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(54) **A load-bearing composite slab for buildings**

(57) The invention relates to load bearing slab structures used in buildings. The slab structure (1) comprises at least a corrugated joining plate (3) made of metal, a concrete layer (7) arranged on top of said slab and attached thereto, and below said slab a heat insulation layer (8) that is at its top surface (Py) engaged with the joining plate. The joining plate (3) is arranged to carry those tensile stresses of the total load that are directed thereto during the use of the slab structure, while the concrete (C) is hardened. In addition, the slab structure comprises a continuous steel sheet part (4) that is attached to the bottom surface (Pa) of the heat insulation layer by surface engagement, or a number of adjacent steel sheet profiles attached to said surface by surface engagement. Said sheet part or profiles have dimensions to carry those tensile stresses that are directed thereto while the concrete layer of the slab structure is in the form of non-hardened concrete mass (B). The slab structure and the concrete layer constitute the principal load bearing part of the slab structure.

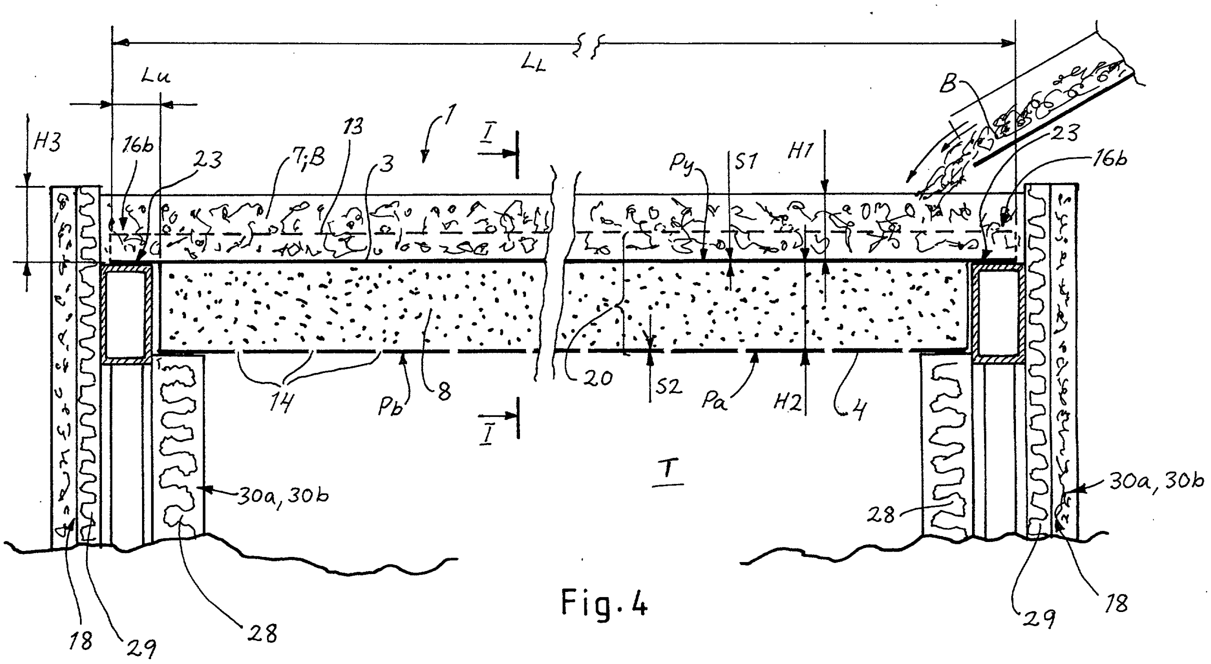

Fig. 4

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Description

[0001] The invention relates to a load bearing slab structure in buildings, where the slab structure comprises at least an upper metal sheet construction, a concrete layer provided on top of it and a heat insulation layer provided underneath it and arranged to join said slab construction at the top surface of said insulation layer, as well as a lower steel sheet construction provided at the bottom surface of said heat insulation layer, which steel sheet construction has a surface joint with to the bottom surface of said heat insulation layer, so that the distance between the upper and lower steel sheet constructions is defined by the heat insulation layer. Another object of the invention is a prefabricated element in order to realize in buildings a load bearing slab structure of the above-described type.

[0002] Corrugated metal sheet has for a long time been used for instance in base floor structures, both as a casting mold and as a replacement for concrete reinforcements, in which case the corrugated sheet and the attached concrete together form a so-called composite structure. The combination of metal sheet and hardened concrete is generally called a composite slab. A critical feature in the design of said slab is the deformation created in the casting process prior to the hardening of the concrete. Said deformation is seen in a drawing of the patent publication GB-1,094,581, and in order to prevent the creation of such deformations, it is suggested that the corrugated metal sheet is supported, for the duration of the casting process, by auxiliary structures provided underneath, which structures are removed after the concrete mass is hardened. According to said publication, it also is advantageous to provide the corrugated metal sheet by an additional, generally straight metal sheet that is attached underneath it.

[0003] There are known several different types of corrugated metal sheets, i.e. joining plates, for composite structures. Publications GB-1,094,581 and US-5,566,522 disclose preferred joining plates provided with more or less dovetail-shaped ribs, the sides of said ribs being located on the upwardly directed surface so that they are spaced further apart than at the intermediate sections connecting said ribs. This type of design effectively receives the perpendicular forces directed to the joining plate, thus in part preventing the joining plate and the hardened concrete from being detached in the composite slab during loading. In addition, said publications illustrate additional transversal corrugations arranged at least on the bottom of the ribs, the purpose of which is further to prevent the concrete and the joining plate from being detached during the loading of the composite slab, i.e. to receive shearing forces that are directed, in the parallel direction of the joining plate, to the border area between the joining plate and the hardened concrete. Said US publication does not, however, at all discuss the problems that arise when casting wet, fluid concrete mass onto the joining plate.

[0004] In the patent publication FI-61,067, there is described a slab structure designed for base floor, intermediate floor, roof and wall structures of buildings, through which structures an air stream is arranged to flow for heating or cooling purposes. In order to form the base and/or wall structures essentially completely of said slab structure, the slab structure comprises at least the following layers in a combined sandwich structure: an insulating layer made of self-adhesive, expandable insulation material; a corrugated sheet provided with grip protuberances; an intermediate sheet or the like arranged in between the two aforementioned layers, which intermediate sheet together with the corrugations of said corrugated sheet defines an air duct system in the structure, and which sheet prevents the corrugations of the corrugated sheet from being filled at said air ducts when producing the insulation layer of an expanding material; a casting component, for instance a concrete layer, which is either precast or cast on site, by using said corrugated sheet as the mold sheet, on the opposite side of the corrugated sheet with respect to said insulation layer, so that said casting component together with the corrugated sheet forms a load bearing composite structure owing to the grip protuberances of the corrugated sheet. Thus, an additional sheet is provided underneath the corrugated sheet, in similar fashion as in the above described publication GB-1 094 581, but here the purpose is to obtain in the corrugated sheet such air ducts that remain open irrespective of the casting and expansion of the insulation layer, which procedure is applied directly onto the combination of the corrugated sheet and the additional sheet. Said FI publication does not, however, at all discuss the problems that arise when casting wet, fluid concrete mass onto the corrugated sheet, i.e. onto the joining plate.

