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(54) TRUSS TRACK STRUCTURE AND RAIL

(57) The invention relates to the aboveground (elevated) transport systems of trussed type, which provide high-speed cargo and passenger traffic.

The trussed track structure includes rail cords, (3) and (4), of main (3_1) and auxiliary (4_1) load-bearing members of track structure S, performed in the form of longitudinally prestressed load-bearing elements (5.1) brought together in a load-bearing structure (5), positioned in the extended body (6). In parallel, rail cords are connected with each other in a truss G of superstructure by zigzag oriented rod elements (9) with plates (10) rigidly fastened on the ends thereof (10) and fastening components (11), with use of which transverse forces of clamping of plates (10) and load-bearing elements (5.1) are formed, and fixing of joined ends P_1 and P_2 of load-bearing element (5.1) of longitudinally stressed load-bearing structure (5) is performed.

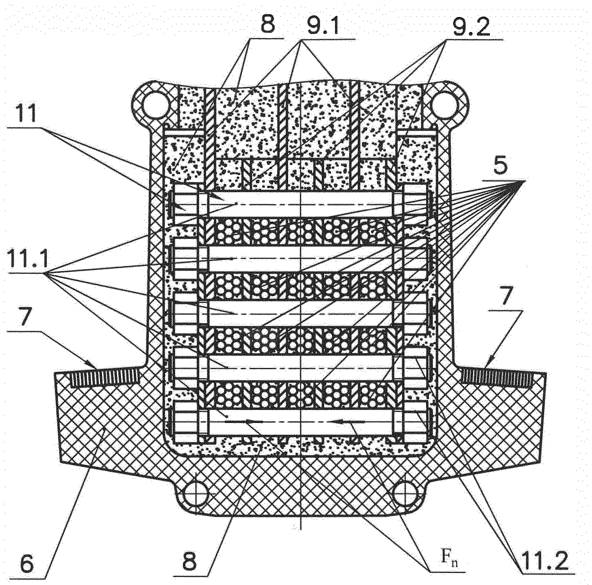

Fig.6

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Description

Technical field

[0001] The invention relates to the area of track transport systems, particularly, to the aboveground (elevated) transport systems of trussed type, which provide high-speed cargo and passenger traffic.

Background Art

[0002] The structures of transport systems based on trusses (trussed structures) have been widely known. Thus, transport system [1] is known, which track is formed with a truss of triangular cross-section, whereas the transport module, comprising two carriages rigidly connected with each other and including the truss, moves along the rail installed on the top of the truss cross-section. To maintain the balance, the module also rests on two other rails installed on the truss sides.

[0003] The transport trussed structure [2] is known, representing a track formed with the tubes of circular or rectangular cross-section, or profiles (I-beams, channel sections, etc.) and connected with each other by means of trusses having a triangular profile in cross-section. The movement of transport modules or trains can be carried out along the supporting rails (main length of rails) installed in its lower part, whereas the vertical stabilization of the carriages is due to the contact between their carrying wheels and carrying rails (auxiliary rail cords), located in its upper part. Both the supporting and carrying rails can simultaneously represent load-bearing elements of trusses. The track can be covered with a housing, which protects it from atmospheric precipitation. The trusses rest on supports, which are pillars of tubular cross-section that can be made telescopic for the convenience of their height adjustment in order to adapt the track to surface irregularities, or framed structures similar to high-voltage power lines pylons.

[0004] The general drawback of the specified trussed structures is transportation difficulties during delivery thereof to site of installation of bulky continuous trusses of superstructures, as well as their labor-consuming assembling process under complex-terrain field conditions and limited capacity of use of conventional technologies and equipment.

[0005] The further development of transport trussed structures happened due to the elaboration and implementation of prestressed string-rod components therein.

[0006] The Yunitski's transport system [3] is known, with the track structure in the form of a prestressed string-rod truss. The main and auxiliary rail cords therein are made with a prestressed load-bearing member and located at different levels between the adjacent supports. They are connected with each other by a sequence of rod elements regularly oriented in a zigzag manner. The longitudinal axes of the rod elements form triangles together with the longitudinal axes of the main and auxiliary rail cords. Also, the method for the construction thereof is known, including its installation on the foundation of anchor and intermediate supports, tensioning and mounting of load-bearing members of track structure on different levels of anchor supports - at least, one main rail cord (main length of rail cord) and one auxiliary rail cord, fixing of main rail cord and auxiliary rail cord on the corresponding levels of intermediate supports, as well as fixing of mutual position of main rail cord and auxiliary rail cord in the span between adjacent supports.

[0007] In the known transport system, it is possible to embody the auxiliary cord both in the form of a load-bearing member, either without a solid body (when the body transforms into a multitude of connecting shells spaced along the load-bearing member), or with a solid extended body comprising a load-bearing member. In the latter case, an auxiliary rail cord (one or more), being located under the main cord in the same plane therewith, can be used as a retaining rail, which has a lateral rolling surface for spatial orientation of wheeled vehicles for the monorail-type system.

[0008] Thanks to the combination and interrelation between the properties of the prestressed track structure and the properties of constructions having structural stiffness, i.e. trusses, the longitudinal rigidity of the system is increased. Moreover, it becomes possible to increase spans between the supports up to 100 m and more, practically at a zero sag of the main cord. This enables to build transport systems with both multi-rail and single-rail track structures.

[0009] However, the known transport system and the method of construction thereof have the drawbacks associated with insufficient lateral rigidity, whereas the rail cord structure does not allow to achieve the required evenness of the track structure when organizing high-speed movement.

[0010] During embodiment of the method there arise complementary errors of technical execution of connection nodes of load-bearing members under incomplete unification of structural components.

[0011] The Yunitski's transport system [4] is known, taken as a prototype. It comprises at least one trussed track structure, which includes at least one main length of rail cord installed on the supports mounted on the foundation, and at least one auxiliary rail cord located at a different level. The main length of rail cord is structured as a prestressed load-bearing member enclosed in the extended body, with the rolling surface for wheeled vehicles adjacent to it. The auxiliary rail cord is made as a prestressed load-bearing member enclosed in the body. The main and auxiliary rail cords are connected with each other at spans between the adjacent supports by a sequence of rod elements oriented in a zigzag manner. The rod elements are placed between the main and auxiliary rail cords and form triangles with them. Further, at every level the left cords and right cords are assembled with each other by means of cross bulkheads, which are installed in nodes of connection of rod elements and cords.

[0012] The rail cord of the known transport systems is formed by the rails of a string type stretched between anchor supports. The common feature of these rails is the presence of an extended body with the rolling surface conjugating therewith, and with the prestressed longitudinal load-bearing structure enclosed therein. The rolling surface conjugating the body forms a smooth track for the vehicle supporting wheels, each of them giving vertical load on the track structure.

[0013] The common drawback of the known trussed structures comprising rail cords, is the necessity to install additional connection nodes to link together the load-bearing elements of adjacent load-bearing members; consequently, such system has a complicated and reliability-weak assembly technique.

[0014] The rail of transport system by Yunitski [5] is known, comprising hollow tubular body, with prestressed extended load-bearing elements placed inside thereof, whereas the volume of void space is filled up with solid monolithic material, while the extended load-bearing elements are placed inside the body of rail to be in contact with inner surface of its wall along the line of load application and equipped with adjusting gaskets, directly encasing the surface of the load-bearing elements.

[0015] The disadvantage of the mentioned rail is its low technological effectiveness when used as trussed structures, labor intensity at assembly of zigzag oriented rod elements, as well as the necessity to guarantee formation of additional nodes of connection load-bearing elements of adjacent load-bearing members, which will lead to higher complexity and lower reliability of assembly of the system.

[0016] The rail of transport system by Yunitski is known [6], comprising head and hollow body, performed as U-shaped or with side walls inclined to each other. Inside the body, at least one prestressed extended ganged element is positioned. Lower edges of body are designed to have obverse thickenings with preset shape and cross section area.

[0017] The drawback of the mentioned rail is its low technological effectiveness when used as trussed portions of superstructure, in particular, considerable labor intensity at assembly of zigzag oriented rod elements.

[0018] The rail of transport system by Yunitski is known, taken as prototype [7]. It comprises hollow extended body with (positioned inside therein) at least one load-bearing member, containing prestressed in longitudinal direction load-bearing elements, gathered in load-bearing structure. Hereby, load-bearing structure is structured in the form of several wire cables, positioned in horizontal and vertical planes and equipped along its length by clamping means. Further, clamping means are configured as couple: a screw-nut, whereby one element of the couple is rigidly fastened with the body, whereas clamping means of longitudinal ganged element are equipped with saddle and cushion layer, placed between clamping and ganged elements.

[0019] The disadvantage of such embodiment of rail is its low technological effectiveness, which becomes obvious when practically used as main beam of trussed structure of superstructure and labor intensity at assembly of zigzag oriented rod elements. Besides, it is still necessary to form extra nodes of connection to join load-bearing elements of adjacent load-bearing members, which leads to higher complexity and less safe and reliable assembly and operation of such system as a whole.

[0020] At the heart of invention lies the task of achieving the following technical results:

- reducing labor intensity during assembly of trussed track structure;
- securing reliability of joining the elements of load-bearing structure of rail cords into rigidly assembled space structure;
- unification of structural components base of trussed track structure;
- stabilization of technical and performance parameters along the entire rail track length thanks to increasing rigidity, elastic stability (monolithic integrity) of track structure, its reliability and evenness of rail cords;
- providing for smooth and soft ride along each truss of superstructure and along the whole length of the system.

