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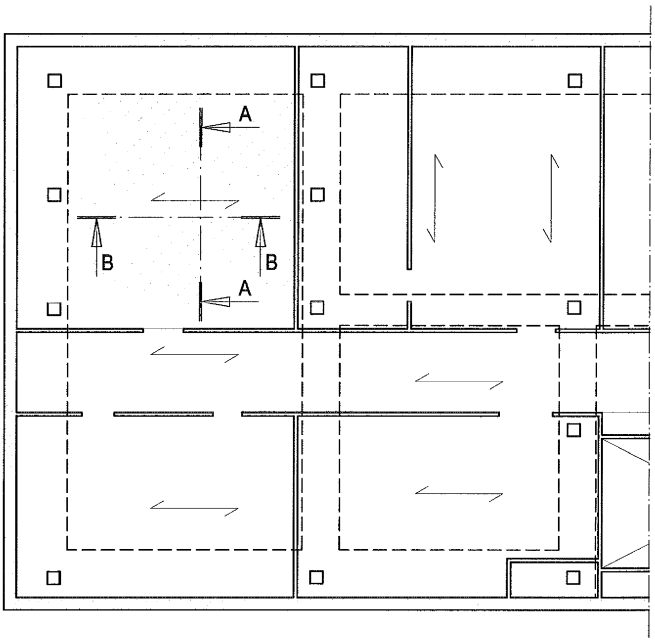
(54) **METHOD FOR THE REINFORCEMENT OF RIBBED FLOORS WITH A DIVISION SLAB MADE OF CAST CONCRETE AND FLOOR THUS REINFORCED**

(57) A method for the reinforcement of ribbed floors essentially comprising a division slab made of cast concrete associated with a series of underlying joists (13, 113, 213, 313), comprising the following steps:
- preparation of a series of steel profiles (17) and arrangement of said profiles (17) at the intrados of the ribbed floor to be reinforced, wherein the arrangement is effected by positioning the profiles (17) close to the ribs of the floor, consisting of the joists (13, 113, 213, 313), according to a direction orthogonal to the direction of the joists (13, 113, 213, 313), forming a transversal connection between the joists (13, 113, 213, 313);
- producing a constraint between the profiles (17) and the joists (13, 113, 213, 313) through stable positioning means (18) forming a dry installation adhering to the intrados of the floor of the profiles (17).

Fig. 1



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Description

[0001] The present invention relates to a method for reinforcing ribbed floors with a division slab made of cast concrete and the floor thus reinforced.

[0002] The field of interest relates to building constructions which provide ribbed floors, i.e. horizontal ribbed structures capable of transferring loads, mainly vertical loads, to other structures of the construction.

[0003] The general term ribbed floor refers to floors which mainly provide floors with prefabricated ribs, installed ribs, ribs with wooden beams or joists, ribs with steel beams or joists. Floors with prefabricated and installed ribs typically refer to brick-cement floors, whereas the other two types relate to wooden floors and mixed steel-concrete floors.

[0004] In all these types of existing floors, there may be a need for restructuring and consolidation interventions.

[0005] This necessity often arises in buildings which undergo changes in destination of use which provide consequent variations in the loads involved, either permanent or variable.

[0006] These interventions are also due and imposed by new specific regulations which are aimed at trying to optimize safety problems of the building structure in question, also with reference to seismic performances.

[0007] Furthermore, ribbed floors of the type described above do not appear rigid, with an evident centreline arrow, and even with a natural sensation of strong oscillations or vibrations.

[0008] The interventions can be aimed at solving further types of problems such as:

- an improvement in the durability of the structures in relation to the natural aging of the structures (age of the buildings);
- a degradation in the ribs due to oxidation and a reduction in the resistant reinforcement section;
- a natural relaxation of the structures;
- problems arising in slender floors;
- lack of section dividers;
- post-fire interventions;
- anti-breakthrough security.

[0009] The reinforcement or consolidation interventions to be effected must therefore have a series of objectives such as:

- increasing the rigidity of the floor;
- reducing centerline arrows;
- overcoming the shortcomings revealed by the increased operating loads of the new destination of use;
- improvement in the transversal behaviour in the absence of section dividers;
- improvement in the case of seismic events;
- improvement in its behaviour with respect to the performances required by new regulations;
- improvement in the performances of floors affected by fire.

[0010] Various solutions proposed by the market deriving directly from current maintenance and construction techniques are currently in use.

[0011] These known proposals indicate various different solutions for reinforcing ribbed floors, which can be summarized in the following three main categories:

use of pultruded sheets or fabrics called CFRP with "carbon fibers";
construction of supplementary collaborating slabs;
installation of section-divider beams.

[0012] With respect to the technique using pultruded sheets or "fiber-reinforced polymer products" or CFRP fabrics with "carbon fibers", this provides the preparation of this additional product in the intrados of the joists or ribs along their entire length.

[0013] This is to provide an integration of the longitudinal flexural load-bearing capacity of the floor. According to this technique, before the application of this additional product, an adequate treatment of the joists or ribs of the floor is necessary.

[0014] Preparation and cleaning operations must be effected of the support, which must be clean and dry and have appropriate mechanical properties. The following steps are therefore generally necessary:

- preparation of the base of the joists by removal of the finishing, demolition of the incoherent parts of the ribs (rod covers) with stripping of the reinforcements for the consequent anticorrosion treatment, reconstruction of the missing parts using structural mortars, and cleaning and finishing of the surface;
- application of a coat of Primer using a roller or brush with a waiting period of $3 \div 4$ hours for the setting of the primer. In the case of excessive absorption of the joist, the application of a second coat of primer may be necessary;
- subsequent application of a first coat of impregnating resin-adhesive;
- application of the carbon-fiber strip and rolling to eliminate any possible blisters;
- application of a second coat of impregnating resin-adhesive;
- application of quartz sand on fresh resin to improve the adhesion of the subsequent plaster finish.

[0015] From the above, it can be immediately seen that this known technique on the whole has various advantages such as additional weight with zero impact, no connection with the vertical load-bearing structures, it requires no perturbation of the extrados of the floor, and it acts on the behaviour in the main direction of the floor.

[0016] Various disadvantages must also be taken into

consideration, consisting in: relatively lengthy preparation and installation times, the use of specialized labour, with consequent costs for its implementation of a certain relevance, and there is no improvement of the transversal behaviour of the floor.

[0017] With respect, on the other hand to the second known technique indicated, as already mentioned, this provides the construction of supplementary collaborating slabs. This technique is based on the construction of a new slab made of reinforced concrete, at the extrados of the structural component of the existing floor, perfectly collaborating with the existing floor with the use of mechanical or chemical connectors.

[0018] A first notation is that this technique as a whole is extremely invasive at the extrados of the floor. It requires, in fact, the stripping of the structural component with the removal of the flooring, subfloor with plants and stripping of the joists, it requires relatively lengthy implementation times as it provides casting the concrete with water, normal concrete curing after shoring operations during said curing and new reconstruction of the finishings and flooring.

[0019] It should also be pointed out that it creates a significant additional weight, for which a static evaluation of the new conformation of the structure is appropriate together with a verification of the performances with respect to seismic actions. An alternative is to exploit the use of concretes and new lightened blocks, containing not more than the thicknesses.

[0020] This technique generally requires connections with the perimetric structures.

[0021] Other disadvantages relating to costs, times, labor, and the fact that no remediation is effected of the intrados of the slabs and ribs, should also be remembered.

[0022] With respect to the third known technique used, this provides the introduction of section-divider beams, generally made of steel.

[0023] This technique is based on the introduction at the intrados of the floor, in a direction orthogonal to the trend of the supporting ribs, of beams that create a further constraint to the deformability of the floor.

[0024] This operation does not require the introduction of perturbations with respect to the extrados of the floor.

[0025] This technique, moreover, generally requires the necessity of triggering the new restraining mechanism (also by the construction of counter-mounts).

[0026] The new structural element introduced must also be connected to the vertical structures, if present, in the positioning points of the new section dividers so as to transfer the additional vertical loads to the foundations. Furthermore, this solution cannot always be easily implemented for buildings with a frame bearing structure and not load-bearing masonry.

[0027] In this way, the new constraint causes a variation in the internal stress that requires a static evaluation of the new conformation of the structure, and also a verification of the performances with respect to seismic actions.

[0028] An example of the technique is also disclosed by GB 2175036 A which teaches how to constrain existing metal joists with brackets to be hot bent that completely envelop said metallic joists. The additional brackets are arranged in the same direction as the metal joists and are connected to plates or panels that extend beneath the whole floor. A metallic net is positioned between the plates or panels and the brackets thus constrained to the joists, to which an application of concrete is added, forming an additional reinforcing slab.

[0029] In this way, a considerable weight is added to the existing slab, weighing even more on the existing weakened structure to be reinforced.

[0030] A further example of the known art is disclosed by ES2048047A2 wherein existing metal joists are reinforced by prefabricated elements designed for supporting them, following their same direction beneath them and partially embracing them. These prefabricated reinforcing elements are self-supporting reinforced concrete structures that have to be inserted or engaged in the walls or vertical side load-bearing walls. They therefore have a negative impact on the existing vertical load-bearing structure which is affected, and a negative impact due to their additional weight.

