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(54) Process for consolidating or reinforcing masonry structures and the like

(57) The invenction concerns a process used to intervene for structural purposes on manufactured products such as, in particular, masonry walls. A masonry wall is combined with a skeleton, consisting of an extensive framework of linear elements, arranged according to a texture that is adjusted on the base structure as a function of the configuration of the same structure, determining a sort of load bearing cage. Pre-existing manufactured products can thus be integrated through the elements distributed in them, conserving their residual static capabilities and, remaining prevalent in the resulting structure, the physical characteristics of their materials. The process is suitable equally well to repair interventions and to fresh realisations.

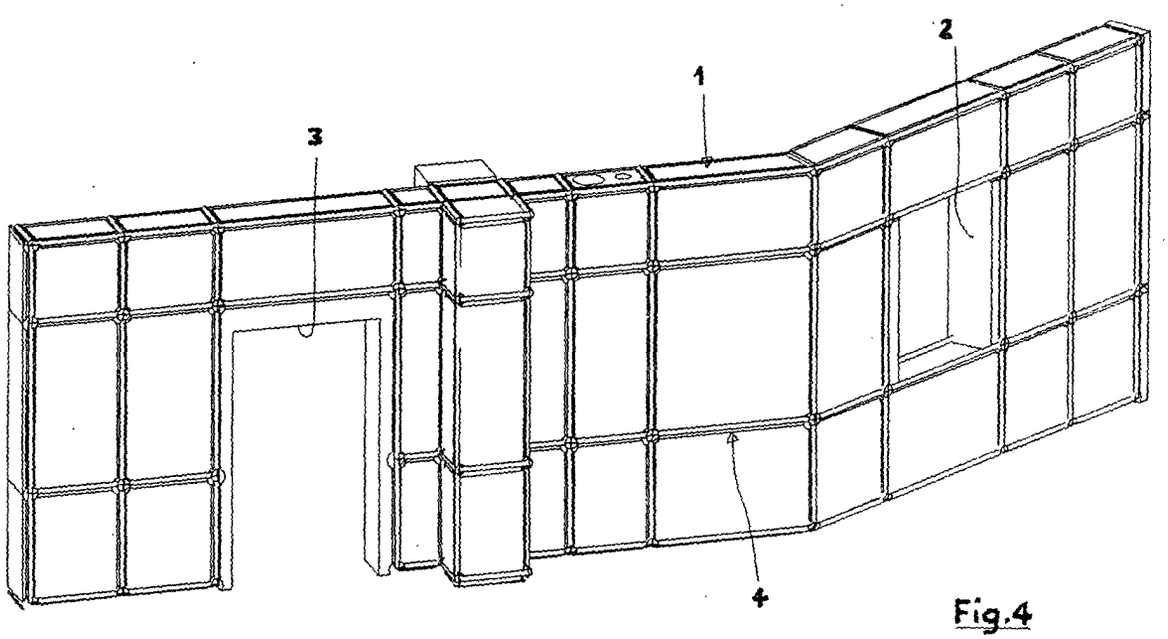

Fig.4

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Description

[0001] The present invention concerns the field of building. More specifically, it concerns a new process for consolidating and/or reinforcing masonry structures and the like, both for restructuring and repair interventions, and for new buildings.

[0002] The prior art comprises intervention systems generally used in the structural recovery of masonry walls, above all in areas subject to seismic risk. In particular, apart from those methods that provide for the arrangement of layers of reinforced concrete on the two faces of a pre-existing masonry wall, it is known to actually insert beams and columns linked in frames to make more rigid or replace the masonry wall itself. Such methods, besides being rather burdensome in terms of costs, have drawbacks for the structures and the pre-existing materials, with various negative repercussions: difficulty should demolition or cutting be necessary, possible dishomogeneous response to stresses by the materials arranged together, assessment of the variations in physical and surface finish characteristics between one material and another, and a potential increase in loads.

[0003] In general, therefore, the risk is incurred of changing the global behaviour of the structure or of the pre-existing material from various points of view. Further and recent techniques, based upon the use of composite materials (e.g. carbon fibre), closer to reinforced concrete and less invasive than the previous ones, whilst carrying out an extensive integration of the masonry walls, do not add structural elements to it; therefore, they cannot do without the requirements of structural efficiency of the wall support to which they are applied, nor can they replace it, with consequent limitation in use.

[0004] The object of the present invention is that of overcoming the aforementioned drawbacks, providing a process for the integration of wall-type structures, both during construction and in repair, which adds extensive rigidity still with a low degree of intervention on the base structure, and leaves the masonry wall's continuity as unaltered as possible, preserving the structural efficiency and the global characteristics of the materials and being more adjustable and versatile than known systems.

[0005] In particular, in case of use for repair, it is an object of the present invention to provide a method of the aforementioned type, which allows extensive demolition works to be avoided, and in any case limits the invasiveness of the interventions upon pre-existing structures, integrating their static behaviour through a rigid and extensive structure, preserving and using their mechanical capabilities, also permitting possible subsequent interventions on the final structure.

[0006] Such object are accomplished with the process for consolidating and reinforcing wall structures and the like according to the present invention, the essential characteristics of which are defined in the attached claim 1.

[0007] The process is substantially based upon the combination of two structures, one of the masonry type, possibly pre-existing, and the other forming an extensive skeleton. The size and arrangement of the skeleton structure, made up of single linear elements assembled together by means of repeatable and rigid joints, are derived from a mesh scanning carried out on the masonry wall so as to extensively cover it, and which therefore is a function of the geometry and composition thereof. According to the network and the nodes thus identified, on the faces of the wall and transversally, surface channels and through holes are formed, for linear elements of the skeleton and the relative connections to be inserted, together constituting a further general structural system in rigid frameworks with which the wall itself can participate.

[0008] The masonry remains largely integral and absolutely prevalent in the assembly, given the small size of the linear elements composing the framework. This type of intervention also excludes extensive demolition or through cuts. The inserted structure, with rigid elements and connections, is such as to have its own autonomy.

[0009] The characteristics and advantages of the process according to the present invention shall become clearer from the following description of an embodiment thereof, given as an example and not limitative, with reference to the attached drawings, in which:

- figure 1 represents, in a schematic axonometric view, a portion of wall structure to be consolidated with the process according to the invention;
- figure 2 shows the portion of figure 1, from a different angle, after having undergone a first scanning step of the process;
- figure 3 represents, from the opposite side with respect to the previous figures, a skeleton structure intended for coupling with the portion of wall;
- figure 4 shows, like in figure 3, the skeleton structure mounted on the portion of wall;
- figures 5 to 7 represent a further exemplifying embodiment of the process, in respective subsequent steps;
- figures 8 and 9 are cros sections of the portion of wall of figures 5 to 7, respectively taken along lines VIII and IX of figures 5 and 6;
- figures 10 and 11 represent in a perspective view, respectively in an assembled and exploded configuration, an example of a joint of the skeleton structure according to the invention;
- figure 12 is a perspective view, in assembled configuration, of a different type of junction for angled joints; and
- figure 13 is a plan view from above of the junction of figure 12.

[0010] The following description refers, as an exam-

ple, to two possible applications: integration of an entire masonry wall of an ordinary dwelling (figures 1 to 4); intervention to frame an opening adjacent to a recess inside the wall (figures 5 to 9). In the first application a general criterion for configurating the additional structure is outlined.

