(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 480 376 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.05.2019 Bulletin 2019/19

(51) Int Cl.:
E04B 1/24 (2006.01) ***E04B 5/29*** (2006.01)

(21) Application number: **17199904.8**

(22) Date of filing: **03.11.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(54) **FLOORING SYSTEM**

(57) The present invention belongs to the field of structural sections for floor and building frames, particularly to the field of light gauge steel (LGS) structural flooring systems, and discloses a structural flooring system and a method for mounting a structural flooring system.

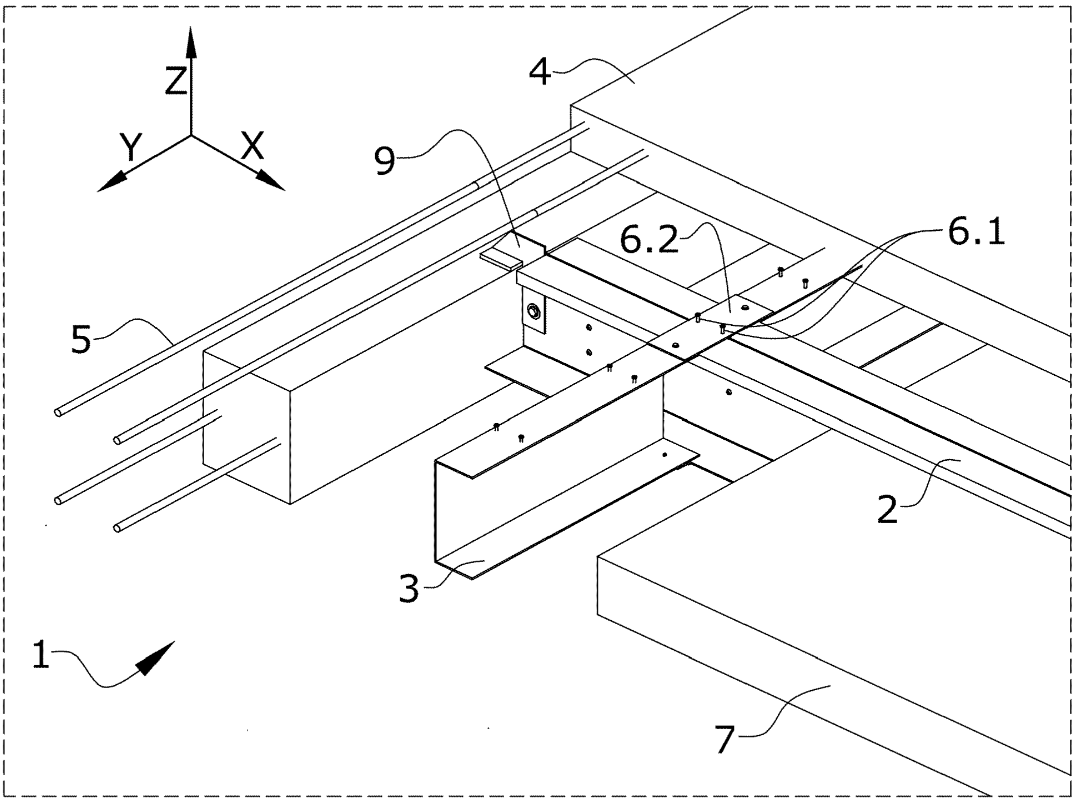

FIG.8

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention belongs to the field of structural sections for floor and building frames, particularly to the field of light gauge steel (LGS) structural flooring systems.

BACKGROUND OF THE INVENTION

[0002] Traditionally, structural steel sections for floor and building frames are categorized in different classes (namely, classes 1 to 4) according to their behaviour under flexural loads. This classification enables engineers to choose a particular shape for the section with distinct moment-deflection behaviour without an extensive failure analysis for the individual elements of the shape of the section.

[0003] Sections which typically exhibit local buckling of elements in compression as the limit state of structural resistance are class-4 sections, such as light gauge steel (LGS) structural systems.

[0004] The behaviour of such structural systems requires LGS members with section properties that allow the compressive stresses developed within non-composite sections to remain below those which would cause failure due to local buckling.

[0005] Therefore, once composite action develops between an LGS member and a concrete element or topping, the geometry of the resultant section is such that the neutral axis of the system is located within said concrete topping, so that the entire LGS member section is in tension, as it is not embedded within the concrete. This facilitates the full tensile yield strength of the steel of the section of the LGS member.

[0006] Traditional LGS structural systems, particularly LGS structural flooring systems only use the compressive strength of the concrete element in the direction wherein the beams are distributed, resulting in an inefficient use of said concrete element, which causes the need for a steel reinforcement throughout the entire concrete element and therefore the entire floor. This causes the flooring system to be heavy as well as expensive.

SUMMARY OF THE INVENTION

[0007] The present invention provides a solution to the aforementioned problems, by a structural flooring system according to claim 1 and a method for mounting a structural flooring system according to claim 13. In dependent claims, preferred embodiments of the invention are defined.

[0008] In a first inventive aspect, the invention provides a structural flooring system, comprising:

- at least one primary joist,
- at least one secondary joist,
- at least one splice plate and at least one shear connector,
- at least one slab, the slab comprising a first face and a second face, being the first face located in an upper position than the second face according to the gravity direction (Z), and
- at least one slab reinforcement,

wherein:

- the primary joists are oriented according to a first mounting direction (X) perpendicular to the gravity direction (Z), and
- the secondary joists are oriented according to a second mounting direction (Y) perpendicular to the gravity direction (Z),
- the section of the primary joists is a built-up section, said section comprising a first section end and a second section end, being the first section end located in an upper position than the second section end according to the gravity direction (Z),
- the section of the secondary joists is a C section, said section comprising a first section end and a second section end, being the first section end located in an upper position than the second section end according to the gravity direction (Z),
- each secondary joist comprises an upper flange located at the first section end and a lower flange located at the second section end, and at least a cantilever portion located on one or both ends of the upper flange,
- each primary joist comprises a lower flange at the second section end and an upper flange at the first section end, wherein the upper flange supports a cantilever portion of at least one secondary joist,
- the lower flange of the primary joist and the lower flange of the secondary joist are pressed together by means of the splice plate and the at least one shear connector,
- the slab is located adjacent to the primary joists and to the secondary joists, covering the first section end of the primary joist and the first section end of the secondary joist, and
- the slab reinforcement is located on the first face of the slab.

[0009] Throughout this entire document, a built-up section will be understood as the section of a joist made from at least two individual plates fastened together, such as welded or bolted, thus achieving a structural member, in contrast with a non-composite, which is made of a unique formed plate. The C section of the secondary joists is a non-composite section.

[0010] Every secondary joist is supported at least on one primary joist by means of a cantilever portion located on the first section end of the secondary joist. Said cantilever portion of the secondary joist rests on the upper flange of the primary joist. Said cantilever portion projects from the secondary joist in the longitudinal direction of the mentioned secondary joist.

[0011] Because of the mentioned mounting, the primary joists support the weight of the entire arrangement whereas the secondary joists provide also some support due to catenary action.

[0012] The secondary joist comprises a lower flange, located at the second section end of the secondary joist, in addition to the upper flange, located at the first section end of the secondary joist. The primary joist comprises a lower flange, located at the second section end of said primary joist.

[0013] Said lower flanges of the secondary joist and primary joist are pressed together by means of a splice plate, which compresses both flanges, and by means of at least one shear connector which maintains the three aforementioned elements in place.

[0014] In a particular embodiment, the lower flange of the secondary joist rests on the lower flange of the primary joist for additional support, remaining the lower flange of the primary joist between the lower flange of the secondary joist and the splice plate.

[0015] Advantageously, a flooring system as defined in the first inventive aspect behaves as a two-way spanning system, which utilizes the compressive strength of the slab in two directions, namely the first and second mounting directions (X, Y), both being different and perpendicular to the gravity direction (Z). Therefore, the slab is set into stress on both first and second mounting directions (X, Y) due to the plan and sectional geometric design of the system. Such a behavior is in contrast to that of traditional LGS structural flooring systems, which act as one-way spanning systems, thus being less efficient.

[0016] The state of stress in the primary and secondary joists can be different, being greater in a particular embodiment in the primary joists. Said state of stress is similar to prestressed precast slab that later receives a topping, being the state of stress in the topping lower than in the slab.

[0017] The structural flooring system according to the present invention is, advantageously, more solid given that beams or joists are provided in two different directions and therefore loads can be distributed along both directions. Additionally, the present system is also cheaper, as the behavior of the system due to the orientation and sections of the different joists in combination with the slab eliminates the need for steel or fiber reinforcement on both faces of the slab.

[0018] Although the reinforcement on both faces of the slab is avoided with the present invention, reinforcement is present in one of the faces of the slabs, particularly for slabs of continuous edges, in order to resist live and superimposed dead loads. Said continuous edges are those where the slab is able to transfer load to an adjacent slab through that edge.

[0019] In an embodiment the slabs embed the upper flange of the primary joists and the upper flange of the secondary joists.

[0020] In an embodiment the reinforcement is made of steel. This steel reinforcement is, in a particular embodiment, bonded and allows the resistance of the tensile stresses in the top part of the slab.

[0021] In a particular embodiment, the slab is strengthened along the first (X) and second (Y) mounting directions by means of the loading of the primary and secondary joists.

[0022] Throughout this entire document, strengthening shall be interpreted as the development of composite action through the maturing and strengthening of the concrete.

[0023] In a particular embodiment, the strengthening of the slab is such that said slab is set in compression along the first (X) and second (Y) mounting directions. Said primary and secondary joists are loaded vertically by loads, such as live loads and superimposed dead loads, which then set the slab in compression in both directions perpendicular to the gravity direction (Z). The increased tensile stresses developed in the flanges of the primary and secondary joists balances the compressive stresses in the slab.

[0024] Thus, in this embodiment the slab is set into stress on both first and second mounting directions (X, Y), being said stress a compression. The plan and sectional geometric design of the system allows the slab to reliably support the mentioned stress.

