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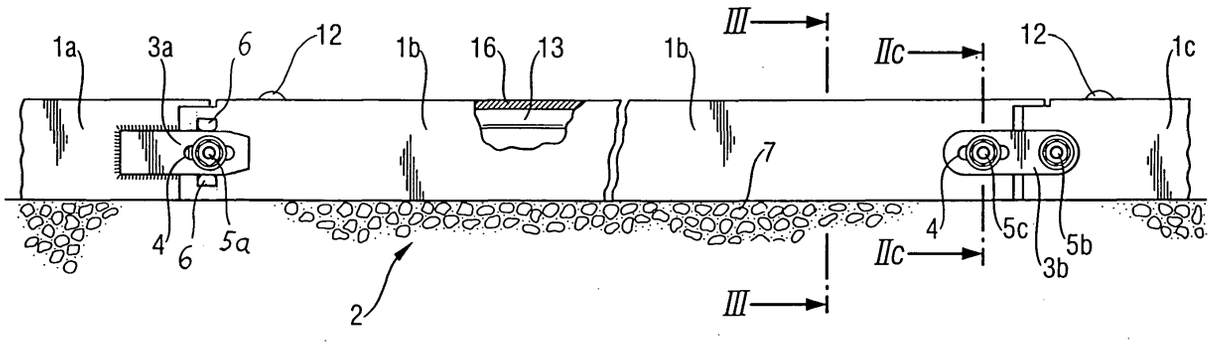
(54) Road construction

(57) According to a method for producing roadways the supporting portion of a roadway is composed of metallic, on the ground (2,6) placed cellular sandwich structures (1a-1g), which by themselves are able to bear the load applied to the roadway. The cellular sandwich structures form fairly long road modules (1a-1g), which are connected to one another in the longitudinal direction of the roadway by a joint structure (3-6) allowing thermal expansion and retraction.

Fig. 1



EP 1 408 156 A1

Description

[0001] The invention relates to a road building method according to the preamble of claim 1 and to a road structure produced by applying said method.

[0002] The building of a road in an area, where the ground down to a considerable depth, in winter reaches a temperature of less than 0° C, is extraordinary expensive and demanding. This is true also generally for areas, where the bearing capacity of the ground is low or where the water contents in the ground vary considerably. The object of the invention is to provide a method, by means of which the problems of traditional road building can be avoided in a manner that is favourable with respect to the costs. The object of the invention is obtained in the manner stated in claim 1.

[0003] In this specification and in the claims, a cellular sandwich structure means a welded metal structure having two outer surface plates at a distance from each other and being generally mutually parallel. Between the surface plates, there is a core comprising a great number of intermediate walls extending from one surface plate to the other and being inclined, usually in pairs, in opposite directions and being attached at their ends to the surface plates. The inclination angle of the intermediate walls is the smaller angle between the surface plate and the intermediate wall. A recommended inclination angle is at least 40°, preferably at least 45°, and at the most 70°, preferably at the most 60°. The core is in many applications best formed as a corrugated plate. Such a core plate can be easily positioned and welded to the surface plates. The corrugations, that is, the folds of the core plate may be basically V-shaped. At both sides, the crests of the V-folds are welded to the surface plates. A too sharp V-fold is disadvantageous, because the crests should have a sufficiently broad attachment surface parallel to the surface plates. That is why the so-called hat-profile is the most favoured fold form. A hat-profile includes V-shaped folds having their crests truncated to a "hat" parallel to the surface plates. The hats form attachment and support portions between the core and the surface plates. The width of the hat is generally, dependent on the distance between the surface plates and on the plate thickness used, 1 to 200 mm. If the distance between the outer sides of the surface plates is h and the hat width is s, one can in many applications presuppose that $s = qh$, where q is about 0,1 to 0,5.

