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(54) CUTTING UNIT, METHOD FOR FORMING PERIODIC ROAD MARKINGS AND RUMBLE ROAD MARKING

(57) The invention relates to a cutting unit (14) for forming periodic road markings (100) in a road surface (102), which cutting unit (14) includes
- a cutting frame (16) for supporting the cutting unit (14) on a supporting work machine (4),
- a rotary cutting tool (18),
- a supporting wheel (20) joined to the cutting frame (16), and
- oscillation means (35) for deflecting the cutting tool (18) in an essentially vertical direction,
- an auxiliary frame (24) attached in an articulated manner to the cutting frame (16) for supporting the cutting tool (18), wherein the cutting tool (18) is a main drum (40) for forming a road marking (100) with an even base (104) in a transverse direction of the road markings (100), and the cutting unit (14) further includes two bevel cutting surfaces (44) mounted in bearings on the cutting frame (16) and arranged so as to form edges (106), wherein a speed of rotation of the main drum (40) and the bevel cutting surfaces (42) is configured to grind the road marking (100).

The invention also relates to a system, a method and a rumble road marking.

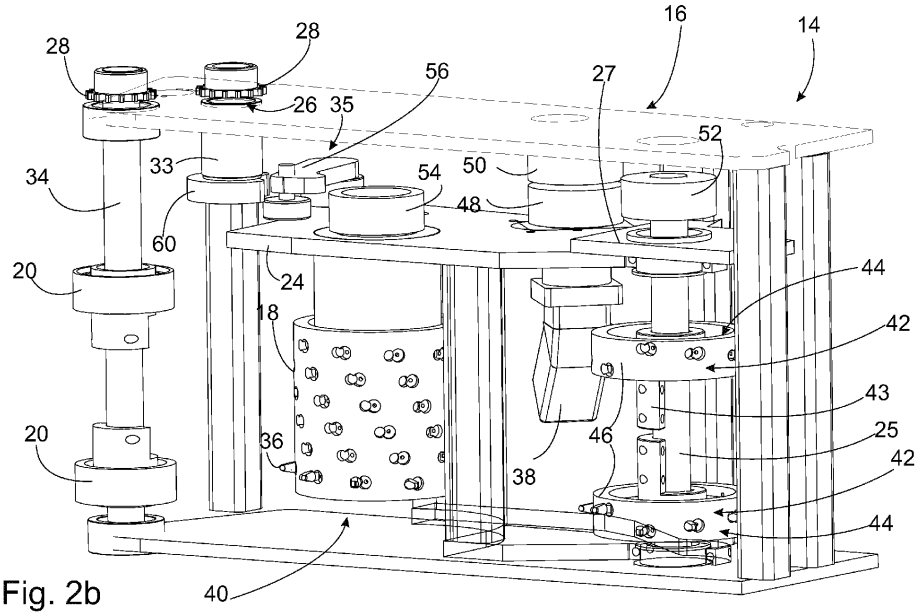

Fig. 2b

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Description

[0001] The invention relates to a cutting unit for forming periodic road markings in a road surface, wherein the cutting unit includes

- a cutting frame for supporting the cutting unit on a supporting work machine,
- a rotary cutting tool for cutting a road marking into a road surface,
- a supporting wheel joined to the cutting frame for supporting the device on the road surface, and
- oscillation means for deflecting the cutting tool in an essentially vertical direction in order to form a periodic, preferably undulating base of the road marking.

[0002] The invention also relates to a system and to a method for forming periodic road markings in a road surface as well as to a corresponding road marking.

[0003] EP 3266935 B, which discloses a milling device for milling rumble road markings into a road surface, is known in the prior art. In this device, a milling device joined to a road vehicle slowly mills material from a road surface by means of a rotary tool while simultaneously moving vertically with a reciprocating motion on an asymmetrical supporting wheel. Detached material is simultaneously collected by means of a suction unit. A significant improvement in efficiency is achieved with this milling device compared to traditional milling devices that come with their own base machine, which are only designed for milling and which require a separate vacuum vehicle and warning vehicle.

[0004] A problem with the cited milling device is, however, the roughness of the resulting edges of the road markings formed by milling as the slowly rotating milling drum tears material from the road surface. In order to obtain a neat final result, the speed of rotation of the milling tool must be set with great precision and the speed of travel must be kept moderate.

[0005] Moreover, for example in Norway, national regulations regarding road markings require road markings to have straight and bevelled edges as well as an even base in a transverse direction of the road marking, so that water is distributed more evenly over the base of the road marking. Such a road marking cannot be formed with a device of the prior art that only has one milling drum like the one cited in the foregoing. With the aforementioned apparatus, it is only possible to form a road marking 100 according to the prior art like the one illustrated in Figure 4, in which the edges 106 undulate just like the base 104 of the road marking. Such a road marking does not meet, for example, national requirements in Norway.

[0006] An object of the invention is to provide a cutting unit that is more efficient than the solutions of the prior art as well as a system and a method for forming road markings by means of which it is possible to form road markings that have bevelled and straight edges as well as an even base in a transverse direction of the road marking faster than the solutions of the prior art. A further object the invention is to provide a rumble road marking with a smoother surface roughness than the rumble road markings of the prior art. The characteristic features of a cutting device according to the invention are set out in the attached patent claim 1; the characteristic features of a system according to the invention are set out in the attached patent claim 10; the characteristic features of a method according to the invention are set out in the attached claim 12; and the characteristic features of a road marking according to the invention are set out in the attached patent claim 15.

[0007] The object of a cutting unit according to the invention can be achieved with a cutting unit for forming periodic road markings in a road surface, which cutting unit includes a cutting frame for supporting the cutting unit on a supporting work machine, a rotary cutting tool for cutting a road marking into a road surface and an auxiliary frame, on which the cutting tool is supported, that is attached in an articulated manner to the cutting frame by means of a transverse first axle of the cutting unit. The cutting unit further includes a supporting wheel joined to the cutting frame for supporting the device on the road surface as well as oscillation means for deflecting the auxiliary frame and the cutting tool in an essentially vertical direction in order to form a periodic, preferably undulating base of the road marking. The cutting tool is a main drum for forming a road marking with an even base in a transverse direction of the road markings. The cutting unit further includes two bevel cutting surfaces mounted in bearings on the cutting frame and arranged so as to form bevelled edges on both sides of the base of the road marking. A speed of rotation of the main drum and the bevel cutting surface is configured to grind the road marking into the road surface.

[0008] With the cutting device according to the invention, it is possible to form road markings with straight and bevelled edges as well as an even base in a transverse direction of the road marking with a significantly higher efficiency than the solutions of the prior art through the use of the grinding technique and the separate implementation of the main drum and the bevel cutting surfaces. The bevel cutting surfaces form bevelled and straight edges of the road marking at a constant depth, whereas the main drum arranged in the articulated auxiliary frame forms by means of the oscillating movement in a vertical direction a base which is even in a transverse direction of the road marking and which varies periodically in depth, i.e. preferably undulates, in a longitudinal direction. By means of the rapidly rotating main drum and bevel cutting surfaces, material is removed from the road surface by grinding, so that the surface of the road marking forms a smoother layer than the asphalt layer of the road surface. This in turn constitutes an advantage for the painting of the road markings, as a smoother surface consumes less paint than the rougher surface according to the prior art.

[0009] Preferably, the bevel cutting surfaces are arranged before the main drum in the direction of travel of the cutting unit in order to form bevelled edges of the road marking on both sides of the base of the road marking.

[0010] For the main drum and the bevel cutting surfaces to grind the markings, as opposed to milling, the main drum and the bevel cutting surfaces are preferably configured to rotate at a peripheral speed of at least 50 m/s, preferably at least 70 m/s, so as to grind the road marking into the road surface.

[0011] More specifically, the main drum and the bevel cutting surfaces can be configured to rotate at a peripheral speed of 50-300 m/s, preferably 70-130 m/s, so as to grind the road marking into the road surface. Using a higher speed than this wastes energy and can damage the structure of the main drum or bevel cutting surfaces.

[0012] Preferably, each bevel cutting surface is formed by a separate bevel drum, which bevel drums are arranged at a distance from each other. By using two bevel drums in this way, the weight of the cutting unit is reduced.

[0013] Alternatively, the bevel cutting surfaces can also be formed in a single bevel drum, which extends over the entire width of the road marking and comprises a bevel cutting surface at each edge. When a single bevel drum is used, a width of the road marking is more difficult to adjust than when two separate bevel drums are used.

[0014] Preferably, the axis of rotation of the main drum is arranged so as to be perpendicular to the direction of travel of the cutting unit and parallel to the road surface.

[0015] Preferably, the bevel drums are rigidly attached to the cutting frame by an axle so that the bevel drums do not oscillate, but only the main drum oscillates vertically. In other words, the bevel drums are arranged so as to travel at an essentially constant depth, whereas the main drum, which is mounted in bearings in the articulated auxiliary frame, oscillates vertically when the oscillation means deflects the auxiliary frame.

