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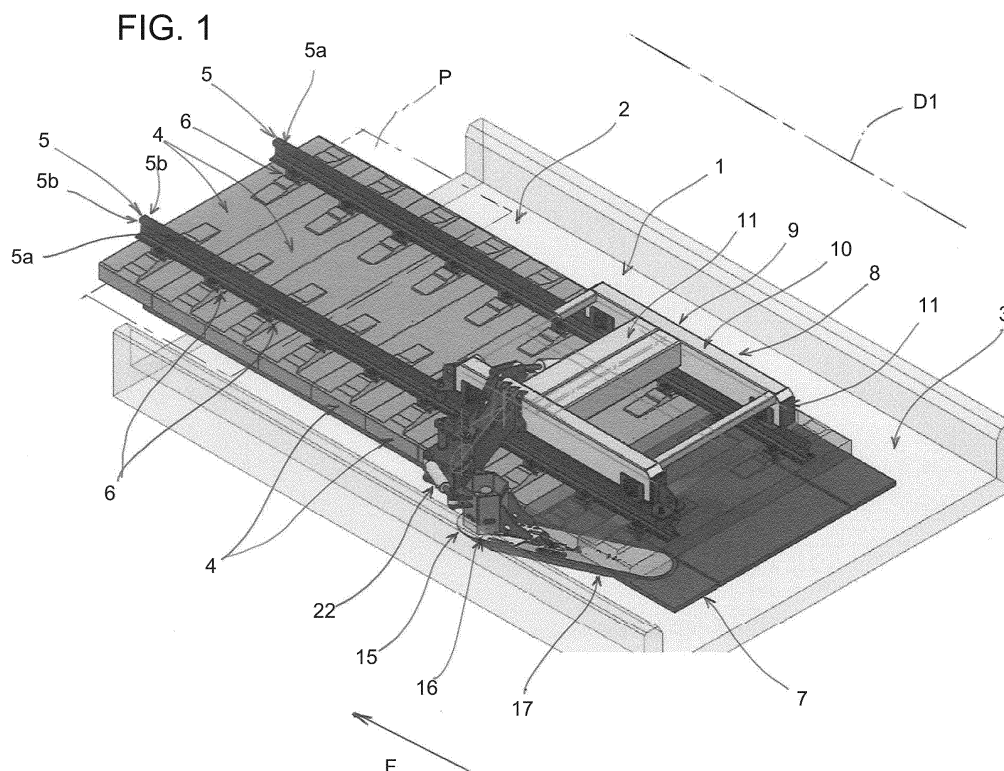
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(54) **APPARATUS AND METHOD FOR THE REHABILITATION OF THE BASE OF A RAILWAY LINE**

(57) Apparatus (1) for the rehabilitation of the base of a railway line (2) having a horizontal layer (7) of compact material positioned below the tracks (5), comprising a carriage (8) slidable along the tracks (5) of the railway line (2) and an operating head (15) for at least partly removing the horizontal layer (7) of compact material po-

sitioned below the tracks (5), the operating head (15) comprising a blade (17) having a substantially plane extension, wherein the apparatus further comprises a connecting arm (21) for connecting the operating head (15) to the carriage (8).



Description

[0001] This invention relates to an apparatus for the rehabilitation of the base of a railway line.

[0002] In particular, the invention relates to an apparatus for the rehabilitation of the base of a railway line having a horizontal layer of compact material positioned below the tracks.

[0003] This invention also relates to a method for the rehabilitation of the base of a railway line.

[0004] In the past, most of the railway lines were made by placing a stone ballast on the one on which the sleepers designed to support the actual tracks were positioned.

[0005] As an alternative to this long-established technique, in some circumstances with difficult construction and costly and complex maintenance, in tunnels and on viaducts, a reinforced concrete foundation has been used on which are positioned in succession pre-compressed reinforced concrete platforms, designed to directly support the tracks.

[0006] This type of construction is used, for example, in some tunnels with a length of more than 2000 metres on European railway lines in which, also with the aim of making the tunnel suitable for use by vehicles with rubber tyres, such as rescue vehicles, the stone ballast has been eliminated.

[0007] A compact solid layer, advantageously made of bituminous mortar, is normally interposed between the base foundation and the pre-compressed reinforced concrete platforms is normally interposed, designed to support and regularise the contact between the two above-mentioned components, as well as absorbing the stresses of the railway loads.

[0008] Unfortunately, due to the presence of very aggressive water circulating along the tracks, in general due to the infiltrations always present in the tunnels, this layer of bituminous mortar is exposed to a deterioration which is sometimes even rapid.

[0009] The consequence of the deterioration of the bituminous mortar layer is an instability on the railway structure, with generation, with the transit of the railway trains, of harmful vibrations which in the long term can cause dangerous failures.

[0010] At present, the only known method for overcoming the problem of the deterioration of the bituminous mortar layer consists in removing it after removal of the railway tracks and the removal of the pre-compressed reinforced concrete platforms which overly the layer of bituminous mortar.

[0011] This operation, as well as being particularly onerous in operational terms, is sometimes difficult to perform on account of the long railway traffic stoppage which it requires.

[0012] The technical times necessary for all the above-mentioned operational steps, as well as the necessary re-positioning of the parts removed, is not in fact compatible with the required operations for normal railway

lines.

[0013] The aim of the invention is to provide an apparatus and a method for rehabilitating the base of the railway line which are able to overcome the drawbacks of the prior art.

[0014] A further aim of the invention is to provide an apparatus and a method for rehabilitating the base of the railway line which is able to limit the necessary intervention times.

[0015] Another aim of the invention is to provide an apparatus and a method for rehabilitating the base of the railway line which allows the operations to be performed at the site to be simplified.

[0016] The technical features of the invention, with reference to the above aims, can be easily inferred from the appended claims, in particular claim 1, and preferably any of the claims that depend, either directly or indirectly, on claim 1.

