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(54) A concrete floor slab and a method of manufacturing a concrete slab

(57) A concrete floor slab (1) includes an upper slab side (2) and a lower slab side (3). The slab (1) comprises a reinforcement (8) which is embedded in the concrete and includes an upper reinforcement side (8a) and a lower reinforcement side (8b). The slab (1) also comprises a tube (9) for heating or cooling fluid which includes an upper tube side (9a) and a lower tube side (9b). The lower tube side (9b) of at least the major portion of the tube (9) lies below the upper reinforcement side (8a).

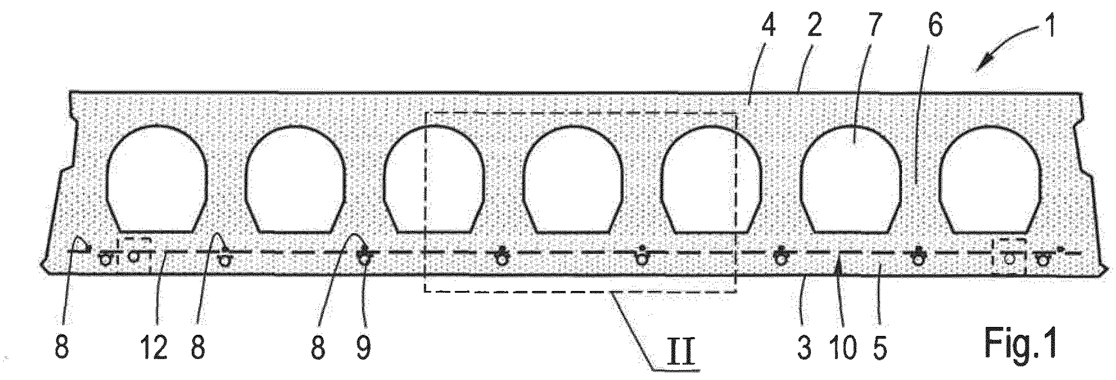

Fig.1

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Description

[0001] The present invention relates to a concrete floor slab including an upper slab side and a lower slab side, comprising a reinforcement which is embedded in the concrete and includes an upper reinforcement side and a lower reinforcement side, and a tube for heating or cooling fluid which includes an upper tube side and a lower tube side.

[0002] Such a concrete floor slab is known in the art, in particular a thermally activated concrete hollow core floor slab. In the known slab the major portion of the reinforcement is formed by parallel reinforcement bars located in a lower layer of the slab, and the tube for heating or cooling fluid is mounted as a tube circuit on the reinforcement bars. After installing the known floor slab in a building the tube can be connected to a heating or a cooling system, all or not together with other similar slabs. This provides the opportunity to heat or cool the slab such that the space adjacent to the lower slab side can be heated or cooled, for example if one side of the slab forms a ceiling surface. A disadvantage of the current known slab is its slow transfer of heat from the tube to an outer surface of the slab.

[0003] It is an object of the present invention to provide a concrete floor slab which has a fast response to heating or cooling.

[0004] This is achieved by the concrete floor slab according to the invention, wherein the upper tube side of at least the major portion of the tube lies below the upper reinforcement side. This means that the lower tube side is relatively close to the lower slab side. For example, if the lower slab side forms a ceiling after installing it in a building, the lower tube side is relatively close to the ceiling surface. The major portion of the tube means more than 60%, preferably more than 80%.

[0005] It is noted that if the slab comprises an auxiliary reinforcement at a distance above the reinforcement, in fact the reinforcement forms a lower reinforcement, which means that according to the invention the lower tube side of at least the major portion of the tube lies below the upper side of the lower reinforcement.

[0006] It is known that a concrete floor slab requires a minimum distance between the lower slab side and the lower reinforcement side. For example, when the reinforcement is made of steel the concrete layer between the lower slab side and the reinforcement prevents the reinforcement against corrosion. However, such a distance is not necessary for a tube for heating or cooling fluid. Therefore, the concrete layer adjacent to the lower slab side can be used for receiving the tube. On the one hand, a relatively quick heat transfer to the lower slab side can be created, and on the other hand, a layer for receiving the tube above the reinforcement can be omitted such that the total thickness of the slab can be minimized, or in case of hollow core slabs larger cores at a similar thickness of the slab can be applied.

[0007] The terms upper and lower refer to the orientation of the concrete floor slab as it will be used in a building. For example, when the floor slab is mounted in a building the upper slab side forms a floor and the lower slab side forms a ceiling. Hence, the upper reinforcement side is closer to the upper slab side than the lower reinforcement side, and the upper tube side is closer to the upper slab side than the lower tube side.

[0008] The upper tube side of at least the major portion of the tube may lie below the lower reinforcement side. In other words, in all cases the lower tube side lies closer to the lower slab side than the lower reinforcement side.

[0009] The lower reinforcement side may be formed by lower sides of reinforcement bars or prestressing tendons extending in longitudinal direction of the slab, whereas the upper reinforcement side may be formed by upper sides of reinforcement bars or prestressing tendons extending in longitudinal direction of the slab. Such reinforcement bars or prestressing tendons provide a major portion of the stiffness of the slab.