[0025] The slab is therefore, in this particular embodiment, cast in situ and matures attaining the required crushing strength, through composite action with primary and secondary joists along the first (X) and second (Y) mounting directions, the slab increasing the vertical load carrying capacity of the overall structural flooring system in the gravity direction (Z). Any additional vertical load in the gravity direction (Z) applied to the structural flooring system is subsequently supported through composite action by the slab being set in stress along the first (X) and second (Y) mounting directions.

[0026] Advantageously, the slab behaves in a more efficient way when being set into compression compared to alternative stresses.

[0027] The present invention therefore provides a solution to the problems of the state of the art based on a two-way spanning flooring system, by means of beams or joists located in two directions wherein the slab, particularly of concrete, utilizes a compressive strength along said two directions. The configuration of the secondary joist, namely the cantilever portion or portions arranged at the end/ends of said secondary joist allows suitable connection between the primary and the secondary joists.

[0028] In a particular embodiment of the structural flooring system continuous primary joists are arranged along with non-continuous secondary joists supported on the primary joists.

[0029] In a particular embodiment, the built-up section of the primary joist is made up of two elements, wherein each of said elements comprises:

- a web, comprising a first web end and a second web end,
- a curved top flange, located on the first web end, and
- a right-angled bottom flange, located on the second web end,

and the two elements are located with their respective webs facing one another such that both flanges of both elements extend along opposite directions.

[0030] In the present particular embodiment, the upper flange of the primary joist is formed by the curved top flanges of the two elements, and the right-angled bottom flanges of the two elements form the lower flange located at the second section end of the primary joist.

[0031] Advantageously, a right-angled flange is cheaper to manufacture, whilst a curved-flange offers a more resistant flange, localizing buckling when loaded.

[0032] In a particular embodiment, the built-up section of the primary joist is made up of two elements, wherein each of said elements comprises:

- a web, comprising a first web end and a second web end,
- a first right-angled top flange, located on the first web end, and
- a second right-angled bottom flange, located on the second web end,

and the two elements are located with their respective webs facing one another such that both flanges of both elements extend along opposite directions.

[0033] In the present particular embodiment, the first right-angled top flanges of the elements form the upper flange of the primary joist, and the second right-angled bottom flanges form the lower flange of the primary joist.

[0034] In an embodiment the two elements of the built-up section of the primary joist are fastened together, preferably using welding and/or bolts.

[0035] In a particular embodiment the first mounting direction (X) is selected according to the smaller dimension available where the structural flooring system is to be placed, whereas the second mounting direction (Y) is selected according to the larger dimension available where the structural flooring system is to be placed. The primary joists are then mounted on the first mounting direction (X), being this first mounting direction (X) the one corresponding with the shortest distance available for the placing of the structural system, while the secondary joists are mounted on the second mounting direction (Y), being this the one corresponding with the largest distance available for the placing of the structural system. Thus, the load capacity varies according both to the section of the mounted joist as well as the distance available for said mounting, being in a particular embodiment the first mounting direction (X) the one with a higher load capacity.

[0036] In a particular embodiment, the first mounting direction (X) and the second mounting direction (Y) are perpendicular. This provides the effect of sharing any additional load on the system by both the primary and secondary joists, being placed orthogonally. Advantageously, this provides a compression stress on both orthogonal directions on the first face of the slab, thus eliminating the need of steel or fiber reinforcement on both first and second faces of the mentioned slab. Additionally, it also allows the reduction of the size of both the primary and secondary joists substantially, referring said size of the primary and secondary joists to the section area and to the thickness of the joists. It also allows the reduction of other properties such as section modulus, moment of inertia, etc.

[0037] In a particular embodiment, shear connectors are arranged at the upper or lower flange of the primary joists, or both. Said shear connectors allow any additional load to be shared by both the primary and the secondary joists.

[0038] In a particular embodiment, the splice plate or connecting plate is connected to the secondary joist by at least one shear connector.

[0039] In an embodiment, an additional splice plate or connecting plate is placed on the upper flange of the secondary joist and is connected to said secondary joist by at least one shear connector.

[0040] In an embodiment, one splice plate located at the upper flange of two different secondary joists joins the two secondary joists together.

[0041] In a particular embodiment, the slab is made of concrete. Concrete allows a better performance under compression stress, which is here achieved on both first and second mounting directions (X, Y).

[0042] In a particular embodiment, the slab reinforcement is steel or fibre reinforcement. This allows a better resistance of both the live and dead loads of the system so that a minimal seismic load is generated whilst reducing the weight of the whole system as the reinforcement is only present on the first face of the slab, achieving a safer lightweight structure. Additionally, this allows the inclusion of a thinner slab, particularly a concrete slab, than the ones used in the state of the art, thus the seismic load on the structure being reduced, that is, the structural flooring system allows the same seismic load with a slab thinner than the one allowed in known structural systems.

[0043] In a particular embodiment, the system further comprises an insulation layer, located on the second face of the slab. Advantageously, the use of an insulation layer increases thermal and sound insulation of the system. Preferably, the insulation layer is a polystyrene panel or a combination of two or more such panels.

[0044] In a particular embodiment, the insulation layer forms the underside of the slab thus being usable as the formwork for casting the slab, particularly a concrete slab. Additionally, if the concrete is cast on top of the insulation layer, said insulation layer remains in place, being the insulation layer dual purposed as formwork as well as for enhancing thermal and sound insulation.

[0045] In a particular embodiment, the primary and secondary joists are made of light gauge steel. This allows a reduction in foundation costs for the structural flooring system, as well as a rapid construction of the same.

[0046] In a preferred embodiment, the slab is made of concrete whilst the primary and secondary joists are made of light gauge steel. This system provides a structure which uses different materials, namely steel and concrete, achieving simultaneously a lightweight structure as well as below-normal imposed loads, which is relevant in the behavior of the structure on different situations, such as earthquakes redounding on an enhanced seismic performance.

[0047] In a particular embodiment, the primary and secondary joists have both the same depth, wherein the depth is the height of the joist in the gravity direction (Z). Advantageously, the same depth of the primary and secondary joists facilitates the assembling of the structural flooring system.

[0048] In a second inventive aspect, the invention provides a method for mounting a structural flooring system according to the first aspect of the invention, said method comprising the following steps:

a) providing a plurality of primary joists and secondary joists according to the dimensions of the space for building a floor,
b) placing the primary joists along the first mounting direction (X) and the secondary joists along the second mounting direction (Y), leaving a distance between each of the primary joists and between each of the secondary joists according to the dimensions of the slab,
c) fixing the ends of the joists,
d) placing at least one formwork panel between the primary and secondary joists,
e) forming the slabs on the formwork panel placed between the primary and secondary joists, the formed slab covering the first section end of the primary joist and the first section end of the secondary joist, and
f) strengthening the slabs in both the first and second mounting directions (X, Y).

[0049] Step a) of the present method requires the provision of a plurality of primary and secondary joists. Said number of primary and secondary joists depends on the space available for the mounting of the structural flooring. That is, the room available where the structural flooring system is to be located and its mounting conditions in both mounting directions, as well as the number of primary joists and the number of secondary joists that can be used for the mentioned mounting.

[0050] Step b) of the method establishes a distance between adjacent joists of each type, that is, a distance between consecutive joists of the plurality of primary joists, and a distance between consecutive joists of the plurality of secondary joists. Both distances are conditioned by the dimension of the slab, which must be able to support the corresponding loads of the structural system.

[0051] In a particular embodiment, step b) comprises selecting the first mounting direction (X) according to the smallest dimension of the space for building a floor, being said smallest dimension the smallest mounting dimension available, and selecting the second mounting direction (Y) according to the largest dimension of the space for building a floor, being said largest dimension the largest mounting dimension available.

[0052] According to step e), the slab is formed adopting its shape from the formwork provided by the formwork panel and the primary and secondary joists, that is, the slab is molded over the formwork and embedding the upper flange of the primary joists and the upper flange of the secondary joists.

[0053] In a particular embodiment, the slab is molded in the space available between the formwork and 50mm above the upper flange of the primary joists.

[0054] Advantageously, the method according to the invention provides a more simple and economic construction of a flooring system. Additionally, the mounting method of said system becomes modular, enhancing the speed of the construction of the structure.

[0055] In an embodiment the formwork panel of step d) comprises at least one insulation layer. In a preferred embodiment an insulation layer is the formwork used for casting the slab, particularly a concrete slab. The concrete is cast on top of the insulation layer and the insulation layer remains in place, being said insulation layer therefore dual purposed as formwork as well as for enhancing thermal and sound insulation.

[0056] In a preferred embodiment the slab of the structural flooring system formed in step e) is poured in place or cast in situ. Therefore, said slab is formed during the mounting of the structural flooring system without the need of transporting a slab and adapting its shape and size to the available space provided by the formwork in each of the areas formed by the primary and secondary joists.

[0057] In an embodiment where the built-up sections of the primary joists are made up of two identical elements being joined in a mirror-fashion way, said primary joists are manufactured by means of a combination of steps which comprise:

- decoiling and peeling of the material of the primary joist, preferably steel,
- several coil straightening and punching of the material,
- cold forming, by means of at least one tooling station, the straightened coil into the shape of the section of one of the elements which give rise to the primary joist, and
- joining the two elements in order to form the primary

joist.

[0058] In an embodiment, the C-sections of the secondary joists are manufactured by means of a combination of steps which comprise:

- decoiling and peeling of the material of the secondary joist, preferably steel,
- several coil straightening and punching of the material,
- cold forming, by means of at least one tooling station, the straightened coil into the shape of the C-section of the secondary joist.

[0059] The primary and secondary joists are, therefore, cold-formed profiles.

[0060] All the features described in this specification (including the claims, description and drawings) and/or all the steps of the described method can be combined in any combination, with the exception of combinations of such mutually exclusive features and/or steps.