Summary of invention

[0021] The technical tasks in accordance with the aim set forth by the present invention are achieved by using trussed structure of high-speed transport system by Yunitski, *wherein* the supports mounted on the foundation with rail cords installed thereon of at least one main load-bearing member, and at least one auxiliary load-bearing member located at a different level, contain longitudinally prestressed load-bearing elements brought together in a load-bearing structure, whereby the cords of main and auxiliary load-bearing members form a load-bearing structure positioned in the extended body and filled with hardening material, whereas the extended body is performed with conjugating rolling surface, whereby the cords of main and auxiliary load-bearing members, with use of fastening components, are connected with each other by zigzag oriented rod elements via plates rigidly fixed on the ends thereof, forming a truss of the superstructure, whereas the longitudinal axes of the rod elements, together with the longitudinal axes of the cords, form triangles with corners in nodes of connection of rod elements and cords, whereby the plates and fastening components are configured to be installed in those nodes with aim of formation, in the load-bearing structure, of transverse force of clamping F_n, N, determined by the ratio:

$0,1 \leq F_n/F_0 \leq 0,95$,

whereby: F_0, N - tensile breaking force of fastening component, whereas minimum lateral dimension a, m, of rod elements and their length *l*, m, are related by the ratio:

$5 \leq l/a \leq 50$.

[0022] It is expedient to perform in plate at least one profiled slotted through hole, which will permit configuring the plates with feasibility of axial and sidewise displacement relative to load-bearing structure and fastening component.

[0023] Preferably, the plates of multidirectional rod elements are to be positioned on the opposite lateral sides of load-bearing element. Hereby, in the plate, on the side of load-bearing element, a profiled axial slot can be performed, with the shape corresponding to the shape of the load-bearing element.

[0024] Alternative is an embodiment wherein main and/or auxiliary cords are designed at least paired.

[0025] The designated result is achieved also by interconnecting at each level the paired cords with rigid cross bulkheads, which, further, are installed in nodes of connection of rod elements and cords and made together with fastening components.

[0026] Achieving the assigned technical task is guaranteed also by using rail of the described trussed track structure, *wherein* at least one load-bearing member has longitudinally prestressed load-bearing elements brought together in a load-bearing structure, positioned in the extended body and filled with hardening material, whereas the extended body is equipped with conjugating rolling surface and performed with feasibility to accommodate plates and fastening components, installed in nodes of connection of rod elements and cords with aim of formation in load-bearing structure of transverse forces of clamping, whereby the length *L,* m, of plate, its width *H,* m, and thickness *T,* m, are related to minimum lateral dimension *d,* m, of load-bearing element, by the ratios:

$5 \leq L/d \leq 50$,
$3 \leq H/d \leq 30$,
$0,1 \leq T/d \leq 2$.

[0027] Hereby, it is expedient that the length *L,* m, of plate and its thickness *H,* m, would be connected by the dependence:

$0,2 \leq L/H \leq 5$.

[0028] Attaining the proposed aim is also facilitated by the following specific essential features of the claimed invention.

[0029] As fastening components, structural components of the extended body are used, i.e. threaded and unthreaded holes, arranged coaxially to force of clamping of plates and load-bearing elements in nodes of connection of rod elements and cords.

[0030] Load-bearing element can be produced in the form of twisted or untwisted cables, cords, strands (ropes), strips, bands or other standard extended elements manufactured from any high-strength materials.

[0031] It is recommendable that the length *L,* m, of plate, would be related to the length L_k, m, of the end of the joined load-bearing element, by dependence, determined by the ratio:

$2 \leq L/L_k \leq 5$.

[0032] Alternative embodiment of the rail involves load-bearing elements in vertical direction being separated by clamping straps, whereby these clamping straps can be performed with through holes, arranged coaxially to central axes of symmetry of the profiled slotted holes of plates.

[0033] Preferably, on plates and/or clamping straps, on the side of load-bearing element, a profiled axial slot is arranged which shape corresponds to the shape of the load-bearing element.

Brief description of drawings

[0034] The essence of the present invention is clarified by the drawings in Figs.1 - 17, which illustrate the following:

Fig.1 - trussed track structure - general view;
Fig.2 - schematic view of node of connection by fastening components of plates of zigzag oriented rod elements and load-bearing elements;
Fig.3 - schematic view of plate;
Fig.4 - schematic view of cross slot of plate (embodiment);
Fig.5 - schematic view of cross slot of plate (embodiment);
Fig.6 - schematic view of cross slot of body of rail cord (embodiment);
Fig.7 - schematic view of node of connection of plates of zigzag oriented rod elements with load-bearing elements;
Fig.8 - schematic view of clamping strap;
Fig.9 - schematic view of cross slot of clamping strap (embodiment);
Fig.10 - schematic view of cross slot of clamping strap (embodiment);

Fig.11 - schematic view of rod element with plates;
Fig.12 - schematic view of fragment of truss of superstructure, formed by rail cords of main and auxiliary load-bearing members, connected by zigzag oriented rod elements;
Fig.13 - schematic view of cross slot of clamping straps with load-bearing elements clamped thereby (embodiment);
Fig.14 - schematic view of fragment of truss of superstructure, formed by left and right rail cords of load-bearing members, connected by rigid cross bulkheads - top plan view;
Fig.15 - schematic view of cross bulkhead (embodiment) - front plan view;
Fig.16 - schematic view of cross bulkhead (embodiment) - side view;
Fig.17 - schematic view of node of connection of cross bulkhead with rail cord.

Embodiments of invention

[0035] The essence of the proposed technical approach related to the claimed trussed track structure of high-speed transport system by Yunitski is further presented in a closer detail as follows.

[0036] On supports 2 (of anchor 2a type and intermediate 2b type) spaced apart at different levels along the track on ground foundation 1, rail cords 3 and 4 of at least one main 3_1 load-bearing member and, on another level, at least one auxiliary 4_1 load-bearing member of track structure S are located, which are joined together and mounted above the foundation 1, so that the rail cords 3 and 4 of the main 3_1 load-bearing member and the auxiliary 4_1 load-bearing member of the track structure S would form, at least, one truss G of superstructure between the adjacent supports (see Fig. 1).

[0037] The design of superstructures G can vary depending on the terrain features, design parameters and engineering viability. Hereby, alternative embodiment of superstructure G of trussed track structure will be a cable-stayed truss, suspended and/or combined system (not shown on Fig.).

[0038] Depending on the parameters of the foundation, the place of installation and characteristics, anchor 2a supports and intermediate 2b supports may take various design appearance - in the form of towers, pillars with caps, steel and ferroconcrete columnar and frame buildings and constructions, equipped with passenger platforms and/or cargo terminals, other special-purpose constructs or trussed structures.

[0039] Trussed track structure S is designed to host transportation lines (passenger and/or cargo, and/or cargo-passenger). Vehicle (not shown on Fig.) can be either wheeled on the track structure S, or suspended thereto from below.

[0040] Anchoring devices of rail cords 3 and 4 of, respectively, main 3_1 and auxiliary 4_1 load-bearing members of track structure S, on anchor 2a supports and intermediate 2b supports or in superstructure G, involve any known devices, similar to those used in suspended and cable-stayed bridges, cableways and prestressed reinforced concrete structures for fastening (anchoring) of stretched load-bearing members.

[0041] Rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S are embodied as longitudinally prestressed load-bearing elements 5.1 brought together in a load-bearing structure 5, positioned in the extended body 6 (respectively, 6.1 and 6.2 for rail cords 3 and 4). Prestressing of load-bearing elements 5.1 allows to transfer tension force, respectively, to F_1, N, and F_2, N, which are applied to the mentioned load-bearing elements 5.1 of load-bearing structure 5 of rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S (see Fig.1, 12).

[0042] Rail cords 3 and 4 are embodied as follows.

[0043] Load-bearing elements 5.1 are brought together in a load-bearing structure 5 and positioned in the extended body 6 with rolling surface 7 conjugating thereto (see Fig.6) for vehicle wheels (not shown on Fig.). Hereby, load-bearing structure 5 is formed by filling up with hardening material 8 of the portion of internal space of the extended body 6 which is vacant of load-bearing elements 5.1.

[0044] According to each of non-limiting methods of application of hardening material 8, as such, according to design option, mixes on the basis of polymer binding composites, concrete mixes (see Figs.6,12) and/or analogous hardening materials can be used.

[0045] As a result, grouting of rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S is ensured, whereby transfer and redistribution of external forces and stresses onto all prestressed longitudinal elements of the structure is performed, to substantially increase the flexural rigidity of the body 6 of rail cord 3 and/or 4 (see Fig.6).

[0046] Hereby, load-bearing members 3_1 and 4_1, of, respectively, rail cords 3 and 4, are acting in trussed track structure S not as a flexible member, but as a continuous stiffening girder.

[0047] Alternatively, depending on design option and required engineering data, as load-bearing structure 5, one and/or more strands of load-bearing elements 5.1 are used, embodied, as example, as one or several twisted or untwisted steel cables, as well as cords, strands (ropes), strips, bands or other extended elements produced of any high-strength materials. Hereby, as prestressed longitudinal element, longitudinally oriented elements of track structure can be used - e.g., body 6 of rail cord 3 and/or 4 of main 3_1 and/or auxiliary 4_1 load-bearing members of track structure S.

[0048] For practical embodiment, main 3 rail cord and auxiliary 4 rail cord may be realized as bodies 6.1 and 6.2 with load-bearing structures 5 positioned therein, and represent, respectively, main and auxiliary beams of truss chord G of superstructure (see Fig.12).

[0049] The mentioned embodiment of trussed track structure S provides for the use of suspended vehicle on the main rail cord 3 of main truss chord G of superstructure and mounted vehicle on the auxiliary rail cord 4 of auxiliary truss chord (not shown on Fig.).

[0050] Fig.6 represents a schematic view of embodiment of cross slot of body 6 of main 3 rail cord.

[0051] Selection of a most effective embodiment of main and auxiliary rail cords 3 and 4 for building transport system is determined by operating conditions thereof, design requirements thereto, first of all, its application, type of the cargos, weight and speed of vehicles.

[0052] Extended body 6.1 of main rail cord 3, positioned on one level, represents the main chord of trussed structure, which can be lower or upper, depending on the position relative to auxiliary cord 4 and design of vehicle in use (not shown on Fig.).

[0053] Further, auxiliary rail cord 4 comprises its own body 6.2 (if present) and represents auxiliary truss chord - which can be upper or lower, depending on the position relative to main cord 3, which is determined by conditions of the specific design and engineering concept and design of vehicle in use (not shown on Fig.).