[0010] In a practical embodiment the concrete floor slab is a hollow core floor slab having an upper layer, a lower layer and vertical webs which connect the upper and lower layers, hence forming open channels, wherein the major portion of the reinforcement is disposed in the lower layer of the slab.

[0011] The reinforcement may comprise a plurality of reinforcement bars extending substantially parallel to each other. In case of the hollow core floor slab the reinforcement bars may extend parallel to the channels. Furthermore, the reinforcement bars may extend equidistantly with respect to each other.

[0012] The tube may have a meandering shape in a substantially flat plane parallel to the lower slab side. In practice, the tube may form a circuit of parallel tube portions in the slab as seen in a direction perpendicular to the upper slab side, whereas adjacent tube portions are connected to each other via 180° bend portions near opposite sides of the floor slab. Preferably, the tube is located below a web and extends in longitudinal direction, which provides the opportunity to create a recess at one or more hollow cores whereas the slab maintains its constructive characteristics.

[0013] The tube may be directly attached to a carrier, whereas the carrier is at least partly disposed below the reinforcement and the tube is at least partly disposed between the carrier and the lower slab slide. Of course, in the slab the tube and carrier are fixed to each other via the concrete, but in this embodiment the tube is also directly fixed to a carrier, which is advantageous during transport and manufacturing of the floor slab. The intended location of the tube can be maintained during manufacturing, particularly in case of a flexible tube. In case of a tube in combination with a recess in the slab the intended location of the tube and the recess can be predetermined accurately and maintained during manufacturing.

[0014] Preferably, the carrier is grid-shaped since the concrete can form a continuous layer through the openings in the grid.

[0015] The distance between the tube and the lower slab side should be small in order to create a fast heat transfer in the portion of the slab between the tube and the lower slab side. The distance may be smaller than 10 mm, and preferably smaller than 5 mm.

[0016] The reinforcement may be made of metal, for example stainless steel. The carrier may also be made of metal.

[0017] The invention is also related to a method of manufacturing a concrete slab by means of a substantially horizontal slipform casting process in which a casting mould is moved in a manufacturing direction, wherein before the step of pouring concrete in the casting mould a tube circuit is placed at the casting mould and then a reinforcement is placed on top of at least a part of the tube circuit. This method provides the opportunity to obtain a slab in which the tube circuit is close to the bottom of the resulting slab, such as described in relation to the floor slab hereinbefore.

[0018] The tube circuit may be placed at the casting mould before the reinforcement is placed on top of at least a part of the tube circuit or the tube circuit and the reinforcement may be prepared, for example attached to each other, before placing them together at the casting mould.

[0019] The method is also applicable in the field of manufacturing concrete hollow core floor slabs where the horizontal slipform casting process is well known. It is advantageous that the tube is incorporated in the slab in a same manufacturing process as in case of manufacturing a slab without a tube.

[0020] The tube circuit may be fixed to a carrier before placing the reinforcement. This ensures a stable location of the tube circuit during the manufacturing process, in particular when the tube is flexible. The carrier may have similar characteristics as described hereinbefore, such as a grid shape.

[0021] Preferably, the carrier including the tube are placed such that the tube circuit is located below the carrier in the casting mould, since this creates the opportunity to obtain a slab in which the tube circuit is very close to the bottom of the resulting slab.

[0022] The invention will hereafter be elucidated with reference to the very schematic drawings showing embodiments of the invention by way of example.

Fig. 1 is a cross-sectional view of an embodiment of a concrete floor slab according to the invention.

Fig. 2 is a part of the embodiment as shown in Fig. 1 and indicated by II in Fig. 1, on a larger scale.

Fig. 3 is a top view of a carrier for supporting a tube embedded in the slab of Fig. 1.

Fig. 4 is a transparent bottom view of the embodiment of Fig. 1, illustrating the carrier including the tube embedded in the concrete floor slab.

Fig. 5 is a sectional view of the embodiment of Fig. 4 along the line V-V on a larger scale.

Fig. 6 is a transparent bottom view of parts of two adjacent floor slabs that are installed in a building, illustrating a connection between tubes of the slabs.

Fig. 7 is a similar view of as Fig. 5 of an alternative embodiment of the slab.

Fig. 8 is a perspective top view of parts of two adjacent floor slabs that are installed in a building, illustrating a connection between tubes of the slabs.

Fig. 9 is a front view of an embodiment of an apparatus for manufacturing a floor slab according to the invention.

Fig. 10 is a top view of a plurality of tubes that are mounted on a carrier before manufacturing floor slabs.

[0023] Fig. 1 shows an embodiment of a concrete floor slab 1 according to the invention. The embodiment is a so-called hollow core floor slab 1 which has an upper slab side 2 and a lower slab side 3. In practice, the floor slabs 1 have rectangular or partly or entirely trapezoid, flat upper and lower slab sides 2, 3 which are substantially parallel to each other. The slab 1 comprises an upper layer 4 and a lower layer 5 whereas vertical webs 6 connect the upper layer 4 and the lower layer 5. The vertical webs 6 form walls between open channels or cores 7 which extend in longitudinal direction of the slab 1. The embodiment of Fig. 1 has seven open channels 7, but a lower or higher number of channels 7 is conceivable.