[0031] US 2004/068944 discloses a construction method in houses. The document discloses *inter alia* how in some new constructions finishing elements can be positioned beneath the slabs of the floors, proposing joists including metal channels to which said finishing elements are constrained.

[0032] From the brief description and definition of the above-mentioned known techniques, it can be seen that they have various critical aspects, making them invasive and costly.

[0033] The general objective of the present invention is to provide a method for reinforcing ribbed floors with a division slab made of cast concrete and a floor thus reinforced, which is capable of overcoming the above drawbacks of the known art in an extremely simple, economical and particularly functional way.

[0034] A further objective of the present invention is to provide a method for reinforcing ribbed floors which does not require preliminary surface treatment operations, or the removal of civil finishings of the intrados, or prolonged installation times due to setting and hardening necessities and/or activation of wet materials.

[0035] Another objective of the present invention is to provide a method for reinforcing ribbed floors which does not require a link or connection with the vertical load-bearing structures, so as not to require works aimed at transferring additional loads to the foundation.

[0036] Yet another objective of the present invention is to provide a method for reinforcing ribbed floors with an installation intervention of the floor at the intrados that does not involve any perturbation of the extrados, such as the removal of flooring or finishings.

[0037] A further objective of the present invention is to

provide a method for reinforcing ribbed floors that does not involve additional weight or weight with a minimum impact with respect to the weight of the floor itself.

[0038] Another objective of the present invention is to provide a reinforced ribbed floor which is particularly simple to obtain and with limited production and installation costs.

[0039] The structural and functional characteristics of the present invention and its advantages with respect to the known art will appear even more evident from the following description, referring to the enclosed schematic drawings which show embodiment examples of the method itself in a reinforced ribbed floor according to the invention. In the drawings:

- figure 1 is a plan view from above of a generic intervention area, such as a room, in a ribbed floor in which the reinforcement method of the present invention is implemented;
- figures 2 and 3 are two enlarged sectional views according to the directions A-A and B-B respectively of figure 1 when, in the intervention area, the ribbed floor is made of brick cement with prefabricated ribs;
- figures 4 and 5 are two sectional views completely similar to those of figures 2 and 3 in which the method of the invention also provides the application of a sheet with an anti-breakthrough function;
- figures 6 and 7 are two enlarged sectional views according to the directions A-A and B-B respectively of figure 1 when, in the intervention area, the ribbed floor is made of brick cement with ribs cast in situ;
- figures 8 and 9 are two sectional views completely similar to those of figures 6 and 7 in which the method of the invention also provides the application of a sheet with an anti-breakthrough function;
- figures 10 and 11 are two enlarged sectional views according to the directions A-A and B-B respectively of figure 1 when, in the intervention area, the ribbed floor is made of wood with ribs of wooden joists;
- figures 12 and 13 are two sectional views completely similar to those of figures 10 and 11 in which the method of the invention also provides the application of a sheet with an anti-breakthrough function;
- figures 14 and 15 are two enlarged sectional views according to the directions A-A and B-B respectively of figure 1 when, in the intervention area, the ribbed floor is a mixed steel-concrete floor with ribs of steel joists;
- figures 16 and 17 are two sectional views completely similar to those of figures 14 and 15 in which the method of the invention also provides the application of a sheet with an anti-breakthrough function.

[0040] With reference to the figures in general, these show details in a sectional view of a ribbed floor, in various embodiments of the floor, in all of which a reinforcement method according to the present invention is implemented, thus also illustrating reinforced ribbed floors according to the invention.

[0041] It should be noted that all the various embodiments of ribbed floors, shown in the respective sections, in which the reinforcement method according to the present invention is implemented, refer to a generic intervention area, such as a room, shown in the plan view from above of figure 1 for the sake of convenience.

[0042] The ribbed floors essentially comprise a division slab made of cast concrete associated with a series of underlying joists, having various forms and materials, with the possible addition of further completion construction elements.

[0043] Figures 2 and 3, which, as already mentioned are two enlarged sectional views according to the directions A-A and B-B respectively of figure 1, refer to a ribbed floor made of brick cement with prefabricated ribs.

[0044] In particular, it can be noted that this type of floor consists of a division slab in case concrete which comprises a series of interspaced hollow bricks 12 between joists are positioned, in this case prefabricated joists 13. The slab is completed by reinforcement rods 14 (partially shown) and a filling of concrete casting 15 to block the whole assembly, upon complete engagement. A lower finishing plaster normally completes the floor in its original construction, but this is not compulsory.

[0045] When a reinforcement of the floor is required to try to annul or reduce centreline arrows and increase the rigidity of the floor, a method according to the present invention is implemented so as to produce a reinforced ribbed floor whose final form is shown in the figures.

[0046] The following steps are in fact provided.

[0047] A series of steel profiles 17 is first prepared and they are then positioned at the intrados of the floor.

[0048] This arrangement is obtained by positioning the profiles 17 close to the ribs of the floor, in this specific example consisting of prefabricated joists 13. This arrangement is effected by positioning the profiles 17 orthogonally to the direction of the ribs or prefabricated joists 13, forming a transversal connection between the various joists 13.

[0049] When these steps have been completed, a constraining step is effected between the profiles 17 and joists 13 using stable positioning means, such as, in this case, mechanical anchoring dowels 18.

[0050] In this way, a dry installation is formed, adhering to the intrados of the floor of this series of profiles 17.

[0051] Said profiles can have the most suitable sectional configurations for implementing the method of the present invention and can have various forms and shapes, such as typically "I"-, "C"-, "U"-shaped, box-like, open or closed, etc.

[0052] In the exemplifying but non-limiting embodiment illustrated, these profiles 17 are in particular profiles with a steel omega-shaped section. Figures 2 and 3 show how this omega-shaped section preferably consists of an upper portion of the omega composed of an upper flat central and straight section 20 which extends into two straight side tracts 21, diverging outwardly, terminating

with a further two straight base sections 22. Said straight base sections 22 also preferably diverge outwardly and receive stable positioning means, i.e. the mechanical anchoring dowels 18.

[0053] Figures 4 and 5 are two sectional views completely analogous to those of figures 2 and 3, in which the reinforcement method of the floor according to the invention provides a further step after the application of the profiles by means of the steps previously described.

[0054] Again according to the invention, in fact, in order to guarantee the anti-breakthrough function, an application step is effected of one or more sheets having an anti-breakthrough function 23 under said profiles 17. Said sheets 23 first of all form a dry covering of the above-mentioned profiles 17.

[0055] Said sheets 23 can generally be gypsum-fiber sheets or the like, which, in addition to forming a connection between the profiles 17, provide the floor thus reinforced with the capacity of sustaining possible breakthroughs.

[0056] It should be pointed out that in brick-cement floors installed in buildings, a drawback can arise due to the detachment and subsequent falling of the intrados, i.e. the lower portion of the brick-cement blocks and relative coating, made of cement or with plaster. This phenomenon is called "breakthrough" in technical jargon. The reasons for this subsidence can depend on the characteristics of the materials forming the floor, the specific situation of use, project accuracy or lack of accuracy and how the floor itself is actually laid on site. This therefore explains the "anti-breakthrough function" previously indicated.

[0057] Figures 6 and 7, as also figures 8 and 9, show a further embodiment of a floor reinforced according to the method of the invention.

[0058] In this second example, the same elements are indicated with the same reference numbers and, as for the previous example, the enlarged sectional views are taken according to the directions AA and BB respectively of figure 1 in a generic intervention area.

[0059] This second example shows how this type of ribbed floor is produced in brick-cement with ribs defined by joists cast on site 113.

[0060] The further characteristics are similar and the method implemented for obtaining the reinforcement consists in the same operational steps indicated above, for both the application of the profiles 17 and in the application step of the sheets having an anti-breakthrough function 23.

[0061] With respect to the example of figures 10 to 13, the ribbed floor to be reinforced in this case consists of a division slab comprising a concrete casting 215 positioned above a wooden planking 24. The whole unit is supported by a series of wooden joists 213 forming this type of ribbed floor. An intrados in wattle or finishing plastered network 216 generally completes the floor in its original construction, but this is not compulsory.

[0062] Also in this case, when a reinforcement of the floor is required to try to annul or reduce centreline arrows and increase the rigidity of the floor, a method according to the present invention is implemented producing a reinforced ribbed floor whose final form is shown in figures 10 to 13.

[0063] Also in this case, the method provides exactly the same steps indicated for the first two examples of a floor. In this case, the profiles 17 are obviously positioned close to the ribs of the floor, in this specific example consisting of wooden joists 213. This arrangement is effected by positioning the profiles 17 orthogonally to the direction of the ribs or wooden joists 213, forming a transversal connection between the various joists 213.

[0064] The constraining step of the method, in this case is effected between the profiles 17 and wooden joists 213 using stable positioning means, such as, in this case, mechanical anchoring dowels 18, for example specific for wood.

[0065] Also for this ribbed floor with wooden joists 213, a positioning and completion step of anti-breakthrough sheets 23 is provided for retaining the detachment of the intrados in wattle or plastered network 216.