DESCRIPTION OF THE DRAWINGS

[0061] These and other characteristics and advantages of the invention will become clearly understood in view of the detailed description of the invention which becomes apparent from a preferred embodiment of the invention, given just as an example and not being limited thereto, with reference to the drawings.

Figures 1A and 1B show a perspective view of the mounting of a primary joist and a secondary joist, according to a first and a second embodiment of the structural flooring system.

Figure 2A shows the section of a primary joist according to an embodiment of the invention.

Figure 2B shows the section of a secondary joist according to an embodiment of the invention.

Figure 3 shows a schematic plan view of an example of a structural flooring system when mounted.

Figure 4 shows a perspective view of an embodiment of a primary joist.

Figure 5 shows a perspective view of an embodiment of a secondary joist.

Figure 6A shows a section of an embodiment of the mounting of a primary joist as in figure 4 and two secondary joists as in figure 5.

Figure 6B shows the section of figure 6A along with a mounted slab.

Figure 7A shows a perspective view of the mounting of a primary joist and a secondary joist, according to an embodiment of the invention.

Figure 7B shows a perspective bottom view of the same mounting of figure 7A.

Figure 8 shows an exploded view of the elements of an embodiment of the structural flooring system.

Figures 9A-9B show two different one-way spanning LGS structural systems of the prior art.

DETAILED DESCRIPTION OF THE INVENTION

[0062] Figures 9A and 9B show two different one-way spanning LGS structure systems of the prior art.

[0063] Particularly, figure 9A shows a decking system wherein a conformed joist (J) is embedded in a concrete slab (S). The joist acquires a specific outline, and several joists are joined by means of welds (W). This solution known in the state of the art requires steel reinforcement throughout the top face of the slab (S) whilst the joists (J) are very limited as they must be made of very thick sheets of steel, particularly LGS sheets, which drastically increase manufacturing costs.

[0064] Figure 9B shows a truss system wherein a stamped and shaped joist (J) is partially embedded in a concrete slab (S). The system further comprises a metallic mesh (M), which provides the slab with rigidity. This solution also available in the state of the art requires the same steel reinforcement throughout the top face of the slab (S) as in the decking system, but involves the problem of cracking along the top face of said slab (S) along the line of the joist (J) due to the development of tensile stresses. Additionally, the structure of figure 9B is limited to short distances when applied in buildings, particularly up to maximum 8m, whereas the present invention allows distance covering of up to 12m, with a more reliable structure.

[0065] Figures 1A and 1B show two different embodiments of a structural flooring system (1) according to the invention, comprising a primary joist (2) and two secondary joists (3), all made of steel, mounted in order to give rise to said structural flooring system (1), which also comprises two formwork panels (7) in these embodiments. The primary joist (2) and the secondary joists (3) are both of the same depth in order to facilitate the assembly shown. Figure 1A also shows a bracket (9), the bracket (9) being an additional element which is fixed on an end of the primary joist (2) in this embodiment and which allows an additional support for the structural flooring system (1) on a building frame (8), not shown in these figures.

[0066] The slabs (4), not shown in figures 1A and 1B, are placed on the formwork panels (7) and partially embedding the primary (2) and secondary (3) joists, as shown in following figures.

[0067] The primary joists (2) of both embodiments are oriented according to the first mounting direction (X), whereas the secondary joists (3) are oriented according to the second mounting direction (Y), being said directions (X, Y) perpendicular.

[0068] Figure 1A shows a first embodiment of a primary joist (2) made up of two elements fastened together, each element having right-angled top (2.1.4) and bottom (2.1.3) flanges. Said primary joist can be observed in detail in figures 2A and 4.

[0069] Figure 2A shows a front view of this first embodiment of the section (2.1) of a primary joist (2). As can be observed, said section (2.1) is formed by two identical elements joined together in a mirror-fashion way. The primary joist (2) comprises a first section end (2.2) and a second section end (2.3), being the first section end (2.2) located in an upper position to that of the second section end (2.3) according to the gravity direction (Z). An upper flange (2.4) is located in the first section end (2.2) whilst a lower flange (2.5) is located in the second section end (2.3).

[0070] Figure 4 shows a perspective view of this embodiment of a primary joist (2) having a built-up section (2.1) and preferably made of steel. In this embodiment the two elements forming the primary joist (2) can be seen, which when attached one to another configure the whole primary joist (2). Said elements are located in mirror-shape fashion, so that the built-up section (2.1) of the joist (2) is symmetrical.

[0071] Each of the elements forming the primary joist (2) includes the following members:

- a web (2.1.1) comprising a first web end and a second web end,
- a right-angled flange (2.1.4), located on the first web end, and
- a right-angled flange (2.1.3), located on the second web end.

[0072] As mentioned, both elements are located with their respective webs (2.1.1) facing one another such that the flanges (2.1.3, 2.1.4) of both elements extend along opposite directions. This means that the right-angled top flanges (2.1.4), according to the gravity direction (Z), of both elements are located together although oriented in a mirror-shape fashion. The same occurs with the right-angled bottom flanges (2.1.3), according to the gravity direction (Z), of both elements.

[0073] Figure 4 also shows in the front of the primary joist (2) a portion of each element, particularly on the side of the first section end (2.2), with no right-angled flange (2.1.4). This portion facilitates the placement of a bearer or bracket (9) attached to the primary joist (2), particularly to the web (2.1.1) of the two elements of the primary joist (2), such as the bracket (9)shown in figure 1A to sit on top of an edge beam or wall of a building frame (8).

[0074] Coming back to figure 1A, a secondary joist (3) as the one shown in this figure can be observed in detail in figures 2B and 5. In figure 2B a front view of said embodiment of the C-section (3.1) of the secondary joist (3) is shown. The secondary joist (3) has a section (3.1) with the shape of a C, said section (3.1) comprising a first section end (3.2) and a second section end (3.3), the first section end (3.2) being located in an upper position to that of the second section end (3.3) according to the gravity direction (Z).

[0075] An upper flange (3.4) is located in the first section end (3.2) whilst a lower flange (3.5) is located in the second section end (3.3), the upper (3.4) and lower (3.5) flanges of the secondary joist (3) being right-angled flanges.

[0076] Figure 5 shows a perspective view of this embodiment of a secondary joist (3), with a section (3.1) in the form of a C and preferably made of steel. As seen in the figure, the secondary joist (3) comprises an upper flange (3.4) located at the first section end (3.2) of the joist (3), and a lower flange (3.5) located at the second section end (3.3) of the secondary joist (3), being the upper flange (3.4) located in an upper position than the lower flange (3.5) according to the gravity direction (Z). Reference numbers for the first (3.2) and second (3.3) section ends are not shown in the present figure, although they can be observed in figure 2B.

[0077] The secondary joist (3) of figure 5 also comprises a cantilever portion (3.6) located on the upper flange (3.4). Said cantilever portion (3.6) is placed on one end of the secondary joist (3). A second cantilever portion (3.6) can be provided on the opposite end of the secondary joist (3).

[0078] Figure 1B shows a second embodiment of a primary joist (2) wherein the primary joist (2) is made up of two elements, having a curved top flange (2.1.2) and a right-angled bottom flange (2.1.3). The secondary joist (3) in the embodiment of Figure 1B is as the one disclosed in connection with Figure 1A.

[0079] As a common feature to the embodiments shown in figures 1A and 1B, it can be observed how the secondary joists (3) are supported on the right-angled bottom flanges (2.1.3) of the primary joists (2).

[0080] The primary (2) and secondary (3) joists are connected by means of their upper flanges (2.4, 3.4). In particular, the cantilever portion (3.6) of the secondary joist (3) rests on the upper flange of the primary joist (2). Also, it can be observed in Figures 1A and 1B how the joint between the primary joist (2) and each secondary joist (3) is achieved by means of splice plates (6.2) or connecting plates (6.2) located on the upper flanges (2.4, 3.4) of both primary and secondary joists (2, 3) and fastened by means of shear connectors (6.1). Said shear connectors (6.1) and connecting plates (6.2) are also placed on the lower flanges (2.5, 3.5) of the primary and secondary joists (2, 3), thus achieving a pressure of the lower flanges (2.5, 3.5) together.

[0081] Due to this joint, the primary joists (2) support the weight of the whole structural flooring system (1), whereas the secondary joists (3) offer support through catenary action.

[0082] Figure 3 shows an schematic plan view of a structural flooring system (1) valid for every embodiment of the primary (2) and secondary (3) joists, wherein said primary joists (2) are oriented according to the first mounting direction (X) and said secondary joists (3) are oriented according to the second mounting direction (Y), being said directions perpendicular in the embodiment shown in figure 3.

[0083] As it can be observed, in this embodiment the first mounting direction (X) has been selected according to the smaller mounting dimension available, thus being the mounting distance available for the first mounting direction (X) smaller than the mounting distance available for the second mounting direction (Y), as said second mounting direction (Y) has been selected according to the larger mounting dimension available. The state of stress in the primary (2) and secondary (3) joists is different in this embodiment, particularly greater in the primary joists (2).

[0084] A slab (4) (not shown) is located in each of the spaces which are surrounded by the primary (2) and secondary (3) joists, therefore being adjacent to said joists (2, 3), and is preferably set in compression along the along the first (X) and second (Y) mounting directions.

[0085] Figure 3 also shows the joint between the ends of the joists (2, 3) with the building frames (8).

[0086] Figures 6A and 6B show a section of an embodiment of a structural flooring system (1) when mounted. The primary (2) and secondary (3) joists are mounted and joined by means of shear connectors (6.1) and connecting plates (6.2).