[0024] Concrete slabs 1 including longitudinal hollow channels 7 are usually manufactured in great length, for example 150 m, and cut afterwards in shorter elements of for example 5 m, but shorter or longer slabs 1 are conceivable. The slab 1 can be used as part of a floor of a building. The lower slab side 3 may function as a ceiling of a room and the upper slab side 2 may function as a floor of a space above the room.

[0025] The slab 1 is provided with a reinforcement in the form of a number of reinforcement bars or prestressing tendons 8 extending substantially parallel to the channels 7, in this case eight reinforcement bars 8, but a lower or higher number of reinforcement bars 8 is conceivable. The reinforcement bars 8 are embedded in the concrete in the lower layer 5 of the slab 1. The reinforcement bar 8 itselve may be a bundle of reinforcement wires, for example. In the embodiment as shown in Fig. 1 the reinforcement bars 8 are made of steel, but alternative materials are conceivable. Referring to Fig. 2 the reinforcement bars 8 have an upper reinforcement side 8a and a lower reinforcement side 8b.

[0026] The slab 1 is also provided with a tube 9 for conducting heating or cooling fluid after the slab has been installed in a building. The tube 9 has a meandering shape in a flat plane extending parallel to the lower slab side 3 and forms parallel tube portions in the slab 1, in this case parallel to the channels 7 and below the webs 6. As a consequence, the cross-sectional view of Fig. 1 shows a plurality of cross sections of the tube 9, in this case eight times, in general being the number of channels

7 plus one, but a lower number of cross sections of the tube 9 is conceivable. Furthermore, the orientation of the tube 9 may be changed, for example such that longitudinal portions of the tube 9 extend transversely with respect to the longitudinal direction of the slab 1. Again referring to Fig. 2 the tube 9 has an upper tube side 9a and a lower tube side 9b.

[0027] Figs. 1 and 2 show that in the embodiment of the slab 1 the upper tube side 9a lies below the lower reinforcement side 8b of the reinforcement bars 8. In general, the outer circumferential diameter of the tube 9 will be larger than the outer circumferential diameters of the reinforcement bars 8.

[0028] The tube 9 is attached to a carrier 10 as illustrated in Fig. 4. In this case the carrier 10 comprises a metal grid which has eight pairs of parallel bars or wires 11 that extend in longitudinal direction of the slab 1 and a plurality of parallel transverse bars or wires 12 which extend in transverse direction of the slab 1. The parallel bars or wires 11 can be pairs of two, as shown in Figs. 3 and 4, but may be single bars in an alternative embodiment. Figs. 2 and 4 illustrate that portions of the tube 9 partly fall between respective pairs of parallel wires 11. This prevents the tube 9 from displacement in transverse and also in longitudinal direction of the carrier 10 during manufacturing. Additionally, the carrier 10 may be connected with the reinforcement bars 8 in the lower layer 5 of the slab 1, which prevents the carrier 10 from displacement during manufacturing. Figs. 1 and 2 show that the carrier 10 including the tube 9 is disposed below the reinforcement bars 8, whereas the tube 9 is disposed between the carrier 10 and the lower slab slide 3. In practice the distance between the lower tube side 9b and the lower slab side 3 is preferably as small as possible, for example smaller than 10 mm or even smaller than 5 mm, but there may be at least a film layer of concrete covering the tube 9. The film layer may be such that the tube 9 is still visible, which is advantageous in the construction phase since it avoids that someone drills into the tube 9.

[0029] It is noted that the parallel wires 11 might be seen as part of the reinforcement bars 8 because of their - limited - contribution to the reinforcement of the slab 1. In that case, in the embodiment as shown in Figs. 1 and 2 the parallel wires 11 and the reinforcement bars 8 together would form a common reinforcement of which the upper reinforcement sides 8a of the bars would form the upper reinforcement side and the lower sides of the parallel wires 11 would form the lower reinforcement side. Furthermore, the upper tube side 9a would lie below the upper reinforcement side 8a, and the lower tube side 9b would still lie below the lower reinforcement side. In other words, the lower tube side 9b lies always closer to the lower slab side 3 than the reinforcement.

[0030] Fig. 4 shows that end portions of the tube 9 at opposite lateral side edges of the grid 10 leave the cooperating pairs of parallel wires 11 and lie closer to the opposite side edges. This means that the end portions of the tube 9 in the resulting slab 1 are also located close to the side edges thereof. Fig. 5 shows a sectional view of an end portion of the resulting slab 1, in which an end portion of the tube 9 is bent downwardly such that it extends below the lower slab side 3. This provides the opportunity to connect the tube 9 to a tube of another floor slab 1 after installing the slabs 1 in a building. This is illustrated in Fig. 6, which shows parts of two adjacent floor slabs 1 of which the corresponding tubes 9 are connected to each other, whereas other end portions of the respective tubes 9 are connected to a heating or cooling source. The arrows in Fig. 6 show that after installing the slabs 1 in this way a heating or cooling fluid can be conducted through both slabs 1. It is noted that the slab 1 of Figs. 4 and 5 is provided with cavities at the lower slab side 3 in order to be able to handle the end portions of the tube 9 more easily.