[0016] Preferably, the bevel drums include diamond teeth that are arranged over the width of the bevel drum, wherein a length of the diamond teeth in a radial direction of the bevel drum increases or decreases over the width of the bevel drum in order to form a bevelled edge of the road marking. When the bevel drums rotate, each diamond tooth removes material from the road surface when in contact with the road surface, so that the amount of material removed by a single tooth is small and the mark cut is smooth.

[0017] Preferably, the axis of rotation of each bevel drum is perpendicular to the direction of travel of the cutting unit and parallel to the road surface.

[0018] Preferably, the main drum also includes diamond teeth. These are very durable.

[0019] Preferably, each diamond tooth can be attached to the bevel drum or to the main drum individually. It is thereby possible to replace the diamond teeth singly should they become damaged, rather than having to replace the entire bevel drum or main drum whenever a single diamond tooth becomes damaged.

[0020] The oscillation means pivots the auxiliary frame with respect to the first axle in a reciprocating manner, so that the distance of the main drum from the road surface also changes in order to form the undulating base of the road marking.

[0021] Preferably, the oscillation means comprises an asymmetrically shaped wheel mounted in bearings in the cutting frame on which the auxiliary frame rests in order to pivot the auxiliary frame with respect to the first axis in order to obtain the vertical movement of the auxiliary frame. A shaped wheel is a reliable and simple way to achieve a vertical reciprocating oscillating movement of the main drum.

[0022] The oscillation means can also be called periodic deflection means.

[0023] Preferably, the cutting unit includes a power transmission in order to transmit rotational motion from the supporting wheel to the shaped wheel. The shaped wheel thereby automatically rotates in a synchronized manner with the speed of travel of the cutting device.

[0024] Preferably, the bevel drums and the auxiliary frame are arranged on the first axle, wherein the auxiliary frame is mounted in bearings on the first axle and the bevel drums are attached to the first axle in such a manner that the rotational movement of the first axle is transmitted to the bevel drums. The bevel drums thus constantly travel at the chosen constant cutting depth, whereas the main drum, which is mounted in bearings in the auxiliary frame pivoting about the first axis, moves with a varying cutting depth while using the same first axis as a support structure.

[0025] The bevel drums can be attached to the first axle in a releasable manner, so that the position of the bevel drums on the first axle can be changed in order to change the width of the road marking to be cut. This makes it possible to use the same cutting device to produce road markings of different widths without any structural modifications.

[0026] According to one embodiment, the cutting unit includes a first actuator, preferably a hydraulic motor, for rotating the main drum and a second actuator, preferably a second hydraulic motor, for rotating the bevel drums. All in all, hydraulic motors are reliable actuators, for which hydraulics can be supplied from the work machine, for example the truck or tractor, carrying the cutting unit. Alternatively, the actuators can also be electric motors.

[0027] In one embodiment, the shape of the outer perimeter of the shaped wheel corresponds to a sine wave. The vertical movement of the auxiliary frame resting on the shaped wheel is thereby sinusoidal and is simultaneously transmitted to the main drum mounted in bearings in the auxiliary frame and thereby to the shape of the base of the road marking.

[0028] The object of a system according to the invention can be achieved with a system for forming periodic road markings in a road surface, which system includes an apparatus for cutting road markings and a road vehicle

or a trailer of the same for carrying the apparatus, wherein the apparatus includes a frame for suspending the cutting unit from the road vehicle or its trailer and a cutting unit for cutting road markings into a road surface according to any of the embodiments mentioned in the foregoing, which is joined to the frame. The apparatus further includes suction means arranged at least partially in conjunction with the cutting unit for sucking up material of the road surface that has become detached during cutting from the road surface, and height adjustment means arranged in conjunction with the cutting frame for moving the cutting frame in a vertical direction relative to the frame and for setting the cutting depth of the cutting tool into the road surface.

[0029] The system according to the invention integrates both a suction apparatus and a cutting unit in conjunction with a road vehicle or its trailer, so that it is possible with the cutting unit to simultaneously both grind road markings and collect material. In a system according to the invention, the cutting unit can be integrated as part of the road vehicle or its trailer, so that a separate and expensive self-propelled cutting unit is not necessary. In the system according to the invention, the vertical position of the cutting unit in relation to the frame of the apparatus attached to the frame of the road vehicle can be set by means of the height adjustment means in order to obtain a desired depth of the road marking. As the high rotational speed of the main drum and the bevel drums of the cutting unit enables a fast and precise grinding of road markings into the road surface even at high cutting speeds, the use of a road vehicle for the suspension of the cutting unit is optimal, as a road vehicle can easily reach high speeds.

[0030] Preferably, the system includes cooling means for cooling the main drum and the bevel drums, wherein the cooling means includes a water tank, nozzles arranged in conjunction with the main drum and the bevel drums for supplying water, preferably for spraying water onto the main drum and the bevel drums, a pump for pumping water from the water tank to the nozzles, and lines for joining the water tank to the nozzles. The importance of cooling the main drum and bevel drums is increased in a system according to the invention, in which the main drum and the bevel drums of the cutting unit rotate at a remarkably high peripheral speed compared to a milling drum of a milling device according to the prior art. The water supplied by the cooling means also binds dust and prevents the spread of dust into a surrounding area.

[0031] Preferably, the cutting unit is arranged in a longitudinal direction of the road vehicle at a distance between wheels of the road vehicle, mainly underneath the frame of the road vehicle. Arranged in this manner, the cutting unit is protected from shocks and does not increase the overall length of the road vehicle.

[0032] Preferably, the suction means includes a vacuum tank joined to the road vehicle or its trailer for collecting material detached from the road surface during milling, a vacuum unit for providing suction and a vacuum hose for vacuuming material detached from the road surface during milling from the milling tool into the vacuum tank by means of the vacuum created by the vacuum unit. This makes it possible for the road markings to be formed by a single worker who steers the road vehicle while simultaneously controlling the operation of the device.

[0033] Preferably, the road vehicle is a truck. A truck has enough power available to operate the cutting unit and the suction means as well as a sufficient load-bearing capacity for the recovery of the material generated in conjunction with the formation of the road marking. Moreover, when a truck is used, transportation operations can be carried out quickly and the truck can be used for other purposes in winter by detaching the apparatus from the truck.

[0034] Preferably, two cutting units are provided, one on each side of the road vehicle. The cutting unit thus does not have to be detached and reattached when a cutting side is changed.

[0035] The object of the method according to the invention can be achieved with a method for forming periodic road markings in a road surface, in which method a work machine is driven over a road surface, a road marking is formed in the road surface by means of a rotary cutting tool, the cutting tool removing material from the road surface, so that straight bevelled edges are formed in the road marking by means of two rotary bevel cutting surfaces arranged at a distance from each other and an even base is formed in a transverse direction of the road markings using a main drum as the cutting tool. In the method, the main drum is additionally deflected in a vertical direction in order to produce a continuously undulating shape in a longitudinal direction the road marking. In the method, the bevel cutting surfaces and the main drum are arranged in the same cutting unit and the main drum and the bevel cutting surfaces are rotated at a selected peripheral speed to grind the road marking into the road surface.

[0036] In the method according to the invention, the formation of the road marking is a two-part process in which straight edges of a constant depth are formed in the road marking by means of bevel drums arranged at a constant height while the undulating base of the road marking is preferably formed by means of an oscillating main drum following the bevel cutting surfaces. Alternatively, the bevel drums can also be arranged after the main drum in the direction of travel of the cutting unit. By means of the bevel drums that are rigidly supported at a constant depth, a side of the road marking is formed that is of a constant depth and that has smooth edges, while an undulating base of the road marking is formed between the bevel cutting surfaces by means of the vertically oscillating main drum, which is supported on an articulated auxiliary frame.

[0037] The main drum and the bevel cutting surfaces can be rotated at a peripheral speed of 50-300 m/s, pref-

erably 70-130 m/s, so as to grind the road marking into the road surface. Using a higher speed than this wastes energy and can damage the structure of the main drum or bevel drums.

[0038] Preferably, the axis of rotation of the main drum is arranged so as to be perpendicular to the direction of travel of the cutting unit and parallel to the road surface.

[0039] Preferably, a cutting unit for forming road markings according to one of the embodiments described in the foregoing is used in the method.

[0040] Preferably, the periodic road marking that can be formed with the cutting unit, the system and the method according to the invention is a so-called rumble road marking. It is understood, however, that the cutting unit, the system and the method can also be used to form, for example, centre markings of a road or other periodically repeating markings instead of rumble road markings preferably located at the side of the road. Such other road markings do not necessarily cause the same jarring vibration as a rumble road marking but act as an attention-grabbing element in some other manner.

[0041] The object of the road marking according to the invention can be achieved with a periodic road marking for an asphalt road, which includes a base, wherein the base is parallel to the plane of the road surface in a transverse direction of the road marking and undulates in a longitudinal direction of the road marking, and bevelled edges, wherein the edges are joined to the base. The bevelled edges run in the longitudinal direction of the road marking and are essentially straight. The surface roughness (Ra) of the road marking at essentially all surfaces of the road marking lies between 0.2-10 μm, preferably 0.4-6 μm.