[0011] With reference to figures 1 to 4, a generic load bearing masonry wall 1 (figure 1), with a typical thickness of about 40 centimetres and defined by floors (not represented), has a broken planimetrical development and includes a window 2 and a door 3. According to the invention, a scanning of the wall 1 is carried out, so as to define a network R comprising meshes M that are typically quadrilateral like in the example, so that the wall 1 itself is extensively covered and geometrically reconstructed by said scanning.

[0012] The network is in practice obtained by squaring the wall 1, on both sides, into meshes M, as a consequence of carring out a division of the same wall into at least three horizontal bands and, adopting the width of the bands as reference, according to vertical bands in a number such as to cover its extension, also in this case in a number of no less than three. The division is obviously further developed and/or adapted considering the specific characteristics of the wall 1, and in particular the need to suitably involve the end parts, the corners, the openings, recesses, cavities, columns, portions made from different materials and/or with different load situations and whatever else. Consequently, the squarings, and therefore the width and/or the number of bands are adjusted.

[0013] The meshes M, the vertexes of which are represented by nodes N, symmetrically define a plurality of flat regions on the two sides of the wall 1. Considering the imaginary transversal connections CT between corresponding nodes N on the two sides, the three-dimensional drawing of the network R is completed.

[0014] The network R thus identifies a texture for an extensive skeleton structure 4 (figure 3), typically made from metal material, configured following the composition of the wall, with a depth that is never greater than the thickness of the masonry wall 1. In particular, the skeleton structure 4 is formed from single linear elements or rods 5 of varying lengths, assembled in succession according to the aforementioned texture, and therefore rigidly connected, through a joint system 6, preferably of a modular type, which shall be discussed later on, at the junctions N. The rods 5 thus precisely follow the shape of the meshes M and of the relative transversal connections CT.

[0015] The process according to the invention then comprises the step (figure 2) of forming, on the wall 1, again carefully following the texture established by the network R, a series of channels or grooves 7 and transversal through holes 8 suitable for housing precisely the rods 5 of the skeleton structure 4. More specifically, the grooves 7 are intended to receive the longitudinal rods 5, i.e. those to be arranged along the meshes M, whereas the through holes 8 allow the insertion of the transversal rods along the connections CT.

[0016] As represented in figure 4, the subsequent step of the process consists precisely of the mounting of the structure 4 on the wall 1 thus prepared. In the assembly thus obtained, the surface or longitudinal rods 5 are arranged within, or immediately close to, the two opposite faces of the wall 1. The transversal rods 5, on the other hand, are intended for the connection between the two surface frameworks of the structure 4, jointly applying a consolidating and containment action.

[0017] When the various rods 5 with the relative joints 6 are housed, grooves 7 and holes 8 are finally closed with suitable methods known in the field of masonry. A composite structure is thus actually realised in which the base masonry element and the skeleton structure 4 encase one another. The mutual arrangement and the branching of the structure 4 combine to extend their connection and collaboration.

[0018] The wall 1 still keeps its core intact, which can therefore continue to carry out load bearing functions. The size and the spacing of the holes 8 induce a negligible weakening in the masonry structure, with effects that are incomparable with those deriving from through cuts or demolition. The load bearing capability is, however, integrated by the added skeleton structure 4. The latter, with single elements and joints with suitable characteristics and size can, indeed, assume its own load hearing function.

[0019] In any case, it is clear that a masonry portion surrounded by any square of the skeleton structure 4 realises a plugging effect, simulating the presence of a diagonal element. As shall been seen shortly, the skeleton structure 4 can, however, be integrated by actual diagonal rods, arranged inside a single square on a face of the wall 1.

[0020] Now with reference to figures 5 to 9, in the case in which it is specifically needed to carry out the consolidation of a wall 11 around a window 12, the network R' of the wall shall be based upon a succession of meshes M' that define and surround the window itself, of variable width according to the structural and/or rigidity objectives that one wishes to achieve (figure 5). The consequent structural texture, again divided into three horizontal and vertical bands, shall thus be realised according to the process already described. Then, through holes 18 and grooves or channels 17 are made, for the assembly of a skeleton structure 14 with rods 15 connected on the junctions N by joints 16, surrounding the window 12 (figure 6).

[0021] In the presence of a cavity inside the wall 11, for example hydraulic or venting ducts 19 (figures 7 and 9), the wall has a locally reduced thickness. The skeleton structure 14 can be placed adjacently to the outside of the residual masonry and/or structurally replace it. Where considered suitable (figure 7) the structure 14 can comprise additional diagonal rods 15', as well as be accompanied by a new and adjacent masonry part 11',

also of low thickness, to coat the skeleton structure 14 on one face of the wall 1, which eases the anchoring to the existing wall. Finally, in the presence of recesses or projections in the masonry, the joints 16 can be used to connect other skeleton structures, also textured in the same way but having a different depth to the main one.

[0022] As stated, the rods 5, 15 of the skeleton structure 4, 14 shall usually be made from metal material, selected based upon the requirements. However, any material can in general be used provided that, for its characteristics of rigidity, weight, workability and cost, is suitable for achieving the aforementioned objectives. For example, it is possible to use elements made from wood or composite materials. As far as the joints 6, 16 are specifically concerned, various constructive devices can be used, which take into account the connection requirements and the operating conditions for their insertion.

[0023] As an example, an advantageous configuration is in any case proposed in figures 10 to 13, to which reference is made hereafter. Considering, for the sake of simplicity, using steel, the rods 5, 15 can have an overall T-shaped section, in practice consisting of two distinct semi-elements, each with an L-shaped section. The T-shaped section makes the rods 5 easier to insert into the grooves or channels 7, 17.

[0024] In case of a flat junction, and therefore having a joint 6, 16 operating between rods 5, 15 coplanar to each other, with reference in particular to figures 10 and 11, said joint comprises four brackets 20, each rigidified by a triangular element 21 in which a slot 21a is formed near to the right angle of the bracket. In the two arms of each bracket 20 holes 20a are also formed for the connection with the rods 5, 15, in turn having suitable holes 28, through screw means (not represented).

[0025] The joint also comprises a locking plate 22 with a quadrilateral profile, suitable for being arranged substantially coplanarly with the face of the wall 1 in which the channels 7, 17 are formed. From one side of the plate 22 four platelets 23 project in a off-centered manner. On the plateles 23, again with bolted connections (not represented), the brackets 20 are secured through the same connection elements also engaging with the rods 5, 15. For such a purpose, the platelets 23 have holes 23a suitable for corresponding with the holes 20a of the brackets 20. The platelets 23 also act, as shall be seen shortly, as shims between the brackets 20.

[0026] On the plate 22 four openings 22a are centrally defined that correspond to the slots 21a of the reinforcing elements 21 of the brackets 20. A traverse 24, intended to connect two joints 6, 16 passing through a transversal hole 8, 18 of the wall 1, 11, comprises four tubular profiles 25, each with a section corresponding to the profile of the slots 21a and of the openings 22a. The four profiles 25 are connected together by spaced groups of clamps 26 suitably fixed onto the outer surfaces of the profiles, with the cooperation of cross-shaped plugs 27, arranged centrally, of which two at respective ends of the traverse 24, all intended to compose the same traverse 24 in a single element. The end plugs, however, are smaller in size than that (or those) on the inside, thus defining, in cooperation with the profiles, a seat intended to engage with the brackets 20. The arms of such end plugs 27 thus, in practice, have the same thickness and side surfaces matching with the platelets 23, for the entire depth of the brackets 20.

