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# (54) A LOAD-BEARING FRAME FOR A SINGLE-NAVE HALL

(57) The subject of the invention is a load-bearing frame of a single-nave steel hall, two steel posts (1 and 1') of which, converging on one side, are made of two cold-formed semi-closed C-bars (2 and 2'), the upper ends of which are adjoin the inwardly cut lower ends of the roof transoms (3 and 3'), also converging on one side, also made of cold-formed semi-closed C-bars (4 and 4'), while both in the external flat walls (5 and 5') of webs of semi-closed C-bars (2 and 2') of both these posts as well as in the external flat walls (19 and 19') of webs of semi-closed C-bars (4 and 4') there are transverse mounting through openings arranged in several rows spaced apart, with the outer flat walls (5 and 5') of webs of the semi-closed C-bars (2 and 2') of the posts (1 and 1') and the outer flat walls (19 and 19') of webs of the semi-closed C-bars (4 and 4') of the roof transoms are placed opposite to each other, and between them and opposite to openings in the walls of the posts plate trapezoidal distance connectors (13 and 13'), (14 and 14'), (15 and 15') are placed with through openings made in them, while opposite the through openings in the walls of these transoms plate distance connectors (27 and 27'), (28 and 28'), (29 and 29') and the ridge connector (30) are placed, all with through openings made in them, and also opposite through openings made in the upper oblique ends of cold-formed C-bars (2 and 2') of the posts (1 and 1') and opposite through openings made in the lower oblique ends of cold-formed C-bars (4 and 4') of the transoms (3 and 3'), there are profile distance plate eaves connectors (32 and 32'), also with through openings located opposite the through openings of the oblique ends of the posts (1 and 1') of the transoms (3 and 3'), bolts (16) with nuts screwed on them are embedded in the through openings of these posts and in their distance connectors (13 and 13'), (14 and 14') and (15 and 15'), and screws (33) with nuts screwed on them are mounted in the through openings of both transoms (3 and 3') in the upper oblique parts of the columns (1 and 1') and the openings in the plate distance connectors (27 and 27'), (28 and 28'), (29 and 29') and in the ridge connector (30) and eaves connectors (32 and 32').

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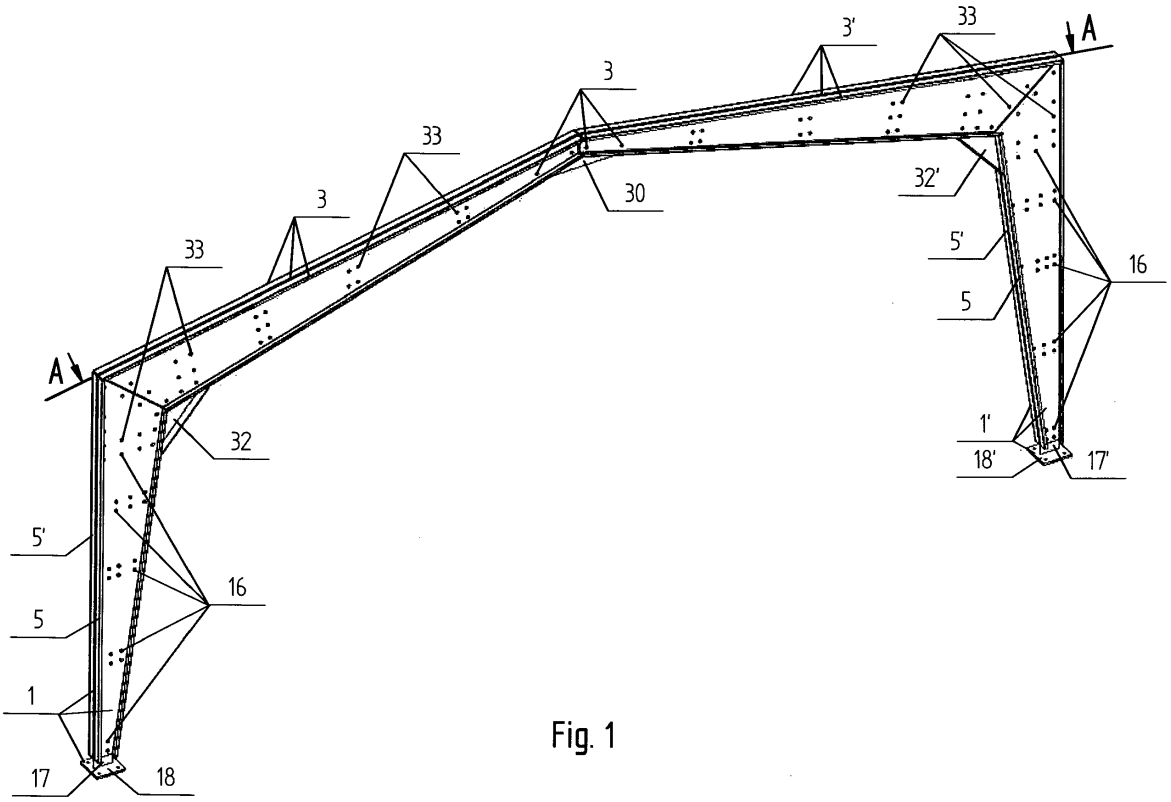


Fig. 1

## Description

**[0001]** The subject of the invention is a load-bear frame for a single-nave steel hall with posts and transoms made of cold-formed profiles connected to each other, applicable as one of subassemblies of the load-bearing structure, especially gable production, warehouse, sports halls, hangars and similar facilities with a large span, usually 10 m, 12 m , 15 m, 18 m, or 20 m.

**[0002]** Steel portal frames are commonly used subassemblies of load-bearing systems in the construction of production halls as well as hangars, workshops and check-in halls constituting the aviation infrastructure. The task of these load-bearing systems is to take over and safely transfer both horizontal forces usually originating from the force of wind pressure and from the impact of transporting devices, especially cranes constituting the equipment of production halls, as well as from vertical loads acting on the foundation of a given building object, caused by the weight of its own structure and the load of the roof.

**[0003]** Known from the Polish specification of the utility model No. W.106820, the steel-structure hall consists of any number of flat load-bearing units, and each of these units consists of a post with a variable stiffness increasing from the bottom, rigidly connected by welding with a transom, also with a variable stiffness, but decreasing from the bottom and further through a joint with the other symmetrical part attached by two further joints to the foundation. Posts and transoms of these load-bearing units are made of sections of I-beams, in which webs are cut obliquely and symmetrically in relation to the center of symmetry of the section of the I-beam, which are welded together after rotation.

**[0004]** From the patent specification of the Polish patent application No. P.395719, a load-bearing structure of the building is also known, the said load-bearing structure consists of posts and rafters supported on these posts, in which rafters are intended to support the gable roof of the building. In the load-bearing structure according to this solution, at least some of the support rafters are made of an I-beam having a web and two parallel shelves situated perpendicular to the web, in the middle of which a zigzag slot is made at defined distances from both shelves of the beam. The resulting two complementary portions of this web are offset from each other and re-welded together to form a series of identical hexagonal openings in the web between parallel shelves of the I-beam. In the second embodiment- of this load-bearing structure of the building, shown in Fig. 3, both load-bearing posts and rafters crowning their upper ends have I-beams converging on one side with identical hexagonal openings in their webs, while the open-work I-beam posts have a downward convergence, and its several-segment rafters have a common convergence towards the top of the gable roof.

