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(54) **A METHOD OF MAKING A BUILDING ELEMENT AND AN APPARATUS FOR MAKING THE BUILDING ELEMENT**

VERFAHREN ZUM HERSTELLEN EINES BAUELEMENTS UND VORRICHTUNG ZUR HERSTELLUNG DES BAUELEMENTS

PROCÉDÉ DE FABRICATION D'UN ÉLÉMENT DE CONSTRUCTION ET APPAREIL POUR FABRIQUER L'ÉLÉMENT DE CONSTRUCTION

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Description

[0001] The present invention relates generally to the manufacturing of reinforced slab-shaped building elements having a length, a width and a thickness, the slab-shaped building element comprising an upper concrete plate anchored to lower concrete, with a top surface of the lower concrete defining an internal interface, and with the lower concrete also defining the bottom face of the building element. The upper concrete plate is cast from relatively higher strength concrete laid out upon the top surface of the lower concrete, the lower concrete portion being of a less strong concrete. One example of such a building element is disclosed in BE patent 481 221 where the lower concrete is constituted by a plurality of porous concrete blocks arranged next to each other and with intermediate U-shaped channel elements. DE 226 154 shows another slab-shaped building element with U-shaped channel elements

[0002] NL-A-8 100 138 discloses a method of casting a reinforced slab-shaped building element in accordance with the preamble of claim 1.

[0003] US-A-1 463 841 discloses an apparatus in accordance with the preamble of claims 9 and 14.

[0004] Building elements of this type are sometimes preferred as an alternative to conventional slab-shaped building elements of the type having internal parallel tubular hollow ducts in usually having a reduced overall weight, improved acoustical properties and a high resistance to structural damage resulting from exposure to fire. However, in some cases the prior art building elements do not give satisfactory results from an acoustical and aesthetical point of view.

[0005] The object of the present invention is to provide a method for making an improved building element and an apparatus suitable for making the building element.

[0006] More specifically, a building element includes a lower concrete plate that has a base that is contiguous with a plurality of upwardly projecting raised portions integral therewith, with the raised portions being spaced apart in the direction of the length and width, and with the plurality of raised portions defining between them a network of recesses, at least some of the recesses including reinforcing bars. The raised portions and the recesses together define the aforementioned top surface and the upper concrete plate forms a plurality of virtual compression arches having a height in the direction of said thickness increasing from the raised portions towards said recesses. With the invention there is also a reduced tendency for local heat transmission since the concrete cast on top of the lower concrete plate cannot flow to the bottom surface of the lower concrete plate.

[0007] Preferably, the lower concrete plate is of a porous concrete with an expanded clay aggregate of median size of 4-10 mm, possibly with a minor 0-4 mm fraction, and in addition thereto fine sand.

[0008] The method of making the building element, and the apparatus suitable therefore, involves using dedicat-

ed raised portions molds and discharging a first type and low strength concrete from each raised portions mold while vibrating the concrete so as to form the contiguous lower concrete plate without non-bonded interfaces between the discharged material.

[0009] The invention will be discussed further below, with reference to the drawings which show a presently preferred embodiment.

10 Fig. 1a shows three blocks arranged next to each other, as in the prior art, before high strength concrete is poured onto the top surface thereof,

15 Fig. 1b shows a portion of an example of a preformed light aggregate concrete lower plate, the longitudinal direction of the plate being marked by letter L,

20 Fig. 2 shows a slab-shaped building element and comprising two monolithic lower concrete plates, and

25 Figs. 3a-g shows the various steps in the molding of the lower plate of a building element according to the invention, using a first embodiment of a molding apparatus,

30 Fig. 4 shows an embodiment of a monolithic lower plate of a building element, wherein a raised portion has been skipped,

35 Figs. 5-9 show the various steps in the molding of the lower plate of a building element according to the invention, using a second embodiment of a molding apparatus,

40 Figs. 10 and 11 show an insert placed where a raised portion has been skipped, before and after pouring of higher strength concrete,

45 Fig. 12 and 13 shows stages in the making of an embodiment of a building element according to the invention with curved sides,

50 Fig. 14 and 15 show various inserts that may be used to provide for surface recesses in the building element, and

55 Fig. 16 shows reinforcements for anchoring of an additional top layer of concrete poured in a subsequent step.

[0010] Fig. 1a shows three individual prior art preformed light aggregate porous concrete blocks B laid out next to each other for the purpose of subsequent concrete overlaying in a known process. The blocks B have flattened top portions 5, longitudinal sides 6 and transverse sides 9; reinforcing bars (not shown) are placed along the longitudinal sides 6 prior to the overlaying.

[0011] In the overlaying process a layer (not shown) of concrete of higher strength is poured onto the top surface of the blocks B to form a coherent slab-shaped building element having at least dimensions L and W, as shown, and a thickness exceeding the height H of the blocks B.

[0012] The blocks B have a base 1 with a lower surface which is visible from below the finished building element. A small inherent gap 2 between the blocks B allows for

some of the poured concrete to flow in the direction from the top surface of the blocks B and towards the lower surface, and to be visible from below the finished building element. After the poured concrete has hardened the building element becomes a coherent unitary structure by the poured concrete slightly penetrating into and bonding to the upper surface of the porous concrete blocks B. The blocks B provide for a fire resistance by protecting the overlaid concrete against direct exposure to fire, and for certain desired acoustical properties of the building element resulting from the porous structure of the light aggregate concrete.

[0013] Fig. 1b shows a corner section of an example of a preformed light aggregate concrete plate 10 and which is a monolithic structure made using a number of individual molds, as will be explained further below. The plate 10 has a base 11 contiguous with a plurality of raised elongated portions 14 integral therewith and upon which concrete of higher strength is poured in a subsequent step of making a slab-shaped building element. The raised portions 14 have top faces 15, longitudinal sides 16 and transverse sides 19. The plate 10 will in the following be referred to as a "lower" concrete plate while a higher strength plate formed as the overlaid concrete sets will be referred to as an "upper" concrete plate bonded to the lower concrete plate to form the slab-shaped building element. The sides 16, 19 preferably diverge outwards in direction from the top face 15, to allow for an easy upward removal of the molds used for making the raised portions, as explained below.

[0014] Fig. 2 shows such a slab-shaped element E comprising two such monolithic lower concrete plates 10, 10' described with reference to fig. 1b placed next to each other and overlaid with higher strength concrete forming an upper concrete plate drawn schematically in thin line and identified by numeral 20. Each lower concrete plate 10, 10' is a monolithic structure having a base 11 with in this case a total of nine raised portions 14 integral therewith. The dimensions of the lower concrete plate may be selected in accordance with a given modular configuration; by way of example a plate module may have dimensions of 1.2 m x 2.4 m corresponding to a lower plate having a base 11 contiguous with, by way of example, an arrangement of three by four identical raised portions 14.

[0015] Prior to the pouring of the higher strength concrete a network of recesses 17, 29 extending between the raised portions 14 in the direction of the width W and the length L of the lower plate 10 is filled with reinforcing bars. Preferably the reinforcing bars in the direction of the length L are pre-tensioned such that compressive forces are set up in the upper plate portion of the finished element E in that direction. The slab-shaped element E may then be used as a floor element in a building, spanning between opposite supports, such as opposite walls. To provide for longer spans the building element may be composed of several prefabricated monolithic plates 10, 10' laid out next to each other and overlaid with concrete

after arranging pre-tensioning cables along a combined length of the plates 10, 10'. As shown by letters CA the upper plate in the direction of the width W acts to take up forces in the manner of a plurality of compression arches having a height increasing, preferably continuously, from the top faces 15 towards the recesses 29, the top faces preferably appearing slightly vaulted when seen from the end face 9. The upper concrete plate preferably is poured to extend also beyond the sides of the lower concrete plate, such that the element E appears with sides 25 enclosing the sides of the lower concrete plate 10.

[0016] Fig. 3a shows an apparatus A including various molds used for making a monolithic lower plate 10 as shown in fig. 2. The apparatus A generally includes a first mold 100 in the form of a flat bed having dimensions corresponding approximately to the dimensions L and W shown in fig. 2, and of which only a small portion is shown. A frame (not shown) supports a second, box-shaped mold 120 in such a manner that this second mold 120 can be moved up and down away from and towards the first mold 100, into a lowered position leaving a gap 110 between a lower peripheral edge 122 of the second mold 120 and the upper surface of the first mold 100.

[0017] The box-shaped second mold 120 has dimensions and internal shape corresponding to a raised portion 14 to be formed, and is open at the top to receive a portion 210 of the first type of relatively low strength concrete referred to above, which preferably is porous and includes a light aggregate, supplied by a supply unit 200 movable to a position above the top opening of the second mold 120. The second mold 120 has opposite parallel side walls shaped according to the form of the sides 16, 19 of the raised portions 14, and is open at the bottom to form a discharge opening.

[0018] Fig. 3b shows the supply unit 200 in position above the second mold 120 with concrete being discharged into the second mold. In fig. 3d the supply unit 200 has been moved away and a head 185 of a piston has been moved through the top opening of the second mold 120 to compress the concrete material 210 in the second mold 120, such as to give a 10%-30% dimensional reduction in the second mold 120, and to give the top face 15 of the raised portion 14 a desired flat or upwardly curved shape. Simultaneously, or in connection with this compression, the material 210 in the second mold 120 is vibrated, by the first or the second mold, such that a small portion of the material on the second mold 120 will stand out sideways from the second mold at the gap 110, and for the purpose of bonding this material portion with that of a base 11 of a raised portion 14' previously formed on the surface of the first mold 100, as illustrated schematically in fig. 3g. The material portion at the gap 110 eventually defines the aforementioned base 11 of the lower plate 10 as this material portion of all successively molded material 210 is bonded through the vibration.

[0019] It will be understood that the frame discussed

in connection with figs. 3a-g may carry several second molds 120 to mold in one step one row of contiguous raised portions 14 and base portions 11, whereafter the frame is moved relative to the first mold 100 such that a next row contiguous therewith may be formed, the vibration providing a bonding of the two rows at the level of the base 11. An embodiment of such an apparatus A, for making a monolithic lower concrete plate 10 as shown in fig. 4 will be discussed in the following with reference to figs. 5-9. As will be understood many of the operating principles and apparatus parts now described will correspond to those discussed above.

[0020] The apparatus A of fig. 5 generally includes a first mold 1000 in the form of a flat bed having a width corresponding to the width of the final building element E, and of which only a small portion is shown. A frame F of the apparatus A is configured to move stepwise along the length of the flat bed 1000, in one direction of the arrows marked by letter L to indicate a longitudinal direction as in fig. 2. The frame F supports a hopper H (not shown in details) that spans across the width of the flat bed 1000 and that supplies concrete to individual movable box-shaped dosing devices 2000 located on the frame between the hopper H and the flat bed 1000. In fig. 5 the dosing devices 2000 are shown in an initial retracted position. The frame F also supports a number - in this case six - of second molds 1200 by means of respective hydraulically adjustable cylinders mounted to allow for the particular movement of the dosing devices 2000 described below. Each second mold 1200 has an internal configuration with sides that resemble the shape of the sides 16, 19 of a respective raised portion 14 (see fig. 2) and is open at the top and at the bottom, with the sides having a lower peripheral edge 1220.