[0031] Similarly, the end portions of the tube 9 of a floor slab 1 can be bent upwardly in order to connect the tube 9 to other tubes. This is illustrated in Figs. 7 and 8. Fig. 8 shows a situation in which two adjacent floor slabs 1 including their respective tubes 9 are installed in a building in a similar way as illustrated in Fig. 6, but now connected at upper portions of the slabs 1. It may be clear that it is advantageous that during manufacturing of the concrete slab 1 fresh concrete is removed from the slab 1 at the end portions of the tube 9 before curing, such that cavities 13 are present where a connection between tubes and end portions of other tubes 9 can be made. In the embodiments of Figs. 7 and 8 the cavities are located at the upper slab side 2.

[0032] Fig. 9 shows a front view of an embodiment of an apparatus 14 for manufacturing a concrete hollow core floor slab 1 by means of a slipform casting process according to the invention. The apparatus 14 comprises a frame 15 which can be moved by means of wheels 16 in a manufacturing direction over a work floor 17. The wheels 16 are located on lateral sides of the frame 15. On the work floor 17 two opposite mould parts 18 are located at a predefined distance from each other between which concrete 19 can be poured. The contours of the mould parts 18 define the shapes of sidewalls of the resulting slab 1. Both upright mould parts 18 and the bottom or work floor 17 form part of a movable casting mould 20.

[0033] The apparatus 14 comprises channel recess elements 21 for obtaining the hollow channels 7 in the slab 1 to be made. The channel recess elements 21 are elongated bodies that are fixed to the frame 15. The length of a channel recess element 21 may be 1 m, for example, but a longer or shorter channel recess element 21 is conceivable. During the manufacturing process the frame 15 including the channel recess elements 21 move continuously forwardly and concrete 19 is supplied into the mould 20 simultaneously by means of a concrete-pouring system which is also fixed to the frame 15. As a consequence, at the rear side of the apparatus 14 the slab 1 obtains a cross-section comparable to that as shown in Fig. 1. Due to the continuous manufacturing process the channel recess elements 21 are removed from the resulting slab 1 after the step of pouring concrete 19. It is noted that the process is illustrated and described in a simplified way, but in practice it may be a more complicated two-step process. The apparatus 14 may be provided with compacting members (not shown) for compacting the concrete. The compacting members may comprise vibrating elements so as to fluidize the concrete.

[0034] In a first step of an embodiment of the method according to the invention grid-shaped carriers 10 are provided with tubes 9 as depicted in Fig. 10. Fig. 10 illustrates the intended slabs 1 by reference signs 1'. In this case two tubes 9 are attached to a common carrier 10 which is cut together with the finished slabs 1 afterwards. Alternatively, the common carrier may be longer, or separate carriers 10 for each intended slab 1' may be applied. The tubes 9 are attached on top of the carrier 10 by means of thin stainless steel wires or the like. Then the carrier 10 including the tubes 9 is turned upside down such that the tubes 9 contact the work floor 17 and the carrier 10 rests on the tubes 9. This condition is illustrated in Fig. 9.

[0035] After laying the carrier 10 including the tubes 9 on the work floor the reinforcement bars or prestressing tendons 8 are laid on the carrier 10, possibly pre-stressed and connected to the carrier 10, after which the apparatus 14 including the channel recess elements 21 and the concrete-pouring system may pass. Upon pouring concrete 19 into the mould 20 the carrier 10 including the tubes 9 may tend to move upwardly, but this can be avoided by maintaining the reinforcement bars 8 at a certain height above the working floor by means of the passing apparatus 14. As a consequence, a very thin layer of concrete can be forced between the work floor 17 and the lower tube side 9b.

[0036] It is noted that in this embodiment of the method of manufacturing the carrier 10 including the tube 9 functions as a distance keeper for the reinforcement bars or prestressing tendons 8.

[0037] It is also possible to lay the tube circuits 9 first on the work floor 17, then place the carrier 10 onto the tube circuits 9 and subsequently attach the tube circuits to the carrier 10.

[0038] After a concrete bed of great length has been finished and hardened it has to be cut in shorter elements hence creating separate concrete hollow core floor slabs 1 including a tube circuit 9.

[0039] From the foregoing, it will be clear that the invention provides a concrete floor slab which has a fast response to heating or cooling. Furthermore, the invention provides an efficient method of manufacturing such a concrete slab.

[0040] The invention is not limited to the embodiments shown in the drawings and described hereinbefore, which may be varied in different manners within the scope of the claims and their technical equivalents.

Claims

1. A concrete floor slab (1) including an upper slab side (2) and a lower slab side (3), comprising a reinforcement (8) which is embedded in the concrete and includes an upper reinforcement side (8a) and a lower reinforcement side (8b), and a tube (9) for heating or cooling fluid which includes an upper tube side (9a) and a lower tube side (9b), wherein the upper tube side (9a) of at least the major portion of the tube (9) lies below the upper reinforcement side (8a).

2. A concrete floor slab (1) according to claim 1, wherein the upper tube side (9a) of at least the major portion of the tube (9) lies below the lower reinforcement side (8b).

3. A concrete floor slab (1) according to claim 1 or 2, wherein the lower reinforcement side (8b) is formed by lower sides of reinforcement bars or prestressing tendons (8) extending in longitudinal direction of the slab (1).

4. A concrete floor slab (1) according to one of the preceding claims, wherein the upper reinforcement side (8a) is formed by upper sides of reinforcement bars or prestressing tendons (8) extending in longitudinal direction of the slab (1).