[0054] Depending on design concept of vehicle and track structure, the conjugating with bodies rolling surfaces of main and/or auxiliary rail cords 3 and 4 are positioned on upper and/or lower, and/or side outer surfaces of bodies 6.1 and 6.2.

[0055] Fig.12 represents embodiment of track structure, where main rail cord comprises lower chord of truss G of superstructure and is prestressed under applied tension force F_1, as shown on Fig.1, whereas auxiliary cord, - being under tension force F_2, - comprises upper chord of truss G.

[0056] Moreover, a bodyless embodiment of auxiliary cord 4 (not shown on Fig.), which in such case represents a prestressed extended load-bearing structure 5, comprised of one or several stressed load-bearing elements 5.1.

[0057] Thus, auxiliary cord 4 can come without body 6 (without formation of auxiliary rail track), or auxiliary cord 4 may be realized with a body 6.2 in the form of auxiliary beam of upper chord of truss G of superstructure of track structure S.

[0058] In parallel with making rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members (see Fig.CM. фиг.12) of track structure S, those are connected together in truss G of superstructure by zigzag oriented rod elements 9 (marked respectively 9.1 and 9.2 on Fig.2), with plates 10 rigidly fastened on their ends and fastening components 11 (see Fig.6), with use of which transverse forces of clamping of plates 10 and load-bearing elements 5.1 are formed, and, when required, i.e. when those are present, fixing of joined ends P_1 and P_2 of load-bearing element 5.1 of longitudinally stressed load-bearing structure 5 is performed (see Fig.7).

[0059] Zigzag oriented rod elements 9 can be produced as profile (shaped) with cross section in the form of a tube (circular or shaped) or, alternatively, profiled in cross section from any known profiles, such as: T-beam, I-beam, channel section, angle or a strip, or various combinations thereof.

[0060] Fastening components 11 may be embodied in any traditional way know in the art. In particular, as fastening components 11, it is expedient to use, for example, a threaded joint of type screw 11.1 - nut 11.2 (see Fig. 6, 15, 16).

[0061] In the process of construction of truss G of superstructure (see Fig.1, 6 and 12), the assembly thereof is done so that the longitudinal axes W and Z of rod elements 9, together with the longitudinal axes X and Y, respectively, of rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S, form triangles ABC with tops A, B, C, in nodes of connection of rod elements 9 with cords 3 and/or 4 (see Fig. 12).

[0062] The joined ends P_1 and P_2 of load-bearing member 5.1 (see Fig. 7) are positioned, according to design specifications, in node A and/or B and/or C of connection of multidirectional zigzag oriented rod elements 9.1 and 9.2 and cords 3 and/or 4 (see Fig. 2, 7).

[0063] Notably, in nodes A, B, C of connection of rod elements 9 with cords 3 and/or 4, with use of plates 10 and fastening components 11, there happens formation of transverse forces of clamping of plates 10 and load-bearing elements 5.1 in load-bearing structure 5 with force F_n, N, (see Fig. 6), determined by ratio:

$$0{,}1 \leq F_n/F_0 \leq 0{,}95, \qquad (1)$$

where: F_0, N, - tensile breaking force of fastening component.

[0064] The mentioned values of ratio (1) indicate the optimum range of transverse forces and allow without any difficulties to secure the clamping of plates 10 and load-bearing elements 5.1 in load-bearing structure 5 with optimum force, providing for fixing of joined ends P_1 and P_2 of load-bearing element 5.1 of longitudinally stressed load-bearing structure 5, requiring reliability and durability of joining elements of load-bearing structure, load-bearing capacity of truss G of superstructure and its manufacturability. As a result, the rail cords of load-bearing members will have fewer local inhomogeneity areas along them, while the trussed track structure S itself becomes more reliable and less complex to manufacture.

[0065] If the ratio (1) will be less than 0,1, then it will be impossible to secure the force of clamping of plates 10 and load-bearing elements 5.1 in load-bearing structure 5, required for fixing of joined ends P_1 and P_2 of load-bearing element 5.1, as well as - required rigidity and load-bearing capacity of nodes of truss G of superstructure.

[0066] If the ratio (1) will be more than 0,95, then possibility increases of overstressing in nodes of connection and, in particular, in fastening components 11, which may result in loss in reliability of the whole truss G of superstructure and its disintegration under high-cycle loading.

[0067] Force of clamping F_n, N, (see Fig. 6) is secured by fastening component 11 of type screw 11.1 - nut 11.2 and by plates 10 (see Figs. 2, 6, 15, 16, 17).

[0068] In plates 10, profiled slotted through holes 12 are performed, which guarantee the feasibility of plates 10 to sidewise displace themselves relative to load-bearing structure 5 and fastening component 11, as well as the feasibility of plates 10 to axially displace themselves relative to load-bearing structure 5 and fastening component 11 (see Figs. 2, 3, 5, 7, 11).

[0069] The profiled slotted through holes 12, performed in plates 10, allow the plates 10 to clamp transversally the load-bearing elements 5.1 of load-bearing structure 5 in nodes A, B, C of connection of rod elements 9 with cords 3 and/or 4 (see Fig. 12), as well as to adjust axially, in situ, in those nodes of truss G of superstructure, the gaps and accumulated errors of linear dimensions of the elements of its structure. As a result, achieved is the fixing in nodes A, B, C of connection of ends P_1 and P_2 of load-bearing element 5.1 in longitudinally prestressed load-bearing structure 5 and straightness (alignment) of rail cords 3 and 4 with zero other-than-designed values of local overstressing of the structure, that could penalize reliability and durability of the entire trussed track structure S.

[0070] Plates 10 of multidirectional zigzag oriented rod elements 9.1 and 9.2 (see Fig. 2) are positioned on the opposite lateral sides of load-bearing element 5.1, which allows to build load-bearing structure 5 with load-bearing elements 5.1 rigidly fastened against each other, to guarantee the evenness of clamping thereof in nodes A, B, C of connection of rod elements 9 with cords 3 and/or 4 and uniformity of distribution of forces in multidirectional zigzag oriented rod elements 9.1 and 9.2 of truss G of superstructure. In doing so, assembling process of extended trusses G of superstructures and rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members, including, in field conditions, is considerably simplified.

[0071] Plates 10 are embodied with length *L,* m, width *H,* m, and thickness *T,* m, (see Figs. 4, 5, 7, 11, 13), values of which are given in the description of the design of trussed track structure of high-speed transport system by Yunitski.

[0072] To guarantee in nodes of connection A, B, C the reliable fixing of ends P_1 and P_2 of load-bearing element 5.1 by clamping force F_n, N, the length *L,* m, of plate 10 is performed according to the dependence between the length *L,* m, of plate 10 and the length L_k, m, of end P_1 and/or P_2 of joined load-bearing element 5.1, determined by the ratio:

$$2 \le L/L_k \le 5. \qquad (2)$$

[0073] If the sizes of length *L,* m, of plate 10 and length L_k, m, of end P_1 and/or P_2 of joined load-bearing element 5.1 are performed with values corresponding to the ratio (2), it becomes easier to secure the required fixing of the connected ends P_1 и P_2 of load-bearing element 5.1 of longitudinally stressed load-bearing structure 5, as well - the required rigidity and load-bearing capacity of truss G of superstructure with excellent manufacturability thereof.

[0074] If the ratio (2) will be less than 2, subsequently, to reliably fix the joined ends P_1 and P_2 of load-bearing element 5.1, secondary clamping forces and/or use of other engineering decisions for securing the process of fixing of joined ends P_1 and P_2 of load-bearing element 5.1 will be required, which leads to track structure cost overrun.

[0075] If the ratio (2) will be more than 5, it will result in untenable overspending of structural materials and, as a consequence, - track structure cost overrun.

[0076] Alternative embodiment of trussed track structure involves separation in vertical direction of load-bearing elements 5.1 by plates 10 and clamping straps 13 in load-bearing structure 5 and their specific allocation in that structure horizontally - in single or several vertical layers and/or in single and/or several horizontal layers (see Fig. 8, 9, 10, 13, 17).

[0077] Use of clamping straps 13 as vertical separation layers between load-bearing elements 5.1 of load-bearing structure 5, in addition to plates 10 and fastening components 11 used for the same technical purpose, allows to structurize load-bearing elements 5.1 in load-bearing structure 5 and form the latter with required preset technical parameters via preliminary distribution of load-bearing elements 5.1 in body 6 according to the design pattern with required positioning of each of elements in respective portion of body 6 of rail cord 3 and/or 4.

[0078] Depending on design option, if one and/or more strands of load-bearing elements 5.1 are used as load-bearing structure 5, positioned, at least, in single/or several horizontal layers and/or vertical layers, use of plates 10 and/or clamping straps 13, joined by fastening components 11, allows to securely divide and position apart load-bearing elements 5.1, to determine, as per design pattern, their location in body 6 with required positioning of each of them and exclude the feasible snarling at assembly of track structure S.

[0079] Such embodiment of trussed track structure S ensures design shaping and distribution of stress pattern of load-bearing structure 5, results in better manufacturability and increased durability while reducing material consumption of trussed track structure S, as well as its increased safety and reliability in case of breaking of one of load-bearing elements 5.1 of load-bearing structure 5 in operation.

[0080] Use of clamping strap 13 is reasonable and justified if its length, width and thickness are equal to those of plate 10, but with hole 14, arranged coaxially to central axes of symmetry of the profiled slotted through hole 12 of plate 10 (see Figs 3, 4, 5, 8, 9, 10, 11).

[0081] Thanks to using clamping straps 13, it becomes easier to assembly load-bearing elements 5.1 in load-bearing structure 5, to align and position load-bearing elements 5.1 relative to fastening components 11 and body 6 of rail cord 3 and/or 4, which, in turn, results in higher torsional rigidity and load-bearing capacity of trussed track structure S as a whole and truss G of each superstructure in particular.

[0082] Improved positioning and fixing of load-bearing elements 5.1 in load-bearing structure 5 and body 6 of rail cord 3 and/or 4 is secured by profiled axial slot 15, which, alternatively, is made in clamping strap 13 or plate 10 from the side of load-bearing element 5.1 (see Fig. 4, 8, 9).