[0004] Also a plate corrugated in waveform can be used as a core plate. A typical cellular sandwich structure is made of steel plates having a thickness of 1 to 2 mm, sometimes also of thicker plates, for instance of 4 mm plates. The distance between the outer sides of the surface plates is thereby typically 60 to 80 mm, but is in special applications considerably greater, for instance 1000 mm. The core may have a slightly smaller plate thickness than the surface plates, but generally all plates have the same thickness. In case a cellular sandwich structure is to be used as a horizontal support member that is likely to be subject to loads concentrated to small areas, it might be of advantage to make the upper load carrying surface plate of thicker material than the other plates. In extreme cases, the minimum plate thickness of a cellular sandwich structure is about 0,2 mm and the maximum plate thickness is about 60 mm. In case the core plate thickness is very great, the making of the core as a corrugated plate is not always rational. Then the core may be made from separate plates or beams.

[0005] By building the supporting portion of a roadway as a cellular sandwich structure, several advantages are obtained. The cellular sandwich structure is able to bear by itself the loads applied on the road. The long interconnected cellular sandwich structure elements of the roadway, that is, the road modules, form a bearing structure that relatively effectively insulates the ground from the influence of the air temperature. Neither is the structure very much influenced by ground deformations caused by variations in the ground water contents and temperature. A cellular sandwich structure is extraordinary favourable from the strength point of view. It minimises the amount of material needed for obtaining a certain level of bearing capacity. Thus, road building of cellular sandwich structures is favourable as to the costs of material. This makes it feasible to use stainless steel as construction material, whereby corrosion problems are avoided and the maintenance costs of the roadway are minimised. The wearing surface of the road may be made of steel, whereby the wear problems are substantially reduced as compared to a road surface made of asphalt or concrete. However, roughening thereof is recommended, because a steel surface is relatively slippery.

[0006] The road modules may favourably have a length of 16 to 32 m. Even longer modules may be used, provided that suitable transport means are available. At the joint sections between the road modules, the joint structure must allow thermal expansion and retraction in the longitudinal direction of the road. There should also be movements allowing arrangements at the road surface. For instance, one road module could have a flap or the like that overlaps the road surface of the following module, or a flexible joint member could be placed in the gap between road modules.

[0007] The core between the surface plates is preferably so constructed, that it forms ducts running in the longitudinal direction of the roadway. These ducts form convenient spaces for cables, tubing and the like. Hence, it is possible, with very small extra costs, to add to the road structure items for other purposes, such as telephone, electric or fibre optic cables, gas or district heating tubing, etc. Also items serving the need of the road may be placed in the ducts, for instance, equipment needed for road illumination or heating. Road illumination means and lights marking traffic lanes may thus be arranged in the road surface or at the border area there-

of.

[0008] From the point of view of road bearing capacity, it is of advantage, that the core is so formed, that between the surface plates, substantially trapezoid, preferably uniform ducts are formed. This is easily obtained by forming the core of a corrugated plate with trapezoid folds. The bearing capacity of the road is also dependent on the total height of the cellular sandwich structure. Roads having a high bearing capacity require a total height of about 400 mm. For dimensions of that range, the manufacture of the core of a corrugated plate is difficult. In that case, the core may more easily be made, for instance, of separate hat-profile beams, being arranged side by side in parallel and welded to the surface plates.

[0009] With regard to bearing capacity, it is recommendable, that the road modules are so formed, that, in a cross-section of the roadway, the portions of the core being parallel to the surface plates have a length of 0,1 to 1,0 times, preferably 0,25 to 0,4 times the length of the portions of the core extending between the surface plates. The smaller values are appropriate for higher bearing capacities. A higher bearing capacity is obtained, if the intermediate walls passing from one surface plate to another are arranged close to one another. However, this increases the number of welds and the amount of material required per length unit of the structure, which raises the production costs. Dimensioning the core according to the preferred dimensional range 0,25 to 0,4 usually results in favourable total costs.

[0010] The thermal expansion and retraction occurring in the longitudinal direction of the road must be taken into account. Thus, there must be, between the road modules, a joint structure allowing such movements. It is recommended that at the road modules, preferably at their longitudinal side surfaces, have connection elements that allow movements of the modules in the longitudinal direction of the roadway, but guide and lock the modules relatively one another cross-wise to the roadway. This gives a strong joint, for which maintenance and service can be easily arranged. The clearance required between the road modules is generally in average 18 to 25 mm for 100 m of road length.