[0066] The further example of figures 14 to 17 proposes a ribbed floor to be reinforced consisting of a division slab comprising a concrete casting 315 positioned above a series of upper adjacent flooring blocks 25 supported by a series of steel joists 313. The steel joists 313 represented have an I-shaped section, but may have different sections in any case suitable for exerting the same function. A series of lower adjacent flooring blocks 26 also supported by the above series of steel joists 313 forms the ceiling part of the environment, which is preferably subsequently finished and covered with a plaster 16. This further example of a similar ribbed floor is thus obtained.

[0067] Also in this case, when a reinforcement of the floor is required to try to annul or reduce centreline arrows and increase the rigidity of the floor, the method according to the present invention is implemented producing a reinforced ribbed floor whose final form is shown in figures 14 to 17.

[0068] Also in this case, the method provides the implementation of the general step previously indicated for the other examples of a floor.

[0069] In order to proceed in this sense, the profiles 17 are positioned close to the plaster 16, if present, or the steel joists 313 that act as ribs for the floor.

[0070] This arrangement is effected by positioning the profiles 17 orthogonally to the direction of the ribs or steel joists 313, forming a transversal connection between the various joists 313.

[0071] The constraining step of the method is effected between the profiles 17 and steel joists 313 using stable positioning means, such as, in this case, mechanical anchoring dowels 18, for example specific for steel.

[0072] A positioning step of sheets with an anti-breakthrough function 23 for the lower completion of the floor or slab of the environment thus created, can also be pro-

vided for this ribbed floor with steel joists 313, as shown in figures 16 ad 17.

[0073] The floor in all of its embodiments when obtained with the method of the invention, creating a cross warping at the intrados, confers an improved behaviour in the transversal distribution of the loads.

[0074] The dry installation of the whole system does not require preliminary surface treatment operations or the removal of civil finishings of the intradoses, accelerating the reinforcement operations with a reduction in times and costs associated therewith. With the method of the invention, there are no prolonged installation times due to setting and hardening necessities and/or activation of wet materials, such as those seen in part of the art so far known.

[0075] The reinforcement of floors using the method of the invention therefore leads to an improvement in the flexural rigidity of the floors, in both the direction of the load-bearing ribs (joists) and also in the transversal direction, in addition to an improvement in performances in ultimate limit state (ULS) verifications.

[0076] Another important advantageous feature of the reinforcement method of ribbed floors according to the present invention lies in the fact that no link or connection is required with the vertical load-bearing structures of the building. The preparation and implementation of all operations suitable for transferring additional loads to the foundation are therefore superfluous.

[0077] It is in fact more than enough to exploit the existing vertical load-distribution trends.

[0078] A further advantageous feature relates to the anti-breakthrough function within the context of installation in which the phenomenon is present or to be prevented.

[0079] Another advantageous feature is the rigidity of the plane which is such as to impart rigid diaphragm characteristics for seismic purposes.

[0080] Yet another advantage is that the implementation of the method of the invention for effecting a reinforcement intervention does not require any perturbation of the extrados, such as the removal of flooring and finishings, and even less so floor plants, necessary in the case of interventions to be effected at the extrados.

[0081] Finally, the additional weight of the floor thus reinforced can be considered as having "zero impact" with respect to the weight of the pre-existing floor to be reinforced.

[0082] This weight variation is considered as being widely containable in the measurement uncertainty coefficients of vertical loads with their own weight.

[0083] The forms of the structure for implementing a method for the reinforcement of ribbed floors of the invention, as also the materials and assembly modes, can naturally differ from those shown for illustrative and non-limiting purposes in the drawings.

[0084] The objective mentioned in the preamble of the description has therefore been achieved.

[0085] The protection scope of the present invention is defined by the enclosed claims.

Claims

1. A method for the reinforcement of existing ribbed floors, wherein said existing ribbed floors essentially comprise a division slab made of cast concrete associated with a series of underlying joists (13, 113, 213, 313), **characterized in that** it comprises the following steps:

   - preparation of a series of reinforcing steel profiles (17);
   - arrangement of said reinforcing steel profiles (17) in the intrados of the existing ribbed floor to be reinforced, wherein said arrangement is effected by positioning said steel profiles (17) close to the ribs of the existing floor, consisting of said joists (13, 113, 213, 313);
   - arrangement of said steel profiles (17) according to a direction orthogonal to the direction of the joists (13, 113, 213, 313), forming a transversal connection between said joists (13, 113, 213, 313);
   - producing a constraint between said steel profiles (17) and said joists (13, 113, 213, 313) through stable positioning means (18) forming a transversal connection between said joists (13, 113, 213, 313);
   - creating a dry installation adhering to the intrados of the floor of said steel profiles (17).

2. The method according to claim 1, **characterized in that** it comprises a further application step of one or more sheets having an anti-breakthrough function (23) under said profiles (17).

3. The method according to claim 1 or 2, **characterized in that** it provides that said profiles (17) have an omega-shaped section.

4. The method according to claim 1 or 2, **characterized in that** it provides that said profiles (17) have an omega-shaped section, in which an upper portion of the omega consists of an upper flat straight central section (20) which extends into two straight side sections (21), diverging outwardly, tilted downwards, and terminating with a further two straight base sections (22) which receive said stable positioning means (18) of said profiles (17).

5. The method according to claim 4, **characterized in that** said straight base sections (22) diverge towards the outside of the section for receiving said stable positioning means (18).

6. A ribbed floor essentially comprising a division slab

made of cast concrete casting associated with a series of underlying joists (13, 113, 213, 313), **characterized in that** it comprises a series of steel profiles (17) positioned at the intrados of the ribbed floor to be reinforced, wherein said profiles (17) are arranged in dry adherence to said joists (13, 113, 213, 313), according to an orthogonal direction with respect to the direction of the joists (13, 113, 213, 313), forming a transversal connection between said joists (13, 113, 213, 313), stable positioning means (18) also being provided between said profiles (17) and said joists (13, 113, 213, 313).

7. The floor according to claim 6, **characterized in that** said joists are prefabricated brick-cement joists (13).

8. The floor according to claim 6, **characterized in that** said joists are joists cast in situ (113).

9. The floor according to claim 6, **characterized in that** said joists are wooden joists (213).

10. The floor according to claim 6, **characterized in that** said joists are steel joists (313).

11. The floor according to any of the claims from 6 to 10, **characterized in that** said stable positioning means are mechanical anchoring dowels (18).

12. The floor according to any of the claims from 6 to 10, **characterized in that** said profiles (17) have an omega-shaped section.

13. The floor according to any of the claims from 6 to 10, **characterized in that** said profiles (17) have a section which is typically "I"-, "C"-, "U"-shaped, box-like, open or closed, etc.