[0005] The publication WO-96/02711 specifies a prefabricated sandwich element comprising an upper metal or steel sheet, a lower metal or steel sheet and a core part provided therebetween, said core part being made of expanded polystyrene, polyurethane or mineral wool. The sheets are joined to the core by gluing, heat-fusion or by adhesion. In the first embodiment, the side edges of the elements are provided with undercuts, and in said area, i.e. between the element edges, there are provided the edge parts of the lower sheet with their concrete engagements and the folds of the upper sheet with their concrete engagements. In the second embodiment, the edges of the lower sheet are folded to above the upper sheet, and in this area, there are arranged respective lower sheet edge parts with concrete engagements and upper sheet folds with concrete engagements. In the first embodiment, the elements can be joined together at said edges, or simply, in the second embodiment, arranged in a mutual butt contact. On top of said combination, there is cast concrete, which is engaged with the edge elements described above. Although the publication mentions a possibility to provide the upper sheet with protuberances, it on the other hand states that the principle of the invention includes the exclusion of any upwardly projecting parts and elements. Consequently, one of the teachings of said publication is that the concrete must in the first place engage the lower sheet of the sandwich element, as is the case in all described embodiments and drawings of the publication. Said engagement of the concrete to the edges of the lower sheet takes place either in the narrow slots between the elements, or above the top surface of the elements. A second defined teaching of said publication is that the concrete layer and element form, as a uniform entity, a load bearing structure, where the lower metal sheet carries the tensile stress, and the hardened thin concrete layer carries the compression stress. When observing the drawings of the publication, it is found out that the concrete layer is fairly thin, i.e. the question is mainly of a concrete coating, which is not and cannot be the major load bearing structure element in the way it is described in the above mentioned publication. However, irrespective of the designs of said publication, it is difficult to achieve a high load bearing capacity when using the suggested structure. Moreover, the suggested structure may suffer from strength-weakening corrosion problems when it is used in base floors. The fact that the lower sheet extends at the element edges through the thickness of the core part, as far as the concrete layer, leads to the creation of cold bridges in the structure, i. e. to a phenomenon where heat flows from the inside of the building, via the metal sheet folds provided at the element edges, to the exterior, which means that the use of the structure as base floors and roofs is disadvantageous, to say the least. Moreover, the fire resistance of the suggested structure with respect to the space provided underneath it is below standard, which makes it difficult to use the structure as intermediate floors and roofs.

[0006] Hence, the object of the present invention is to attain an element, suitable to be prefabricated, that can be installed, if possible, to rest only at the ends or side edges on the top edge of the foundation or of the walls, on top of which element there can then be poured fluid concrete mass without causing remarkable deformations in said element. Thus the aim is to avoid the use of any supports that are arranged underneath the element in order to support it during the concrete casting, but are disassembled or removed after the concrete is hardened, even if the bearing distance should be large. A second object of the invention is to attain a load bearing slab structure for buildings, which slab structure is based on metal sheets and a concrete layer and is capable of bearing even large loads. A third object of the invention is to attain a slab structure of the described type, which could also function as an ideally effective heat insulation without harmful cold bridges and could insulate, when used as a base floor, the space above it for instance against the radon emitted from the ground underneath the slab without having to perform additional work on site. Further an object of the invention is to attain a load bearing slab structure with first-class fire resistance, which can accordingly be used in many different building subjects.

[0007] The above described problems are solved and the objects are achieved by means of a slab structure according to the invention, characterized by what is set forth in the characterizing part of claim 1, and by means of a prefabricated element according to the invention, characterized by what is set forth in the characterizing part of claim 13.

[0008] The most essential advantage of the slab structure of the invention is the fact that it can be used, apart from a base floor with a creeper space in buildings, also as an intermediate floor and a roof, and it already has an excellent load bearing capacity in itself, which capacity can be further adjusted by means of additional concrete reinforcements and by the thickness of the concrete casting, although in most cases additional reinforcements are not needed at all, or only to a minimal degree. An additional advantage is that in most cases, after the concrete has hardened, it is not necessary to do for example insulation work, because the slab structure already includes insulation against moisture, heat and radon, and the slab structure is compacted, without any special measures, for instance against the heat insulation of the foundation. The most essential advantage of the prefabricated element to be utilized in the production of the slab structure is that it is capable of carrying the load of the wet concrete mass even with a large bearing distance, for instance 6 - 7 m, without specially added props or supports, with only minimal deformations. This means that in most cases the elements can be installed at their ends and/or edges only, to rest on the foundation or the wall edges, and extra intermediate supports are not needed. After casting, the load bearing slab is ready, because the structure does not need dismountable molds or casting supports, and piping and the like for various purposes can be suspended in the slab structure. Among the special functional features of the invention, let us point out first of all that during concrete casting, the joining plate functions by compression stress, and after the concrete is hardened, when the base floor is loaded, it functions by tensile stress, and secondly, that the tensile stress created in the bottom surface sheet of the heat insulation and the compression stress created in the joining plate receive the deformation moment directed towards the element by the weight of the wet concrete. The ready-made slab structure according to the invention has excellent fire resistance, because there the steel parts that in part receive the total loads, i.e. the joining plate in particular, are effectively heat insulated during a fire, also against heat that comes from below. This makes it possible to use the slab structure according to the invention also as intermediate floors and roofs. The ready-made slab structure according to the invention also has an excellent heat insulation capacity, because the joining plate provided on top and the steel sheet part or steel profiles provided underneath are not at any point in mutual contact and do not even come near to each other. Thus both heat losses and condensation water problems are avoided, and the slab structure of the invention can be used both as base floors and as roofs without extra heat insulation. Moreover, among the advantages of the invention let us point out the possibility to lay the foundations of a building at a rapid speed, particularly when combined with steel beams. A remarkable amount of time and money is saved in reduced earth-moving and digging work. Because the base floor is not supported against the earth, it need not be built and evened out. A light and accurately measured prefabricated element, combined of an insulation, a joining plate and a steel sheet part or steel sheet profiles, is economical to transport even at longer distances, and these elements are easily installed irrespective of the weather conditions. For instance the installation of floor heating in cast concrete is conveniently carried out. All of the above mentioned features result in cost-effective, rapid and ecologically efficient building.