[0017] The advantages of the invention will become more apparent from the detailed description which follows, with reference to the accompanying drawings which illustrate preferred embodiments of the invention provided merely by way of example without restricting the scope of the inventive concept, and in which:

- Figure 1 is a schematic perspective view, with some parts transparent and others cut away for simplicity, of a preferred embodiment of the apparatus for rehabilitation of the base of a railway line according to the invention, in a relative operating configuration installed on respective tracks;
- Figure 2 is a schematic perspective view of the apparatus of Figure 1; Figure 3 is a schematic plan view from above of the apparatus of Figure 2;
- Figures 4a and 4b are schematic top plan views from above of a detail of the apparatus of the above-mentioned drawings in two different configurations of use: respectively non-operational and operational;
- Figure 5 is a schematic perspective view of the apparatus of the above-mentioned drawings, in a non-operational configuration;
- Figure 6 is a schematic perspective view, with some parts transparent and some parts cut away to better illustrate others, of a detail of a variant embodiment of the apparatus of the above-mentioned drawings in a respective configuration of use;

[0018] Figure 7 is a schematic perspective view of a detail of the apparatus of Figure 6.

[0019] As illustrated in the drawings, the reference numeral 1 denotes in its entirety a preferred embodiment of an apparatus for rehabilitation of the base of a railway line 2, according to the invention.

[0020] The railway line 2 comprises a base foundation 3 made of reinforced concrete and a plurality of pre-compressed reinforced concrete platforms 4, positioned in succession on the base foundation 3.

[0021] The railway line 2 also comprises tracks 5 which

are fixed to the above-mentioned platforms 4 by means of respective clips 6 of known type.

[0022] The tracks 5 extend longitudinally along a predetermined direction D1.

[0023] A horizontal layer 7 of compact material is interposed between the base foundation 3 and the pre-compressed reinforced concrete platforms 4.

[0024] The above-mentioned horizontal layer 7 of compact material has a thickness of several centimetres.

[0025] The material with which the horizontal layer 7 is made is normally a bituminous mortar.

[0026] As illustrated in Figure 1, the apparatus 1 comprises a carriage 8 slidable along the tracks 5.

[0027] Also with reference to Figures 2 and 3, the carriage 8 has a quadrangular frame 9 comprising two longitudinal members 10 designed to be positioned parallel to the tracks 5, and a plurality of transversal members 11 for connection to the above-mentioned longitudinal members 10.

[0028] At both longitudinal ends of each longitudinal member 10, the carriage 8 has respective wheels 12 designed to engage in a rolling fashion on the upper surface 5a of the tracks 5.

[0029] The wheels 12 are advantageously mounted in an idle fashion on the longitudinal members 10, since the carriage 8 is designed to be moved by a further pulling vehicle, not illustrated.

[0030] At the opposite longitudinal ends of one of the two longitudinal members 10, the carriage 8 supports respective guide elements 13 designed to engage laterally with a track 5 for keeping the carriage 8 in the correct position for resting on both the tracks 5.

[0031] In detail, each guide element 13 has two idle rollers 14 designed to slidably engage on the flanks 5b of the track 5 as the carriage 8 moves forwards.

[0032] For example, according to preferred experimented embodiments of use, the carriage 8 is connected to an arm, not illustrated, of an operating machine designed to move on tracks.

[0033] As illustrated in Figures 2 and 3, the apparatus 1 comprises an operating head 15.

[0034] As is explained in more detail below, the operating head 15 is configured to at least partly remove the above-mentioned horizontal layer 7 of compact material.

[0035] The operating head 15 comprises a central body 16 and a blade 17 emerging from the central body 16.

[0036] The blade 17 has a substantially flat extension.

[0037] The blade 17 is designed to engage with the above-mentioned horizontal layer 7 of compact material to perform a milling operation.

[0038] According to the embodiment illustrated in Figures 1 to 5, the blade 17 comprises a flat plate 18 and a chain 19 looped on the flat plate 18 and slidable along the perimeter of the plate 18. The flat plate 18 represents a support and guide element for the chain 19.

[0039] In the accompanying drawings, the chain 19 is represented schematically in the form of a belt, since the

individual links from which it is in reality made are not graphically reproduced.

[0040] The chain 19 also comprises, also not illustrated, distributed uniformly along its extension, a plurality of removable excavation teeth designed for removing the compact material with which they enter into contact during the movement of the chain 19.

[0041] According to the preferred embodiment illustrated in the accompanying drawings, the central body 16 of the operating head 15 is hexagonal in shape.

[0042] The head 15 also supports, housed inside the central body 16, a motor element 20 designed to move the chain 19 in movement around the above-mentioned plate 18.

[0043] In other words, the motor element 20 is configured to activate the blade 17 in its operating motion.

[0044] The motor unit 20 advantageously comprises a rotary hydraulic motor. The hydraulic motor is supplied by pressurised oil.

[0045] The hydraulic connections designed for operation of the motor element 20 are not illustrated in the accompanying drawings.

[0046] The above-mentioned motor element 20 comprises a pinion, not illustrated, rotatable about a respective first axis A1 of rotation of the above-mentioned rotary hydraulic motor, and engaging inside the chain 19, that is, with the inner part of its links, for rotating the chain 19 about the flat plate 18.

[0047] At the relative central body 16, the operating head 15 is pivoted on a connecting arm 21 for connecting the head 15 to the carriage 8.

[0048] The head 15 is pivoted on the connecting arm 21 to rotate relative to it about a second axis A2 parallel to the above-mentioned axis A1.

[0049] More in detail, the connecting arm 21 comprises a slider 29 to which the head 15 is physically pivoted.

[0050] The slider 29, which is box-shaped, is slidable relative to the remaining portion of the connecting arm 21 through two cylindrical guides 30 extending along a direction D2 parallel to the above-mentioned axis A2.

[0051] With the connecting arm 21 and the operating head 15 positioned as illustrated in Figure 2, the sliding direction D2 of the slider 29 is substantially at a right angle to a predetermined plane P tangent to the upper surface 5a of the tracks 5.

[0052] The sliding of the slider 29 along the above-mentioned cylindrical guides 30 is actuated by a lead nut and screw mechanism 31 only partly illustrated in the accompanying drawings.

[0053] As described in more detail below, the sliding of the slider 29 and the operating head 15 along the direction D2 constitutes an adjustment movement for positioning the blade 17 in the correct working position of the horizontal layer 7.

[0054] As illustrated in Figures 4a and 4b, the operating head 15 rotates about the second axis A2 to move between a non-operating position of the blade 17, illustrated in Figure 4a, wherein the chain 19 is not operatively en-

gaged with the horizontal layer 7, and an operating position of the blade 17, visible in figure 4b, wherein the chain 19 engages in the milling of the horizontal layer 7 of compact material.

[0055] In both the positions mentioned above, and illustrated in Figures 4a, 4b, the blade 17 is has the relative flat plate 18 substantially parallel to the above-mentioned predetermined plane P tangent to the upper surface 5a of the tracks 5.

