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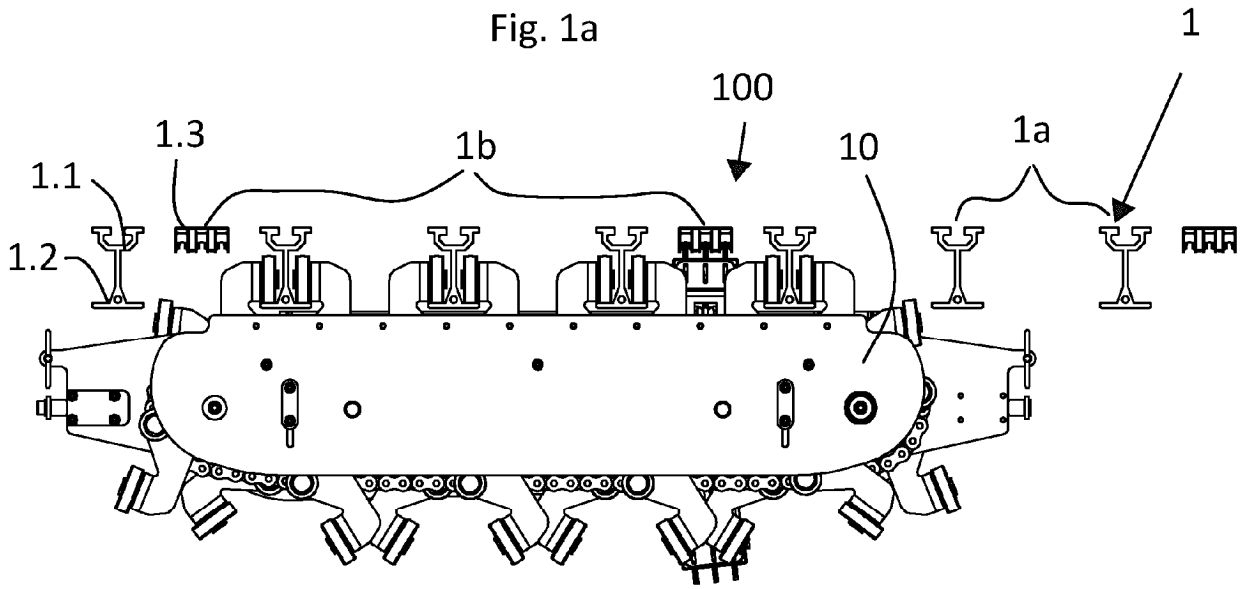
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(54) CRAWLER TYPE VEHICLE WITH POWER TRANSFER UNIT, CRAWLER TYPE VEHICLE ARRANGEMENT AS WELL AS METHOD OF SUSPENDING THE CRAWLER TYPE VEHICLE

(57) The invention relates to a crawler type vehicle (10) configured for traveling in a suspended manner especially headlong at a structure (1), wherein the vehicle (10) comprises:
- a plurality of suspension elements (13, 13b) configured for suspending the vehicle (10) and configured for coupling the vehicle (10) to the structure,
- at least one first drive unit (11), and
- at least one second drive unit (11') configured to be driven together with the at least one first drive unit, wherein the at least one second drive unit comprises a plurality of power transfer units (14) configured to transfer power between a power grid and the crawler type vehicle by dis-/engaging a subset of the plurality of the power transfer units (14) into/out of an interface (1.3) of the power grid, when the power transfer units are guided along the two circumferential tracks by the circumferential motion.

Fig. 1a



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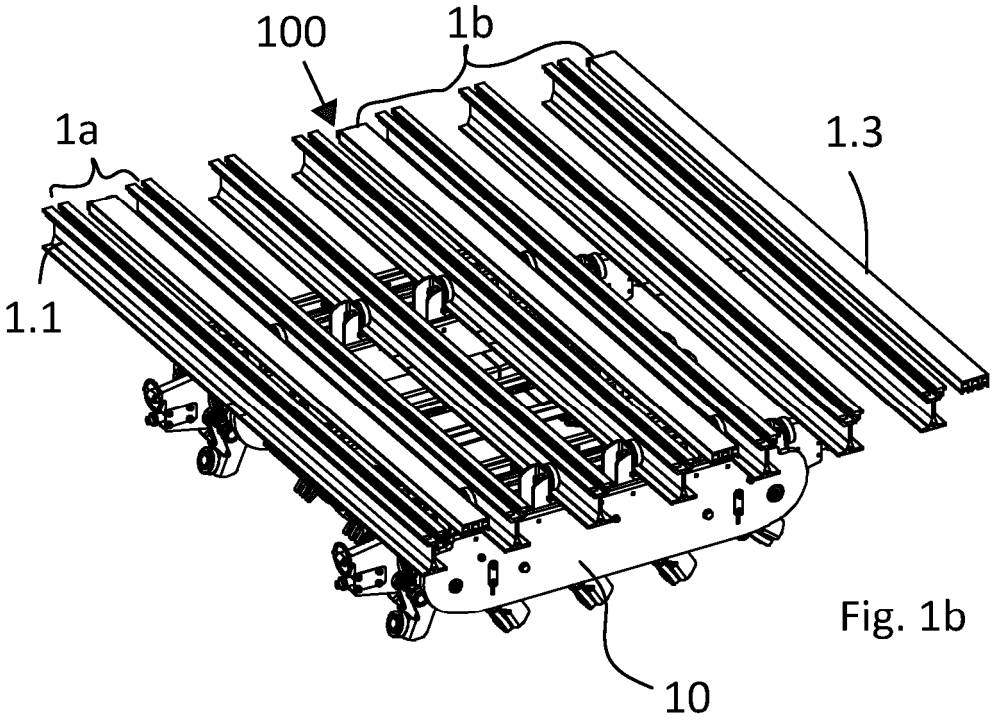


Fig. 1b

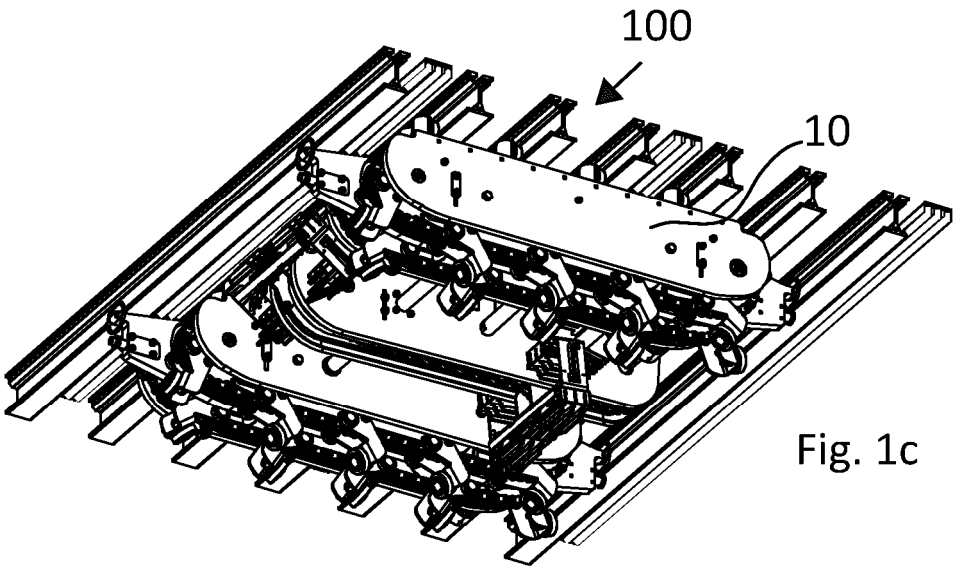


Fig. 1c

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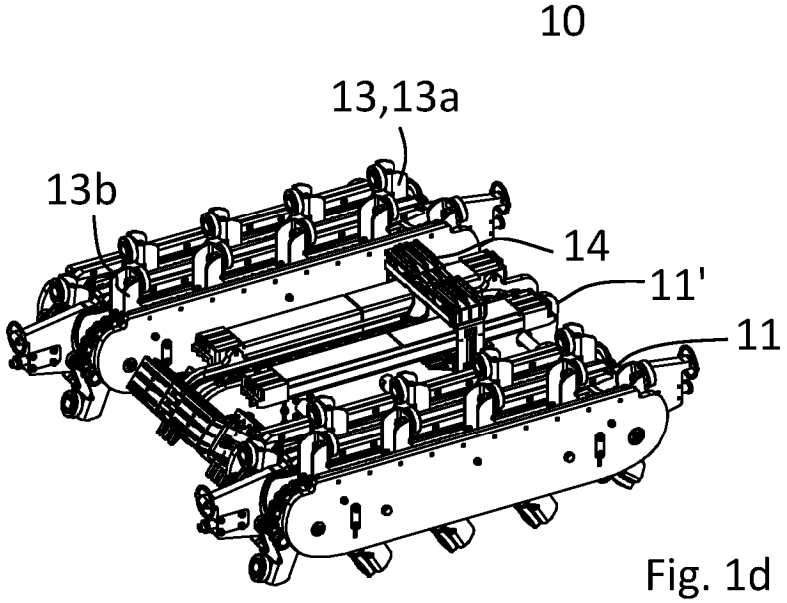


Fig. 1d

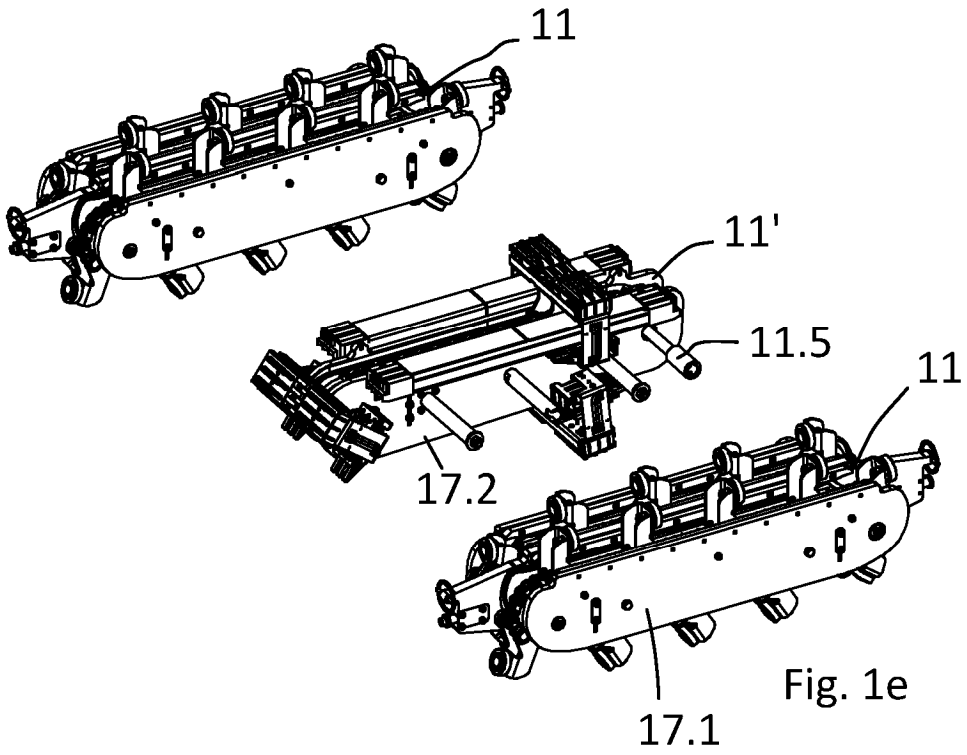


Fig. 1e

Description

TECHNICAL FIELD

[0001] The present invention refers to crawler type vehicles with power transfer units. Further, the present invention refers to a method of suspending the crawler type vehicles at a structure, especially at a ceiling structure, especially in context with two-dimensional positioning of the ceiling unit while ensuring stable power connection. In particular, the present invention refers to devices and methods according to features of the enclosed independent and dependent claims.

BACKGROUND OF THE INVENTION

[0002] In prior art, multiple design philosophies have already been established in context with provision of systems which shall be able to ensure a predefined position or motion also in rough terrain or in context with unpredictable reaction forces or at high inclination or in an overhead arrangement. In EP 4 273 030 B1, the inventor has developed a novel approach to interacting with a (ceiling) structure, departing from the idea that a unit or vehicle or any means of transportation should engage / interact in a predefined manner with a predefined structure at a wall or at the ceiling (e.g. overhead cranes, wall crawling robots) e.g. in a storehouse or in a machinery hall. Some ideas of provision of reliable contact between the structure and the unit have already been published in context with diagnosis and parameter measurement in nearly inaccessible areas or systems (e.g. ductwork, canal systems), including magnetic adhesion / interference. As disclosed therein, the crawler type vehicles are suitable for connecting to further components, such as robotic arms and the like. For this purpose and for active motion of the crawlers, especially without the need for charging big battery packs inside the crawlers, it is desirable to be able to establish a constant energy connection.

SUMMARY OF THE INVENTION

[0003] It is an object of the present invention to provide for a mechanism which harmoniously interacts with a system for reliable and accurate suspension/positioning/traveling of at least crawler type vehicle at a structure, especially for realizing variable two-dimensional tracks of motion of the vehicle. In particular, the object also includes providing for a power transfer unit allowing for securely engaging with a power grid.

[0004] The object of the present invention is solved by the features of the independent main claims. Advantageous features are indicated in the subclaims. If not explicitly excluded, the teachings of the subclaims can be combined arbitrarily with the teachings of the main claims and the subclaims.

[0005] According to a first aspect, the present invention provides for a crawler type vehicle configured for traveling in a suspended manner especially headlong at a structure, wherein the vehicle comprises:

- a plurality of suspension elements configured for suspending the vehicle and configured for coupling the vehicle to the structure,
- at least one first drive unit configured for circumferential motion and accommodating a first circumferential track and a second circumferential track having a different circumferential shape/contour than the first circumferential track, wherein the suspension elements are attached to the first circumferential track at predefined first longitudinal positions corresponding to a first predefined raster, wherein the vehicle is configured for moving along the structure by decoupling a subset of the plurality of suspension elements from resp. coupling them into the structure when the suspension elements are guided along the two circumferential tracks by the circumferential motion,
- at least one second drive unit configured to be driven together with the at least one first drive unit, wherein the at least one second drive unit comprises a plurality of power transfer units configured to transfer power between a power grid and the crawler type vehicle, wherein the second drive unit is configured for circumferential motion accommodating a third circumferential track and a fourth circumferential track, having a different circumferential shape/contour than the third circumferential track, wherein the power transfer units are attached at predefined longitudinal positions corresponding to a second predefined raster, wherein the vehicle is configured for connecting to the power grid by engaging a subset of the plurality of the power transfer units into an interface of the power grid.

[0006] Preferably pulling a subset of the plurality of the power transfer units out of the interface of the power grid, when the power transfer units are guided along the two circumferential tracks by the circumferential motion can be added, respective follow, especially as a subsequent process step.

[0007] While "power grid" can unproblematically refer to the conventional electricity grid, the term "power grid" is synonymous with any form of electrical network that can be used to transport electrical energy, both AC and DC voltage networks with any number of phases, poles or potentials.

[0008] The transferring of power between the power grid and the power transfer unit can be oriented in any direction, i.e., it is not excluded that power is transferred from the power transfer unit and fed into the power grid. However, a power transfer from the power grid to the power transfer unit may be the more common case. It is also not necessarily the case that the power is (exclusively) transferred to the crawler itself, i.e., it is possible to use the crawlers (especially also moving passively) as a

flexibly placeable power outlet. The crawlers can for instance use some power available via the power transfer units for themselves while feeding the rest of the power, e.g., via a cable to a (humanoid) robot performing a task in proximity to the crawler or being suspended via the crawler for example for maintenance of a robot.

[0009] A crawler (type vehicle) at their core are defined through a plurality of suspension elements configured for suspending the vehicle and configured for coupling the vehicle to the structure, and have at least one first drive unit configured for circumferential motion and accommodating a first circumferential track and a second circumferential track having a different circumferential shape/-contour than the first circumferential track, wherein the suspension elements are attached to the first circumferential track at predefined first longitudinal positions corresponding to a first predefined raster, wherein the vehicle is configured for moving along the structure by decoupling a subset of the plurality of suspension elements from resp. coupling them into the structure when the suspension elements are guided along the two circumferential tracks by the circumferential motion.

[0010] The crawler type vehicle can of course further comprise a motor/actuator for actively driving the crawler along the structure. It should be noted that the crawler can also be guided by a user, pulling/pushing the crawler into a specific direction, i.e., active drives are not necessarily provided. In particular, in conjunction with appropriate sensor-actor-arrangements, the crawler may follow an intended direction resp. an intended path of motion (especially as a kind of semi passive guide mode; guidance via physical and/or visual interaction with an individual).

[0011] According to the present disclosure, when it is referred to "ceiling structure" or "structure", a structure which may also extend (at least in parts) on the ground or along a wall or on an inclined plane (or the like) can be designated. The present invention can preferably be applied for crawler type ceiling units (resp. ceiling vehicles) being arranged at resp. traveling along a ceiling structure, and in addition, the present invention also allows for any motion along any structure with alternative orientation and/or arrangement. Thus, referring to a "structure" or "ceiling structure" includes reference to any other "structure" comprising the features presently described allowing for coupling with/to the inventive crawler and corresponding de-/coupling kinematics.

[0012] According to the present disclosure, when it is referred to "vehicle" or "ceiling vehicle", the disclosure also generally refers to crawler type units or vehicles and its relative spatial arrangement or traveling motion (e.g. also on the ground or on an inclined plane or at the wall).

[0013] According to the present disclosure, when it is referred to "circumferential track", the disclosure also generally refers to closed loop guidings and lines and predefined contours along which the suspension elements are guided and/or driven, e.g. chains or any such traction means providing for a closed loop.

[0014] According to the present disclosure, when it is referred to "profile units" or "profiles" or "T-profiles", the disclosure also generally refers to different kinds of profiles like e.g. I-profiles or L-profiles which may provide for advantageous/favourable arrangements in individual applications. The profile units respectively has at least one tread, wherein each suspension element comprises at least one element of motion (for gliding or rolling, especially at least one wheel) arranged and configured for at least passively moving (especially gliding or rolling) the crawler type ceiling unit in said first spatial direction.

[0015] The crawler can be configured for enabling at least one closed loop trajectory of respective suspension elements along corresponding circumferential tracks, especially configured for enabling at least two closed loop trajectories of at least two subsets of respective suspension elements.

[0016] The circumferential tracks are for example shaped in such a manner that the respective suspension elements are de-/coupled from/into the ceiling structure when passing a curved section of the tracks.

[0017] For example, a subset of the suspension elements are attached to one of the circumferential tracks (resp. a subset of the first subset, momentary) and at least one further subset of the suspension elements are attached to a further one of the circumferential tracks (resp. a subset of the second subset, momentary) respectively at predefined first and second (further) longitudinal positions respectively corresponding to the structural regularity, in particular with each suspension element being guided by a pair of circumferential tracks.