[0021] The support of the second molds 1200 is such that the second molds 1200 can be moved up and down individually away from and towards the first mold 1000, into a lowered position as shown in fig. 6 leaving a gap 1100 between their lower peripheral edge 1220 and the upper surface of the first mold 100. The frame F with the hopper H and the dosing devices 2000 is preferably adjustable in the height to allow for the mounting below the dosing devices 2000 of other molds 1200 of the second type that have a greater height, to form raised portions 14 of a greater height.

[0022] In fig. 6 all the second molds 1200 have been lowered to a position leaving the aforementioned gap 1100. In fig. 7 each dosing devices 2000 has then been advanced relative to the frame F in the direction of the arrow shown in fig. 5 to the shown position above its corresponding second mold 1200, the bottom of the hopper H being now closed by a closure, such as one or more slidable plates.

[0023] The dosing devices 2000 are essentially box-shaped structures that taper from an open top towards an open bottom, with respective closures at the bottom configured to withhold material M in the dosing device 2000 as the latter is subsequently retracted back to the

initial position below the hopper H; these closures may by way of example comprise a plate structure mounted on the frame F and onto which the dosing devices 2000 slide during retraction. In this way the dosing devices 2000 may be configured to contain a relatively large volume of material M for a relatively large volume shot, such that replacement of the dosing devices 2000 may not be required where relatively small volume second molds 1200 are replaced for forming raised portions 14 of a greater height, as discussed above.

[0024] In fig. 7 each second mold 1200 is supplied at this time by gravity with concrete from a respective one of the dosing devices 2000, and this material is deposited on the flat bed 1000. A small portion of this material flows sideways out of the second molds 1200 at their open bottom; in a subsequent process step this outflowing material M is worked so as to bond with material previously deposited on the flat bed 1000, as explained below. The two molds 1200 of the second type located at each opposite edge 1010 of the flat bed 1000 may be so configured along a part 1220' of their peripheral edge 1220 close to the edge 1010 that essentially no gap 1100 is provided for, to limit sideways outflow of concrete from the second mold 1200, as shown in fig. 7.

[0025] Turning now to fig. 8 a series of pistons 1800 having respective heads 1850 are shown. Having retracted the dosing devices 2000 to their initial position the heads 1850 may now be lowered into the box-shaped second molds 1200 through their open top, in principle in the manner shown in fig. 3d. The heads 1850 are shaped to give the raised portions 14 their desired shape as the heads are pressed lightly against material M inside the second molds 1200. At the same time vibrators V mounted to each second mold 1200 are activated to vibrate to second molds 1200 and, hence, material M therein. Preferably, damping means are provided such that vibrations are limited to the second molds 1200. The vibrations not only provides for a good compacting of the material M within the second molds 1200 but also ensures that all deposited material M close to the flat bed 1000 is worked together to establish a material bond not only cross-wise to the flat bed 1000 but also in the longitudinal direction L thereof, i.e. by being worked together also with material previously discharged before advancing the frame F in the direction of the arrow shown in fig. 5. Proper vibration time and pressure applied by the heads 1850 may be determined experimentally. Since the material M, i.e. the less strong concrete, typically has a low flowability excessive material will not exit at the gap 1100.

[0026] In a final step shown in fig. 9 the second molds 1200 are preferably first raised by the cylinders 1210 with the heads 1850 still in contact with the top portion of the discharged material M. This is to prevent any material from following the second molds 1200 by providing a slight downward oriented pressure on the material. The heads 1850 are then raised fully to allow for subsequent unrestricted movement of the dosing devices 2000 and

the frame F is advanced as desired to mold a desired length of the monolithic plate shown in fig. 4.

[0027] After having molded a desired length of the monolithic plate 10 falsework (not shown) may be placed across the width of the flat bed 1000. The frame F may then be moved past this falsework after which molding of another lower concrete plate 10 is initiated in the manner discussed above. The falsework is preferably positioned at a certain minimum distance from the raised portions 14, such as eg. 10-30 cm, and the higher strength concrete poured onto the cured lower concrete plate 10 in the final process step discussed below flows into the space between the cured lower concrete plate 10 and the falsework to define what regularly will be one of the ends of the building element E, i.e. a part resting on a supporting building structure.

[0028] In the final step of making the building element E concrete of higher strength is poured onto the material M previously deposited on the flat bed 1000 as described above, to form the upper concrete plate 20. For this purpose the flat bed first mold 1000 has side plates (not shown) mounted to or mountable onto the opposite edges 1010 and extending up to and above the level of the top of the raised portions 14, preferably at a distance from the sides 16 of the outermost raised portions. In this configuration the cured lower plate 10 together with the side plates and any cross-wise falsework as mentioned above will define a third mold for curing the concrete of the upper concrete plate 20. As will be understood, in this manner the concrete of higher strength flows to completely cover all the parts of the lower concrete plate 10 visible in fig. 4.

[0029] The length of the flat bed defining the first mold 100 may by way of example be in the order of 50-100 m with tensioning devices being arranged at each end for establishing a pre-tension in wires (not shown) extended between the ends of the first mold 100 after completion of a desired number of the processes described above with reference to figs. 5-9. After curing of the upper plate portion 20, building elements E of desired length are made by transverse cuts cutting the pre-tensioned wires to setup compressive forces in the upper plate portion of the individual finished building element E that may have a length in the order of 10 metres. As will be understood the making of a building element E is a continuous process carried out within a relatively short time, such as 12 hours, which will allow for curing of the light aggregate concrete, laying out of the reinforcing bars in the recesses 17, 29 between the raised portions 14, and overlaying by the high strength concrete in a step of pouring out this higher strength concrete on top of the plate(s) 10, while the lower plate 10 is still supported by the first mold 100, 1000, and then a leveling of this material to provide for a smooth and even upper face of the element E, after which curing of the higher strength concrete is allowed for.

[0030] In principle the higher strength concrete may be a concrete having similar or identical properties to con-

crete normally used for making slab-shaped flooring elements for buildings. The less strength concrete is preferably a mixture of cement, sand and a light aggregate such as expanded clay or pumice and which has little or no tensile strength and a low compressive strength. In the uncured form this material 210, M has a high viscosity and the purpose of the aforementioned compression or compacting and vibrating is not only to give the raised portions 14 the desired shape but also to ensure a high degree of intimate bonding between the material of one material discharge with that of an adjoining one as material exits the narrow gap 110, 1100 and contacts adjoining material. This bonding has the effect that the lower plate 10 appears as a monolithic structure without any furrows appearing on the lower surface thereof. Such furrows could allow for the higher strength concrete subsequently applied to flow towards the lower surface of the lower plate 10 and be visible on the lower surface of the finished building element E, reducing the acoustical properties and also providing an undesired pathway for direct heat transmission between a lower building level and an upper one.

[0031] It is noted that according to an alternative embodiment a continuous layer of the first type concrete material 210, M may be spread onto the first mold 100, 1000 as a first step, with this layer having a thickness corresponding essentially to that of the gap 110, 1100 discussed above, whereafter the concrete material 210, M is discharged and vibrated as discussed above to provide for a monolithic plate 10; with the apparatus of figs. 5-9 the second molds 1200 would in this case be placed with their lower peripheral edge in direct contact with the layer spread onto the first mold 1000.

[0032] A first layer C (shown in fig. 2) of another cementitious material, such as mortar, or of another material such as a glass fiber web, may additionally be spread or placed onto the first mold 100 before applying the first type concrete material 210, in which case the second type molds 120, 1200 will be held at a distance above this first layer corresponding to the aforementioned gap 110, 1100. Such a layer may better prepare the finished building element E for painting.

[0033] Where the finished building element E is to have through-going openings it may in some cases be desirable to form the lower plate 10 with through-going apertures by leaving out some of the raised portions 14. Fig. 10 shows an example where some portions or blocks 14 have been skipped, such as by not discharging concrete from one of the molds 1200 in a row when using an apparatus with several such molds of the type shown in fig. 5-9. An insert I with a vertical passage may then be placed on the first mold 1100 where a block 14 has been skipped, as shown in fig. 10, after which pouring of the higher strength concrete is initiated. Fig. 11 shows the element E with the insert I having a vertical passage with a square cross-section.

[0034] Where the term strength is used herein reference is generally made to the compressive strength of

the finished cured concrete plate. Where in this text the phrase "at least one second mold" is used reference is made to any apparatus having one second mold, or a group comprising two or more second molds linked together.

EXAMPLE:

[0035] A first type concrete for making the lower concrete plate 10 was prepared with an expanded clay aggregate of median size of 4-10 mm, and in addition thereto fine sand, the wet concrete being compressible by 10%-30%, the compression and vibration yielding a final density of about 600-800 kg/m³. A compressive strength in the order of 3MPa was obtained thereby.

[0036] Fig. 12 and 13 shows stages in the making of an element E before and after pouring the higher-strength concrete and where falsework FW is placed cross-wise on the first mold 1000 to give the building element E curved sides.

[0037] Fig. 14 and 15 show various inserts I2 that may be placed on the first mold 100 to provide for surface recesses in the element E.

[0038] Fig. 16 shows reinforcements RF anchored in the higher strength concrete to allow for anchoring of an additional top layer of concrete poured in a subsequent step, preferably after a raking or other surface roughening of the higher strength concrete that forms the concrete plate 10, 10 shown in fig. 2.

Claims

1. A method of casting a reinforced slab-shaped building element (E) having a length (L), a width (W) and a thickness, said slab-shaped building element (E) comprising an upper concrete plate (20) anchored to a lower concrete plate (10) with a top surface and a bottom surface, said upper concrete plate (20) being cast from relatively higher strength concrete laid out upon said top surface, said lower concrete plate (10) being of a less strong first type concrete, said lower concrete plate (10) including a base (11) contiguous with a plurality of raised portions (14) integral therewith, **characterised in that** said raised portions (14) being spaced apart in the direction of said length (L) and said width (W), said plurality of raised portions (14) defining between them a network of recesses (17, 29), at least some of said recesses (17, 29) including reinforcing bars (R), said raised portions (14) and said recesses (17, 29) together defining said top surface, said method comprising the steps of: i) providing a first mold (100, 1000) defining a support for said lower plate (10) being cast and at least one second mold (120, 1200) having an internal shape corresponding to a respective one of said raised portions (14), ii) preparing a first type concrete, iii) filling said at least one second mold (120,

1200) with said first type concrete and discharging said first type concrete from said at least one second mold (120, 1200) into said first mold (100, 1000) to form said lower plate (10), iv) at least partially curing said first type concrete discharged into said first mold (100, 1000), v) laying out said reinforcing bars (R) into at least some of said recesses (17, 29), vi) preparing a higher-strength type concrete stronger than said first type concrete, and vii) using said lower plate (10) as a third mold to complete said slab-shaped building element (E) by applying said higher-strength type concrete upon said top surface to cast said upper plate (20).

2. The method according to the previous claim, comprising repeating step iii) while successively relocating said at least one second mold (120, 1200) in neighboring positions relative to previously discharged concrete.

3. The method according to the previous claim, said step iii) including successively lifting and lowering said at least one second mold (120, 1200) in a direction away from or towards said first mold (100, 1000).

4. The method according to any of the previous claims, wherein before said step iii) said first mold (100, 1000) is filled with a layer of said first type concrete to form said base (11).

5. The method according to any of the previous claims, wherein said step iii) includes a compacting and vibrating of said first type concrete while in said at least one second mold (120), to form said lower plate (10) by said first type concrete bonding to first type concrete previously discharged into said first mold (100, 1000).