[0042] The surface of a road marking according to the invention is smoother than the road markings according to the prior art, which makes it visually neater while also reducing the amount of paint used for painting the road marking. The decrease in paint consumption is a result of the smoother surface, the specific surface area of which is smaller than a rough and porous surface.

[0043] Preferably, the road marking is formed with a method according to one of the embodiments described in the foregoing, in which the road marking is ground into the road surface. Grinding gives the road marking its characteristic surface roughness.

[0044] The invention, which is not limited to the embodiments described in the following, is explained in more detail with reference to the attached figures, wherein

Figure 1a	illustrates a side view of a system according to the invention,
Figure 1b	illustrates a top view of a system according to the invention,
Figure 2a	illustrates a rear axonometric view of a cutting unit according to the invention in isolation obliquely from above,
Figure 2b	illustrates a front axonometric view of a cutting unit according to the invention in isolation obliquely from below,
Figure 2c	illustrates a rear view of a cutting unit according to the invention in isolation,
Figure 2d	illustrates a top view of a cutting unit according to the invention in isolation,
Figure 2e	illustrates a partially sectioned side view of a cutting unit according to the invention in isolation,
Figure 2f	illustrates a view of an opposite side of a cutting unit according to the invention in isolation with respect to Figure 3e,
Figure 3a	illustrates an axonometric view of a system according to the invention without the structures on top of the frame of the road vehicle,
Figure 3b	illustrates a top view of a system according to the invention without the structures on top of the frame of the road vehicle,
Figure 3c	illustrates an axonometric view of a system according to the invention without the structures on top of the frame of the road vehicle obliquely from below,
Figure 4	illustrates an axonometric view of a road marking according to the prior art,
Figure 5	illustrates an axonometric view of a road marking according to the invention,
Figure 6	illustrates a sectional view of a road marking according to the invention in the longitudinal direction of the road marking,
Figures 7a-7c	illustrate, in a cross-sectional view of the road marking, steps for forming a road marking according to the invention with a method according to the invention.

[0045] Figures 1a and 1b illustrate a system 11 according to the invention, the basic parts of which include a road vehicle 1 or a trailer of the same and a road-marking apparatus 10, which comprises a frame 12 of the apparatus 10 attached to a frame 3 of a work machine, preferably a road vehicle 1, a cutting unit 14 which can be attached to the frame 12, suction means 22 for collecting material detached from the road surface 102 during cutting, and height adjustment means 15 for setting a cutting height of the cutting unit 14. The basic idea of the invention is to combine a cutting unit 14 and suction means 22 with a conventional road vehicle 1 or a trailer of the same, so that a plurality of working steps can be carried out by a single person with the same system. Although only road markings made in asphalt are described in this application as markings, the invention can also be applied to road surfaces made of other materials, such as concrete. According to Figures 1a and 1b, the system 11

and the cutting unit 14 according to the invention are formed in conjunction with a truck 2 acting as the road vehicle 1, preferably behind a front tyre 5 of the truck 2, mainly underneath the frame 3 of the truck. Henceforth, a truck will be used as the road vehicle in the description of the embodiments, although it is understood that, instead of a truck, the road vehicle can also be a tractor or wheel loader.

[0046] The cutting unit according to the invention can be used as part of the system according to the invention or entirely separately without the system according to the invention, for example supported on the front lifting apparatus of a wheel loader. In this case, however, the collection of detached material and the warning of other traffic must be carried out with separate work units, which increases the manpower required.

[0047] As illustrated in Figures 2a-2f, the cutting unit 14 according to the invention includes a cutting frame 16 for supporting the cutting unit 14 on a supporting work machine, preferably a road vehicle, and an auxiliary frame 24 attached in an articulated manner inside the cutting frame 16, wherein the auxiliary frame 24 is deflected essentially vertically by oscillation means 35 so as form an undulating base of the road marking. A rotary main drum 40, which acts as the cutting tool 18 of the cutting unit 14, is mounted in bearings in the auxiliary frame 24 and forms the base of the road marking as it rotates. The cutting unit 14 further includes two bevel cutting surfaces 44, which are separate from the main drum 40 and arranged at a distance from each other, for forming bevelled edges of the road marking. Preferably, the bevel cutting surfaces 44 are formed in separate bevel drums 42, one in each bevel drum 42. Preferably, the distance between the bevel drums 42 essentially corresponds to the width of the main drum 40, so that the bevelled edges lie at the edges of the base of the road marking.

[0048] As shown in Figures 2a-2f, the cutting frame 16 can be a preferably rectangular assembly consisting of two parallel steel plate sections 17, wherein the steel plate sections 17 are joined together by means of crosspieces 19. The cutting frame can consist of 5-15 mm steel plate sections and crosspieces 19 made of a 2-8 mm profile, which are welded together. The purpose of the crosspieces 19 is to join the steel plate sections 17 together.

[0049] The auxiliary frame 24 is formed inside the cutting frame 16, wherein the auxiliary frame 24 also consists of two steel plate sections 17 arranged at a distance from each other and a crosspiece 19 that joins them together. The auxiliary frame 24 is preferably mounted in bearings on a first axle 25, which in turn is mounted in bearings in the cutting frame 16 between a steel plate section 17 and a bracket 27, as shown in Figures 2b and 2d. Preferably, the first axle 25 is placed at one end of the cutting frame 16. The main drum 40 is mounted in bearings in the auxiliary frame 24 as shown in Figure 2b and is moved vertically in a reciprocating manner by means of the auxiliary frame 24 during the cutting of the road marking.

[0050] The cutting unit 14 is supported on the road surface by means of a supporting wheel 20, or preferably by two supporting wheels 20 as shown in Figures 2a to 2f, which are located on a second axle 34 which is mounted in bearings on the cutting frame 16 at an opposite end to the first axle 25. Preferably, the cutting unit 14 includes a power transmission 26, which can be realized by means of a gear transmission using a toothed gear 28 mounted on an extension of the second axle 34. The figures do not illustrate a chain or belt of the gear transmission. As the cutting unit 14 advances over the road surface, the supporting wheel or wheels 20 resting on the road surface, which are preferably pushed by the road vehicle, transmit rotational motion to the second axle 34 with which the toothed gear 28 rotates. This rotary motion is transmitted by means of a chain or belt to a third axle 33, which is mounted in bearings on the cutting frame 16 as shown in Figure 2b. A toothed gear is also attached to an extension of the third axle 33, which toothed gear receives the drive transmitted by the chain or belt and thus rotates the third axle 33. Preferably, a shaped wheel 60 is arranged on the third axle 33, wherein the outer shape of the shaped wheel 60 determines the shape of the base of the road marking to be formed in the longitudinal direction of the road marking. Preferably, the shape of the outer surface of the shaped wheel 60 corresponds to a sine wave, so that the shape of the base of the road marking is formed accordingly in the longitudinal direction of the road marking. The auxiliary frame 24 is preferably supported on the shaped wheel via an arm 56, which is rigidly attached to the auxiliary frame 24. The arm 56 transmits the motion of the rotating shaped wheel 60 to the auxiliary frame 24, which pivots about the first axle 25, thus providing a vertical, reciprocating motion of the rotating main drum 40. In other words, the second axle 34, the supporting wheel or wheels 20, the power transmission 26, the third axle 33, the shaped wheel 60 and the arm 56 constitute the oscillation means 35 of the cutting unit 14 in a preferred embodiment.

[0051] Alternatively, the oscillation means can also be realized by supporting the auxiliary frame directly on the road surface by means of a shaped wheel mounted in bearings on the auxiliary frame, but in this case the problem can occur that the shaped wheel starts to slide against the substrate, which stops the oscillation. The implementation of the oscillation means illustrated in Figure 2b does not have this problem, as the weight of the entire cutting unit rests on the supporting wheel or wheels 20.

[0052] Should the problem of a slippage of the supporting wheel arise, it is possible to use an attachment point 30, as shown in Figure 2a, in order to install a separate motor as part of the power transmission with which a synchronized movement of the auxiliary frame is ensured relative to the speed of travel.

[0053] Preferably, the supporting wheels are laterally

adjustable on the second axle. The supporting wheels can thus be arranged so as to move at least partially over the bevel to be cut, so that an uneven shape of the road does not cause a defect in the road marking being cut.

[0054] In the cutting unit 14 according to the invention, the main drums 40 and the bevel cutting surfaces 44 are rotated at a peripheral speed of at least 50 m/s, preferably at least 70 m/s. With a diameter of the main drum of 200 mm, the speed of rotation is in the order of 3000 rpm. When the main drum and the bevel cutting surfaces meet the road surface, the rotational speed is so high that the material is removed by grinding off small layers of material, in contrast to a milling according to the prior art in which a thick layer of material is removed all at once at a slow speed of rotation. Preferably, both the main drum 40 and the bevel drums 42 which advantageously comprise the bevel cutting surfaces are rotated using a hydraulic motor, which is indicated in Figures 2a-2f by the reference number 38. The hydraulic motor can comprise a gearbox in order to increase the rotational speed of the power output axle. The torque that a motor requires when grinding is considerably lower than for milling, but the required speed of rotation is higher.