[0009] The invention is described in more detail with reference to the appended drawings.

[0010] **Fig. 1** represents a first embodiment of a load-bearing slab structure according to the invention and of an element prefabricated for said structure, shown in a cross-section corresponding to the plane I - I of figure 4, and seen in an axonometric illustration.

[0011] **Fig. 2** represents a second embodiment of a load-bearing slab structure according to the invention and of an element prefabricated for said structure, shown in a cross-section corresponding to the plane I - I of figure 4, and seen in an axonometric illustration.

[0012] **Fig. 3** represents a third embodiment of a load-bearing slab structure according to the invention and of an element prefabricated for said structure, shown in a cross-section corresponding to the plane I - I of figure 4, and seen in an axonometric illustration.

[0013] **Fig. 4** illustrates a fourth embodiment of a load-bearing slab structure according to the invention and of an element prefabricated for said structure, seen in a longitudinal section corresponding to the plane II - II of figures 1 - 2, and shown as installed in the final location, on the foundation or walls of a building.

[0014] In general, the slab structure 1 comprises at least an upper metal sheet construction, on top of it a concrete layer 7 and underneath it a heat insulation layer 8, the top surface Py of said heat insulation layer being fixed with said sheet construction, as well as a lower steel sheet construction installed at the bottom surface Pa of said heat insulation layer, which lower steel sheet construction is in surfaced fixing with the bottom surface of the heat insulation layer, so that the distance between the upper and lower steel sheet constructions is defined by the thickness H2 of the heat insulation layer.

[0015] In the drawings, there is seen the load bearing slab structure 1 for buildings. This slab structure 1 is suited to be used in buildings as base floors, intermediate floors and roofs, but especially as base floors and reinforcements owing to the heat insulation layer 8 that constitutes the structural part thereof. The ready-made slab structure 1 according to the invention comprises at least a corrugated metal joining plate 3 and a concrete layer 7 that is cast and hardened on site on top of said slab structure and is thus attached to the joining plate provided with several concrete engagement ribs 13. Moreover, a ready-made slab structure 1 includes a heat insulation layer 8 provided underneath said joining plate 3 and attached to said slab 3 at its top surface Py. In particular, the slab structure 1 also includes either a continuous steel sheet part 4 attached to the bottom surface Pa of said heat insulation layer by means of a surfaced fixing, or a number of adjacent steel sheet profiles 5, 6 attached thereto by means of a surface joint. Said steel sheet part 4 or respectively the steel sheet profiles 5, 6 have dimensions to carry, in the slab structure 1, at least those tensile stresses that are directed thereto, during the casting of the concrete mass B and after it, when the concrete mass still is in fluid state. As regards the joining plate 3, it has shapes and dimensions to carry at least the tensile stresses, directed thereto during the use of the slab structure, of the total load C + F, composed of the weight of the hardened concrete C and of the external other load F resting on the slab structure when the concrete C is hardened, while the joining plate and the hardened concrete C together form the main load bearing structure of the ready-made slab. In addition, the joining plate 3 has shapes and dimensions to carry the compression stresses caused by the fluid, not yet hardened concrete mass created by the concrete layer 7. Thus the materials of the slab structure include, starting from the top: concrete or reinforced concrete, typically a joining plate made of steel, and heat insulation, as well as the steel profiles or steel sheet provided at the bottom surface. The load bearing slab structure 1 according to the invention is composed of four superimposed and mutually joined structural parts with a structural joining effect between them.

[0016] According to the invention, in order to realize the above described load bearing slab structure 1 in buildings, there is first produced an industrially made, prefabricated element 20, which is brought to the building site to be used as an underlay for base floors, intermediate floors or roofs. Said prefabricated element 20 comprises a composite steel slab 3 provided with at least several concrete engagement ribs 13, a heat insulation layer 8 directly attached to said slab 3, and a continuous steel sheet part 4, or a number of adjacent steel sheet profiles 5, 6 provided at the bottom surface Pa of the heat insulation layer. The joining plate 3 is advantageously composed of a continuous steel sheet, i.e. one continuous steel sheet, provided with several concrete engagement ribs 13 that are widened when proceeding away from the heat insulation layer, i.e. in the direction W2→W1. The top surface Py of the heat insulation layer 8 is directly, i.e. immediately, without other sheet material layers, attached to at least the downwardly directed intermediate sections 12 arranged between the concrete engagement ribs 13, i.e. the sections that are located against the heat insulation layer. Said intermediate sections 12 may be planar in shape, or they may include various patterns 19 in order to enhance the engagement of the concrete layer 7, or in order to further reinforce the prefabricated element 20. In said case that even includes patterns 19, the envelope surface of the intermediate sections 12 is advantageously a plane, and at least 50% or advantageously at least 70% of the area of the planar and intermediate sections is connected to said envelope surface, so that in a preferred embodiment of the heat insulation, the planar top surface Py is attached to the joining plate 3 in a sufficiently large area. In a case where the heat insulation layer 8 is cast onto the composite steel slab, said planar feature is of no remarkable importance. At the bottom surface Pa of the heat insulation layer, there is attached, in the same way as above, by surface grip, the continuous steel sheet part 4 or adjacent steel sheet profiles 5, 6. The sheet part and respectively the profiles have shapes and dimensions to carry at least the tensile stresses directed thereto when the concrete layer 7 of the slab structure is still in the form of non-hardened concrete mass B.

[0017] In order to achieve the above described effects, the bending resistance of the joining plate 3 is higher than the bending resistance of the part 4 of the continuous steel sheet, or the added bending resistance of the adjacent steel sheet profiles 5, 6, in which values there are taken into account both the material thickness and shape of the concrete engagement ribs 13, and possibly the shape of the longitudinal corrugations 15. Advantageously the bending resistance of the joining plate is essentially higher, for instance at least 1.5 times as high or typically at least double or possibly at least triple in comparison with the bending resistance of the continuous steel sheet par, or with the added bending resistances of the adjacent steel sheet profiles. Normally also the material thickness S1 of the joining plate 3 is larger than the material thickness S2 of the continuous steel sheet part, or the average of the material thickness S3 of the adjacent steel sheet profiles, i.e. the real material thickness when calculated as distributed throughout the whole slab.