Fig. 1

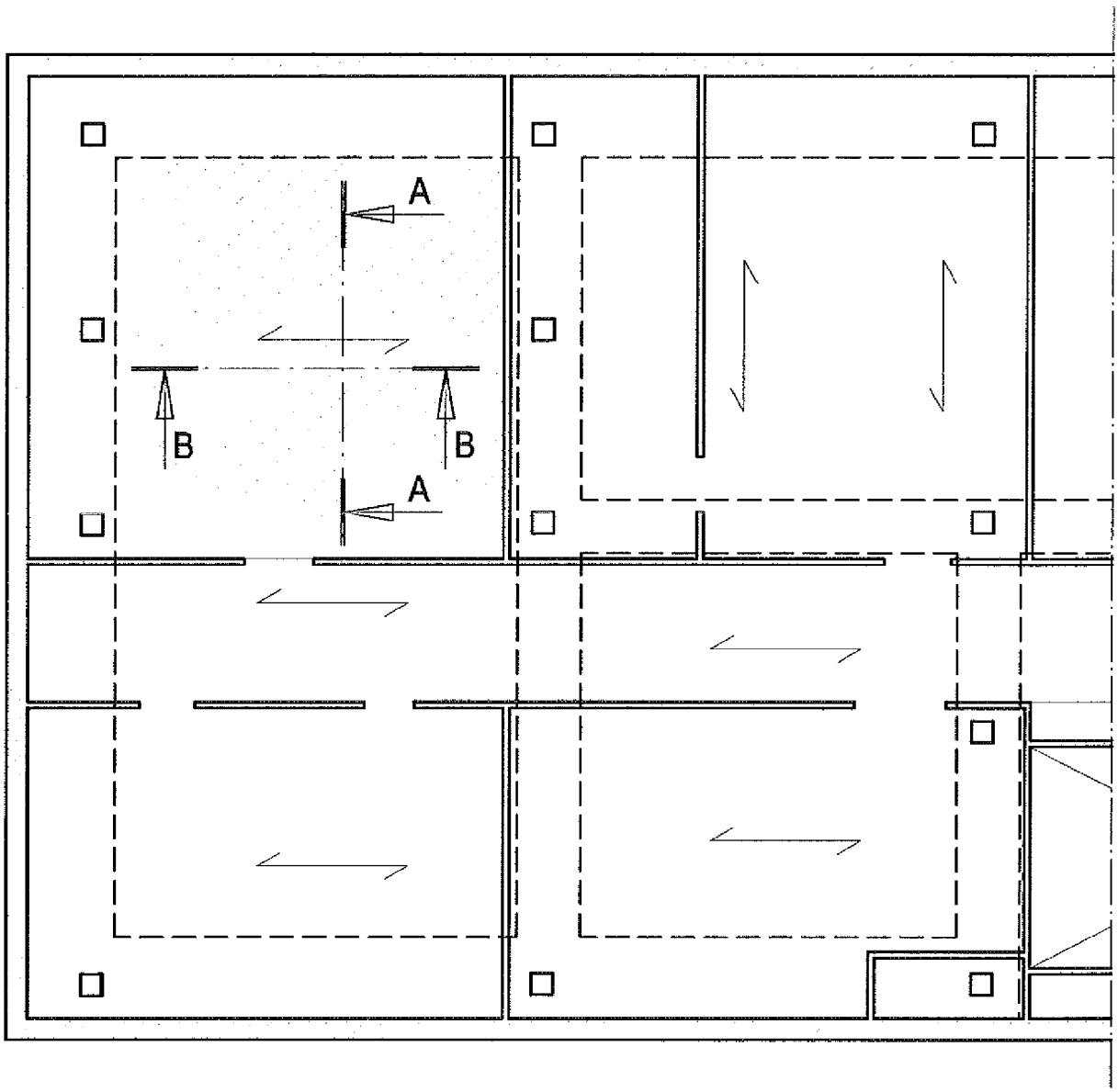

Fig. 2

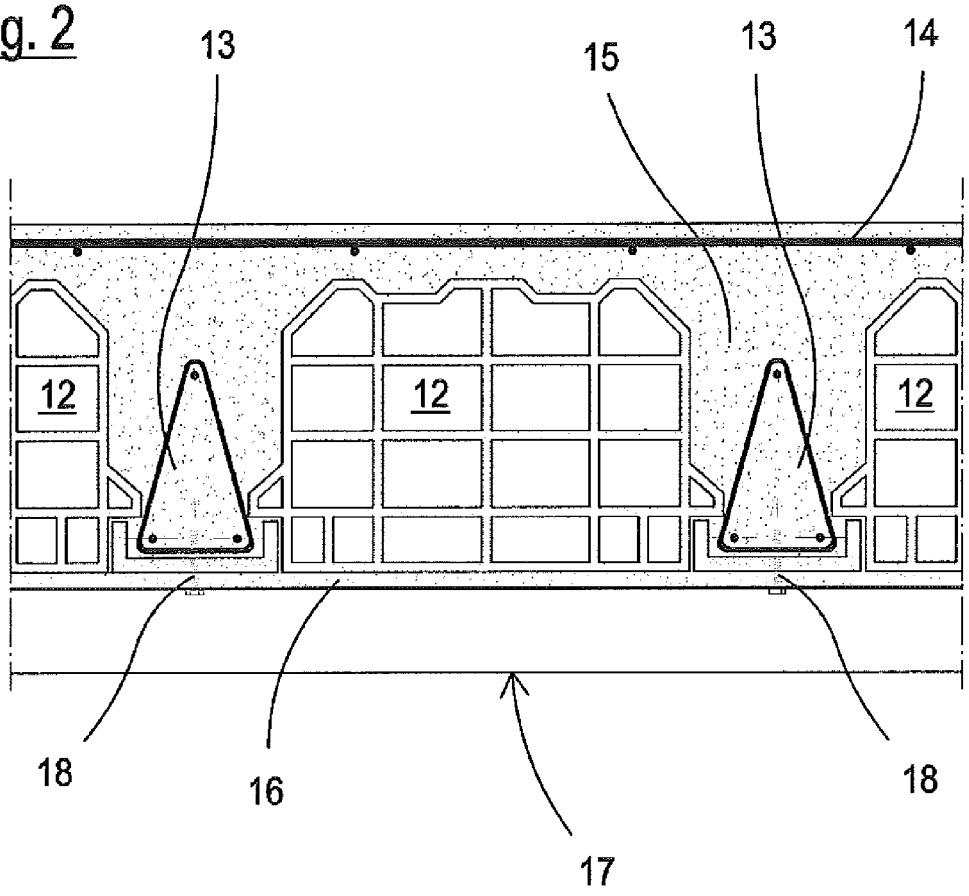
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Fig. 3

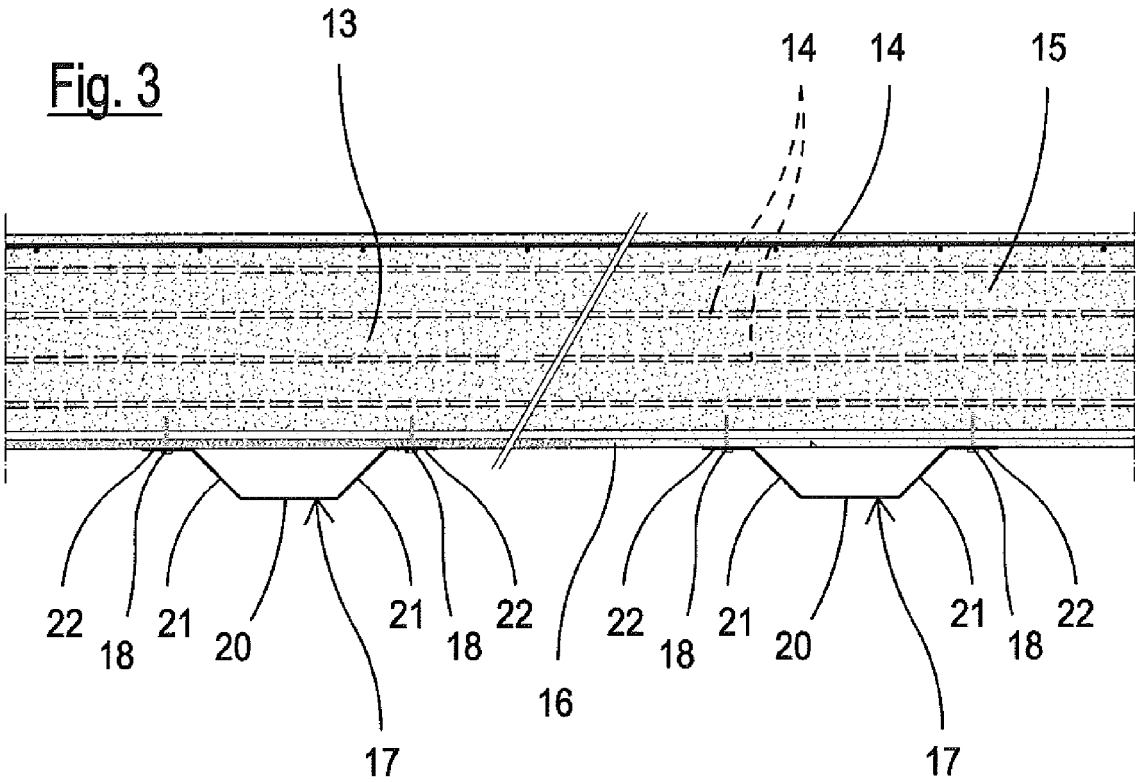
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Fig. 4

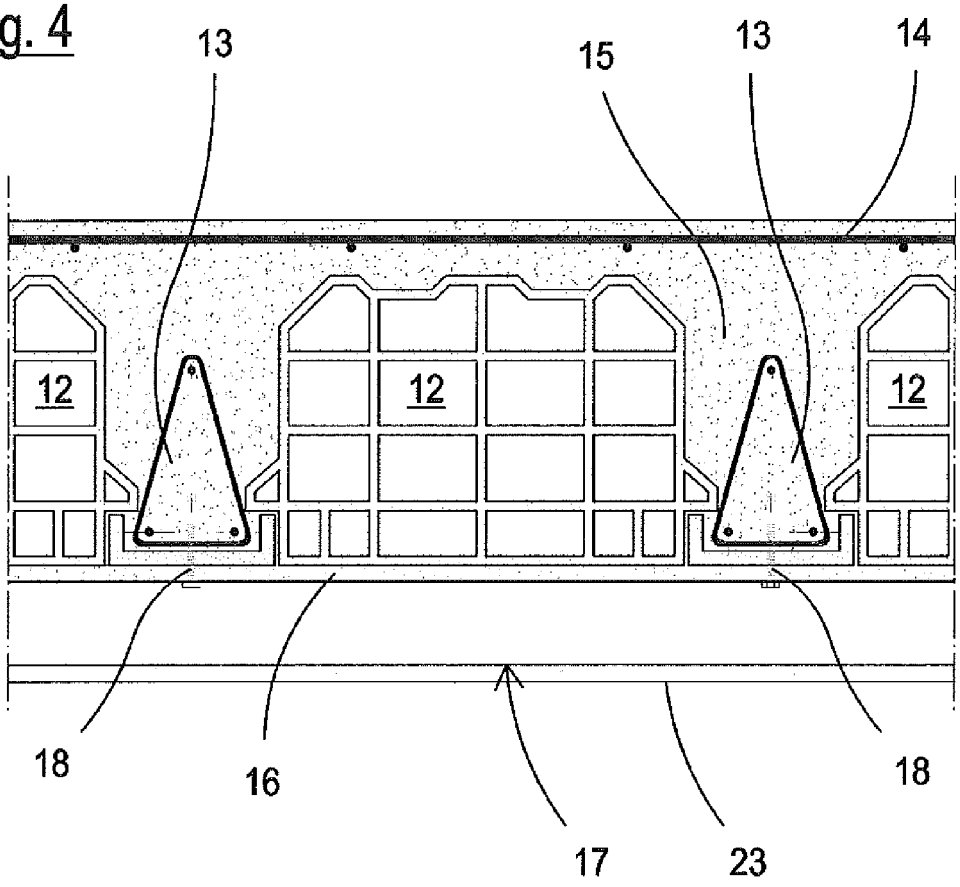
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Fig. 5