[0055] Preferably, two drive wheels 48 and 50, which are visible in Figure 2b, are arranged on the output axle of the transmission of the hydraulic motor 38. These allow power to be transmitted to the main drum 40 and to the bevel drums 42, preferably by means of a belt drive. More specifically, the belt is arranged between a first drive wheel 48 and a third drive wheel 54, which is arranged on an extension of the axle of the main drum 40, and between a second drive wheel 50 and a fourth drive wheel 52, which is arranged on an extension of the first axle 25, although the belts are not illustrated in the figures. Alternatively, instead of using a belt drive, drive can also be transmitted using, for example, toothed gears and a chain.

[0056] As shown in Figure 2b, the bevel drums 42 are fastened to the first axle 25 so that the first axle 25 transmits rotational motion to the bevel drums 42. The bevel drums 42 can be attached to the first axle using a clamping fastener 43 connected to each bevel drum 42. By loosening the bolts 43 of the clamping fastener, the bevel drums 42 comprising the bevel cutting surface 44 can be moved along the length of the first axle 25 to desired positions for cutting road markings of different widths.

[0057] Preferably, diamond teeth 36 are attached to both the bevel drums 42 and the main drum 40 in a staggered arrangement as shown in Figure 2c. The diamond teeth are preferably individually attached to recesses formed in the outer surface of the bevel drums 42 and of the main drum 40, so that the diamond teeth can be replaced individually if necessary. It is mainly the diamond teeth that are in contact with the road material, not the outer surfaces of the drums. Contact of the outer surfaces of the drums with the road material only occurs when material that has become detached strikes the outer surface. The diamond teeth can be 5-20 mm, preferably 8-12 mm, in diameter and can be individually soldered to machined receptacles formed in the outer surface of the drum. Like the main drum, the outer surface of the bevel drums can be parallel to the axis of rotation and constant in diameter, although the desired cutting result is a bevelled edge in the road marking. The bevelled shape is preferably achieved by altering the length of the diamond teeth of the bevel drum in the radial direction of the drum so that the diamond teeth closer to the centre of the cutting unit are longer than they are as one moves over the bevel drum towards the edges of the cutting unit. Preferably, the bevel drums and the main drum used are continuous, i.e. they have diamond teeth all around the drum and the drum rotates continuously.

[0058] Figures 3a-3c illustrate in more detail an attachment of a cutting unit 14 according to the invention as part of the apparatus 10 designed to cut road markings, which forms part of the system 11 according to the invention. In this embodiment, the wheels 4 in the frame 3 of the road vehicle 1 are arranged in a different manner than in the embodiment of Figures 1a and 1b, although the cutting unit 14 is located between the wheels 4 in both embodiments. The frame 12 of the apparatus 10 is formed by a transverse frame plate 70, which is better visible in Figure 3c, which forms a forked structure that envelops the frame 3 of the road vehicle 1. The transverse frame plate 70 is connected to lateral translation guides 72, which can be telescopic. The cutting unit 14 is connected to a movable carriage 80 on the lateral translation guides 72, wherein the carriage 80 can be translated on the lateral translation guides 72 by pushing by means of lateral translation cylinders 76. The lateral translation cylinder 76 can be joined between the transverse frame plate 70 and the carriage 80. An analogous transverse frame plate can also be used in order to attach the rear lateral translation guide in the direction of travel to the frame or attachment can also occur as shown in Figures 3a-3c by means of an attachment plate 82 attached directly to the side of the frame 3 of the road vehicle 1. Although only one lateral translation cylinder 76 is shown in Figures 3a-3c, it is understood that lateral translation cylinders are preferably provided in conjunction with both lateral translation guides 72 and carriages 80 in order to allow the cutting unit 14 to be moved to one side of the road vehicle 1 or into a position hidden underneath the road vehicle 1 for transport. In other words, the frame 12 is preferably formed by a transverse frame plate 70, lateral translation guides 72 and carriages 80.

[0059] Although Figures 3a-3c only illustrate a single cutting unit 14 arranged on one side of the road vehicle 1, it is understood that the system according to the invention and an apparatus of the same preferably include two frames and two cutting units, one on each side of the frame of the road vehicle.

[0060] The system 11 according to the invention includes height adjustment means 15 by means of which it is possible to set a cutting depth of the bevel drums 42

of the cutting unit 14. In the embodiment shown in Figure 3a, the height adjustment means 15 includes a transverse pivot joint 84 arranged in conjunction with the carriage 80 on the rear lateral translation guide 72 in the direction of travel, about which transverse pivot joint 84 the cutting frame 16 can be rotated by means of a lifting cylinder 74 belonging to the carriage 80 on the front lateral translation guides 72 in the direction of travel. The lifting cylinder 74 is arranged between the carriage 80 and the cutting frame 16 and, by altering the length of the lifting cylinder 74, the cutting frame 16 can be rotated relative to the transverse pivot joint 84.

[0061] According to one embodiment, the height adjustment means can be an adjustment means of the air springs of the truck with which it is possible to adjust a distance between the frame of the truck and the road surface in order to obtain the right cutting depth.

[0062] According to one embodiment, the lifting cylinder 74 can also be used, where necessary, to press the cutting unit against the substrate in cases where the cutting unit tends to lift off the road surface.

[0063] The suction means used can in principle be commercially available devices according to the prior art, which are integrated in a road vehicle or the like using components manufactured for this purpose.

[0064] The suction means can be, for example, the high-power vacuum manufactured by the Finnish company KEOX Oy, which has a capacity of 2200-9600 m^3/h. The power requirements of a high-power vacuum can be 60-100 kW during operation. A high-power vacuum preferably acting as the suction means 22 includes, as shown in Figure 1a, a vacuum tank 66 for material detached from the road surface 102, a vacuum unit 68 for forming a vacuum and a vacuum hose 64 for conveying the material to the vacuum tank 66. The end of the vacuum hose on the side of the cutting unit can include a separate vacuum box for this purpose, which is arranged behind the cutting unit in its direction of travel. It is possible for 30-80%, preferably 60-70%, of the airflow generated by means the vacuum unit to be recirculated as a blast associated with the main drum in order to lift the milled road surface material into the air while the remaining amount of air is sucked into the tank in order to collect the detached material. The material on the road surface that has been detached by the main drum can thus be lifted into the air and is thereby conveyed together with the vacuum flow along the vacuum hose into the vacuum tank.

[0065] In the system 11 according to the invention, the vacuum tank 66 and the vacuum unit 68 comprised by the suction means 22 can be arranged on a pallet so that they can be easily lifted onto a truck 2 and potentially also tipped. Alternatively, the suction means 22 can be arranged directly in the tipping frame of a truck. As shown in Figure 1b, the cutting unit 14 can be used on either side of the road vehicle 1.

[0066] Preferably, the apparatus 10 includes cooling means for cooling the main drum and the bevel drums, wherein the cooling means includes a water tank 86 that is visible in Figures 3a-3c, nozzles arranged in conjunction with the main drum and the bevel drums for supplying water, preferably for spraying water onto the main drum and onto the bevel drums, a pump for pumping water from the water tank to the nozzles, and lines for joining the water tank to the nozzles. The nozzles are preferably arranged close to the main drum and the bevel drums so that the water they spray or sprinkle comes into contact with the drums, thereby binding dust and cooling the diamond teeth.

[0067] Figure 5 shows a road marking 100 according to the invention in an axonometric view. The bevelled edges 106 of the road marking 100 formed by the bevel drums are straight, because the bevel drum travels at a constant height. The base 104 of the road marking 100, on the other hand, is undulating in a longitudinal direction of the road marking 100, as shown in Figure 6, and even in a transverse direction. By forming the surfaces by grinding, the edges of the road marking according to the invention are very precise and neat and the plane surfaces are very smooth compared to road markings formed by milling. The surface of the road marking is essentially smoother than a smoothness of the asphalt of the road surface, with surface irregularities that are 5-50% of the depth of the irregularities of the road surface.

[0068] Figures 7a-7c show steps of a method according to the invention in a cross-sectional view of a road marking. In a preferred embodiment, the bevelled edges 106 of the road marking are first formed in the road surface 102 by means of the bevel drums 42, as shown in Figure 7a. There follows, as shown in Figure 7b, the main drum 40, which forms the base 104 of the road marking 100 between the bevelled edges 106, wherein a depth of the base 104 can vary between the depth of the bevelled edges and a maximum depth illustrated in Figure 7c, which can be, for example, 10-60 mm greater than the minimum depth. Alternatively, the road marking can also be realized in such a manner that the main drum first forms the base of the road marking before the road marking is finished with the formation of the bevelled edges.