[0087] Figure 6A shows a primary joist (2) according to an embodiment as in figures 2A and 4 and two secondary joists (3) according to an embodiment as in figures 2B and 5. As shown in the figure, the secondary joists (3) are placed on the primary joist (2) such that the lower flanges (3.5) of the secondary joists (3) are supported on the lower flange (2.5) of the primary joist (2). The lower flange (2.5) of the primary joist (2) and the lower flanges (3.5) of the secondary joists (3) are joined by means of a splice plate (6.2) and shear connectors (6.1) which pass through a common bore to the splice plate (6.2) and the lower flange (3.5) of the secondary joist (3). This arrangement keeps the lower flange (2.5) of the primary joist (2.5) between the lower flanges (3.5) of the secondary joists (3) and the splice plate (6.2), whilst the splice plate (6.2) presses said lower flanges (2.5, 3.5) together, preventing the shift of any of them. Additionally, the upper flanges (3.4) of the secondary joists (3), in particular the cantilever portions (3.6), rest on the upper flange (2.4) of the primary joist (2), and are preferably joined therewith, for example by welding or bolts. In this embodiment an additional splice plate (6.2) is arranged on the upper flanges (3.4) of the two secondary joists (3) and is joined therewith by means of shear connectors (6.1).

[0088] Figure 6B shows the same mounting of the system (1) as in figure 6A but including the slab (4). Particularly, a concrete slab (4) is placed along with the primary joists (2) and the secondary joists (3), embedding the upper flanges (2.4, 3.4) of the primary and secondary joists (2, 3). The shear connectors (6.1) and connecting plates (6.2) located on the upper flanges (2.4, 3.4) of the primary and secondary joists (2, 3) are also embedded in the concrete slab (4).

[0089] As can be seen in figure 6B, the concrete slab (4) has a first face (4.1) and a second face (4.2), wherein in this embodiment said second face (4.2) is located adjacent to an insulation layer (7), not shown in the figure. Said insulation layer (7) shall be placed in the space available between the second face (4.2) of the slab (4) and the lower flange (3.5) of the secondary joist (3).

[0090] Figures 7A and 7B show a perspective view, top and bottom respectively, of a mounting of a continuous primary joist (2) and two secondary joists (3), all made of steel, wherein the mounting gives rise to a structural flooring system (1). Each primary joist (2) and secondary joist (3) is of the same depth in order to facilitate the assembly shown. The structural flooring system (1) is complete once the slabs (4), slab reinforcements (5) and insulation layers (7) are arranged on the present mounting of joists (2, 3). The primary joist (2) is configured as the embodiment shown in Figure 4, whereas the secondary joists (3) are configured as the embodiment shown in Figure 5. The mounting of the joists (2, 3) is as the one shown in figure 1A.

[0091] The primary joist (2) is oriented according to the first mounting direction (X), whereas the secondary joist (3) is oriented according to the second mounting direction (Y), being said directions (X, Y) perpendicular.

[0092] It can be seen in figure 7A how the secondary joists (3) are mounted on a primary joist (2) by means of a cantilever portion (3.6). Said cantilever portion (3.6) is supported by the upper flange (2.4) of the primary joist (2). The cantilever portion (3.6) is fastened to the upper flange (2.4) of the primary joist (2) by means of a connecting plate (6.2) which is in turn secured to the primary (2) and secondary (3) joists by means of shear connectors (6.1). Additionally, the mounting has an additional connecting plate (6.2) secured by means of shear connectors (6.1) which fasten the lower flanges (2.5, 3.5) of the primary (2) and secondary (3) joists.

[0093] The mounting of the two secondary joists (3) is symmetric, given that the primary joist (2) is a built-up section configured in a mirror-shape fashion such that two secondary joists (3) can be mounted in the same way on the same primary joist (2).

[0094] Additionally, figure 7A shows a bearer or bracket (9), which is the portion located next to the upper flange (2.4) of the primary joist (2).

[0095] Figure 7B shows the same mounting of figure 7A, although as a bottom perspective view. The connecting plate (6.2) which presses together the lower flanges (2.5, 3.5) of the primary (2) and secondary (3) joists is clearly visible in this figure. Particularly, figure 7B shows how each right-angled bottom flange (2.1.3) of the section (2.1) of the primary joist (2) are covered by the connecting plate (6.2) and secured by means of shear connectors (6.1) to the lower flange (3.5) of the secondary joist (3).

[0096] A view of the bracket (9) from the bottom can also be seen, thus observing a portion of said bracket (9) which is flat, in order to help supporting the mounting of joists (2, 3) of figures 7A and 7B to the building frame (8) thus configuring a final structural flooring system (1).

[0097] Figure 8 shows an exploded view of the elements of the structural flooring system (1). A primary joist (2) and two secondary joists (3) are depicted in the present figure, being thus only a part of a complete structural flooring system (1). Said primary (2) and secondary (3) joists are joined by means of a connecting plate (6.2) along with shear connectors (6.1). Said primary (2) and secondary (3) joists are made of light gauge steel.

[0098] The primary joist (2) has a built-up section with a right-angled upper flange (2.1.4) and a right-angled bottom flange (2.1.3), whereas the secondary joist (3) has a C-section. The depth of both sections of the primary (2) and secondary (3) joists is the same, being in the present embodiment 300mm deep each.

[0099] A bracket (9) is fixed to the primary joist (2), which provides additional support to the mounting of joists (2, 3), as the bracket (9) rests in the building frame by means of the flat portion of the bracket (9), shown in figure 7B.

[0100] The primary joist (2) is oriented according to the first mounting direction (X), and the secondary joists (3) are oriented according to the second mounting direction (Y), perpendicular to the first mounting direction (X). The gravity direction (Z) is perpendicular to both mounting directions (X, Y), as can be observed in figure 8.

[0101] A concrete slab (4) is located embedding parts of the primary (2) and secondary (3) joists, and the slab (4) is reinforced by means of a slab reinforcement (5), made of steel in this embodiment. The concrete slab (4) in the present embodiment is a 100mm thick deck slab.

[0102] This figure also shows an insulation layer (7), located on the second face (4.2) of the slab (4), in the present figure the face located lower according to the gravity direction (Z). The insulation layer (7), when arranged, covers the space present between the second face (4.2) of the slab (4) and the lower flange (3.5) of the secondary joists (3).

[0103] Additionally, steel elements can be seen in figure 8, corresponding said elements to part of the building frame which supports the structural flooring system (1).

[0104] The real loading in the present structural flooring system (1) comprises dead loads (corresponding to self-weight of structural elements), construction loads (corresponding to loads due to workers on deck, concrete pouring equipment, etc.), superimposed dead loads (such as weight of non-structural elements such as partitions, tile, etc.) and live loads (those due to the system in use, that is, people occupying the building, furniture, etc.), being the sections (2.1, 3.1) of the primary (2) and secondary (3) joists able to support both the mentioned loads in combination as well as the effect due to attributed bending strength generated in the redistribution of the mentioned loads. Stress levels of the structural elements and deflections are kept within the standards due to the different joists (2, 3).

Claims

1. Structural flooring system (1), comprising:

- at least one primary joist (2),
- at least one secondary joist (3),
- at least one splice plate (6.2) and at least one shear connector (6.1),
- at least one slab (4), the slab (4) comprising a first face (4.1) and a second face (4.2), being the first face (4.1) located in an upper position than the second face (4.2) according to the gravity direction (Z), and
- at least one slab reinforcement (5),

wherein

- the primary joists (2) are oriented according to a first mounting direction (X) perpendicular to the gravity direction (Z),
- the secondary joists (3) are oriented according to a second mounting direction (Y) perpendicular to the gravity direction (Z),
- the section (2.1) of the primary joists (2) is a built-up section, said section (2.1) comprising a first section end (2.2) and a second section end (2.3), being the first section end (2.2) located in an upper position than the second section end (2.3) according to the gravity direction (Z),
- the section (3.1) of the secondary joists (3) is a C section, said section (3.1) comprising a first section end (3.2) and a second section end (3.3), being the first section end (3.2) located in an upper position than the second section end (3.3) according to the gravity direction (Z),
- each secondary joist (3) comprises an upper flange (3.4) located at the first section end (3.1) and a lower flange (3.5) located at the second section end (3.2), and at least a cantilever portion (3.6) located on one or both ends of the upper flange (3.4),
- each primary joist (2) comprises a lower flange (2.5) at the second section end (2.3) and an upper flange (2.4) at the first section end (2.2), wherein the upper flange (2.5) supports a cantilever portion (3.6) of at least one secondary joist (3),
- the lower flange (2.5) of the primary joist (2) and the lower flange (3.5) of the secondary joist (3.5) are pressed together by means of the splice plate (6.2) and the at least one shear connector (6.1),
- the slab (4) is located adjacent to the primary

joists (2) and to the secondary joists (3), covering the first section end (2.2) of the primary joist (2) and the first section end (3.2) of the secondary joist (3), and
- the slab reinforcement (5) is located on the first face (4.1) of the slab (4).

2. Structural flooring system (1) according to claim 1 wherein the slab (4) is strengthened along the first (X) and second (Y) mounting directions by means of the loading of the primary (2) and secondary (3) joists.

3. Structural flooring system (1) according to claim 2 wherein the strengthening of the slab (4) is such that said slab (4) is set in compression along the first (X) and second (Y) mounting directions.

4. Structural flooring system (1) according to any of the preceding claims wherein the built-up section (2.1) of the primary joist (2) is made up of two elements, wherein each of said elements comprises:

- a web (2.1.1), the web (2.1.1) comprising a first web end and a second web end,
- a curved top flange (2.1.2) located at the first web end, and
- a right-angled bottom flange (2.1.3), located at the second web end,

and the two elements are located with their respective webs (2.1.1) facing one another such that the flanges (2.1.4, 2.1.3) of both elements extend along opposite directions.

5. Structural flooring system (1) according to any of claims 1 to 3 wherein the built-up section (2.1) of the primary joist (2) is made up of two elements, wherein each of said elements comprises:

- a web (2.1.1), the web (2.1.1) comprising a first web end and a second web end,
- a right-angled top flange (2.1.4), located at the first web end, and
- a right-angled bottom flange (2.1.3), located at the second web end,

and the two elements are located with their respective webs (2.1.1) facing one another such that the flanges (2.1.2, 2.1.3) of both elements extend along opposite directions.

6. Structural flooring system (1) according to any of the preceding claims wherein the first mounting direction (X) is selected according to the smaller mounting dimension available and the second mounting direction (Y) is selected according to the larger mounting dimension available.