[0056] The apparatus 1 comprises a first linear hydraulic actuator 22 designed to actuate the above-mentioned rotation movement of the head 15 relative to the connecting arm 21.

[0057] More in detail, the first hydraulic actuator 22 is supported by the slider 29 of the connecting arm 21.

[0058] The first linear hydraulic actuator 22 is of known type and comprises a cylinder 23 and a rod 24 which are slidably engaged and pivoted with each other, at the relative longitudinal ends, on one and on the other of the above-mentioned head 15 and connecting arm 21.

[0059] The first hydraulic actuator 22 defines, for the apparatus 1, actuator means for moving the blade 17 inside the horizontal layer 7 of compact material which is able to keep the blade 17 substantially parallel to the above-mentioned predetermined plane P.

[0060] As clearly illustrated in Figures 2 and 5, the connecting arm 21 is in turn pivoted on a longitudinal member 10 of the carriage 8, to rotate about a third axis A3 parallel to the direction of extension of the longitudinal members 10 and, when the carriage 8 is engaged on the tracks 5, parallel also to the direction of extension D1 of the tracks 5.

[0061] The connecting arm 21 is movable between a first lowered operating configuration at which the blade 17 is positioned substantially parallel to the above-mentioned predetermined plane P, for removing the compact material of the horizontal layer 7, and a raised non-operating configuration at which the blade 17 is disengaged from the horizontal layer 7, for allowing an easy movement of the carriage 8 along the tracks 5.

[0062] As illustrated in Figures 1 to 3, the apparatus 1 comprises a second linear hydraulic actuator 25 designed to actuate the above-mentioned movement of rotation of the connecting arm 21 relative to the longitudinal member 10 of the carriage 8.

[0063] The second linear actuator 25 is of known type and comprises a cylinder 26 and a rod 27 which are slidably engaged and pivoted with each other, at the relative longitudinal ends, one on a crosspiece 11 of the carriage 8 and the other, by means of suitable linkages 28, on the connecting arm 21.

[0064] The hydraulic connections designed for the operation of both the first hydraulic actuator 22 and of the second hydraulic actuator 25 are not illustrated in the accompanying drawings.

[0065] As illustrated in Figures 6 and 7, in which a variant embodiment of the apparatus 1 described above is shown, the blade 17 comprises a circular cutter 32.

[0066] The circular cutter 32 is mounted rotatably on an emerging plate 33 protruding from the central body 16 of the operating head 15.

[0067] The circular cutter 32 is designed to rotate about a fourth axis of rotation A4, parallel to the first axis of rotation A1 of the above-mentioned rotary hydraulic motor.

[0068] Advantageously, the transmission of the motion from the rotary hydraulic motor housed in the central body 16 to the circular cutter 32 is performed by means of a flexible transmission element, not illustrated, such as a chain or elastic belt.

[0069] As illustrated in Figure 7, the circular cutter 32 has, distributed along its circumference, a plurality of protruding portions 34 configured to remove the compact material of the horizontal layer 7 during the rotation of the circular cutter 32 about its own axis A4 of rotation.

[0070] The protruding portions 34 are advantageously removable to be periodically replaced when worn.

[0071] As described above with reference to the embodiment of the apparatus 1 illustrated in Figures 1 to 5, also relative to the embodiment of Figures 6 and 7, the hydraulic connections designed for the operation of both the motor element 20 and the first and the second hydraulic actuators 22, 25 are not illustrated in the accompanying drawings.

[0072] In use, with particular reference to Figure 1, the apparatus 1 according to the invention is used to remove, on both sides of the tracks 5, a continuous longitudinal portion 7a of the horizontal layer 7 of compact material.

[0073] In other words, by means of the apparatus 1 according to the invention, two lateral strips of the horizontal layer 7 are removed, with a constant depth, for creating respective cavities designed to receive new resinous material.

[0074] This new resinous material is injected in fluid form in the space created following removal of the continuous longitudinal portions 7a, in such a way as to reconstitute, after hardening, the integrity of the horizontal layer 7 of compact material under the platforms 4.

[0075] The apparatus 1, with the connecting arm 21 in its raised non-operating configuration, illustrated in Figure 5, is moved close to the work site, making it slide along the tracks 5 of the railway line 2.

[0076] As mentioned above, the transport of the apparatus 1 is actuated by a pulling vehicle which is not illustrated.

[0077] In order to prepare the apparatus 1 for the operation, that is, the milling, of the horizontal layer 7 of compact material, the connecting arm 21 is rotated, by means of the second hydraulic actuator 25, in its first lowered operating configuration illustrated in Figure 2, at which the blade 17 is positioned substantially parallel to the above-mentioned predetermined plane P.

[0078] As illustrated in Figure 4a, when the connecting arm 21 is moved to the above-mentioned lowered operating configuration, the blade 17 is disengaged from the horizontal layer 7.

[0079] Thanks to the above-mentioned lead nut and screw mechanism 31, adjustment of the position of the blade 17 is performed with respect to the horizontal layer 7.

[0080] In other words, the aim of this adjustment is to align the height of the blade 17 relative to the horizontal layer 7 of compact material to be milled.

[0081] After reaching the desired height along the direction D2, the operating head 15 is rotated about the axis A2, by means of the first hydraulic actuator 22, in an anticlockwise direction with reference to Figure 4a.

[0082] At the same time as the operating head 15 rotates, the motor element 20 is activated in such a way as to operatively move the blade 17.

[0083] With reference to the first embodiment of the apparatus 1 illustrated in Figures 1 to 5, the chain 19 is moved which therefore starts to slide along the periphery of the flat plate 18.

[0084] Proceeding with the rotation of the operating head 15 relative to the axis A2, at a certain point the chain 19 encounters the horizontal layer 7 of compact material and starts removing parts, cutting it, thus being able to penetrate inside it for the desired depth, as defined for the continuous longitudinal portion 7a.

[0085] After reaching the desired processing depth, the operating position of the blade 17, shown in Figure 4b, is stably defined, in which the chain 19 engages in the milling of the horizontal layer 7 of compact material.

[0086] Starting from that position, the carriage 8 is advanced in the direction D1 in the direction indicated by the arrow F, so as to continue with the processing of the above-mentioned continuous longitudinal portion 7a of the horizontal layer 7 of compact material.

