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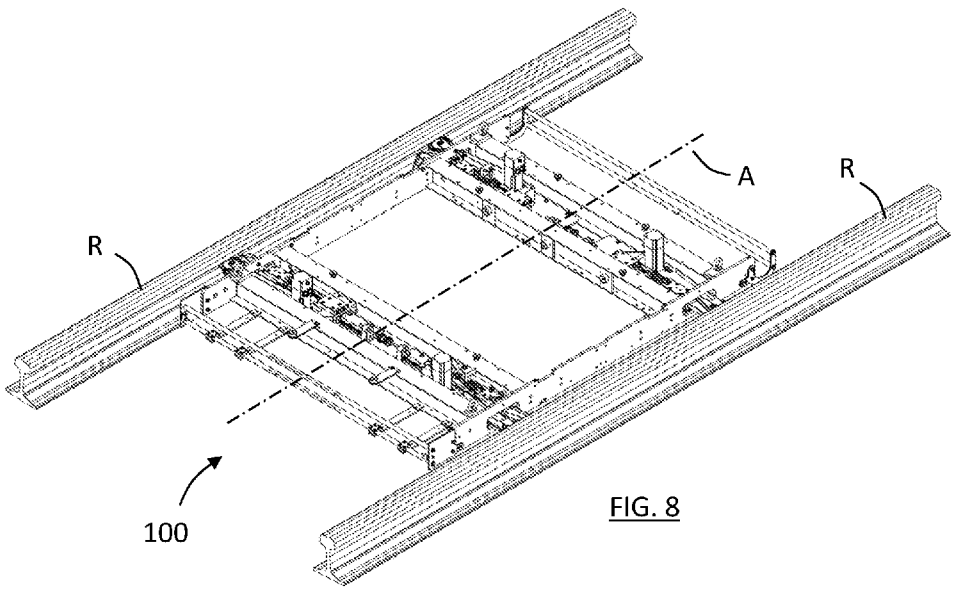

FIG. 8

(57) Abstract: A preload and retraction device (10, 10') of a wheel assembly comprises a linear guide (11), an internal slider (12) and an external slider (13) movable along the linear guide (11), a linear elastic member (14) arranged to connect the two sliders (12) (13), a first wheel support arm (15) integral with the internal slider (12) and a second wheel support arm (19) integral with the external slider (13), with the external slider (13) carrying a weight support wheel (20) that is actuated and the internal slider (12) carrying a traction wheel (16) that comes into contact with a rolling surface with a preload force that is a function of the geometry of the system. The use of the device (10, 10') is particularly advantageous for supporting the wheels in a self-propelled cart (100) of the type suitable for moving along a railway track for the inspection of the underbody of railway vehicles as it greatly facilitates and at least partially automates the installation of the self-propelled cart (100) on the track.

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PRELOAD AND RETRACTION DEVICE OF A WHEEL ASSEMBLY AND SELF-PROPELLED CART COMPRISING SAID DEVICE

TECHNICAL SECTOR

[0001] The present invention relates to the technical field of mechanical suspension and locomotion assemblies on wheels.

[0002] The invention finds advantageous application in carts on wheels suitable for moving in confined spaces between two substantially facing guide surfaces, and more particularly in carts designed for moving along a railway track and intended for the inspection of the underbody of railway vehicles.

BACKGROUND ART

[0003] Robotic or self-driving vehicles on wheels are increasingly widespread in many areas in order to replace humans in the performance of particularly difficult or dangerous activities for the safety of a human operator.

[0004] In some specific applications, the aforementioned vehicles must be designed to move autonomously in narrow and confined spaces between substantially vertical facing walls. Think, for example, of robotic, and sometimes miniaturized, vehicles on wheels for the inspection of ducts or pipes. In these types of vehicles, the suspension and locomotion assemblies often have passive wheels with a substantially horizontal axis intended to support the weight of the vehicle and motorized traction wheels that have a vertical axis or in any case inclined according to the inclination of the facing walls between which the vehicle must move ahead which allow centring the vehicle with respect to the duct or pipe to be inspected.

[0005] Needs and similar solutions can be found in certain vehicles intended to move head along tracks, such as the platform on wheels for the inspection of the underbody of railway

vehicles subject-matter of the international application WO2020105018 A1. This vehicle allows the inspection of the underbody of railway vehicles directly on site without the vehicles being transferred to special maintenance premises as the vehicle of the invention has extremely limited vertical overall dimensions and moves ahead along the tracks leaning and centring between the tracks exploiting the internal surface of the rail stem and the rail foot plane so that the platform can move below the vehicle without the wheels of the vehicle itself obstructing its movement.

[0006] In any case, a problem common to all the above types of self-driving vehicles having suspension and locomotion assemblies with support wheels with a substantially horizontal axle and centring and locomotion wheels with a substantially vertical axle concerns the installation procedures in the work environment, i.e. on the tracks, in the ducts or in the pipes. In fact, in most situations, for them to be able to be installed in the work position, both the passive suspension wheels and the centring and locomotion wheels must be able to move from a retracted configuration with minimum transverse overall dimensions into an extracted operating configuration. For example, in the specific application of a platform for the inspection of the underbody of railway trains subject-matter of the above-mentioned international application, the platform must be lowered manually from above between the rails while both the passive rest wheels and the active centring and locomotion wheels are in a retracted configuration. When the platform is approximately in position the support arms of the passive wheels are manually rotated into the operating position and locked, after which the active wheels that until then had to be kept manually retracted against the action of the preload force of a spring can be released outwards. It is therefore understandable that the installation on a track and the subsequent removal of the platform must take place manually with non-standardised procedures and with significant time expenditure.

SUMMARY OF THE INVENTION

[0007] Aim of the present invention is to propose a mechanical suspension and locomotion assembly on wheels, in particular in vehicles destined to move ahead in confined spaces, which solves the problems highlighted above relating to the simplicity and speed of installation and centring of the vehicle.