[0083] Additionally, depending on design concept, to improve clamping and fixing of load-bearing element 5.1, adjusting gasket and/or insert 16 is used, manufactured from metal and/or composite material and positioned in slot 15 between load-bearing element 5.1 and clamping strap 13 and/or plate 10 (see Fig.13).

[0084] Main 3 and auxiliary 4 rail cords of load-bearing members 3_1 and 4_1, respectively, with all the above-mentioned characterizing features, are performed, at least, as couple, - left and right. Thus, for main cord 3 - such are the strings of load-bearing members $3^L{}_1$ and $3^P{}_1$, with longitudinal axes, respectively, X_1 and X_2, which have been prestressed in longitudinal direction due to forces F_1, N, and $F_{1.1}$, N, (see Fig. 14), applied to load-bearing structures. In the same way, load-bearing members of auxiliary cord 4 are also performed as couple (not shown on Figs).

[0085] Depending on design option and according to technical requirements of increased rigidity of trussed track structure, left $3^L{}_1$ and right $3^P{}_1$ rail cords of main 3_1 load-bearing member of track structure S are connected together in lower chord of space truss G of superstructure via stiff cross bulkheads 17 (see Fig.14). Identically, left and right auxiliary 4 rail cords of the respective load-bearing member 4_1 of track structure S are connected together in upper chord of space truss G of superstructure via stiff cross bulkheads 17 (not shown on Figs).

[0086] Hereby, the form of cross bulkhead is determined exclusively by the parameters of approved design and engineering concept, calculated values of technical characteristics of trussed track structure, the shape and dimensions of vehicle, aesthetic requirements and appearance of transport structure, materials consumption and cost thereof, and may be chosen to have an arbitrary shape from all the variety of embodiments thereof, as long as it is satisfactory in the view of optimization of the above mentioned requirements.

[0087] As a result, formed is the trussed track structure S of increased rigidity both in longitudinal and transverse directions of superstructure, which allows to reduce materials consumption of the mentioned structure and increase the length of spans.

[0088] Cross bulkheads 17 are installed, respectively, in nodes A, A_1 (A^n, $A_1{}^n$) and/or C, C_1 of connection of rod elements 9 with main left $3^L{}_1$ and main right $3^P{}_1$ (see Fig.14) rail cords of load-carrying structures (of lower chord) of truss G of superstructure, and are made together with fastening components 11 (see Figs. 15, 16, 17) with all above mentioned characterizing features.

[0089] In the same way, cross bulkheads 17 may be produced and installed in nodes of connection of rod elements 9 with the right and left auxiliary cords of load-bearing structures (of upper chord) of truss G of superstructure (not shown on Figs).

[0090] Using cross bulkhead 17 in nodes of connection of rod elements 9 and cords 3 and/or 4 together with fastening component 11 (11.1) allows to unify the nodes of track structure S of space truss G of superstructure, in order to make the structure more rigid, reduce labor intensity and manufacturing costs thereof.

[0091] Described by the above embodiments, the trussed track structure comprises supports 2 (of anchor 2a and intermediate 2b types), distributed on foundation 1 from soil along the track. On supports 2, on different levels, rail cords 3 and 4 are positioned, of at least one main 3_1 load-bearing member and, at a different level, of at least one auxiliary 4_1 load-bearing member of track structure S, which are connected together, fastened above the foundation 1 and make, at least, one truss G of superstructure (see Fig.1).

[0092] Rail cords 3 and 4 of main 3_1 load-bearing member and auxiliary 4_1 load-bearing member of track structure S are made in the form of longitudinally prestressed load-bearing members 5.1 unified in load-bearing structure 5. Pre-stressing thereof is ensured by application of tension forces, respectively, of F_1, N, and F_2, N, applied to the mentioned load-bearing elements 5.1 of the load-bearing structure 5 (see Fig.1, 12).

[0093] Load-bearing elements 5.1, brought together in the load-bearing structure 5, are placed into extended body 6 with rolling surface 7 conjugating thereto. Hereby, the load-bearing structure 5 is formed by filling up with hardening material 8 of volume of extended body 6 void of load-bearing elements 5.1 (see Fig. 6).

[0094] As hardening material 8, depending on design option, mixtures on the basis of polymer binding composites, concrete mixtures (see Fig. 6, 12) and/or analogous hardening materials can be used.

[0095] As a result, rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S are grouted and the required rigidity and load-bearing capacity thereof are attained.

[0096] Rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S are connected with each other in a truss G of superstructure with use of zigzag oriented rod elements 9 (on Fig.2 are indicated, respectively - 9.1 and 9.2) with plates 10 rigidly fastened on the ends thereof and fastening components 11 (see Fig. 2, 6).

[0097] Longitudinal axes W and Z of rod elements 9 with longitudinal axes X and Y of, respectively, rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members of track structure S, are forming triangles ABC with corners A, B, C, in nodes of connection of rod elements 9 with cords 3 and/or 4 (see Fig.1, 6 and 12).

[0098] Further, plates 10 and fastening components 11 are positioned in those nodes with possibility of forming of transverse forces of clamping in load-bearing structure 5.

[0099] To attain the required rigidity and load-bearing capacity of truss G of superstructure of track structure S, it is necessary to guarantee the stability of rod elements 9.

[0100] Here, the minimum lateral dimension *a,* m, of rod elements 9 and their length *l*, m, (see Fig.11) are connected by ratio:

$$5 \leq l/a \leq 50. \qquad (3)$$

[0101] Inclusion into truss G of superstructure of zigzag oriented rod elements 9, for which the value of ratio (3) corresponds to the specified range of values, allows to optimize both engineering parameters and materials consumption, and, subsequently, - the cost of track structure.

[0102] If the ratio (3) will be less than 5, then such rod element structure will have unreasonably high material intensity and cost.

[0103] If the ratio (3) will be more than 50, then such structure of rod elements 9 will have the following insufficient parameters: stability (esp. when longitudinally compressed), load-bearing capacity, rigidity and durability.

[0104] Load-bearing capacity of such track structure considerably exceeds load-bearing capacity of rail cords included therein thanks to increased rigidity of the whole system. Hereby, as far as material consumption (therefore, the cost) of the high-speed transport system is concerned, it is crucially important that it becomes feasible to increase work load on the trussed track structure as a whole.

[0105] Rail of the trussed track structure of the high-speed transport system by Yunitski also constitutes a part of the matter of the claimed invention.

[0106] The rail according to the proposed engineering solution includes, at least, one load-bearing member, which contains longitudinally prestressed load-bearing elements 5.1, brought together in the load-bearing structure 5, positioned in extended body 6 and filled up with hardening material 8, whereas the extended body has a rolling surface 7 conjugating therewith, and is configured with possibility to accommodate therein plates 10 and fastening components 11 (11.1 and 11.2), positioned in the nodes A, B, C of connection of rod elements 9 and cords 3 and 4, with aim to form transverse forces of clamping F_n, H in load-bearing structure 5.

[0107] In some cases of alternative embodiments of body 6 (6.1 and/or 6.2), in a preferred variant, as fastening components 11, structural parts 18 of extended body 6 in the form of threaded 18.1 or unthreaded 18.2 holes are used, positioned therein coaxially to clamping force F_n, N, of plates and load-bearing elements 5.1 in nodes A, B, C of connection of rod elements 9 and rail cords 3 and 4 (see Fig.12).

[0108] Embodiment in extended body 6 of structural parts 18 in the form of threaded 18.1 or unthreaded 18.2 holes of fastening components 11 allows to ensure the correct unification of structural components and technological effectiveness of joining structural components of truss G of superstructure in nodes of connection of rod elements 9 and cords 3 and/or 4 of trussed track structure S.

[0109] The form and dimensions of the plate guarantee the reliability and technological effectiveness of joining of structural components of truss G of superstructure in nodes of connection of rod elements 9 and cords 3 and/or 4.

[0110] Hereby, the length *L,* m, of plate, its width *H,* m, and thickness *T,* m, are connected with minimum lateral dimension *d,* m, (see Figs.2, 3, 5, 7, 11, 13) of load-bearing element 5_1 by the following ratios:

$$5 \leq L/d \leq 50, \qquad (4)$$

$$3 \leq H/d \leq 30, \qquad (5)$$

$$0{,}1 \leq T/d \leq 2. \qquad (6)$$

[0111] The specified ranges of ratios (4), (5), (6) define the optimal ranges of values of linear dimensions of plates 10 and/or clamping straps 13 relative to minimum lateral dimension *d,* m, of load-bearing element 5_1, accuracy of which guarantees the retention of the form and contact surface area in the process of clamping by plates 10 and/or clamping straps 13 of load-bearing element 5.1.

[0112] If the ratio (4) will be less than 5, then fixing of joined ends P_1 and P_2 of load-bearing element 5.1 becomes less reliable.

[0113] If the ratio (4) will be more than 50, then the materials consumption unjustifiably increases.

[0114] If the ratio (5) will be less than 3, then such embodiment of the structure of node of connection will be impossible due to insufficient area on the plate to provide for the contact with fastening component 11.

[0115] If the ratio (5) will be more than 30, then such embodiment of the structure of node of connection will be unjustifiably material-consuming and, consequently, the cost of the entire transport system will rise up, too.

[0116] If the ratio (6) will be less than 0,1, then such embodiment of plates 10 and/or clamping straps 13 may not secure the retention of their form, contact area flat surface accuracy or bending stiffness, which play defining effect in creating lateral stresses due to fixing of joined ends P_1 and P_2 of load-bearing element 5.1.

[0117] If the ratio (6) will be more than 2, then such embodiment of the plates 10 and/or clamping straps 13 leads to unjustifiable material consuming and, as a result, to the higher cost of the entire transport system.

[0118] Further, the length *L,* m, of plate and its width *H,* m, are connected by ratio:

$$0{,}2 \leq L/H \leq 5. \qquad (7)$$

[0119] Embodiment of plates 10, for which the value of ratio (7) corresponds to the range of values specified therein, will allow to optimize their technical and performance parameters.