6. The method according to any of the previous claims wherein said at least one second mold (120, 1200) is arranged with a gap (110, 1100) above said first mold (100, 1000) during said discharging.

7. The method according to any of the previous claims, wherein before said step iii) said first mold (100, 1000) is covered by a layer of a cementitious material, such as mortar, glass fiber web or paint, to define a covering layer configured to cover said bottom surface, said at least one second mold (120, 1200) being arranged in said step iii) with said gap (110, 1100) above said layer of material during said discharging.

8. The method according to any of the previous claims, wherein said first mold (100, 1000) defines a support during the entire casting process of said element (E).

9. An apparatus for carrying out steps i)-iii) of the meth-

- od of any of claims 1-8, said apparatus including a) a first mold (100, 1000) defining a support for said lower plate (10) being cast, b) a plurality of second molds (120, 1200) having an internal shape corresponding to a respective one of said raised portions (14) and having an opening at a bottom thereof, and c) a dosing device (2000) for administering a first type concrete to said second molds (120, 1200), **characterised in** d) a frame (F) movable along a length of said first mold (1000), said frame (F) supporting said plurality of second molds (120, 1200), said second molds (120, 1200) being vertically movable in relation to said frame (F), and e) vibrating devices (V) mounted to each of said second molds (120, 1200) for vibrating said second molds.
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10. The apparatus of claim 9, including a hopper (H) dispensing said first type concrete into dosing devices (2000) corresponding to a respective second mold (1200), said dosing devices (2000) being movable relative to said second molds (1200) along the length of said first mold (1000).
11. The apparatus of claim 9 or 10, including pressure heads (185, 1850) configured to be lowered into said second molds (1200) through an open top thereof, said pressure heads (1850) having a shape corresponding to a top face (15) of said raised portions (14).
12. The apparatus according to claim 9, a closure being provided to prevent discharge of said first type concrete on said dosing devices (2000) being moved away from said second molds (1200).
13. The apparatus according to any of claims 9-12, including tensioning devices arranged at each end of said first mold (1000) for establishing a pre-tension in wires (not shown) extended between said ends.
14. An apparatus for carrying out steps i)-iii) of the method of any of claims 1-8, said apparatus including a) a first mold (100, 1000) defining a support for said lower plate (10) being cast, b) a plurality of second molds (120, 1200) having an internal shape corresponding to a respective one of said raised portions (14) and having an opening at a bottom thereof, and c) a dosing device (2000) for administering a first type concrete to said second molds (120, 1200), **characterised in** d) a frame (F) movable along a length of said first mold (1000), said frame (F) supporting said plurality of second molds (120, 1200), said second molds (120, 1200) being individually vertically movable in relation to said frame (F), and e) vibrating devices (V) for vibrating said second molds.
15. The apparatus of claim 14, including a hopper (H) dispensing said first type concrete into dosing devices (2000) corresponding to a respective second mold (1200), said dosing devices (2000) being movable relative to said second molds (1200) along the length of said first mold (1000).
16. The apparatus of claim 13 or 14, including pressure heads (185, 1850) configured to be lowered into said second molds (1200) through an open top thereof, said pressure heads (1850) having a shape corresponding to a top face (15) of said raised portions (14).
17. The apparatus according to claim 14, a closure being provided to prevent discharge of said first type concrete on said dosing devices (2000) being moved away from said second molds (1200).
18. The apparatus according to any of claims 14-17, including tensioning devices arranged at each end of said first mold (1000) for establishing a pre-tension in wires (not shown) extended between said ends.

25 Patentansprüche

1. Verfahren zum Gießen eines verstärkten plattenförmigen Bauelements (E) mit einer Länge (L), einer Breite (W) und einer Dicke, wobei das plattenförmige Bauelement (E) eine obere Betonplatte (20) umfasst, die auf einer unteren Betonplatte (10) mit einer oberen Oberfläche und einer unteren Oberfläche verankert ist, wobei die obere Betonplatte (20) aus einem Beton einer relativ höheren Festigkeit gegossen ist, der auf der oberen Oberfläche verlegt worden ist, wobei die untere Betonplatte (10) ein Beton eines ersten Typs ist, der eine niedrigere Festigkeit besitzt, wobei die untere Betonplatte (10) ein Bauteil (11) einschließt, das mit einer Mehrzahl von darin eingebetteten erhobenen Abschnitten (14) zusammenhängend ist, **dadurch gekennzeichnet, dass** die erhobenen Abschnitte (14) in Richtung der Länge (L) und der Breite (W) voneinander beabstandet angeordnet sind, wobei die Mehrzahl von erhobenen Abschnitten (14) unter ihnen ein Netzwerk von Aussparungen (17, 29) definieren, wobei zumindest einige der Aussparungen (17, 29) Verstärkungsstäbe (R) umfassen, wobei die erhobenen Abschnitte (14) und die Aussparungen (17, 29) zusammen die obere Oberfläche definieren, wobei das Verfahren die folgenden Schritte umfasst:

- i) Bereitstellen einer ersten Form (100, 1000), die eine Unterstützung für die untere Platte (10), die gegossen wird, definiert, und zumindest einer zweiten Form (120, 1200), die eine Innenkontur aufweist, die einer jeweiligen der erho-

- benen Abschnitte (14) entspricht,
 ii) Herstellen eines Betons eines ersten Typs,
 iii) Füllen zumindest einer zweiten Form (120, 1200) mit dem Beton des ersten Typs und Aus-
 tragen des Betons des ersten Typs aus der zu-
 mindest einen zweiten Form (120, 1200) in die
 erste Form (100, 1000) zur Bildung der unteren
 Platte (10),
 iv) zumindest teilweises Aushärten des Betons
 des ersten Typs, der in die erste Form (100,
 1000) ausgetragen wird,
 v) Verlegen der Verstärkungsstäbe (R) in zumin-
 dest einige der Aussparungen (17, 29),
 vi) Herstellen eines Betons eines Typs einer hö-
 heren Festigkeit als der erste Typ von Beton,
 und
 vii) Verwendung der unteren Platte (10) als eine
 dritte Form zur Fertigung des plattenförmigen
 Bauelements (E) durch Auftragen des Betons
 einer höheren Festigkeit auf die obere Oberflä-
 che zum Gießen der oberen Platte (20).
2. Verfahren nach dem vorgehenden Anspruch, um-
 fassend das Wiederholen des Schrittes iii), während
 die zumindest eine zweite Form (120, 1200) nach-
 folgend in benachbarten Positionen relativ zu vorher
 ausgetragenem Beton verlagert wird.
 3. Verfahren nach dem vorgehenden Anspruch, wobei
 der Schritt iii) das nachträgliche Heben und Senken
 der zumindest einen zweiten Form (120, 1200) in
 einer Richtung weg von der ersten Form (100, 1000)
 oder gegen diese einschließt.
 4. Verfahren nach einem der vorgehenden Ansprüche,
 wobei vor dem Schritt iii) die erste Form (100, 1000)
 mit einer Schicht des Betons des ersten Typs zur
 Bildung des Basisteils (11) gefüllt wird.
 5. Verfahren nach einem der vorgehenden Ansprüche,
 wobei der Schritt iii) ein Komprimieren und Vibrieren
 des Betons des ersten Typs einschließt, während es
 sich in der zumindest einen zweiten Form (120) be-
 findet, zur Bildung der unteren Platte (10) durch den
 Beton des ersten Typs, der sich an den Beton des
 ersten Typs bindet, der vorher in die erste Form (100,
 1000) ausgetragen wurde.
 6. Verfahren nach einem der vorgehenden Ansprüche,
 wobei die zumindest eine zweite Form (120, 1200)
 mit einem Spalt (110, 1100) über der ersten Form
 (100, 1000) während des Austragens versehen ist.
 7. Verfahren nach einem der vorgehenden Ansprüche,
 wobei vor dem Schritt iii) die erste Form (100, 1000)
 von einer Schicht eines zementösen Materials, wie
 beispielsweise Mörtel, Glasfasergewebe oder Far-
 be, abgedeckt ist, um eine Deckschicht zu definie-
 ren, die zum Abdecken der unteren Oberfläche aus-
 gelegt ist, wobei die zumindest eine zweite Form
 (120, 1200) im Schritt iii) mit dem Spalt (110, 1100)
 über der Schicht von Material während des Austragens
 angeordnet wird.
 8. Verfahren nach einem der vorgehenden Ansprüche,
 wobei die erste Form (100, 1000) eine Unterstü-
 tzung während des gesamten Gießvorgangs des Ele-
 ments (E) definiert.
 9. Vorrichtung zum Ausführen der Schritte i)-iii) des
 Verfahrens nach einem der Ansprüche 1-8, wobei
 die Vorrichtung Folgendes umfasst
 - a) eine erste Form (100, 1000), die eine Unter-
 stützung für die untere Platte (10), die gegossen
 wird, definiert,
 - b) eine Mehrzahl von zweiten Formen (120,
 1200), die eine Innenkontur entsprechend ein-
 em jeweiligen der erhobenen Abschnitte (14)
 aufweist und eine Öffnung an einem Boden da-
 von aufweist, und
 - c) eine Dosiervorrichtung (2000) zur Abgabe ein-
 es Betons eines ersten Typs an die zweiten
 Formen (120, 1200), **gekennzeichnet durch**
 d) einen Rahmen (F), der entlang einer Länge
 der ersten Form (1000) beweglich ist, wobei der
 Rahmen (F) die Mehrzahl von zweiten Formen
 (120, 1200) unterstützt, wobei die zweiten For-
 men (120, 1200) relativ zum Rahmen (F) vertikal
 beweglich sind, und
 - e) Vibrationsvorrichtungen (V), die an jeder der
 zweiten Formen (120, 1200) zum Vibrieren der
 zweiten Formen montiert sind.
 10. Vorrichtung nach Anspruch 9, umfassend einen
 Trichter (H), der den Beton des ersten Typs in Do-
 siervorrichtungen (2000) entsprechend einer jewei-
 ligen zweiten Form (1200) abgibt, wobei die Dosier-
 vorrichtungen (2000) relativ zu den zweiten Formen
 (1200) entlang der Länge der ersten Form (1000)
 beweglich sind.
 11. Vorrichtung nach Anspruch 9 oder 10, umfassend
 Pressköpfe (185, 1850), die ausgelegt sind, um in
 die zweiten Formen (1200) durch einen offenen Teil
 davon gesenkt zu werden, wobei die Pressköpfe
 (1850) eine Kontur aufweisen, die einer oberen Flä-
 che (15) der erhobenen Abschnitte (14) entspricht.
 12. Vorrichtung nach Anspruch 9, wobei ein Verschluss
 zum Verhindern eines Austragens des Betons des
 ersten Typs auf die Dosiervorrichtungen (2000) vor-
 gesehen ist, die von den zweiten Formen (1200) weg
 bewegt werden.
 13. Vorrichtung nach einem der Ansprüche 9-12, um-

fassend Vorspanneinrichtungen, die an jedem Ende der ersten Form (1000) zum Etablieren einer Vorspannung in zwischen den Enden ausgezogenen (nicht gezeigten) Drähten vorgesehen sind.