[0018] The suspension elements can be fixedly attached/coupled by means of a first pulley to/with a/the first circumferential track and are guided within a/the second circumferential track by means of a second pulley respectively, wherein the first and second pulley preferably are arranged at a lever arm of the respective suspension element.

[0019] Each suspension element exemplarily comprises a first pulley and a second pulley arranged in longitudinal distance with respect to the first pulley at a lever arm of the respective suspension element, wherein the suspension element is coupled to a/the first and a/the second circumferential tracks via the first and second pulleys.

[0020] A respective subset of said suspension elements is connected to each other by means of longitudinal connecting elements, especially by chain elements, thereby forming a closed loop of interrelated suspension elements distanced to each other in a/the predefined structural regularity. A respective subset of the power transfer units is connected to each other by means of longitudinal connecting elements, such as chain elements, also forming a closed loop of interrelated power transfer units distanced to each other in a second predefined structural regularity corresponding to the second raster.

[0021] For example, the respective circumferential

track comprises a chain or is provided/defined by a chain forming a closed loop of interrelated chain elements.

[0022] The crawler is for example configured for lifting a/the respective suspension elements out of the structure in an unloaded state, especially such that both de-/coupling kinematics for a subset of momentarily unloaded suspension elements and suspension of the crawler type ceiling unit by a subset of momentarily loaded suspension elements is ensured.

[0023] The crawler exemplarily for example comprises at least two kinds/types of suspension elements, wherein the different types of suspension elements are de-/coupled according to individual kinematics (especially in opposite directions/sides at the profile units, especially both in and opposite to the second spatial direction resp. travel direction of the crawler type ceiling unit), wherein a first subset of the suspension elements are attached to a first pair of circumferential tracks (resp. a subset of the first subset, momentary) and at least one further subset of the suspension elements are attached to a second pair of circumferential tracks (resp. a subset of the second subset, momentary) respectively at predefined first and second (further) longitudinal positions respectively corresponding to the structural regularity (resp. to the distance of the profile units defined by said structural regularity), wherein the first and second pairs of circumferential tracks provide for individual kinematics for the first and second subsets of suspension elements, especially such that the crawler type ceiling unit is secured with respect to opposite sides/directions (of the second spatial direction) at the structure resp. at the profile units. Accordingly, the crawler exemplarily comprises two kinds/types of power transfer units, wherein the different types of power transfer units are dis-/engaged according to individual kinematics (especially in opposite directions/sides at the interface of the power grid, especially both in and opposite to the second spatial direction resp. travel direction of the crawler type ceiling unit), wherein a first subset of the power transfer units are attached to a first pair of (third and fourth) circumferential tracks (resp. a subset of the first subset, momentary) and at least one further subset of the power transfer units are attached to a second pair of (third and fourth) circumferential tracks (resp. a subset of the second subset, momentary) respectively at predefined first and second (further) longitudinal positions respectively corresponding to the second structural regularity (according to the second raster), wherein the first and second pairs of (third and fourth) circumferential tracks provide for individual kinematics for the first and second subsets of power transfer units, especially such that the crawler is connected to the interface of the power grid with respect to opposite sides/directions (of the second spatial direction).

[0024] For example, each suspension element is guided by a pair of circumferential tracks, wherein the crawler type ceiling unit comprises at least three pairs of circumferential tracks each guiding a subset of the suspension elements, wherein said de-/coupling kinematics are predefined by said three pairs of circumferential tracks in such a manner that that respective suspension elements (resp. a subset of the respective subset, momentary) simultaneously de-/couple both at a first side (resp. first longitudinal position) of a respective profile unit and at a second side (resp. second longitudinal position) of a respective profile unit, especially such that the crawler type ceiling unit is secured with respect to opposite sides/directions (of the second spatial direction) at the ceiling structure, especially with all suspension elements being guided in same circumferential direction, especially with all circumferential tracks being arranged in parallel to each other.

[0025] The crawler exemplarily comprises at least one load attachment point configured for transferring loads of an external load (e.g. an object or a subject/individual to be carried/transported/moved along the ceiling in one- or two-dimensional manner) attached to the crawler type ceiling unit.

[0026] The crawler can further comprise at least one hoist unit, wherein the hoist unit is configured for transferring loads of an external load (e.g. an object or a subject/individual) to the ceiling structure. The hoist can for example comprise means to transfer power from the power transfer unit(s) to a load connected to the hoist.

[0027] The crawler according to the invention comprises at least one further (a second) drive unit, which is configured to be driven together with the at least one first drive unit. For example, the first and second drive unit are connected via a common shaft, or other couplings or toothed belts. The second drive unit is configured for circumferential motion accommodating a third circumferential track and a fourth circumferential track, having a different circumferential shape/contour than the third circumferential track. For example, the tracks can be shorter or longer than the tracks of the first and second circumferential tracks or the second drive unit(s), which is/are arranged parallel to the at least first drive unit (accommodating the first and second circumferential tracks) are longer or shorter than the first drive unit(s). The power transfer units can be fixedly attached/coupled by means of their own pair of pulleys, i.e., attached/-coupled by means of a first pulley to/with the third circumferential track and are guided within the fourth circumferential track by means of a second pulley respectively, wherein the first and second pulley can be arranged at a lever arm of the respective power transfer unit.

[0028] The movement of the power transfer units is defined by guiding the power transfer units along the third and fourth circumferential tracks. The power transfer units are spaced apart according to the second raster. For example, the power grid is realised by a number of power rails running parallel to profile units of the structure but have an offset in the y direction. Preferably, every relevant phase of the power grid can be located in a (common) rail between two profile units. The power

transfer units are attached at predefined longitudinal positions corresponding to the second predefined raster, wherein the vehicle is configured for connecting to the power grid by engaging a subset of the plurality of the power transfer units into an interface of the power grid resp. pulling a subset of the plurality of the power transfer units out of the interface of the power grid, when the power transfer units are guided along the two circumferential tracks by the circumferential motion.

[0029] According to one embodiment, the second predefined raster is arranged relative to the first predefined raster such that the second predefined raster complements a periodic structure of the first raster by fitting into every n-th gap, with n being a positive integer. Preferably, power rails of the power grid are placed parallelly to the profile unit and for example in the middle between every third profile unit. This allows for a particular economical design.

[0030] According to one embodiment, the first and second circumferential tracks are shaped in such a manner that the suspension elements are de-/coupled from/into the structure only when passing a curved section of the first and second circumferential tracks and wherein the third and fourth circumferential tracks are shaped in such a manner that the power transfer units are plugged into / out of the interface of the power grid only when passing a curved section of the third and fourth circumferential tracks, wherein the power transfer units are configured to move essentially straight towards / away from the interface when the power transfer units are passing the curved section of the circumferential tracks.

[0031] According to one embodiment, the crawler further comprises a spring mechanism, wherein the power transfer units comprise sliding contacts, and wherein the sliding contacts are pre-/loaded via a restoring force of the spring mechanism against an upper plate when the power transfer units are not engaged with the interface and the restoring force is configured to push/-press the sliding contacts against the interface of the power grid, especially against power rails of the power grid, thus ensuring stable power connection. The power transfer units generally must satisfy the condition that they can be "dragged" along with the vehicle in the x-direction without breaking the electrical contact(s). A sliding contact made from cupper and carbon for example can provide a particularly long lifespan, wherein - under reasonable spring force - when the contacts are slid along power rails, the contacts lose about 1 mm of contact material for every 1000 km of sliding the contact.

[0032] According to one embodiment, the crawler further comprises a guiding mechanism configured to guide and reinforce the sliding contacts with respect to their orientation to the interface of the power grid, especially when the power transfer units are engaging with the interface of the power grid. Preferably, this guiding mechanism is connected in one piece to the upper plate and/or the spring mechanism. When the sliding contacts of the power transfer units are engaging the interface of the power grid, the sliding contacts are pushed down. The guiding mechanism ensures that the sliding contacts are pushed straight down against the spring and do not tilt or break.

[0033] According to one embodiment, the crawler type vehicle further comprises at least one conductor rail connected to a power circuit of the crawler type vehicle, wherein the power transfer units are configured to connect to the conductor rail when the power transfer units are engaging with the interface of the power grid. Essentially simultaneously, the power transfer units are connecting to the power grid and the internal conductor rail.

[0034] According to a further preferred embodiment, the conductor rail(s) are power rails connected to an internal power bus of the crawler type vehicle, wherein the power transfer units comprise further sliding contacts for connecting to the internal power rails, wherein the further sliding contacts are loaded against the internal power rail via a restoring force of a spring mechanism. The number of conductor rail(s) typically corresponds to the number of power lines of the power grid.

[0035] According to one embodiment, each power transfer unit comprises at least two electrical contacts, especially sliding contacts. Preferably, the electrical contacts, especially sliding contacts, engage with the interface of the power grid in a predefined manner, especially one after another, wherein the predefinition is achieved by elevating an electrical contact with respect another electrical contact such that when the power transfer unit is closing in on the interface of the power grid the elevated electrical contact engages first with the interface. It is further preferable, that a neutral or ground potential is connected first when the power transfer unit approaches the interface of the power grid and wherein the neutral or ground potential is disconnected last when the power transfer unit moves away from the structure.

[0036] According to one embodiment, the power transfer units are fixedly attached/coupled by means of a first pulley to/with the third circumferential track, wherein the power transfer units are guided within the fourth circumferential track by means of a second pulley respectively, wherein the first and second pulley preferably are arranged at a part, especially a sheet metal part of the respective power transfer unit; and/or wherein each power transfer unit comprises a first pulley and a second pulley arranged in longitudinal distance with respect to the first pulley at a metal plate of the respective power transfer unit, wherein the power transfer unit is coupled to the third and fourth tracks via the first and second pulleys; and/or wherein each power transfer unit comprises a metal plate accommodating/supporting a/the pulley guided by the second track, wherein the pulley is arranged at a free end of the metal plate, and wherein in a linear section of the track, the metal plate is parallel to a driving/traveling plane, at least partly; and/or wherein the power transfer units are connected to each other by means of longitudinal connecting elements, especially by longitudinal connecting elements being connected at

the axis of a/the first pulley of the power transfer unit, thereby forming a closed loop of interrelated power transfer units distanced to each other in the predefined second raster.

[0037] According to one embodiment, the first circumferential track and the third circumferential track each comprise a chain or are provided/defined by a chain forming a respective closed loop of interrelated chain elements, and/or wherein the first circumferential track and the third circumferential track are each defined by a chain connecting the suspension elements / power transfer units respectively.

[0038] According to one embodiment, the at least one first drive unit and the at least one second drive unit are configured to be driven together via a common shaft.

[0039] According to a second aspect, a crawler type vehicle arrangement is provided, comprising at least one crawler type vehicle as described above and at least one structure extending in at least two spatial directions, wherein the structure comprises a plurality of profile units extending in a first spatial direction, wherein the structure defines at least one structural regularity in a second spatial direction,

wherein the structure comprises a power grid, wherein the power lines extend in the first spatial direction with a second predefined raster, wherein the second predefined raster is offset in the second spatial direction relative to the first predefined raster such that the second predefined raster complements the periodic structure of the first raster by fitting between every n-th profile unit, with n being a positive integer.

[0040] The ceiling suspension arrangement (especially the at least one crawler) comprises a sensing device with at least one sensor from the following group: speed sensor, distance sensor, position measuring sensor, force sensor, acceleration sensor resp. gyroscope; wherein the suspension arrangement can be configured for controlling the at least one crawler based on (depending on) momentary measuring data of the at least one sensor. The (respective) crawler preferably comprises a communicating unit configured for wireless communication at least within the suspension arrangement, wherein the (respective) crawler provides energy to the communicating unit (e.g., via power transferred from the power transfer unit or via energy from energy storing means).

[0041] The suspension arrangement is exemplarily configured for locating individual crawlers based on at least one locating signal transmitted by individual crawlers (passively or actively, e.g. passively based on at least one individual transmitter, especially based on individual identification features).

[0042] The profile units of the suspension arrangement are for example arranged according to at least two different structural regularities (especially structural densities) respectively with respect to said second spatial direction (i.e., distributed according to at least two equidistant regularities), namely a first structural regularity defining a/the relative distance of the profile units matching with the relative (longitudinal) distance of the suspension elements attached at the tracks (with respect to each other), and a second structural regularity being a whole-number multiple of said first structural regularity (resp. of the relative longitudinal distance of the suspension elements attached at the tracks), wherein the number of momentarily engaging/coupling suspension elements preferably is at least two within a/the overlapping area of the second structural regularity, and wherein a/the area of the first structural regularity preferably has a first load-bearing capacity and the area of the second structural regularity has a second load-bearing capacity (especially smaller than the first load-bearing capacity).

[0043] The profile units of the suspension arrangement can define spatially at least two different allowable loads (according to at least two different/specific load-bearing capacities) in at least two spatial sections of the ceiling suspension arrangement along the ceiling (wherein the cross section remains identical, geometrically).

[0044] For example, at least a subset of the profile units of the suspension arrangement respectively comprises at least one delimitating zone or boundary line defining a limit between a traveling area for the at least one crawler type ceiling unit and an inaccessible boundary area of the ceiling structure (in which the at least one crawler type ceiling unit shall not travel or shall not be positioned).

[0045] The suspension arrangement can also be coupled with/to a further suspension arrangement, wherein the profile units of the ceiling suspension arrangement are arranged according to a first structural regularity (especially structural density), wherein the profile units of the further suspension arrangement are arranged according to a second structural regularity, wherein the second structural regularity is a whole-number multiple of said first structural regularity; wherein the suspension arrangements may extend for example on at least two different levels of altitude or floors.

[0046] According to another aspect, a method of suspending or positioning at least one crawler type vehicle of the kind described above at a structure extending in at least two spatial directions is disclosed for providing at least two degrees of freedom for at least two-dimensional positioning or two-dimensional motions of the crawler type vehicle, especially in a suspended manner headlong a ceiling structure in conjunction with actively moving/-driving the crawler type vehicle along the structure, especially by actively re-orientating the crawler type vehicle's traveling direction, wherein the structure comprises a plurality of profile units extending in a first spatial direction, wherein the structure defines at least one structural regularity in a second spatial direction, thereby defining a first raster, wherein the crawler type vehicle is suspended by means of a plurality of suspension elements coupling the crawler type ceiling unit to the structure by means of de-/coupling kinematics depending on a relative motion of the crawler type vehicle with respect to the structure in at least said second spatial direction, wherein the suspension elements are attached to and guided by at least

two circumferential tracks of the crawler type vehicle, wherein the circumferential tracks respectively define a specific path of circumferential motion of the respective suspension elements, thereby providing for de-/coupling kinematics which suspend and relatively move the respective suspension element with respect to the structure during a relative motion of the crawler type vehicle in said second spatial direction,
wherein the crawler type vehicle is connected to a power grid, which is placed according to a second raster to fit between gaps of the first raster, wherein the crawler type vehicle connects to the power grid by means of a plurality of power transfer units engaging with an interface of the power grid by means of dis-/engaging kinematics depending on a relative motion of the crawler type vehicle with respect to the structure in at least said second spatial direction (y), wherein the power transfer units are attached to and guided by at least two further circumferential tracks of the crawler type vehicle, wherein the further circumferential tracks respectively define a specific path of circumferential motion of the respective power transfer unit, thereby providing for dis-/engaging kinematics during a relative motion of the crawler type vehicle in said second spatial direction with the crawler type vehicle remaining movable in said first spatial direction along the profile units irrespective of momentary motion in said second spatial direction.

[0047] Further advantages, features, and advantageous refinements of the invention are derived from the dependent claims and the following description of preferred embodiments with reference to the figures.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0048] These and other aspects of the present invention will also be apparent from and elucidated with reference to the embodiments described hereinafter. Individual features disclosed in the embodiments can constitute, alone or in combination, an aspect of the present invention. Features of different embodiments can be carried over from one embodiment to another embodiment. In the drawings:

Figures 1a - 1e show a crawler type vehicle according to the invention comprising first and second drive units;
Figures 2a - 2n show in perspective views and in side views components of a crawler type vehicle resp. of the corresponding suspension arrangement;
Figures 2o - 2q show in perspective views an arrangement of suspension elements and respective arrangement along a circumferential track of a crawler type vehicle according;
Figures 2r - 2t show in perspective views details of suspension elements of a crawler;
Figures 3a - 3e show in perspective views and in side views components of a crawler;
Figures 4a - 4c show in perspective views details of suspension elements (and their suspension) of a crawler type vehicle;
Figures 4d - 4e show in side views details of suspension elements of a crawler;
Figure 4f shows in a perspective view details of a crawler;
Figure 5a - **5m** show in side views details of a second drive unit of a crawler;
Figure 6 shows a perspective view of aspects related to power transfer units of a crawler;
Figure 7a - 7b show the structure of features of power transfer units;
Figure 8a - 8b show aspects of power transfer units with three contacts;
Figure 9a - 9b show an interface of a power grid;
Figure 10a - 10b show aspects of power transfer units engaged in an interface of the power grid;
Figure 11a - 11b show chain elements for the second drive unit;
Figure 12a - 12b show two mirror inverted power transfer units;
Figure 13a - 13c show a crawler type vehicle connected to a structure and a power grid according to one embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

[0049] First, the reference signs are described in general terms; individual reference is made in connection with respective figures.

[0050] The present invention provides for a crawler type vehicle 10 having at least one, preferably at least two housings 17.1, 17.2. The vehicle 10 is configured for moving / traveling along a structure 1 with a predefined first structural regularity or raster 1a which is, e.g., defined by T-profiles resp. T-rails 1.1 or any such profile unit. The profile units 1.1 comprise at least one wheel tread 1.2. A second raster 1b according to which interfaces 1.3 of a power grid are distributed providing for energy transfer, wherein the power grid is arranged between some of the profile units 1.1. The crawler type vehicle 10 is coupled to the structure 1 and suspended via a plurality of suspension elements 13, 13a, 13b (e.g. each including at least one element of a closed loop or chain). A suspension arrangement 100 is composed of at least one vehicle 10 and at least one structure 1 (at least one type of structure).