[0120] Thus, if the ratio (7) will be less than 0,2, then such embodiment of the plates 10 limits the possibility to ensure its axial displacement relative to load-bearing structure 5 and fastening component 11, which, in turn, reduces technological effectiveness, labor intensity and unification of structural components base of trussed track structure.

[0121] If the ratio (7) will be more than 5, then such embodiment of the plates 10 limits the possibility to ensure clamping of load-bearing structure 5, produced in accordance to technical requirements of design option of cords 3 and 4 of, respectively, main 3_1 and auxiliary 4_1 load-bearing members of track structure S.

[0122] Embodiment of plate with the specified form and dimensions ensures the unification of components base and technological effectiveness of joining of structural components of truss G of superstructure in nodes of connection of rod elements 9 and cords 3 and/or 4 of trussed track structure S.

[0123] Hereby, in plate, at least one profiled slotted through hole is performed (see Fig. 2, 3, 7, 11).

[0124] Further, the plates of multidirectional rod elements are positioned on opposite lateral sides of load-bearing member (see Fig. 2, 6, 7).

[0125] Performing in plate 10 of profiled slotted through hole 12 allows to guarantee both the clamping by such plates 10 of load-bearing elements 5.1 of load-bearing structure 5 in longitudinal direction in nodes A, B, C of connection of rod elements 9 with cords 3 and/or 4, as well as correction of gaps and accumulated errors of linear dimensions of elements of trussed track structure in each span. As a result, fixing is secured of ends P_1 and P_2 of load-bearing element 5.1 of longitudinally stressed load-bearing structure 5 in nodes A, B, C of connection of rod elements 9 with cords 3 and/or 4, and straightness (alignment) is achieved of rail cords 3 and 4 with zero other-than-designed values of local overstressing of the structure, which penalize reliability and durability of the entire trussed track structure S.

[0126] The position of plates 10 of multidirectional zigzag oriented rod elements 9.1 and 9.2 (see Fig. 2, 6, 12) on opposite lateral sides of load-bearing element 5.1 allows to form the load-bearing structure 5 with rigidly fixed position of load-bearing elements 5.1 in relation to each other and guarantee uniformity of clamping of those load-bearing elements 5.1 in nodes A, B, C of connection of rod elements 9 with cords 3 and/or 4. Moreover, the mentioned position of plates 10 guarantees the uniformity of distribution of forces in multidirectional zigzag oriented rod elements 9.1 and 9.2 of truss G of superstructure. Hereby, simplified is the process of assembling of extended trusses G of superstructures and rail cords 3 and 4 of main 3_1 and auxiliary 4_1 load-bearing members, while kinematic and performance parameters along the entire rail track are stabilized, and safety and reliability of the entire trussed track structure S are secured, in case of breakage of one of load-bearing elements 5.1 of load-bearing structure 5.

Industrial applicability

[0127] The selection of the particular embodiment of main and auxiliary cords for construction of the transport system is defined by its operating conditions, design requirements thereto, the purpose of its use, the type of cargo, weight and motion speed of vehicles.

[0128] Construction of trussed track structure of high-speed transport system and the rail thereof includes the following stages: the supports are mounted on the foundation, with the rail cords - of at least one main load-bearing member, and, on another level, of at least one auxiliary load-bearing member - positioned thereon;
whereby the load-bearing member is produced from the longitudinally prestressed load-bearing elements, whereas the load-bearing elements are brought together into the load-bearing structure and placed into the extended body with the rolling surface conjugating thereto;
whereas the load-bearing structure is formed by filling up with hardening material of the volume of space in the extended body void of load-bearing elements, whereas the cords of main and auxiliary load-bearing members are connected together in the truss of superstructure by means of zigzag oriented rod elements with plates rigidly fixed on the ends thereof and fastening components;
whereby the longitudinal axes of the rod elements, together with the longitudinal axes of the cords, form triangles with corners in nodes of connection of rod elements and cords, and the joined ends of load-bearing element are positioned in the node of connection of rod elements and cords;
whereas the plates and fastening components are configured to be installed in those nodes with formation, in the load-bearing structure, of transverse force of clamping F_n, N, determined by the ratio:
$0{,}1 \leq F_n/F_0 \leq 0{,}95$,
where: F_0, N, - tensile breaking force of fastening component; forming of transverse forces is achieved with feasibility of fixing of joined ends of load-bearing element in longitudinally prestressed load-bearing structure; the plates are configured with feasibility of axial and sidewise displacement relative to the load-bearing structure and the fastening component.

[0129] Embodiment of the proposed trussed track structure and its rail for high-speed transport system by Yunitski according to the above outlined manufacturing process thereof, allows to attain the following advantages: lowering labor intensity during assembly of trussed track structure; securing reliability of joining of elements of load-bearing structure of rail cords into rigidly assembled space structure; unification of structural components base of the entire structure; stabilization of technical and performance parameters in the entire transport system; stability (monolithic integrity) of the trussed track structure; durability and evenness of bodies of its rail cords; smooth and soft motion of vehicle (not shown on Fig.) along each truss of superstructure and along the entire length of the system.

Information sources

[0130]

1. Inventor's Certificate. CCCP N 35209, publ.31.03.1934 r.
2. Patent RU 2328392, MПK B61B1/00, B61B5/02, B61B13/00, E01B25/00, publ. 10.07.2008 r.
3. Patent EA 6112, MПK B61B 3/00, 5/00, E01B 25/00, publ. 25.08.2005.
4. Patent RU 2520983, MПK B61B5/02, B61B13/00, E01B25/00, publ. 27.06.2014 r.
5. Patent RU 2204640, MПK E01B5/08, E01B25, B61B5, B61B3/02, B61B 13/04, publ. 20.05.2003 r.
6. Patent RU 2201482, MПK E01B5/08, E01B25, publ. 27.03.2003 r.
7. Patent RU 2208675, MПK E01B25/00, publ. 20.07.2003 r.

Claims

1. Trussed track structure of high-speed transport system, *wherein* the supports mounted on the foundation with rail cords installed thereon, of at least one main load-bearing member, and at least one auxiliary load-bearing member located at a different level, which contain longitudinally prestressed load-bearing elements brought together in a load-bearing structure, whereby the cords of main and auxiliary load-bearing members form a load-bearing structure positioned in the extended body and filled with hardening material, whereas the extended body is performed with conjugating rolling surface, whereby the cords of main and auxiliary load-bearing members, with use of fastening components, are connected with each other by zigzag oriented rod elements via plates rigidly fixed on the ends thereof, forming a truss of the superstructure, whereas the longitudinal axes of the rod elements, together with the longitudinal axes of the cords, form triangles with corners in nodes of connection of rod elements and cords, whereby the plates and fastening components are configured to be installed in those nodes with aim of formation, in the load-

bearing structure, of transverse force of clamping F_n, N, determined by the ratio:
$0,1 \leq F_n/F_0 \leq 0,95$,
whereby: F_0, N - tensile breaking force of fastening component, whereas minimum lateral dimension a, m, of rod elements and their length /, m, are related by the ratio:
$5 \leq l/a \leq 50$.

2. Trussed track structure according to claim 1, ***characterized in that*** the plates are configured with feasibility of axial and sidewise displacement relative to load-bearing structure and fastening component due to presence in plates of profiled slotted through holes.

3. Trussed track structure according to claim 1, ***characterized in that*** the plates of multidirectional rod elements are positioned on the opposite lateral sides of load-bearing element.

4. Trussed track structure according to claim 3, ***characterized in that*** in the plate, on the side of load-bearing element, a profiled axial slot is performed which shape corresponds to the shape of the load-bearing element.

5. Trussed track structure according to claim 1, ***characterized in that*** the main cord and/or auxiliary cord are arranged at least as paired.

6. Trussed track structure according to claim 5, ***characterized in that*** the paired cords are joined together at each level by rigid cross bulkheads.

7. Trussed track structure according to claim 6, ***characterized in that*** the cross bulkheads are installed in nodes of connection of rod elements and cords.

8. Trussed track structure according to claim 7, ***characterized in that*** the cross bulkheads in nodes of connection of rod elements and cords are performed together with fastening components.

9. Rail of trussed track structure according to claim 1, *wherein* at least one load-bearing member has longitudinally prestressed load-bearing elements brought together in a load-bearing structure, positioned in the extended body and filled with hardening material, whereas the extended body is equipped with conjugating rolling surface and configured to accommodate plates therein and fastening components, installed in nodes of connection of rod elements and cords with aim of formation in load-bearing structure of transverse forces of clamping, whereby the length *L,* m, of plate, its width *H,* m, and thickness *T,* m, are related to minimum lateral dimension d, m, of load-bearing element, by the ratios:

$5 \leq L/d \leq 50$,
$3 \leq H/d \leq 30$,
$0,1 \leq T/d \leq 2$,

whereby the length *L,* m, of plate and its thickness *H,* m, are connected by the dependence:
$0,2 \leq L/H \leq 5$.

10. Rail according to claim 9, ***characterized in that*** the fastening components - threaded or unthreaded holes, arranged coaxially to force of clamping of plates and load-bearing elements in nodes of connection of rod elements and cords.

11. Rail according to claim 9, ***characterized in that*** the load-bearing element is made in the form of twisted or untwisted cables, cords, ropes, strips, and/or bands, and/or other standard extended elements manufactured from any high-strength materials.

12. Rail according to claim 9, ***characterized in that*** the length *L,* m, of plate, is related to the length L_k, m, of the end of the joined load-bearing element, with dependence, determined by the ratio:

$2 \leq L/L_k \leq 5$.

13. Rail according to claim 9, ***characterized in that*** the load-bearing elements in vertical direction are separated by clamping straps.

14. Rail according to claim 13, ***characterized in that*** the clamping strap is performed with a through hole, arranged coaxially to central axes of symmetry of the profiled axial slot of plate.

15. Rail according to claim 13, ***characterized in that*** in the clamping strap, on the side of load-bearing element, a profiled axial slot is performed which shape corresponds to the shape of the load-bearing member.