[0008] Another aim of the present invention is to propose a self-propelled cart, intended to move forward in confined spaces, provided with mechanical suspension and locomotion assemblies on wheels that allow operations of installation and removal from the confined space in which they must move fast, to be semi-automatic and standardised.

[0009] Still, an aim of the present invention to propose a self-propelled cart on wheels for the inspection of the underbody of railway vehicles that is suitable for moving along a railway track below the rolling surface taking into account all the encumbrance constraints deriving from the presence of a railway vehicle and the variability of the components that constitute the railway superstructure and that is provided with mechanical suspension and locomotion assemblies on wheels that facilitate and automate at least partially the operations of installation on the track and removal therefrom.

[0010] In accordance with a first aspect of the present invention the above aims are achieved by means of a mechanical suspension and locomotion assembly on wheels according to independent claim 1.

[0011] In accordance with another aspect of the present invention the above aims are achieved by means of a self-propelled cart according to claim 4.

Further advantageous features of the self-propelled cart of the invention and specific embodiments are expressed in the following dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The characteristics of the invention will be easily understood from the following description of embodiments thereof, provided as non-limiting examples, with reference to the attached figures in which:

- FIG. 1 shows a perspective view of a device according to the invention;
- FIG. 2 shows a front view of the device of FIG. 1;
- FIG. 3 shows a side view of the device of FIG. 1;
- FIG. 4 shows a top view of the device of FIG: 1;
- FIG. 5 shows a schematic front view of a self-propelled cart according to the present invention inserted respectively in a) a confined space with rectangular section, b) a confined space with elliptical section;
- FIG. 6 shows in top view a self-propelled cart according to the present invention;
- FIG. 7 shows the self-propelled cart of FIG. 6 in perspective view;
- FIG. 8 shows the self-propelled cart of FIG. 6 in perspective view installed on a railway track;
- FIG. 9 shows a preload and retraction device of the cart of FIG. 6, in front view, in three successive steps of the operation of installation of the cart on a railway track.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] With reference to FIGS. 1 to 4, a preload and retraction device of a wheel assembly according to the present invention is indicated overall with 10. The device 10 comprises:

– a linear guide, 11,
– an internal slider, 12, freely movable along said linear guide 11,
– an external slider, 13, movable in controlled mode along said linear guide 11,
– a linear elastic member, 14, arranged to connect said internal slider 12 and external slider 13 to each other so as to hinder relative movements of moving away and/or approaching said internal slider 12 and said external slider 13 with respect to a defined natural length distance,
– a first wheel support arm, 15, integral with said internal slider 12, extending substantially in the direction of said linear guide 11 and suitable for supporting at least a first wheel,

16, in rotatable mode around a relative first axis, 17, with a rolling direction, 18, of said at least a first wheel 16 substantially orthogonal to the direction of said linear guide 11;

- a second wheel support arm, 19, integral with said external slider 13, extending substantially in the direction of said linear guide 11 and suitable for supporting at least a second wheel, 20, in rotatable mode around a relative second axis, 21, with a rolling direction, 22, of said at least a second wheel 20 parallel to the rolling direction 18 of said at least a first wheel 16.

[0014] Preload adjustment members 23 are interposed between said elastic member 14 and at least one between said external slider 13 and said internal slider 12 to adjust the distance between said internal slider 12 and said external slider 13 in the natural length condition of said elastic member 14. In the embodiment shown in the figures, the preload adjustment members 23 consist of an internally threaded tubular member rotatably integral with the internal cart 12 and in which a screw integral with the elastic member 14 meshes. The preload adjustment members 23 are not shown in greater detail as they are made with the same operating principle as a tie-rod adjustment assembly, well known in the art.

[0015] Drive members are integral with at least one of said first wheel support arm 15 and said second wheel support arm 19 to rotate at least one of the supported wheels thereof. In the embodiment shown, the aforementioned drive members are integral with said first wheel support arm 15 to rotate said first wheel 16 and comprise an electric motor, 24, a pulley or toothed wheel, 25, coaxial and integral with said first wheel 16 and a transmission belt, 26, stretched between said pulley or toothed wheel 25 and the drive shaft of said electric motor 24.

[0016] An adjustable end-of-stroke member 27 is provided to determine a retracted limit position of the internal cart 12 along the linear guide 11.

[0017] With reference to FIG. 5, a preload and retraction device of a wheel assembly according to the invention as described above, which in this figure is shown only in an

extremely schematic way and therefore indicated with 10', is designed to be installed on a self-propelled cart, 100', destined to move ahead in a confined space, S, in particular in which there are present at least a base wall, B, on which the aforementioned second wheels 20 can rest to support the weight of the cart 100' and at least facing containment walls, C, on which the first wheels 16 of two devices 10' mounted opposite to the cart 100' can push to centre the self-propelled cart 100' in the confined space and move it forward.

[0018] In this perspective, and with reference also to FIGS. 6 to 9, a specific and particularly advantageous application of a preload and retraction device of a wheel assembly according to the present invention is provided in a self-propelled cart, 100, suitable for moving along a railway track for the inspection of the underbody of railway vehicles.

[0019] The self-propelled cart 100 comprises a platform, 30 and support and movement means on wheels comprising at least two preload and retraction devices 10 of a wheel assembly mounted on said platform 30 in a specular way with respect to a longitudinal axis, A, of said platform 30 defining a direction of advancement of the platform 30 itself.