[0027] The joint is assembled in the following manner. Assuming that the rod 5, 15 that converges to the junction from below is already present, a first pair of brackets 20 is arranged in the space between the two semi-elements of the rod itself. The traverse 24 is then engaged, by inserting the tubular profiles 25 in the slots 21a of the brackets 20.

[0028] Then a further bracket 20 is added, making it slide through the relative slot 21a of the reinforcing element 21 along the corresponding profile 25. Then, in the same way, the last bracket is arranged. Thereafter, the plate 22 is inserted, making it slide a little, through the opening 22a with which it is provided, so as to close the ends of the profiles 25 and also placing the platelets 23 between the brackets 20 acting as shims/spacers. At the same time the end plug 27, slightly spaced apart from the profiles 25 so as to allow the entry (between the plug and the profiles) of the brackets 20, is completely enclosed and integrated by them. Finally, the remaining rods 5, 15 and the connection bolts are arranged.

[0029] The operation can be repeated at the other end of the traverse 24, i.e. at the opposite face of the wall 1, finally applying locking screws (not represented) to prevent a possible sliding of the traverse with respect to the plate 22 and brackets 20 assembly. Such screws are positioned axially in a central hole 22b of the plate 22.

[0030] It should be noted how the clamps 26 that connect the profiles 25 of the traverse 24 near to the ends shall be placed so as to constitute an abutment for the arms of the brackets 20, and a support for the cross-shaped plugs 27. Each end of the traverse 24 is tightly enclosed in extended cavities or pairs of cavities with configurations totally analogous, respectively, to the perimeter of the profiles 25 and of the plug 27. The plates 22 and the reinforcing elements 21 provide flexional rigidity between vertical and horizontal rods, whereas the engagements that are realised on the slots 21a and on the openings 22a allow the torsional and flexional connection between the rods and the traverse 24. The brackets 20, the plate 22, the platelets 23 and the traverse 24, together with the plurality of bolts restore the vertical and horizontal continuity of the rods converging in the junction. Possible further bolted connections, besides allowing diagonal rods 5, 15,to the fixed to the plate 22, can give the pairs of brackets greater rigidity also for flexion on transversal planes with respect to the faces of the wall 1, 11.

[0031] The joint as a whole is thus able to rigidly connect both the rods 5, 15 that converge on a junction N coplanar to a face of the wall, and the rods that reach

the same junction N crossing the wall through a hole 8 - i.e. the traverses 24 - all the above in the conditions envisaged by the proposed process, therefore in the presence of the wall and with the structure accessible only from its faces. Although the mounting of the joint has been described through the progressive mounting of all of its components, it is clear that the plate 22 and brackets 20 assembly can be premounted in a single group possibly stabilised with additional small perimetric plates, the actual mounting being in practice reduced to the engagement of the traverse 24, in turn premounted, in the slots 21a aligned with the openings 22a, and the subsequent insertion of the rods.

[0032] Besides the solution of a flat junction, with criteria totally similar to those described, solutions can be realised that allow the structure to follow the corners of a masonry wall, as shown in figures 12 and 13 in which components identical or similar to those already introduced are indicated at the same reference numeral. In such a case, the various components shall have shapes modified as a consequence of the geometry to be followed. In particular, it should be noted how the reinforcing elements 21 of the brackets 20 can be more suitably angled for a better distribution of stresses. Necessarily, the plates 22, whilst still conserving their function, shall be shaped according to the inner and outer faces of the angle to be followed. The slots 21a and openings 22a shall have contours deriving from the angle with which they are met by the profiles of the traverse 24. However, the joint, and the structure deriving from it, still can be realised and applied according to the above menctioned procedures.

[0033] Returning to the general characteristics of the process according to the invention, the same can clearly also be applied in more general cases than those exemplified. In a totally analogous way to that which has already been described and according to the specific requirements, the process can, indeed, be extended to the entire structure of any building (dwelling or otherwise), or be applied just to some masonry dividing walls or on simple portions of different walls, being, in particular, easly adjustable in order to follow different planimetric or ground configurations. In case of specific structures, for example in a masonry vault, it can be used by adapting the framework, junctions included, to that configuration. The rods 5, 15 can clearly have a variable length according to the scanning carried out (a priori there is nothing to prevent a network texture that is denser, even only locally or else, for other cases, orientated diagonally).

[0034] Finally, the surface of longitudinal rods do not necessarily have to be contained within the masonry thickness; in many cases, it is operatively possible or advantageous for this to be the case, as much as necessary to ease the connection by means of the transversal rods and to improve the integration effect with the base masonry work, both for structural and aesthetic purposes. Especially in case of pre-existing masonry, the arrangement of the skeleton structure can also be carried out with the longitudinal rods completely outside the wall, in contact or spaced a part from the respective faces, and thus merely realising through holes in the masonry.

[0035] The connection between the two structures is thus modulated, even reducing it to the simple co-existence of one in parallel with the other. If an even closer connection is needed, the most suitable anchoring provisions can always be adopted. The surface framework also lends itself to such anchoring as well as to providing support for the application of further coatings, for example insulation systems.

[0036] No particular difficulty is posed by the crossing of a floor for the passage of the rods 5, 15 from one level to the other in the walls of a building, nor by the possible relationship with foundation structures. In this regard, ordinary manufactured products can be used, for example cement curbs for the underpinning of foundations. The rods, if made from compatible material, can be inserted in such reinforced curbs or can be replaced by them in the overall network.

[0037] The same restoring interventions of the masonry structure can take place in a more targeted, and presumably reduced, manner, considering for example the role of masonry walls as diagonal elements in the single meshes. Without losing its validity, the process according to the invention thus allows the new skeleton structure to be combined with other and ordinary types of intervention on the masonry walls themselves.

[0038] In fresh projects it is again possible to conceive a supporting structure like the skeleton structure 4 and combine it with a masonry wall with the advantage of being able to balance such a combination of structures. In such a case, with it remaining possible to give the load bearing function to the skeleton structure, and the filling function to the masonry wall, both can be optimised in order to achieve the most suitable masonry-structure cooperations, actually realising structural groups that can be changed through time, according to the intended use of the construction.

[0039] Applications of the process are then possible both in the field of fresh structures and, in particular, in the consolidation of existing structures, above all when one wishes to recover or conserve both mechanical and physical characteristics, or in all cases in which the intervention criteria described above prove themselves to be adequate.

[0040] The fact that the skeleton structure 4 is realised modularly, i.e. with the repetition of only two types of foundamental elements (rods and joints), clearly constitutes the basis for promoting the production and marketing of systems aimed at a specific use for the process described above.

[0041] Variants and/or modifications can be brought to the process for consolidating or reinforcing masonry structures or the like according to the present invention, without for this reason departing from the scope of protection of the invention itself as defined by the attached

claims.