[0018] In the method according to the invention, the above described element 20 is arranged, at the ends 16b or the edges 16a, 16b, to rest on the foundation 30 or the walls 30b, so that the steel joining plate points upwardly, and the steel sheet part 4 or respectively the steel sheet profiles 5, 6, point downwardly, in which case in the area below the steel sheet part or the steel sheet profiles, restricted by the element ends or side edges, there is left a space T for air, such as a ventilated plinth or a room. The prefabricated element 20 has sufficient rigidity and strength in order to be able to operate at the length L_L and width of the element between the ends 16b or the edges 16a, 16b without intermediate supports that should later be removed. It is of course possible that in the area of the prefabricated element 20, the building may for various reasons be provided with load bearing structures, or with walls at other places than at the ends or edges of the element. However, these supports are not removable but permanent supports, and they do not prevent the achieving of the advantages of the invention, i.e. the extremely long bearing distance or support distance. In the next step, the fluid concrete mass is poured onto the composite steel slab 3 up to the desired thickness H1, whereafter the concrete mass is allowed to be hardened to form the concrete layer 7. In order to achieve the desired properties for the slab structure 1, the thickness H1 of the concrete layer 7 is larger, in a predetermined proportion, than the height H4 of the concrete engagement ribs 13. Typically the thickness of the cast concrete is 100 mm - 160 mm, but depending on the situation it may even fall outside the range of said measures. When necessary, a concrete reinforcement 17 can be added in a suitable way on top of the joining plate profile prior to the casting of the concrete mass B. The simplest way to do this is to arrange the concrete reinforcement in a lattice, so that the first set of reinforcement steels is arranged on top of the concrete engagement ribs 13 of the joining plate, whereafter there is added, transversally on top of them, a second set of reinforcement steels, so that the second set is arranged transversally to the first set and suitably attached thereto, and positioned at least approximately in parallel with the concrete engagement ribs 13 and arranged for example in between them, as is seen in figure 2. In this case, the concrete layer 7 includes, after the concrete mass B is hardened, a concrete reinforcement 17 that is separate from the joining plate, which concrete reinforcement together with the joining plate 3 increases the load bearing capacity of the slab structure, i.e. its rigidity and strength.

[0019] In the prefabricated element 20, at least at the ends 16b and when necessary, also at the side edges 16a - and in this latter case consequently at all edges 16a, 16b - the composite steel slab 3 protrudes out of the heat insulation layer 8 and of the steel sheet part 4 located below it, or respectively out of the steel sheet profiles 5, 6 for the length of the protrusion Lu. The protrusions Lu, or more accurately the intermediate sections 12 shown in said protrusions, are positioned so that they rest on top of the supporting top surfaces 23 of the load bearing areas of the foundation 30a or the walls 30b. Now the fluid concrete mass B can be cast. In order to provide an edge mold for the concrete mass, for restricting the concrete layer in the horizontal direction, the external lining plate 18 of the foundation 30a or of the walls 30b or the like, which plate may on the inner surface include the heat insulation 29 of the foundation or plinth or wall, in the way described in figure 4, is allowed to extend upwardly from the surface 23 supporting the element 20 of the foundation and respectively of the wall, for the length of the mold height H3, in which case the external lining plate 18 serves as the mold for the concrete mass B to be cast. Also it is advantageous to design the prefabricated element 20 so that the bottom surface Pa of its heat insulation layer 8 and/or the bottom surfaces of the steel sheet part 4 or the steel sheet profiles 5, 6 are set, when installing the element in place, against the top edge 28 of the heat insulation possibly provided at the inner surface of the foundation or the wall, in which case a continuous, continuous heat insulation is achieved in the junction of the base floor or the roof and the foundation 30a or respectively the wall 30b.

[0020] Thus the joining plate 3 is preferably made of an element obtained by bending one single steel sheet, which means that the joining plate 3 contains only one layer of steel sheet material, but other corresponding joining plates can, when desired, be supplied for instance in succession and adjacently in the horizontal direction, in the planar direction of the joining plate, i.e. in the installation direction. In practice, said arrangement of the slabs in succession can hardly bring forth any advantages, because it is already possible to manufacture as large joining plates as the transportation conditions of prefabricated elements 20 allow. Glue layers, for instance glue films, or surface coating, such as zinc coating or the like, is naturally not considered as sheet material. As was already maintained, the joining plate 3 is provided with concrete engagement ribs 13 and intermediate sections 12 therebetween. In a composite metal slab 3, the average distances W3 between the concrete engagement ribs 13 are essentially smaller than the width W_L of the joining plate, which means that one prefabricated element 20 includes several, generally at least three concrete engagement ribs 13, but preferably four or several concrete engagement ribs. In cross-section, the concrete engagement ribs are dovetail-shaped, in which case the width W2 of the ribs at the point that is level with the intermediate sections is essentially smaller than the width W1 of the ribs at the bottom 21 of the ribs, which bottom is located at the rib distance H4 from the intermediate sections 12. Typically the height of the concrete engagement ribs 13 can be within the range 30 mm - 70 mm, although other measures can also be applied according to the needs of the situation. The concrete engagement ribs 13 are arranged in the elements 20 so that the width transversal to their length is increased, i.e. W2 < W1, when proceeding away from the heat insulation layer, and they obtain a shape where they are widened towards the inside of the concrete layer 7, W2→W1. Advantageously the bottoms 21 of the concrete engagement ribs 13 are, at least in the direction opposite to the longitudinal direction of the ribs, which is the same as the direction of the length L_L of the element 20, provided with transversal grips 22, such as additional ribs. As regards the composite steel sheet 3, only its overall shape is described here, but it may also include several other details. This type of joining plate and its functions in the hardened concrete layer 7 is known as such, wherefore they are not explained in more detail here.