[0069] The road markings can be 100-500 mm wide, but are preferably either 300 mm or 500 mm as stipulated by standards. In Finland, roadside markings are 300 mm wide on A and B roads, and 500 mm wide on motorways. A width of the cutting unit can be 300-1000 mm, preferably 500-700 mm. The road vehicle used in the system according to the invention, preferably a truck, has the advantage that it is possible to transport sufficiently large loads with the same. The amount of material detached from the road surface produced in sinusoidal cutting is about 2.85 solid cubic metres per kilometre for a cut 300 mm wide, which corresponds to 4.3 loose cubic metres per kilometre.

[0070] In the system according to the invention, a cutting unit configured as part of the truck renders possible,

by grinding, a significantly higher cutting speed than cutting units of the prior art. The system according to the invention is specifically designed to grind, instead of milling, the road markings, so that the cutting unit joined to the frame of the truck can be operated at a much higher speed, up to a speed of travel of 10-20 km/h. Preferably, all operating power requirements of the cutting unit can be realized in the truck, which can be equipped with a separate power unit by means of which 80-150 kW of power, preferably around 110-130 kW of power, can be produced during travel, of which 2/3 goes to the high-power vacuum and 1/3 goes to the cutting unit. The cutting unit is preferably connected to the truck or its power unit by means of quick couplings as well as to the hydraulic, pneumatic and electrical systems of the truck.

[0071] The cutting unit also preferably includes an electronic control unit, which is arranged in the cab of the truck. By means of the control unit, an operator can start up the motor that rotates the main drum and bevel drums of the cutting unit, the suction means and perform lateral and vertical movements. The control unit can also include a display, which is connected to a camera that monitors the road surface. This makes it easier for the operator to keep the cutting unit aligned with a desired line of the road markings to be cut.

[0072] The system according to the invention can also include, for example, a trailer that can be attached to the rear of the truck, the trailer including a warning sign for traffic arriving from the rear and a rear collision protection in order to dampen a potential collision. The system can thus be used without a separate warning car bringing up the rear.

[0073] According to one embodiment, for example instead of a truck or tractor, the cutting unit according to the invention can also be arranged, for example, in a semi-trailer of a truck or tractor. This also allows the cutting unit to closely follow the path travelled by the road vehicle towing it, so that an operator can position the cutting unit precisely at a desired point where the road markings to be cut are made.

[0074] Outside the scope of the invention, it is also conceivable for the cutting unit, the system and the method according to the invention to be used to form other recesses instead of road markings, for example to form periodic recesses to be made in floors in buildings or for some analogous suitable use.

Claims

1. A cutting unit (14) for forming periodic road markings (100) in a road surface (102), which cutting unit (14) includes

   - a cutting frame (16) for supporting the cutting unit (14) on a supporting work machine (4),
   - a rotary cutting tool (18) for cutting a road marking (100) into a road surface (102),
   - a supporting wheel (20) joined to the cutting frame (16) for supporting the device (10) on the road surface (102), and
   - oscillation means (35) for deflecting the cutting tool (18) in an essentially vertical direction in order to form a periodic, preferably undulating base (104) of the road marking (100),

   characterized in that the cutting unit (14) further includes an auxiliary frame (24) attached in an articulated manner to the cutting frame (16) by means of a first transverse axle (25) of the cutting unit (14), on which auxiliary frame (24) the cutting tool (18) is supported, wherein the oscillation means (35) is configured to periodically deflect the auxiliary frame (24), and wherein the cutting tool (18) is a main drum (40) for forming a road marking (100) with an even base (104) in a transverse direction of the road markings (100),
   and the cutting unit (14) further includes two bevel cutting surfaces (44) mounted in bearings on the cutting frame (16), wherein a speed of rotation of the main drum (40) and the bevel cutting surfaces (44) is configured to grind the road marking (100) into the road surface (102).

2. The cutting unit according to claim 1, **characterized in that** the main drum (40) and the bevel cutting surfaces (44) are configured to rotate at a peripheral speed of 50-300 m/s, preferably 70-130 m/s, so as to grind the road marking (100).

3. The cutting unit according to claim 1 or 2, **characterized in that** each bevel cutting surface (44) is formed by a separate bevel drum (42), wherein the bevel drums (42) are arranged at a distance from each other.

4. The cutting unit according to any one of claims 1-3, **characterized in that** the bevel drums (42) include diamond teeth (36) that are arranged over the width of the bevel drum (42), wherein a length of the diamond teeth (36) in a radial direction of the bevel drum (42) increases or decreases over the width of the bevel drum (42) in order to form a bevelled edge (106) of the road marking (100).

5. The cutting unit according to any one of claims 1-4, **characterized in that** the oscillation means (35) comprises an asymmetrically shaped wheel (60) mounted in bearings in the cutting frame (16) on which the auxiliary frame (24) rests in order to pivot the auxiliary frame (24) about the first axis (25) in order to obtain a vertical oscillating movement of the auxiliary frame (24).

6. The cutting unit according to claim 5, **characterized in that** the cutting unit (10) includes a power trans-

mission in order to transmit rotational motion from the supporting wheel (20) to the shaped wheel (60).

7. The cutting unit according to any one of claims 1-6, **characterized in that** the bevel cutting surfaces (43) and the auxiliary frame (24) are arranged on the first axle (25), wherein the auxiliary frame (24) is mounted in bearings on the first axle (25) and the bevel drums (42) are attached to the first axle (25) in such a manner that the rotational movement of the first axle (25) is transmitted to the bevel drums (42).

8. The cutting unit according to claim 7, **characterized in that** the bevel drums (42) are attached to the first axle (25) in a releasable manner, so that the position of the bevel drums (42) on the first axle (25) can be changed in order to change the width of the road marking (100) to be cut.

9. The cutting unit according to any one of claims 1-8, **characterized in that** the cutting unit (14) includes a first actuator, preferably a hydraulic motor, for rotating the main drum (40) and a second actuator, preferably a second hydraulic motor, for rotating the bevel drums (42).

10. A system (11) for forming periodic road markings (100) in a road surface (102), which system (11) includes an apparatus (10) for cutting road markings (100) and a road vehicle (1) or trailer of the same for carrying the apparatus (10), wherein the apparatus (10) includes

- a frame (12) for suspending the cutting unit (14) from the road vehicle (1) or its trailer,
- a cutting unit (14) for cutting road markings (100) into a road surface (102), which is joined to the frame (12),
- suction means (22) arranged at least partially in conjunction with the cutting unit (14) for sucking up material of the road surface (102) that has become detached during cutting from the road surface (102),
- height adjustment means (15) arranged in conjunction with the cutting frame (16) for moving the cutting frame (16) in a vertical direction relative to the frame (12) and for setting the cutting depth of the cutting tool (18) into the road surface (102), **characterized in that** the cutting unit (14) is a cutting unit (14) according to any one of claims 1-9.

11. The system according to claim 10, **characterized in that** the system (1) includes cooling means for cooling the main drum (40) and the bevel drums (42), wherein the cooling means includes a water tank (86), nozzles arranged in conjunction with the main drum (40) and the bevel drums (42) for supplying water, preferably for spraying water onto the main drum (40) and the bevel drums (42), a pump for pumping water from the water tank (86) to the nozzles, and lines for joining the water tank (86) to the nozzles.

12. A method for forming periodic road markings (100) in a road surface (102), wherein in the method

- a work machine (4) is driven over a road surface (102),
- a road marking (100) is formed in the road surface (102) by means of a rotary cutting tool (18), the cutting tool removing material from the road surface (102),
- the cutting tool (18) is deflected in a vertical direction in order to produce a continuously undulating shape in a longitudinal direction of the road marking (100),
characterized in that
- straight bevelled edges (106) are formed in the road marking (100) by means of two rotary bevel cutting surfaces (44) arranged at a distance from each other,
- an even base (104) is formed in the road marking (100) in a transverse direction of the road markings (100) using a main drum (40) as the cutting tool (18),

wherein in the method the bevel cutting surfaces (44) and the main drum (40) are arranged in the same cutting unit (14) and the main drum (40) and the bevel cutting surfaces (44) are rotated at a selected peripheral speed so as to grind the road marking (100) into the road surface (102).

13. The method according to claim 12, **characterized in that** the main drum (40) and the bevel cutting surfaces (44) are rotated at a peripheral speed of 50-300 m/s, preferably 70-130 m/s, so as to grind the road marking (100) into the road surface (102).

14. The method according to claim 13, **characterized in that** a cutting unit (14) for forming road markings (100) according to any one of claims 1-9 is used in the method.

15. A rumble road marking (100) for an asphalt road, which includes

- a base (104), wherein the base (104) is parallel to the plane of the road surface (102) in a transverse direction of the road marking (100) and undulates in a longitudinal direction of the road marking (100), and
- bevelled edges (106), wherein the edges (106) are joined to the base (104), **characterized in that** the bevelled edges (106) run in the longi-

tudinal direction of the road marking (100) and are essentially straight, wherein a surface roughness (Ra) of the road marking (100) at essentially all surfaces of the road marking (100) lies between 0.2-10 μm, preferably 0.4-6 μm.