Claims

1. Process for consolidating or reinforcing a masonry wall (1) **characterised in that** it comprises the following steps: scanning both faces of said masonry wall (1), in a congruent manner, according to a network (R) defining meshes (M) and nodes (N), extending over at least one area of said wall; forming in said wall (1) transversal through holes (8) between corresponding nodes (N) of the network (R) on the two faces; arranging a skeleton structure (4) comprising a plurality of single rigid linear elements (5) of various lengths, to be framed in succession according to said network, and rigid joints (6) for connecting said linear elements at said nodes (N); mounting said skeleton structure (4) on said masonry wall (1), placing said linear elements (5) on said faces in accordance with said networks and using said transversal through holes (8) to connect, through further linear elements (5), said skeleton structure (4) between said faces.

2. The process according to claim 1, wherein a plurality of surface channels (7) suitable for at least partially housing said linear elements are formed in said faces, along the sides of said meshes (M).

3. The process according to claim 2, wherein said channels are formed so as to house said linear elements (5) of said skeleton structure in a substantially flush manner.

4. The process according to claim 2 or 3, wherein said surface channels are closed so as to at least partially cover said skeleton structure.

5. The process according to any one of the previous claims, wherein said skeleton structure also comprises one or more diagonal linear elements arranged inside a single mesh (M) on a face of said masonry wall.

6. The process according to any one of the previous claims, wherein an additional masonry part (11') is realised that at least partially coats said skeleton structure at least on a face of said masonry wall (1).

7. The process according to any one of the previous claims, wherein said joints are realised through a reduced number of sectional modular elements.

8. The process according to any one of the previous claims, wherein said skeleton structure is made from metal material.

9. The process according to any one of the previous claims, wherein said joints are suitable for allowing the connection to said skeleton structure of additional elements projecting from said faces of said masonry wall.

10. The process according to any one of the previous claims, wherein each of said joints comprises a generally plate-shaped assembly for being placed substantially coplanar with a face of said masonry wall, and for realising a bolted connection with said linear surface elements, and a sliding connection with said transversal linear elements.

11. The process according to any one of the previous claims, wherein said linear elements have a doubled structure with an overall T-shaped cross section.

12. The process according to claim 11, wherein said plate-shaped assembly comprises four brackets, each reinforced by a triangular element in which a slot is formed near to the right angle of the bracket, holes being formed in the two arms of each bracket for connection with said linear elements, said assembly also comprising four off-centered platelets each placed between a pair of adjacent brackets, said reinforced brackets and said platelets generally defining an engagement seat for the sliding engagement of a transversal linear element consisting of a traverse comprising four tubular profiles each with a section corresponding to the profile of said slots, connected to each other in a spaced manner.

13. The process according to any one of the previous claims, wherein said masonry wall is a pre-existing structure to be consolidated.