14. Vorrichtung zum Ausführen der Schritte i)-iii) des Verfahrens nach einem der Ansprüche 1-8, wobei die Vorrichtung Folgendes umfasst

a) eine erste Form (100, 1000), die eine Unterstützung für die untere Platte (10), die gegossen wird, definiert,

b) eine Mehrzahl von zweiten Formen (120, 1200), die eine Innenkontur entsprechend einem jeweiligen der erhobenen Abschnitte (14) aufweist und eine Öffnung an einem Boden davon aufweist, und

c) eine Dosiervorrichtung (2000) zur Abgabe eines Betons eines ersten Typs an die zweiten Formen (120, 1200),

gekennzeichnet durch

d) einen Rahmen (F), der entlang einer Länge der ersten Form (1000) beweglich ist, wobei der Rahmen (F) die Mehrzahl von zweiten Formen (120, 1200) unterstützt, wobei die zweiten Formen (120, 1200) relativ zum Rahmen (F) einzeln vertikal beweglich sind, und

e) Vibrationsvorrichtungen (V) zum Vibrieren der zweiten Formen.

15. Vorrichtung nach Anspruch 14, umfassend einen Trichter (H), der den Beton des ersten Typs in Dosiervorrichtungen (2000) entsprechend einer jeweiligen zweiten Form (1200) abgibt, wobei die Dosiervorrichtungen (2000) relativ zu den zweiten Formen (1200) entlang der Länge der ersten Form (1000) beweglich sind.

16. Vorrichtung nach Anspruch 13 oder 14, umfassend Pressköpfe (185, 1850), die ausgelegt sind, um in die zweiten Formen (1200) durch einen offenen Teil davon gesenkt zu werden, wobei die Pressköpfe (1850) eine Kontur aufweisen, die einer oberen Fläche (15) der erhobenen Abschnitte (14) entspricht.

17. Vorrichtung nach Anspruch 14, wobei ein Verschluss zum Verhindern eines Austragens des Betons des ersten Typs auf die Dosiervorrichtungen (2000) vorgesehen ist, die von den zweiten Formen (1200) weg bewegt werden.

18. Vorrichtung nach einem der Ansprüche 14-17, umfassend Vorspanneinrichtungen, die an jedem Ende der ersten Form (1000) zum Etablieren einer Vorspannung in zwischen den Enden ausgezogenen (nicht gezeigten) Drähten vorgesehen sind.

Revendications

1. Procédé de coulée d'un élément de construction en forme de dalle renforcée (E) ayant une longueur (L), une largeur (W) et une épaisseur, ledit élément de construction en forme de dalle (E) comprenant une plaque de béton supérieure (20) ancrée à un plaque de béton inférieure (10) avec une surface supérieure et une surface inférieure, ladite plaque de béton supérieure (20) étant coulée à partir de béton de résistance relativement plus élevée disposée sur ladite surface supérieure, ladite plaque de béton inférieure (10) étant d'un béton de premier type moins résistant, ladite plaque de béton inférieure (10) comprenant une base (11) contiguë à une pluralité de parties surélevées (14) solidaires de celle-ci, **caractérisé en ce que** lesdites parties surélevées (14) sont espacées dans le sens de ladite longueur (L) et de ladite largeur (W), ladite pluralité de parties surélevées (14) définissant entre elles un réseau d'évidements (17, 29), au moins certains desdits évidements (17, 29) comprenant des barres de renforcement (R), lesdites parties surélevées (14) et lesdits évidements (17, 29) définissant ensemble ladite surface supérieure, ledit procédé comprenant les étapes consistant à : i) fournir un premier moule (100, 1000) définissant un support pour ladite plaque inférieure (10) en cours de coulée et au moins un deuxième moule (120, 1200) ayant une forme intérieure correspondant à l'une respective desdites parties surélevées (14), ii) préparer un béton de premier type, iii) remplir ledit au moins un deuxième moule (120, 1200) avec ledit béton de premier type et décharger ledit béton de premier type à partir dudit au moins un deuxième moule (120, 1200) dans ledit premier moule (100, 1000) pour former ladite plaque inférieure (10), iv) durcir au moins partiellement ledit béton de premier type déchargé dans ledit premier moule (100, 1000), v) disposer lesdites barres de renforcement (R) dans au moins certains desdits évidements (17, 29), vi) préparer un béton de type à résistance plus élevée et plus fort que ledit béton de premier type, et vii) utiliser ladite plaque inférieure (10) en tant que troisième moule pour compléter ledit élément de construction en forme de dalle (E) en appliquant ledit béton de type à résistance plus élevée sur ladite surface supérieure pour couler ladite plaque supérieure (20).
2. Procédé selon la revendication précédente, comprenant la répétition de l'étape iii) tout en déplaçant successivement ledit au moins un deuxième moule (120, 1200) dans des positions voisines par rapport au béton préalablement déchargé.
3. Procédé selon la revendication précédente, dans lequel ladite étape iii) comprend successivement le levage et l'abaissement dudit au moins un deuxième

- moule (120, 1200) dans une direction s'éloignant ou vers ledit premier moule (100, 1000).
4. Procédé selon l'une quelconque des revendications précédentes, dans lequel, avant ladite étape iii), ledit premier moule (100, 1000) est rempli d'une couche dudit béton de premier type pour former ladite base (11). 5
 5. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite étape iii) comprend un compactage et une vibration dudit béton de premier type alors qu'il se trouve dans ledit au moins un deuxième moule (120), pour former ladite plaque inférieure (10) par ledit béton de premier type collant au béton de premier type préalablement déchargé dans ledit premier moule (100, 1000). 10
 6. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit au moins un deuxième moule (120, 1200) est agencé avec un espace (110, 1100) au-dessus dudit premier moule (100, 1000) pendant ledit déchargement. 15
 7. Procédé selon l'une quelconque des revendications précédentes, dans lequel, avant ladite étape iii), ledit premier moule (100, 1000) est recouvert d'une couche d'un matériau cimentaire, tel qu'un mortier, une nappe de fibres de verre ou une peinture, pour définir une couche de recouvrement configurée pour recouvrir ladite surface inférieure, ledit au moins un deuxième moule (120, 1200) étant agencé dans ladite étape iii) avec ledit espace (110, 1100) au-dessus de ladite couche de matériau pendant ladite décharge. 20
 8. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit premier moule (100, 1000) définit un support pendant tout le processus de coulée dudit élément (E). 25
 9. Dispositif pour mettre en oeuvre les étapes i) - iii) du procédé selon l'une quelconque des revendications 1 à 8, ledit dispositif comprenant a) un premier moule (100, 1000) définissant un support pour ladite plaque inférieure (10) en cours de coulée, b) une pluralité de deuxièmes moules (120, 1200) ayant une forme intérieure correspondant à l'une respective desdites parties surélevées (14) et ayant une ouverture au fond de celles-ci, et c) un dispositif de dosage (2000) pour administrer ledit béton de premier type auxdits deuxièmes moules (120, 1200), caractérisé par d) un cadre (F) mobile le long d'une longueur dudit premier moule (1000), ledit cadre (F) supportant ladite pluralité de deuxièmes moules (120, 1200), lesdites deuxièmes moules (120, 1200) pouvant se déplacer verticalement par rapport audit cadre (F), et e) des dispositifs vibrants (V) montés à chacun desdits 30
- deuxièmes moules (120, 1200) pour faire vibrer lesdits deuxièmes moules.
10. Dispositif selon la revendication 9, comprenant une trémie (H) distribuant ledit béton de premier type dans des dispositifs de dosage (2000) correspondant à un deuxième moule respectif (1200), lesdits dispositifs de dosage (2000) étant mobiles par rapport auxdits deuxièmes moules (1200) le long de la longueur dudit premier moule (1000). 35
 11. Dispositif selon la revendication 9 ou 10, comprenant des têtes de pression (185, 1850) configurées pour être abaissées dans lesdits deuxièmes moules (1200) à travers un sommet ouvert de ceux-ci, lesdites têtes de pression (1850) ayant une forme correspondant à une face supérieure (15) desdites parties surélevées (14). 40
 12. Dispositif selon la revendication 9, dans lequel une fermeture est prévue pour empêcher le déchargement dudit béton de premier type sur lesdits dispositifs de dosage (2000) étant éloignés desdits deuxièmes moules (1200). 45
 13. Dispositif selon l'une quelconque des revendications 9 à 12, comprenant des dispositifs de tension agencés à chaque extrémité dudit premier moule (1000) pour établir une prétension dans des fils (non représentés) s'étendant entre lesdites extrémités. 50
 14. Dispositif pour mettre en oeuvre les étapes i) - iii) du procédé selon l'une quelconque des revendications 1 à 8, ledit dispositif comprenant a) un premier moule (100, 1000) définissant un support pour ladite plaque inférieure (10) en cours de coulée, b) une pluralité de deuxièmes moules (120, 1200) ayant une forme intérieure correspondant à l'une respective desdites parties surélevées (14) et ayant une ouverture au fond de celles-ci, et c) un dispositif de dosage (2000) pour administrer ledit béton de premier type auxdits deuxièmes moules (120, 1200), caractérisé par d) un cadre (F) mobile le long d'une longueur dudit premier moule (1000), ledit cadre (F) supportant ladite pluralité de deuxièmes moules (120, 1200), lesdites deuxièmes moules (120, 1200) pouvant se déplacer individuellement et verticalement par rapport audit cadre (F), et e) des dispositifs vibrants (V) pour faire vibrer lesdits deuxièmes moules. 55
 15. Dispositif selon la revendication 14, comprenant une trémie (H) distribuant ledit béton de premier type dans des dispositifs de dosage (2000) correspondant à un deuxième moule respectif (1200), lesdits dispositifs de dosage (2000) étant mobiles par rapport auxdits deuxièmes moules (1200) le long de la longueur dudit premier moule (1000).