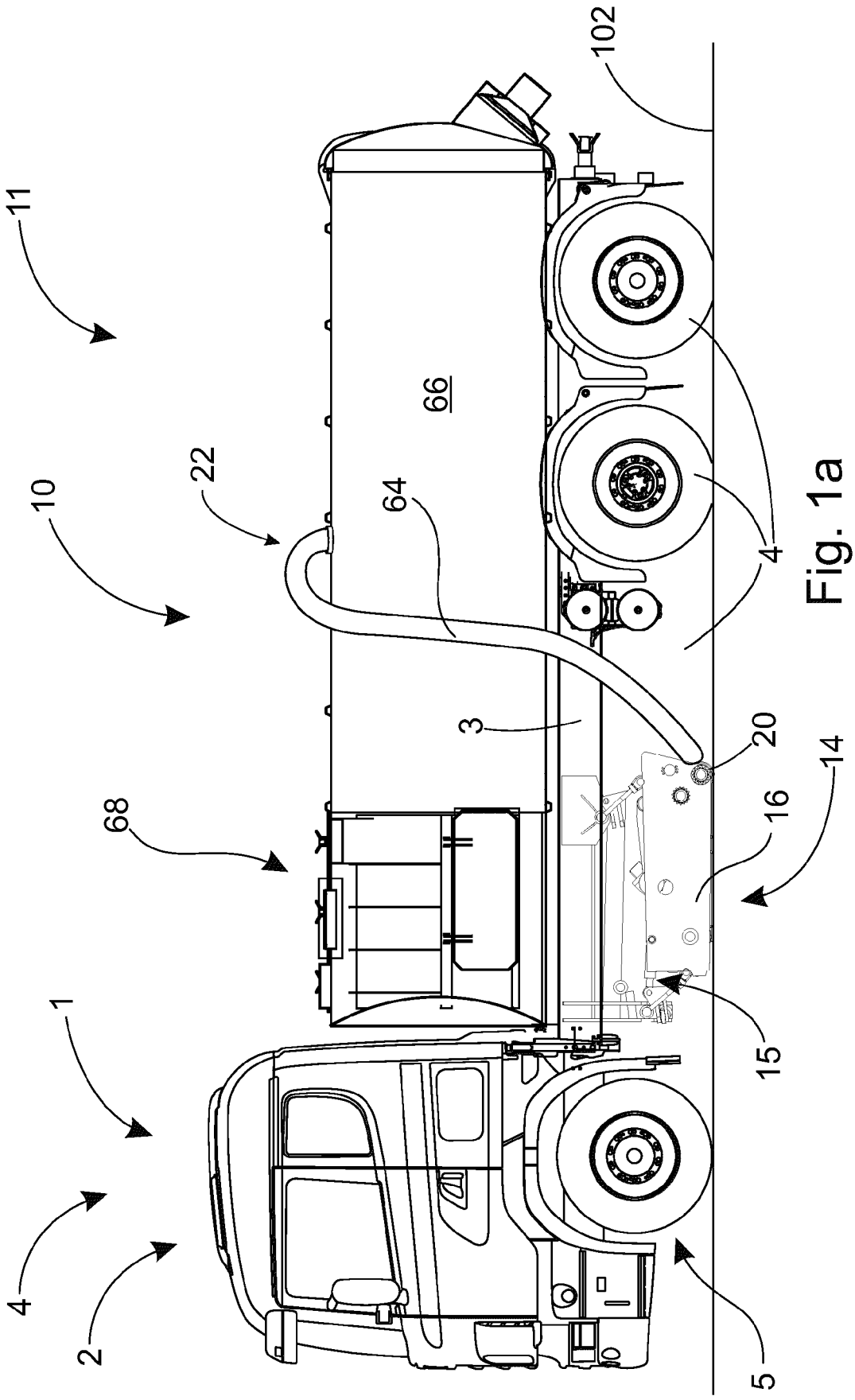

Fig. 1a

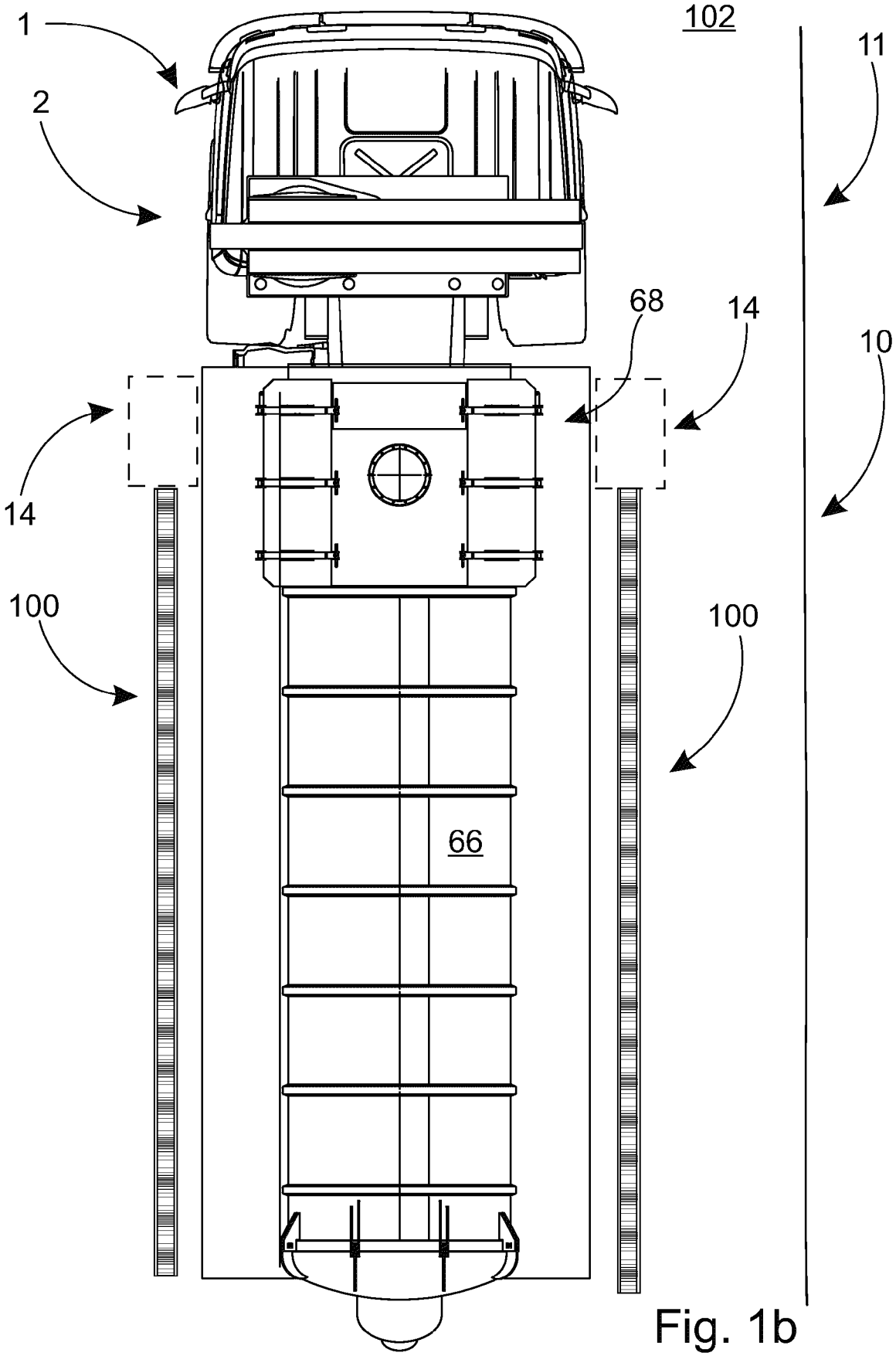

Fig. 1b

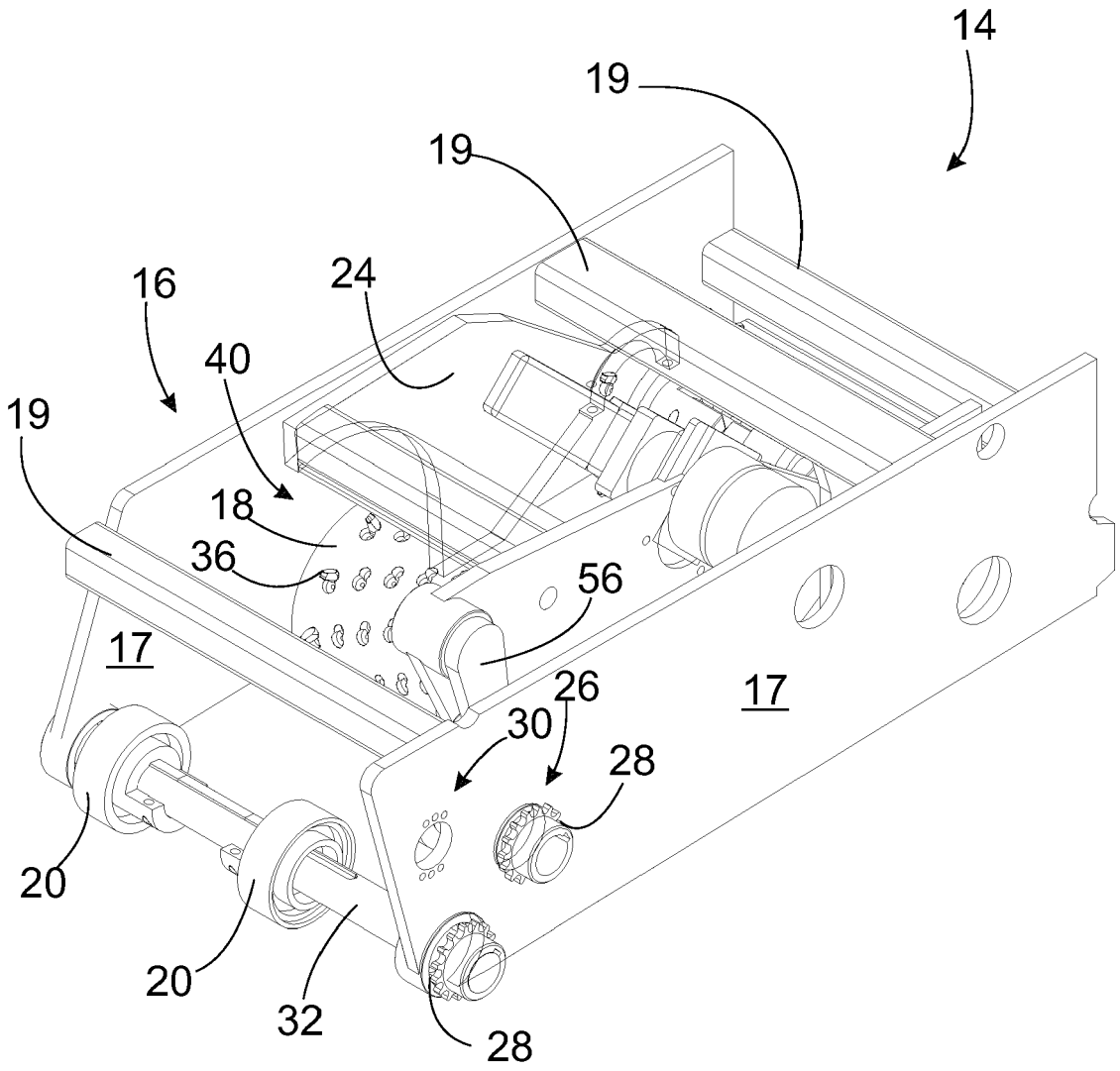