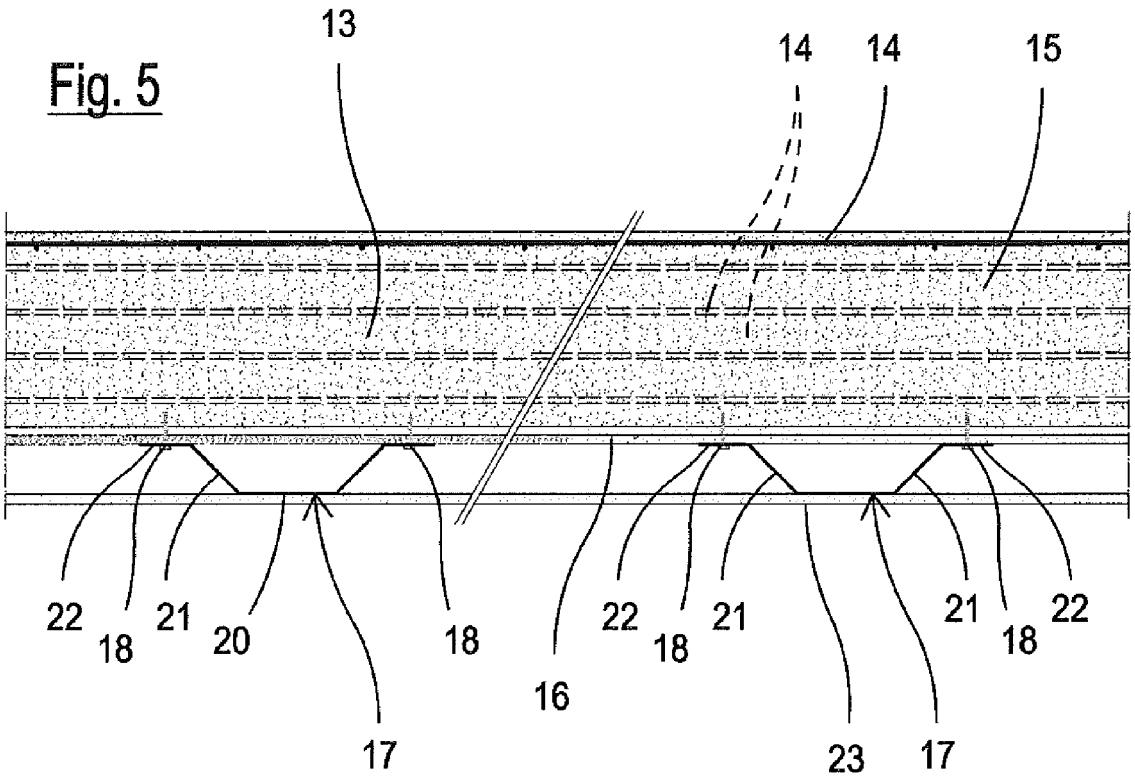
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Fig. 6

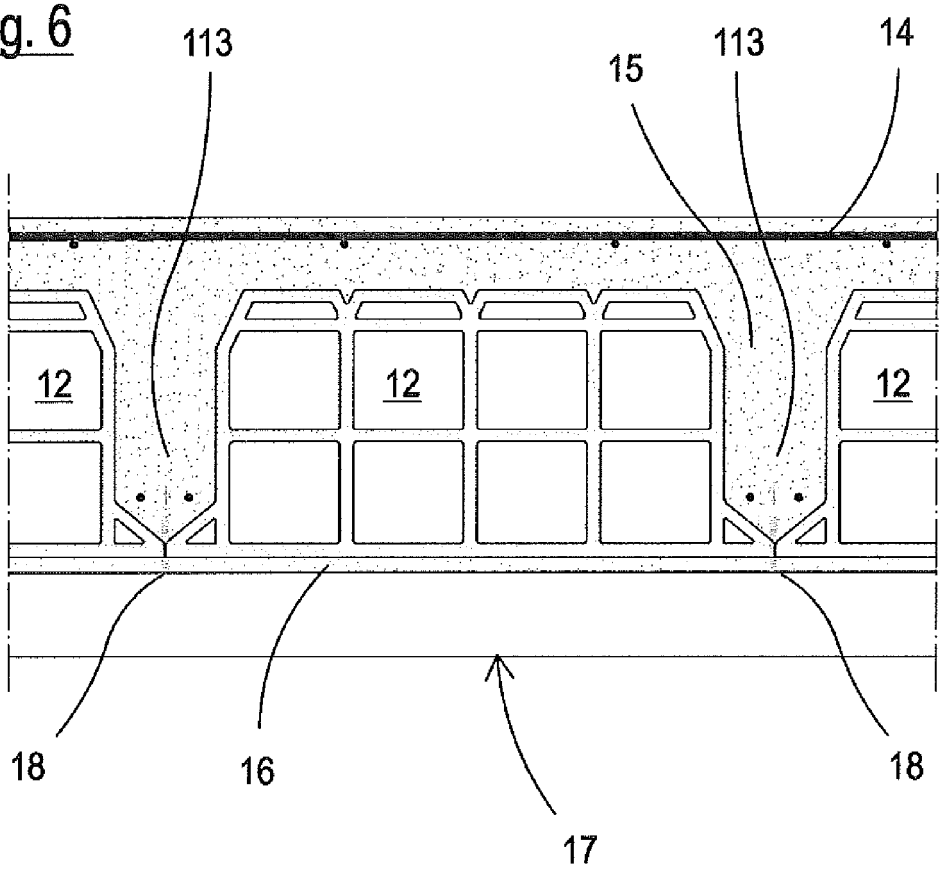
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Fig. 7

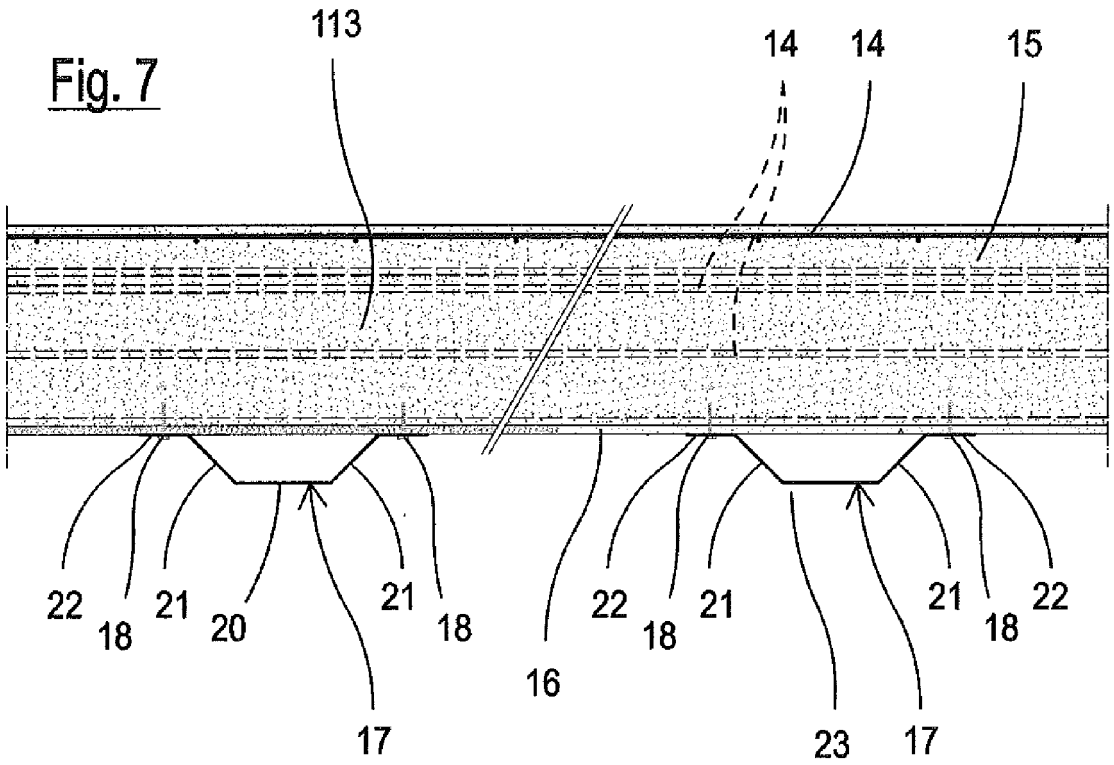
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Fig. 8