[0087] With reference to the second embodiment of the apparatus 1 illustrated in Figures 6 and 7, with the blade 17 positioned substantially parallel to the above-mentioned predetermined plane P, by means of the above-mentioned lead nut and screw mechanism 31, the position of the blade 17 is adjusted relative to the horizontal layer 7.

[0088] After reaching the alignment between the height of the blade 17, that is, of the circular cutter 32 with the horizontal layer 7 of compact material to be milled, the operating head 15 is rotated about the axis A2, as illustrated in Figure 7, by means of the first hydraulic actuator 22.

[0089] At the same time as the rotation of the operating head 15 the motor unit 20 is activated in such a way as to operatively move the blade 17, that is, rotating the circular cutter 32 about the relative axis of rotation A4.

[0090] Similarly to what is described above with reference to the first embodiment, after the circular cutter 32 has penetrated inside the horizontal layer 7 of compact material for the desired depth, the carriage 8 is advanced in the direction D1 so as to continue with the processing of the continuous longitudinal portion 7a of the horizontal layer 7 of compact material.

[0091] The apparatus 1 according to the invention

achieves the preset aims and brings important advantages.

[0092] The main advantage linked with use of the apparatus 1 according to the invention is due to the possibility of removing the layer of compact material without the need to remove the tracks and the platforms on which the tracks are laid.

[0093] This opportunity results in a marked reduction in the time and costs associated with the operation.

Claims

1. An apparatus for the rehabilitation of the base of a railway line (2) having a horizontal layer (7) of compact material positioned below the tracks (5), comprising:

- a carriage (8) slidable along the tracks (5) of the railway line (2);
- an operating head (15) for at least partial removal of the horizontal layer (7) of compact material positioned below by the tracks (5), the operating head (15) comprising a blade (17) having a substantially plane extension;
- a connecting arm (21) for connecting the operating head (15) to the carriage (8), the connecting arm (21) being configured for positioning the operating head (15) with the blade (17) substantially parallel to a predetermined plane (P) which is tangent to an upper surface (5a) of the tracks (5).

2. The apparatus according to claim 1, **characterised in that** it comprises actuator means (22) for moving the blade (17) inside the horizontal layer (7) of compact material keeping the blade (17) substantially parallel to the predetermined plane (P).

3. The apparatus according to any one of claims 1 and 2, **characterised in that** it comprises a motor element (20) configured for activating the blade (17) in its operating motion.

4. The apparatus according to any one of the preceding claims, **characterised in that** the blade (17) comprises a flat plate (18) and a chain (19) looped on the flat plate (18) and slidable along the perimeter of the flat plate (18), the chain (19) being configured for removing the compact material of the horizontal layer (7).

5. The apparatus according to claim 4, **characterised in that** the chain (19) supports, distributed uniformly along its extension, a plurality of removable excavation teeth designed for removing the compact material with which they enter into contact during the movement of the chain (19).

6. The apparatus according to claim 4 or 5, **characterised in that** the motor element (20) comprises a pinion engaging inside the chain (19), the pinion being supported rotatably by the central body (16). 5
7. The apparatus according to any one of claims 1 to 3, **characterised in that** the blade (17) comprises a circular cutter (32) having along its circumference a plurality of protruding portions (34) configured for removing the compact material of the horizontal layer (7) during a rotation of the circular cutter (32) about its own axis (A4) of rotation. 10
8. The apparatus according to any one of the preceding claims, **characterised in that** the connecting arm (21) is movable between a first lowered operating configuration, at which the blade (17) is positioned substantially parallel to the predetermined plane (P) for removing the compact material of the horizontal layer (7), and a raised non-operating configuration at which the blade (17) is disengaged from the horizontal layer (7), for allowing an easy movement of the carriage (8) along the tracks (5). 15 20
9. A method for rehabilitation of the base of a railway line having a horizontal layer (7) of compact material positioned below the tracks, comprising: 25
- a step of removing, on both sides of the tracks (5), a continuous longitudinal portion (7a) of the horizontal layer (7), 30
 - a step of removing the detritus generated during the step of removing the continuous longitudinal portion (7a),
 - a step of injecting a resinous material in a fluid form in the space created following the removal of the continuous longitudinal portion (7a), the resinous material being such as to reconstitute, after hardening, the horizontal layer (7) of compact material. 35 40
10. The method according to claim 9, **characterised in that** the removal step is actuated with the apparatus (1) according to any one of claims 1 to 8. 45