**[0005]** From the Polish specification of the utility model No. PL67310, a load-bearing frame of a single-nave steel hall is also known, the said load-bearing frame consists of the basic elements of the structure, which are trusses and posts made of double-branch, four-bent cold-formed C-bars placed with their webs inwards and in contact with each other, and their shelves on the outside. All nodal connections are bolted through webs of four-bent C-bars, and at the connection points there are batten plates or gusset plates of the same thickness for all types of load-bearing frames.

**[0006]** From the Polish specification of the utility model No. PL69631, a load-bearing frame of a single-nave steel hall with a span of 6-15 m and a height of 6 m, consisting of transoms and posts, is also known, the said load-bearing frame is characterized by the fact that the load-bearing girder of this hall consists of transoms, each of which consists of two cold-formed profiles, thin-walled, permanently connected with their webs, which in the connected ridge node have at one of their ends sections of profiles cut on both sides of a certain length in the places of their bends. Profiles made in this way are connected with each other overlapping and bolted into a compact structure with bolt connections. Transoms and posts in the eaves connection nodes have different profile ends, transoms of which are ended with straight leading edges of shelves and the web, while in individual posts the connecting projection of the outer shelf protrudes in front of the web, and the connecting projection of the inner shelf is retracted behind the edge of the web, creating after combining a uniform structure of eaves connection nodes.

**[0007]** On the other hand, a steel portal frame known from the Polish protective specification of the utility model No. W.126845 consists of two load-bearing posts and two transoms crowning them with bolts and forming a gable profile, with posts and transoms made of open-work one-sided converging I-beams, whose webs in the axis of symmetry of their width and along their entire length have profile through openings symmetrically positioned in relation to each other, and moreover, these posts are positioned so that they have variable stiffness, increasing from the bottom - of the building structure foundation to transoms, which also have variable stiffness rising from tops of these posts to the ridge connection, the webs of both one-sided converging I-beams of posts and webs of one-sidedly converging I-beams of transoms have perforation with variable geometry of their openings with the same profile but with decreasing transverse dimensions in the direction of one-sided convergence of these posts and transoms, and profiles of openings forming the web perforations are trapezoidal openings of identical heights, located symmetrically to each other at identical distances between each of these two openings, and distances between side walls of openings and internal walls of both shelves of these I-beams of posts and transoms are identical. It is advantageous if openings constituting perforations in webs of unilaterally convergent I-beams of posts and transoms connected detachably thereto are made directly in axes of symmetry of these webs.

**[0008]** The purpose of the invention is to develop a new structure of a load-bearing frame for a single-nave steel hall, two posts of which are connected to each other by two transoms, and will have converging cold-formed C-bars, i.e. with a variable width of their webs along their length. A further purpose of this invention is to select such a C-bar of posts and transoms of this frame and to connect them with each other in such a way as to obtain a significant margin of the load-bearing capacity of the set of steel frames in single-nave halls, and at the same time to increase the load of the entire load-bearing system, e. g. caused by heavy snowfall.

**[0009]** The load-bearing frame of the single-nave steel hall according to the invention is characterized by the fact that it has two one-sided converging steel posts made of two cold-formed semi-closed C-bars, the upper, wider, cut inwards, ends of which adjoining the inwardly cut ends of both roof transoms, also one-sidedly converging, also made of two cold-formed semi-closed C-bars. Both in flat walls of webs of both semi-closed C-bars of these posts and in flat walls of webs of both semi-closed C-bars of transoms, there are transverse mounting through openings arranged in several rows spaced apart from each other. Outer flat walls of webs of both semi-closed C-bars of these posts and outer flat walls of webs of both semi-closed C-bars of these roof transoms are situated opposite to each other, and between them and opposite the openings in walls of these posts there are three plate trapezoidal distance connectors with through openings made in them, while opposite through openings in walls of these transoms there are three plate distance connectors and a ridge connector, all with through openings made in them, and also opposite through openings made in upper oblique ends of both cold-formed C-bars of these posts and opposite through openings made in lower oblique ends of both cold-formed C-bars of these transoms, there is a profile plate distance eaves connector, also with through openings located opposite through openings of the diagonal ends of both posts and transoms. In addition, bolts with nuts screwed on them are embedded in through openings of these posts and in their distance connectors, and in openings holes of both transoms, in upper oblique parts of the posts and in openings in three distance plates placed in posts, and openings in the ridge connector and the eaves connector there are bolts with nuts screwed on them embedded.

In addition, between lower ends of the outer flat walls of both semi-closed C-bars of these posts, vertically located upper ends of plate connectors with through openings are placed, in which bolts with nuts screwed on them are embedded through openings of these C-bars, and lower ends of these plate connectors are inseparably connected with lower plate rectangular bases of both of these posts.

**[0010]** Compared to the above-described state of the art of technical solutions related to the subject of the invention, the developed structure of the steel frame, as shown by tests of the mechanical strength of the frame, has the following advantages, namely:

- a geometry of posts and transoms (web cut angle) is adjusted to the course of the internal force diagram (bending moment), which allows for optimal use of the load-bearing capacity of the element and minimization of the weight of the structure under a given load,
- posts of the frame are connected to the foundation footings by means of flexible connections (semi-rigid nodes), which has a positive effect on the value of the horizontal shift of the frame corner nodes - it reduces the shift, increases the stiffness of the system, and at the same time does not load foundations with a significant bending moment,
- a flexible connection (semi-rigid node) was used in the ridge node of the frame, which allows to control the course of the bending moment diagram in the frame structure and to optimally use the load-bearing capacity of posts and transoms,
- the ridge connector is bent in its internal part (from the inside of posts and transoms), which increases the stiffness and buckling capacity of metal sheet from which it was made
- a weight of the developed frame varies between 80-90% of the frame with an analogous span made of hot-rolled or cold-formed elements with a non-converging cross-section,
- a low weight of the structure, the use of cold-formed profiles, and eliminating hot-rolled I-beams significantly reduces the carbon footprint of the structure in relation to other steel frames,

and in addition,

- the frame structure is made entirely of cold-formed elements - four-bent channels with a variable web height,
- dimensions and shape of the cross-sections of posts and transoms - heights of sections at ends - are selected in a way that allows for the waste-free cutting of posts and transoms geometries from rectangular metal sheets,
- individual elements are joined together only by means of bolted connections, which is beneficial and eliminates the need for welding during the assembly,
- all connections in the frame structure are bolt lap connections, which significantly facilitates and speeds up the assembly of the structure,
- almost complete absence of welding processes during the manufacture of the frame eliminates the emission of harmful welding gases into the atmosphere,
- the reduced weight of the structure has a positive effect on the reduction of the time needed for its assembly, compared to competing solutions
- due to the possibility of making the main elements of the frame from galvanized metal sheet, the need for anti-corrosion protection by using paints is eliminated. As a result, there is a significant reduction in

the production of volatile organic compounds in the production process,

- the indicated solution requires a much smaller number of production processes, some of them being eliminated, as a result of which the production process, and thus the waiting time for the delivery of the finished product, is much faster than in the case of competing solutions.