[0011] If a road structure according to the invention is made of stainless steel, the plate thickness may with advantage be 0,5 to 20 mm, preferably 0,7 to 15 mm.

[0012] The invention also relates to a roadway or roadway parts that have been built by applying the method of the invention.

[0013] In the following, some embodiments of the invention are described more in detail, with reference to the attached schematic drawings, in which

- Fig. 1 shows, as a side view, an illustration the principle of application of the method according to the invention,
- Fig. 2a shows the joint structure of the road inodules at the road surface,
- Fig. 2b shows an alternative joint structure of the road modules at the road surface,
- Fig. 2c shows, on a larger scale, section IIc - IIc of Fig. 1,
- Fig. 3 shows section III - III of Fig. 1,
- Fig. 4 shows another embodiment in partial section corresponding to Fig. 3,
- Fig. 5 shows a road module of great bearing capacity in partial section corresponding to Fig. 3.

[0014] In the drawings, 1a, 1b and 1c indicate road modules connected to one another in the longitudinal direction of a roadway. The road modules have been placed directly on the ground 2. Before that, the ground should be levelled and provided with a suitable surface layer, for instance, a gravel layer 7. Extremely weak ground may require reinforcement, for instance, by pile driving. The modules 1a - 1c are connected to one another by means of joint members 3a or 3b. To the left of the Figure a joint member 3a is shown, which has been fixedly welded to the road module 1a. By means of an aperture 4 elongated in the longitudinal direction of the road the member 3a is connected to a fixed bolt 5a in the road module 1b. The elongated aperture 4 allows movements between the road modules 1a and 1b in the longitudinal direction of the road. The vertical strength of the joint can be improved by mounting, above and below the joint member 3a, fixed support members 6, which give the joint member 3a vertical support, but allow small angular movements between the modules 1a and 1b. The joint member 3b between the road modules 1b and 1c is by means of a circular aperture connected to a bolt 5b attached to the road module 1c and by means of an elongated aperture 4 connected to a bolt 5c fixed to the road module 1b. Also in this embodiment, the elongated aperture 4 allows movements of the joined road modules in the longitudinal direction of the road. The joint also allows angular movements between the modules 1b and 1c. The joint arrangements shown are present at both side surfaces of the joined road modules.

[0015] The structure of two joined road modules 1d and 1e at the road surface is shown in Fig. 2a. The module 1d has a flap 8 reaching out a short distance over the module 1e, where it fits into a recess 9 made in the upper surface of module. In the embodiment of Fig. 2b, a flexible but structurally durable rubber element 10b has been inserted between the road modules 1f and 1g. In the solution of Fig. 2a, it is also possible to install a rubber element 10a in the gap between the flap 8 and the module 1e. The solutions shown allow necessary movements between the road modules.

[0016] Fig. 3 shows how the road modules can be provided with auxiliary items needed for the road as well as with items of general use. By way of example, Fig. 3 shows electric cables 11, which may be needed for the roadway, for instance, for the illumination devices 12 of the road, and/or electric cables of other networks. Also

a plurality of tubes are shown. They may be, for instance, water pipes, gas pipes, district-heating pipes or pipes intended for the heating of the road surface. The location and the insulation of the tubes are dependent on the intended use of the tubes. By way of example, also cable bundles 14 are shown. They may include, for instance, electric or fibre optic cables for communication purposes.

[0017] It is recommendable, that the illumination devices 12 of the road are installed in the road surface. By this means lampposts detrimental for traffic safety are avoided. The borders between traffic lanes may advantageously be marked by light spots or the like installed in the road surface.