[0021] The heat insulation layer 8 is attached, with a separate glue layer 9a, as in figure 1, or with a glue 9c contained in the heat insulation layer 8, for instance with the glue formed by the binding agent of mineral wool when said heat insulation is mineral wool, or with glue additionally absorbed therein, as is apparent from figure 3, to the downwardly pointing intermediate sections 12 provided in between the concrete engagement ribs 13. The described adhesion of the joining plate 3 and the heat insulation layer 8 with glue 9a or 9c is obtained, when the heat insulation layer is formed of a separately manufactured heat insulation plate, which can be made of expanded polymer or mineral wool. It is also possible that the heat insulation layer 9 is, due to its own adhering properties 9d, attached both to the flute surfaces 23 of the concrete engagement ribs 13 and to the downwardly pointing intermediate sections 12 provided in between the concrete engagement ribs. This kind of adhesion is achieved by casting the expanded or expandable plastic directly against the joining plate 3 and by allowing it thus to be polymerized to the desired density and hardness, in which case both the heat insulation layer 8 and its adhesion to the joining plate are obtained in one and the same work step. When the heat insulation layer 8 is made of expanded polymer, it advantageously contains rigid expanded polystyrene or rigid expanded polyurethane, but it is possible that other suitable polymers shall also be made commercially available. As an alternative, particularly when for example fire resistance is required, the employed heat insulation layer 8 can be made of mineral wool or a similar material that is bound with a hardening, i.e. polymerizing plastic or with some other binding agent - in which case the fire resistance, or resistance to high temperatures, of said agent must also be taken into account. It is also possible to improve the fire resistance, or resistance to high temperatures, of expanded polymers by a suitable treatment, for instance by adding fire resistant agents. It is not as such necessary that the material of the heat insulation layer 8 maintains its strength at high temperatures, i.e. during a fire, at least not to a high degree, but the most essential requirement is that the material of the heat insulation layer is neither ignited nor destroyed; in other words, it suffices that said heat insulation material maintains an essential part of its fire resistance properties, i.e. is capable to carry its own weight at high temperatures, and thus maintains its porous internal structure as well as its outer shape and measures. The heat insulation layer need not carry external loads in these conditions, i.e. when it is contained in a ready-made slab structure, where the concrete C already is hardened. On the other hand, the material of the heat insulation layer 8 must be sufficiently strong in the installation conditions, for example at room temperature and/or at open air temperatures, where the concrete mass B still is in a fluid state. In order to make the heat insulation layer 8 give the prefabricated elements 20 an adequate rigidity and strength, so that said elements should not be immoderately deformed under the weight of the cast, still wet and non-hardened concrete mass B, the compression strength of the material of the heat insulation layer must be at least 75 kPa, but typically at least 100 kPa. If possible, the compression strength of the heat insulation layer material should be at least of the order 200 kPa - 300 kPa. The thickness H2 of the heat insulation layer is typically about 150 - 200 mm, although other measures are also possible, and it must be resistant to moisture, as well as to stresses caused by the junction effects between the heat insulation layer, the joining plate 3 and the steel sheet part 4, to be explained in more detail below, or the steel sheet profiles.

[0022] In particular, in the prefabricated element 20 according to the invention, and consequently also in the load bearing slab structure 1, the steel sheet part 4 and respectively the steel sheet profiles 5, 6, can be realized by alternative structures. In a first alternative, the continuous steel sheet part 4 is essentially planar, as is shown in figure 4. In another alternative, the continuous steel sheet part 4 contains longitudinal ridges 15 that extend into the heat insulation layer 8, as is shown in figure 2. In a third alternative, in the middle section of the slab structure, the adjacent steel sheet profiles 5 are either planar strip profiles 5a, i.e. steel sheet strips, as is shown in figure 1, or shaped profiles 5b provided with a longitudinal ridge 15, as is shown in figure 3. The steel sheet profiles are generally referred to with the number 5, and the more detailed reference numbers 5a, 5b are only used when special cases are being discussed. The continuous steel sheet part 4 may also contain for example perforations 14. Moreover, the steel sheet part 4, and respectively the outermost profiles 6 of the steel sheet profiles 5, 6, may also contain folds 11 pointing towards the joining plate 3 along the sides 16a of the slab structure. This means that said folds 11 are bent 90° around the edge of the heat insulation layer and extend at a given length along the side surface of the heat insulation, advantageously attached thereto. Thus the grip between the steel sheet part 4, to be described next, and the steel sheet profiles 5, 6, can be further improved. The joining plate 3 and the continuous steel sheet 4 or the steel sheet profiles 5, 6, are at all points arranged at a minimum distance H8, i.e. the joining plate and the continuous steel sheet part or the steel sheet profiles are not in contact at any point. Said minimum distance H8 is secured both between the continuous steel sheet part 4 or the top surfaces of the longitudinal ridges 15 of the steel sheet profiles 5, 6 and the joining plate, and between the steel sheet part 4 or the top edges of the folds 11 provided at the edges of the steel sheet profiles 5, 6 and the joining plate, for example the intermediate sections 12 thereof. When longitudinal ridges 15 and/or folds 11 are provided in the structure, said minimum distance H8 is at least 30% of the thickness H2 of the heat insulation layer, or advantageously at least 50% of the thickness H2 of the heat insulation layer. If longitudinal ridges 15 and/or folds 11 are not provided in the structure, the minimum distance H8 is equal to the thickness H2 of the heat insulation layer.

[0023] The steel sheet part 4 or respectively the steel sheet profiles 5, 6 are arranged to form a surfaced fixing with the heat insulation layer 8 by means of a separate layer of glue 9b, as in figure 1, or by means of the glue 9c contained in the heat insulation layer 8, for example by means of glue formed by the binding agent when the heat insulation is made of mineral wool, or by means of glue additionally absorbed therein, as in figure 3. The described engagement achieved by means of glue 9b or 9c between the steel sheet part 4 or the steel sheet profiles 5, 6 and the heat insulation layer 8 is achieved, when the heat insulation layer is formed of a separately manufactured heat insulation plate, which can be made of expanded polymer or mineral wool. If the steel sheet part 4 provided with longitudinal ridges 15, or particularly the steel sheet profiles 5, i.e. the shaped profiles 5a, should be used, it is possible to press the steel sheet part 4 or the shaped profile 5a against the bottom surface Pa of the heat insulation layer, so that the longitudinal ridges 15 are immersed in the heat insulation layer 8. The heat insulation layer 8 may, owing to its own adhering properties 9d, also be in surface engagement with the steel sheet part 4 or with the steel sheet profiles 5 along the whole surface thereof, irrespective of whether said steel sheet parts or steel sheet profiles, in this case shaped profiles 5b, include longitudinal ridges 15 or not. The latter situation is created by pouring the expanded or expandable plastic directly against the steel sheet part 4 or the steel sheet profiles 5, and by allowing it then to be polymerized to the desired density and hardness, as was already described above. The own adhesive properties of the glue 9b, 9c, or of the heat insulation 9d must have a predetermined strength that is capable of transferring at least those shearing forces that are created when the concrete layer 7 exists as a not yet hardened concrete mass B.

[0024] Either the joining plate 3 and/or the steel sheet part 4 and/or the heat insulation layer 8 and/or at least one of the layers of the glue 9a, 9b is advantageously impermeable to gas, in which case it is possible to make the structure insulate any radon gas emitted from the ground, which is necessary when the slab structure is used as a base floor. This impermeability to gas, when positioned at the right spot, also forms a steam block, which is necessary when the structure 1 is used as a base floor or roof. In principle it could be possible to achieve the gas impermeability feature by means of a separate film placed on either side of the heat insulation layer, but this would increase the work steps and could weaken the surface engagement between the heat insulation layer and the joining plate, or respectively between the heat insulation layer and the steel sheet part 4 or the steel sheet profiles 5, 6.