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FIG. 1

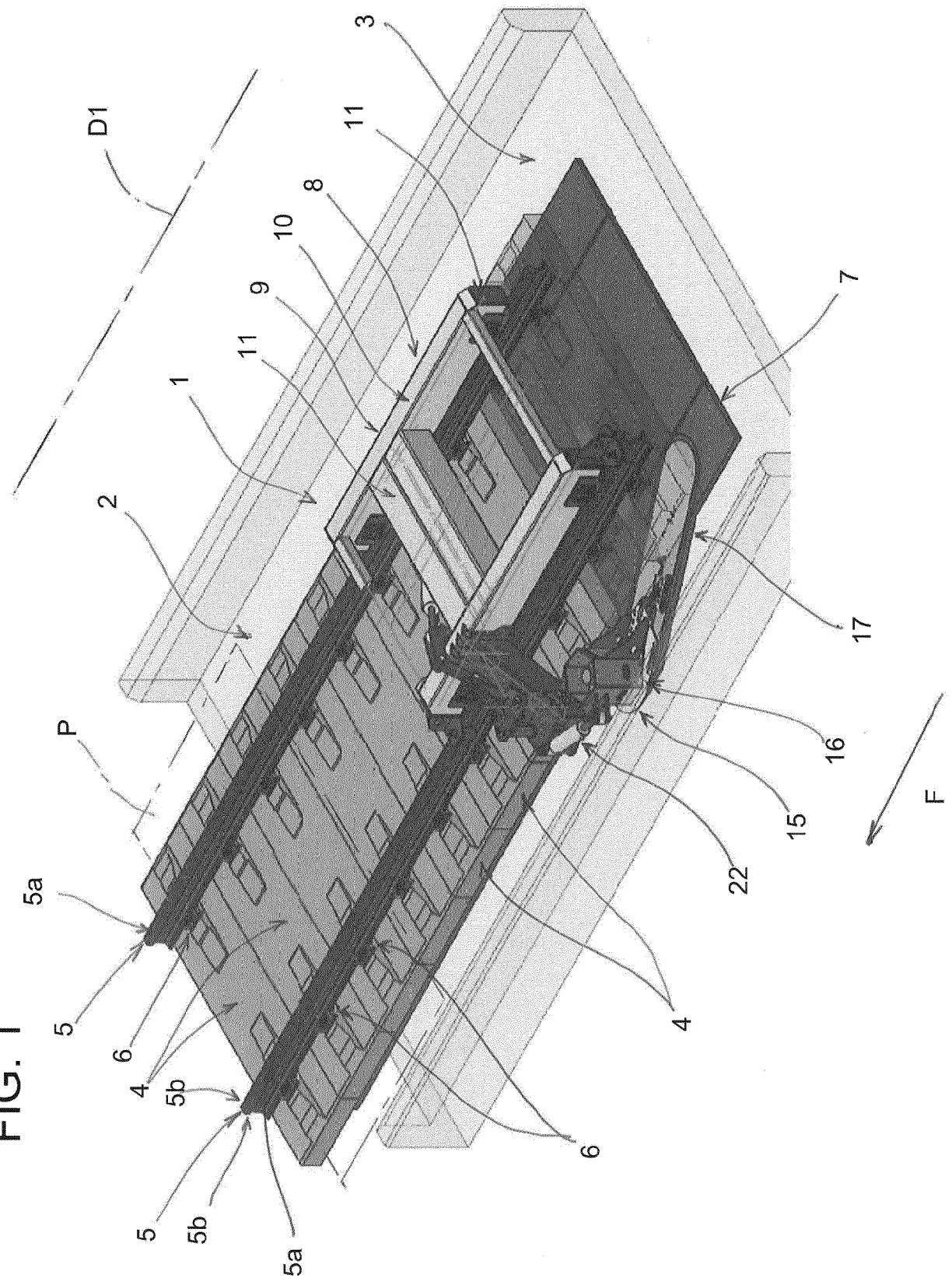


FIG. 3

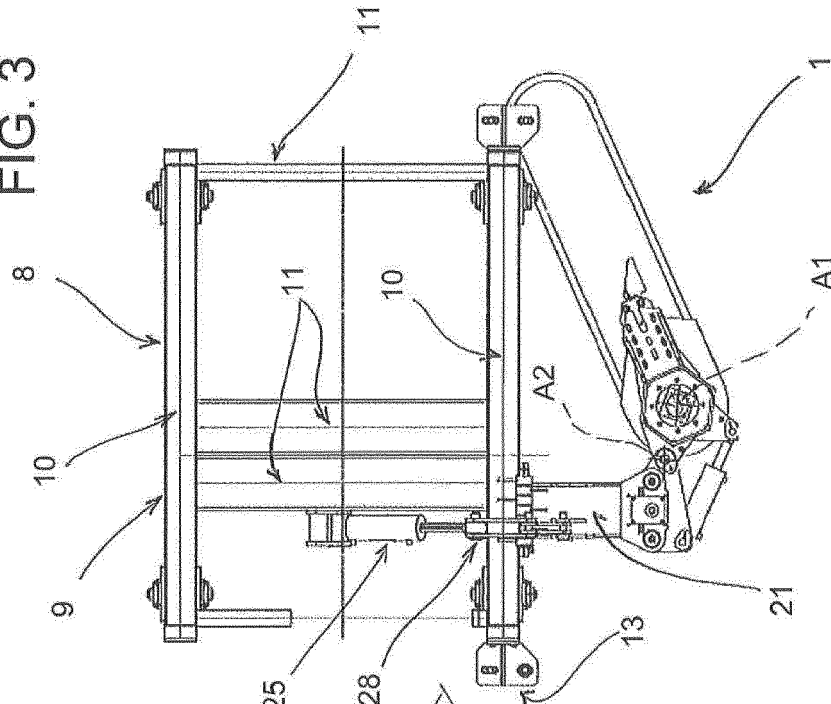