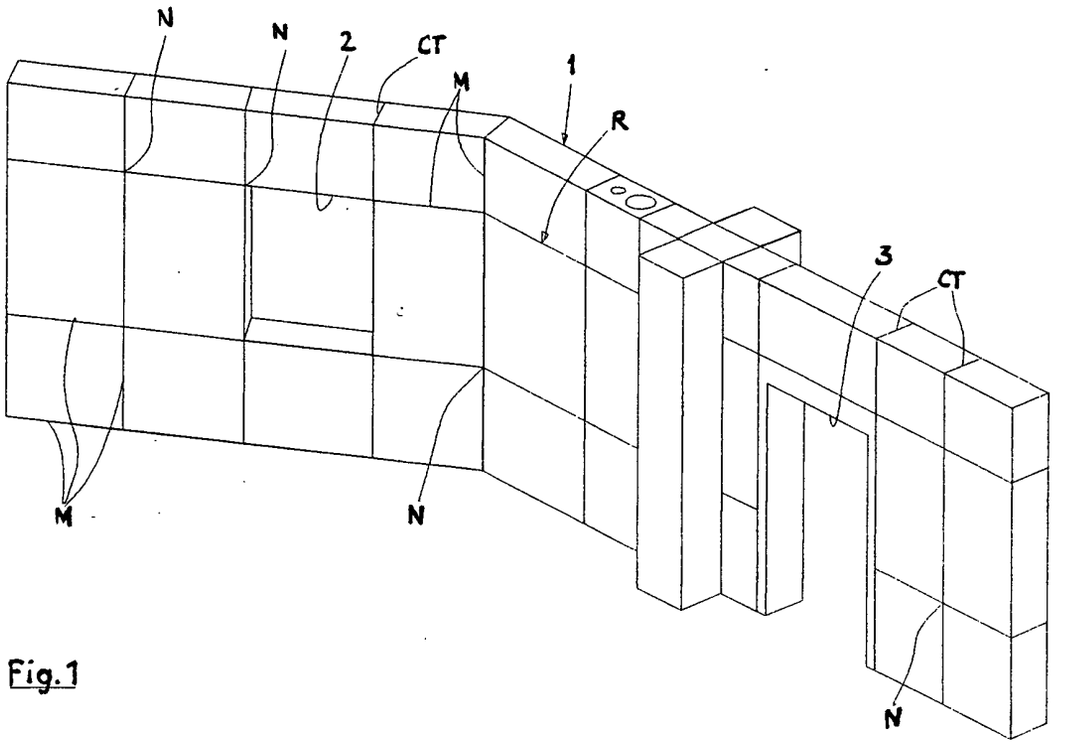

Fig.1

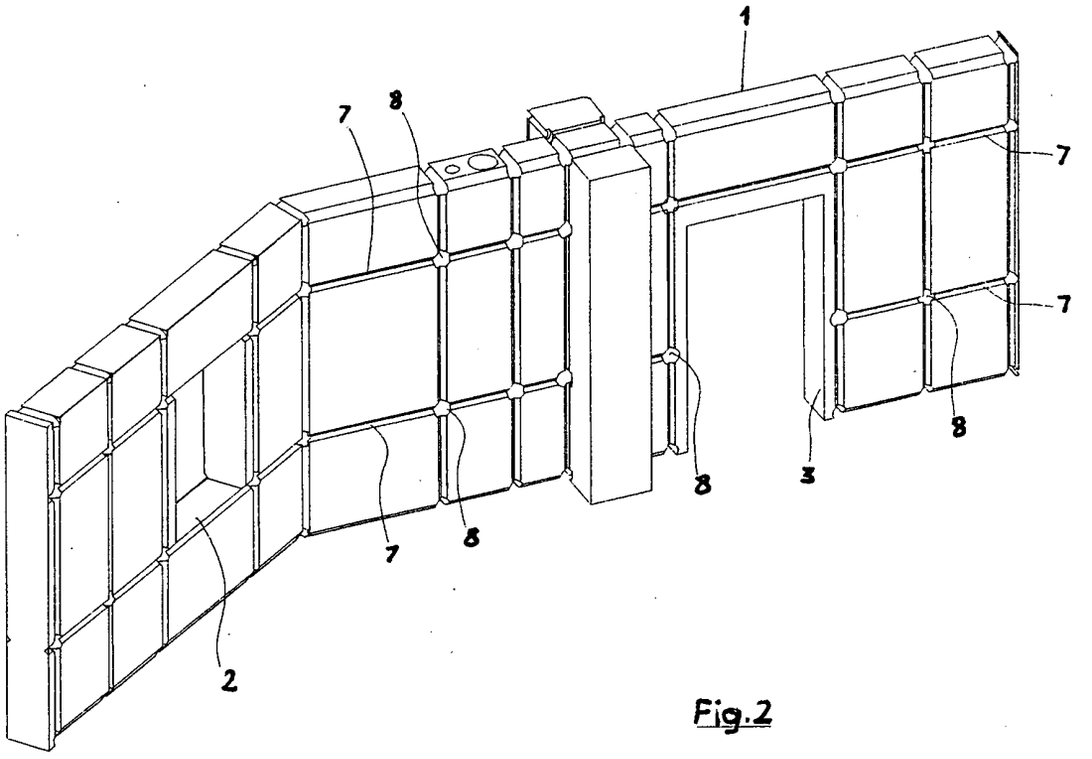

Fig.2

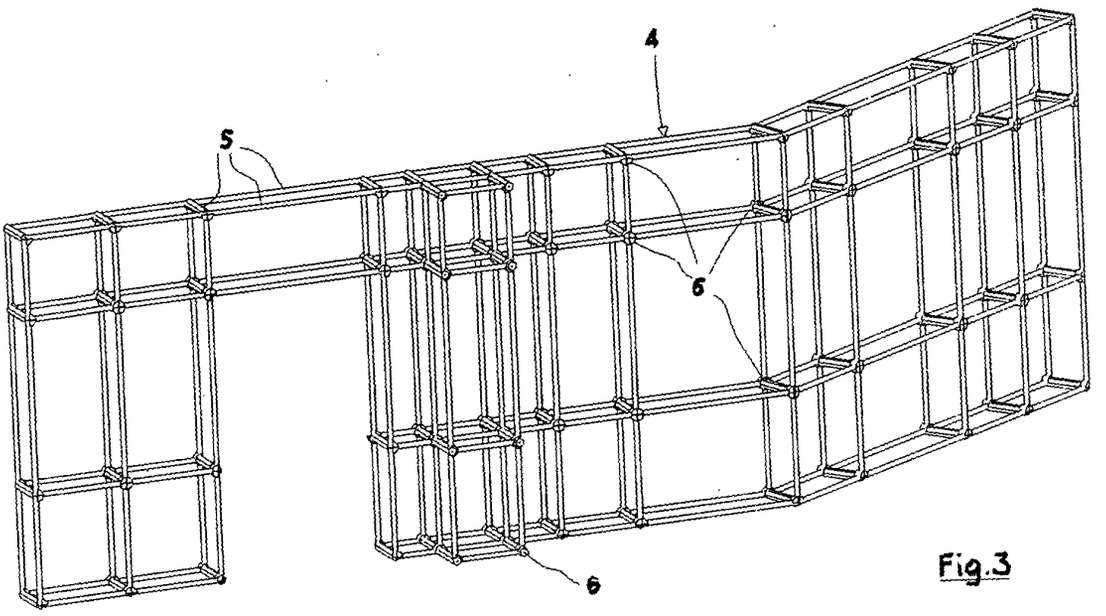

Fig.3

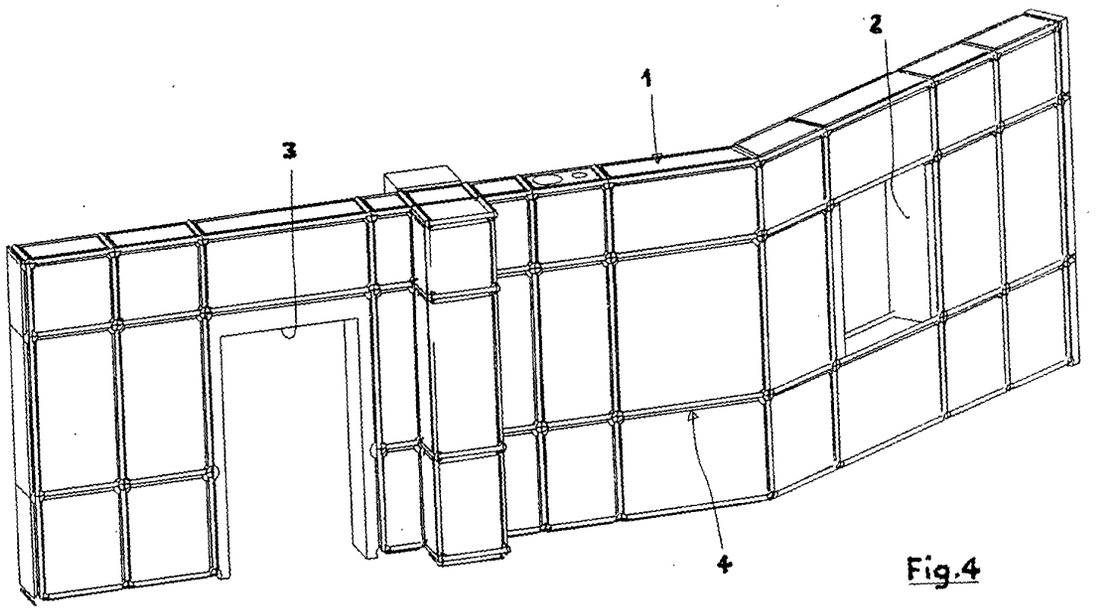