[0051] The at least one first housing 17.1 may provide for accommodation of a crawling or driving mechanism 11.1 (with or without motor(s) or actuator(s)) which allows for circumferential motion of the suspension elements 13 along circumferential tracks 12, namely simultaneously along a first and a second circumferential track 12a, 12b, which tracks comprise individual shapes/contours XZa, XZb. Preferably, the tracks only extend two-dimensionally (2D), i.e. in a plane, and the shape is different at least in curved sections 12r of the tracks. Each track 12a, 12b has a parallel/linear section 12p (resp. two parallel sec-

tions) and at least one redirection/curved section 12r (resp. two curved sections). A lateral area resp. surface shell of the at least one housing is preferably flat, plane, even, respectively on each lateral side. Such a configuration is also favourable in view of interconnection of several chassis (side by side). Respectively, at least one second housing 17.2 may provide for accommodation of a crawling or driving mechanism, synchronized to the first described crawling or driving mechanism 11.1, which allows for circumferential motion of power transfer units 14 along circumferential tracks 12', namely simultaneously along a third and a fourth circumferential track 12'a, 12'b, which tracks comprise individual shapes/contours. Preferably, the tracks only extend two-dimensionally (2D), i.e. in a plane, and the shape is different at least in curved sections 12'r of the tracks. Each track 12'a, 12'b has a parallel/linear section 12'p (resp. two parallel sections), wherein a conductor rail 10.3 can be arranged parallelly to the linear section 12'p, and each track has at least one redirection/curved section 12'r (resp. two curved sections). A lateral area resp. surface shell of the at least one second housing is preferably flat, plane, even, respectively on each lateral side.

[0052] The crawler 10 comprises at least one further first and/or second chassis/housing 17.1, 17.2 comprising first and second (or third and fourth) circumferential tracks 12a, 12b (12'a, 12'b) and accommodating a plurality of further suspension elements 13b (or power transfer units 14b) which are arranged mirror-inverted, with respect to the suspension elements 13 (or power transfer units 14) of the first (or second) housing 17.1 (17.2). As an alternative, both types of suspension elements (or power transfer units) are arranged within the same housing (are part of the same chassis), and optionally, both types of suspension elements (or power transfer units) can be guided by the same pair of circumferential tracks. The chassis may (actively) provide for a traveling motion (e.g. by a synchronous guiding/driving motion of/to the suspension elements or power transfer units). Several chassis, especially housings of different kinds, i.e., accommodating for suspension elements or power transfer units respectively, can be interconnected, e.g. via cross-beams or the like. Also, a first and a second chassis may provide for different driving motions, e.g. in order to force a non-linear, but curved/curvilinear traveling motion. The desired/required traveling motion can be controlled via a control unit 30 which can be coupled to at least one motor or actuator 11 (which is optional). In particular, the crawler can be provided as a kind of passive vehicle which traveling motion is induced by external forces; in such a configuration, the kinematics provide for suspending the crawler (especially in predefinable positions), but not for actively driving the ceiling unit for any traveling motion, and the inventive power transfer unit kinematics ensure that irrespective of the position of the vehicle in the structure, the power transfer units are always electrically connected to the power grid. A drive section may also comprise at least one gear unit 18 configured for interacting with the track(s). A sensor arrangement 40 comprising at least one sensing device 41, may provide sensor data to the control unit.

[0053] Preferably, each suspension element 13, 13a, 13b comprises a first pulley 13.1 and a second pulley 13.2, and optionally, a wheel 13.3 is provided at the free end of the suspension element 13 (bearing point P13). The first and second pulleys are arranged on a lever arm 13.5 in distance from/to each other (y-offset, longitudinal extension y13 of lever arm); the bearing point P13 resp. the wheel 13.3 is arranged at a protruding section resp. suspension arm 13.6 (z-offset). The plurality of suspension elements 13 of a/the respective chassis 17.1 can be interconnected via longitudinal connecting elements 15 which can ensure a closed loop 15a of interrelated suspension elements. The suspension elements 13 are coupled to the respective circumferential tracks. Further preferably, each power transfer unit 14, 14a, 14b has a first pulley 14.1 and a second pulley 14.2 respectively, and preferably, a sliding contact 14.3 is provided at the free end of the power transfer unit 14. The first and second pulleys are arranged on a lever arm or a (lightweight) part, especially a sheet metal part 14.5 in distance from/to each other (y-offset, longitudinal extension y14 of lever arm). At the free end of the power transfer unit 14, the sliding contact 14.3 (conductive slider for energy transfer) is provided in an arrangement 100 geometrically corresponding to a/the interface 1.3 of the power grid. The plurality of power transfer units 14 of a/the respective chassis 17.2 can be interconnected via longitudinal connecting elements 16 which can ensure a closed loop 16a of interrelated power transfer units. The power transfer units 14 are coupled to the respective circumferential tracks.

[0054] In other words: The suspension elements preferably have a wheel 13.3 performing a rolling motion on the profile units 1.1 of the (ceiling) structure 1, allowing for a motion which is orthogonal to the motion predefined and evoked by the tracks, wherein the wheel is positioned and aligned orthogonally with respect to the first and second pulleys. Optionally, the wheel can be motorized e.g. by means of further actuators or motors. Also optionally, the vehicle 10 can comprise an energy storage 19 connected to the drive unit 11. The first pulley 13.1 is engaged with the first or second circumferential track, thereby following the contour defined by said track; also, the second pulley 13.2 is engaged with the first or second circumferential track, thereby following said track (which is different from the track engaged by the first pulley, i.e. vice versa). Lever arm 13.5 is preferably L-shaped, especially provided as integral element in one piece (massive, solid).

[0055] The structure 1 and its first raster 1a is defined by profile units 1.1 being arranged in parallel and with similar distance (pitch) to adjacent profile units 1.1. Each profile unit 1.1 is preferably configured to support geometries/surface(s) which are adequate for interaction with the wheel(s) of the suspension elements (e.g. T-

profile, C-profile, L-profile, I-profile), and a series of such profile units 1.1 preferably provides for a planar surface at least in sections.

[0056] By means of the circumferential tracks and the suspension elements, the (respective) chassis and the kinematics defined by the shape of the tracks provide for de-/coupling kinematics 20 which ensure both vertical motion kinematics and non-circular pivot motion kinematics. Thereby, de-/coupling of each suspension element can be effected via circumferential motion along the tracks without the need of any axial telescopic motion within each suspension element. I.e., the respective suspension element can be designed as purely mechanic unit.

[0057] In particular, in context with logistic tasks, the ceiling unit 10 may have at least one hoist unit providing for a traction mechanism (especially with rope winch) and having at least one transmission means (especially a rope).

[0058] In the following, the kinematics provided by the guiding/driving motion along the circumferential tracks is described in general, first:

The first pulley 13.1 of each suspension element 13 rotates about a first pulley axis and defines a first guiding point G13.1 (coupling the first track and the respective suspension element), and vice versa, the corresponding point of the corresponding circumferential track defines that first guiding point G13.1 for each suspension element. Likewise, the second pulley 13.2 of each suspension element 13 rotates about a second pulley axis (which is preferably aligned in parallel) and defines a second guiding point G13.2 (coupling the second track and the respective suspension element). When referring to the kinematics of each suspension element, an instantaneous centre of rotation of each suspension element is defined by the axis of the first pulley 13.1 being coupled to the first track 12a, wherein coupling/attachment/fixation can be ensured e.g. at the axial section between a/the suspension arm 13.6 and the first pulley 13.1 (cf. Fig. 2r). The two tracks 12a, 12b are arranged with respect to another in such a manner that the contacting/bearing point/area P13 (coupling point) of the respective suspension element 13 can be hooked or hitched on the ceiling structure. According to a preferred arrangement, the wheel 13.3 of each suspension element rotates about a wheel axis which is preferably aligned orthogonally to the first and second pulley axis. Since each suspension element 13 is coupled to the tracks 12a, 12b in predefined positions, namely in a predefined first longitudinal position y12a via the first pulley 13.1 and in a predefined second longitudinal position y12b via the second pulley 13.2, when driving the tracks resp. when guiding the suspension elements along the tracks, the bearing point P13 at the free end of the suspension element 13 is guided according to the relative position/contour and distance of the corresponding tracks (of a pair of tracks guiding the respective suspension element).

[0059] **Fig. 1a, 1b, 1c** shows a crawler according to the invention suspended to a structure and connected to an interface 1.3 of a power grid from a side view and two perspective views. The structure of the full crawler without the structure 1 can be seen in the exploded view of **Fig. 1e.** Two different types of drive units comprising of respective chassis 17.1, 17.2, and interconnected chain elements (suspension elements 13, and power transfer units 14 respectively) are connected to one another via crossbeams and are preferably driven synchronously via a common shaft. The assembled crawler in perspective view can be seen in **Fig. 1d.** The first types of drive units 11 secure the crawler's position in the structure. Their structure and core features are discussed with respect to Fig. 2a - 2t, 3a - 3e and 4a - 4f. Afterwards, the features of the second drive units 11' accommodating for and guiding the power transfer units 14 is discussed with respect to Fig. 5a - 8b and Fig. 11a - 12b.

[0060] **Fig. 2a** shows a ceiling unit 10 (crawler 10) comprising at least one first chassis 17 (17.1) and suspension elements 13, wherein a subset of the suspension elements 13 is momentarily coupled to a/the ceiling structure 1, namely to T-profiles (profile units 1.1). The suspension elements 13 are guided (and optionally also actively driven) along two circumferential tracks (not shown, cf. Fig. 2C), and de-/coupling is carried out in curved sections of circumferential tracks.

[0061] The ceiling unit 10 shown in Fig. 2a is suspended (hanging) at a ceiling structure. Nonetheless, the unit or vehicle 10 may also be suspended in a similar structure being arranged on the ground or at the wall. The crawler 10 is not necessarily provided in the form of a ceiling vehicle but is suitable for being used/implemented as a ceiling crawler; thus, Fig. 2A illustrates an application/use at a structure which extends at a ceiling.

[0062] **Fig. 2B, 2C, 2D, 2E** show separate components of respective first chassis units 17. At least one first drive unit 11 or first drive 11a, 11b, 11c (which is optional, i.e., which can be provided if active driving motion to the suspension elements is desired) provides for circumferential motion of the first and second tracks 12a, 12b (or of the suspension elements interconnected to form a closed loop which is driven along the tracks), especially by means of at least one gear unit 18 engaging the tracks or any chain or traction means providing said closed loop. It is shown that the de-/coupling kinematics are provided within the curved sections 12r of the first and second circumferential tracks 12a, 12b. In contrast, within the parallel section(s) 12p, the suspension elements 13 remain in predefined relative positions at/with respect to the ceiling structure. In that section, the axis of the wheel 13.3 of the respective suspension element 13 is aligned parallel to the parallel section(s) 12p of the tracks. For example, the ceiling unit 10 comprises three first chassis 17 each having at least one first drive, wherein these first drives can be controlled by one single first drive unit. Alternatively, the ceiling unit 10 comprises two or three first types of chassis 17 and comprises only one single drive or drive unit, wherein a circumferential motion can

be coupled to involve several chassis.

[0063] In case the crawler has several chassis, some of these components may also be arranged in a mirror-inverted manner, especially the suspension elements. Thus, any detailed description of the figures relating to any separate/single component of the respective drive unit may also describe a similar configuration of any further drive units or any further redundant components.

[0064] **Fig. 2f, 2g** illustrate the curved sections 12r in more detail; it can be seen that both the radius of curvature and the distance of the tracks with respect to each other deviates/changes in value and direction, thereby effecting a pivot motion of the suspension arm 13.6 (protruding section) and the wheel 13.3 resp. bearing point P13 of the respective suspension element 13 (especially pivoting within the plane yz as shown in Fig. 2f and pivoting about an x-axis and around the instantaneous centre of rotation Cr). Thus, both vertical motion kinematics and non-circular pivot motion kinematics can be provided by means of rigid/stiff components being guided/driven along two circumferential tracks with different shape/contour.

[0065] **Fig. 2h, 2i, , 2j, 2k, 2l**, **2m, 2n** show some more details of the de-/coupling kinematics 20. In particular, it can be seen that the first track 12a has a curvature bent up (upwards), thereby effecting a slight lifting of the wheel 13.3 from the wheel tread 1.2, namely when the first pulley 13.1 is passing that section. In particular, apart from one single section, the shape/contour XZb of the second circumferential track 12b runs (is arranged) within the shape/contour XZa of the first circumferential track 12a.

[0066] **Fig. 2o, 2p, 2q** show a plurality of suspension elements 13 being interconnected via longitudinal connecting elements 15 which thereby ensure a closed loop 15a of interrelated suspension elements. The suspension elements 13 (13a, 13b) are coupled to the respective circumferential tracks 12a, 12b via the first and second pulleys 13.1, 13.2.

[0067] In Fig. 2, the first and second pulleys 13.1, 13.2 are arranged on opposite lateral sides of the respective suspension element 13. Thus, the closed loop 15a of interrelated suspension elements is arranged between the first and second tracks 12a, 12b which extend on both lateral sides of the closed loop 15a.

[0068] The tracks 12a, 12b can be made of any kind of rail guide system components, in particular including at least one chain, belt, cable or the like traction or transmission means. The tracks 12a, 12b may comprise different guide/rail sections coupled together, each having a different radius of curvature or being linear. Also, the tracks 12a, 12b can be formed/made by on single continuous/coherent rail.

[0069] **Fig. 2r, 2s, 2t** show some more details of the suspension elements 13 and the connecting elements 15. E.g., the connecting elements 15 are coupled to the lever arm 13.5 at the axis of the first pulley 13.1, thereby facilitating pivot motion about that axis (resp. around the respective instantaneous centre of rotation Cr).

[0070] **Fig. 3a, 3b, 3c, 3d, 3e** and **Fig. 4a, 4b, 4c** show aspects of a crawler 10 having three chassis 17 each having a drive unit 11a, 11b, 11c providing for circumferential driving motion of the suspension elements along the tracks, wherein the chassis can be interrelated/connected e.g. via cross-beams or the like. Alternatively, one central drive unit may drive the suspension elements of all three first chassis 17. In contrast to the configuration at the first chassis, the suspension elements 13b of the other first types of chassis are arranged in mirror-inverted manner, but the suspension elements 13 of the third chassis (of the first kind) are arranged in the same manner as the suspension elements 13 of the first chassis. As can be seen in Fig. 3d, 3e, that configuration allows for a really good security and stability level (both types of suspension elements 13, 13b are guided along the T-profiles, but on different lateral sides of the T-profiles). Alternatively, the ceiling unit 10 may only comprise two chassis of this kind, or even four chassis of this kind.

[0071] **Fig. 4a, 4b, 4c, 4d, 4e, 4f** show some kinematic aspects of the first chassis accommodating/arranging/-guiding both suspension elements 13 and further suspension elements 13b. Fig. 4f also illustrates that one (each first) chassis 17 may comprise the first circumferential track (here: provided/defined by the chain 15a) and two second circumferential tracks 12b, wherein these two second circumferential tracks 12b are arranged asymmetrically, i.e., the shape/contour XZb is asymmetrical. Such an arrangement also allows for providing de-/coupling kinematics for both a plurality of suspension elements 13a of a first type and a plurality of further suspension elements 13b of a second type, especially in such a manner that both types of suspension elements 13a, 13b may interact and engage in the same (but asymmetrical) manner with the structure 1, especially at the same profile rail 1.1 at opposite lateral sides, respectively. Such an arrangement may also ensure a high security and stability level already by means of one single drive unit 11. Thus, scaling (two, three or even more) of the crawler type vehicle's components (e.g. of the drives) is realizable in even more flexible manner, and individual arrangements can be optimized for each application.

[0072] It should be noted that the first circumferential track resp. a/the chain may/can provide for guiding and driving both the suspension elements 13a and the further suspension elements 13b; both types of suspension elements 13a, 13b can be coupled, e.g., via a protruding axial section (guiding bolt or shaft) 13.7 to the chain structure which protrudes vis-à-vis of the first pulley 13.1, especially along its axis. In particular, the suspension elements 13a and the further suspension elements 13b are arranged with longitudinal offset (y) and mirror-inverted on both sides of the chain 15a. In particular, the longitudinal distance (y) of the respective suspension element 13a and the respective further suspension element 13b of a respective pair of suspension elements 13,

13b corresponds to the extension in cross direction (y) of each element/profile 1.1 of the (ceiling) structure 1.

[0073] In **Fig. 5a, 5b, 5c, 5d, 5e, 5f, 5g, 5h, 5i, 5j, 5k, 5l, 5m** the guided movement of the power transfer units 14 is shown. The third and fourth circumferential tracks 12'a, 12'b define the motion of the power transfer units 14 such that they are first aligned with a respective interface 1.3 of a power grid directly vertically (underneath) before engaging straight upwards into interface 1.3, when the pulleys 14.1, 14.2 of the power transfer units 14 are pulled along the curved section 12'r of the tracks. Approximately simultaneously, an electrical contact is established with an internal power rail 10.3 placed in parallel to a linear section 12'p of the tracks. The tooth gear 18 that can be seen in Fig. 5e - 5h has the same number of teeth as the gears 18 in the described first drive units 11 (Fig. 2 - 4). This condition together with the fixed distance (via a certain number of chain elements) between two power transfer units 14 matching the second raster 1b ensures that, even if the second type of drive unit 11' is shorter (or longer) than the first type of drive unit 11 due to the fact that it does not have to cover the full length of the vehicle in y-direction, the drive units 11, 11' remain synchronized at all times. It is also crucial that, in the case the crawler type vehicle 10 shall be powered via power received through the power transfer unit 14, there is always at least one power transfer unit 14 engaged with the interface 1.3 of the power grid. This can require a small overlap, i.e., when one power transfer unit 14 is approaching the interface 1.3 (and an internal conductor rail 10.3) another power transfer unit 14 is still connected to the interface 1.3 and disengages only after the new connection is securely established. For minimum material requirements, this overlap has to be as small as possible. The first pulley 14.1 is engaged with the third or fourth circumferential track 12'a, 12'b, thereby following the contour defined by said track; also, the second pulley 14.2 is engaged with the third or fourth circumferential track 12'a, 12'b, thereby following said track (which is different from the track engaged by the first pulley, i.e. vice versa).

[0074] The first pulley 14.1 of each PTU 14 rotates about a first pulley axis and defines a first guiding point G14.1 (coupling the third track and the respective PTU 14), and vice versa, the corresponding point of the corresponding circumferential track defines that first guiding point G14.1 for each power transfer unit 14. Likewise, the second pulley 14.2 of each power transfer unit 14 rotates about a second pulley axis (which is preferably aligned in parallel) and defines a second guiding point G14.2 (coupling the fourth track and the respective PTU 14). When referring to the kinematics of each power transfer unit 14, an instantaneous centre of rotation of each PTU 14 is defined by the axis of the first pulley 14.1 being coupled to the third track 12'a. The two tracks 12'a, 12'b are arranged with respect to another in such a manner that the contacting/bearing point/area of the respective PTU 14 can be engaged (preferably straight upwards) into the interface 1.3 of the structure.