[0025] As a conclusion, it is maintained that in the present invention, after the concrete casting, the joining plate 3 and the concrete layer 7 made of hardened concrete, possibly provided with additional concrete reinforcements, constitute the primary load bearing structure, and the heat insulation layer 8 serves as an insulation against radon gas, moisture and heat. In the final structure, the steel sheet profiles 5, 6, or the steel sheet part 4 serve mainly as suspension structures for sewers and pipework. To some extent, the heat insulation layer and the steel sheet profiles 5, 6 or the steel sheet part 4 also increase the rigidity of the ready-made structure, thus reducing deformations and problems owing to vibration. It is a special feature that when casting concrete, when the concrete is fluid concrete mass B, the joining plate 3 operates under compression stress, and after the concrete is hardened, when loading the slab structure 1, under tensile stress. The joining plate 3 has dimensions to be able to carry said compression and tensile stresses. For the sake of clarity, let us point out that compression stresses from the casting period are not transferred to the concrete, because at that stage the concrete is not yet hardened. Compression stresses in the joining plate lower post-casting tension levels during an effective load on the joining plate, but according to the current understanding, this does not have any remarkable effect in the functions of the structure.

Claims

1. A load-bearing slab structure in buildings, which slab structure (1) comprises at least an upper metal sheet construction, a concrete layer (7) placed on top of it and a heat insulation layer (8) positioned below it, the top surface (Py) of said heat insulation layer (8) being fixed with said sheet construction, and a lower steel sheet construction arranged at the bottom surface (Pa) of said heat insulation layer, which lower steel sheet construction has surfaced fixing with the bottom surface of the heat insulation layer, so that the upper and lower steel sheet constructions are spaced apart at a distance defined by the thickness (H2) of the heat insulation layer,
characterized in that:

- said upper metal sheet construction is a continuous joining plate (3) provided with several concrete engagement ribs (13) pointing away from the heat insulation layer, which joining plate is arranged to carry at least those tensile stresses that are directed thereto during the use of the slab structure, of the total load (C + F) while the concrete is hardened; that
- said lower steel sheet construction is either a continuous steel sheet part (4) or a number of adjacent steel sheet profiles (5, 6), said steel sheet part or respectively the steel sheet profiles having dimensions to carry only those tensile stresses that are directed thereto while the concrete layer (7) of the slab structure is as a non-hardened concrete mass (B); and that
- the concrete layer (7) is, at said upper and lower steel sheet constructions, in contact and attached only to the joining plate (3), so that said joining plate and concrete layer constitute the primary load bearing part of the slab structure.

2. A slab structure according to claim 1, **characterized in that** the heat insulation layer (8) is:

- attached with glue (9a, 9c) to the downwardly pointing intermediate sections (12) provided between the concrete engagement ribs (13), the envelope surface of said intermediate sections being a plane; or
- owing to the effect of its own adhering properties (9d) attached to the joining plate, at least to the downwardly pointing intermediate sections (12) provided between the concrete engagement ribs (13) and optionally also to the flute surfaces (23) of the concrete engagement ribs (13).

3. A slab structure according to claim 1 or 2, **characterized in that** in cross-section, the concrete engagement ribs (13) of the joining plate (3) are widened towards the inside of the concrete layer (W2→W1); that the joining plate (3) is arranged to carry also compression stresses caused by the fluid, non-hardened concrete mass (B) created by the concrete layer (7); and that said joining plate is composed of one steel sheet, with which the heat insulation layer (8) is in said direct surface fixing.

4. A slab structure according to claims 1, 2 or 3, **characterized in that** the steel sheet part (4) is either completely planar or also includes longitudinal ridges (15) extending to the heat insulation layer; that in the middle section of the slab structure, the adjacent steel sheet profiles (5) are either planar strip profiles (5a) or shaped profiles (5b) provided with longitudinal ridges (15), each ridge extending to the heat insulation layer (8); and that the joining plate (3) and the continuous steel sheet part (4) or the steel sheet profiles (5, 6) are spaced apart at essentially every point with at least a minimum distance (H8).

5. A slab structure according to any of the preceding claims, **characterized in that** the glue (9b, 9c) creating the surface fixing between said steel sheet or respectively said steel sheet profiles and the heat insulation layer (8), or the own adhering properties (9d) of the heat insulation has such predetermined strength that it is capable of transferring at least those shearing forces that are created while the concrete layer (7) is as a non-hardened concrete mass (B).

6. A slab structure according to any of the preceding claims, **characterized in that** the steel sheet part (4) comprises and respectively the outermost edge profiles (6) of the steel sheet profiles comprise folds (11) pointing towards the joining plate (3) along the side edges (16a) of the joining plate (3), the distance between said folds and said joining plate being at least the minimum distance (H8).

7. A slab structure according to any of the preceding claims, **characterized in that** it further comprises, in the concrete layer (7), concrete reinforcement(s) (17) that is/are separate from the joining plate (3), to which reinforcement the concrete (C) also is attached while hardened.

8. A slab structure according to any of the preceding claims, **characterized in that** either the joining plate (3) and/or the steel sheet part (4) and/or the heat insulation layer (8) and/or at least one of the layers of glue (9a, 9b) is impermeable to gas.

9. A slab structure according to any of the preceding claims, **characterized in that** the average distances (W3) between the concrete engagement ribs (13) in said joining plate (3) made of metal are substantially shorter than the width (W_L) of the joining plate; and that said minimum distance (H8) is at least 30% of the thickness (H2) of the heat insulation layer.

10. A slab structure according to any of the preceding claims, **characterized in that** the ends (16b) and/or side edges (16a, 16b) of said element are provided with protrusions (Lu) of the steel joining plate (3), extending outside the heat insulation layer (8), said protrusions being adapted to rest on the foundation (30a) or on the walls (30b).

11. A slab structure according to any of the preceding claims, **characterized in that** the bottom surface (Pa) of the heat insulation layer (8) of the element and/or the bottom surfaces (Pb) of the steel sheet part (4) or of the steel sheet profiles (5, 6) are adapted for positioning against the top edge of the foundation or of the heat insulation (28) optionally provided on the inner surface of the wall.

12. A slab structure according to any of the preceding claims, **characterized in that** the foundation (30a) or the walls (30b) are provided with an external lining plate (18), which extends from the surface (23) supporting the element (20) of the foundation and respectively of the wall, upwardly, for the length of the mold height (H3), and that said external lining plate serves as the edge mold of the concrete mass (B) to be cast.