Fig. 2a

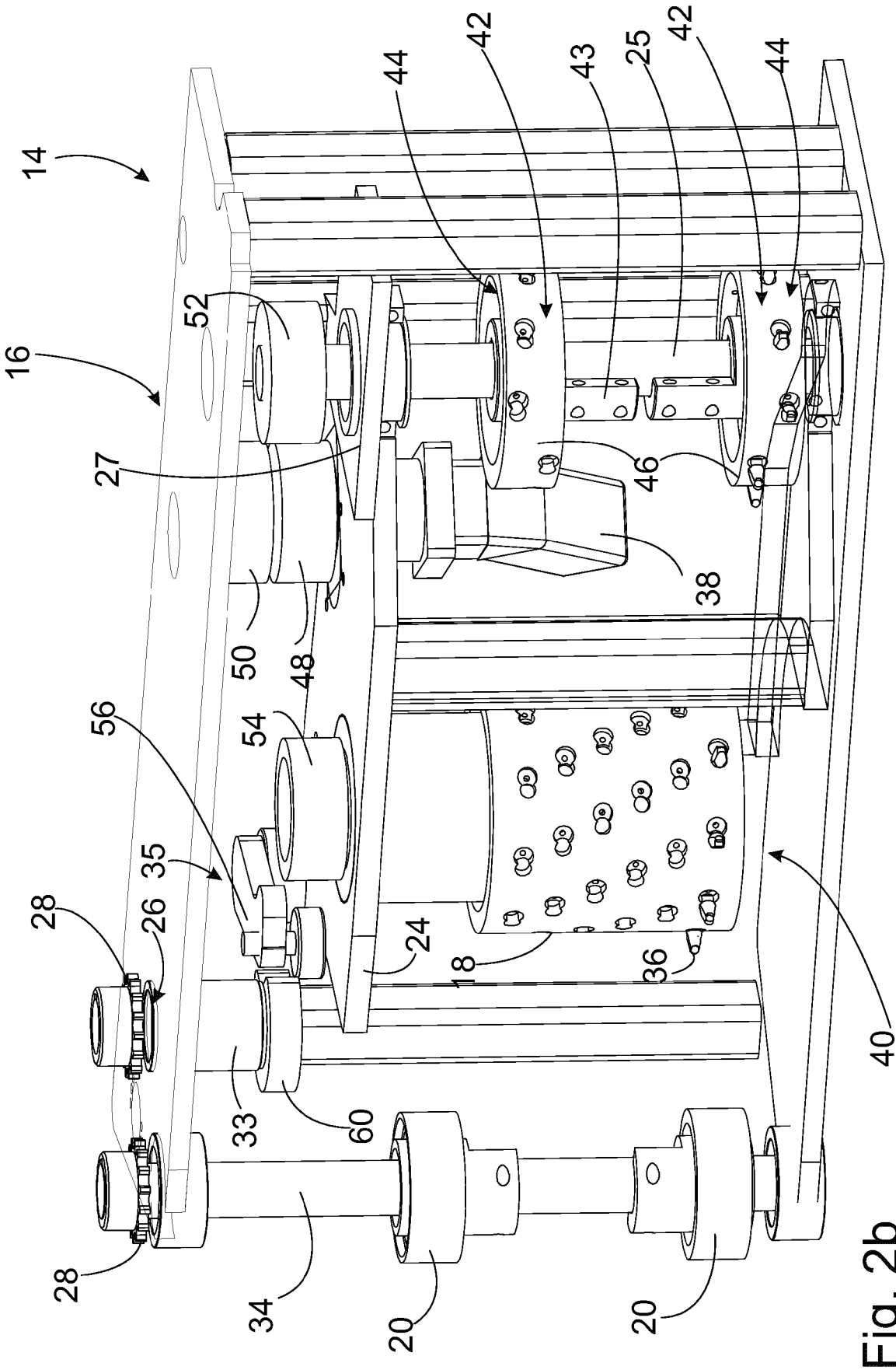
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Fig. 2b