[0075] In **Fig. 7a, 7b** an electrical sliding contact 14.3 is shown in a mounted and exploded view. It consists of the main part, the sliding contact 14.3a, an insulator with a guiding fin 14.3b, and a cable 14.3c connecting to the sliding contact 14.3a. Three of these sliding contacts 14.3 are mounted together in the assembly shown **Fig. 8a, 8b.** As is evident from the exploded view of Fig. 8b, a one-part metal spring 14.4 exerts its restoration force on each respective sliding contact 14.3 upwards against a top plate 14.8. The spring mechanism 14.4 is connected to a guiding plate 14.7 on the side. When the power transfer units 14 are engaging with the interface 1.3 of the power grid (or the internal conductor rail 10.3 respectively), the sliding contacts 14.3 are pushed down, recessing partly under the top plate 14.8. To ensure their orientation remains straight and no part breaks, the guiding plate 14.7 on the side holds the guiding fin on the insulator 14.3b upright.

[0076] **Fig. 9a, 9b** shows the interface 1.3 of the power grid which is preferably placed according to a second raster 1b into every n-th gap of the first raster 1a. However, the internal conductor rail 10.3 can look essentially the same but will be oriented to run parallel to the linear section 12'p of the third and fourth circumferential track 12'a, 12'b. The interaction between the electrical sliding contacts 14.3 and the interface 1.3 (or conductor rail 10.3) is shown in **Fig. 10a, 10b.**

[0077] Preferably, the second drive unit 11' is arranged analogously to the first drive unit 11, with respect to the circumferential tracks. Meaning, as was the case with the first and second circumferential tracks 12a, 12b, the third and fourth circumferential tracks 12'a, 12'b shall also be placed such that two (mirror inverted if necessary) chassis 17.2 are framing a common chain being pulled/driven between the chassis. For this purpose, a special metal plate 14.5 design is shown in **Fig. 11a,** with the exploded view in **Fig. 11b.** The pulleys 14.1, 14.2 are pulled along the third and fourth circumferential tracks 12'a, 12'b. The metal plate 14.5 is connected to an upper part of the metal frame 14.6 shown in **Fig. 12a** and **b.** The metal frame 14.6 additionally bridges over the chain 16 between the chassis, i.e. it cannot be recessed into the housing. This has to be kept in mind when designing the paths of motion of the power transfer units 14 via the circumferential tracks 12'a, 12'b. The sliding contacts 14.3 are consequently also placed mirror invertedly such that the spring mechanisms 14.4 don't interfere with one another. On a lower end of the metal frame 14.6, sliding contacts 14.3 for connecting to an internal conductor rail 10.3 are mounted. The fully assembled power transfer unit 14 can be seen in **Fig. 12a.**

[0078] It is further beneficial to use an additional housing 28 mounted around the drive units 11, 11', as shown in **Fig. 13a, 13b, 13c** with bumpers 29 mounted on all sides of the vehicle 10. As can be seen in the middle of the crawler, an additional housing is placed around the second drive units for further electric discharge protection.

However, it is also feasible to mount an outlet or a cable in this area connected to an internal conductor rail 10.3. This way, the vehicle 10 can also act as a flexible power outlet that can be moved (or actively move) to whatever position where a power outlet is needed.

[0079] In **Fig.14a, 14b, 14c** an alternative arrangement of the collectors depicted in Fig.7a and Fig. 7b with modified spring suspension and lateral guidance by pins in a V-shaped contour for the electrical sliding contact 14.3 is shown in a mounted and exploded view. Three of these sliding contacts 14.3 are mounted together in the assembly shown in **Fig. 14a, 14b**, **15c.** As is evident from the exploded view of Fig. 14b, the metal springs 43 exert their restoration force on each respective sliding contact 14.3 upwards against a top plate 14.8. When the power transfer units 14 are engaging with the interface 1.3 of the power grid (or the internal conductor rail 10.3 respectively), the sliding contacts 14.3 are pushed down, recessing partly under the top plate 14.8. To ensure their orientation remains straight and no part breaks, the and lateral guidance of the pins 44 in the V-shaped contour 42 applies, holding the guiding fin on the insulator 14.3b upright.

[0080] The embodiments shown here are merely examples of the present invention and should not be construed as limiting. Alternative embodiments considered by those skilled in the art are equally encompassed within the scope of the present invention.

List of reference signs:

[0081]

10 -	crawler type ceiling unit
10.3 -	conductor rail
1 -	ceiling structure
1a -	structural regularity or raster
1b -	second raster/second structural regularity
1.1 -	T-profiles/T-rails/profile units
1.2 -	wheel tread
1.3 -	power rail
100 -	ceiling suspension arrangement
11.1 -	crawling/driving mechanism
12 -	circumferential tracks
12a -	first circumferential track
12b -	second circumferential track
12' -	circumferential tracks
12'a -	third circumferential track
12'b -	fourth circumferential track
XZa, XZb -	shapes/contours of tracks
12r -	curved sections of tracks
12p -	parallel/linear sections of tracks
12'r -	curved sections of tracks
12'p -	parallel/linear sections of tracks
y12a, y12b	longitudinal position
13, 13a, 13b -	suspension elements
13.1 -	first pulley
13.2 -	second pulley
13.3 -	wheel
P13 -	bearing point
13.5 -	lever arm
y13 -	longitudinal extension of lever arm
13.6 -	suspension arm
G13.1 -	first guiding point
G13.2 -	second guiding point
14, 14a, 14b	PTU
14.1 -	first pulley
14.2 -	second pulley
14.3 -	electrical contact, especially sliding contact
14.3a -	sliding contact
14.3b -	insulator, especially with a guiding fin
14.3c -	cable
14.4 -	spring mechanism
14.5 -	sheet metal part
y14 -	longitudinal distance between pulleys
14.6 -	metal frame
14.7 -	guiding mechanism
14.8 -	top plate
G14.1 -	first guiding point
G14.2 -	second guiding point
15 -	longitudinal connecting elements
15a -	closed loop of interrelated suspension elements
16 -	longitudinal connecting elements
16a -	closed loop of connecting elements
17, 17.2, 17.2 -	housing
20 -	de-/coupling kinematics
28 -	shell / outer housing
29 -	bumper
30 -	control unit
11, 11' -	drive unit
11.5 -	shaft
18 -	gear unit
19 -	energy storage unit
40 -	sensor arrangement
41 -	sensing device
42	sliding contour
43	spring
44	pin

Claims

1. Crawler type vehicle (10) configured for traveling in a suspended manner especially headlong at a structure (1), wherein the vehicle (10) comprises:

- a plurality of suspension elements (13, 13b) configured for suspending the vehicle (10) and configured for coupling the vehicle (10) to the structure,
- at least one first drive unit (11, 11a, 11b, 11c) configured for circumferential motion and accommodating a first circumferential track (12a)

and a second circumferential track (12b) having a different circumferential shape/contour than the first circumferential track, wherein the suspension elements (13, 13b) are attached to the first circumferential track (12a) at predefined first longitudinal positions corresponding to a first predefined raster (1a), wherein the vehicle (10) is configured for moving along the structure (1) by decoupling a subset of the plurality of suspension elements (13, 13b) from resp. coupling them into the structure (1) when the suspension elements (13, 13b) are guided along the two circumferential tracks (12a, 12b) by the circumferential motion,

- at least one second drive unit (11') configured to be driven together with the at least one first drive unit (11), wherein the at least one second drive unit (11') comprises a plurality of power transfer units (14) configured to transfer power between a power grid and the crawler type vehicle (10), wherein the second drive unit (11') is configured for circumferential motion accommodating a third circumferential track (12'a) and a fourth circumferential track (12'b), having a different circumferential shape/contour than the third circumferential track (12'a), wherein the power transfer units (14) are attached at predefined longitudinal positions corresponding to a second predefined raster (1b), wherein the vehicle (10) is configured for connecting to the power grid by engaging a subset of the plurality of the power transfer units (14) into an interface (1.3) of the power grid.

2. Crawler type vehicle according to claim 1, wherein the second predefined raster (1b) is arranged relative to the first predefined raster (1a) such that the second predefined raster (1b) complements a periodic structure of the first raster (1a) by fitting into every n-th gap, with n being a positive integer.

3. Crawler type vehicle according to claim 1 or 2, wherein the first and second circumferential tracks (12a, 12b) are shaped in such a manner that the suspension elements (13, 13b) are de-/coupled from/into the structure (1) only when passing a curved section (12r) of the first and second circumferential tracks and wherein the third and fourth circumferential tracks (12'a, 12'b) are shaped in such a manner that the power transfer units (14) are engaging with / disengaging from the interface (1.3) of the power grid only when passing a curved section (12'r) of the third and fourth circumferential tracks (12'a, 12'b), wherein the power transfer units (14) are configured to move essentially straight towards / away from the interface (1.3) when the power transfer units (14) are passing the curved section of the circumferential tracks.

4. Crawler type vehicle according to any of claims 1 to 3, further comprising a spring mechanism (14.4), wherein the power transfer units (14) comprise sliding contacts (14.3), and wherein the sliding contacts are (pre-)loaded via a restoring force of the spring mechanism (14.4) against an upper plate (14.8) when the power transfer units (14) are not engaged with the interface (1.3) and the restoring force is configured to push/press the sliding contacts (14.3) against the interface (1.3) of the power grid, especially against power rails of the power grid, thus ensuring stable power connection.

5. Crawler type vehicle according to claim 4, further comprising a guiding mechanism (14.7) configured to guide and reinforce the sliding contacts with respect to their orientation to the interface of the power grid, especially when the power transfer units (14) are engaging with the interface (1.3) of the power grid.

6. Crawler type vehicle according to any of the preceding claims, wherein the crawler type vehicle (10) further comprises at least one conductor rail (10.3) connected to a power circuit of the crawler type vehicle, wherein the power transfer units (14) are configured to connect to the conductor rail (10.3) when the power transfer units (14) are engaging with the interface of the power grid, especially simultaneously.

7. Crawler type vehicle according to claim 6, wherein the conductor rail(s) (10.3) are power rails connected to an internal power bus of the crawler type vehicle, wherein the power transfer units (14) comprise further sliding contacts (14.3) for connecting to the internal power rails (10.3), wherein the further sliding contacts (14.3) are loaded against the internal power rail (10.3) via a restoring force of a spring mechanism (14.4).

8. Crawler type vehicle according to any of the preceding claims, wherein each power transfer unit (14) comprises at least two electrical contacts (14.3), especially sliding contacts.

9. Crawler type vehicle according to claim 8, wherein the electrical contacts, especially sliding contacts (14.3), engage with the interface (1.3) of the power grid in a predefined manner, especially one after another, wherein the predefinition is achieved by elevating an electrical contact with respect another electrical contact such that when the power transfer unit (14) is closing in on the interface (1.3) of the power grid the elevated electrical contact engages first with the interface (1.3).

10. Crawler type vehicle according to claim 9, wherein a

neutral or ground potential is connected first when the power transfer unit (14) approaches the interface (1.3) of the power grid and wherein the neutral or ground potential is disconnected last when the power transfer unit moves away from the structure (1).

11. Crawler type vehicle according to any of the preceding claims, wherein the power transfer units (14) are fixedly attached/coupled by means of a first pulley (14.1) to/with the third circumferential track (12'a), wherein the power transfer units (14) are guided within the fourth circumferential track (12'b) by means of a second pulley (14.2) respectively, wherein the first and second pulley (14.1, 14.2) preferably are arranged at a sheet metal part (14.5) of the respective power transfer unit (14); and/or wherein each power transfer unit (14) comprises a first pulley (14.1) and a second pulley (14.2) arranged in longitudinal distance (y14) with respect to the first pulley (14.1) at a sheet metal part (14.5) of the respective power transfer unit (14), wherein the power transfer unit (14) is coupled to the third and fourth tracks (12'a, 12'b) via the first and second pulleys (14.1, 14.2); and/or wherein each power transfer unit (14) comprises a metal plate (14.5) accommodating/supporting a/the pulley guided by the second track, wherein the pulley is arranged at a free end of the sheet metal part (14.5), and wherein in a linear section of the track, the sheet metal part (14.5) is parallel to a driving/traveling plane, at least partly; and/or wherein the power transfer units (14) are connected to each other by means of longitudinal connecting elements (16), especially by longitudinal connecting elements (16) being connected at the axis of a/the first pulley (14.1) of the power transfer unit (14), thereby forming a closed loop (16a) of interrelated power transfer units (14) distanced to each other in the predefined second raster (1b).

12. Crawler type vehicle according to any of the preceding claims, wherein the first circumferential track (12a) and the third circumferential track (12'a) each comprise a chain or are provided/defined by a chain forming a respective closed loop of interrelated chain elements; and/or wherein the first circumferential track (12a) and the third circumferential track (12'a) are each defined by a chain connecting the suspension elements (13, 13b) / power transfer units (14) respectively.

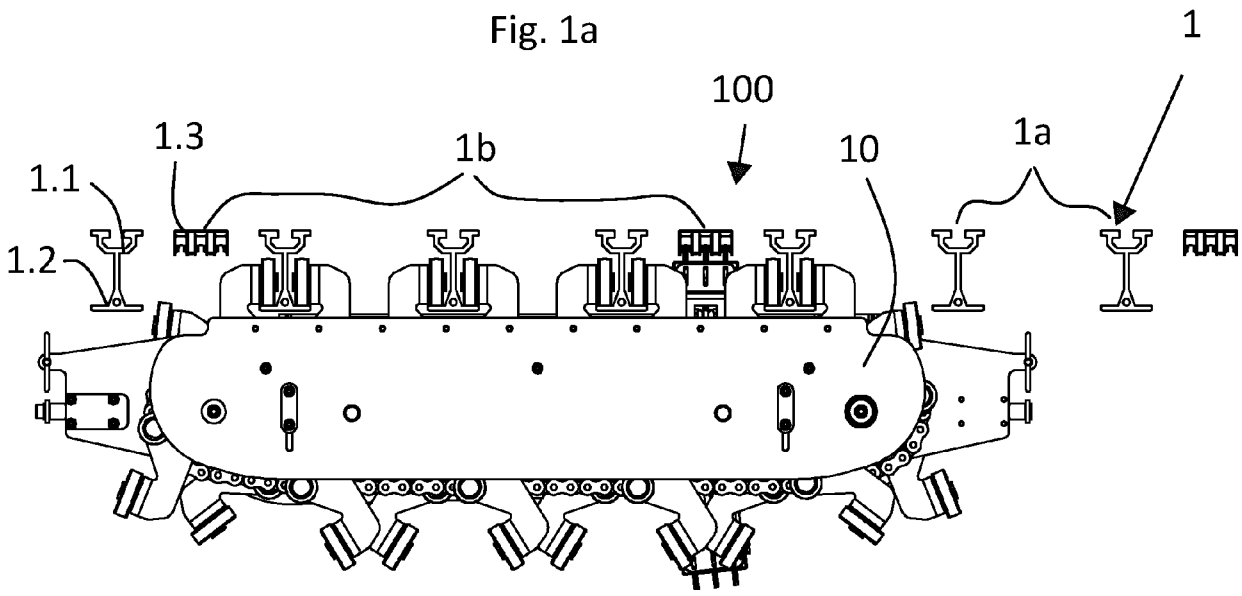
13. Crawler type vehicle according to any of the preceding claims, wherein the at least one first drive unit (11) and the at least one second drive unit (11') are configured to be driven together via a common shaft (11.5).

14. Crawler type vehicle arrangement comprising at least one crawler type vehicle according to one of the preceding claims and at least one structure (1) extending in at least two spatial directions (x, y), wherein the structure (1) comprises a plurality of profile units (1.1) extending in a first spatial direction (x), wherein the structure (1) defines at least one structural regularity (1a) in a second spatial direction (y),
wherein the structure (1) comprises a power grid, wherein the interface (1.3) of the power grid extends in the first spatial direction (x) with a second predefined raster (1b), wherein the second predefined raster (1b) is offset in the second spatial direction (y) relative to the first predefined raster (1a) such that the second predefined raster (1b) complements the periodic structure of the first raster (1a) by fitting between every n-th profile unit (1.1), with n being a positive integer.

15. Method of suspending or positioning at least one crawler type vehicle (10) according to one of the device claims at a structure (1) extending in at least two spatial directions for providing at least two degrees of freedom for at least two-dimensional positioning or two-dimensional motions of the crawler type vehicle (10), especially in a suspended manner headlong a ceiling structure (1) in conjunction with actively moving/driving the crawler type vehicle (10) along the structure (1), especially by actively reorientating the crawler type vehicle's traveling direction, wherein the structure (1) comprises a plurality of profile units (1.1) extending in a first spatial direction (x), wherein the structure (1) defines at least one structural regularity (1a) in a second spatial direction (y), thereby defining a first raster, wherein the crawler type vehicle (10) is suspended by means of a plurality of suspension elements (13a, 13b) coupling the crawler type ceiling unit (10) to the structure (1) by means of de-/coupling kinematics depending on a relative motion of the crawler type vehicle with respect to the structure (1) in at least said second spatial direction (y), wherein the suspension elements (13a, 13b) are attached to and guided by at least two circumferential tracks (12a, 12b) of the crawler type vehicle (10), wherein the circumferential tracks (12a, 12b) respectively define a specific path of circumferential motion of the respective suspension elements (13a, 13b), thereby providing for de-/coupling kinematics which suspend and relatively move the respective suspension element with respect to the structure (1) during a relative motion of the crawler type vehicle (10) in said second spatial direction (y),
wherein the crawler type vehicle (10) is connected to a power grid, which is placed according to a second raster (1b) to fit between gaps of the first raster (1a), wherein the crawler type vehicle (10) connects to the power grid by means of a plurality of power transfer

units (14) engaging with an interface (1.3) of the power grid by means of dis-/engaging kinematics depending on a relative motion of the crawler type vehicle (10) with respect to the structure (1) in at least said second spatial direction (y), wherein the power transfer units (14) are attached to and guided by at least two further circumferential tracks (12'a, 12'b) of the crawler type vehicle (10), wherein the further circumferential tracks (12'a, 12'b) respectively define a specific path of circumferential motion of the respective power transfer unit (14), thereby providing for dis-/engaging kinematics during a relative motion of the crawler type vehicle (10) in said second spatial direction (y) with the crawler type vehicle (10) remaining movable in said first spatial direction (x) along the profile units (1.1) irrespective of momentary motion in said second spatial direction.