**[0011]** The subject of the invention is shown in the embodiment in the drawing, Fig. 1 - Fig. 19, in which Fig. 1 shows the load-bearing frame of a single-nave steel hall in the perspective view, Fig. 2 - the same load-bearing frame in the front view, Fig. 3 - the same load-bearing frame in the vertical section along the line A-A, Fig. 4 - enlarged detail "B" showing the corner connection of the post with the transom with the eaves connector of this frame in the front view, Fig. 5 - the same detail "B" in the horizontal section along the line C-C, Fig. 6 - the same detail "B" in the vertical section along the line D-D, Fig. 7 - enlarged detail "E" of connecting both internal ends of the roof transoms together with the ridge connector in the front view, Fig .8 - the same detail "F" in the top view in the direction of the arrow "F", Fig. 9 - the same detail "F" in the vertical section along the line G-G, Fig. 10 - enlarged detail "H" of the bottom end connection of the post with the base connector in the front view, Fig. 11 - the same detail "H" in the vertical section along the line I-I, Fig. 12 - the same detail "H" in the transverse section along the line K-K, Fig. 13 - the frame post in the front view, Fig. 14 - the same post in the horizontal section along the line L-L, Fig. 15 - the same post in the vertical section along the line N-N, Fig. 16 - the roof transom of the frame in the front view, Fig. 17 - the same transom in the vertical section along the line P-P, Fig. 18 - the same transom in the vertical section along the line R-R and Fig. 19 shows the same load-bearing frame in the exploded state of its components in the perspective view.

**[0012]** The load-bearing frame of the single-nave steel hall consists of two identical vertically and opposite to each other steel posts 1 and 1' converging on one side, with cold-formed semi-closed C-bars 2 and 2' in the front view (Fig. 2), the upper, wider ends of ones, truncated at the angle $\alpha = 50°$, are connected to two identical steel roof transoms 3 and 3', also converging on one side and having also cold-formed semi-closed C-bars 4 and 4' in the front view (Fig. 2), the lower, wider ends of ones, truncated at the angle $\alpha' = 50°$, are connected to the slanted upper ends of both these posts, and the upper, narrower ends of both transoms are connected to each other.

**[0013]** Each of these steel posts 1 and 1' consists of two identical cold-formed one-sidedly converging semi-closed C-bars 2 and 2' positioned by the outer flat walls 5 and 5' of their webs opposite each other with through mounting openings made in them opposite each other and at different distances t and t' apart and in two rows of: four openings 6 and 6', six openings 7 and 7', eight openings 8 and 8', 9 and 9' and 10 and 10' and four openings 11 and 11' arranged obliquely in one row next to the oblique upper sides of these semi-closed C-bars and two vertically openings 12 and 12' made between these sides and openings 11 and 11', positioned next to the long sides of the posts,. In addition, between the two outer flat walls 5 and 5' of these cold-formed semi-closed C-bars 2 and 2' and opposite their through openings 7 and 7', 8 and 8' and 9 and 9', there are plate distance connectors 13 and 13', 14 and 14' and 15 and 15' with trapezoidal profiles and their different lengths adapted to the width of one-sidedly converging external flat walls 5 and 5' of webs of these C-bars, these connectors have through openings in the number and spacing adapted to through openings 7 and 7' , 8 and 8' and 9 and 9', in which there are bolts 16 connecting both semi-closed C-bars 2 and 2', while between lower ends of the outer flat walls 5 and 5' of these C-bars and opposite their four through openings 6 and 6', upper ends of plate connectors 17 and 17' are vertically placed, with through openings in which four bolts 16 are provided for connecting both lower these ends of outer flat walls 5 and 5' of these C-bars to each other as well as, horizontally arranged, plate rectangular bases 18 and 18' of posts 1 and 1' with mounting openings made in their corners.

**[0014]** In turn, each of the steel transoms 3 and 3' also consists of two identical cold-formed one-sidedly converging semi-closed C-bars 4 and 4' located with the outer flat walls 19 and 19' of their webs opposite each other with through mounting openings made in them opposite each other and at different distances z and z' apart and also in two rows of: four openings 20 and 20', six openings 21 and 21' and six openings 22 and 22' and eight openings 23 and 23' and 24 and 24'.

**[0015]** In addition, also in this solution, between two outer flat walls 19 and 19' of these cold-formed semi-closed C-bars 4 and 4' and opposite their through openings 21 and 21', 22 and 22' and 23 and 23' there are also plate trapezoidal distance connectors 27 and 27', 28 and 28' as well as 29 and 29', while between upper, abutting ends of both C-bars there is the plate ridge connector 30 with through openings 31 opposite the through openings 20 and 20' of both C-bars, and between the outer flat walls 5 and 5' of the oblique upper ends of the C-bars 2 and 2' of the posts 1 and 1' and between the outer flat walls 19 and 19' of the oblique lower ends of the roof transoms 3 and 3', there are profile plate eaves connectors 32 and 32' with through openings made on their surfaces, facing the through openings 10 and 10', 11 and 11', 12 and 12' of steel posts 1 and 1' and opposite through openings 24 and 24', 25 and 25' as well as 26 and 26' of roof transoms 3 and 3', wherein bolts 33 are seat in all these openings of the upper part of these posts and transoms and eaves connectors 32 and 32', ridge connector 30, and distance connectors 27 and 27', 28 and 28' as well as 29 and 29' placed between flat outer walls 5 and 5 'and 19 and 19'. So connected, cold-formed semi-closed profiles of C-bars 2 and 2' of steel posts 1

and 1' with distance connectors 13 and 13', 14 and 14' as well as 15 and 15' placed between them and cold-formed profiles of semi-closed C-bars 4 and 4' of roof transoms 3 and 3' with distance connectors 27 and 27', 28 and 28' as well as 29 and 29' placed between them and the ridge connector 30, and with eaves connectors 32 and 32' placed between semi-closed C-bars of the upper ends of these posts and the adjacent semi-closed C-bars of lower ends of these transoms, using bolts 16 and 33 tightened with nuts screwed on them, form one monolithic load-bearing frame of the single-nave hall.

## Claims

1. A load-bearing frame of a single-nave steel hall consisting of two steel posts converging on one side with a variable stiffness increasing from below, detachably connected with two roof transoms, also with a variable stiffness but decreasing from below, the upper ends of which are connected to each other at an obtuse angle, both elements these posts and these transoms are made of cold-formed C-bars, **characterized in that** it has steel posts (1 and 1') converging on one side made of two cold-formed semi-closed C-bars (2 and 2'), the upper, wider, cut inwards, ends of which are adjoin the inwardly cut lower ends of the roof transoms (3 and 3'), also converging on one side, also made of cold-formed semi-closed C-bars (4 and 4'), while both in the external flat walls (5 and 5') of webs of semi-closed C-bars (2 and 2') of both these posts as well as in the external flat walls (19 and 19') of webs of semi-closed C-bars (4 and 4') there are transverse mounting through openings arranged in several rows spaced apart, with the outer flat walls (5 and 5') of webs of the semi-closed C-bars (2 and 2') of the posts (1 and 1') and the outer flat walls (19 and 19') of webs of the semi-closed C-bars (4 and 4') of the roof transoms are placed opposite to each other, and between them and opposite to openings in the walls of the posts plate trapezoidal distance connectors (13 and 13'), (14 and 14'), (15 and 15') are placed with through openings made in them, while opposite the through openings in the walls of these transoms plate distance connectors (27 and 27'), (28 and 28'), (29 and 29') and the ridge connector (30) are placed, all with through openings made in them, and also opposite through openings made in the upper oblique ends of cold-formed C-bars (2 and 2') of the posts (1 and 1') and opposite through openings made in the lower oblique ends of cold-formed C-bars (4 and 4') of the transoms (3 and 3'), there are profile distance plate eaves connectors (32 and 32'), also with through openings located opposite the through openings of the oblique ends of the posts (1 and 1') of the transoms (3 and 3'), bolts (16) with nuts screwed on them are embedded in the through openings of these posts and in their distance connectors (13 and 13'), (14 and 14') and (15 and 15'), and screws (33) with nuts screwed on them are mounted in the through openings of both transoms (3 and 3') in the upper oblique parts of the columns (1 and 1') and the openings in the plate distance connectors (27 and 27'), (28 and 28'), (29 and 29') and in the ridge connector (30) and eaves connectors (32 and 32').