[0018] Fig. 4 shows some principles for dimensioning cellular sandwich structures according to the invention. The total height *h* of a cellular sandwich structure is generally 40 to 50 mm, when the road has a bearing capacity typical for a walking road. It is 100 to 150 mm, when the road has a bearing capacity typical for a town street, and 200 to 400 mm, when the road has a bearing capacity typical for a motor highway or a main road bridge. In a cross-section of the road module, the length of the core portions 17 being parallel to the surface plates 16 is *s* and the length of the portions 18 of the core positioned obliquely between the surface plates is *p*. The relation *s*/*p* should preferably be 0,1 to 1,0. The bearing capacity of the road generally increases, the smaller the relation *s*/*p* is, but the production costs, in particular the welding costs, rise. The most favourable relation *s*/*p* is normally 0,25 to 0,4. The plate thickness *v* of the core 15 is normally the same as the plate thickness *w* of the surface plates 16. It is feasible, that *v* could be somewhat smaller than *w*. The relation *v*/*w* may be 0,5, but generally, there is no good reason for using a smaller relation *v*/*w* than 0,8. It is recommended, that *s* is always at least 3*v*.

[0019] The welds 19 between the surface plates 16 and the portions 17 of the core form welding seams running perpendicularly to the plane of the Figure. Preferably, laser welding is used for forming either a continuos welding seam 19 or a broken seam. A broken seam is somewhat more favourable as to costs, but is somewhat more vulnerable to corrosion than a continuous seam. A continuous seam is appropriate for use in road modules, which should have a high bearing capacity. An alternative welding method is resistance welding, in particular, resistance welding by means of rotating discs. Laser welding can be carried out from the inside of the ducts of the cellular sandwich structure, but this is very difficult to do by means of resistance welding, which thus is meaningful to apply only to the welding of the core to one of the surface plates. A resistance welding carried out by means of suitable equipment will be considerably less expensive than a corresponding laser welding.

[0020] In Fig. 5, the core of the road module has been made of separate parallel beams. Two different structural alternatives 15a and 15b are shown in the Figure. The beam of alternative 15a is attached to the surface plates 16 by welding seams 19. The only substantial difference compared to the embodiments of Figs. 3 and 4 is that the number of welds at one surface plate is doubled. In spite of that, the building of a road module in this way is favourable, if, due to great dimensions, the making of the core of a corrugated plate is not easily accomplished. The beams 15b have a simpler form than the beams 15a, but they require still an additional welding seam. This alternative is worth using, if, because of great material thickness in the beams or because of insufficient machining capacity at hand the beam form 15a cannot be produced. The beams 15a as well as the beams 15b may be advantageously produced by means of cold forming, for instance, roller forming. At areas, where the beams 15a or 15b are very close to one another, it would be possible to adopt a welding technique substituting a single weld for the separate welds 19. However, this is fairly difficult, and thus it should be undertaken with deliberation.

[0021] The invention is not limited to the embodiments shown, but several modifications of the invention are feasible within the scope of the attached claims.

Claims

1. A method for producing roadways, **characterised in, that** the supporting portion of a roadway is composed of a metallic, on the ground (2, 6) placed cellular sandwich structure (1a - 1g), which is so dimensioned, that it by itself is able to bear the load applied to the roadway, and **in that** the cellular sandwich structure is composed of fairly long structural units, road modules (1a - 1g), connected to one another in the longitudinal direction of the roadway and having at their joint sections a joint structure (3 - 6) allowing thermal expansion and retraction.

2. A method according to claim 1, **characterised in, that** a core structure (15) present between the surface plates (16) of the cellular sandwich structure of the road modules (1a - 1g) is built to form ducts running in the longitudinal direction of the roadway, of which ducts at least some are arranged to form location and protective housing for continuous cables, tubing and the like running through the road modules (1a - 1g).

3. A method according to claim 1 or 2, **characterised in, that** light (12) and/or heating arrangements for the roadway are incorporated in the road modules (1a - 1g) and in cable and/or tubing system (11, 13) enclosed therein.

4. A method according to any of the preceding claims, **characterised in, that** the road modules (1a - 1g) are so produced, that between the surface plates

(16) and the core (15) located between them, substantially trapezoid, preferably uniform ducts are formed, which preferably are formed by using a core formed of a corrugated plate (15) with trapezoid folds.