[0020] Each of said preload and retraction devices 10 comprises:

- a linear guide 11 anchored to said platform 30 so as to extend in the plane of said platform in a direction substantially orthogonal to the aforementioned direction of advancement of said self-propelled cart 100,
- an internal slider 12 freely movable along said linear guide 11,
- an external slider 13 movable in a controlled mode along said linear guide 11,
- a linear elastic member 14 arranged to connect said internal slider 12 and external slider 13 to each other so as to hinder relative movements of moving away and/or approaching said internal slider 12 and said external slider 13 with respect to a defined natural length distance,

- a first wheel support arm, 15, integral with said internal slider 12, extending substantially in the direction of said linear guide 11 and suitable for supporting at least a first wheel, 16, in rotatable mode around a relative first axis, 17, with a rolling direction, 18, of said at least a first wheel 16 substantially orthogonal to the direction of said linear guide 11 and parallel to said longitudinal axis A;
- a second wheel support arm, 19, integral with said external slider 13, extending substantially in the direction of said linear guide 11 and suitable for supporting at least a second wheel, 20, in rotatable mode around a related second axis, 21, with a rolling direction, 22, of said at least a second wheel 20 parallel to that of said at least a first wheel 16.
- drive members integral with at least one of said first wheel support arm 16 and said second wheel support arm 19 to rotate at least one of the supported wheels thereof.

[0021] In the embodiment shown in FIGS. 6 to 8 the self-propelled cart 100 comprises four devices 10 arranged two on the left side of the self-propelled cart and two specularly on the right side.

[0022] The first wheels 16 have their first axis 17 substantially orthogonal to the plane identified by said platform 30 and are provided with said drive members so that said first wheels can be rotated to move ahead said self-propelled cart 100.

[0023] The second wheels 20 have their second axis 21 substantially parallel to the direction of extension of said linear guide 11, so that the wheels are arranged substantially vertically to support the weight of the self-propelled cart 100.

[0024] The platform 30 has a maximum transverse dimension, with reference to the direction of longitudinal axis A and therefore to the direction of advancement of said self-propelled cart 100 along a railway track, smaller than the size of the gauge of the rails, R, that form said railway track.

[0025] With reference to FIG. 9, said at least a first wheel 16 and at least a second wheel 20 are arranged externally to said platform 30 with respect to said transverse direction in such a way that following the actuation of said external slider 13 along said linear guide 11 said at least a first wheel 16 and at least a second wheel 20 selectively assume different operating configurations among which at least: a retracted configuration with minimum transverse dimensions of said self-propelled cart 100, FIG. 9 a) in which said at least one first wheel 16 and at least a second wheel 20 are both detached from the surfaces of said rail R; an intermediate first contact configuration, FIG. 9 b), in which said at least a first wheel 16 comes into contact with the internal surface of the stem, G, of a rail R while said at least a second wheel 20 is detached from said rail R; and an extracted work configuration, FIG. 9 c), in which said at least a first wheel 16 is in contact with the internal surface of the stem G of said rail R with a determined contact force and said at least one second wheel 20 is in contact with a lower foot plane, S of said rail R, said drive members being integral with said first arm 15 to rotate said at least a first wheel 16 while said at least a second wheel 20 is arranged to roll freely conducted on said foot plane S of said rail R.

[0026] The overall vertical dimensions of said self-propelled cart 100 are substantially contained in the overall dimensions in height of said rail R so that said self-propelled cart 100 is able to move along said track below the relative rolling plane.

[0027] The above-mentioned characteristics of the self-propelled cart 100 of the invention, and in particular of the preload and retraction devices of a wheel assembly 10 provided therein, are particularly advantageous for speeding up and standardizing the installation operations of the self-propelled cart 100 on a track, so that the self-propelled cart can be quickly moved from one track to another to optimize the scheduled maintenance operations of the railway vehicles.

[0028] In fact, thanks to the structure outlined above, the installation of the self-propelled cart 100 on a track can be carried out by activating actuation members of the external cart

13, not shown as of known type, in such a way that the device 10 moves into the retracted configuration with minimum transverse dimensions, so that the self-propelled cart 100 can be lowered from above between the rails R. While the self-propelled cart is maintained at approximately the correct installation height, the movement means of the external cart 13 are actuated to move the external cart 13 along the linear guide 11 outwards. The movement of the external cart 13 causes the same outward movement of the internal cart 12 as the two carts are connected via the linear elastic member 14, until the intermediate first contact configuration is reached in which, thanks to the sizing of the device 10, the first wheel 16 comes into contact with the internal surface of the stem G of the rail R while the second wheel 20 is still detached from the rail R itself. The actuation of the external cart 13 outwards continues until the second wheel carried by it comes into contact with the lower foot plane S of the rail R, with the internal cart 12 remaining stationary as the first wheel 16 is already in abutment, however increasing the thrust of the latter on the stem G by virtue of the loading of the elastic member 14, which in this case consists of a traction coil spring that stretches as the two carts 12 and 13 move away.

[0029] The actuation of the device 10 therefore allows to switch from a configuration with minimum overall dimensions of the self-propelled cart 100 that allows the latter to be introduced in the work area to a work configuration in which the device 10 brings the relative wheels in contact with the surfaces on which they are destined to roll also automatically centring the self-propelled cart 100 in the confined work environment.

[0030] With respect to the above described by way of example, modifications and variants may certainly be envisaged both to the preload and retraction device of a wheel assembly according to the invention, and to a self-propelled cart as a whole, in light of specific functional or application needs, while still remaining within the scope of protection provided by the claims that follow.

[0031] Such variants and modifications may certainly be considered as equivalent solutions and therefore equally protected by the claims.