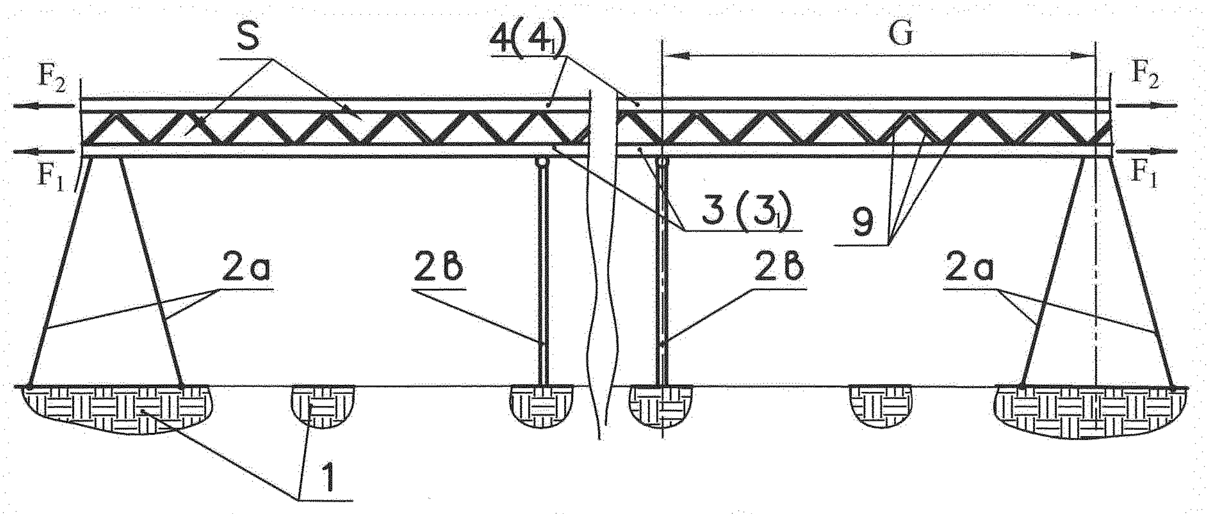

Fig. 1

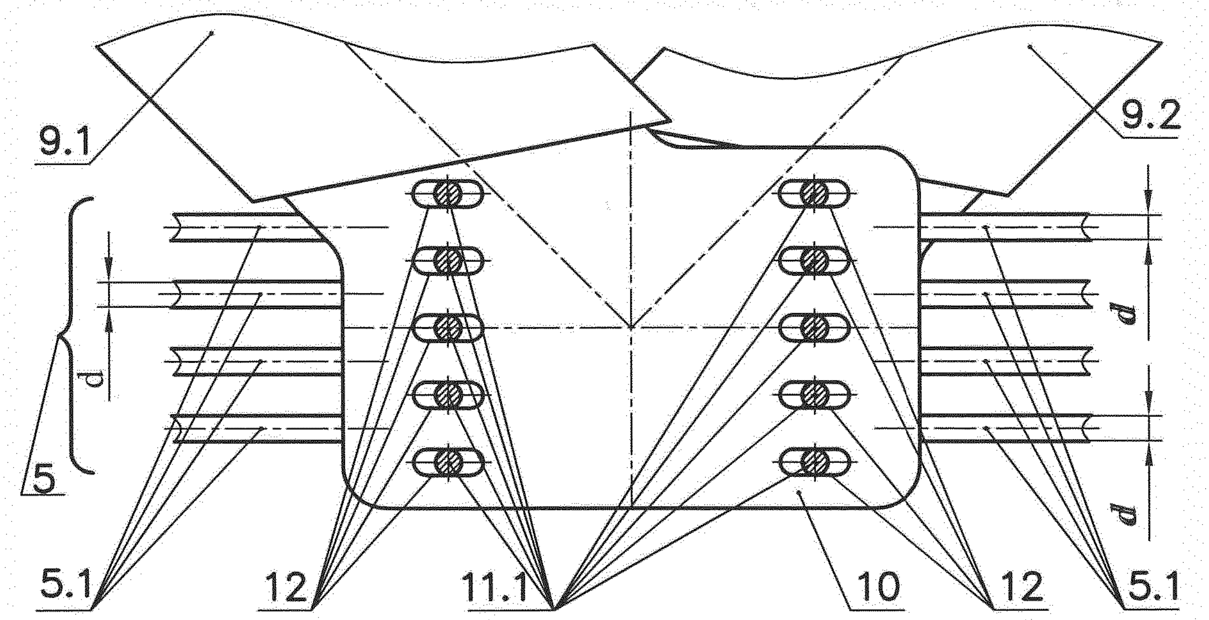

Fig.2

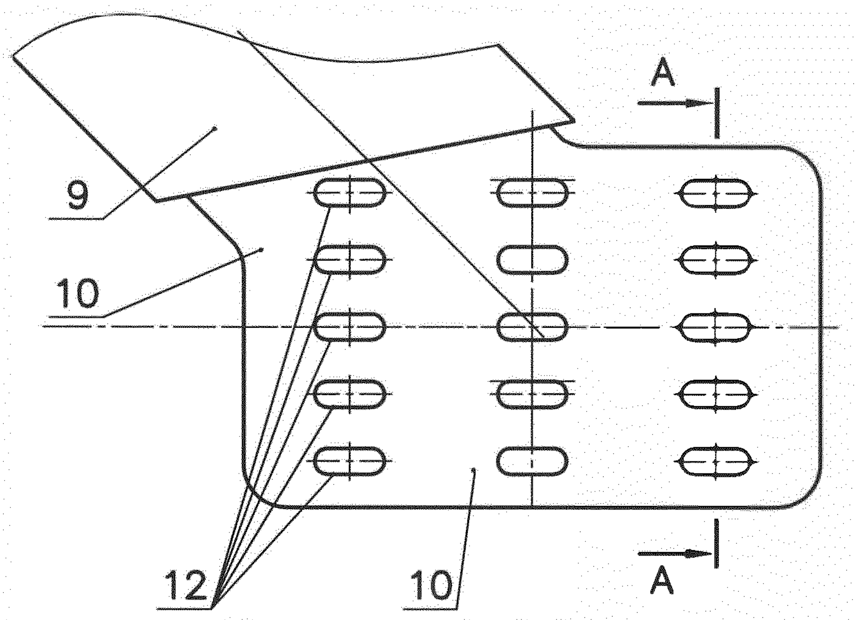

Fig.3

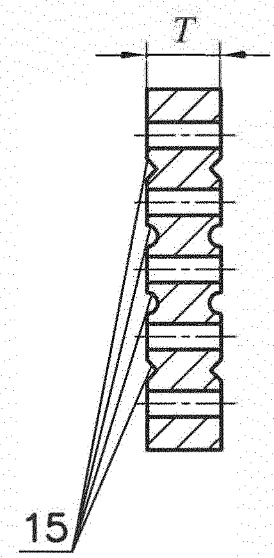

Fig.4

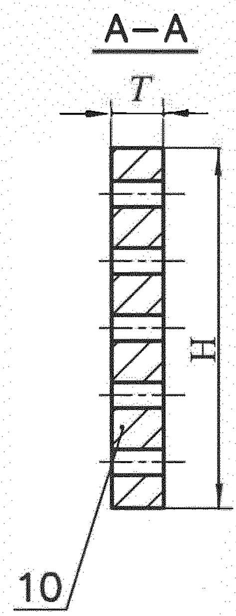

Fig.5

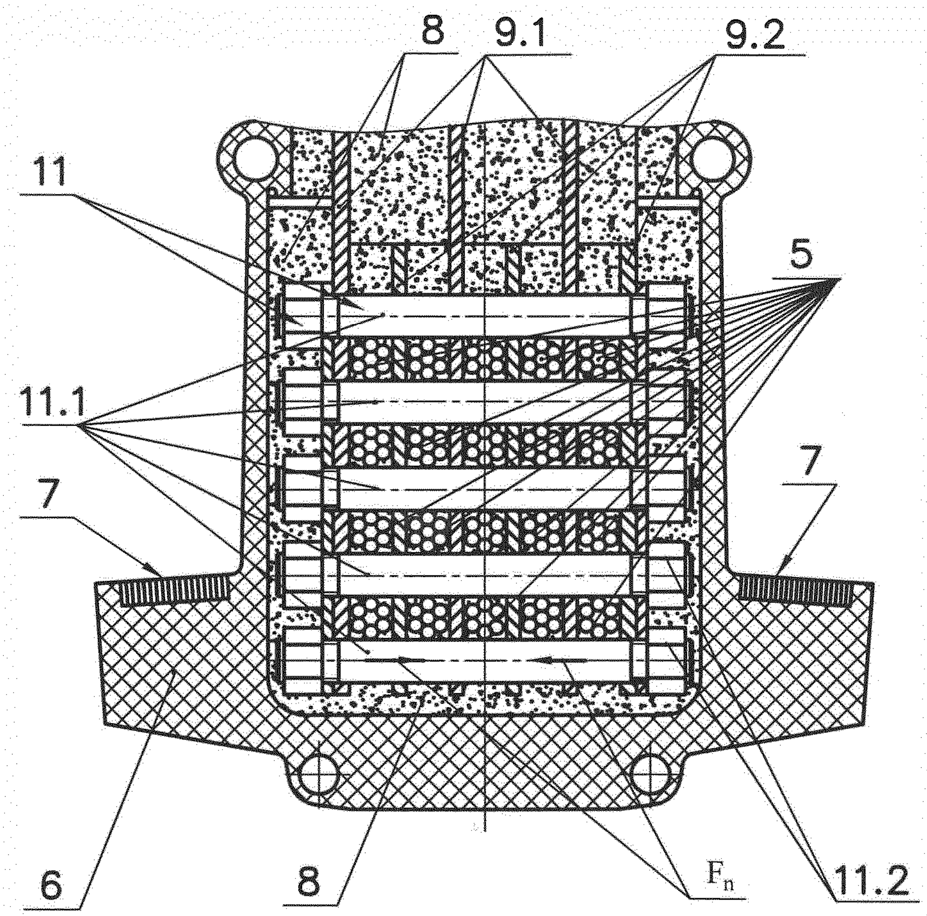

Fig.6

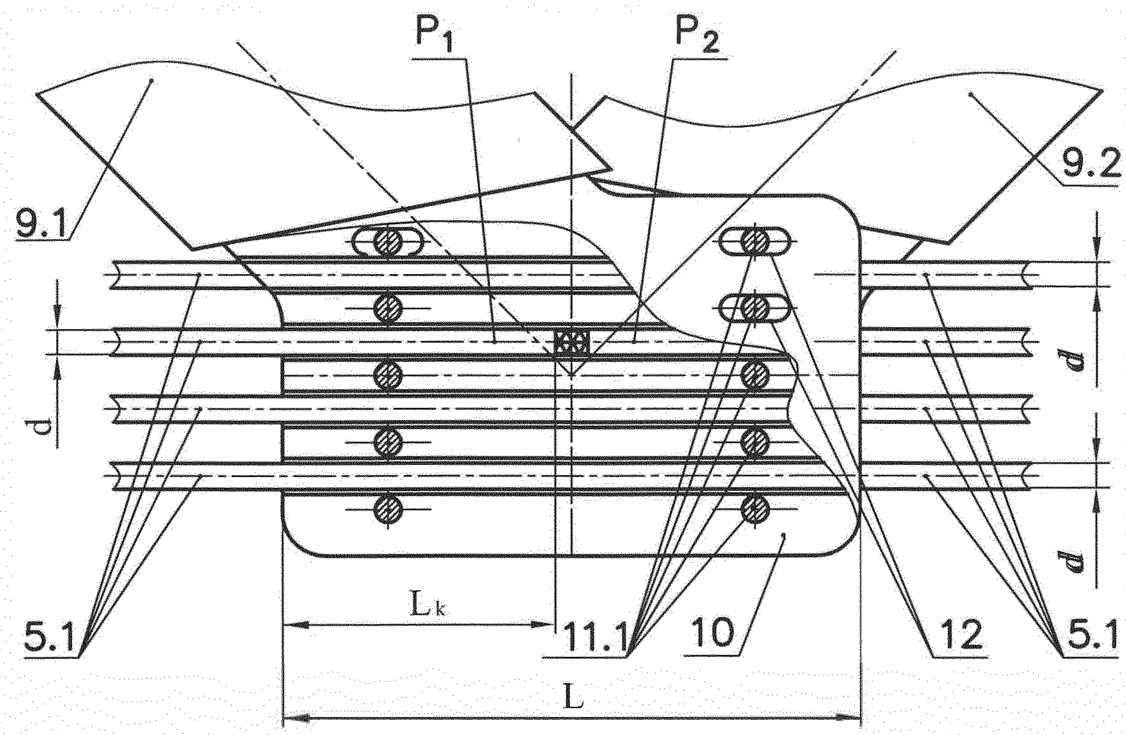

Fig.7

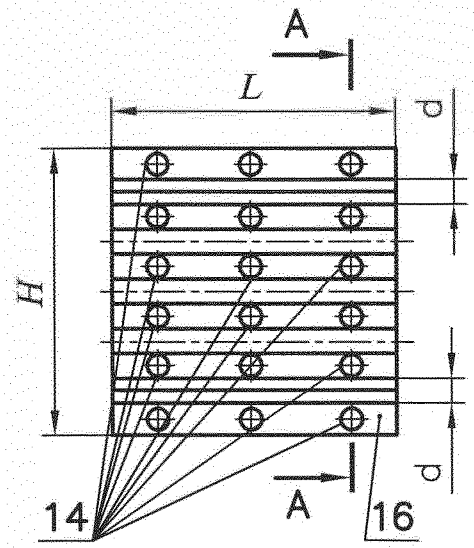

Fig.8

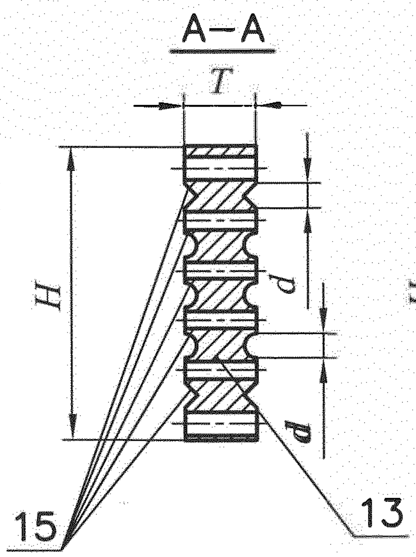

Fig.9

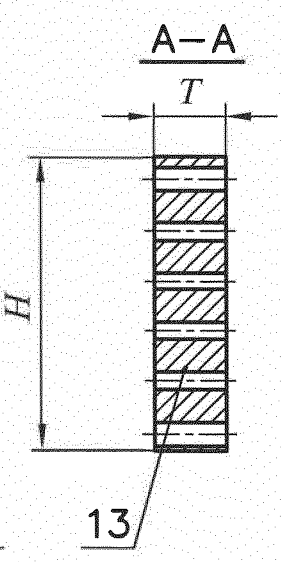

Fig.10

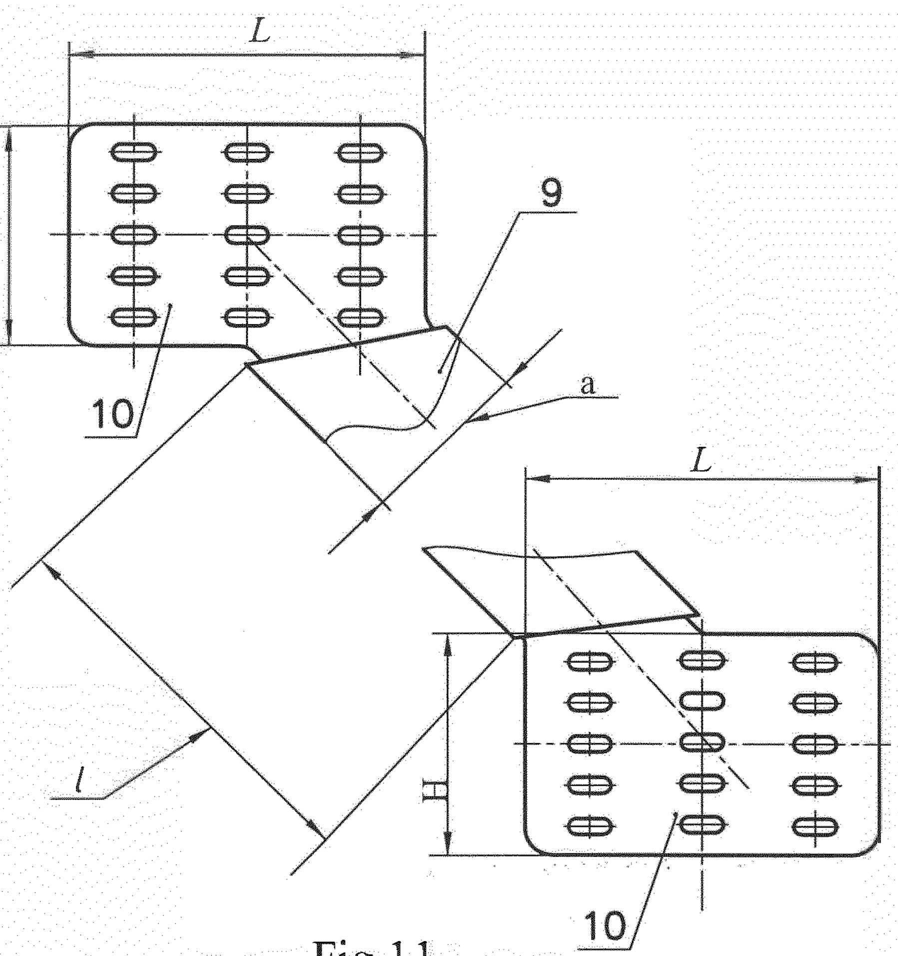

Fig.11

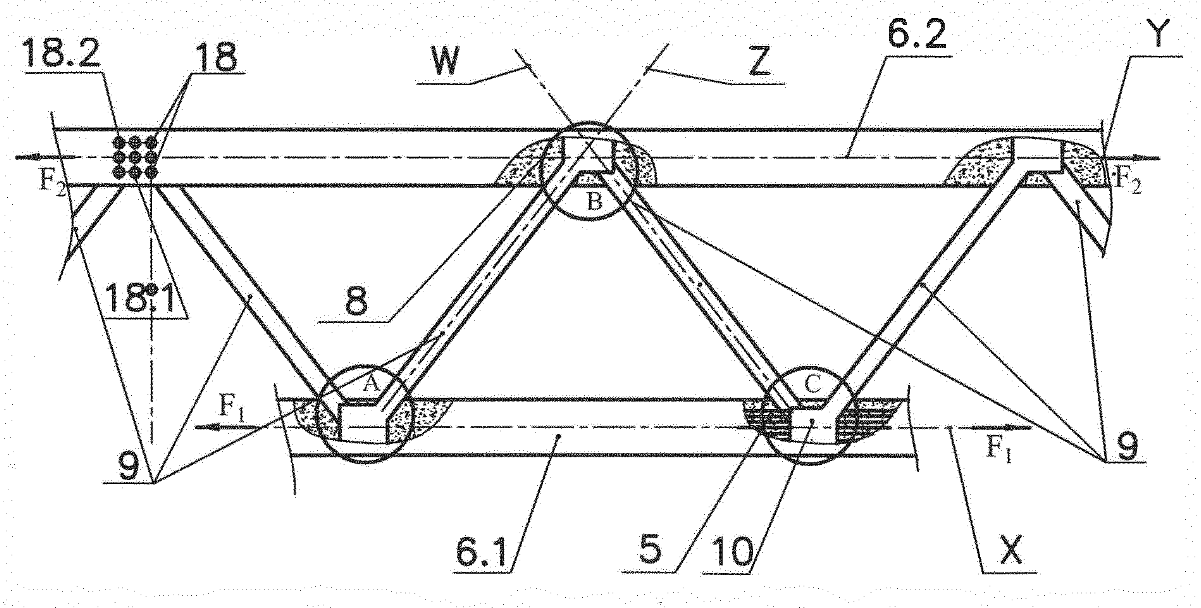

Fig.12

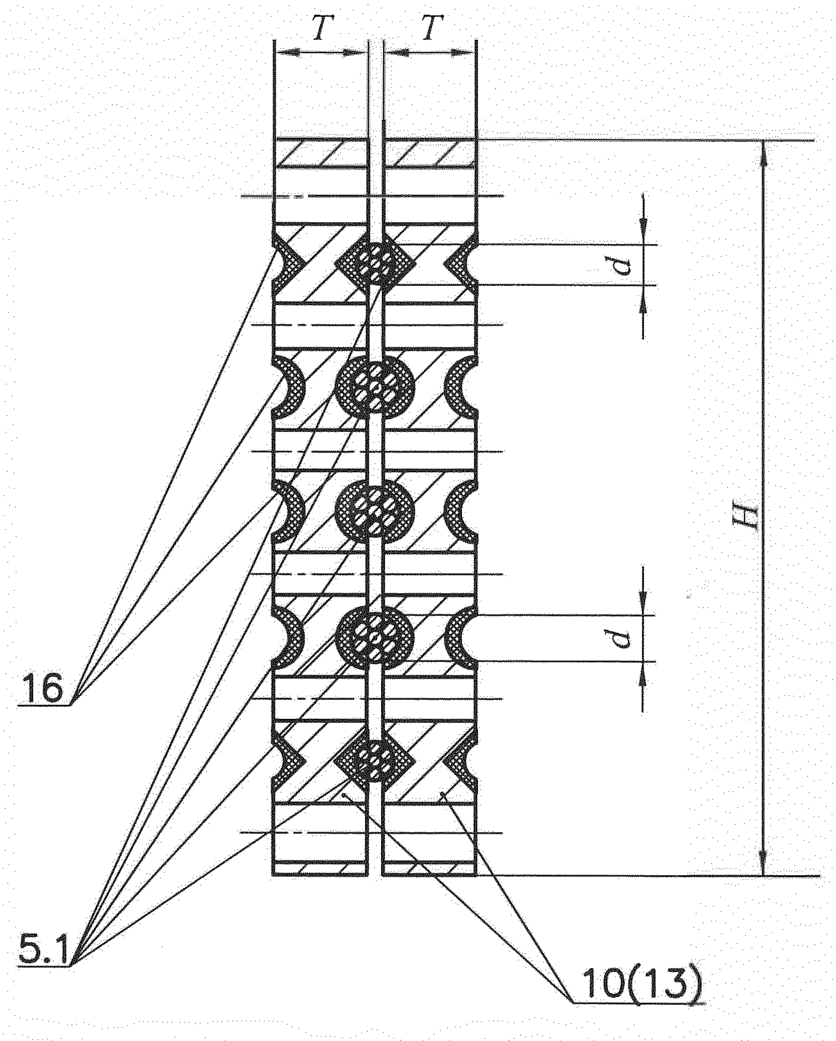

Fig.13

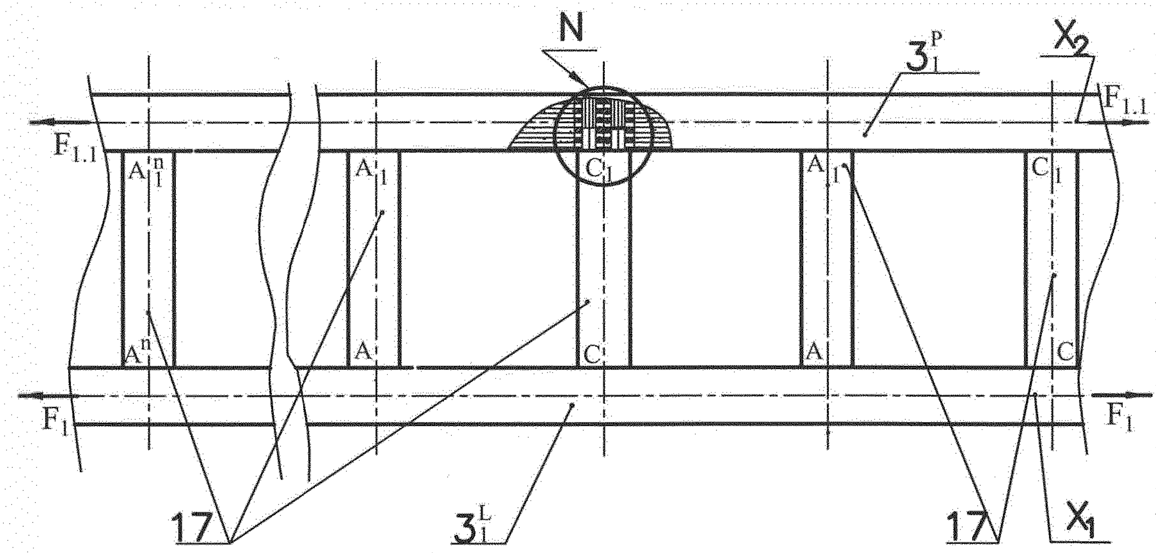

Fig.14