2. A load-bearing frame according to claim 1, **characterized in that** between the lower ends of the outer flat walls (5 and 5') of the semi-closed C-bars (2 and 2') of the posts (1 and 1') there are vertically located upper ends of the plate connectors (17 and 17') with through openings in which, through the openings (6 and 6') of these C-bars, bolts (16) with nuts screwed on them are mounted, and the lower ends of these plate connectors are inseparably connected with the lower plate rectangular bases (18 and 18') both of these posts.

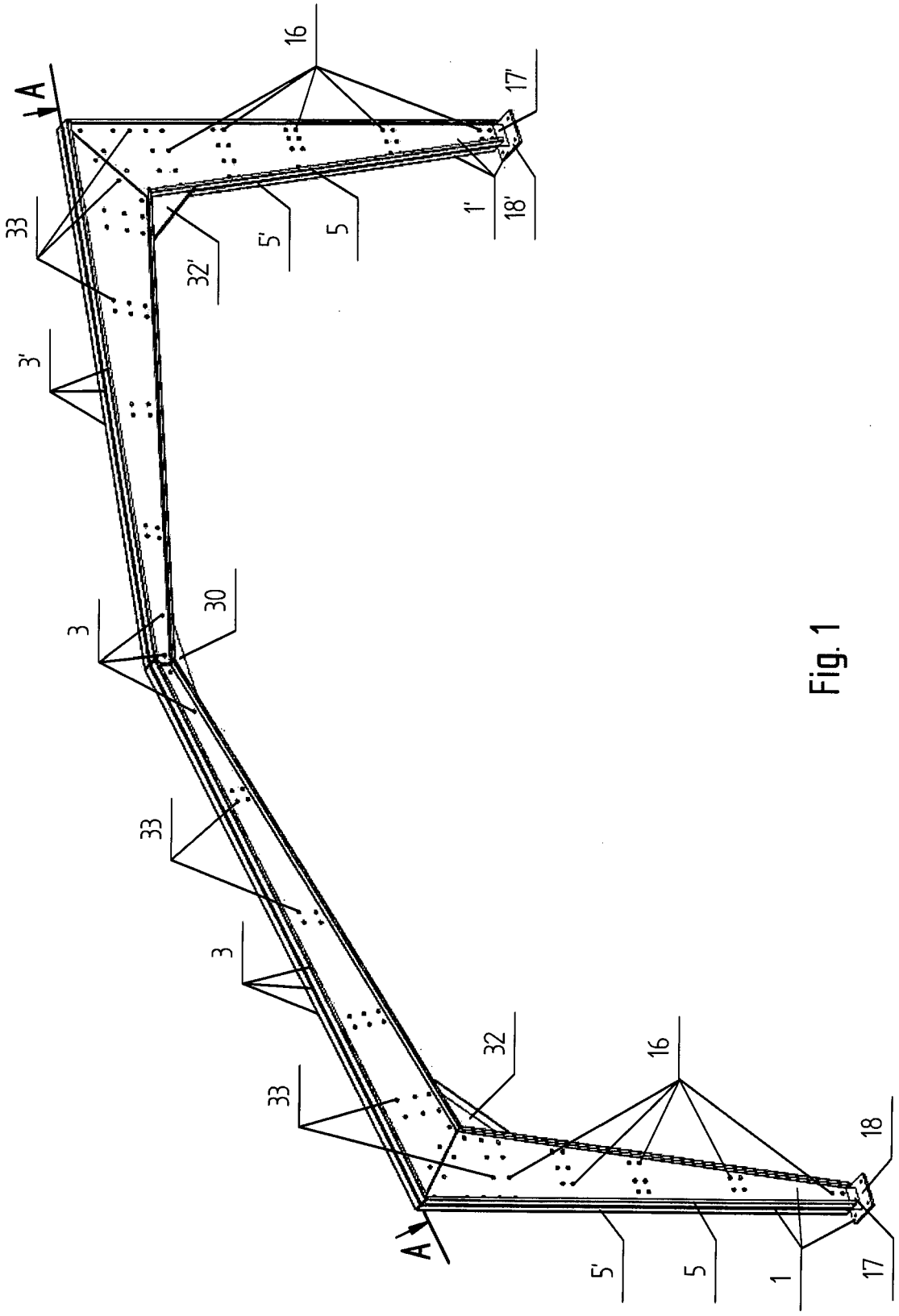


Fig. 1

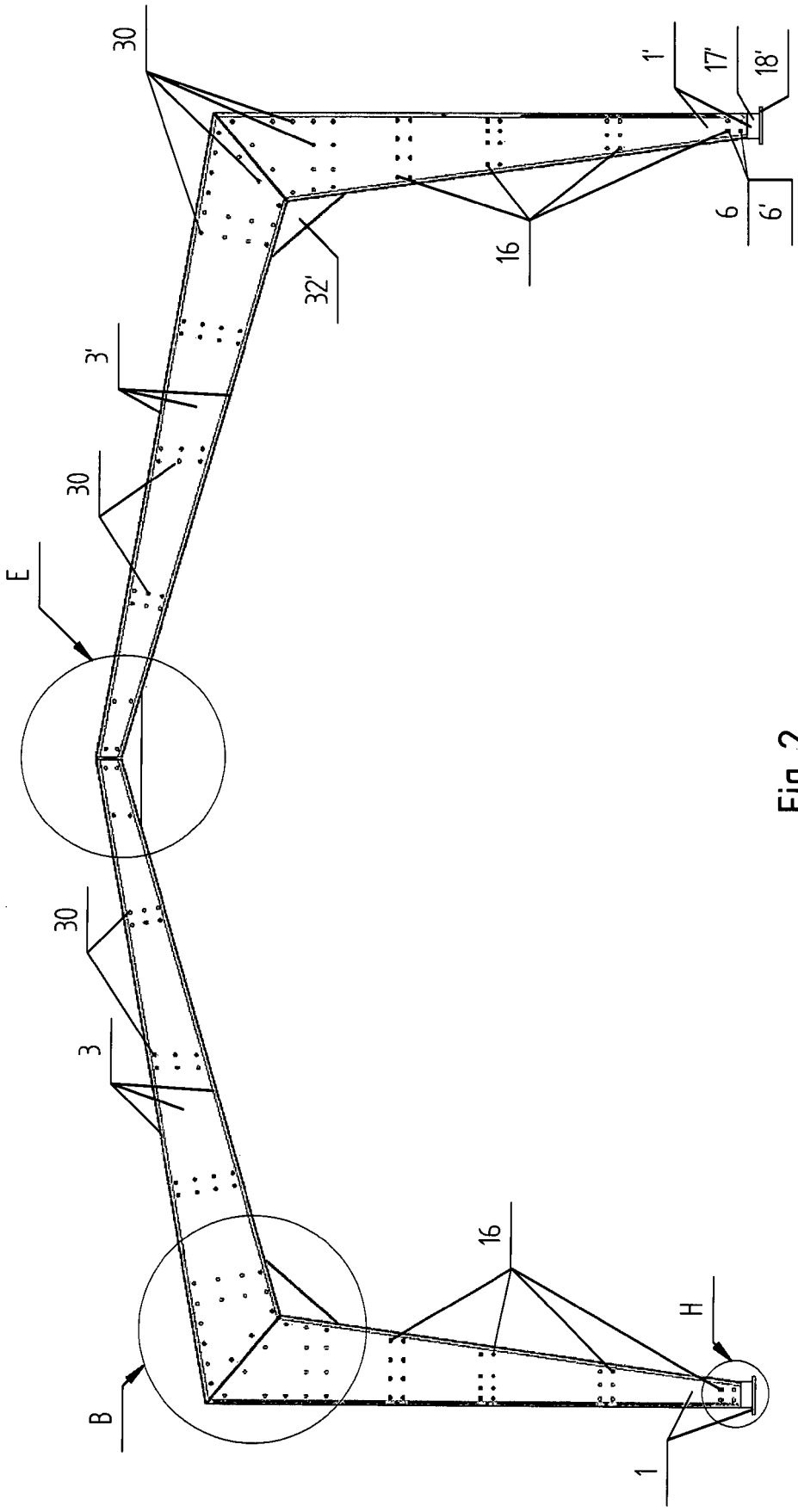


Fig. 2

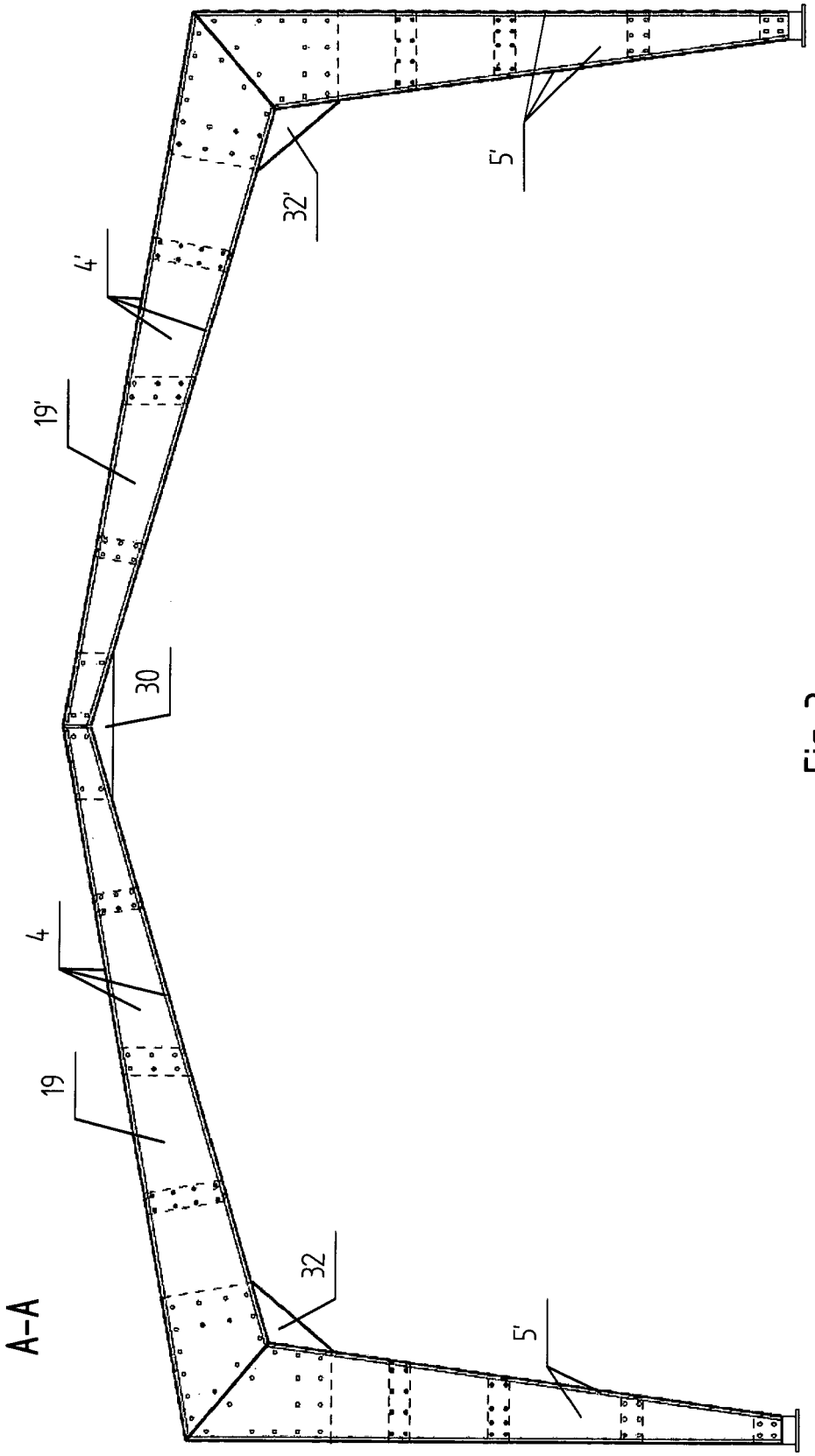


Fig. 3

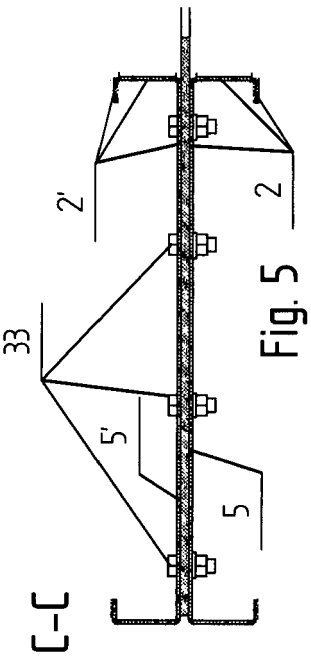


Fig. 5

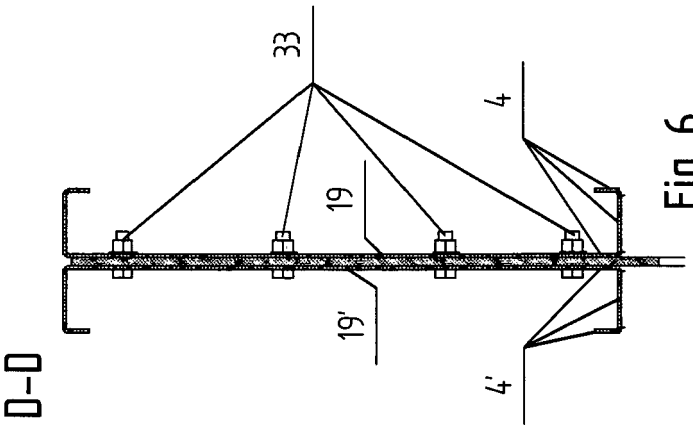


Fig. 6

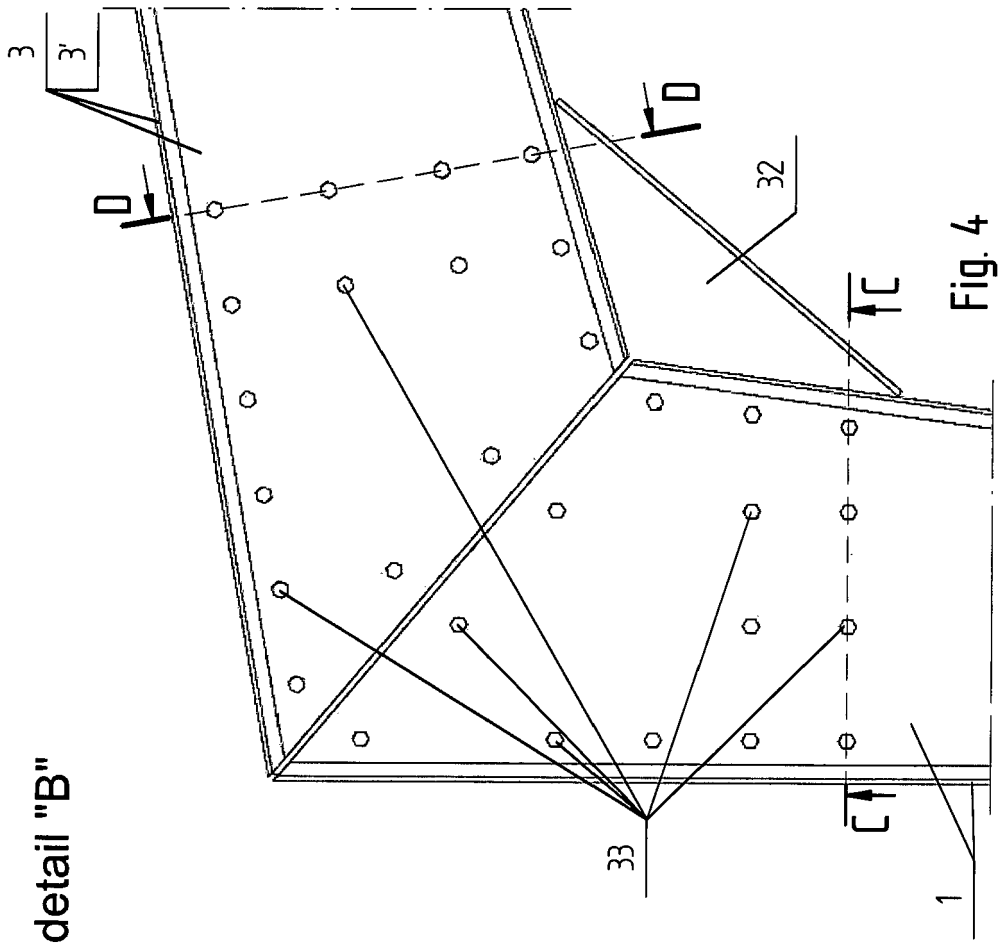


Fig. 4

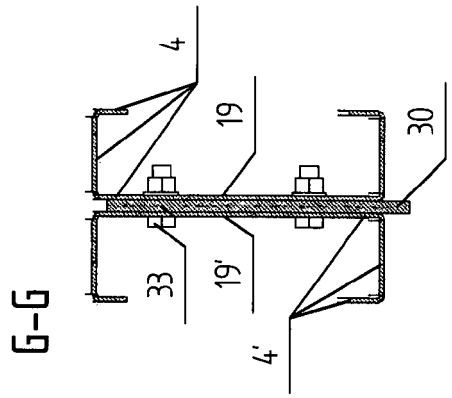


Fig. 9

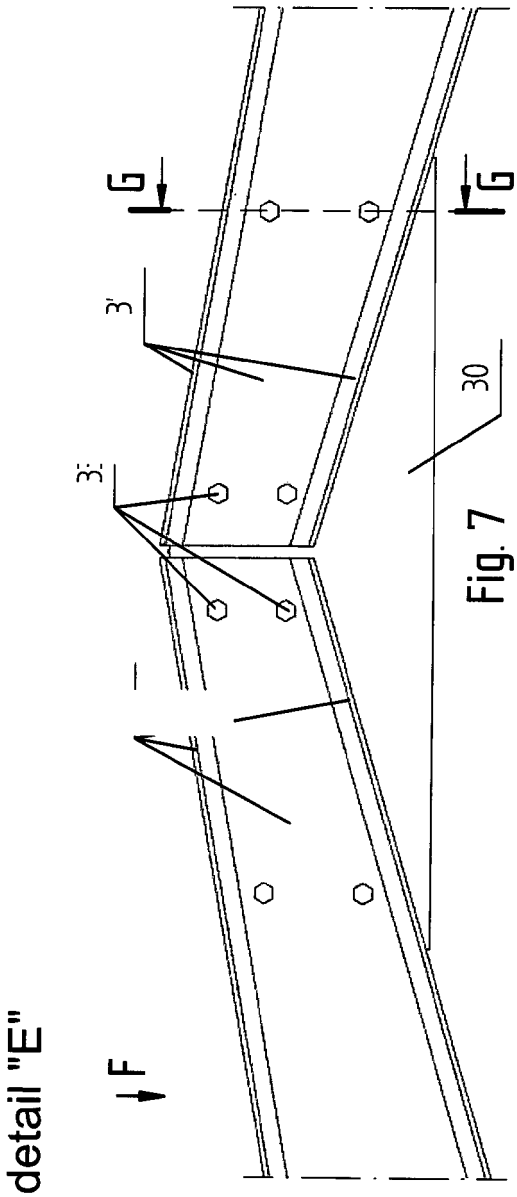