5. A method according to any of the preceding claims, **characterised in, that** the road modules (1a - 1g) are dimensioned to have a total height that is 40 to 50 mm, when the road has a bearing capacity typical for a walking road, 100 to 150 mm, when the road has a bearing capacity typical for a town street, and 200 to 400 mm, when the road has a bearing capacity typical for a motor highway.

6. A method according to any of the claims 4 to 5, **characterised in, that** the road modules (1a - 1g) are so formed, that in cross-section, the portions (17) of the core being parallel to the surface plates, have a length of 0,1 to 1,0 times, preferably 0,25 to 0,4 times the length of the portions (18) of the core being between the surface plates.

7. A method according to any of the preceding claims, **characterised in that**, at the joints of the road modules (1a - 1g), preferably at the longitudinal side surfaces of the modules, strong connection elements (3 - 6) are installed, which allow movements of the modules in the longitudinal direction of the roadway, but guide the modules relatively one another in the cross-wise direction of the roadway.

8. A method according to any of the preceding claims, **characterised in that**, between the road modules (1a - 1g), a clearance is arranged, which in average is 18 to 25 mm for 100 m of road length.

9. A method according to any of the preceding claims, **characterised in, that** the road modules (1a - 1g) are made of steel or of stainless steel with a plate thickness (v, w) of 0,5 to 20 mm, preferably 0,7 to 15 mm.

10. A roadway or the bearing structure of a roadway (1a - 1g), **characterised in, that** it has been accomplished by applying the method of any of the preceding claims.