16. Dispositif selon la revendication 13 ou 14, comprenant des têtes de pression (185, 1850) configurées pour être abaissées dans lesdits deuxièmes moules (1200) à travers un sommet ouvert de ceux-ci, lesdites têtes de pression (1850) ayant une forme correspondant à une face supérieure (15) desdites parties surélevées (14). 5
17. Dispositif selon la revendication 14, dans lequel une fermeture est prévue pour empêcher le déchargement dudit béton de premier type sur lesdits dispositifs de dosage (2000) étant éloignés desdits deuxièmes moules (1200). 10
18. Dispositif selon l'une quelconque des revendications 14 à 17, comprenant des dispositifs de tension agencés à chaque extrémité dudit premier moule (1000) pour établir une prétension dans des fils (non représentés) s'étendant entre lesdites extrémités. 15

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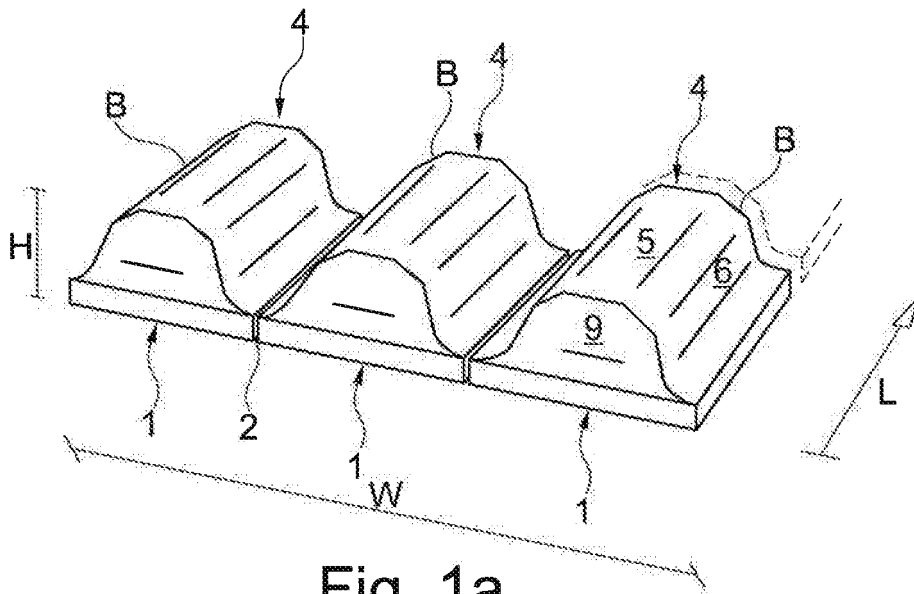


Fig. 1a

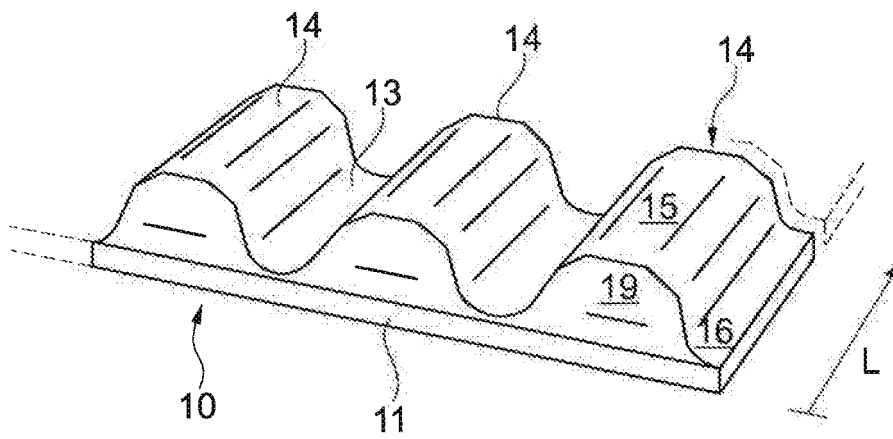


Fig. 1b

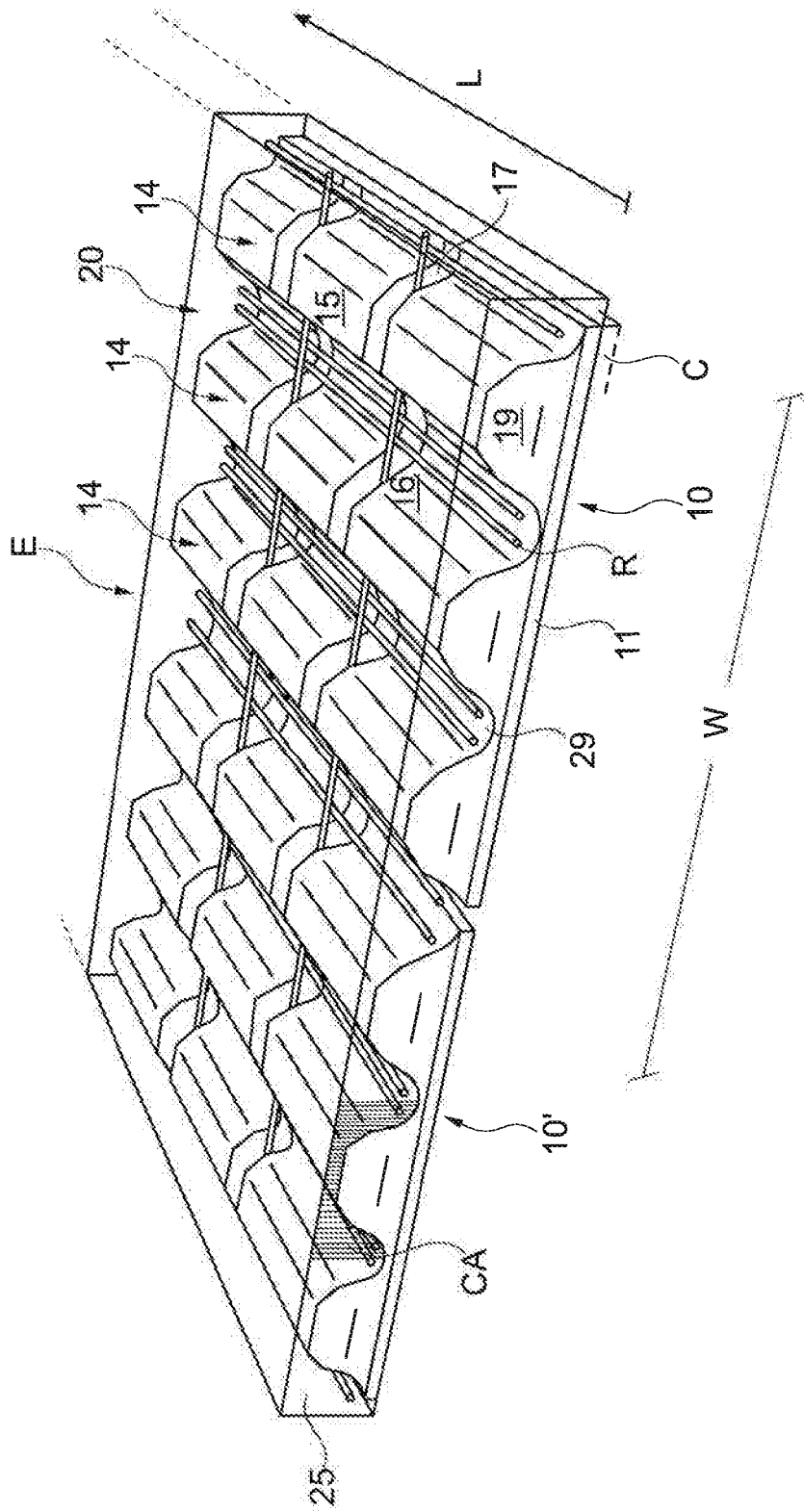
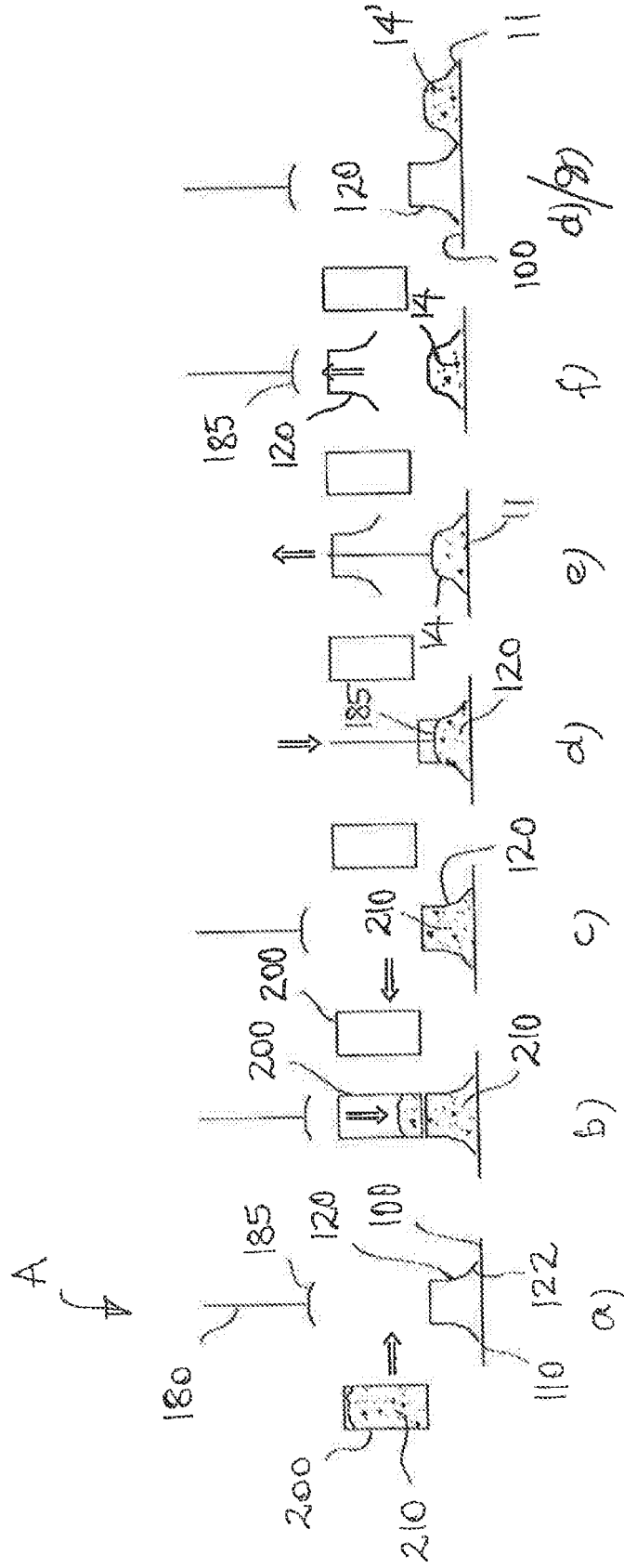