Fig. 7

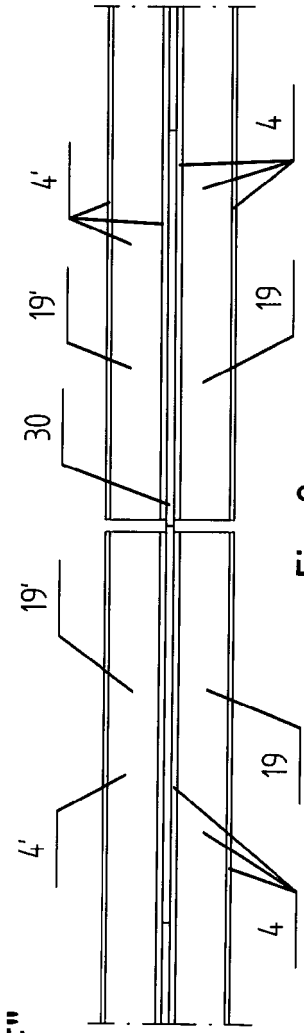


Fig. 8

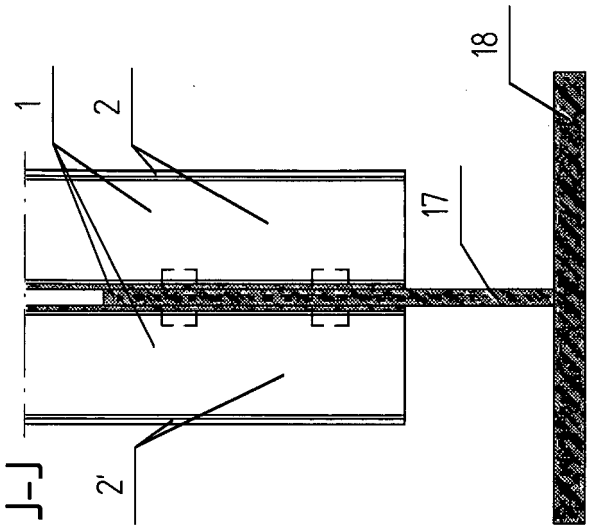


Fig. 11

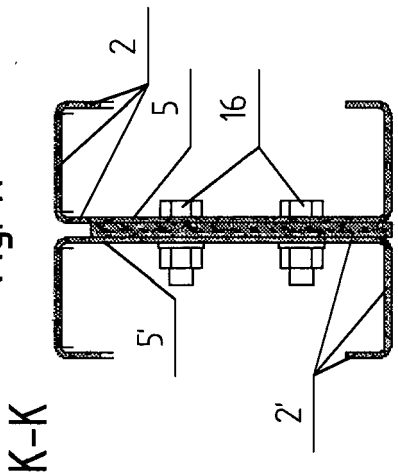


Fig. 12

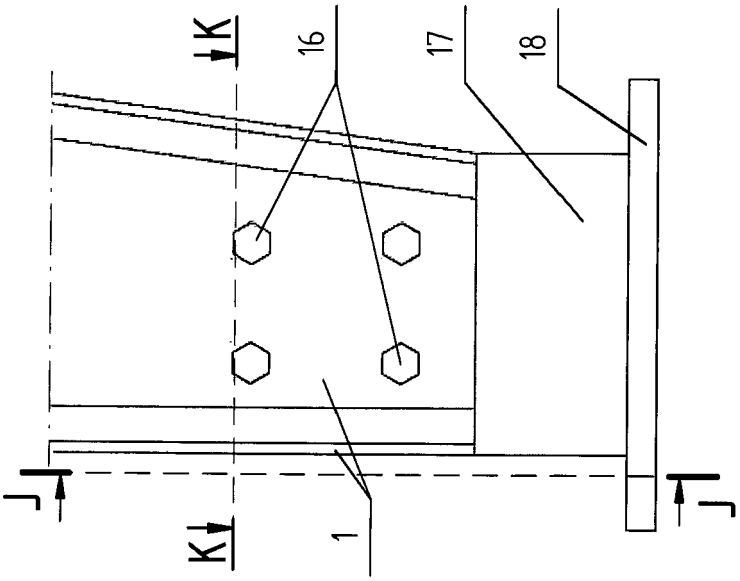


Fig. 10

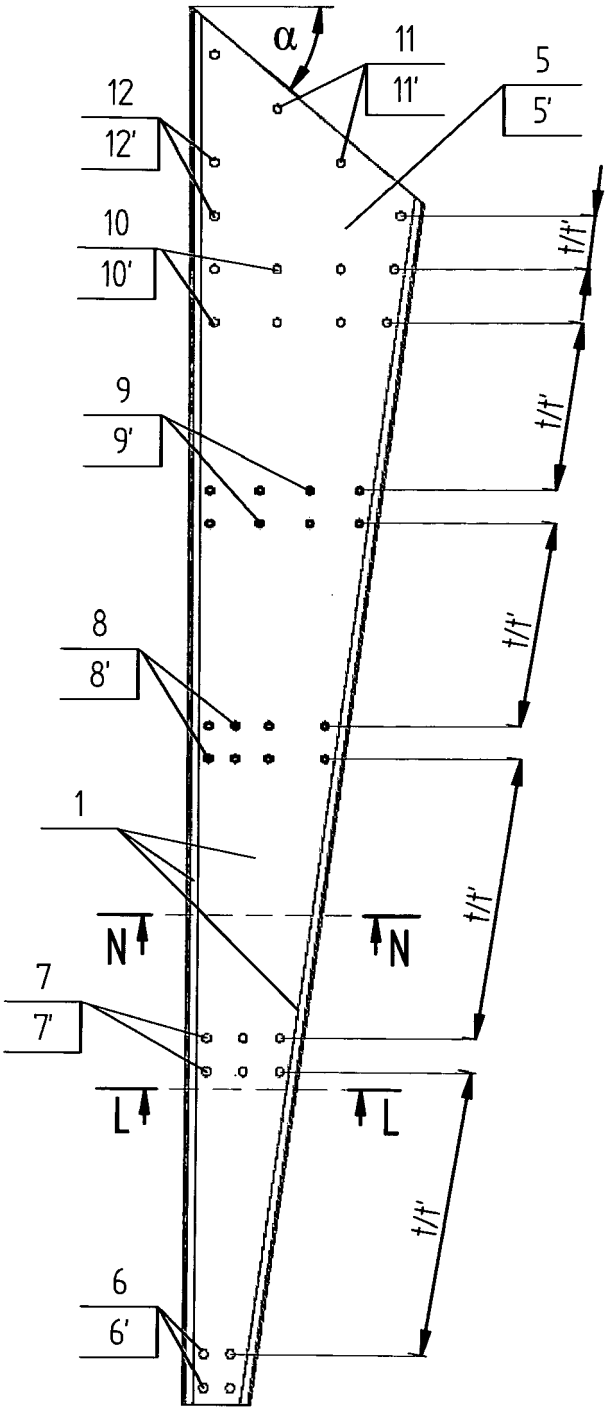


Fig. 13

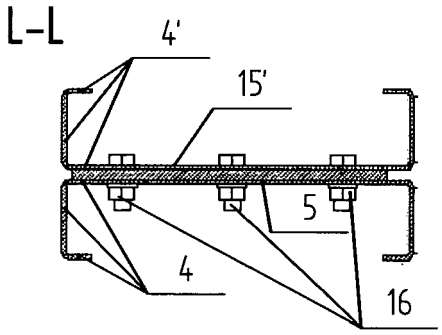


Fig. 14

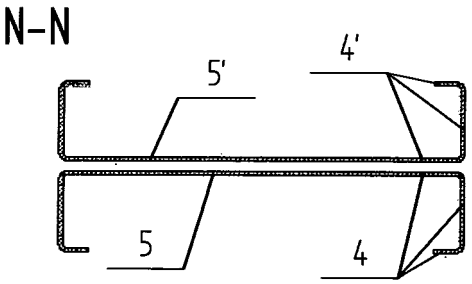


Fig. 15

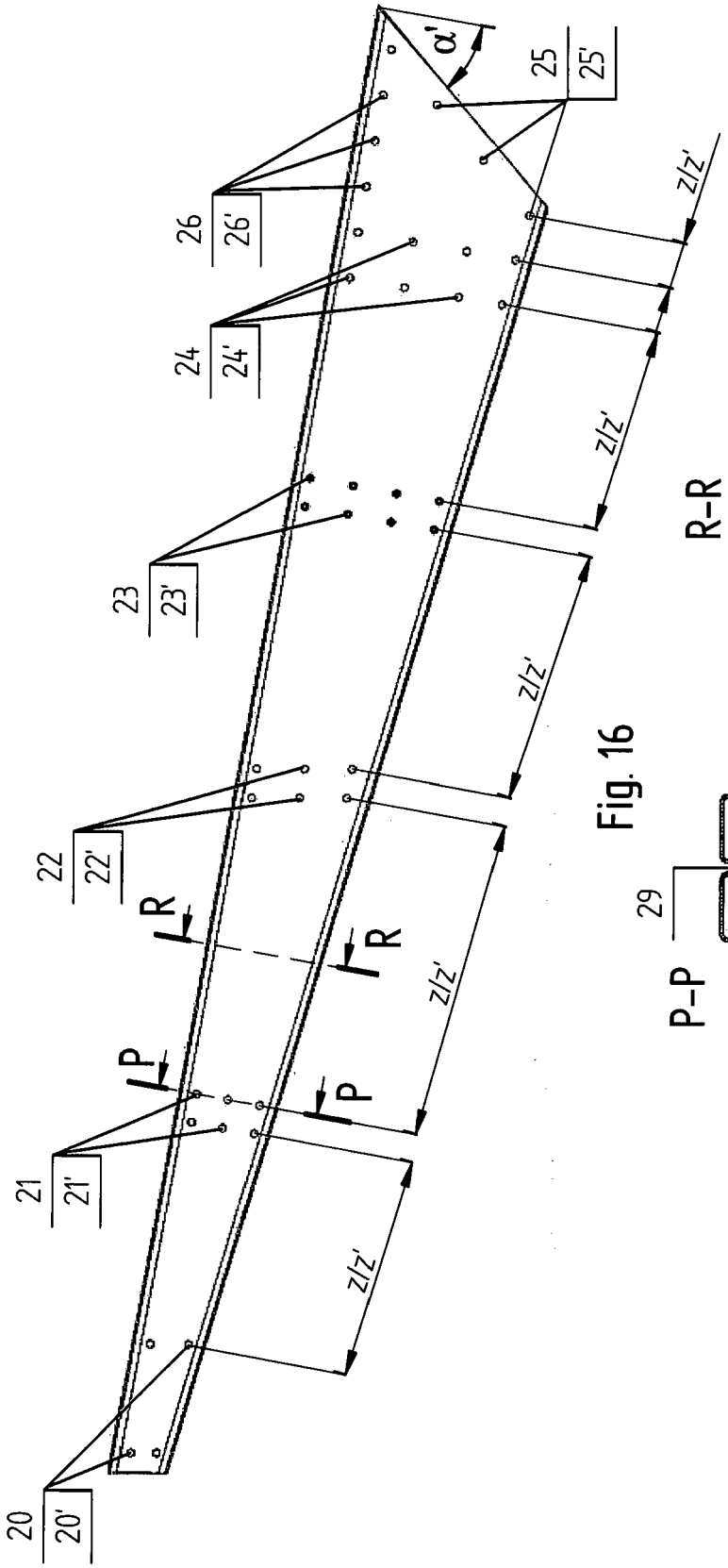


Fig. 16

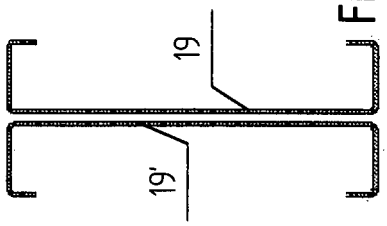


Fig. 18