13. A prefabricated element in order to create a load bearing slab structure in buildings, said element (20) comprising:

- an upper metal sheet construction,
- a lower steel sheet construction,
- a heat insulation layer (8) provided in between the upper and lower metal sheet constructions, which heat insulation layer is provided with a top surface (Py) that is in surfaced fixing with said sheet constructions, and a bottom surface (Pa), said surfaces being substantially spaced apart, so that a thickness (H2) is obtained for the heat insulation layer; whereupon
- the ready-made slab structure (1) also comprises a concrete layer (7) that is located, when cast on site, at least partly on top of said upper metal sheet construction and is in contact with it,

characterized in that further in the element (20):

- said upper metal sheet construction is a joining plate (3) composed of a continuous steel sheet provided with several concrete engagement ribs (13) that are widened in the direction away from the heat insulation layer (W2→W1) as well as their intermediate sections (12), and the joining plate (3) has dimensions and shapes carrying compression stresses during said concrete casting and also to receive tensile stresses caused in the slab structure (1) by the total load (C + F) during usage;
- said lower metal sheet construction is either a continuous steel sheet part (4) or a number of adjacent steel sheet profiles (5, 6), said steel sheet part and respectively the steel sheet profiles having dimensions carrying at least the tensile stresses caused by the non-hardened concrete mass (B) of the concrete layer; and
- the joining plate (3) and the continuous steel sheet part (4) or steel sheet profiles (5, 6) have at least a minimum distance (H8) at substantially every point of the element.

14. A prefabricated element according to claim 13, **characterized in that** the joining plate (3) has dimensions and shapes capable to carry the compression stresses caused by the non-hardened concrete mass (B) of the concrete layer and directed thereto, and to receive tensile stresses directed thereto during the use of the slab structure (1) by the total load (C+F) formed by the external load and the hardened concrete; and that the heat insulation layer (8) is directly attached to said joining plate.

15. A prefabricated element according to claim 13, **characterized in that** the heat insulation layer (8) is made of rigid expanded polystyrene, rigid expanded polyurethane, mineral wool bound with a hardening polymer or the like; that the heat insulation layer (8) is of a material having fire resistance or is treated to be fire resistant; and that the compression strength of the heat insulation layer (8) in the installation conditions is at least 75 kPa, or at least 100 kPa.

16. A prefabricated element according to claim 13, 14 or 15, **characterized in that** said top surface (Py) of the heat insulation layer (8) is directly attached to at least said intermediate sections (12) of the joining plate (3); and that among the alternative structures of the element:

- in the first, the continuous steel sheet part (4) is substantially planar,
- in the second, the continuous steel sheet part includes longitudinal ridges (15) that extend inside the heat insulation layer (8), and that
- in the third, in the middle section of the slab structure, the adjacent steel sheet profiles (5) are either planar strip profiles (5a) or shaped profiles (5b) provided with longitudinal ridges (15), said ridges being located inside the heat insulation layer (8).

17. A prefabricated element according to any of the claims 13 - 16, **characterized in that** the ends (16b) and/or side edges (16a, 16b) of said element are provided with protrusions (Lu) of the composite metal slab (3) protruding from the heat insulation layer (8).

18. A prefabricated element according to any of the claims 13 - 17, **characterized in that** the bending resistance of the joining plate (3) is higher than the bending resistance of the continuous steel sheet part (4) or the added bending resistance of the adjacent steel sheet profiles (5, 6).