Fig.4

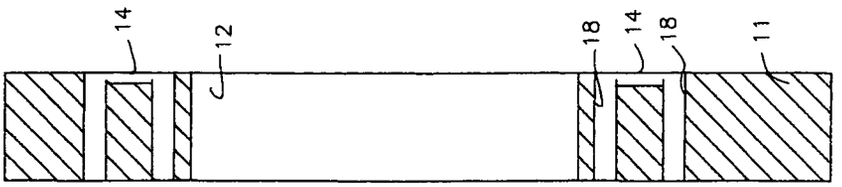

Fig.8

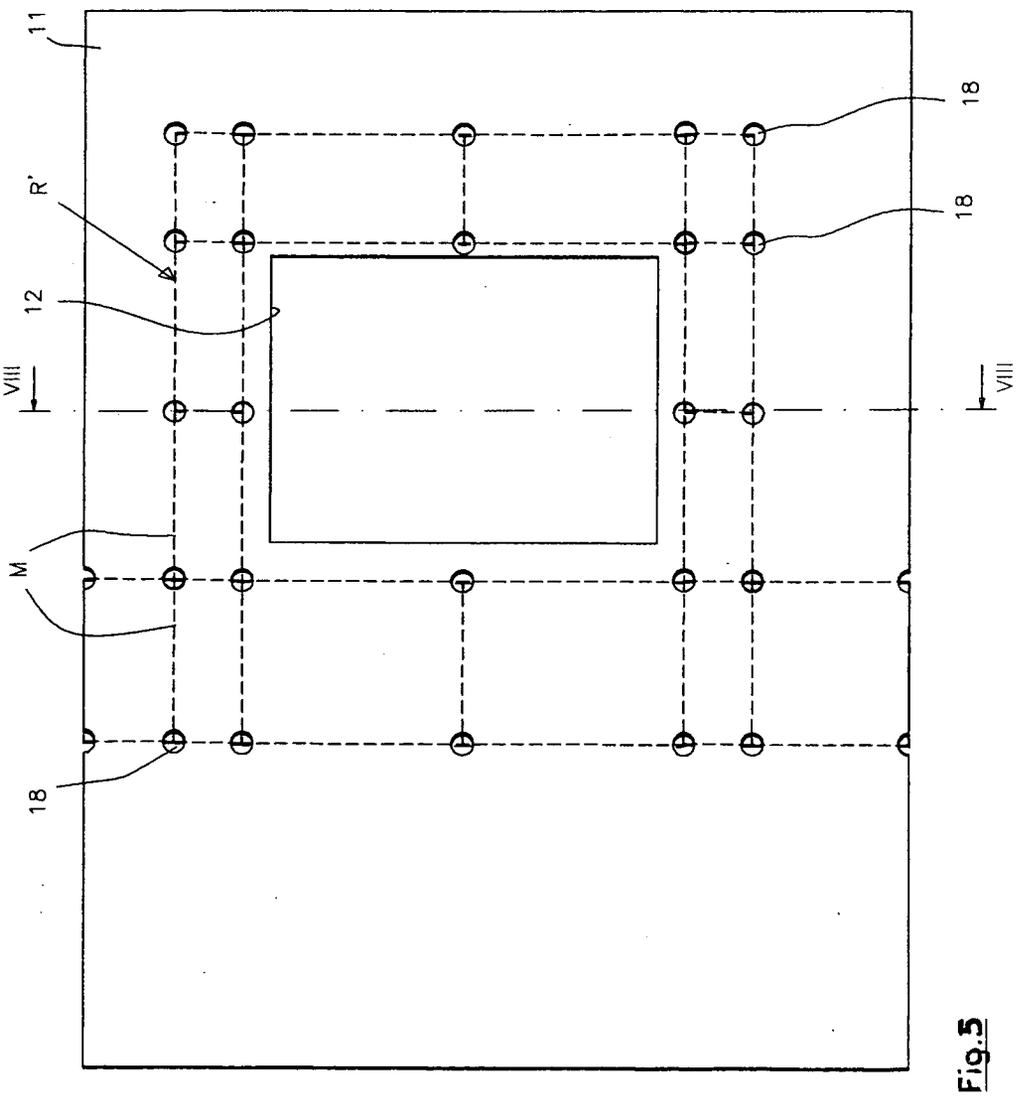

Fig.5

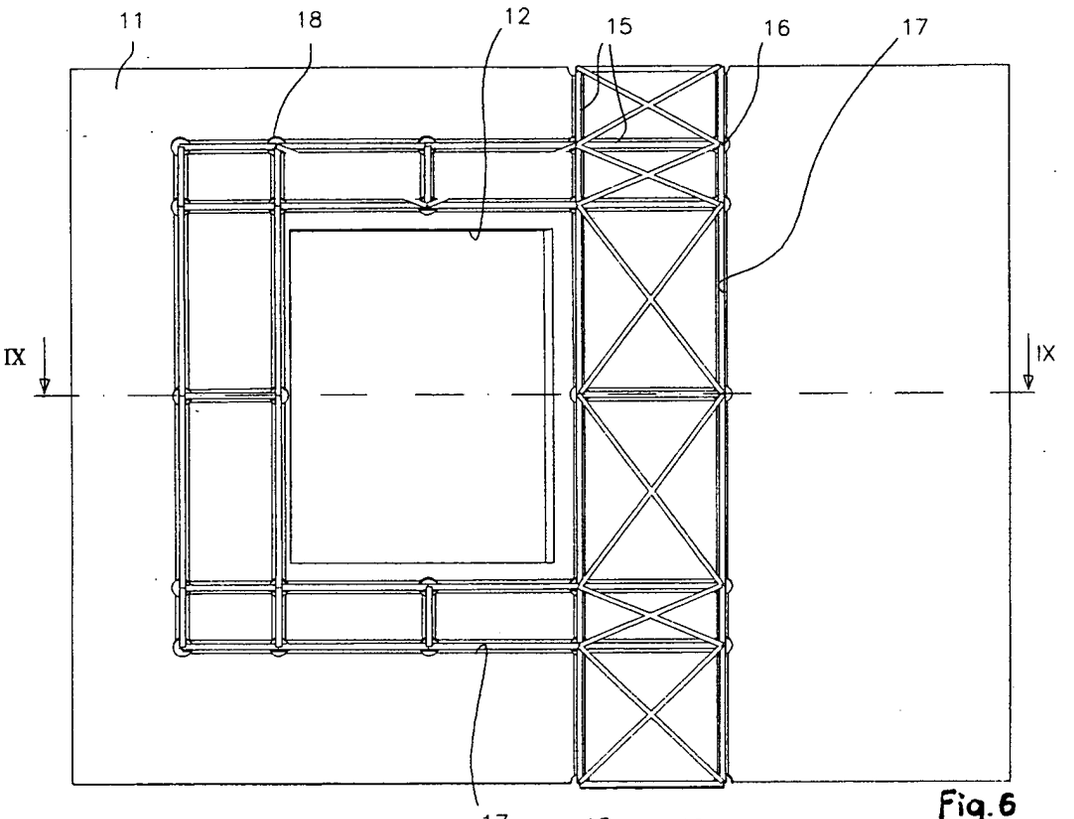

Fig. 6