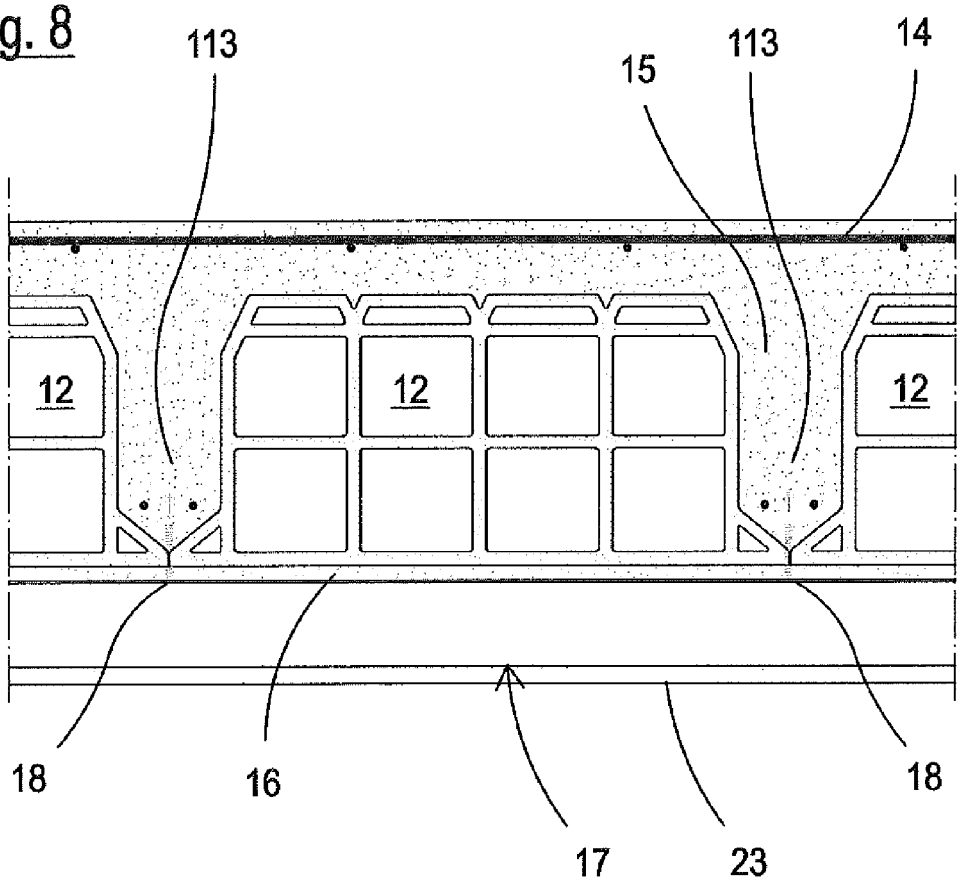
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Fig. 9

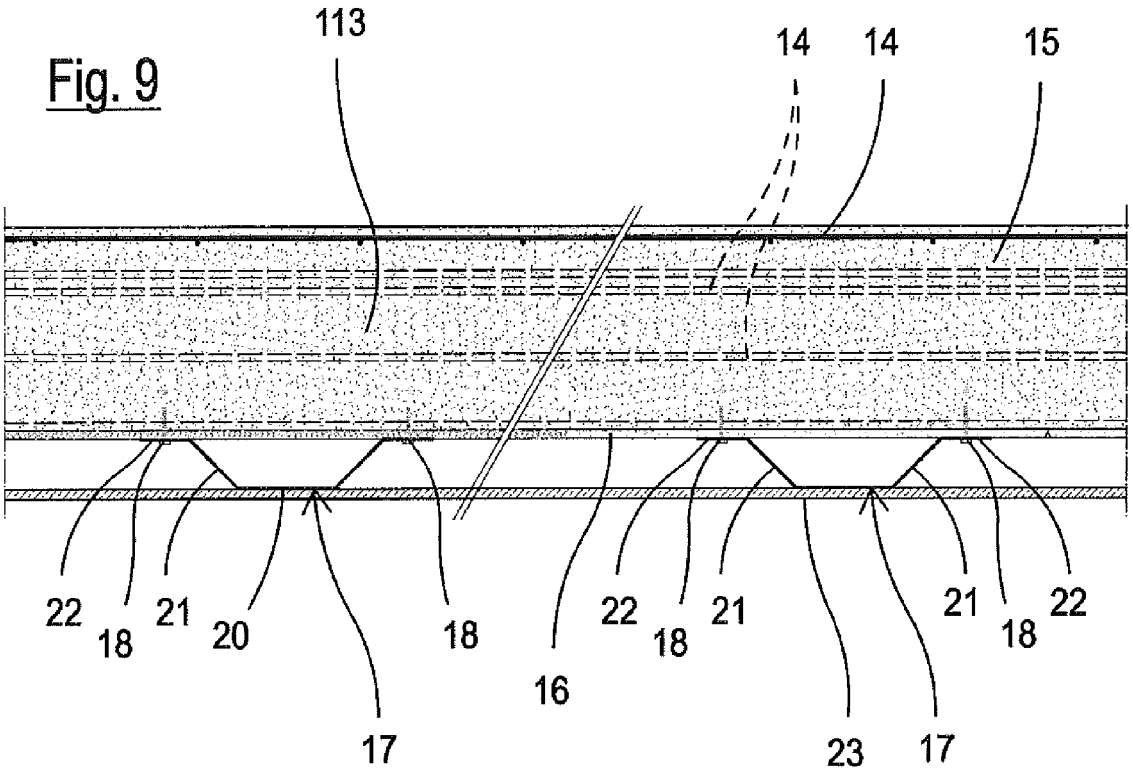
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Fig. 10

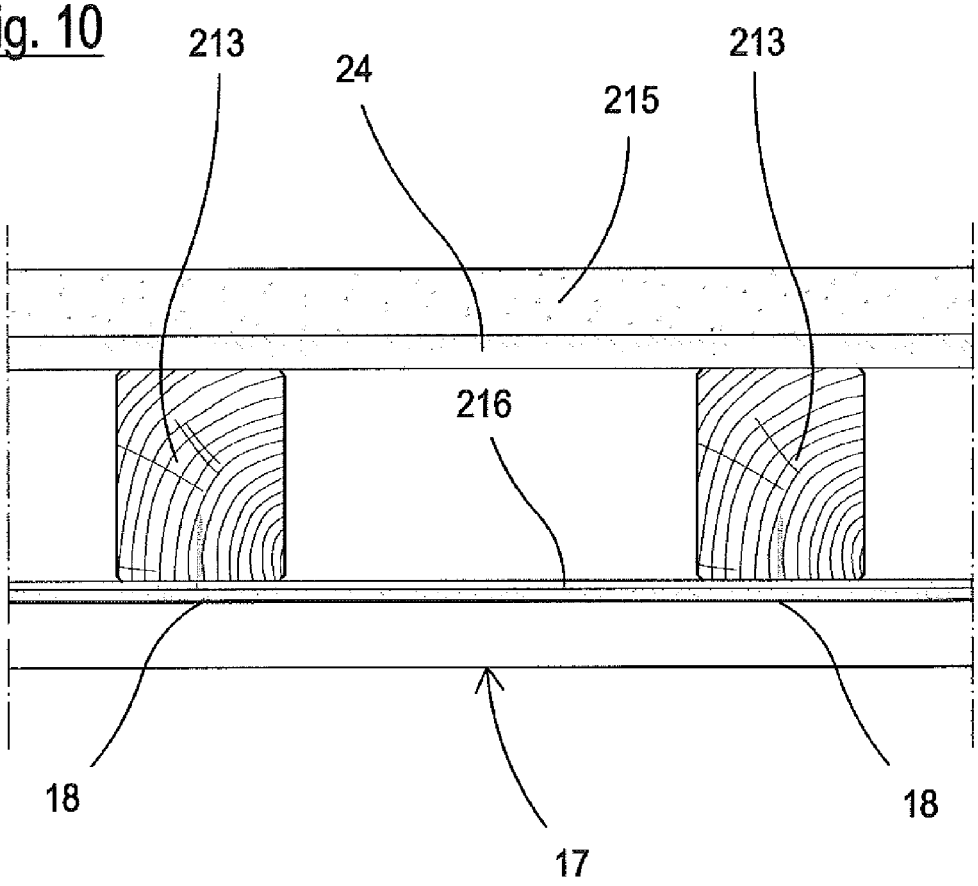
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Fig. 11