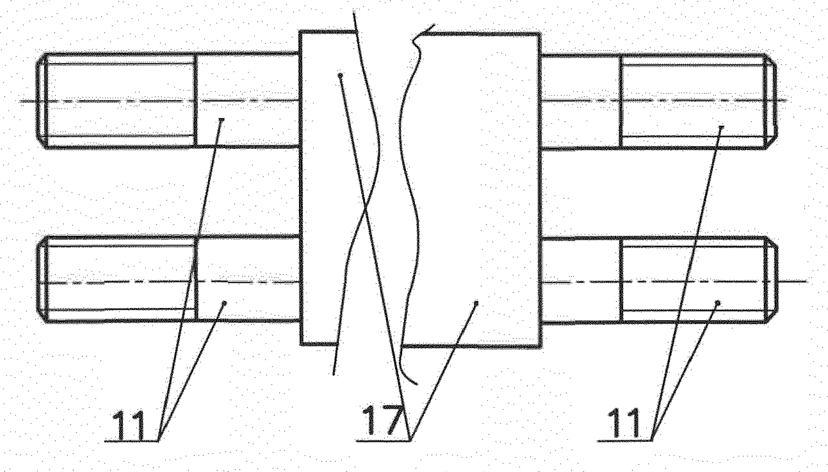

Fig.15

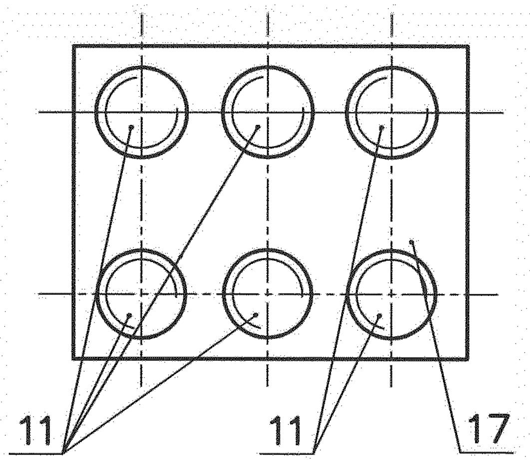

Fig.16

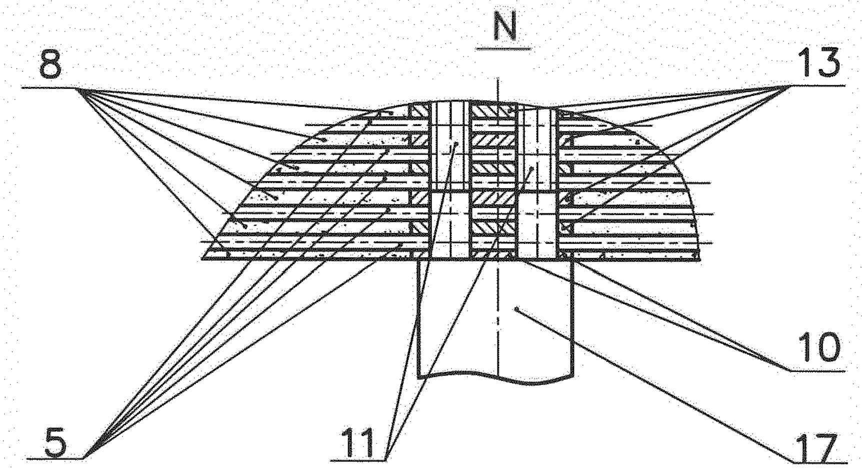

Fig.17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BY 2018/000010

A. CLASSIFICATION OF SUBJECT MATTER

B61B 3/02 (2006.01) B61B 5/00 (2006.01) B61B 13/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61B 3/00, 3/02, 5/00, 5/02, 13/00, 13/04, 15/00, E01B 5/00, 5/02, 5/08, 9/00, 25/00, 25/08, 25/10, 25/22, 25/24, 26/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), Espacenet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A, D	RU 2520983 C2 (IUNITSKII ANATOLII EDUARDOVICH) 27.06.2014	1-15
A	RU 2224064 C1 (IUNITSKII ANATOLII EDUARDOVICH et al.) 20.02.2004	1-15
A	RU 2223357 C1 (IUNITSKII ANATOLII EDUARDOVICH et al.) 10.02.2004	1-15
A	WO 2009/030117 A1 (BEIJING QIXIANG INNOVATION SCIENTIFIC AND TECHNICAL CENTER) 12.03.2009	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
07 August 2018 (07.08.2018)	16 August 2018 (16.08.2018)
Name and mailing address of the ISA/	Authorized officer
Facsimile No.	Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- RU 2328392 **[0130]**
- EA 6112 **[0130]**
- RU 2520983 **[0130]**
- RU 2204640 **[0130]**
- RU 2201482 **[0130]**
- RU 2208675 **[0130]**

Non-patent literature cited in the description

- *Inventor's Certificate. CCCP N 35209, publ.,* 31 March 1934 **[0130]**