5. A concrete floor slab (1) according to one of the preceding claims, wherein the concrete floor slab (1) is a hollow core floor slab having an upper layer (4), a lower layer (5) and vertical webs (6) which connect the upper and lower layers (4, 5), hence forming open channels (7), wherein the reinforcement (8) is disposed in the lower layer (5).

6. A concrete floor slab (1) according to one of the preceding claims, wherein the reinforcement comprises a plurality of reinforcement bars (8) extending substantially parallel to each other.

7. A concrete floor slab (1) according to one of the preceding claims, wherein the tube (9) has a meandering shape in a substantially flat plane parallel to the lower slab side (3).

8. A concrete floor slab (1) according to one of the preceding claims, wherein the tube (9) is directly attached to a carrier (10) and wherein the carrier (10) is at least partly disposed below the reinforcement (8), and wherein the tube (9) is at least partly disposed between the carrier (10) and the lower slab slide (3).

9. A concrete floor slab (1) according to claim 8, wherein the carrier (10) is grid-shaped.

10. A concrete floor slab (1) according to one of the preceding claims, wherein the distance between the tube (9) and the lower slab side (3) is smaller than 10 mm, and preferably smaller than 5 mm.

11. A concrete floor slab (1) according to one of the preceding claims, wherein the reinforcement (8) is made of metal.

12. A method of manufacturing a concrete slab (1) by means of a substantially horizontal slipform casting process in which a casting mould (20) is moved in a manufacturing direction, wherein before the step of pouring concrete (19) in the casting mould (20) a tube circuit (9) is placed in the mould (20) and a reinforcement (8) is placed on top of at least a part of the tube circuit (9).

13. A method according to claim 12, wherein the tube circuit (9) is fixed to a carrier (10) before placing the reinforcement (8).

14. A method according to claim 13, wherein the carrier (10) including the tube circuit (9) are placed such that the tube circuit (9) is located below the carrier (10) in the casting mould (20).

15. A method according to one of the claims 12-14, wherein the reinforcement comprises a number of reinforcement bars (8) that are placed substantially parallel to each other in the manufacturing direction.