7. Structural flooring system (1) according to any of the preceding claims wherein the first mounting direction (X) and the second mounting direction (Y) are perpendicular.

8. Structural flooring system (1) according to any of the preceding claims wherein the lower flange (2.5) of the primary joist (2) rests between the lower flange (3.5) of the secondary joist (3) and the splice plate (6.2).

9. Structural flooring system (1) according to any of the preceding claims wherein the slab reinforcement (5) is steel or fibre reinforcement.

10. Structural flooring system (1) according to any of the preceding claims further comprising an insulation layer (7), located between the second face (4.2) of the slab (4) and the second section end (3.3) of the secondary joist (3).

11. Structural flooring system (1) according to any of the preceding claims wherein the primary (2) and secondary (3) joists are made of light gauge steel.

12. Structural flooring system (1) according to any of the preceding claims wherein the primary (2) and secondary (3) joists have both the same depth.

13. Method for mounting a structural flooring system (1) according to any of the preceding claims, comprising the following steps:

a) providing a plurality of primary joists (2) and secondary joists (3) according to the dimensions of the space for building a floor,
b) placing the primary joists (2) along the first mounting direction (X) and the secondary joists (3) along the second mounting direction (Y), leaving a distance between each of the primary joists (2) and between each of the secondary joists (3) according to the dimensions of the slab (4),
c) fixing the ends of the primary joists (2) and secondary joists (3),
d) placing at least one formwork panel (7) between the primary and secondary joists (2, 3),
e) forming the slabs (4) on the formwork panel (7) placed between the primary (2) and secondary (3) joists, the formed slab (4) covering the first section end (2.2) of the primary joist (2) and the first section end (3.2) of the secondary joist (3), and
f) strengthening the slabs (4) in both the first and second mounting directions (X, Y).

14. Method for mounting a structural flooring system (1) according to the preceding claim, wherein the formwork panels (7) of step d) comprise at least one insulation layer.

15. Method for mounting a structural flooring system (1) according to claims 13 or 14, wherein the slab (4) formed in step e) is poured in place.