Fig. 1a



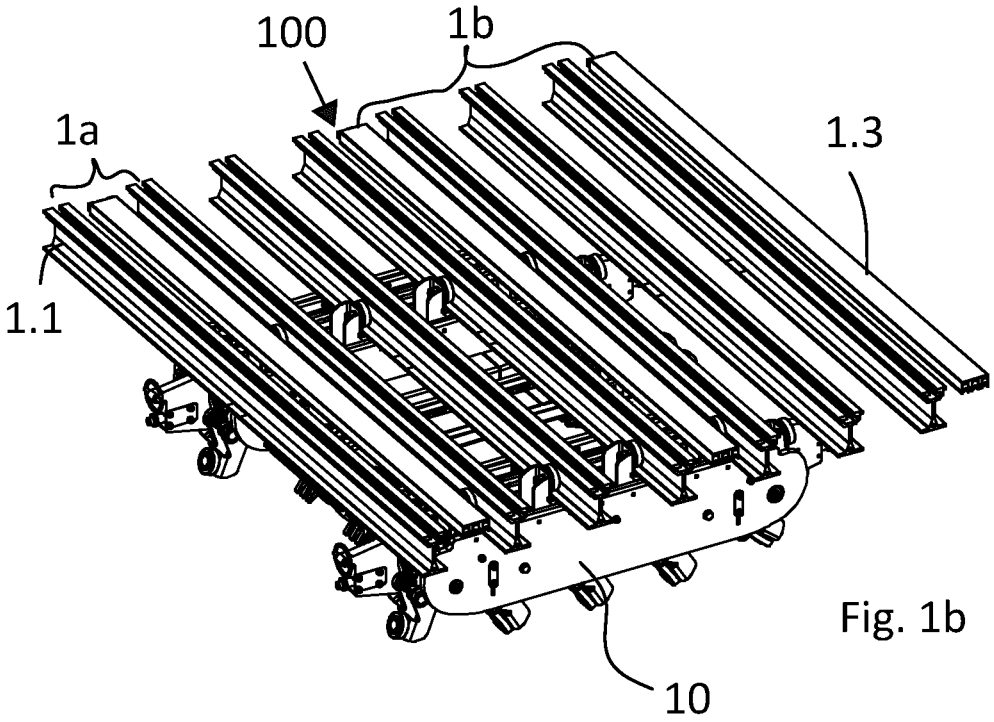


Fig. 1b

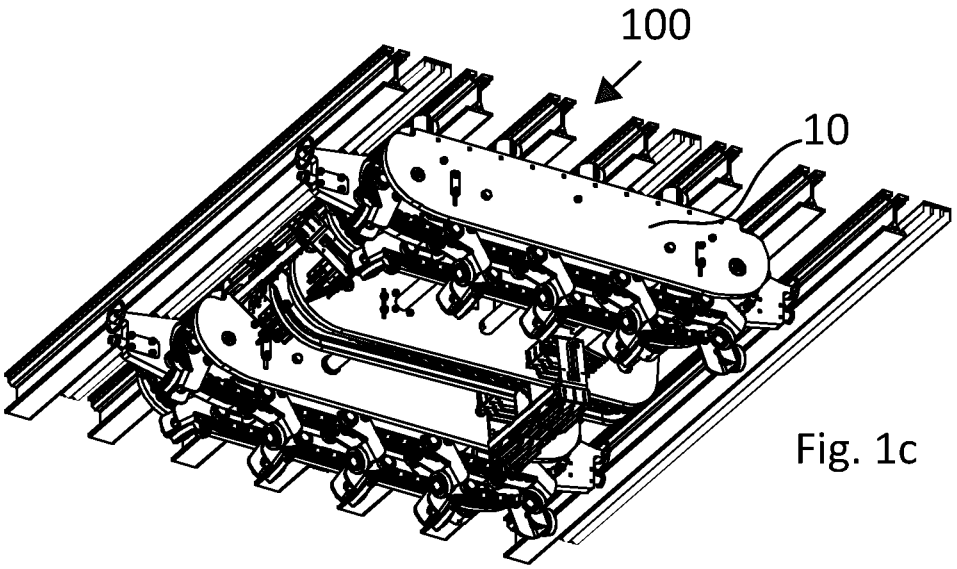


Fig. 1c

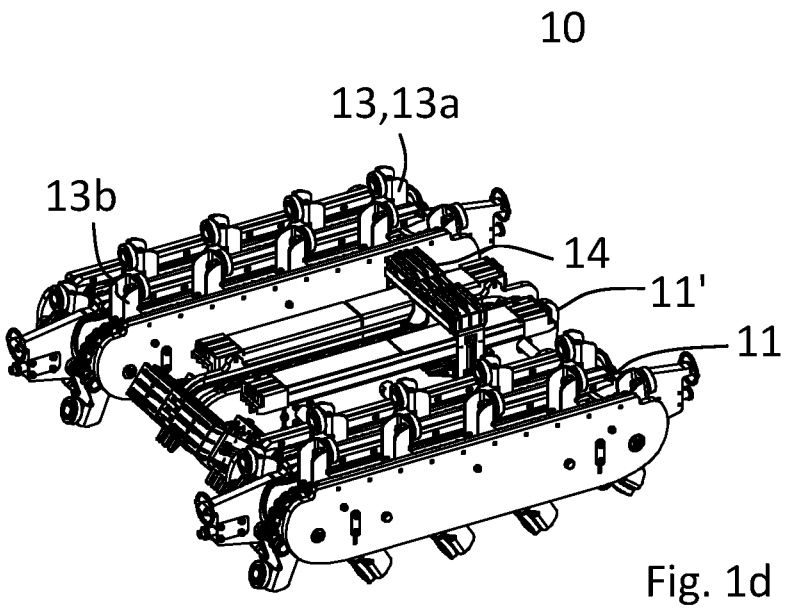


Fig. 1d

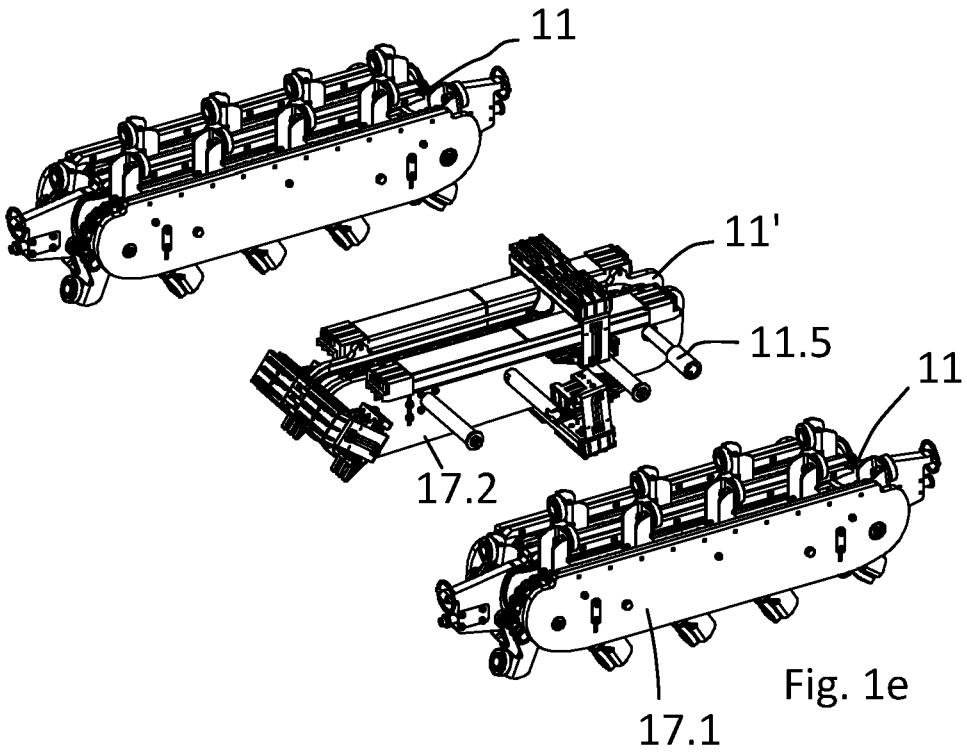


Fig. 1e

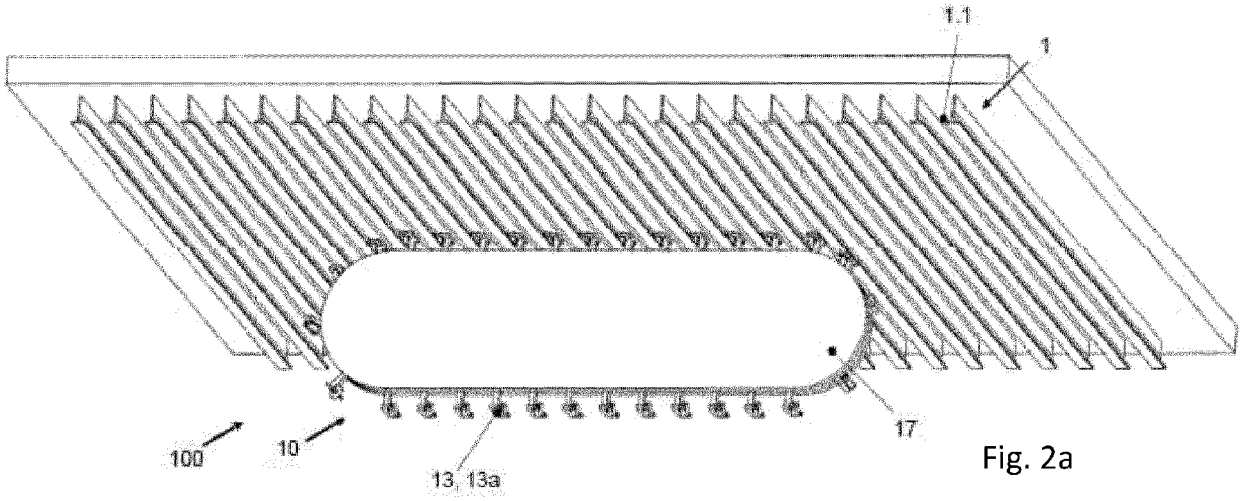


Fig. 2a

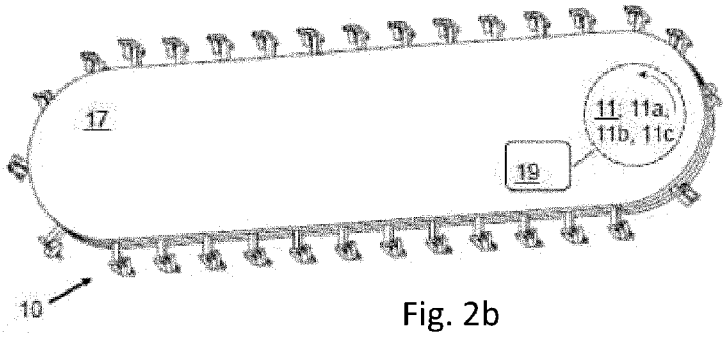


Fig. 2b

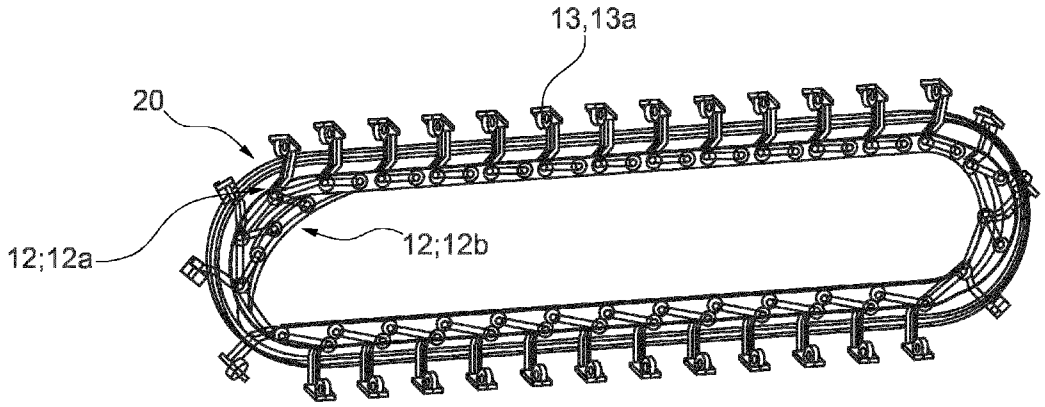


Fig. 2c

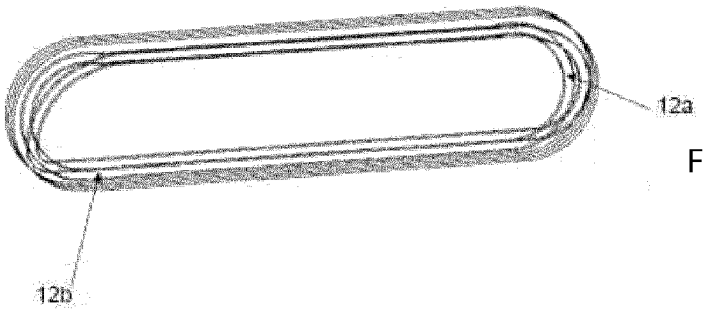


Fig. 2d

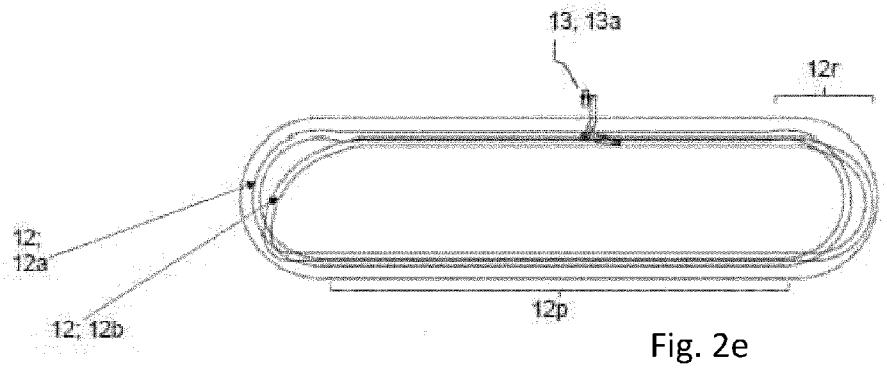


Fig. 2e

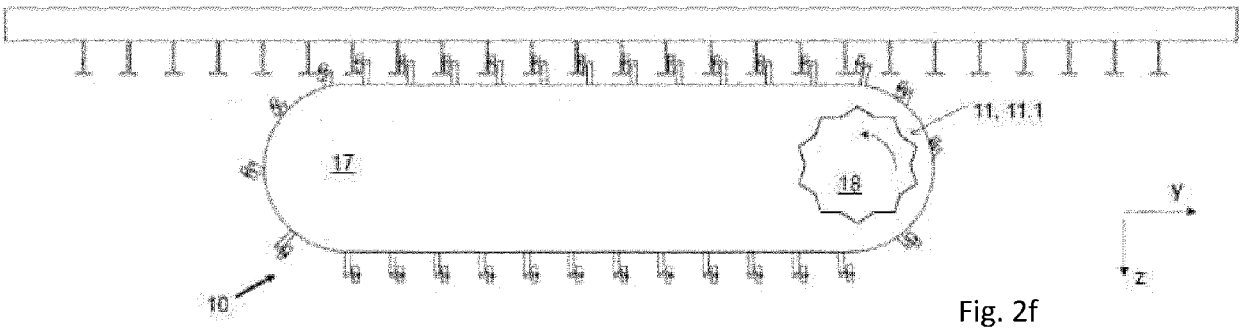


Fig. 2f

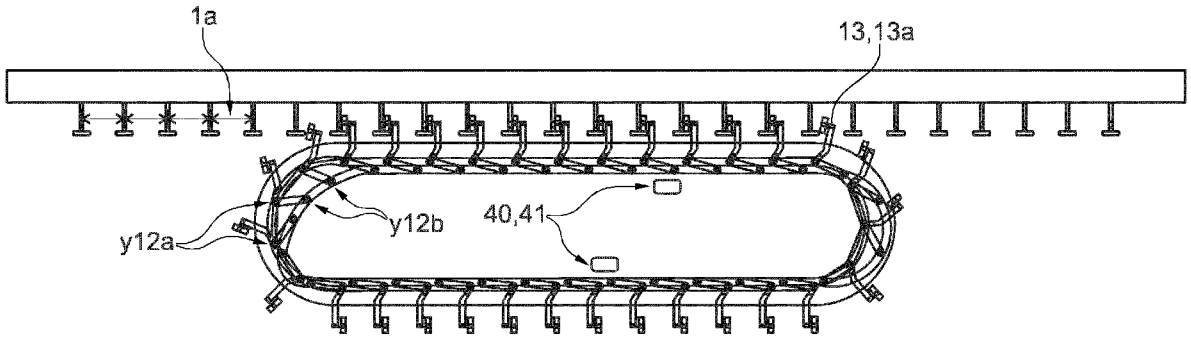


Fig. 2g

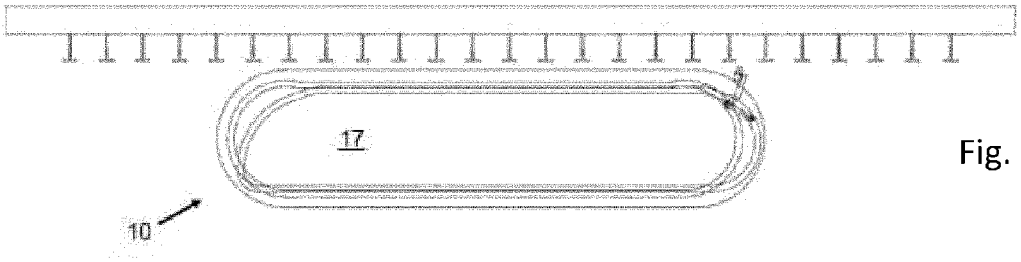


Fig. 2h

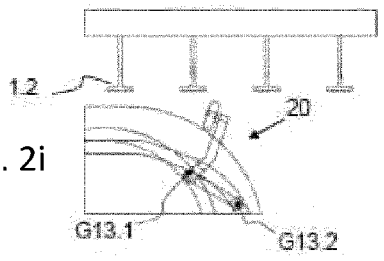


Fig. 2i

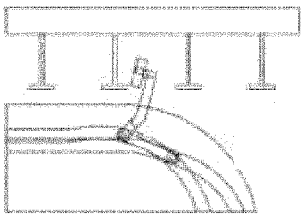


Fig. 2j

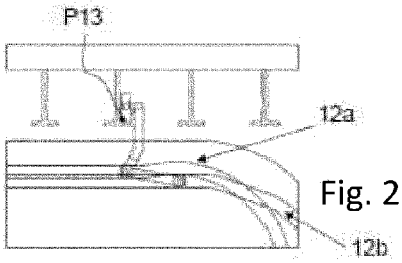


Fig. 2k

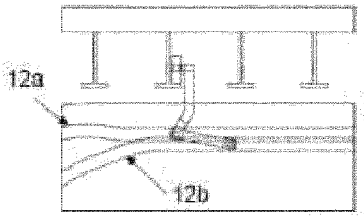


Fig. 2l

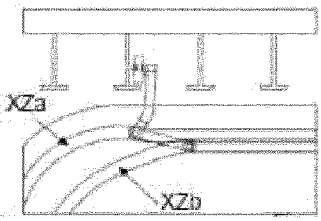


Fig. 2m

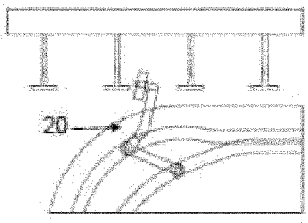


Fig. 2n

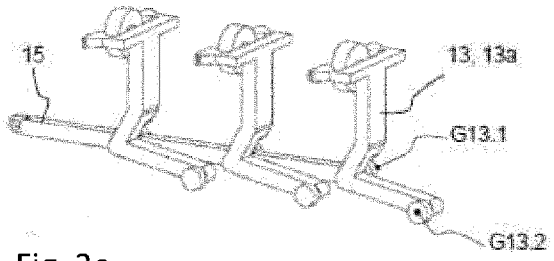


Fig. 2o

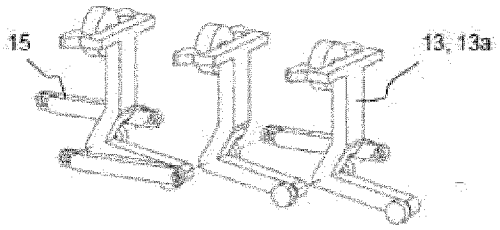


Fig. 2p

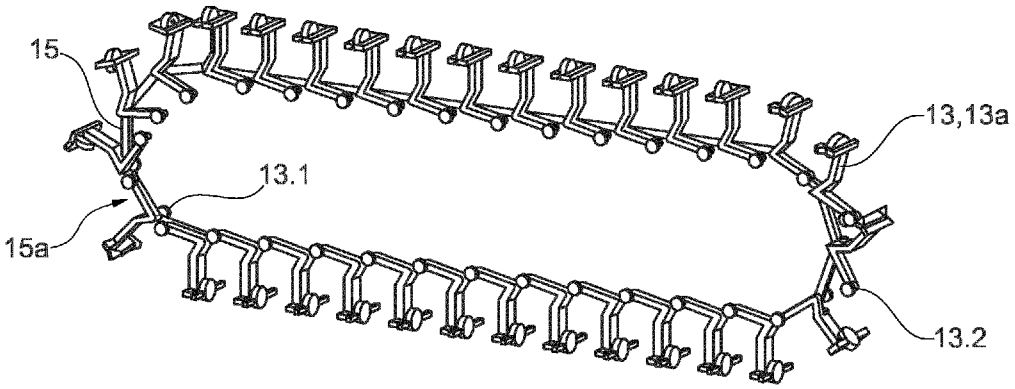


Fig. 2q