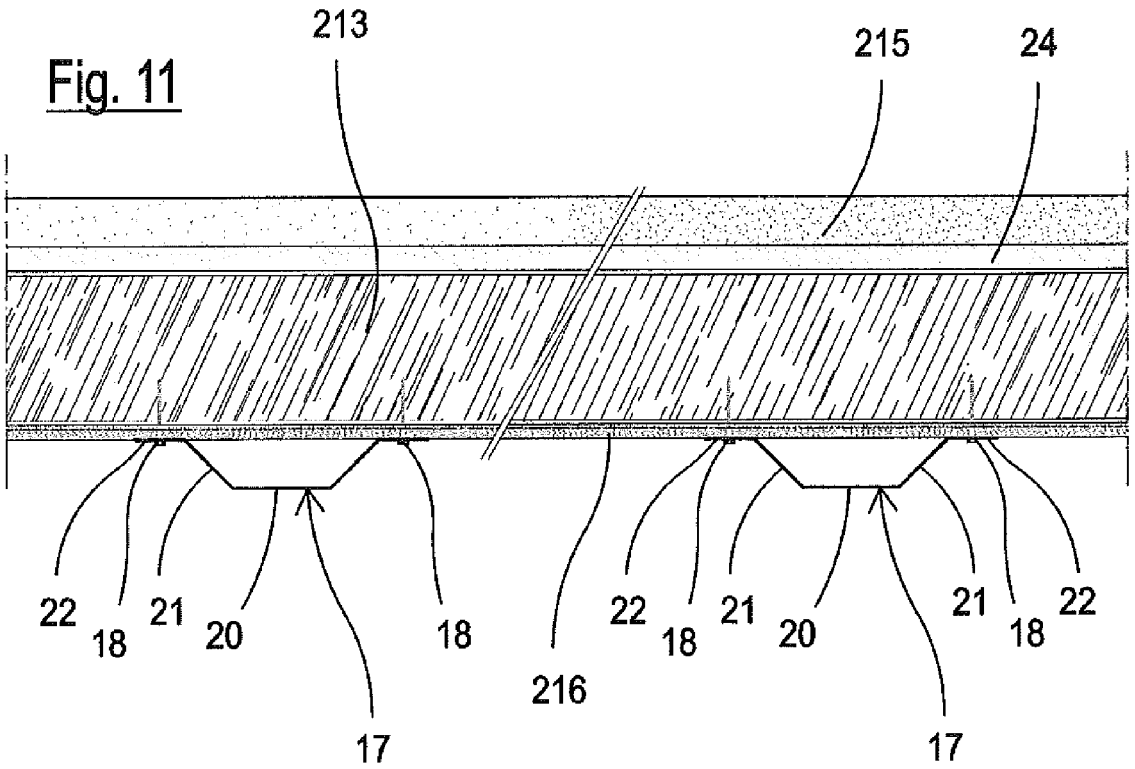
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Fig. 12

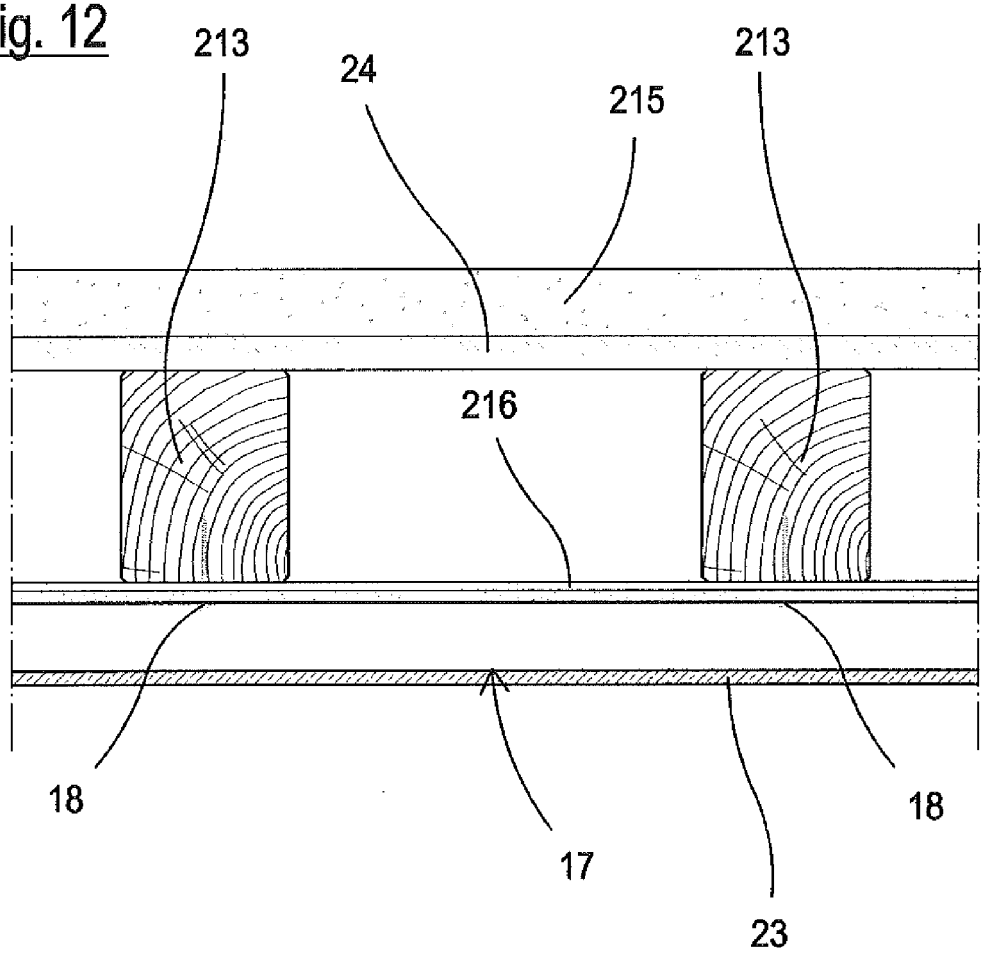
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Fig. 13

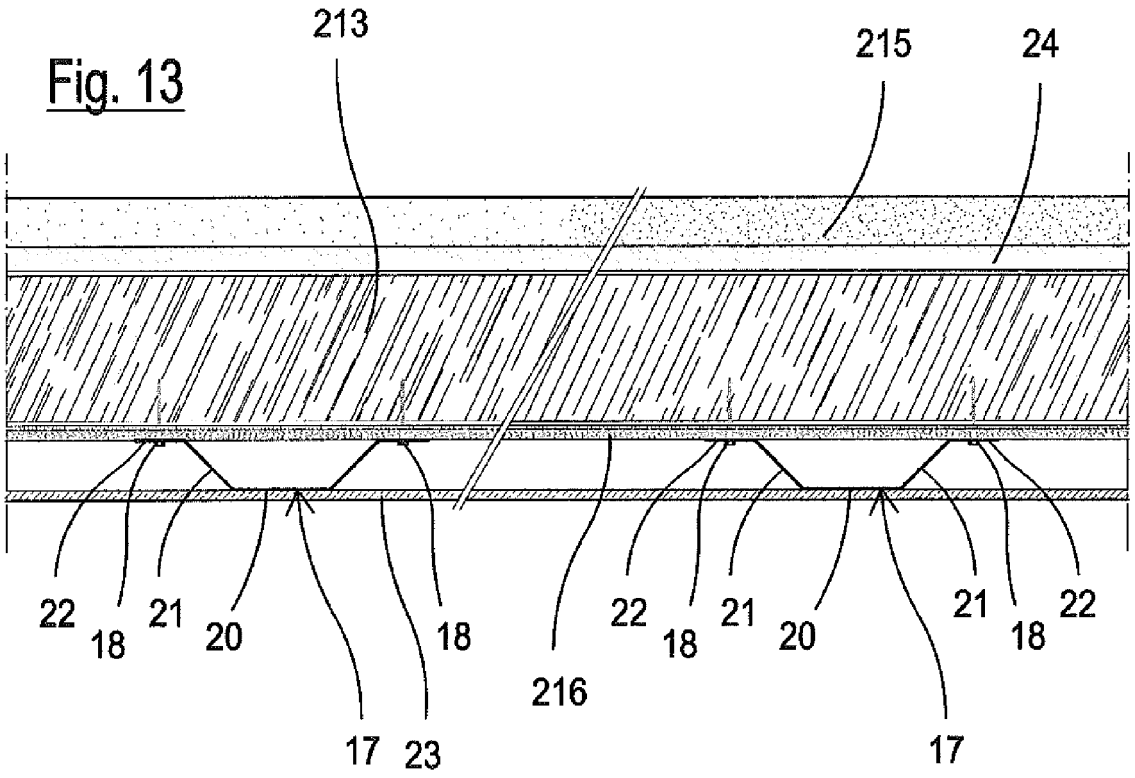
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Fig. 14

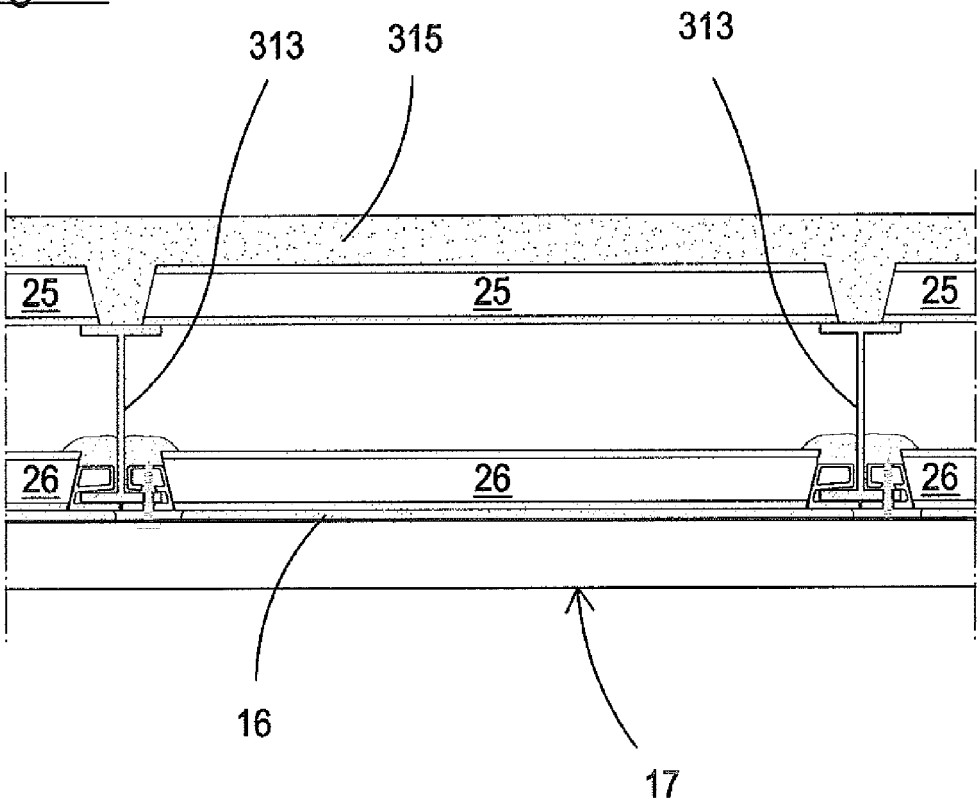
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Fig. 15