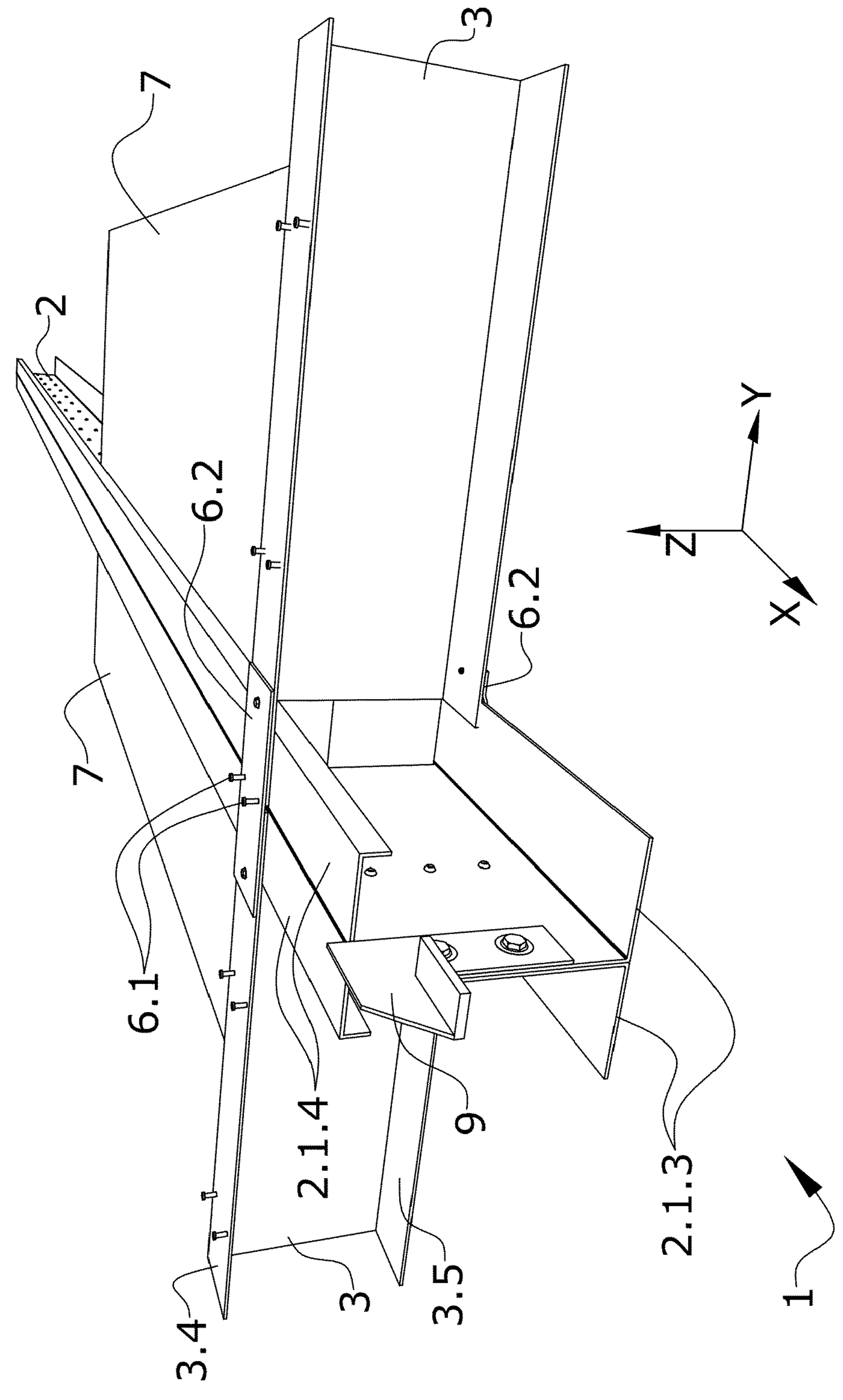

FIG.1A

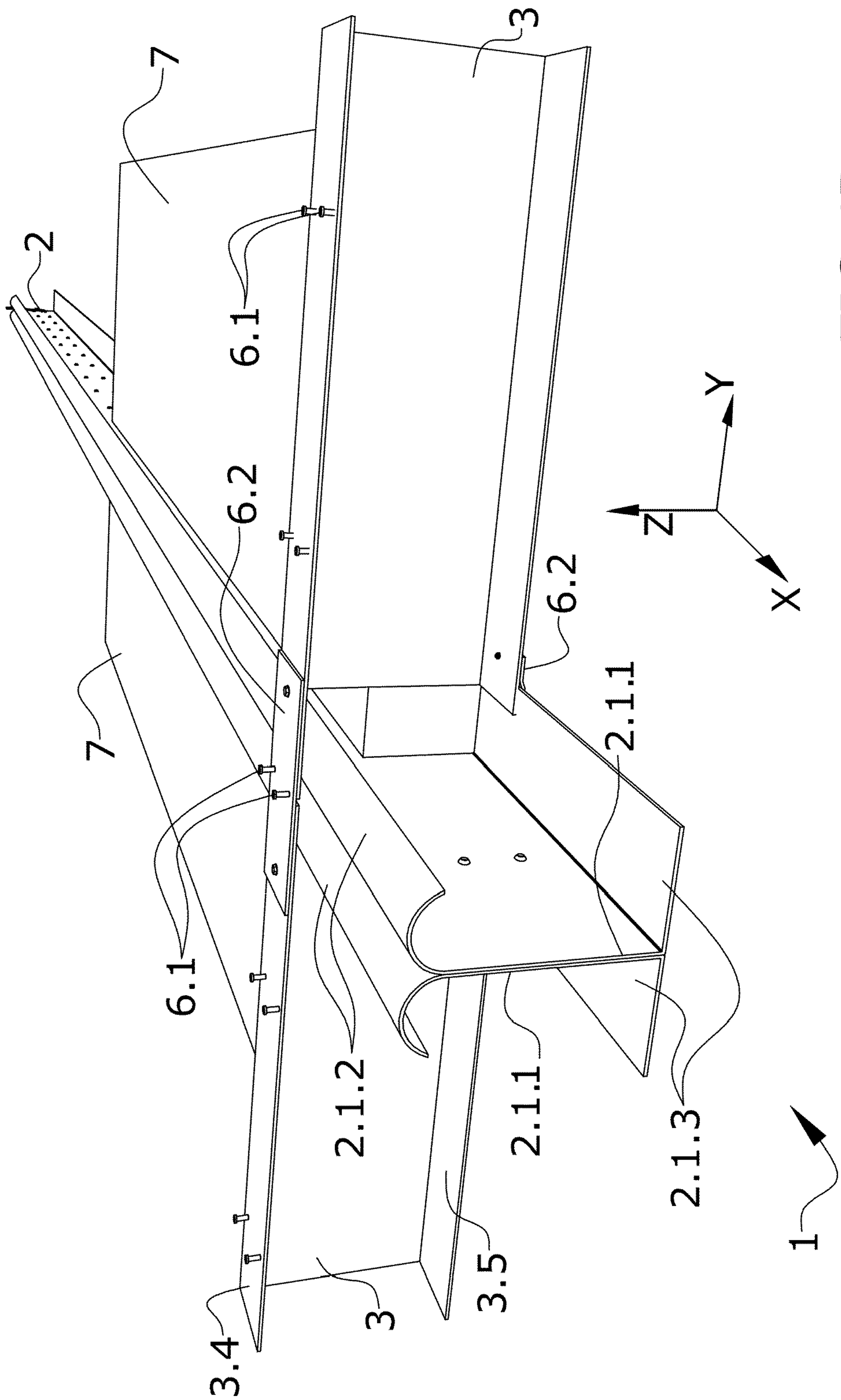

FIG.1B

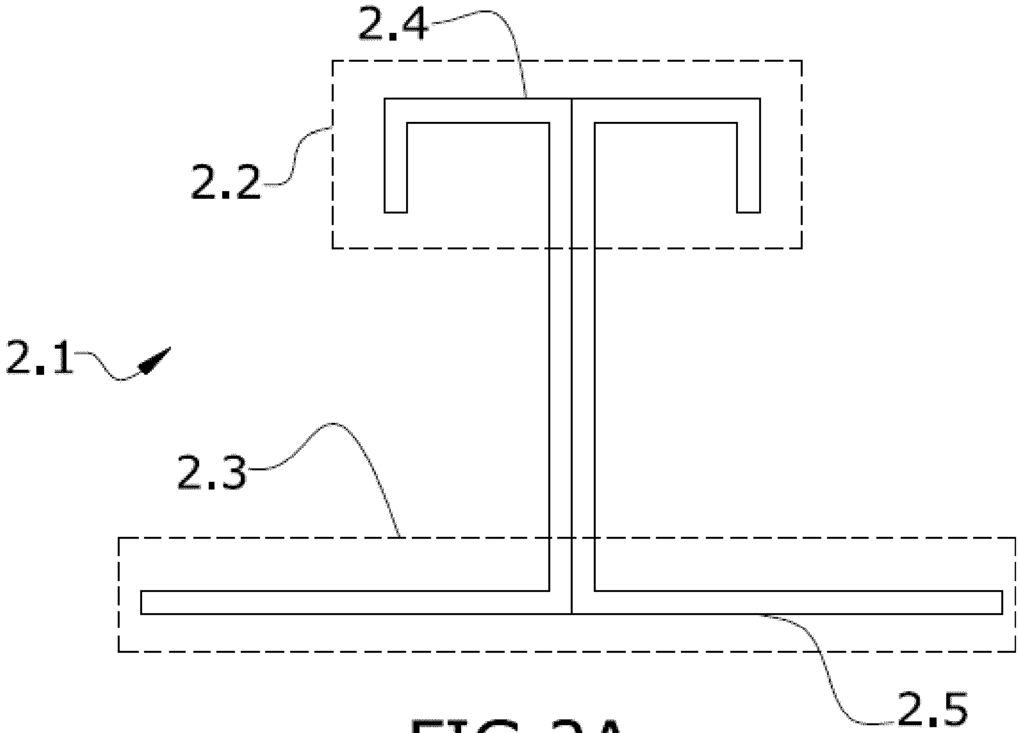

FIG.2A

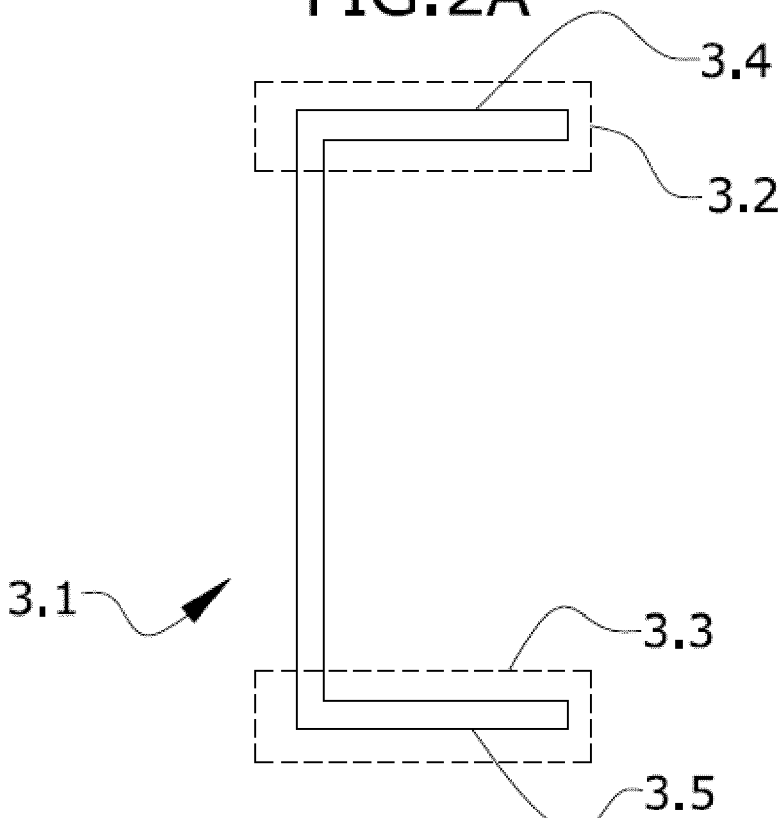

FIG.2B

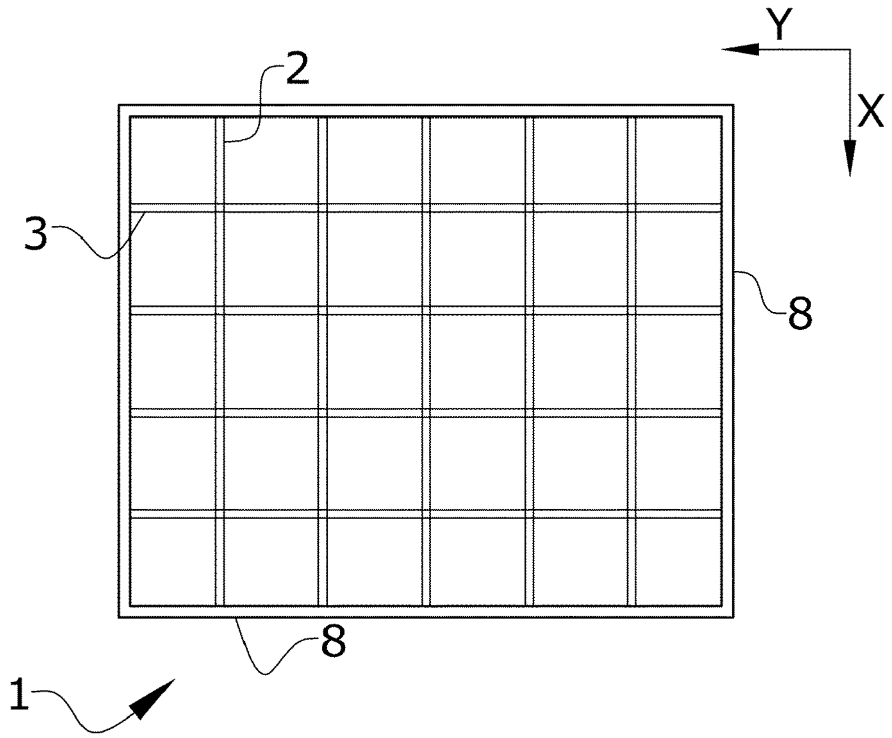

FIG.3

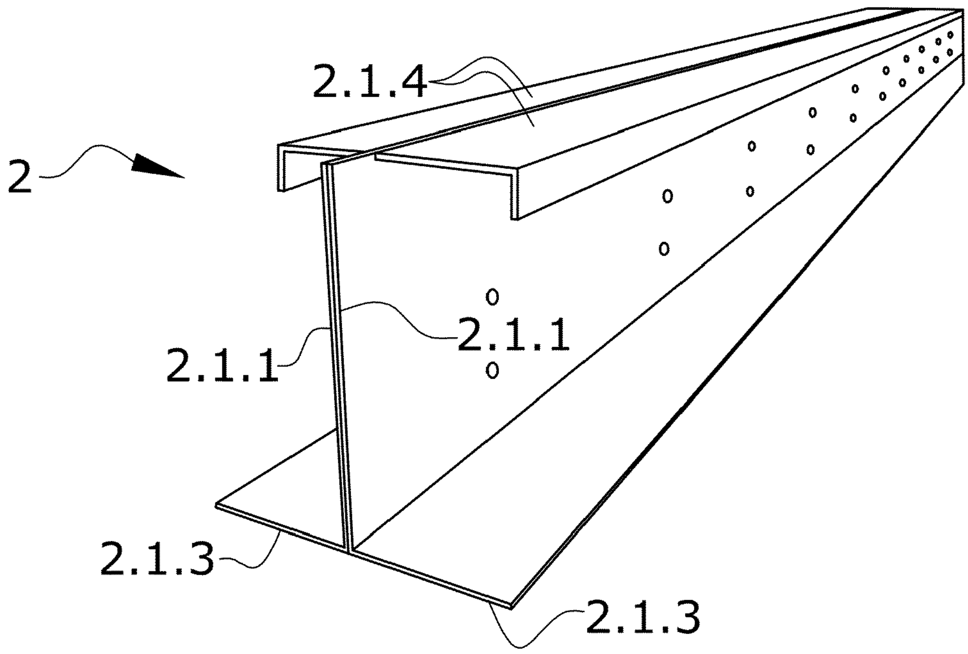