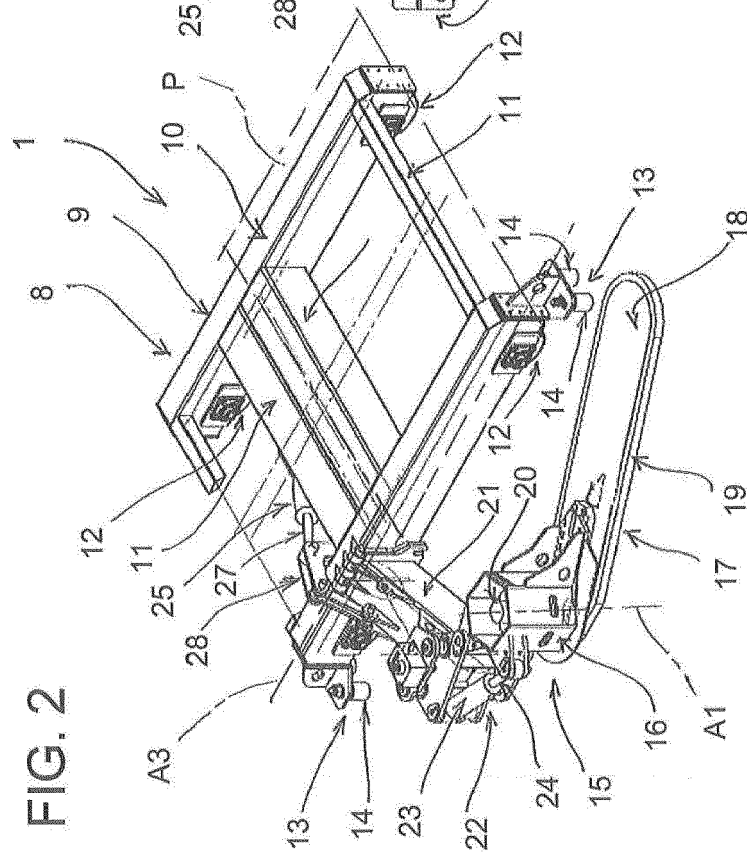
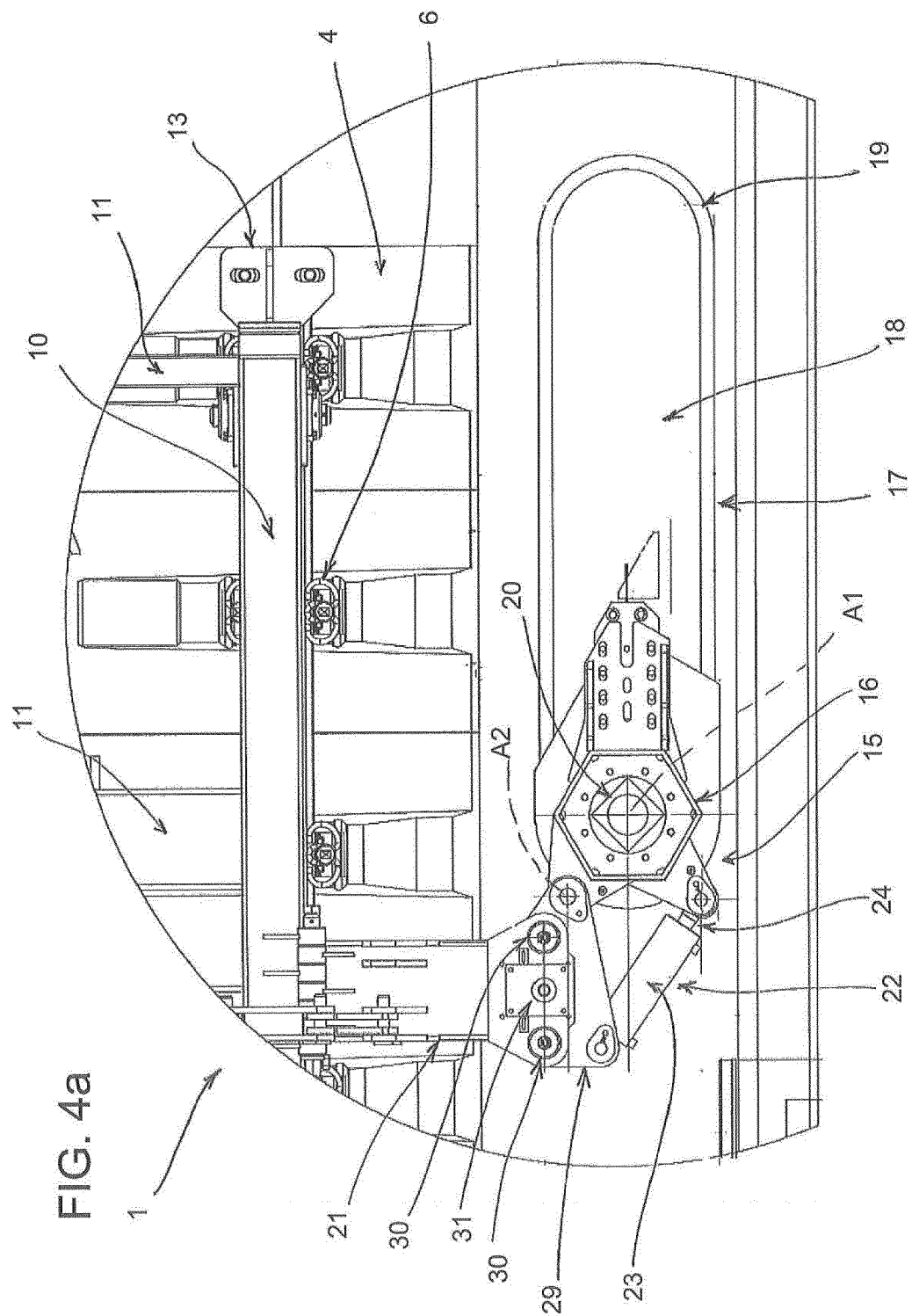
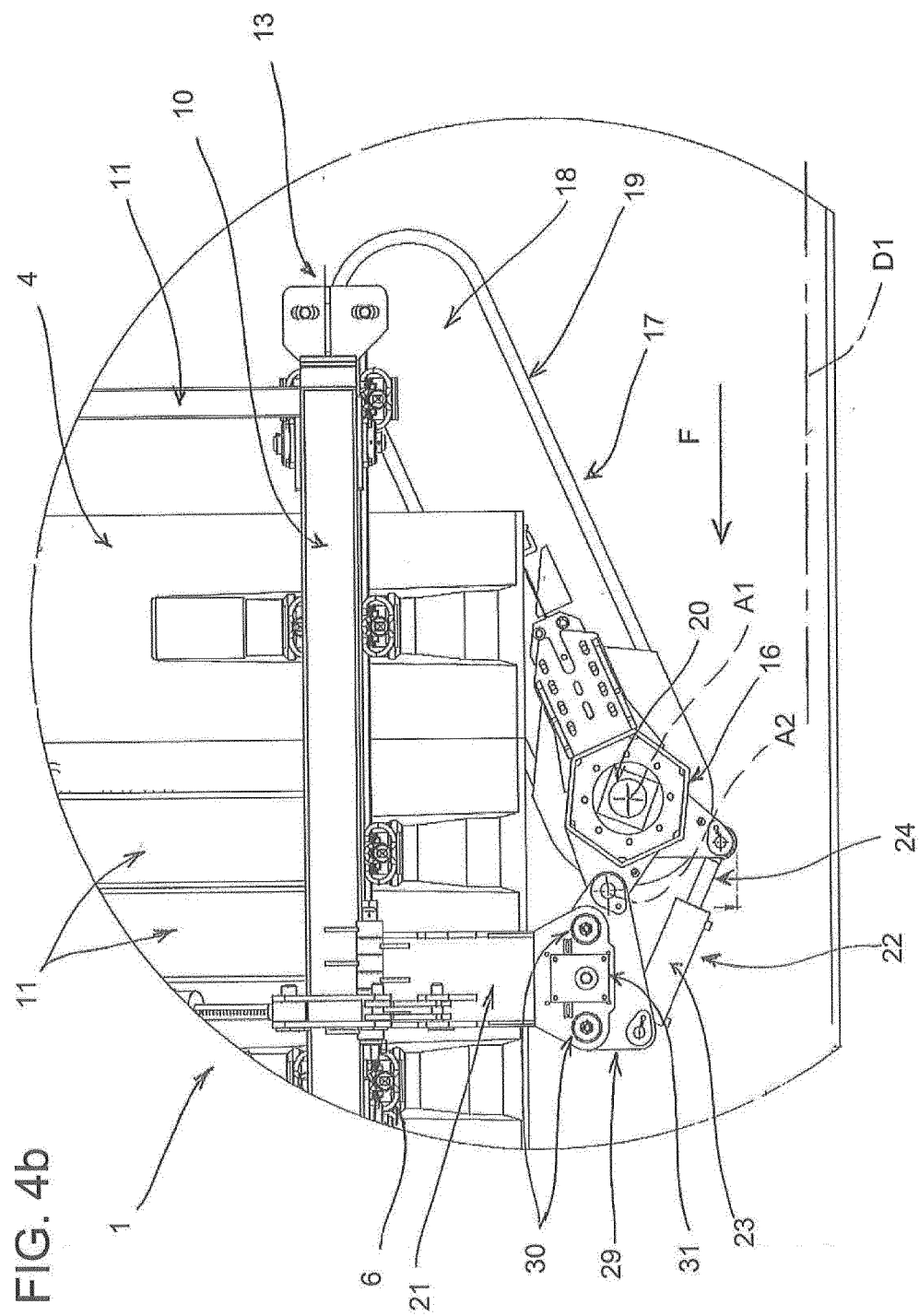