Fig. 2

Fig. 3



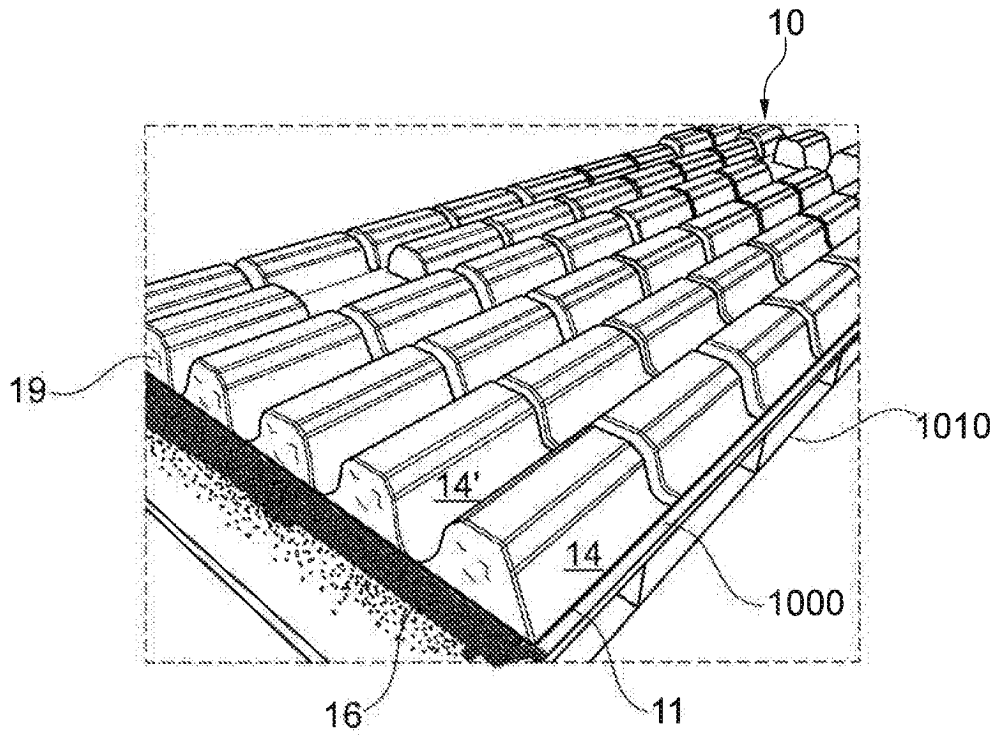


Fig. 4

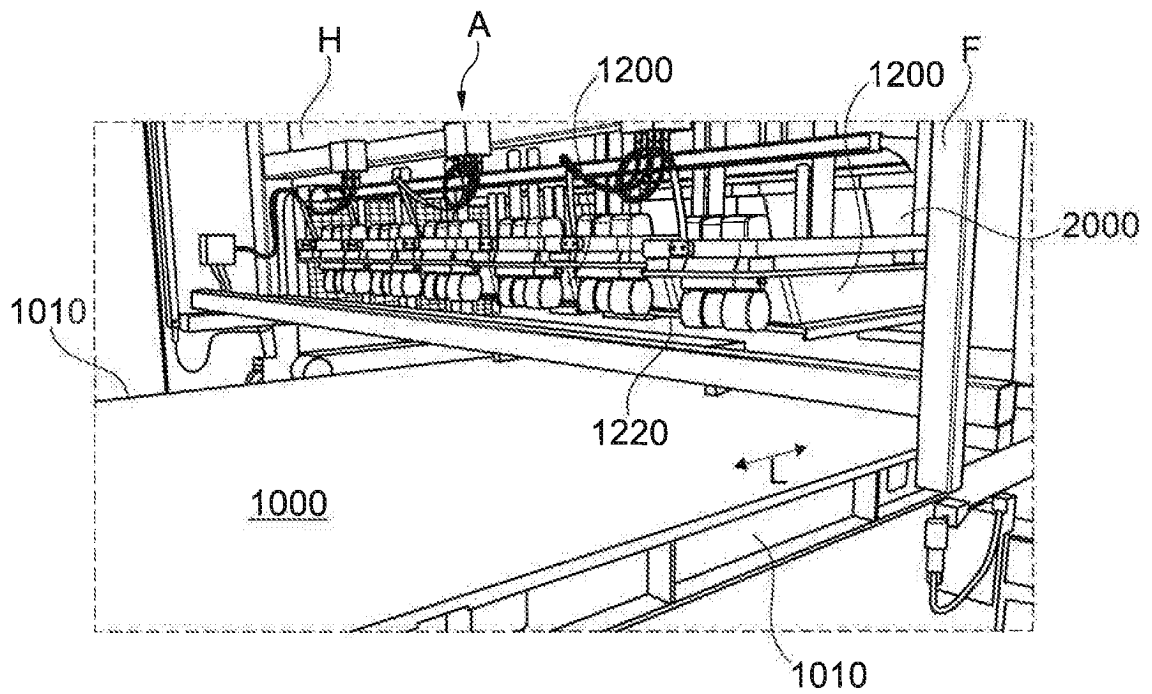


Fig. 5

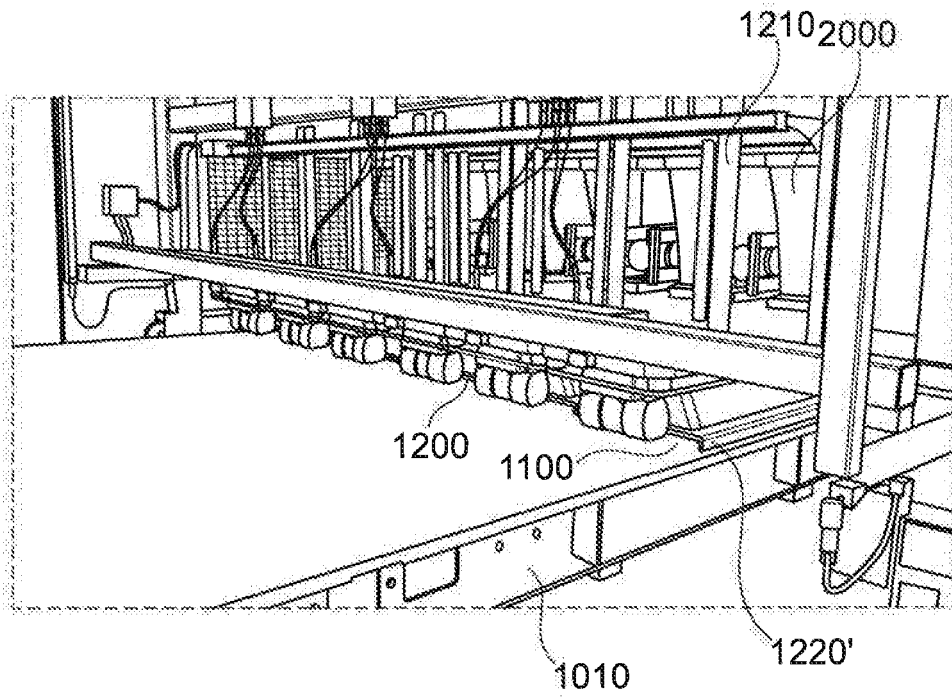


Fig. 6

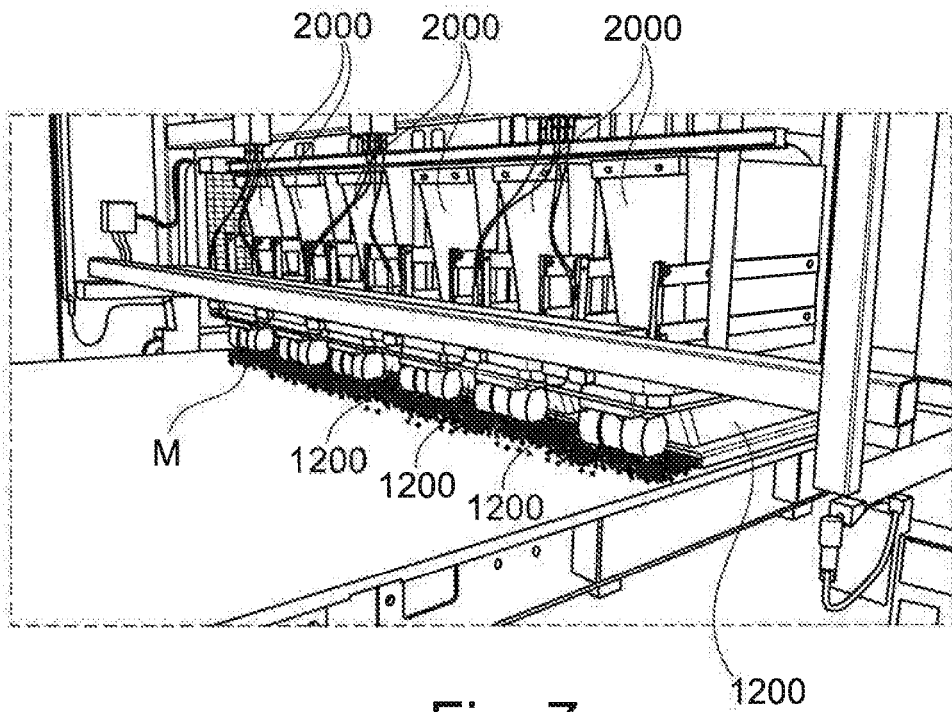


Fig. 7

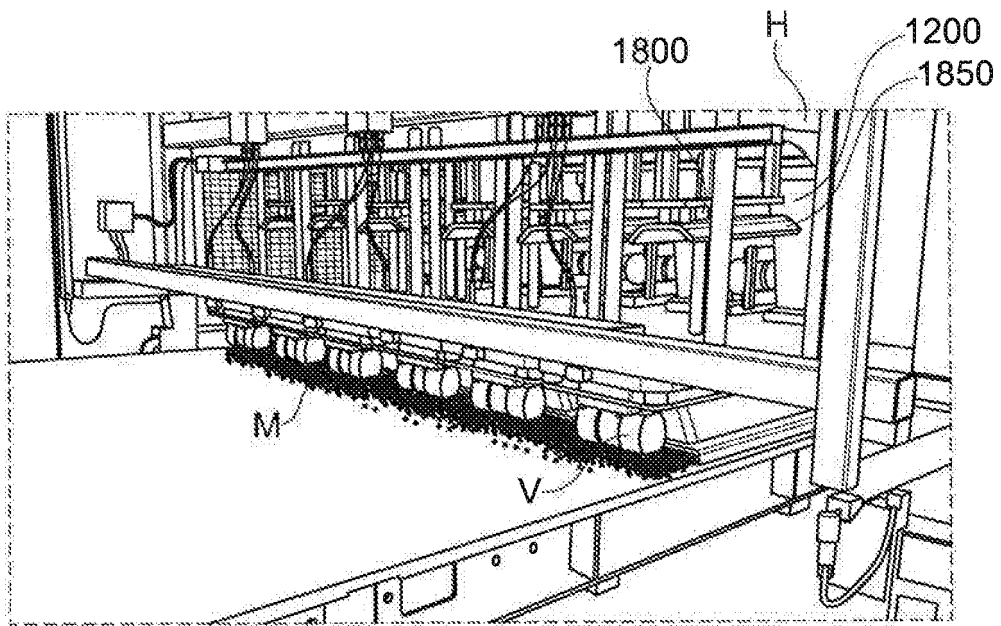