Fig. 1

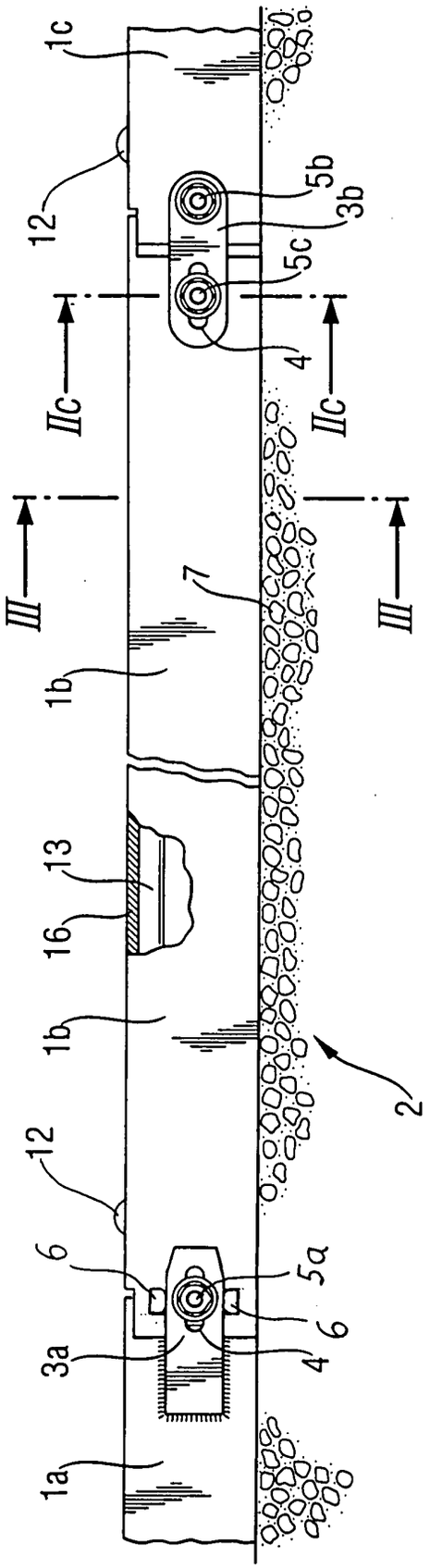


Fig. 2c

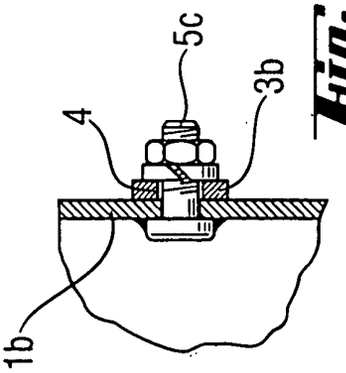


Fig. 2b

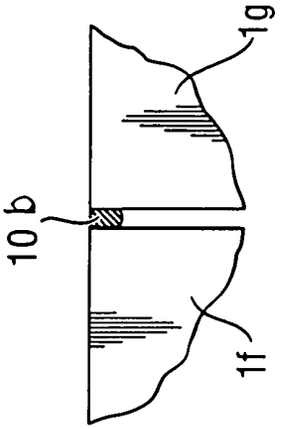
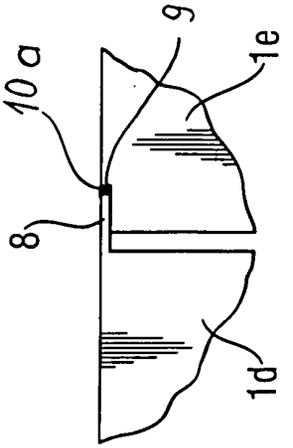