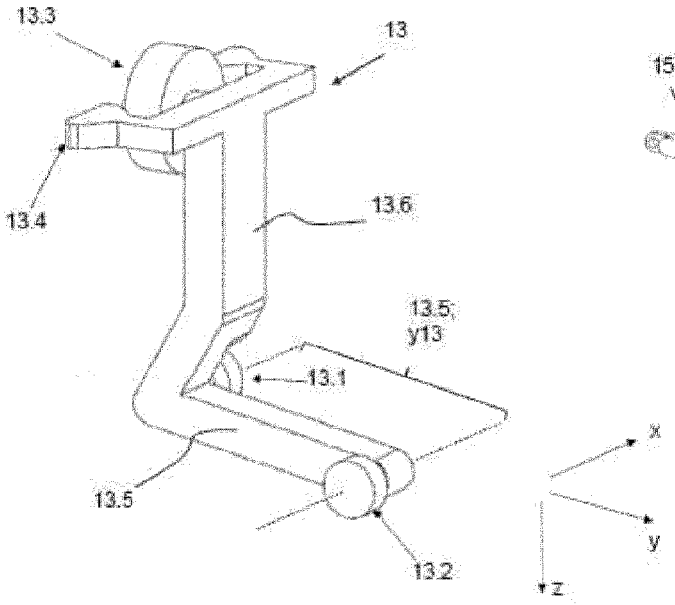
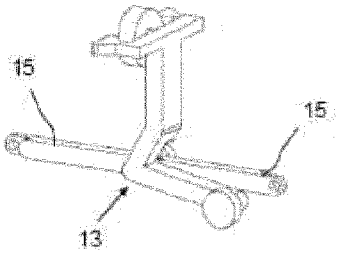


Fig. 2r

Fig. 2s



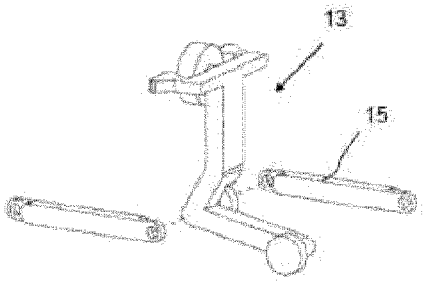


Fig. 2t

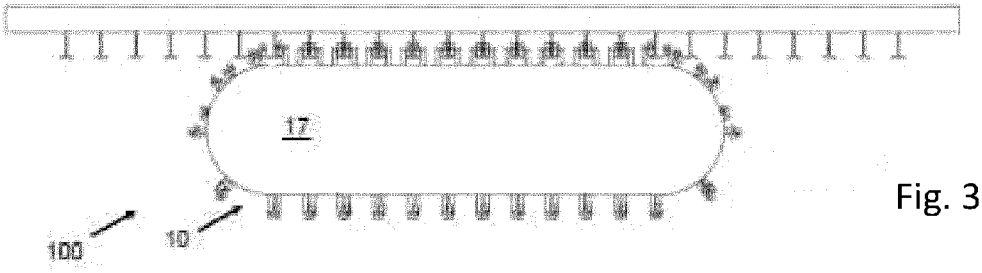


Fig. 3a

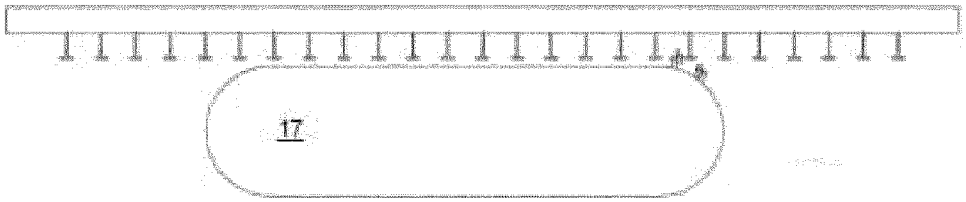


Fig. 3b

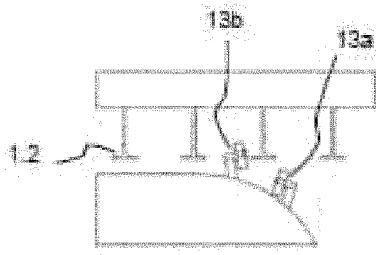


Fig. 3c

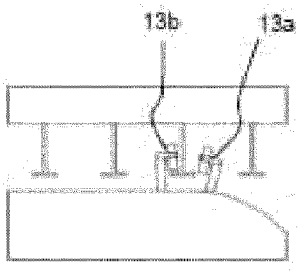


Fig. 3d

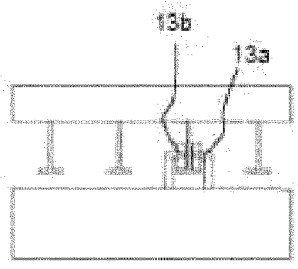


Fig. 3e

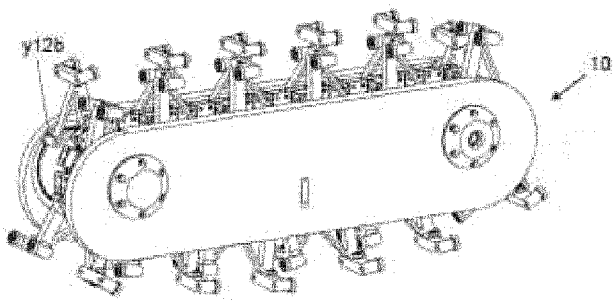


Fig. 4a

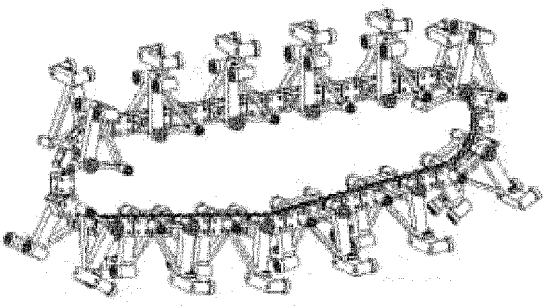


Fig. 4c

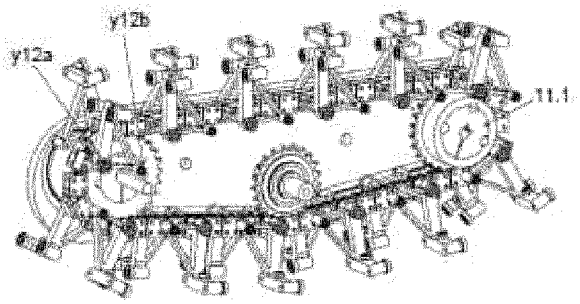


Fig. 4b

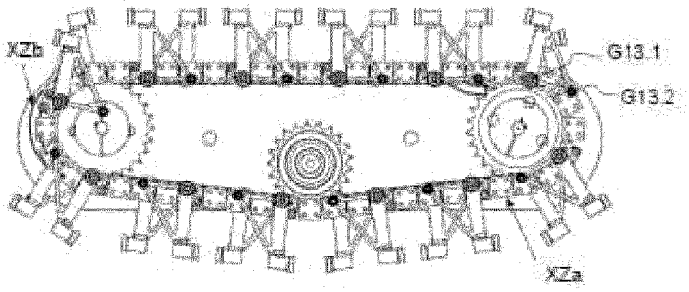


Fig. 4d

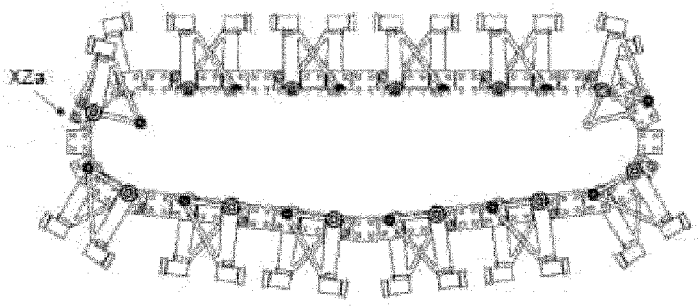


Fig. 4e

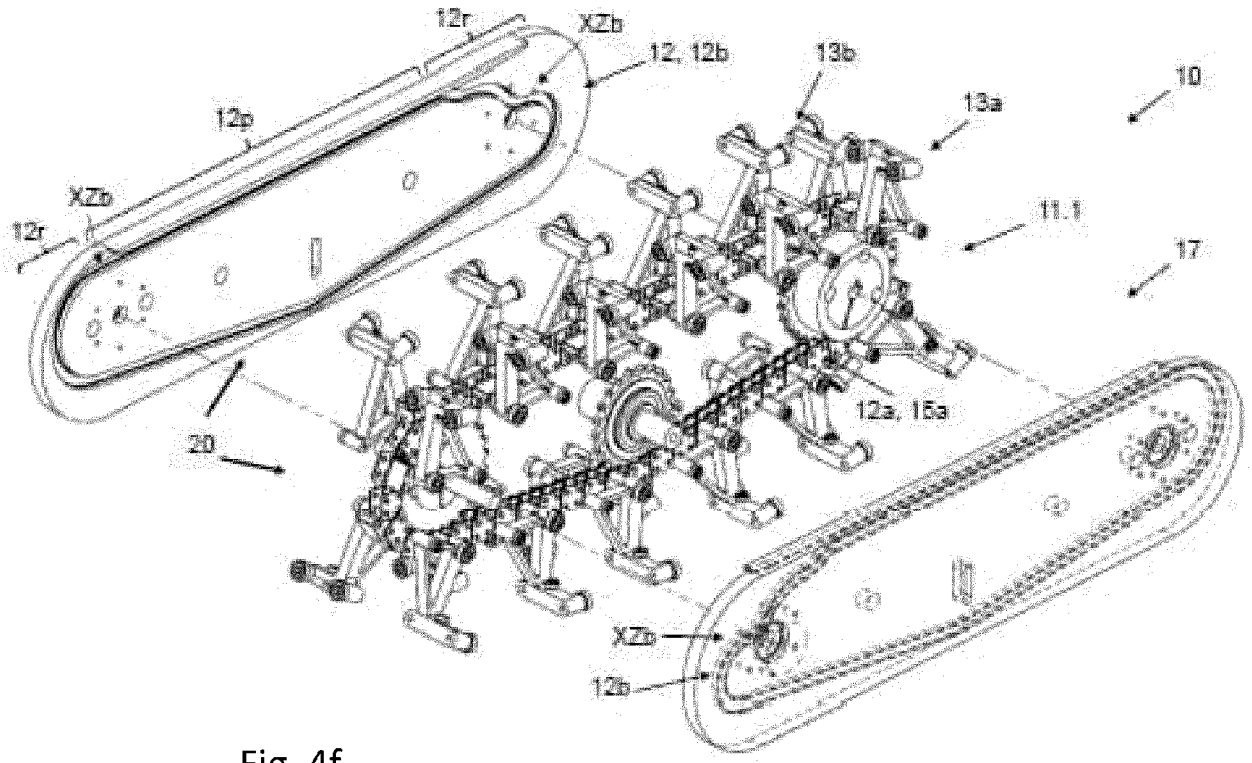


Fig. 4f

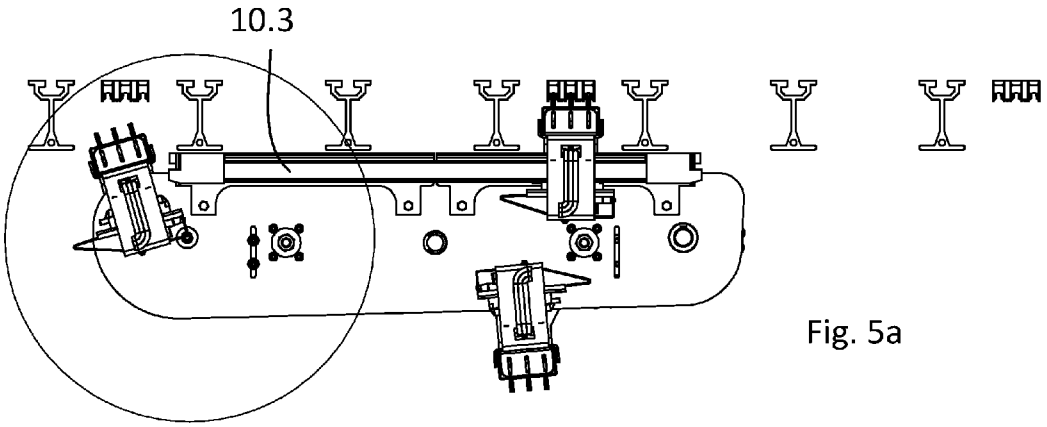


Fig. 5a

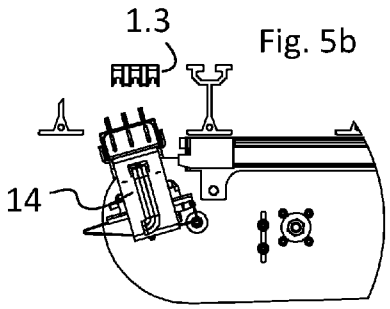


Fig. 5b

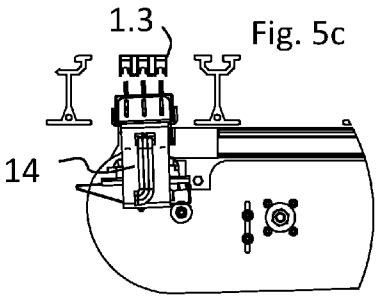


Fig. 5c

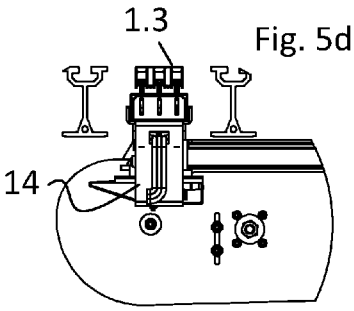


Fig. 5d

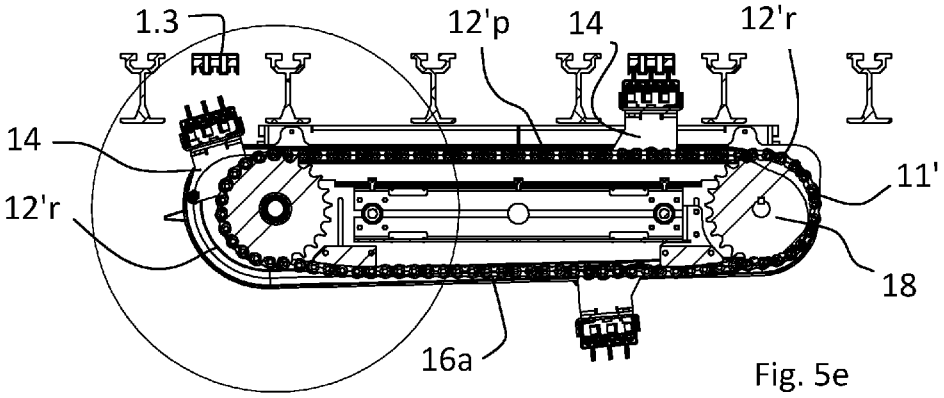


Fig. 5e

Fig. 5f

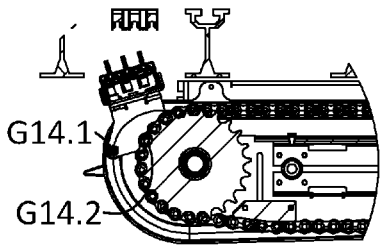


Fig. 5g

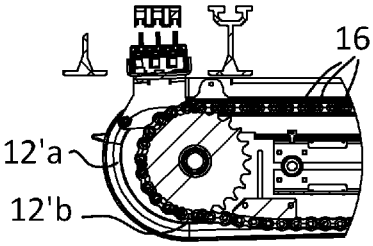
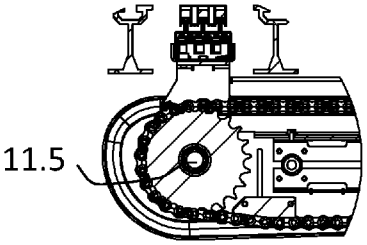