FIG. 2







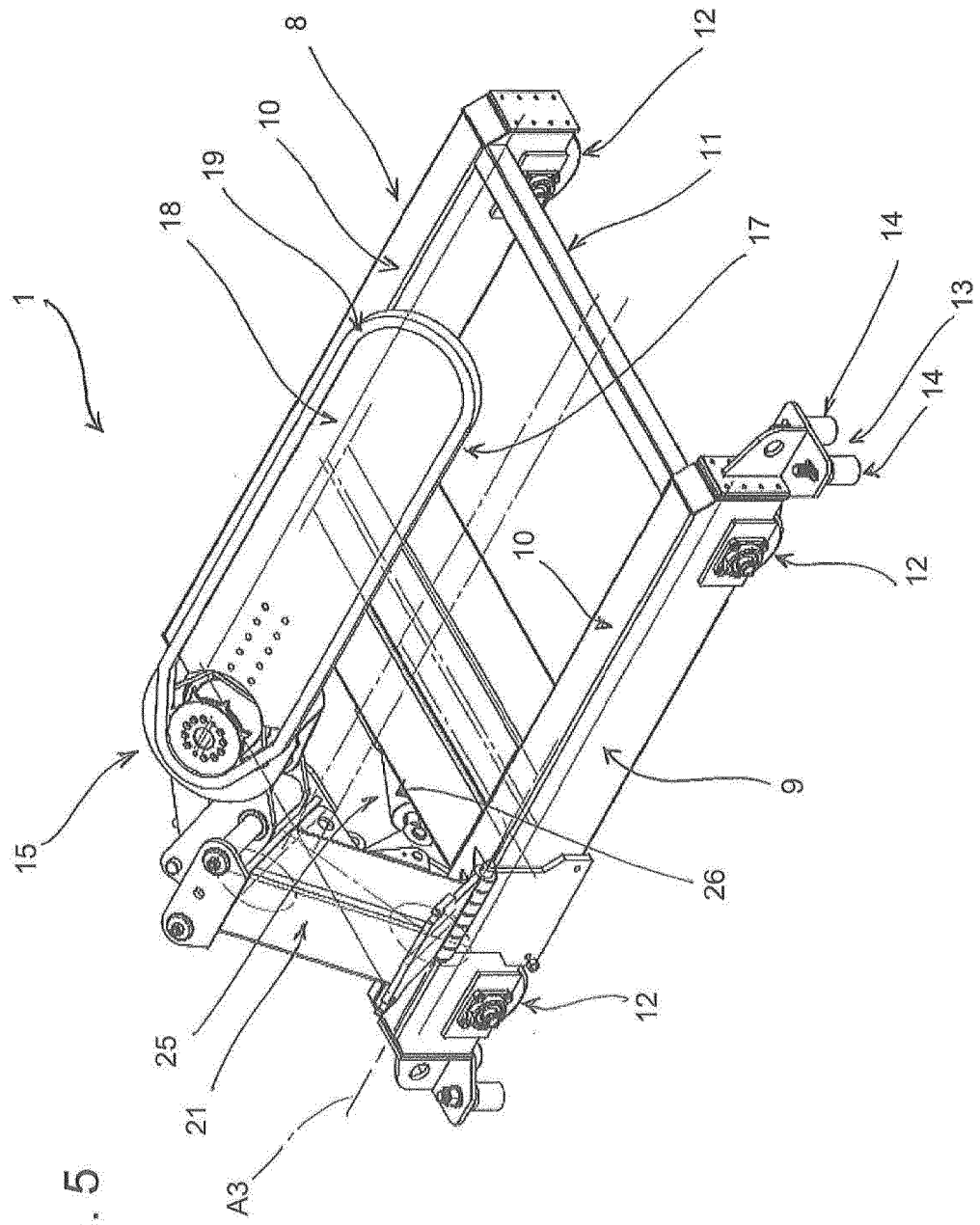


FIG. 5

FIG. 6

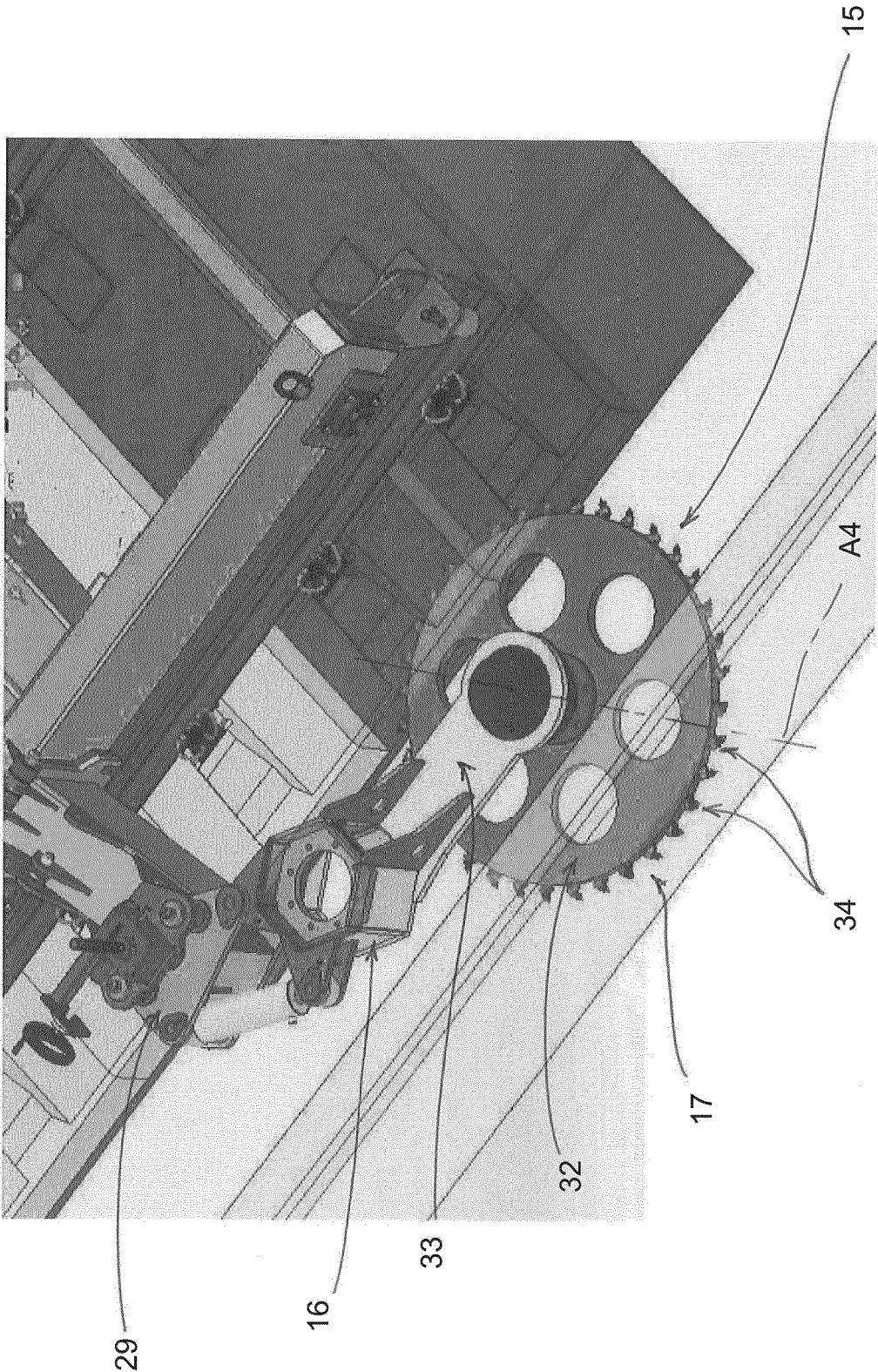
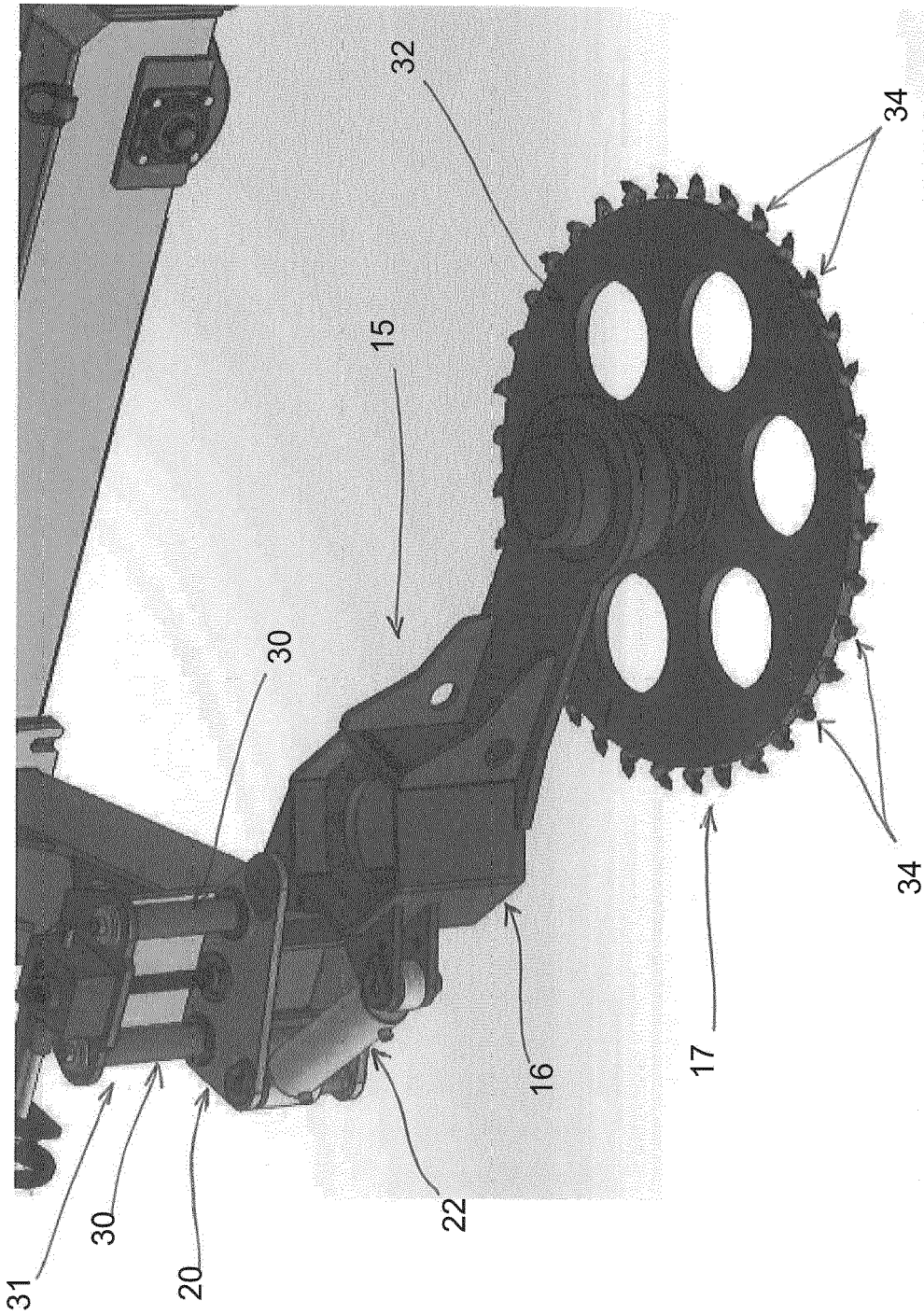


FIG. 7





EUROPEAN SEARCH REPORT

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Place of search		Date of completion of the search	Examiner
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