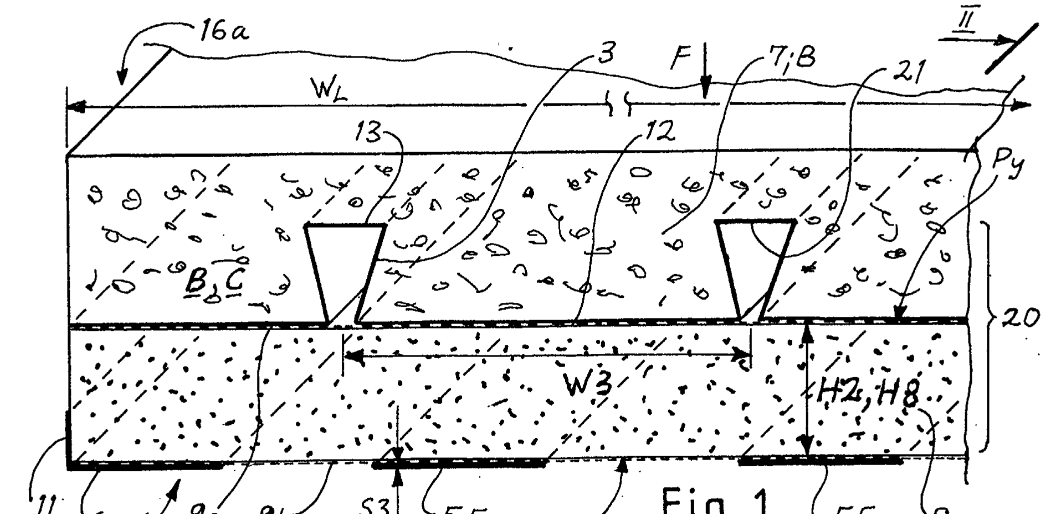

Fig. 1

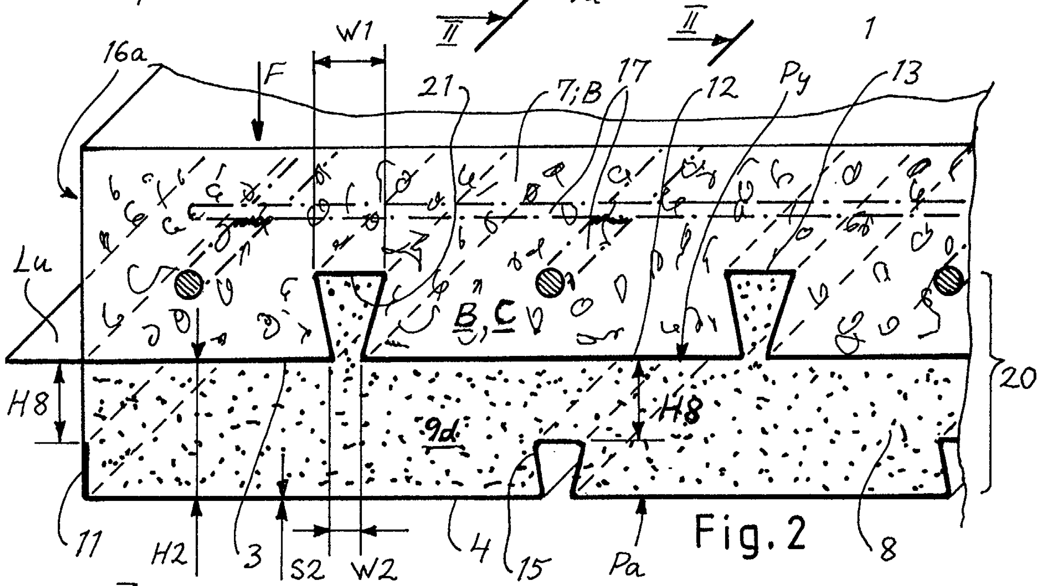

Fig. 2

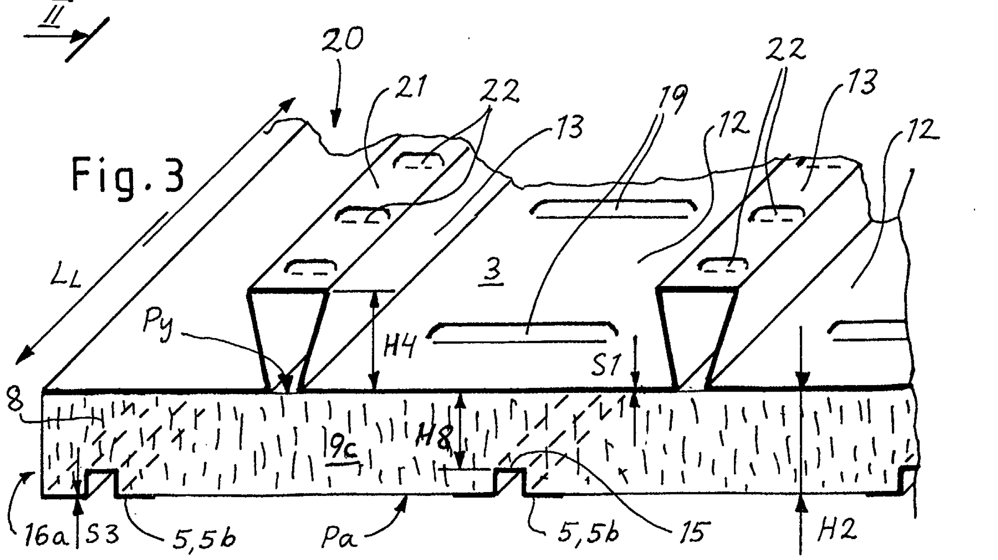

Fig. 3

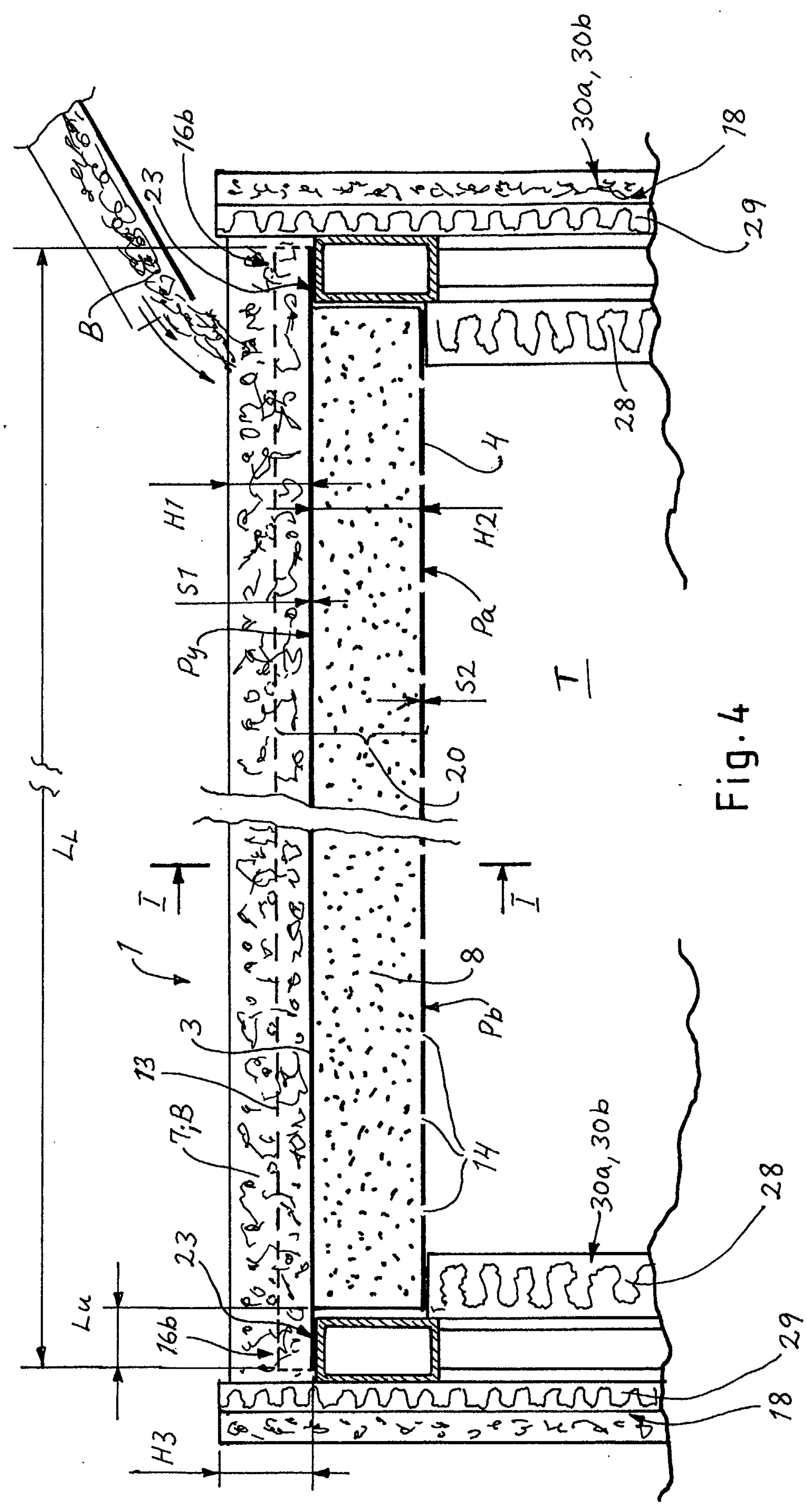
30a, 30b
18
16b
23
B
29
28
4
H1
H2
S1
Pa
Py
S2
T
20
LL
I
1
8
Pb
3
13
7,B
14
Lu
H3

Fig. 4