Fig. 8

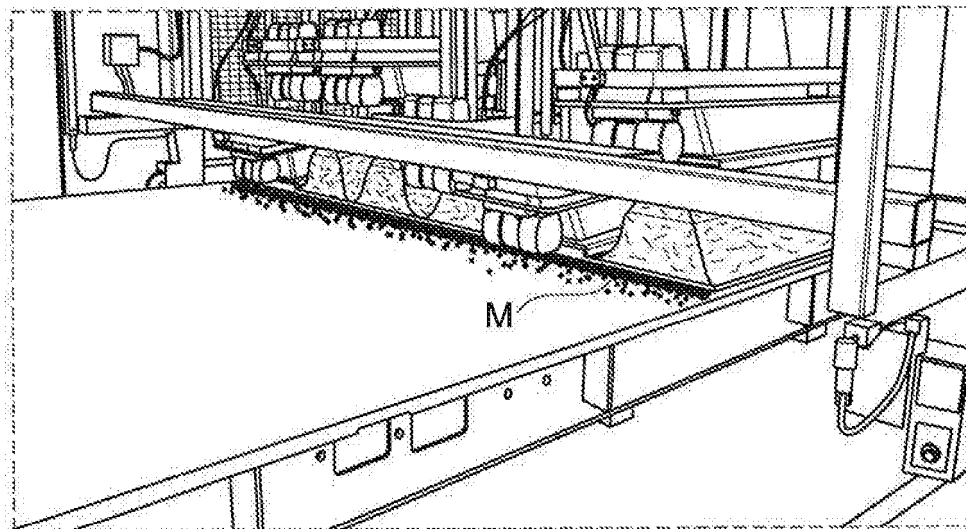


Fig. 9

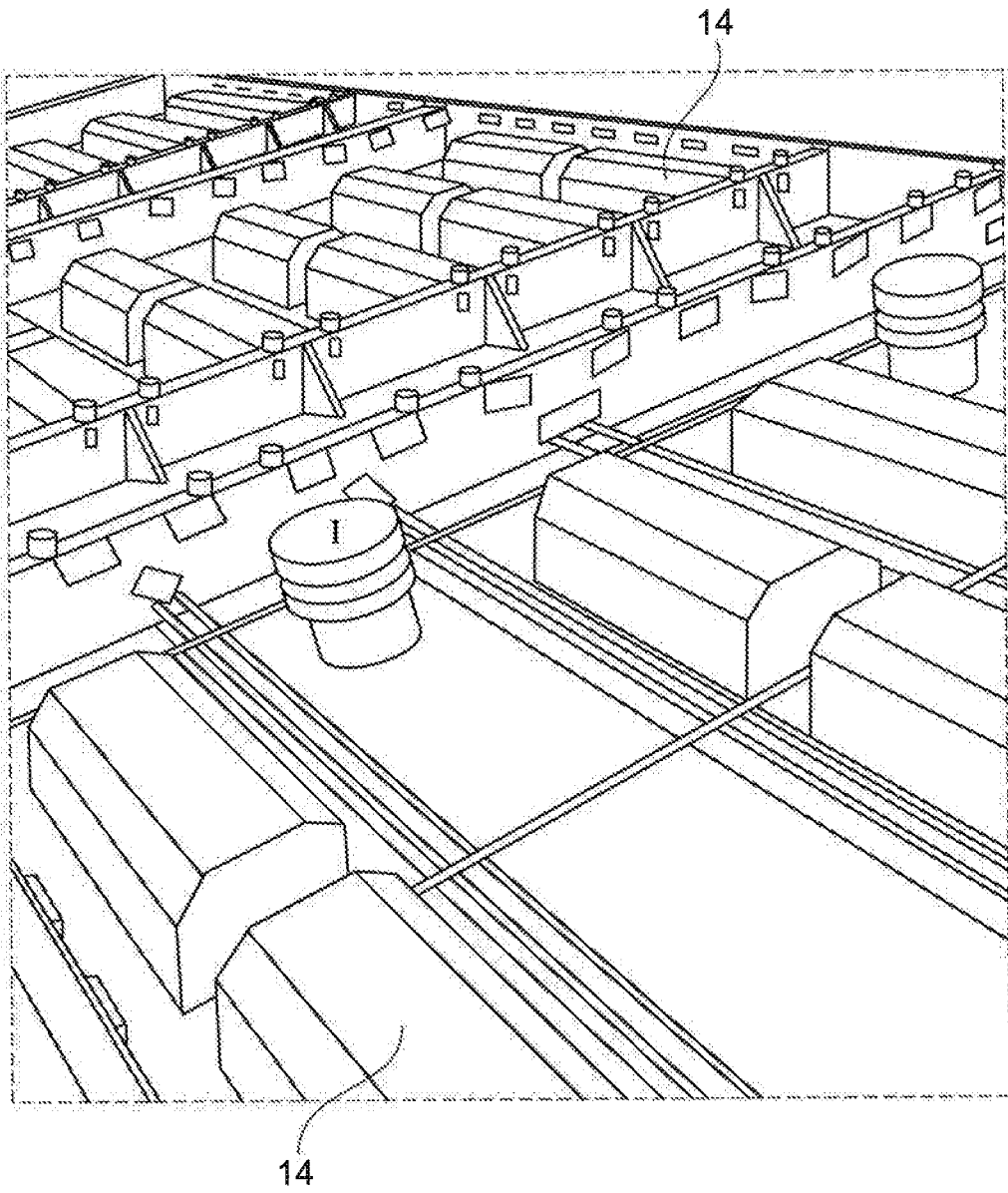


Fig. 10

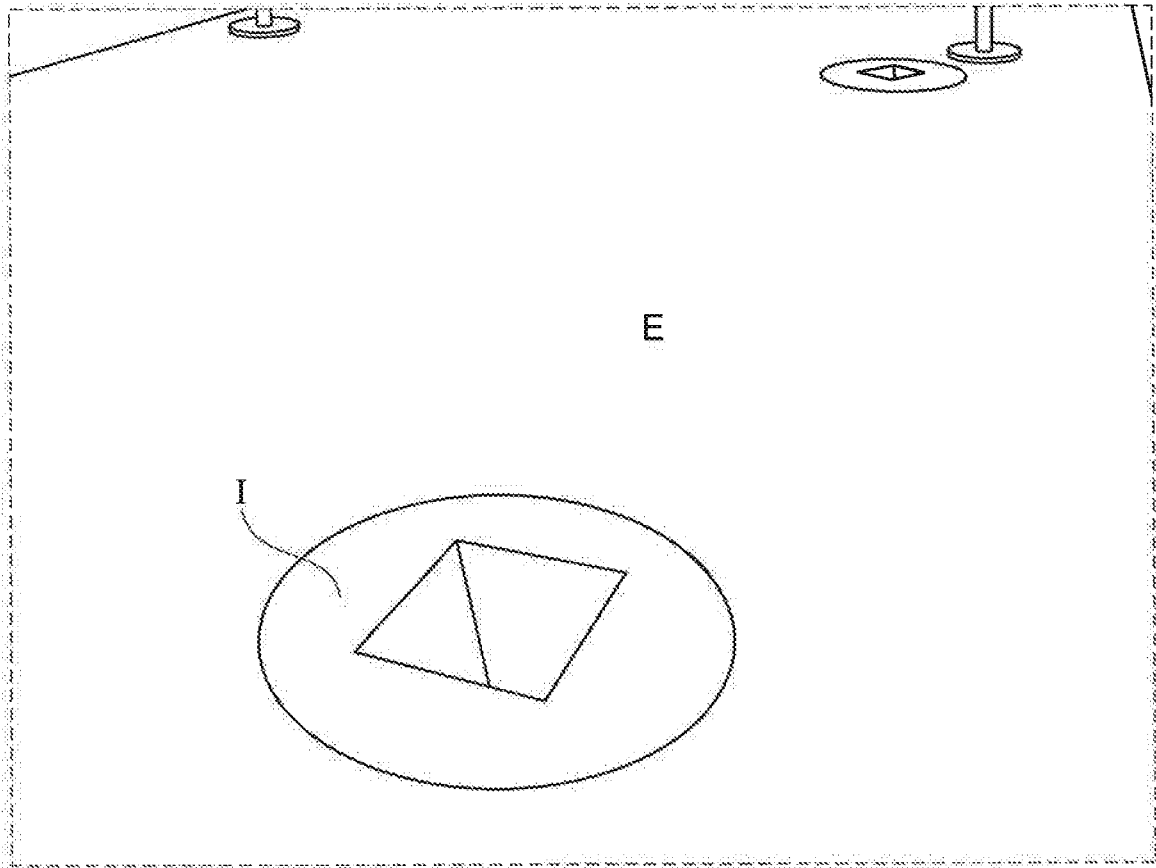


Fig. 11

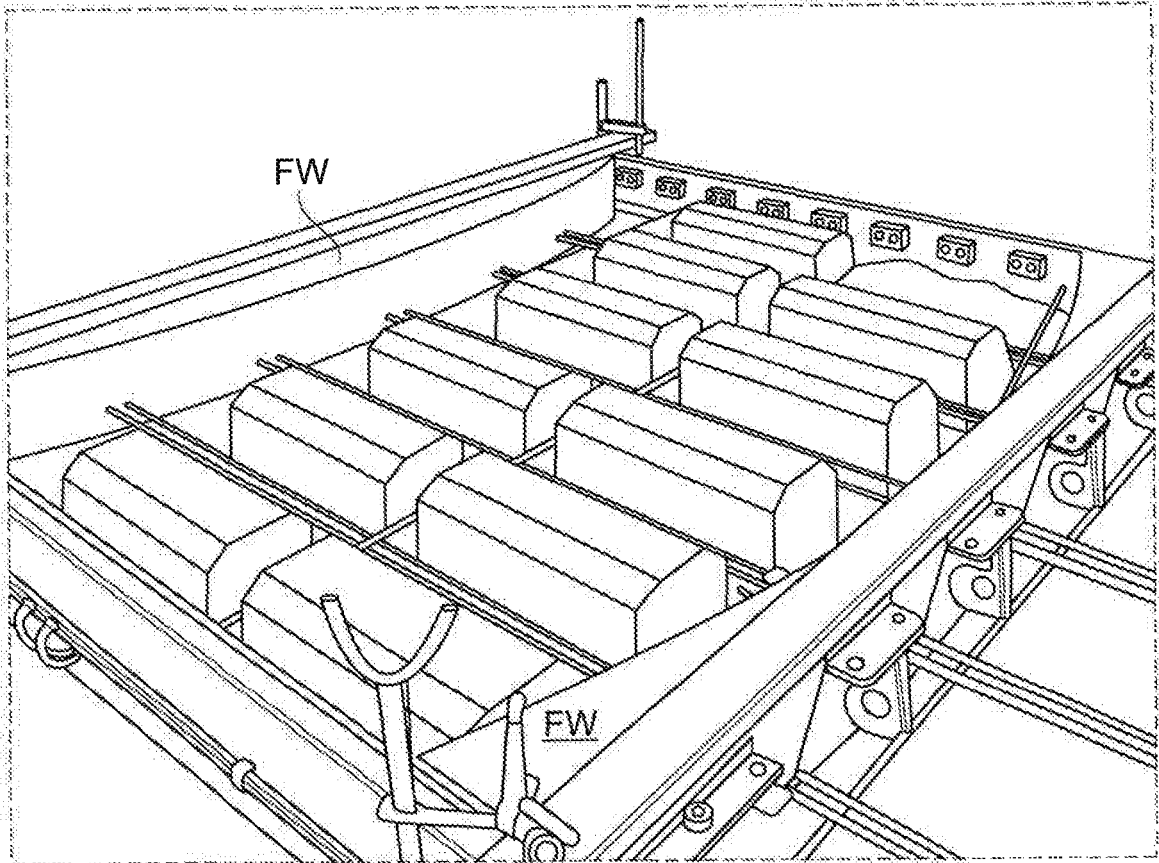


Fig. 12

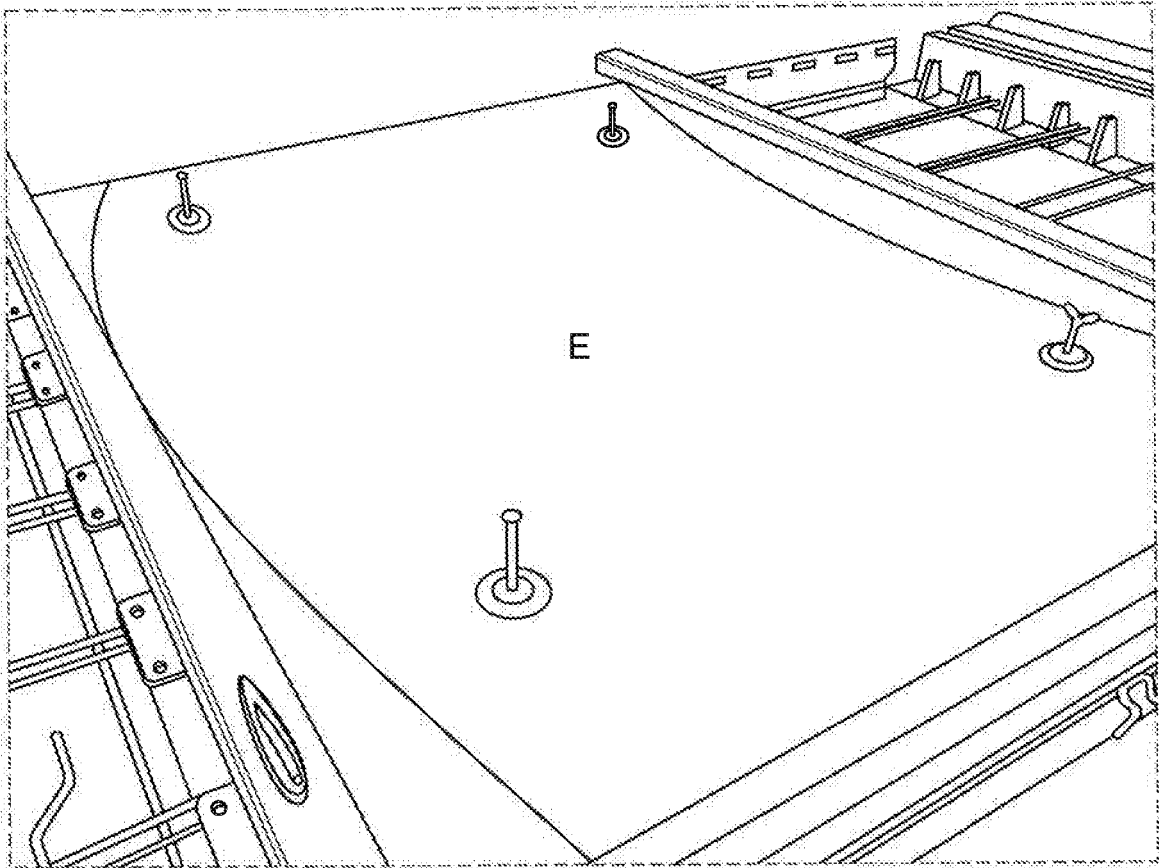