CLAIMS

1. Preload and retraction device (10, 10') of a wheel assembly **characterized in that** it includes:
   - a linear guide (11),
   - an internal slider (12) freely movable along said linear guide (11),
   - an external slider (13) movable in controlled mode along said linear guide (11),
   - an elastic member (14), arranged to connect said internal slider (12) and external slider (13) to each other so as to hinder relative movements of moving away and / or approaching said internal slider (12) and said external slider (13) with respect to a defined natural length distance,
   - a first wheel support arm (15) integral with said internal slider (12), extending substantially in the direction of said linear guide (11) and suitable for supporting at least a first wheel (16) in rotatable mode around a relative first axis (17) with a rolling direction (18) of said at least a first wheel (16) substantially orthogonal to the direction of said linear guide (11);
   - a second wheel support arm (19) integral with said external slider (13) extending substantially in the direction of said linear guide (11) and suitable for supporting at least a second wheel (20) in rotatable mode around a related second axis (21) with a rolling direction (22) of said at least a second wheel (20) parallel to the rolling direction (18) of said at least a first wheel (16).
2. Preload and retraction device (10, 10') of a wheel assembly according to claim 1 **characterized in that** it comprises preload adjustment members interposed

between said elastic member (14) and at least one between said external slider (13) and said internal slider (12) to adjust the distance between said internal slider (12) and said external slider (13) in the natural length condition of said elastic member (14).

3. Preload and retraction device (10, 10') of a wheel assembly according to claim 1, **characterized in that** it comprises drive members integral with at least one of said first wheel support arm (15) and said second wheel support arm (19) to rotate at least one of the supported wheels thereof.

4. Preload and retraction device (10, 10') of a wheel assembly according to the preceding claim, **characterized in that** said drive members are integral with said first wheel support arm (15) to rotate said first wheel (16) and it comprises an electric motor (24), a pulley or toothed wheel (25) coaxial and integral with said first wheel (16) and a transmission belt (26) between said pulley or toothed wheel (25) and the drive shaft of said electric motor (24).

5. Self-propelled cart (100, 100') of the type suitable for moving in confined spaces between two substantially facing guide surfaces, said self-propelled cart comprising:

- a platform (30), and
- support and movement means on wheels,

said self-propelled cart being **characterized in that** said support and movement means on wheels comprises at least two preload and retraction devices (10, 10') of a wheel assembly thereof, said preload and retraction devices (10, 10') being mounted on said platform (30) in a specular way with respect to a longitudinal axis (A) of said platform (30) defining a direction of advancement of the platform (30) itself, each of said preload and retraction devices (10, 10') comprising:

- a linear guide (11) anchored to said platform (30) so as to extend in the plane of said platform in a direction substantially orthogonal to the aforementioned direction of advancement of said self-propelled cart (100),
- an internal slider (12) freely movable along said linear guide (11),
- an external slider (13) movable in a controlled mode along said linear guide (11),
- an elastic member (14), arranged to connect said internal slider (12) and external slider (13) to each other so as to hinder relative movements of moving away and / or approaching said internal slider (12) and said external slider (13) with respect to a defined natural length distance,
- a first wheel support arm (15) integral with said internal slider (12), extending substantially in the direction of said linear guide (11) and suitable for supporting at least a first wheel (16) in rotatable mode around a relative first axis (17) with a rolling direction (18) of said at least a first wheel (16) substantially orthogonal to the direction of said linear guide (11) and parallel to said longitudinal axis (A);
- a second wheel support arm (19) integral with said external slider (13), extending substantially in the direction of said linear guide (11) and suitable for supporting at least a second wheel (20) in rotatable mode around a related second axis (21) with a rolling direction (22) of said at least a second wheel (20) parallel to that of said at least a first wheel (16);
- drive members integral with at least one of said first wheel support arm (16) and second wheel support arm (19) to rotate at least one of the supported wheels thereof.

6. Self-propelled cart (100, 100') according to the preceding claim **characterized in that** said at least a first wheel (16) has its first wheel axis (17) substantially orthogonal to the plane identified by said platform (30) and is provided with said drive members so that said at least a first wheel (16) can be rotated to move ahead / back said self-propelled cart (100).

7. Self-propelled cart according to claims 4 and 5 **characterized in that** said at least a second wheel (20) has its second wheel axis (21) substantially parallel to the direction of extension of said linear guide (11), so that said at least a second wheel (20) is arranged substantially vertically to support the weight of the self-propelled cart (100).

8. Self-propelled cart (100) according to the preceding claim, of the type suitable for moving along a railway track for the inspection of the underbody of railway vehicles, **characterized in that** said platform (30) has a maximum transverse dimension, with reference to the direction of longitudinal axis (A) and therefore to the direction of advancement of said self-propelled cart (100) along a railway track, smaller than the size of the gauge of the rails (R) that form said railway track, said at least a first wheel (16) and at least a second wheel (20) being arranged externally to said platform (30) with respect to said transverse direction in such a way that following the actuation of said external slider (13) along said linear guide (11) said at least a first wheel (16) and at least a second wheel (20) selectively assume different operating configurations, among which at least: a retracted configuration with minimum transverse dimensions of said self-propelled cart (100) in which said at least one first wheel (16) and at least a second wheel (20) are both detached from the surfaces of said rail (R); an intermediate first contact configuration, in which said

at least a first wheel (16) comes into contact with the internal surface of the stem (G) of a rail (R) while said at least a second wheel (20) is detached from said rail (R); and an extracted working configuration, in which said at least a first wheel (16) is in contact with the internal surface of the stem (G) of said rail (R) with a determined contact force and said at least one second wheel (20) is in contact with a rail foot upper plane (S) of said rail (R), said drive members being integral with said first wheel support arm (15) to rotate said at least a first wheel (16) while said at least a second wheel (20) is arranged to roll freely conducted on said rail foot upper plane (S) of said rail (R), the overall vertical dimensions of said self-propelled cart (100) being substantially contained in the overall dimensions in height of said rail (R) so that said the self-propelled cart (100) is able to move along said track below the track rolling surface.