Fig. 5h



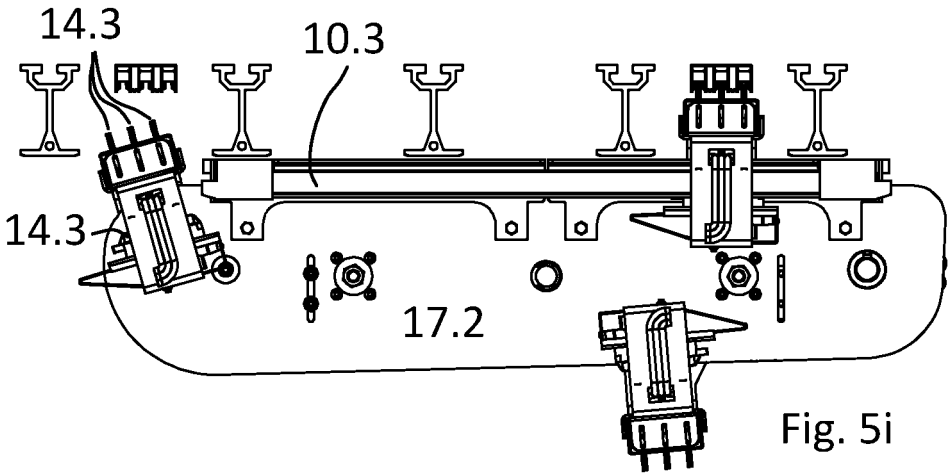


Fig. 5i

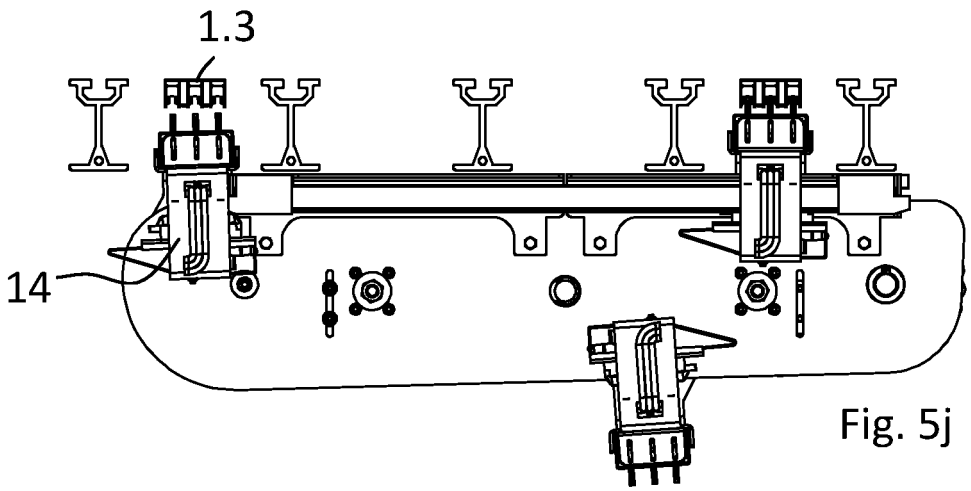


Fig. 5j

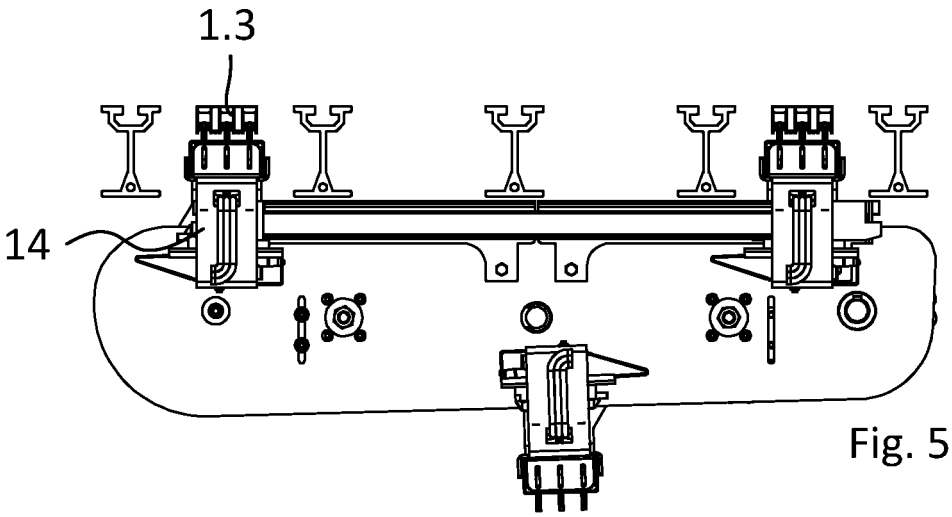


Fig. 5k

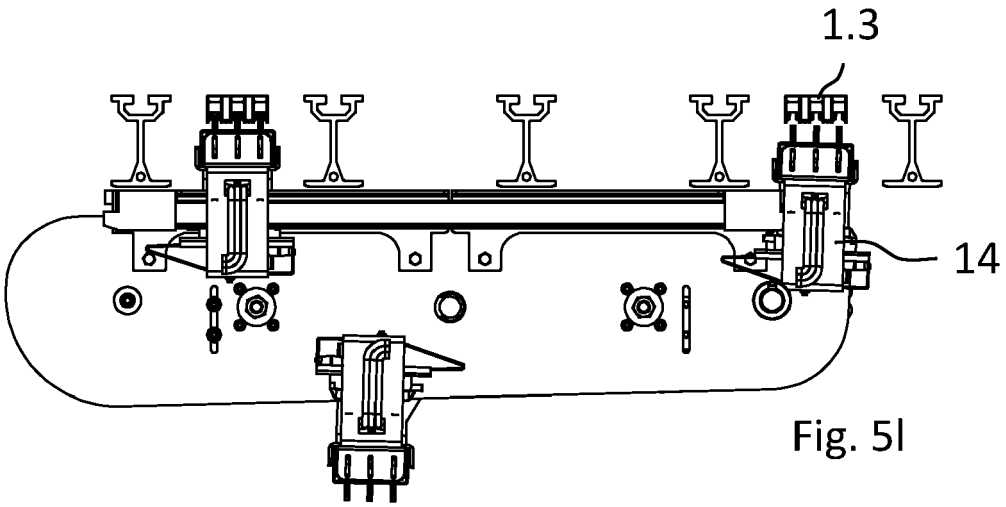


Fig. 5l

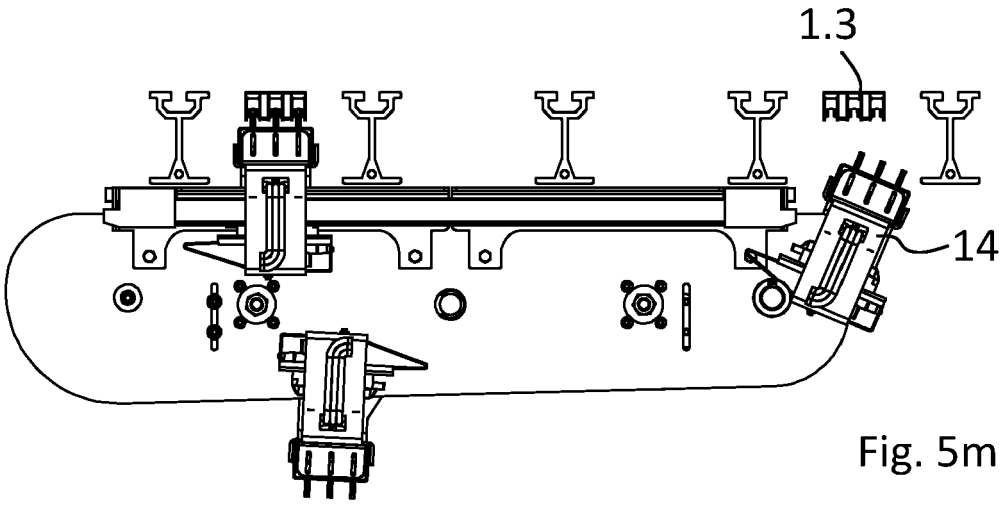
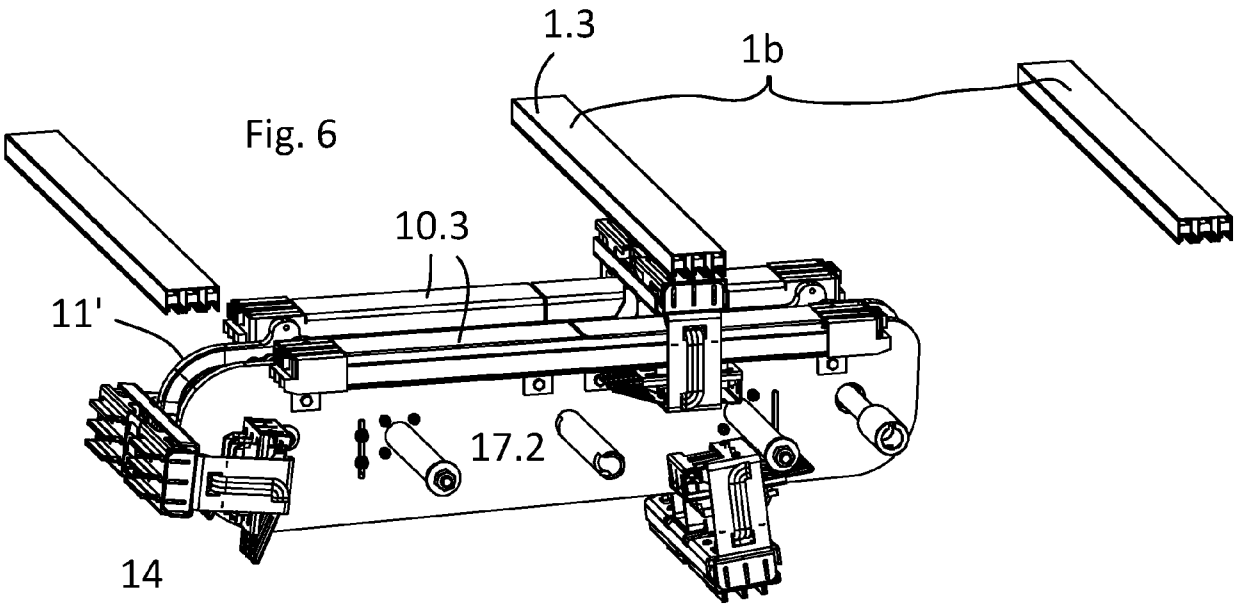


Fig. 5m

Fig. 6



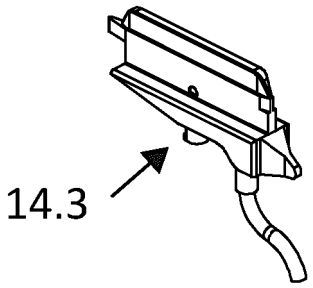


Fig. 7a

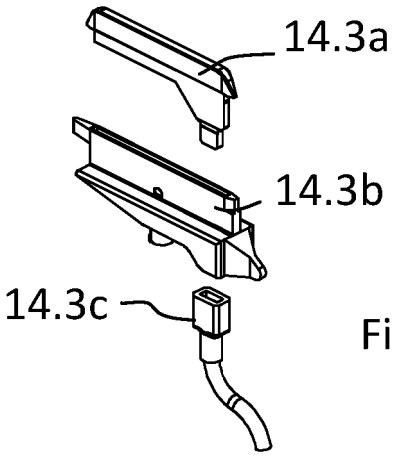


Fig. 7b

Fig. 8a

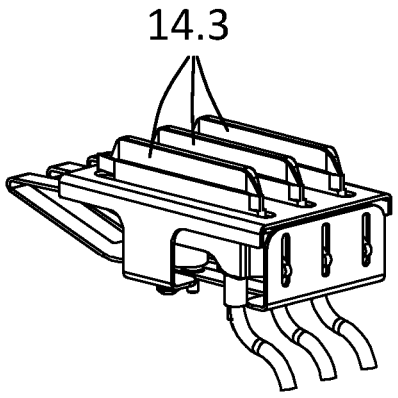
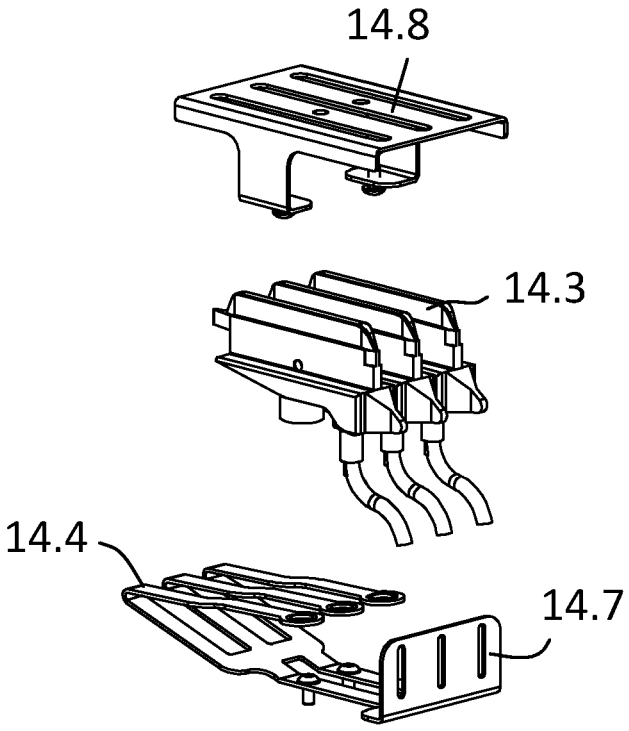


Fig. 8b



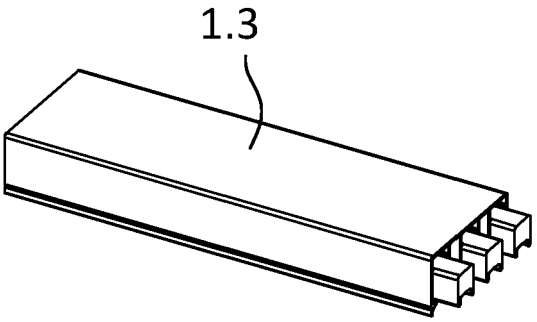


Fig. 9a

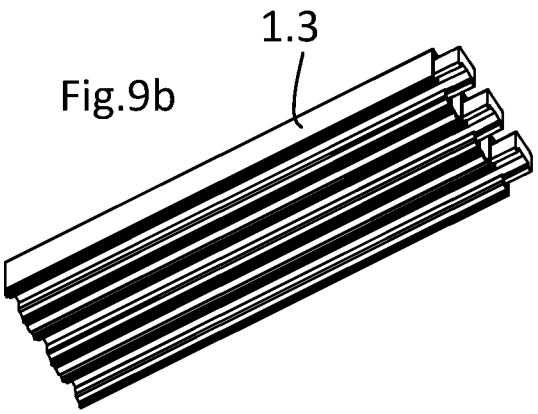


Fig.9b

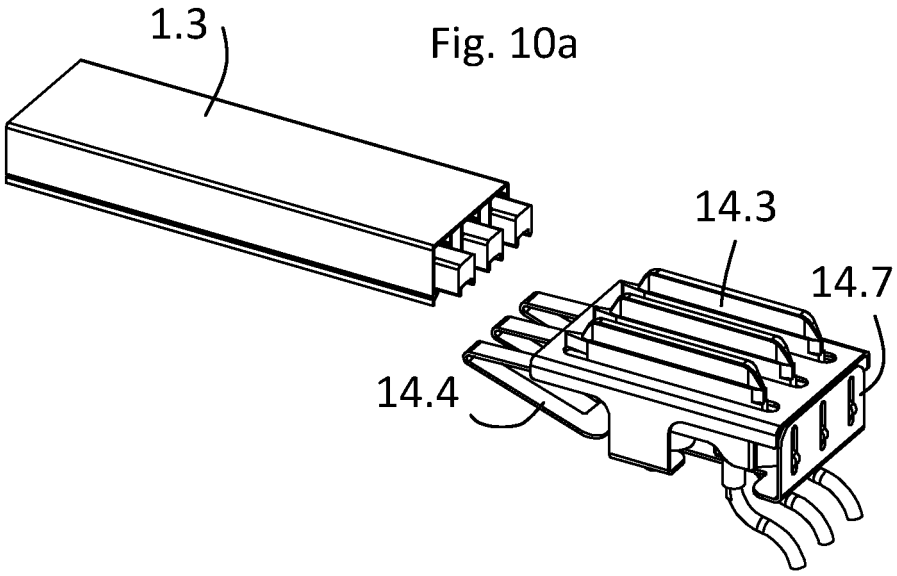


Fig. 10a

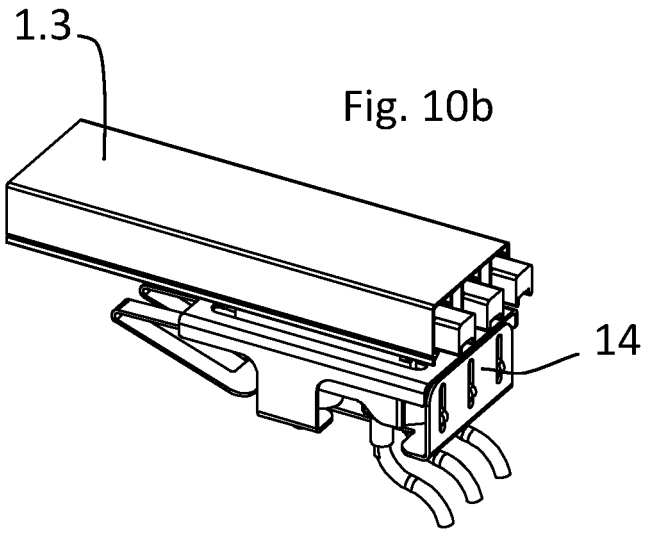


Fig. 10b

Fig. 11a

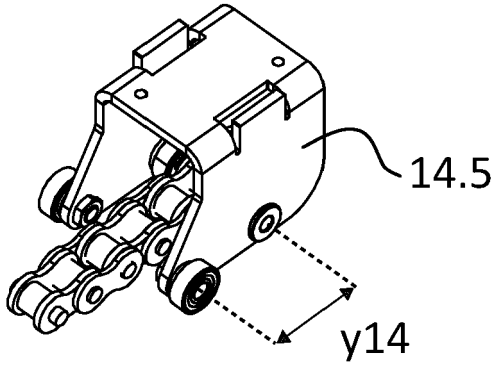
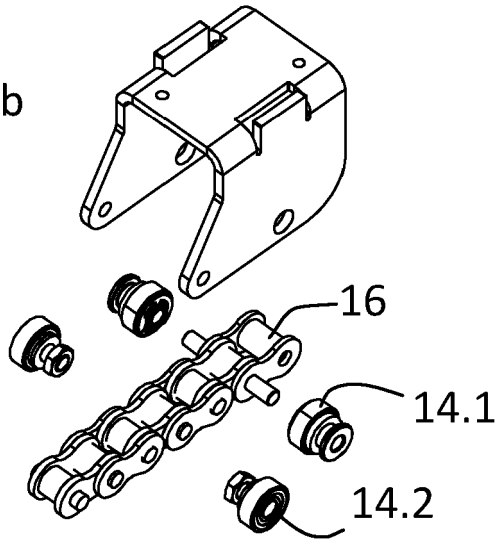