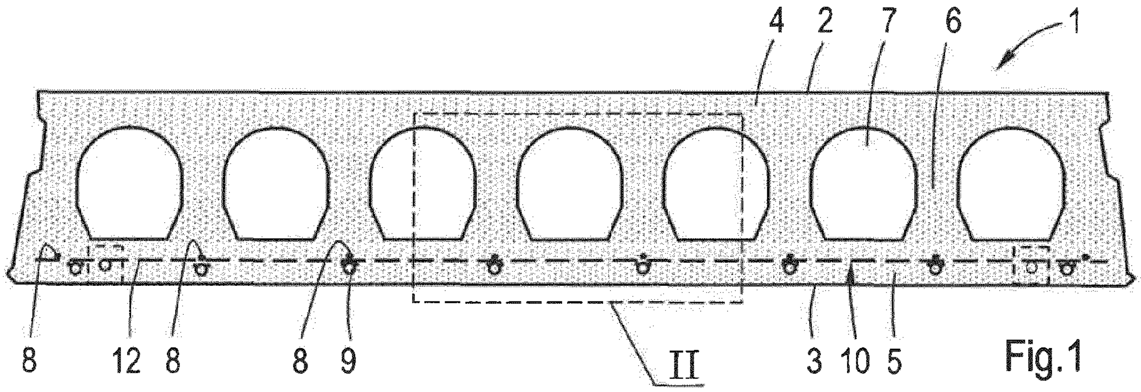

Fig.1

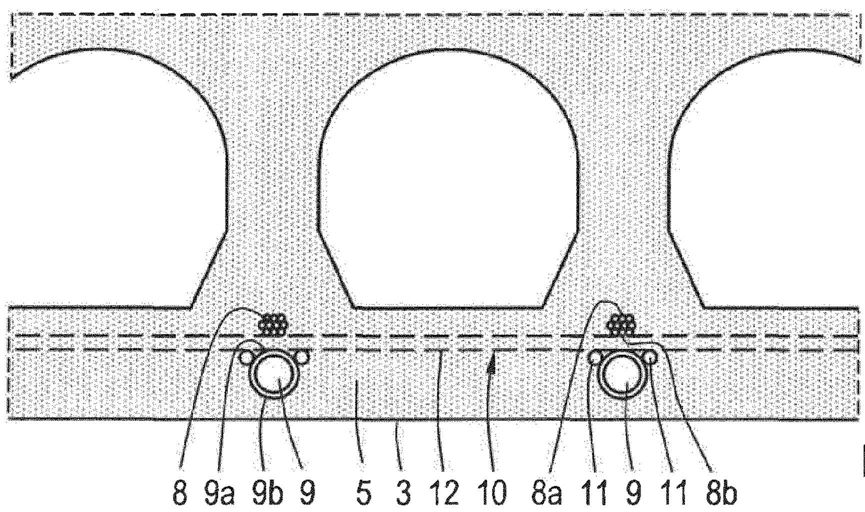

Fig.2

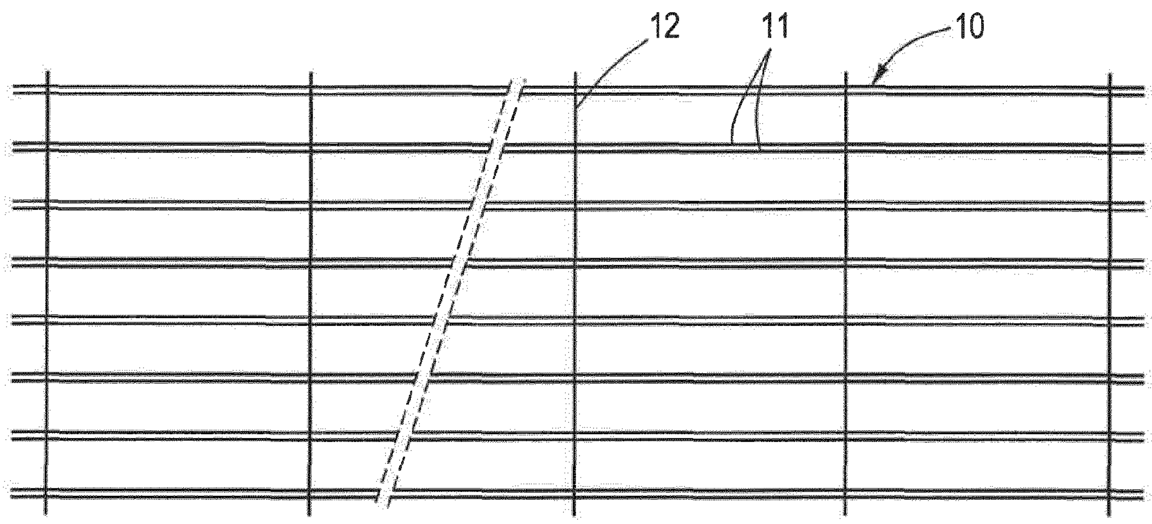

Fig.3

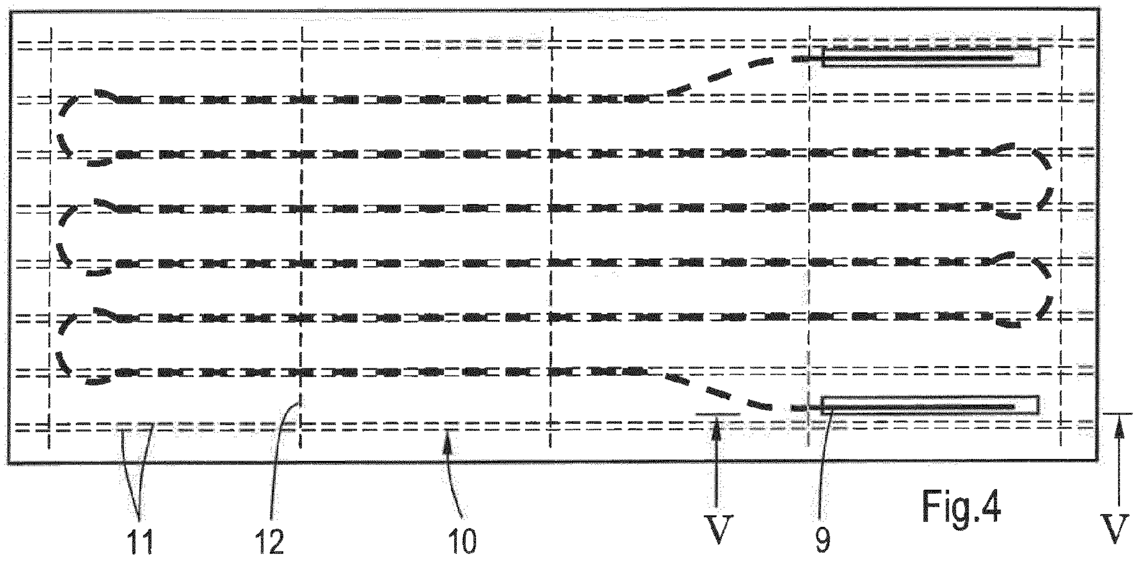

Fig.4

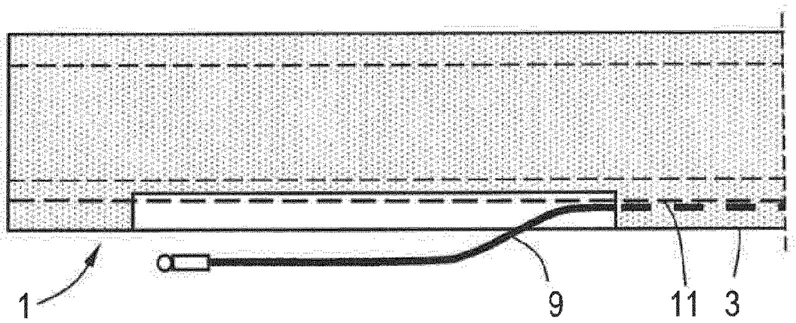

Fig.5

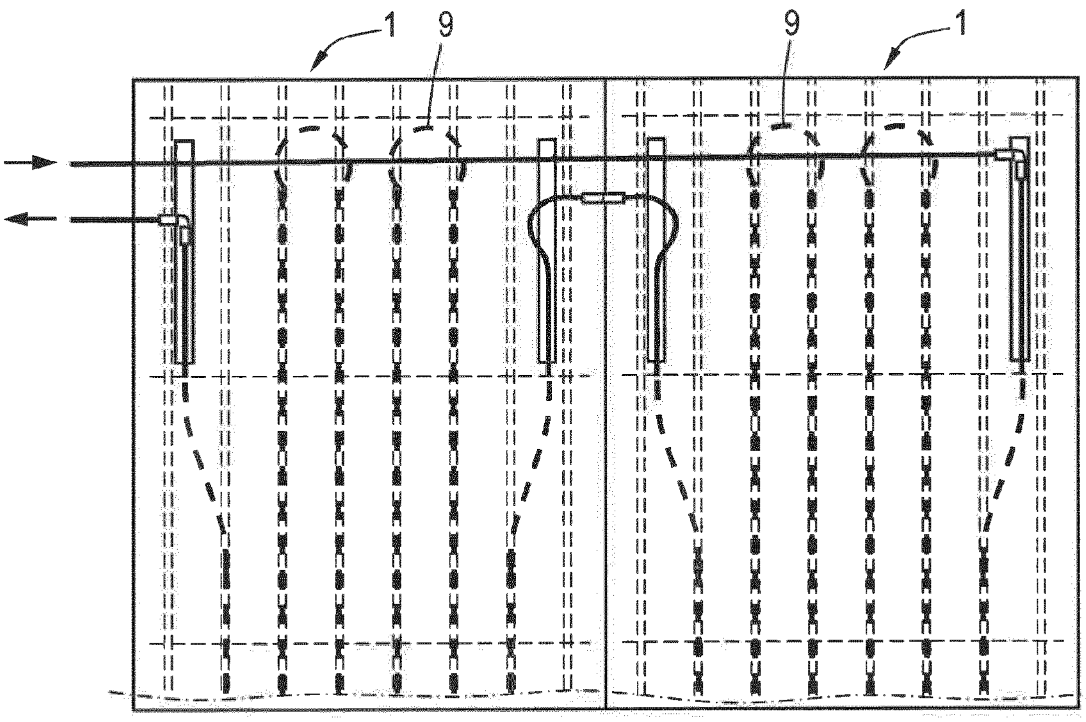

Fig.6

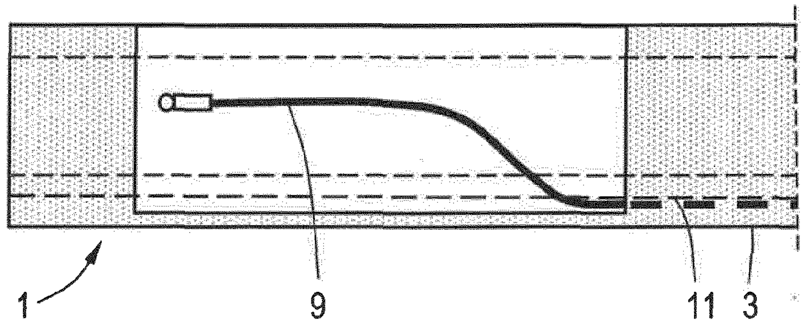

Fig.7

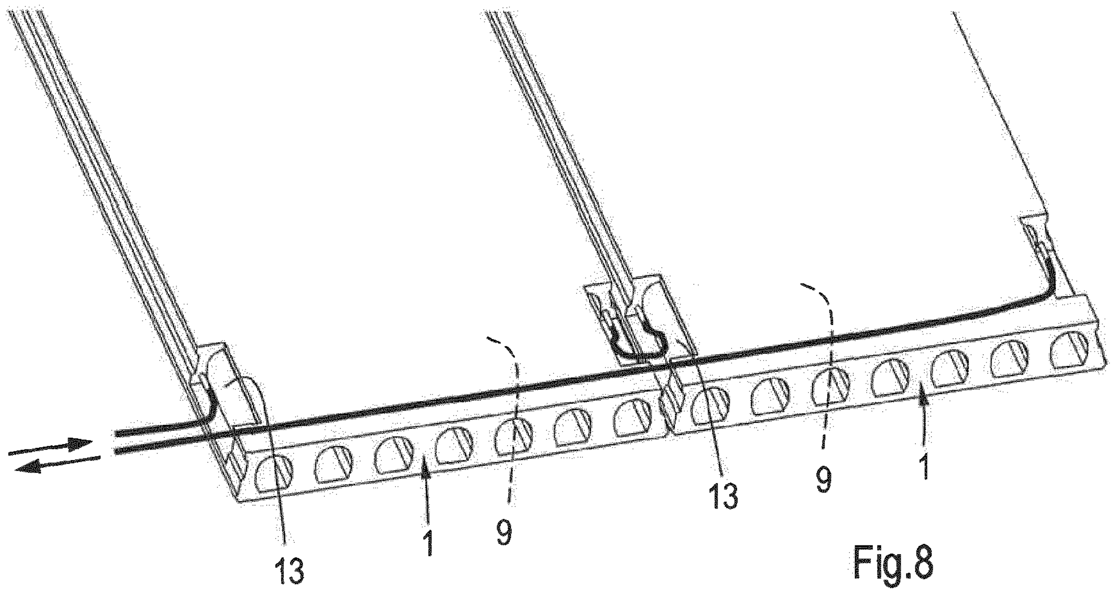