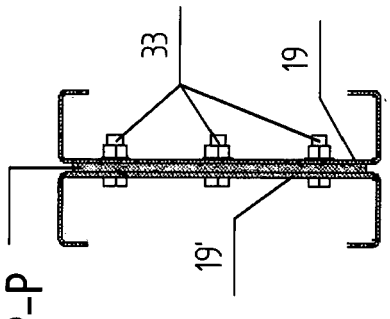


Fig. 17

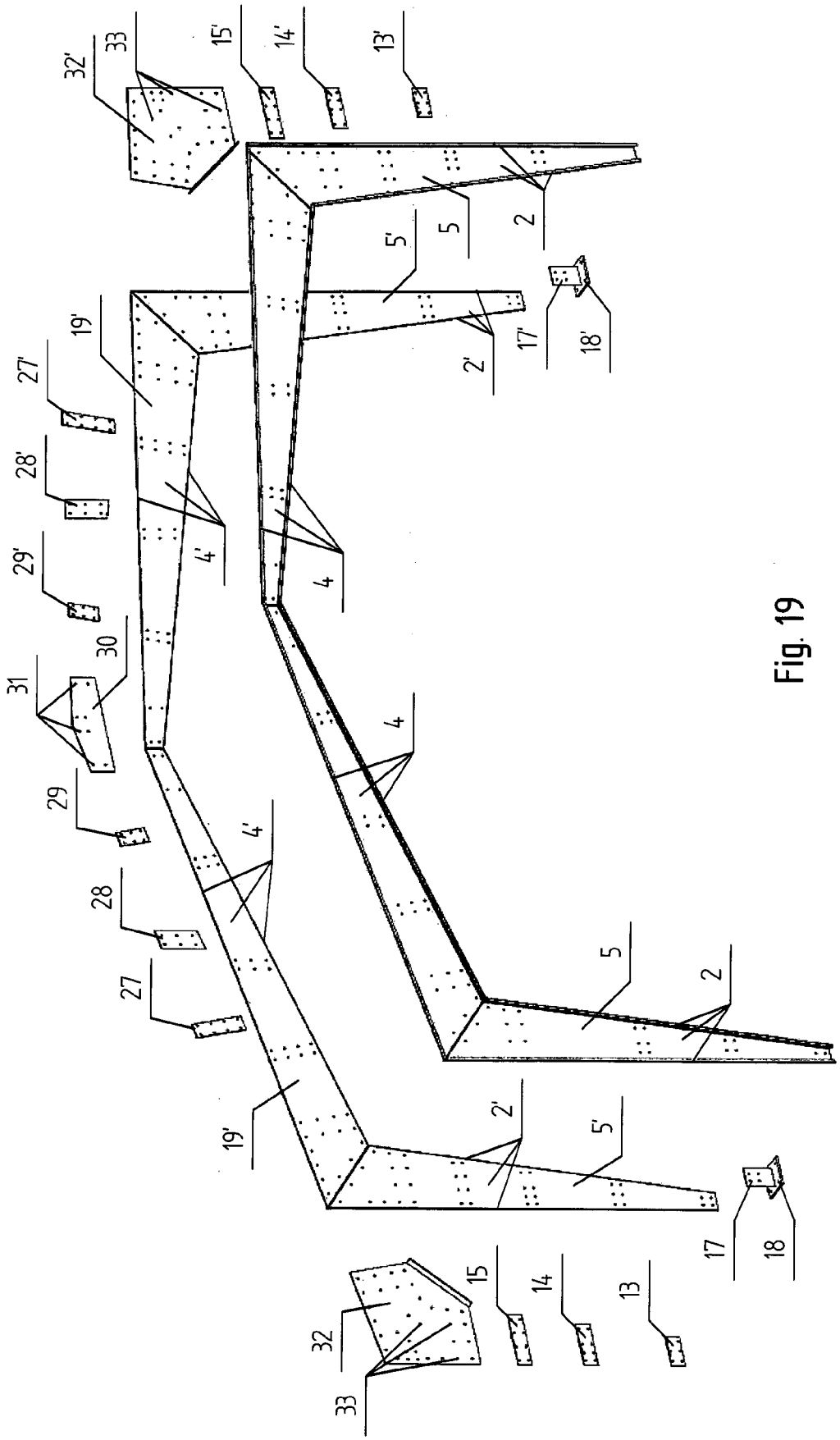
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Fig. 19

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# EUROPEAN SEARCH REPORT

Application Number
EP 20 46 0046

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | EP 0 864 702 A1 (BOCQUET DIDIER [BE])<br>16 September 1998 (1998-09-16)<br>* column 2, line 46 - column 4, line 45; figures 1-10 *<br>----- | 1,2 | INV.<br>E04B1/24<br>E04C3/40<br>E04C3/11<br>E04C3/07 |
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TECHNICAL FIELDS SEARCHED (IPC)

E04B

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 9 June 2021 | Couprie, Brice |

CATEGORY OF CITED DOCUMENTS

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09-06-2021

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

## REFERENCES CITED IN THE DESCRIPTION

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