FIG.4

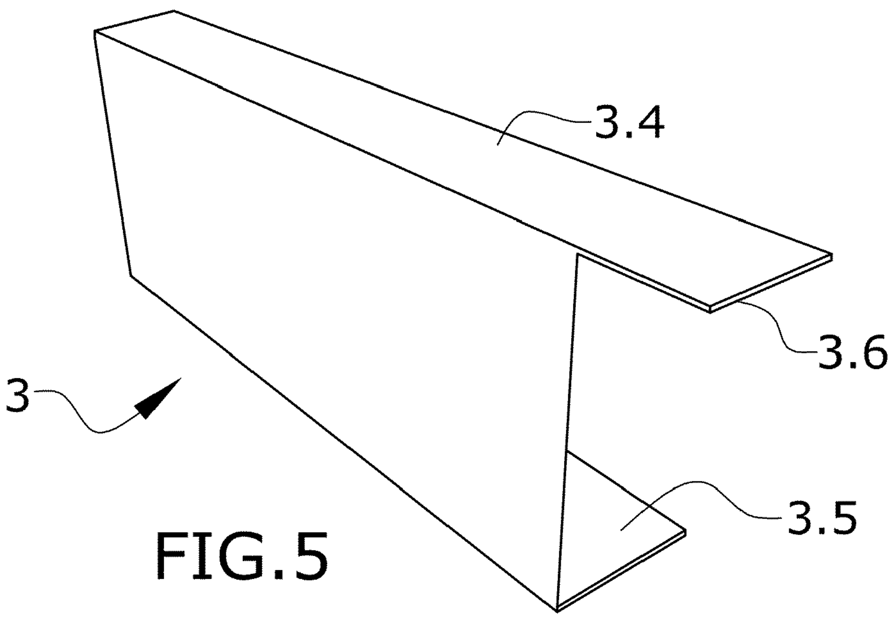

FIG.5

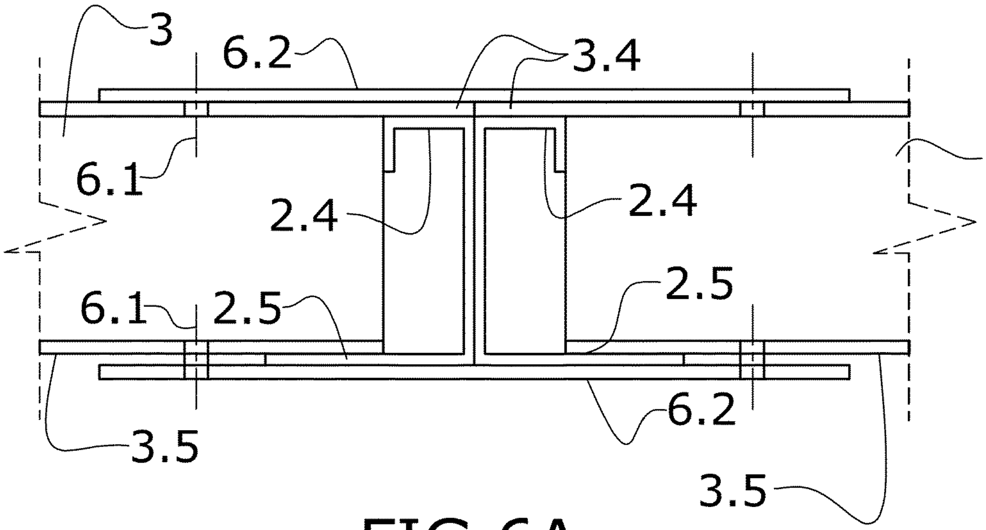
3
6.2
3.4
3
6.1
2.4
2.4
2.5
6.1
2.5
6.2
3.5
3.5

FIG.6A

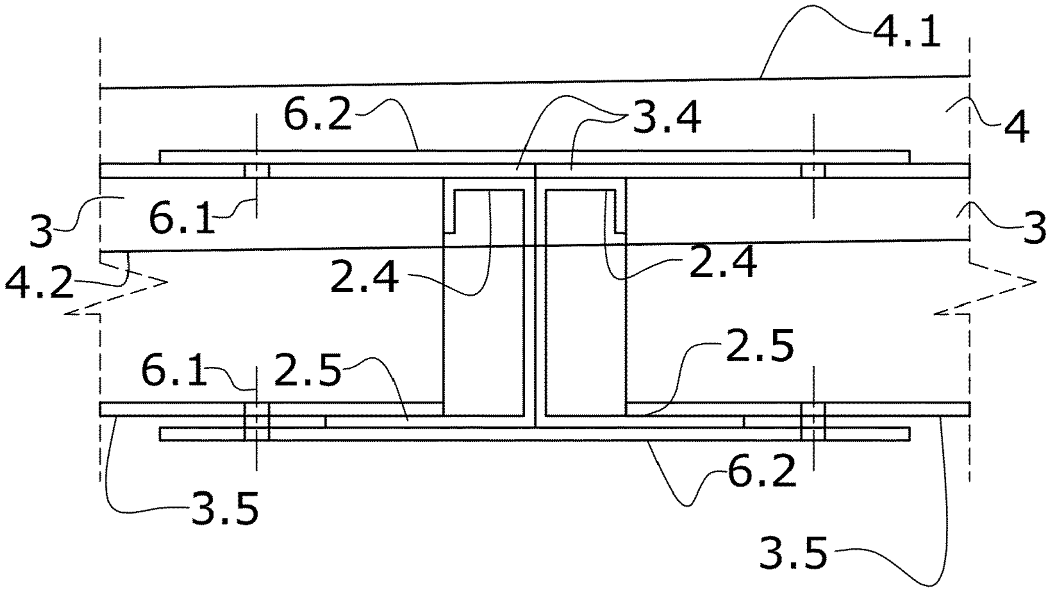
4.1
6.2
3.4
4
3
6.1
3
4.2
2.4
2.4
2.5
6.1
2.5
6.2
3.5
3.5