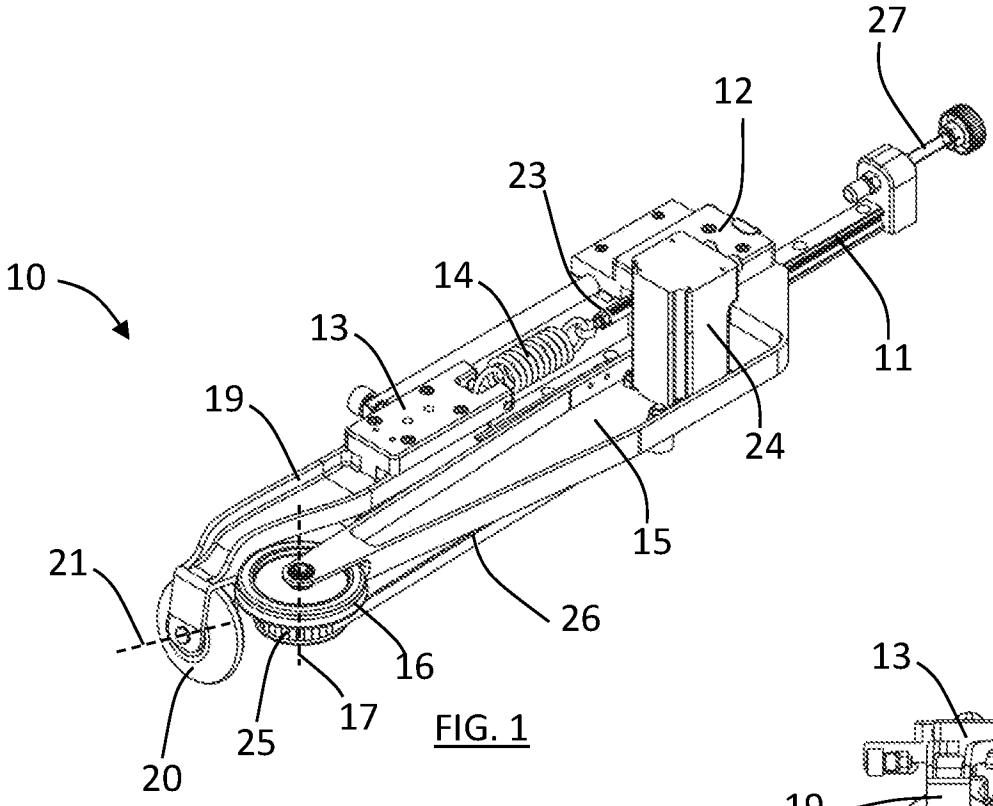

FIG. 1

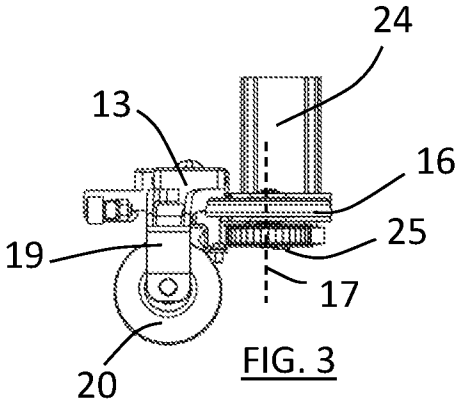

FIG. 3

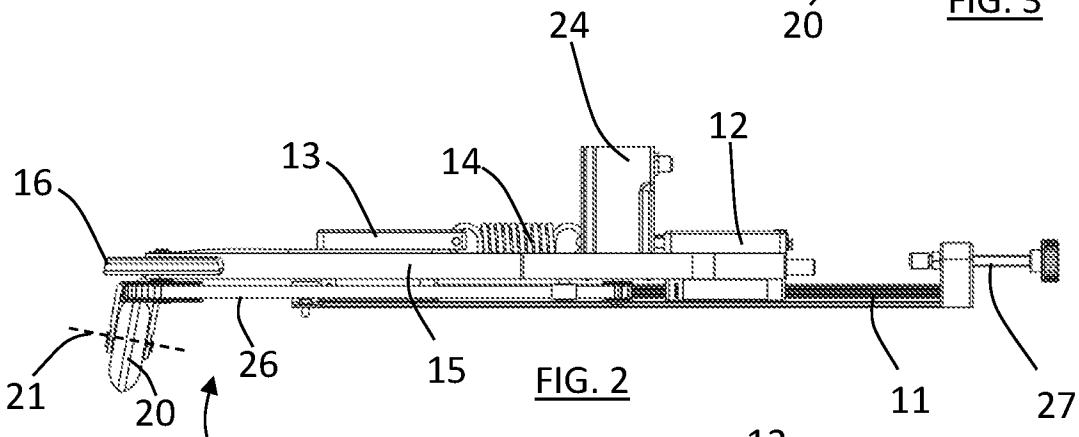

FIG. 2

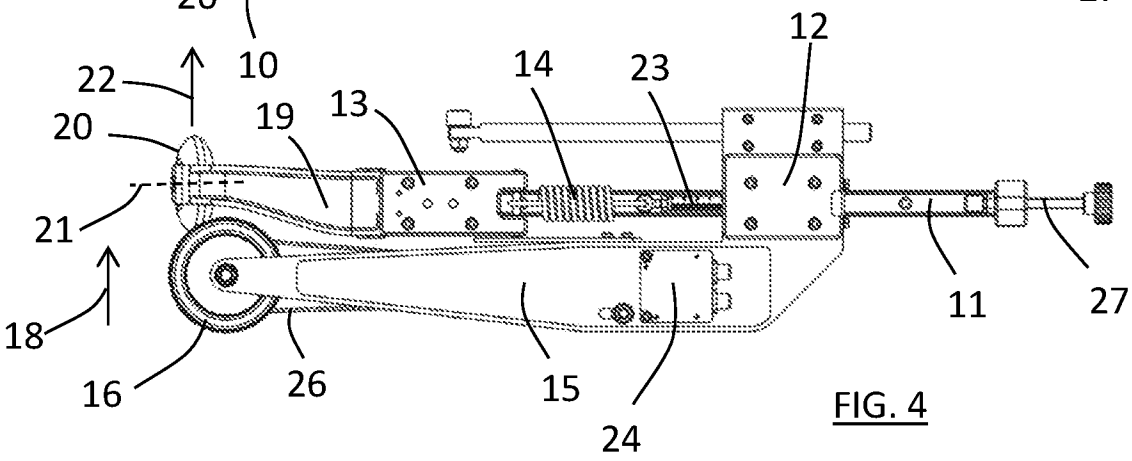

FIG. 4