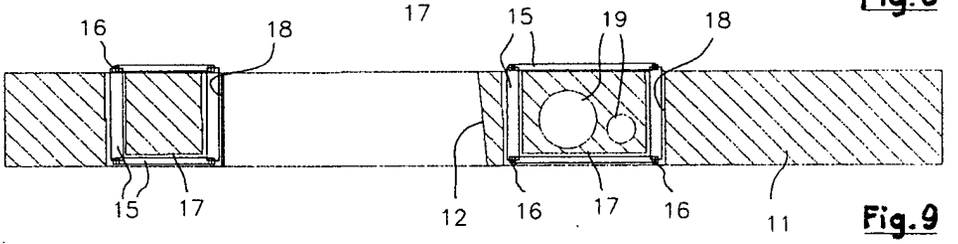

Fig. 9

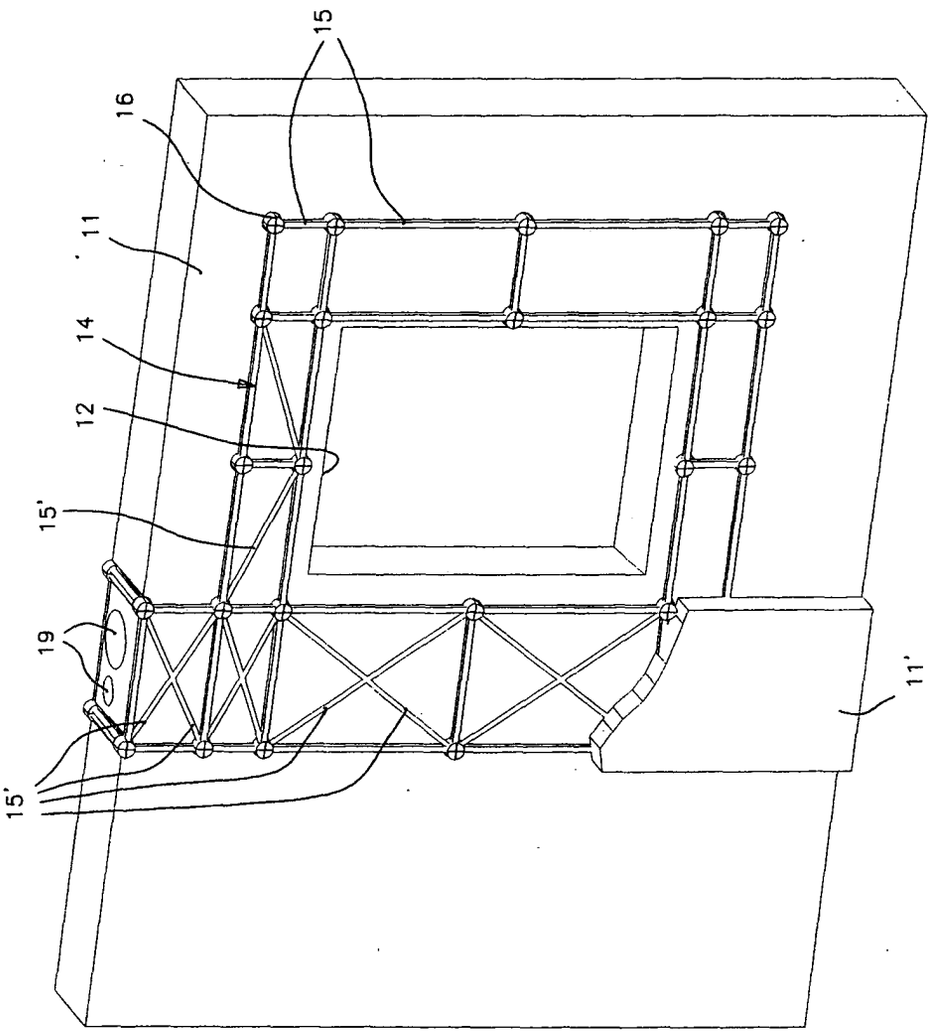

Fig.7

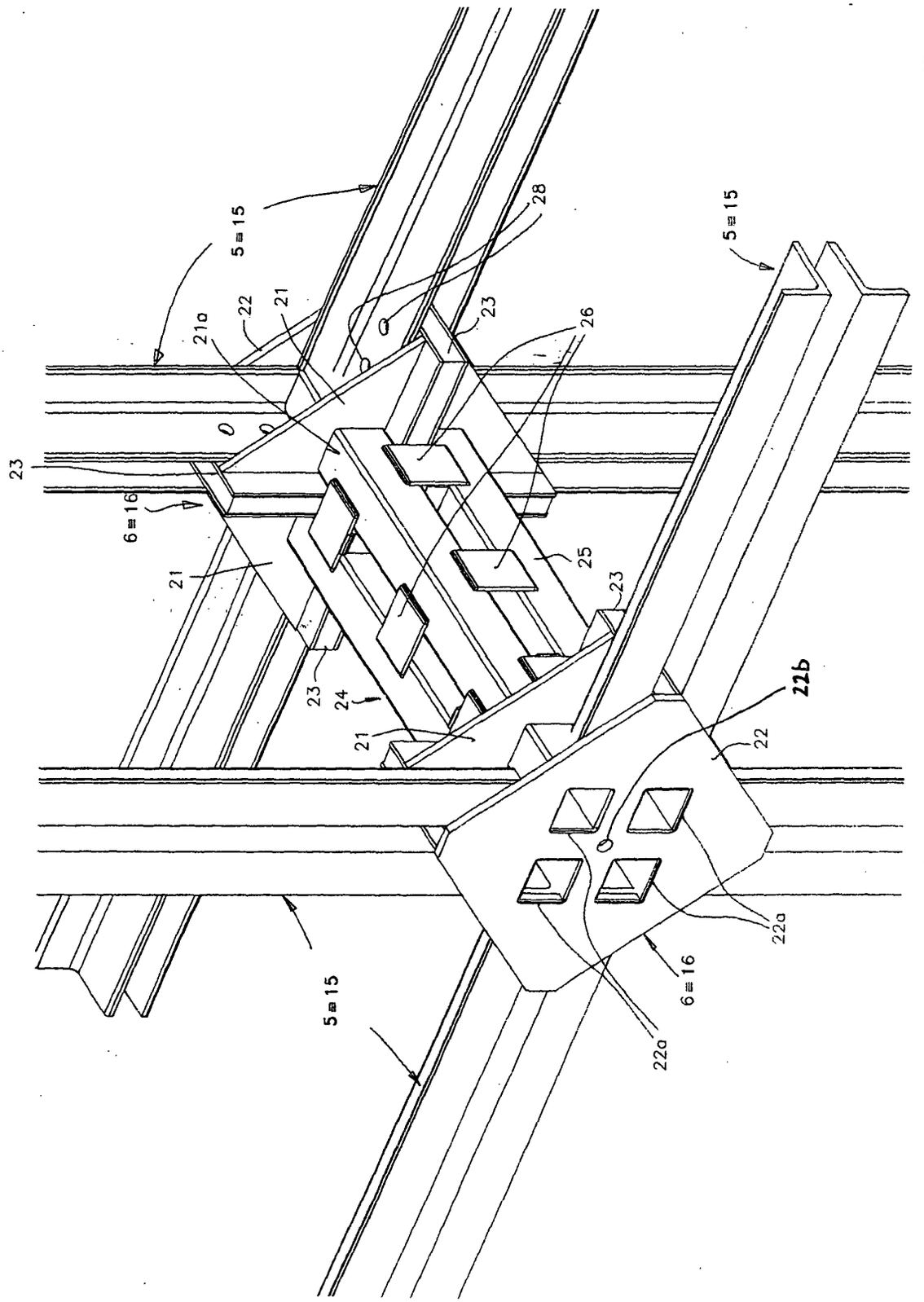
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Fig.10