FIG.6B

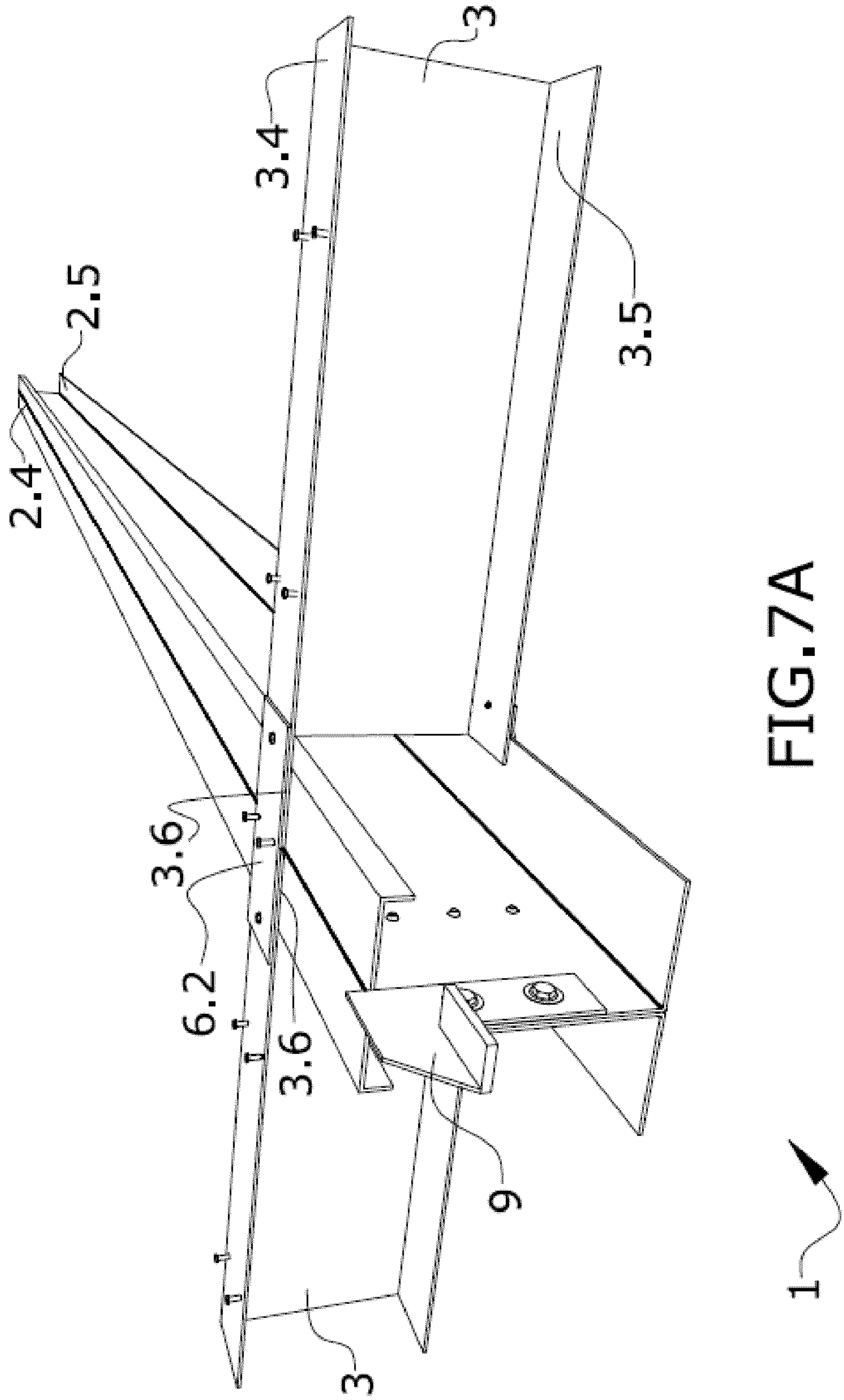

FIG.7A

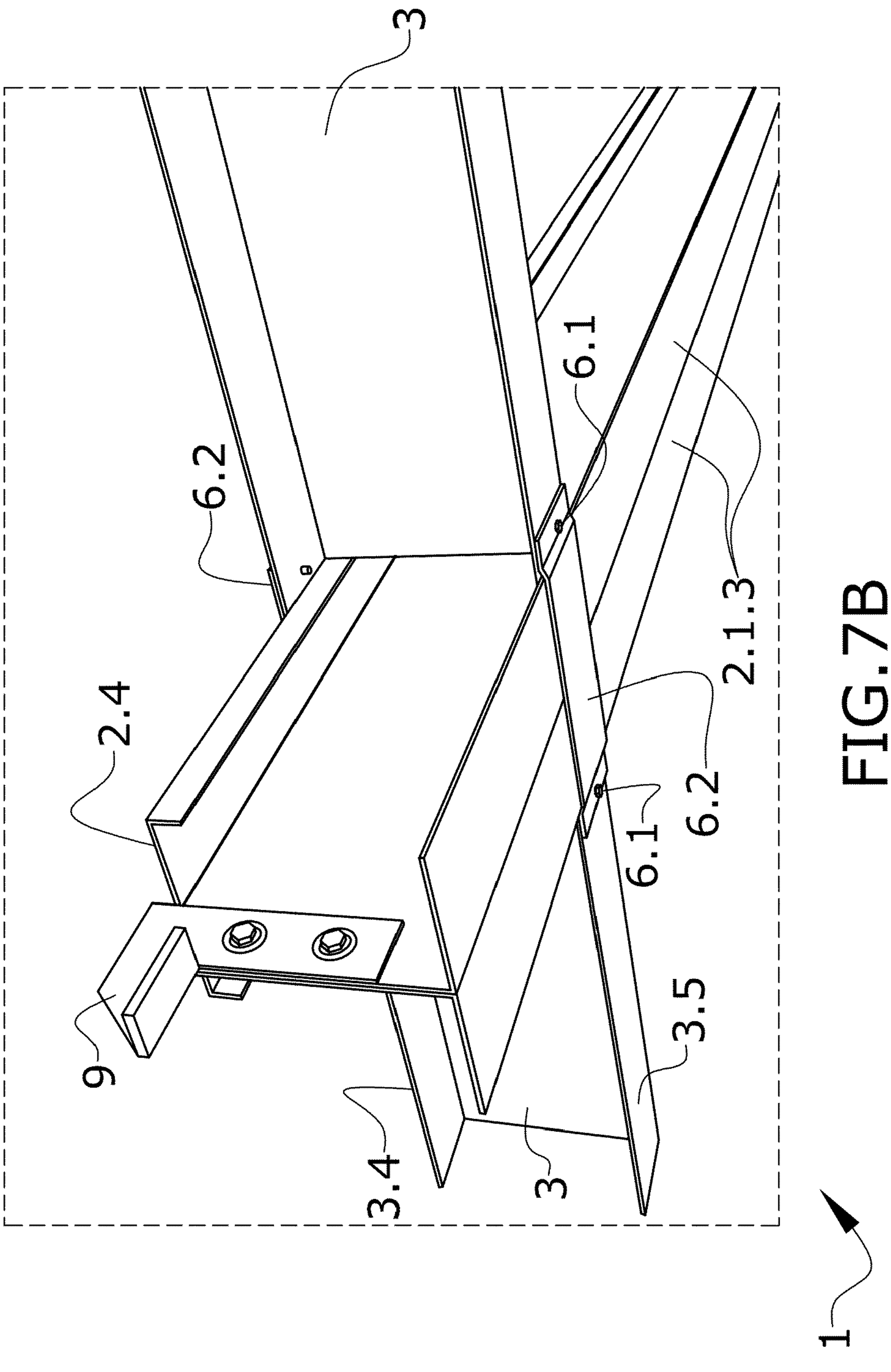

FIG.7B

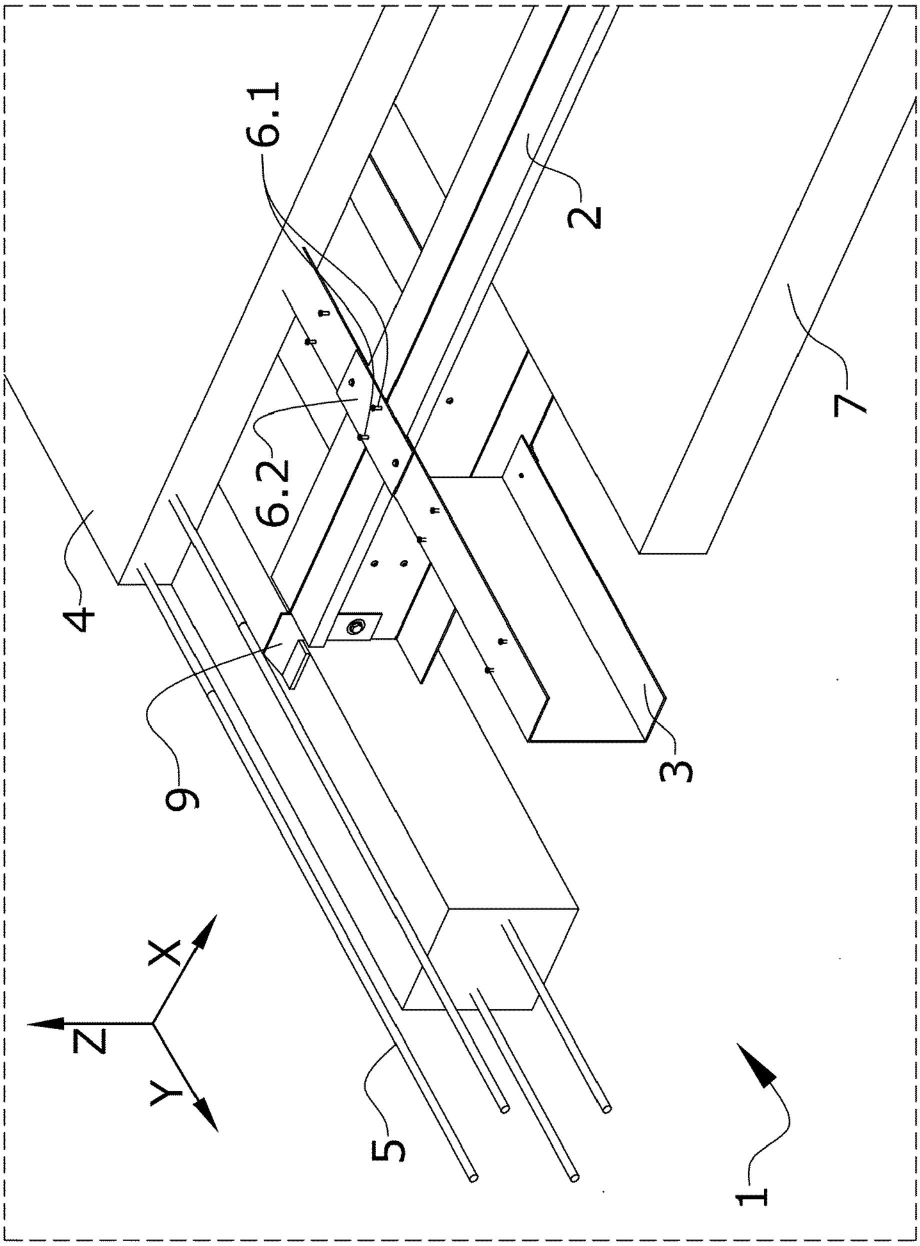

FIG.8

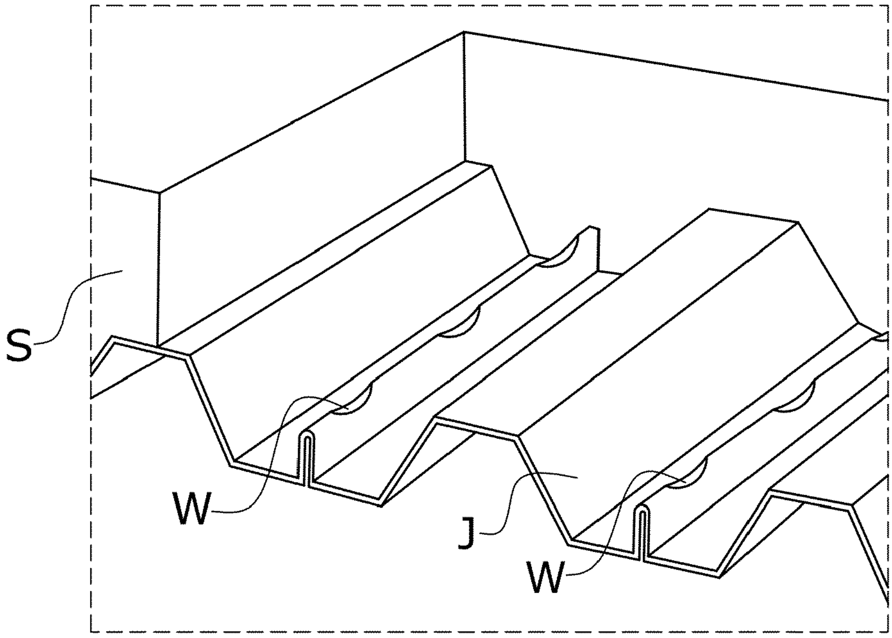

FIG.9A

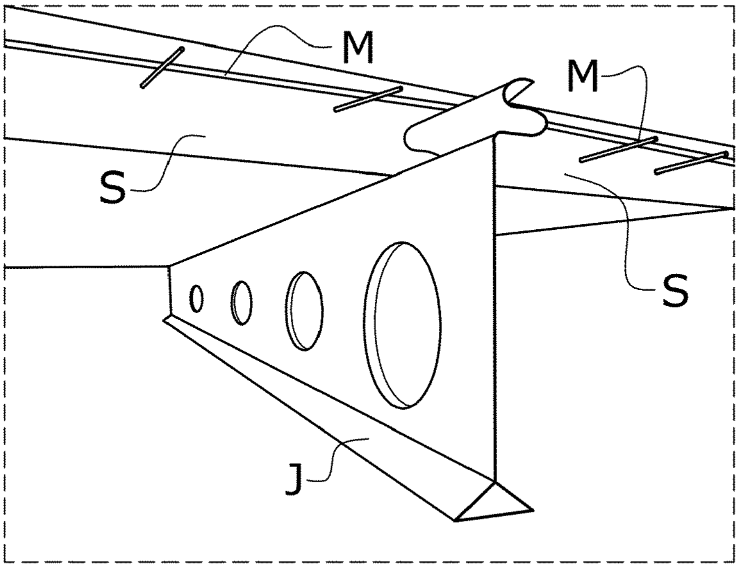

FIG.9B

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 9904

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	US 2005/188638 A1 (PACE MALCOLM J [US]) 1 September 2005 (2005-09-01) * figure 1 * -----	1	INV. E04B1/24 E04B5/29
A	WO 2015/087070 A1 (LAING O ROURKE PLC [GB]) 18 June 2015 (2015-06-18) * figures 5-6 * -----	1	
A	US 2010/037551 A1 (BODNAR ERNEST R [CA]) 18 February 2010 (2010-02-18) * figure 4 * -----	1	

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	12 April 2018	Demeester, Jan

CATEGORY OF CITED DOCUMENTS

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12-04-2018

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