Fig. 2a



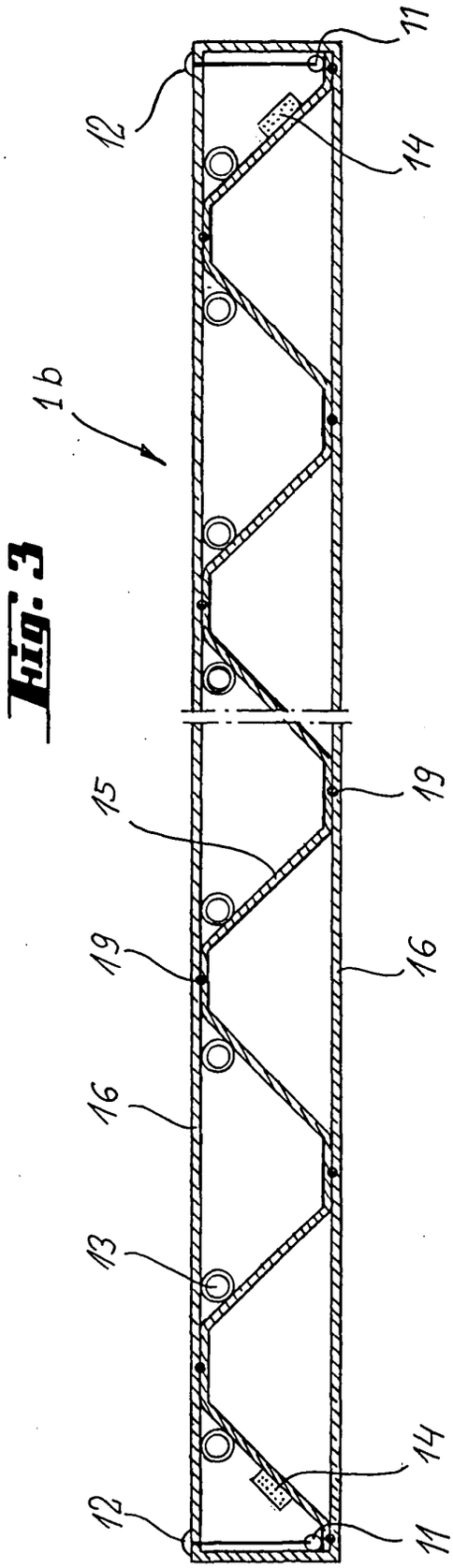


Fig. 3

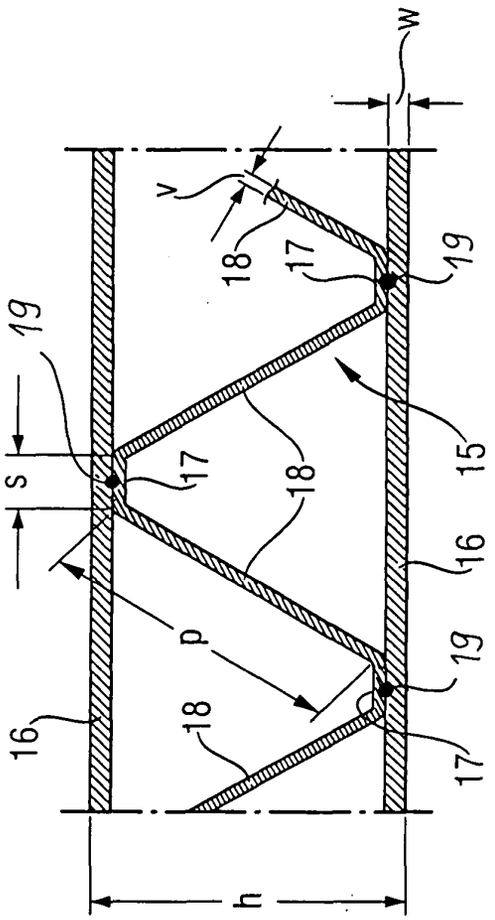
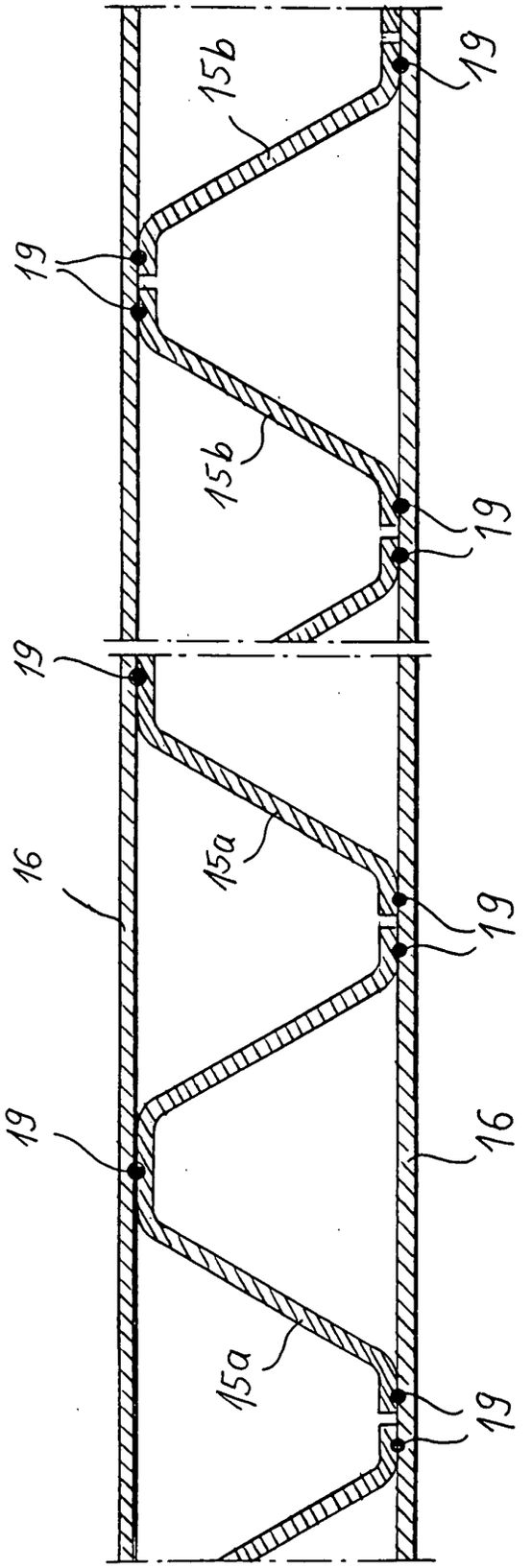


Fig. 4

Fig. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 03 02 2602

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)
X Y	FR 1 467 177 A (TESSONNEAU DOMINIQUE MARCEL ED) 27 January 1967 (1967-01-27) * page 2, paragraph 5 * * page 3, paragraph 1 * * page 4, paragraphs 5-9 * * figures 1-4 *	1-3,5,9,10 7	E01C5/16 E01C11/26
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

E01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	4 December 2003	Kerouach, M

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