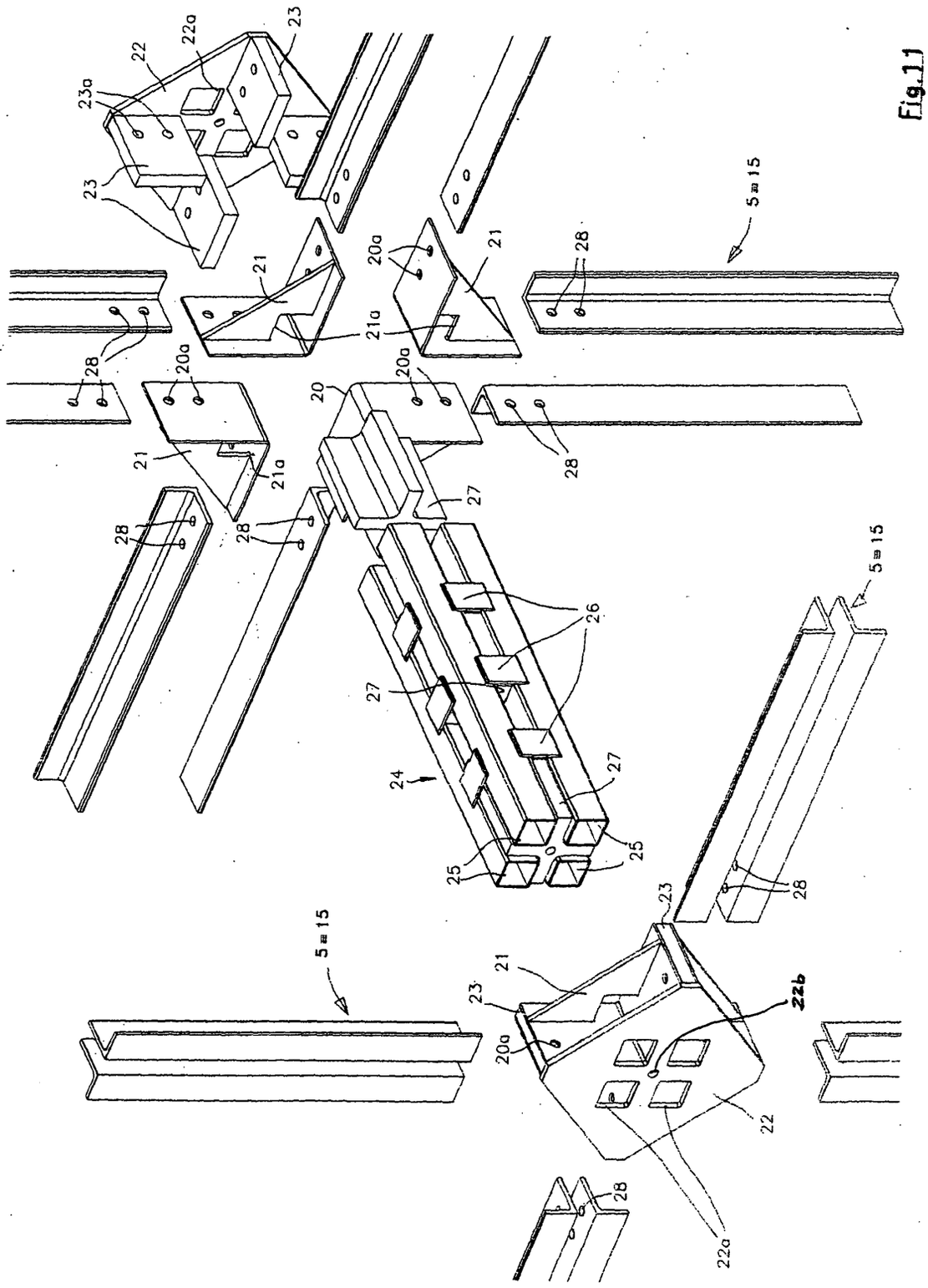

Fig.11

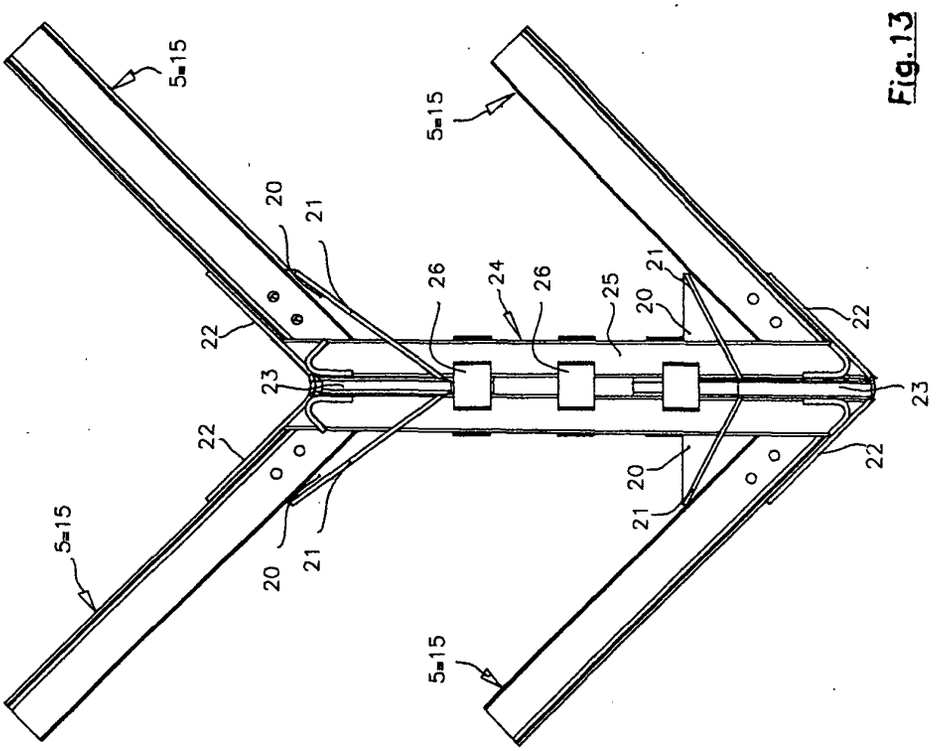

Fig.13

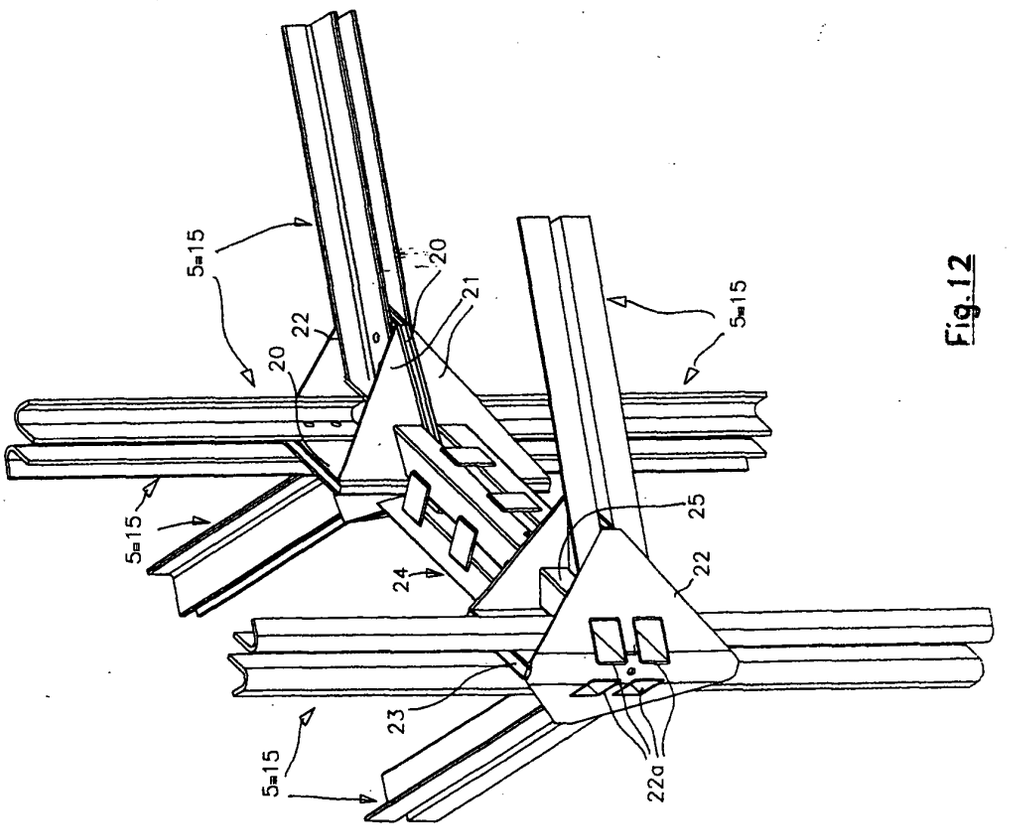

Fig.12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 01 3553

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 November 2004	Vratsanou, V

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