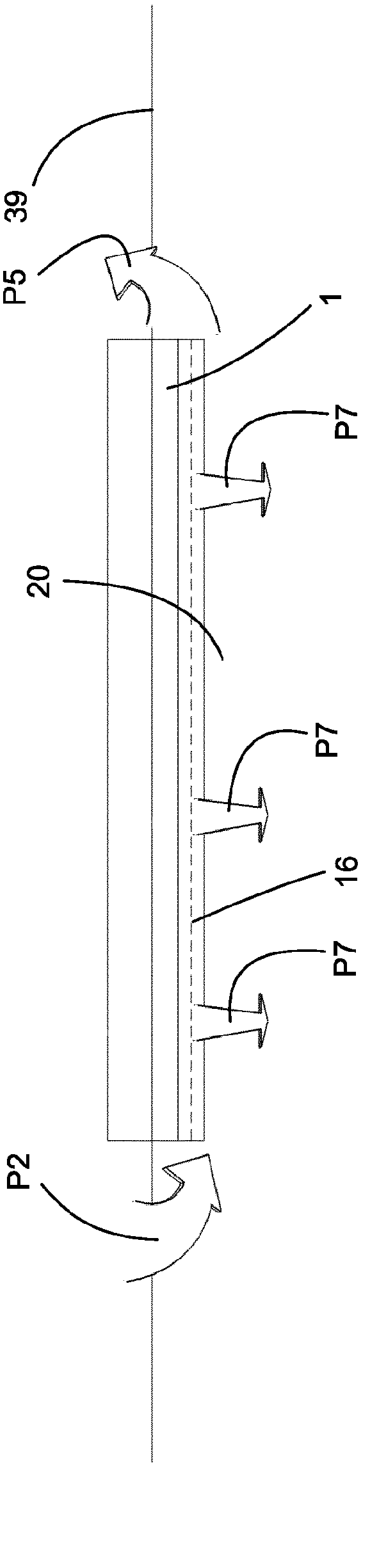

Fig. 6B

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 3307

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2004/106641 A1 (SCHROEDER PETER [DE]) 9 December 2004 (2004-12-09) * the whole document * -----	1-13	INV. E02D27/01

TECHNICAL FIELDS SEARCHED (IPC)
E02D

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	9 February 2015	Geiger, Harald

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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