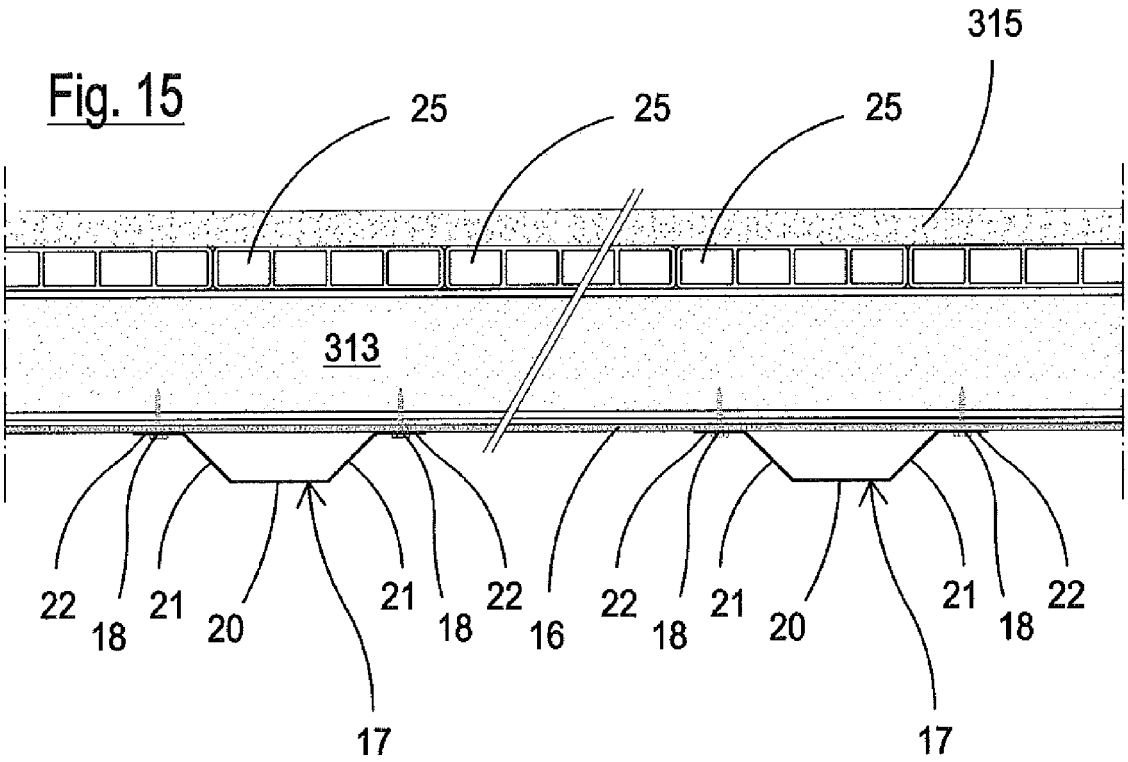
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Fig. 16

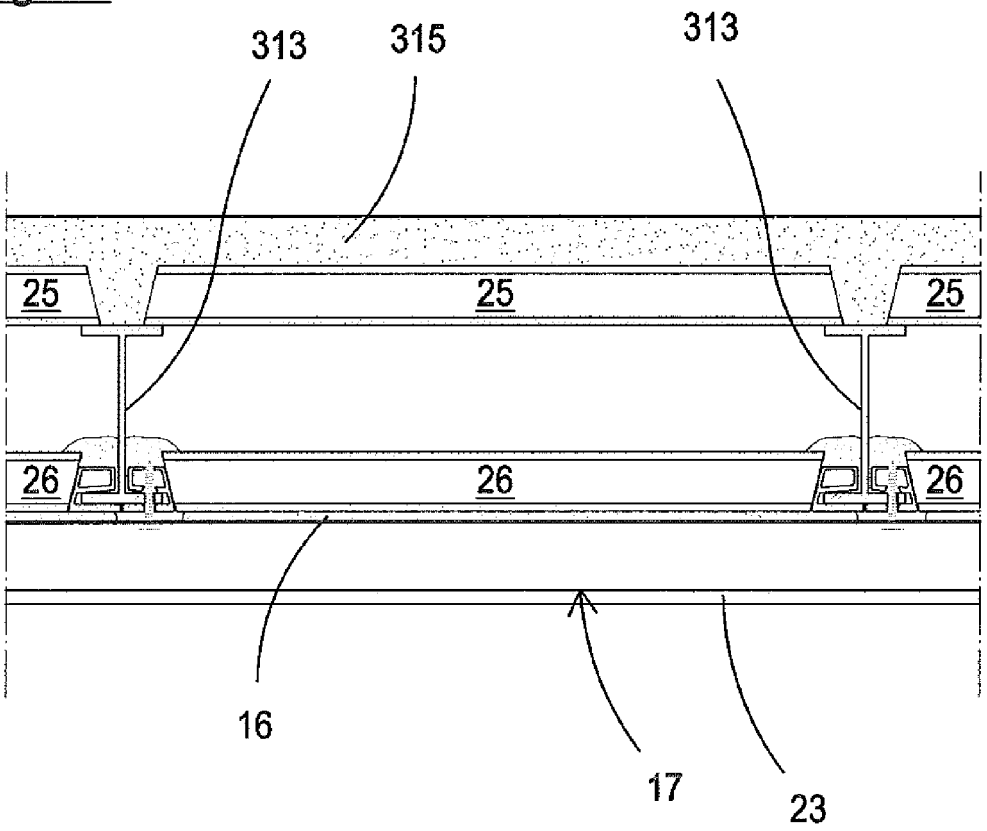
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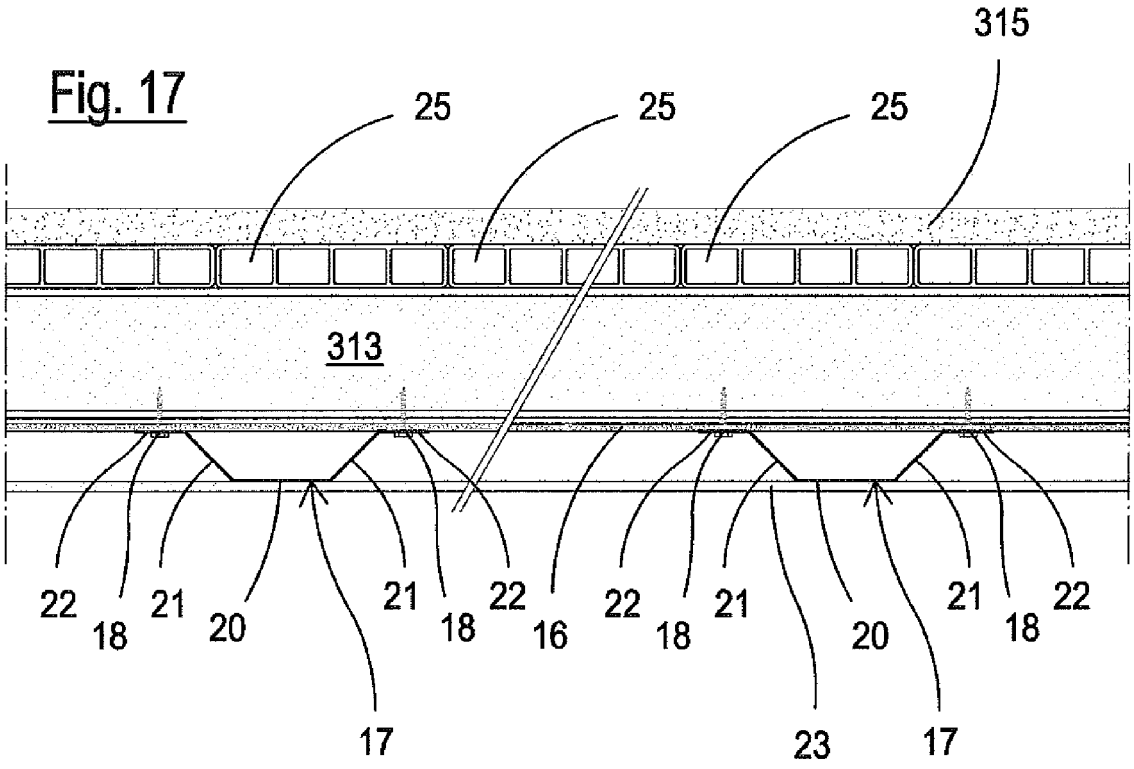
Fig. 17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EUROPEAN SEARCH REPORT

Application Number
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E04B
E01D
E04G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 October 2016	Manera, Marco

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