Fig.8

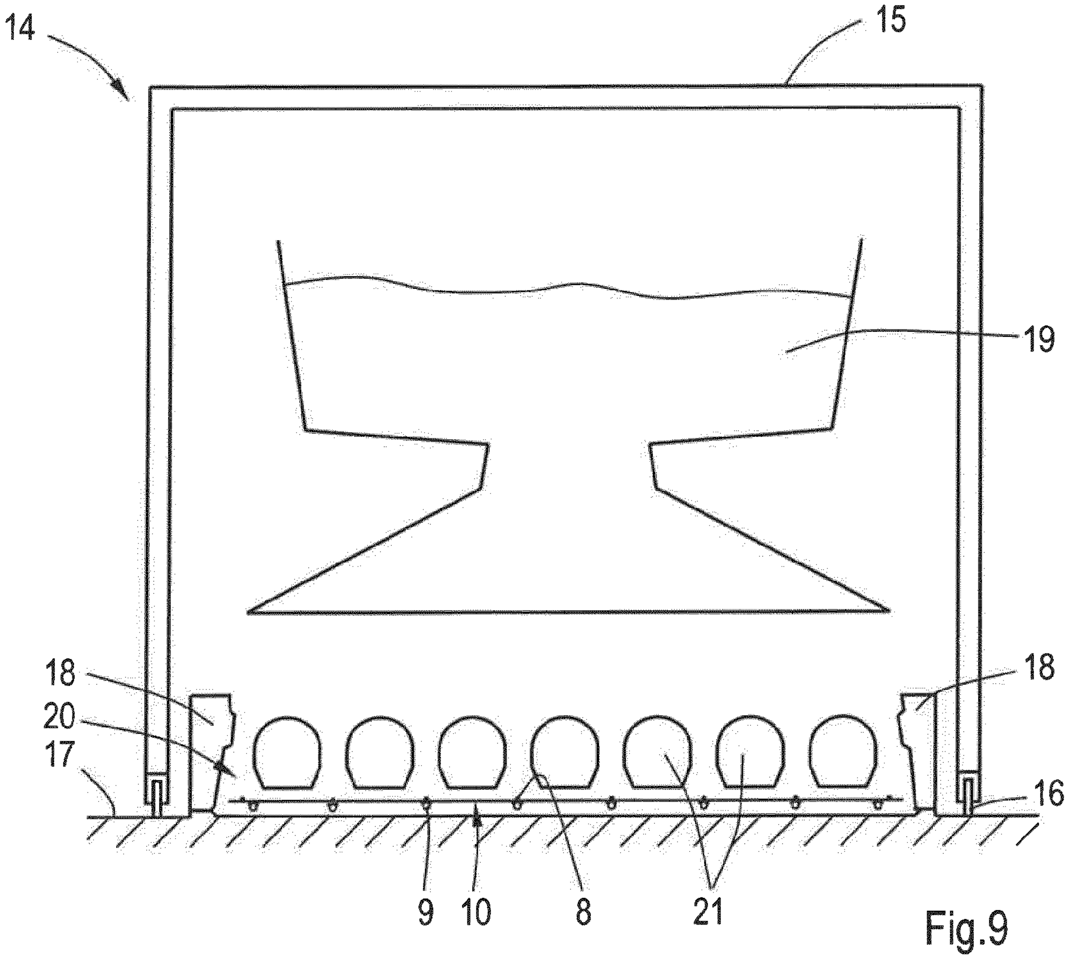

Fig.9

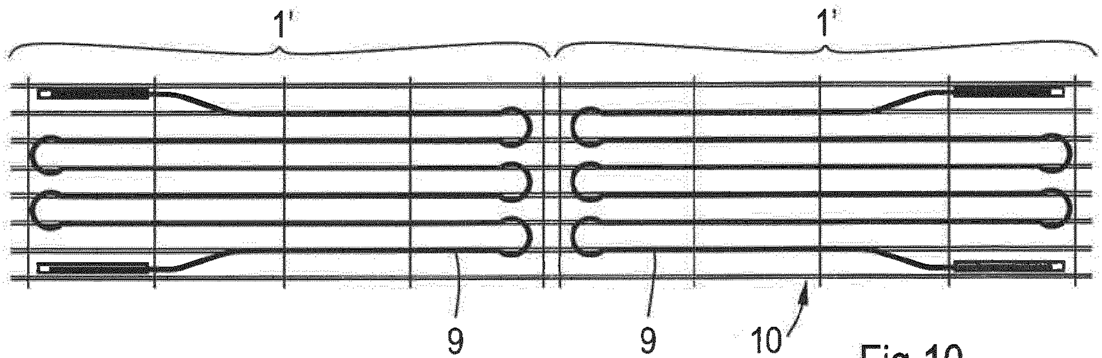

Fig.10

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 4040

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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Y	DE 10 2007 055134 A1 (KETONIA GMBH [DE]) 15 January 2009 (2009-01-15) * figures 1, 14 * * paragraph [0092] - paragraph [0093] *	5,12-15	TECHNICAL FIELDS SEARCHED (IPC) E04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	27 November 2013	Bauer, Josef

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 17 4040

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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27-11-2013

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82