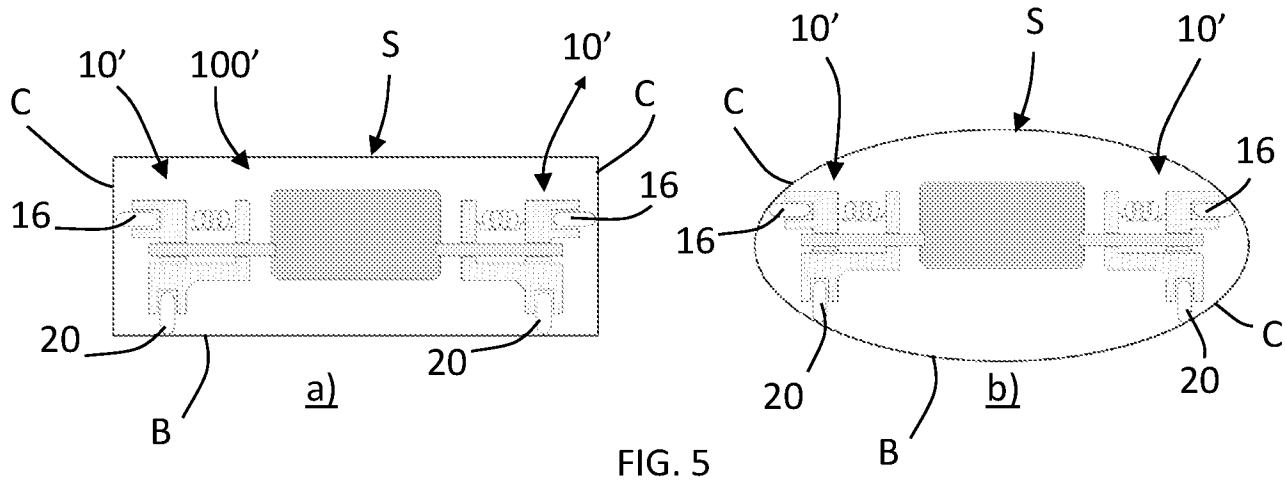
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FIG. 5

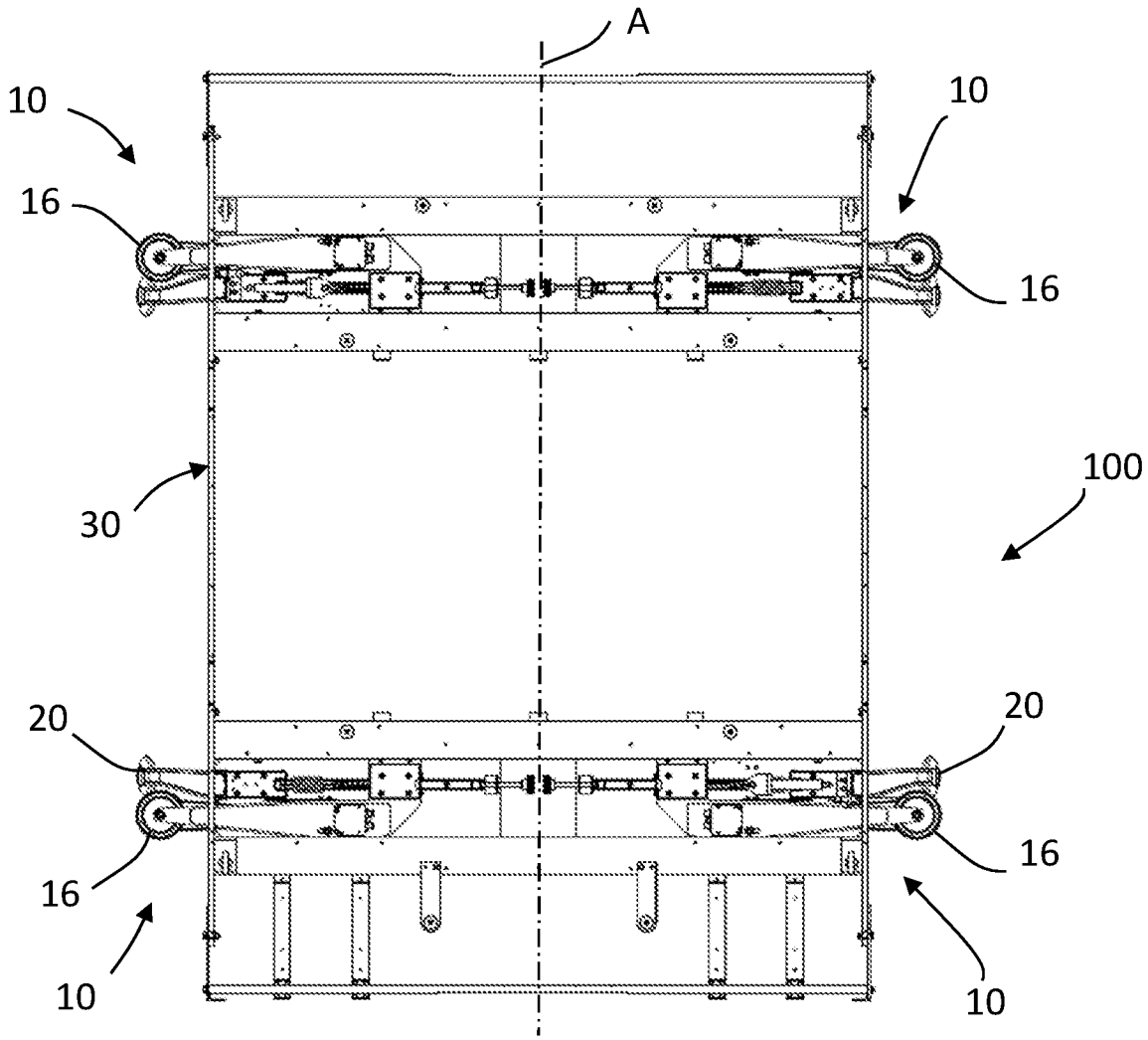
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FIG. 6