Fig. 13

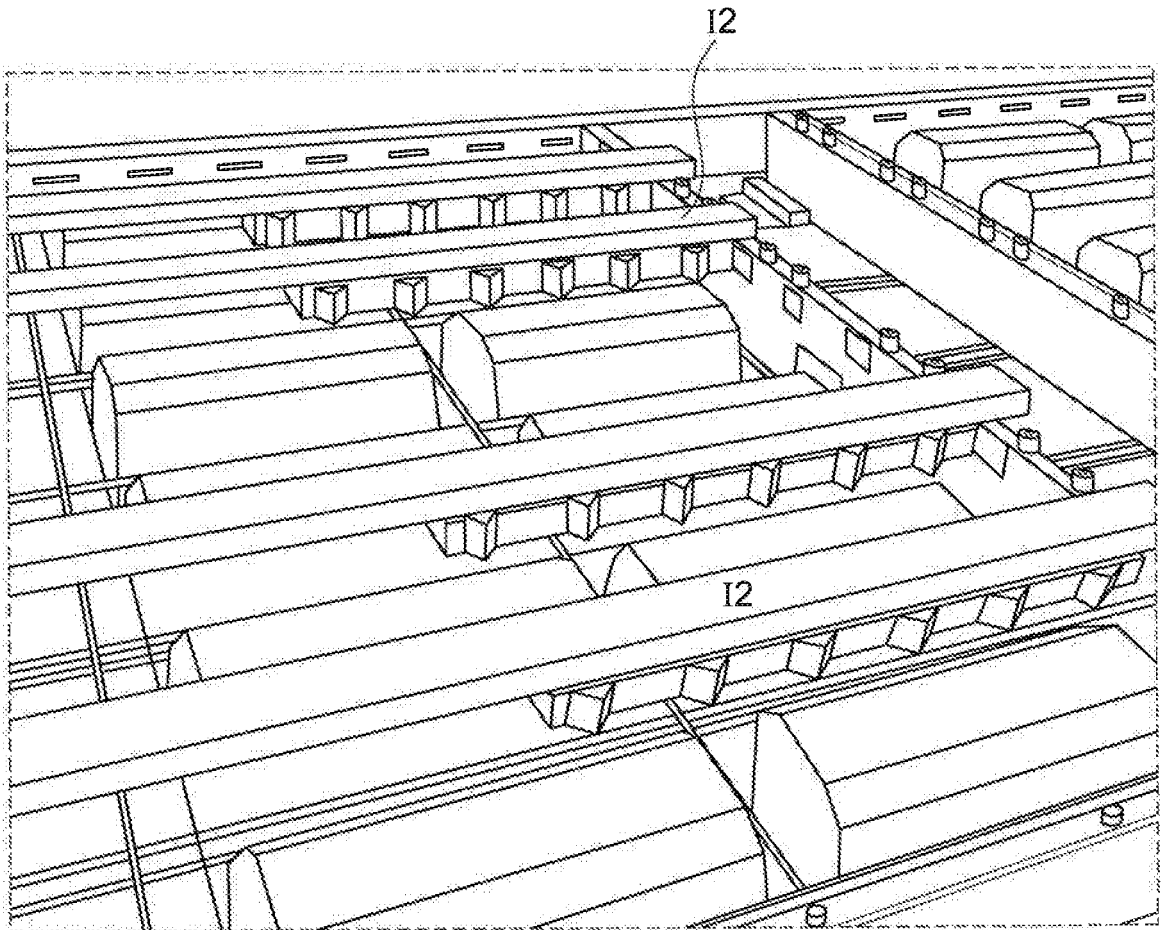


Fig. 14

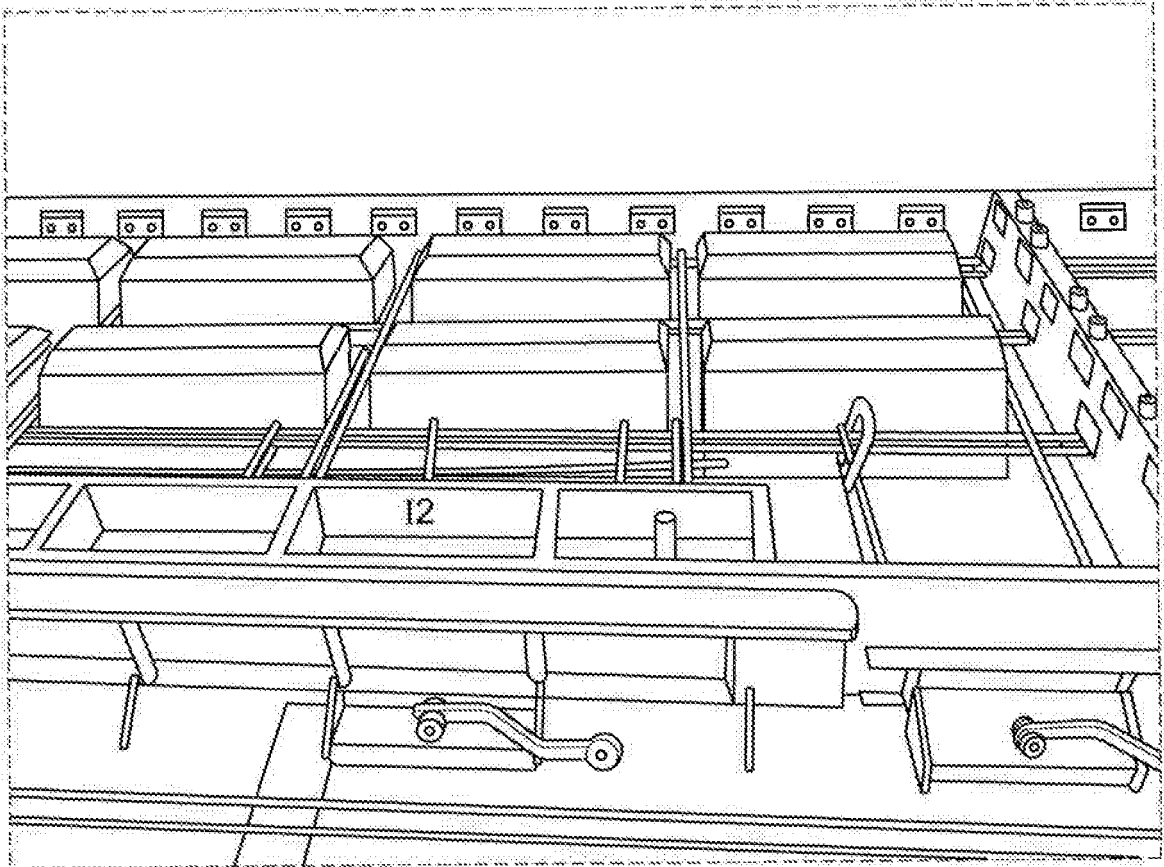


Fig. 15

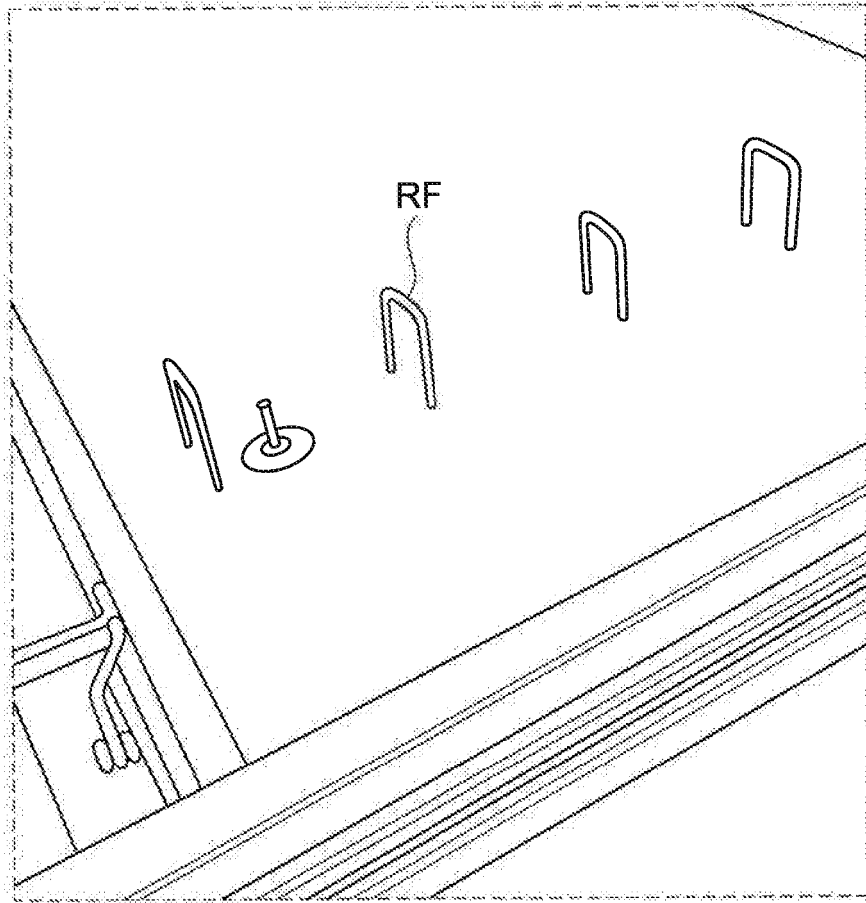


Fig. 16

REFERENCES CITED IN THE DESCRIPTION

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