Fig. 11b



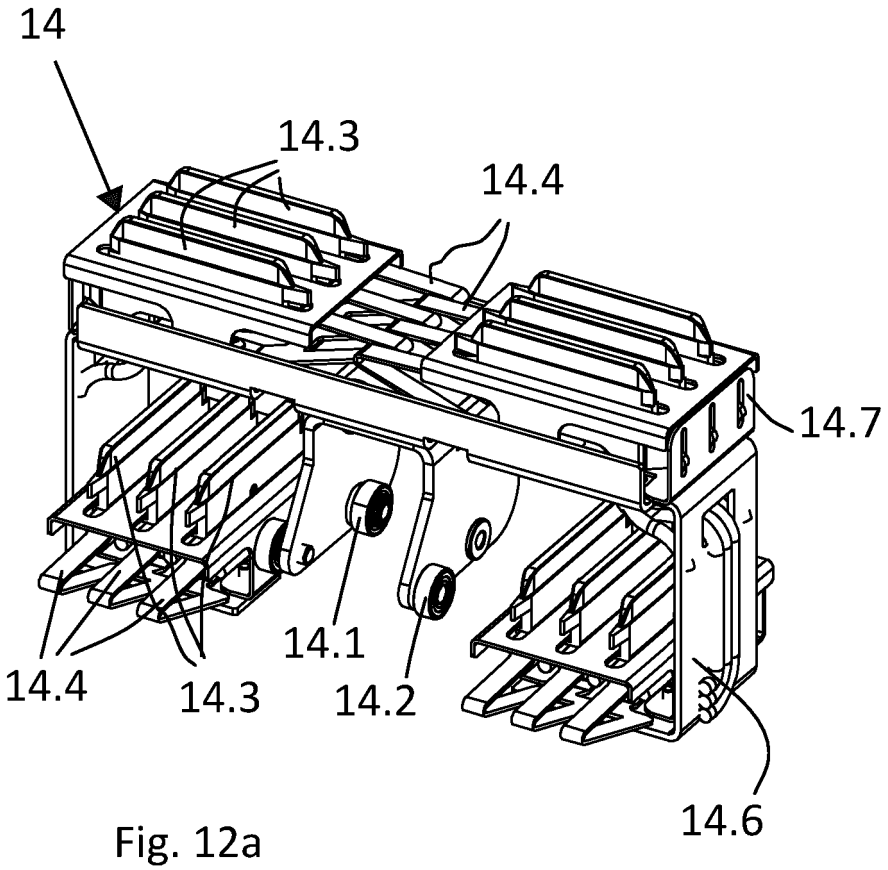


Fig. 12a

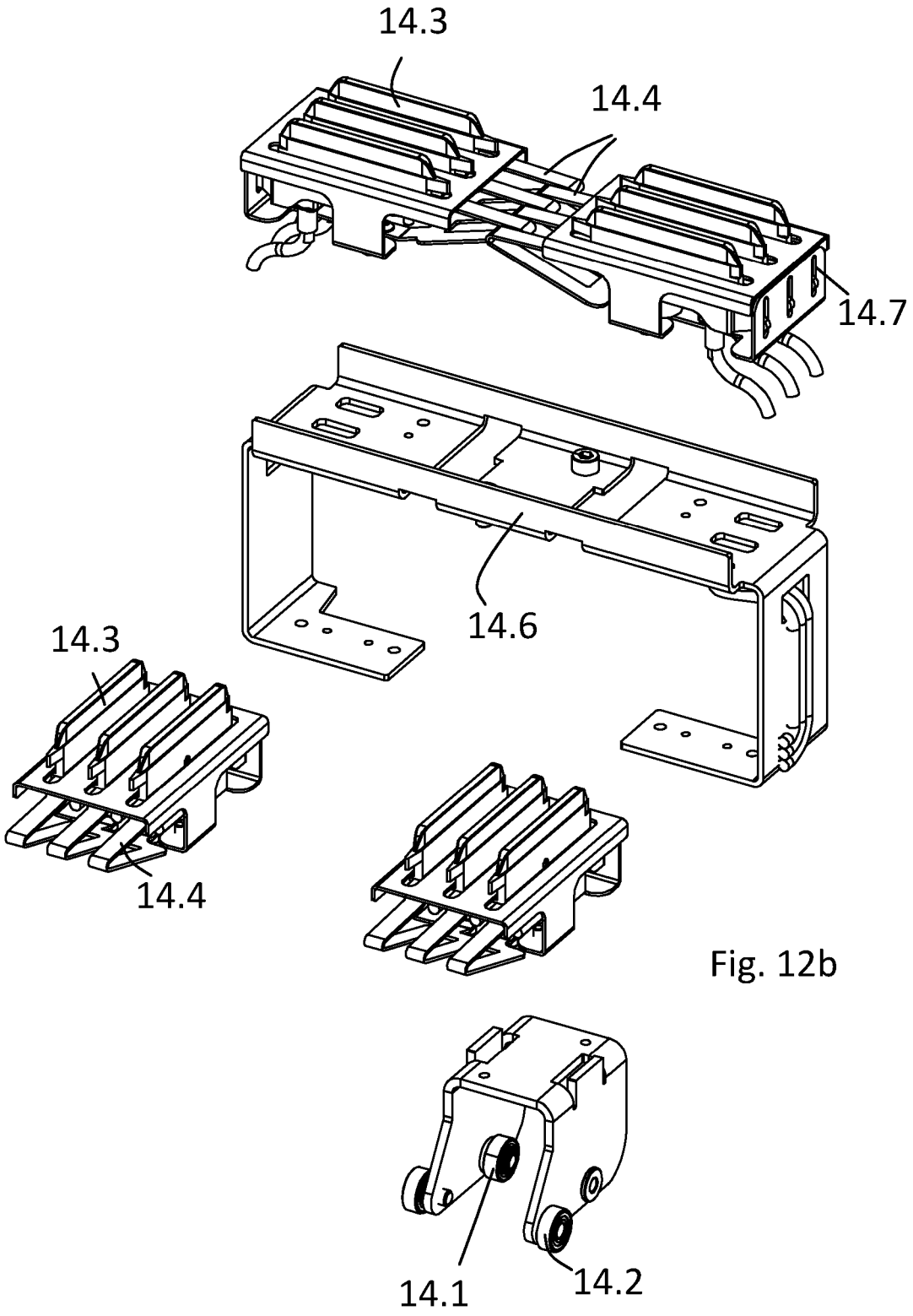


Fig. 12b

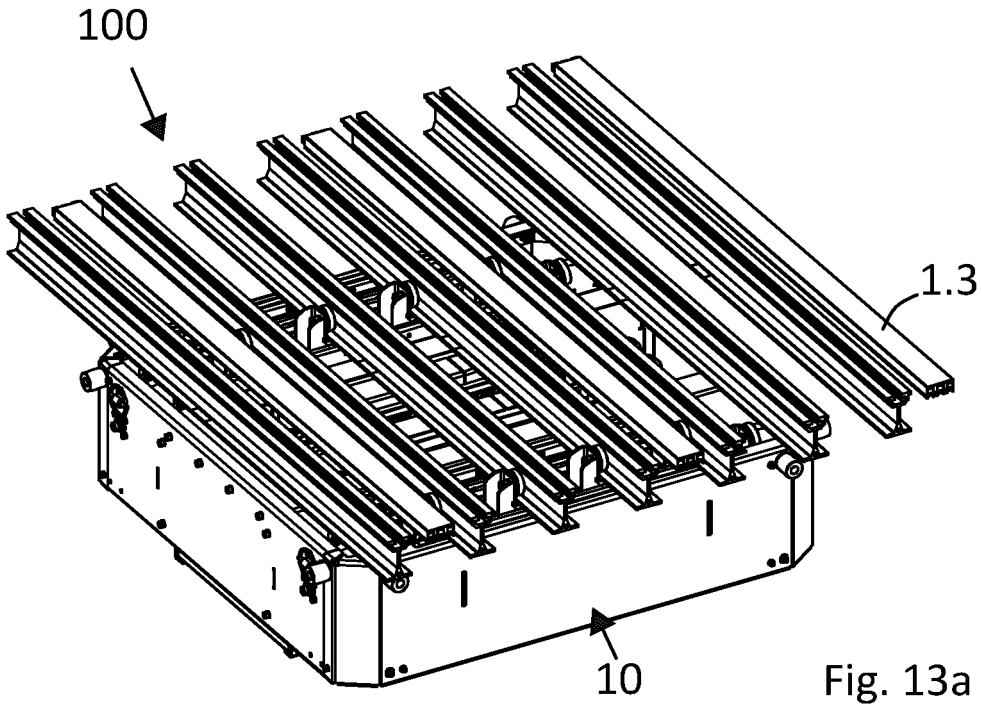


Fig. 13a

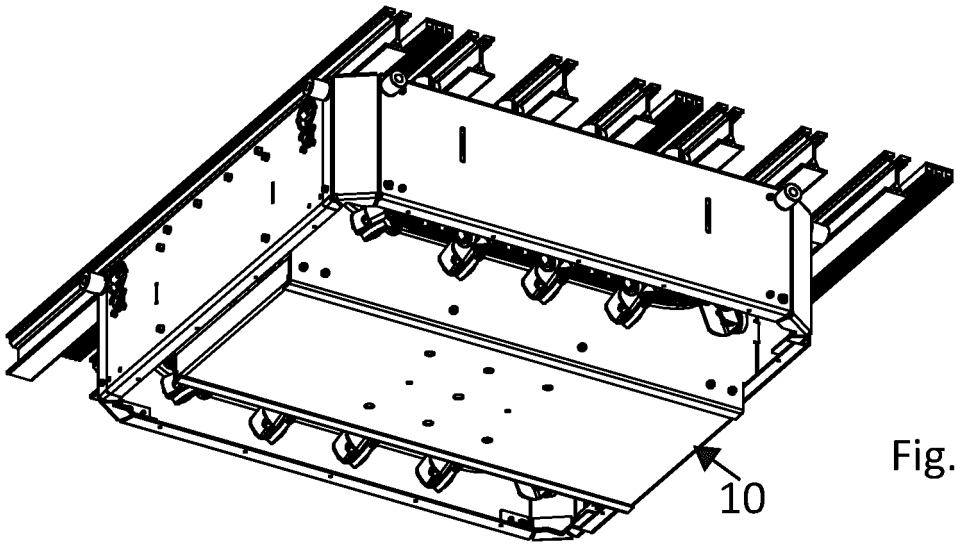


Fig. 13b

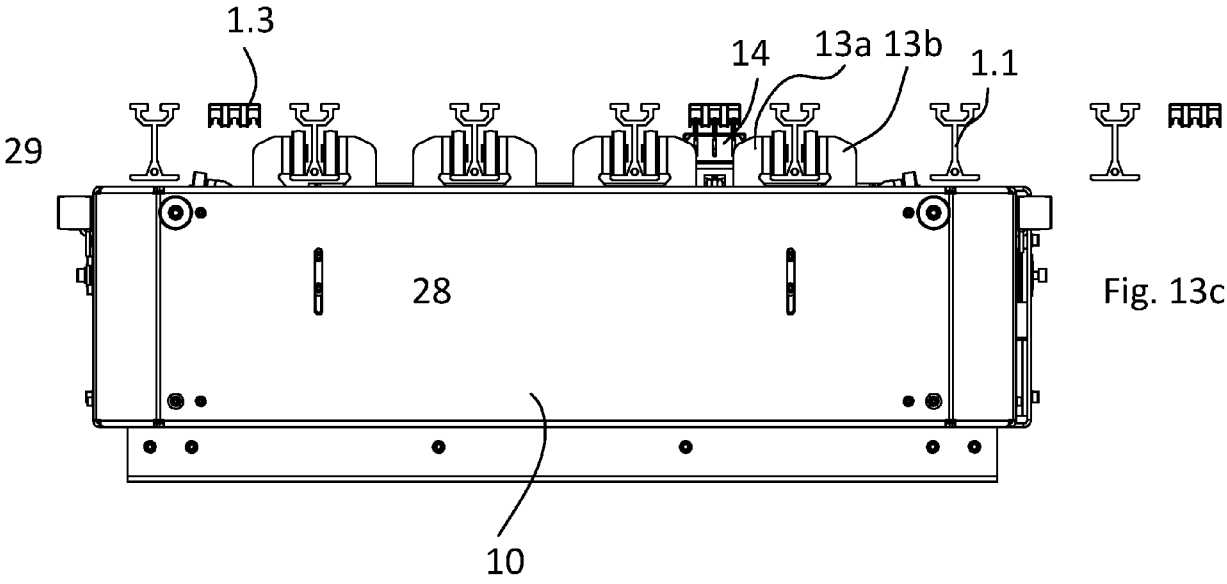


Fig. 13c

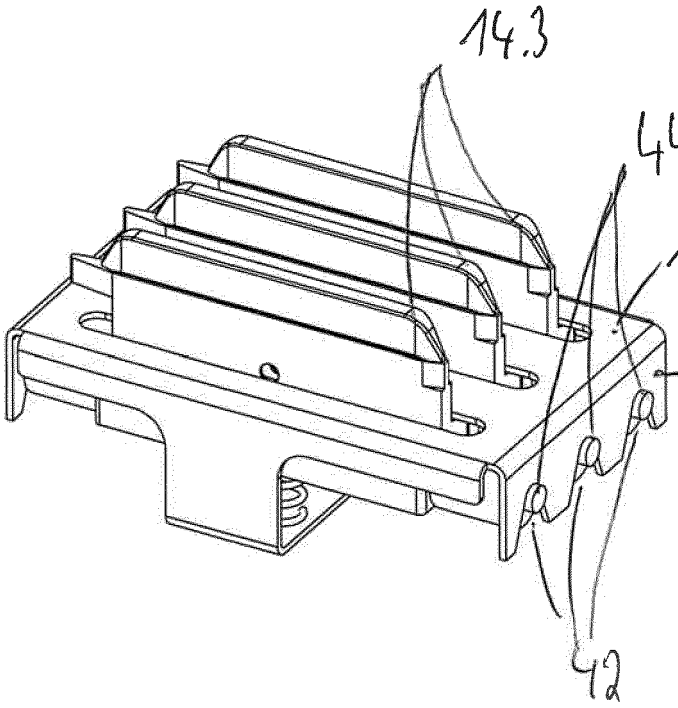


Fig. 14a

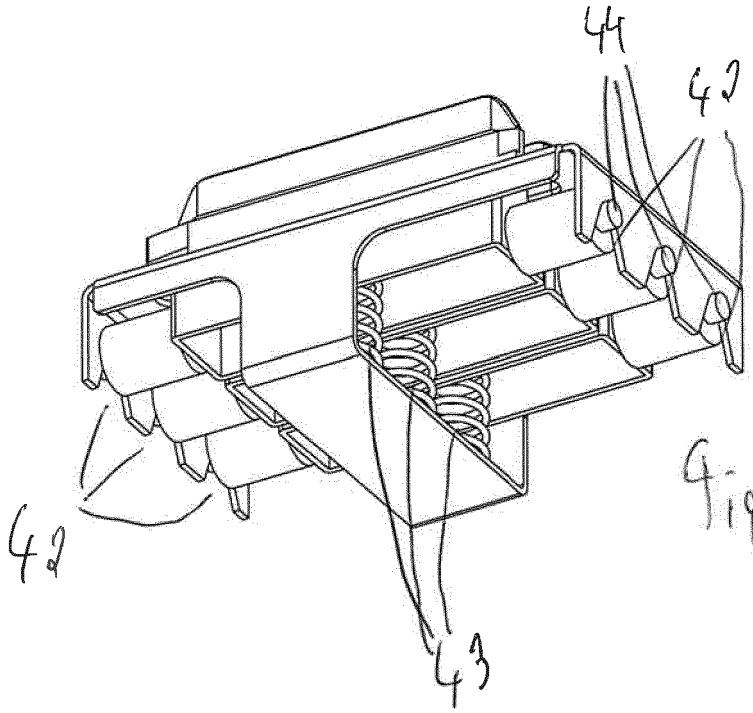


Fig. 14b

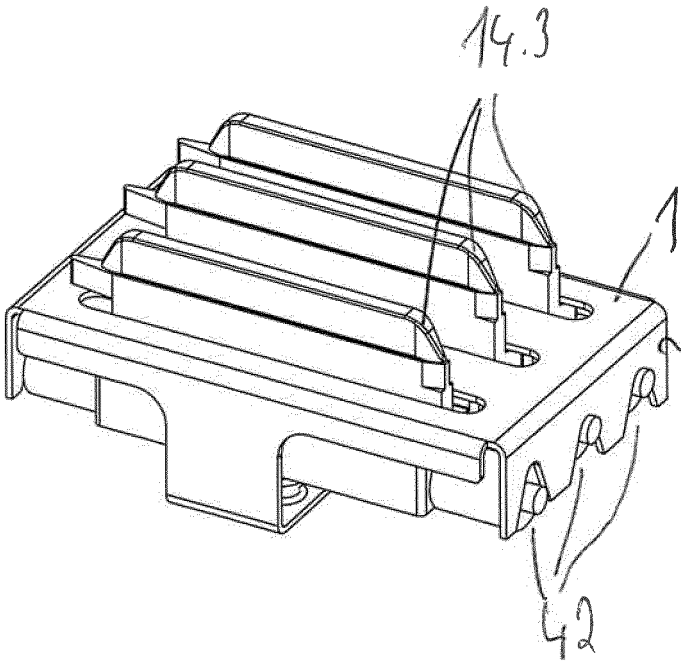


Fig. 14c

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EUROPEAN SEARCH REPORT

Application Number
EP 25 16 7542

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 4 253 202 B1 (CEILIX AG [DE]) 11 December 2024 (2024-12-11) * the whole document *	1-15	INV. B62D55/075
A	FUKUI RUI ET AL: "HanGrawler: Large-Payload and High-Speed Ceiling Mobile Robot Using Crawler", IEEE TRANSACTIONS ON ROBOTICS, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 36, no. 4, 1 August 2020 (2020-08-01), pages 1053-1066, XP011803453, ISSN: 1552-3098, DOI: 10.1109/TRO.2020.2973100 [retrieved on 2020-08-05] * the whole document *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)
B62D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	5 September 2025	Denis, Marco

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05-09-2025

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 4253202 B1	11-12-2024	EP 4253202 A1	04-10-2023
		ES 3028813 T3	20-06-2025
		PL 4253202 T3	07-04-2025

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Patent documents cited in the description

- EP 4273030 B1 **[0002]**