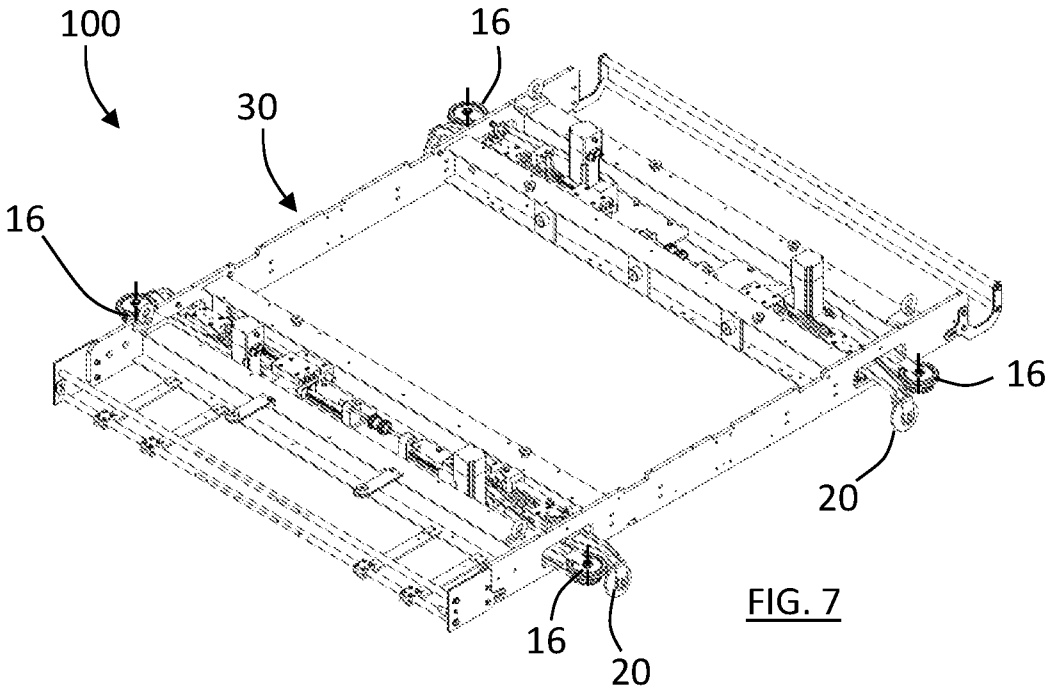

FIG. 7

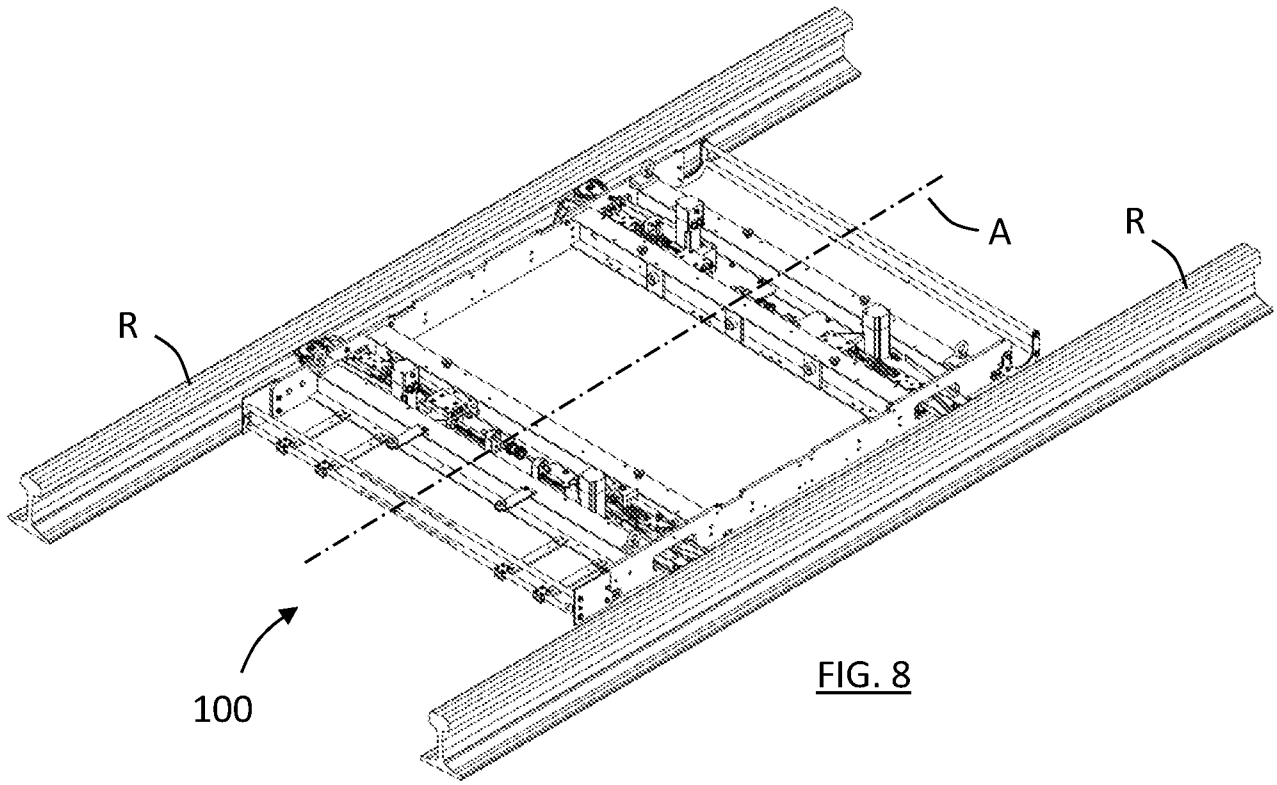

FIG. 8

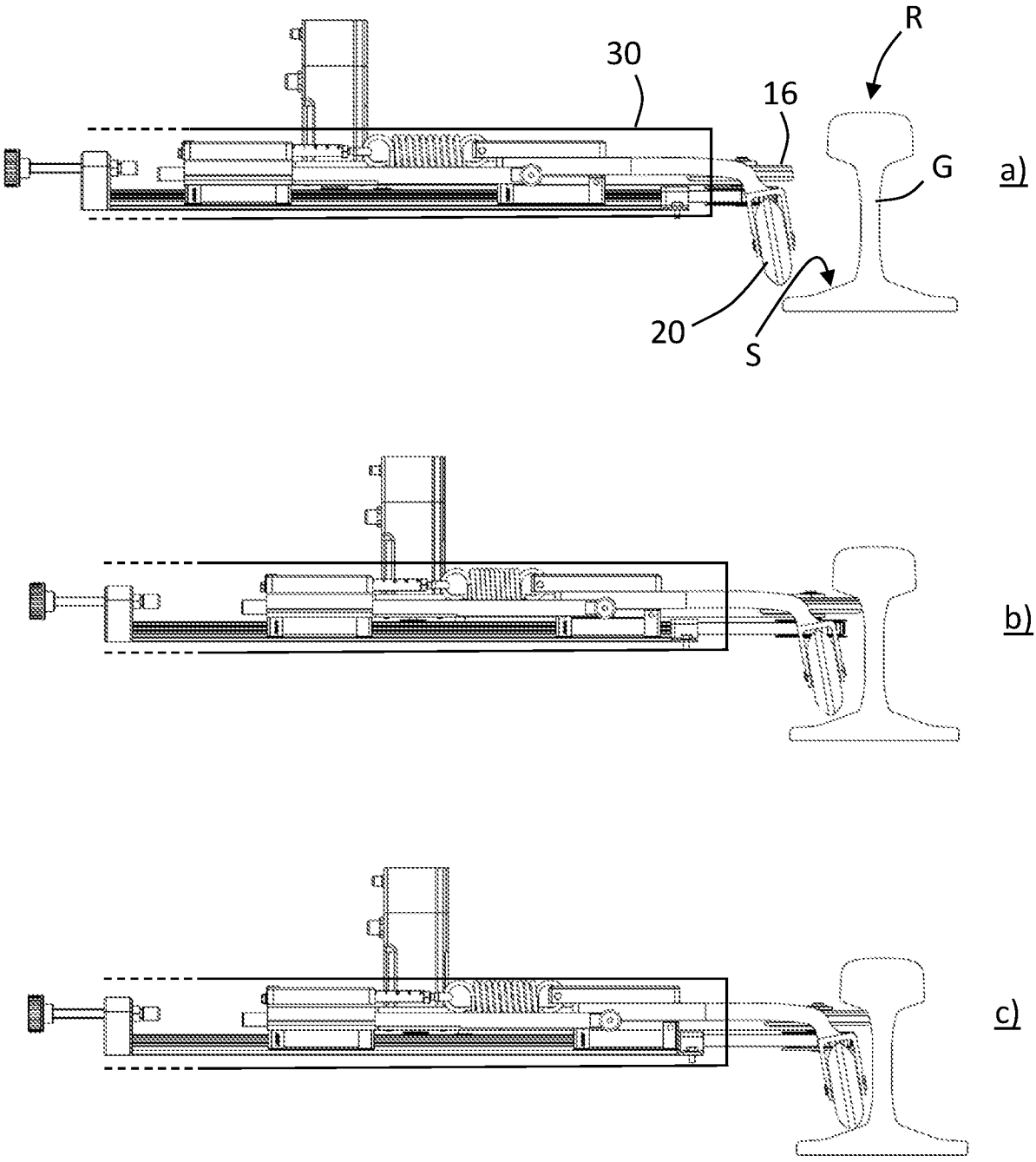

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/050590

A. CLASSIFICATION OF SUBJECT MATTER
INV. B61D15/12
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B61D

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2018/060945 A1 (SCUOLA SUPERIORE DI STUDI UNIV E DI PERFEZIONAMENTO SANTANNA [IT] ET A) 5 April 2018 (2018-04-05) the whole document	1-8
A	CN 204 674 585 U (BEIJING SHEENLINE TECH CO LTD) 30 September 2015 (2015-09-30) figures	1-8
A	DE 10 2012 004328 A1 (ZAPPEL WOLFGANG [DE]) 12 September 2013 (2013-09-12) the whole document	1-8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2023	02/05/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Schultze, Yves

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2023/050590

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018060945 A1	05-04-2018	EP 3519269 A1	07-08-2019
		ES 2899124 T3	10-03-2022
		WO 2018060945 A1	05-04-2018
CN 204674585 U	30-09-2015	NONE	
DE 102012004328 A1	12-09-2013	NONE	