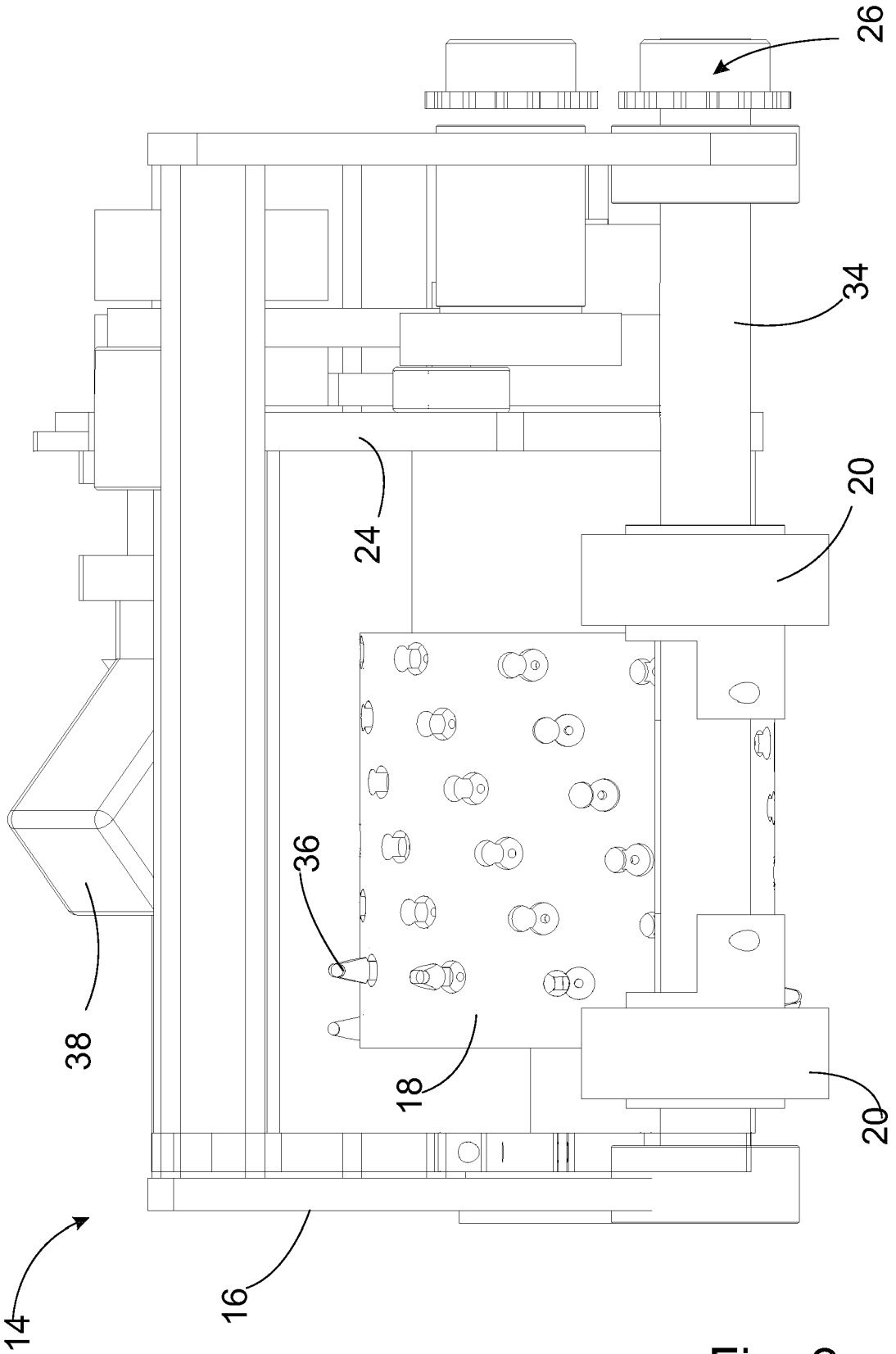

Fig. 2c

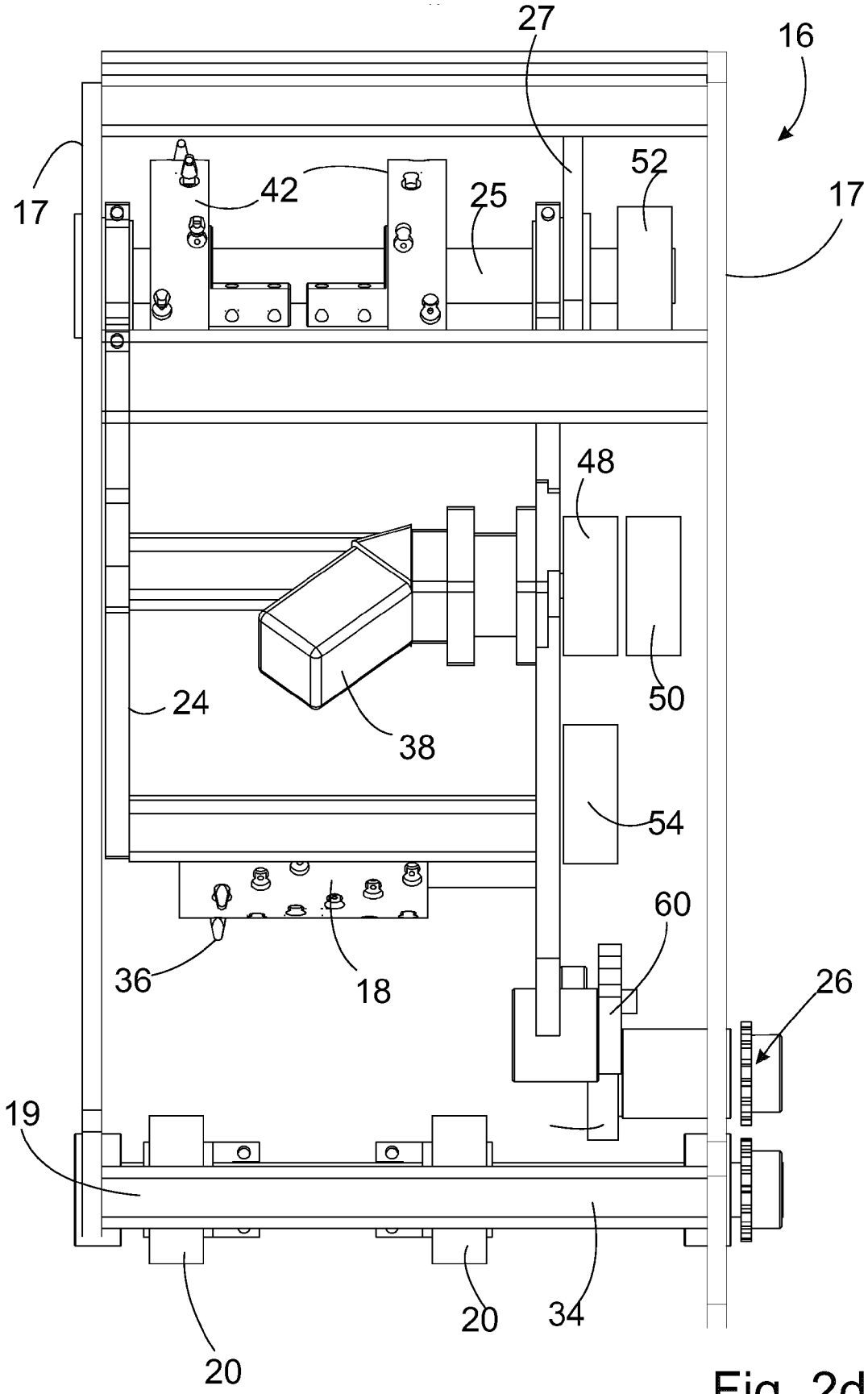

Fig. 2d

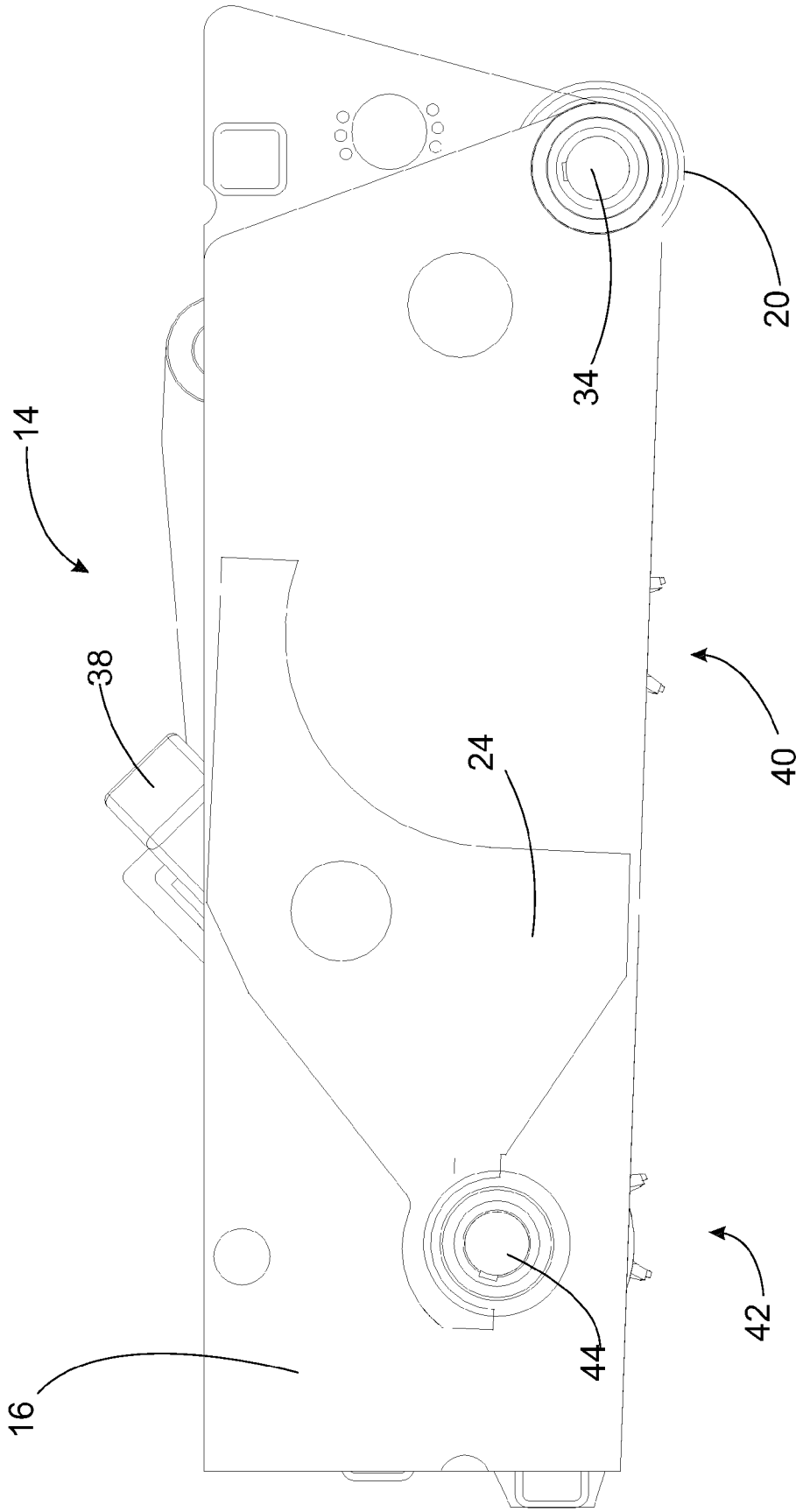

Fig. 2e

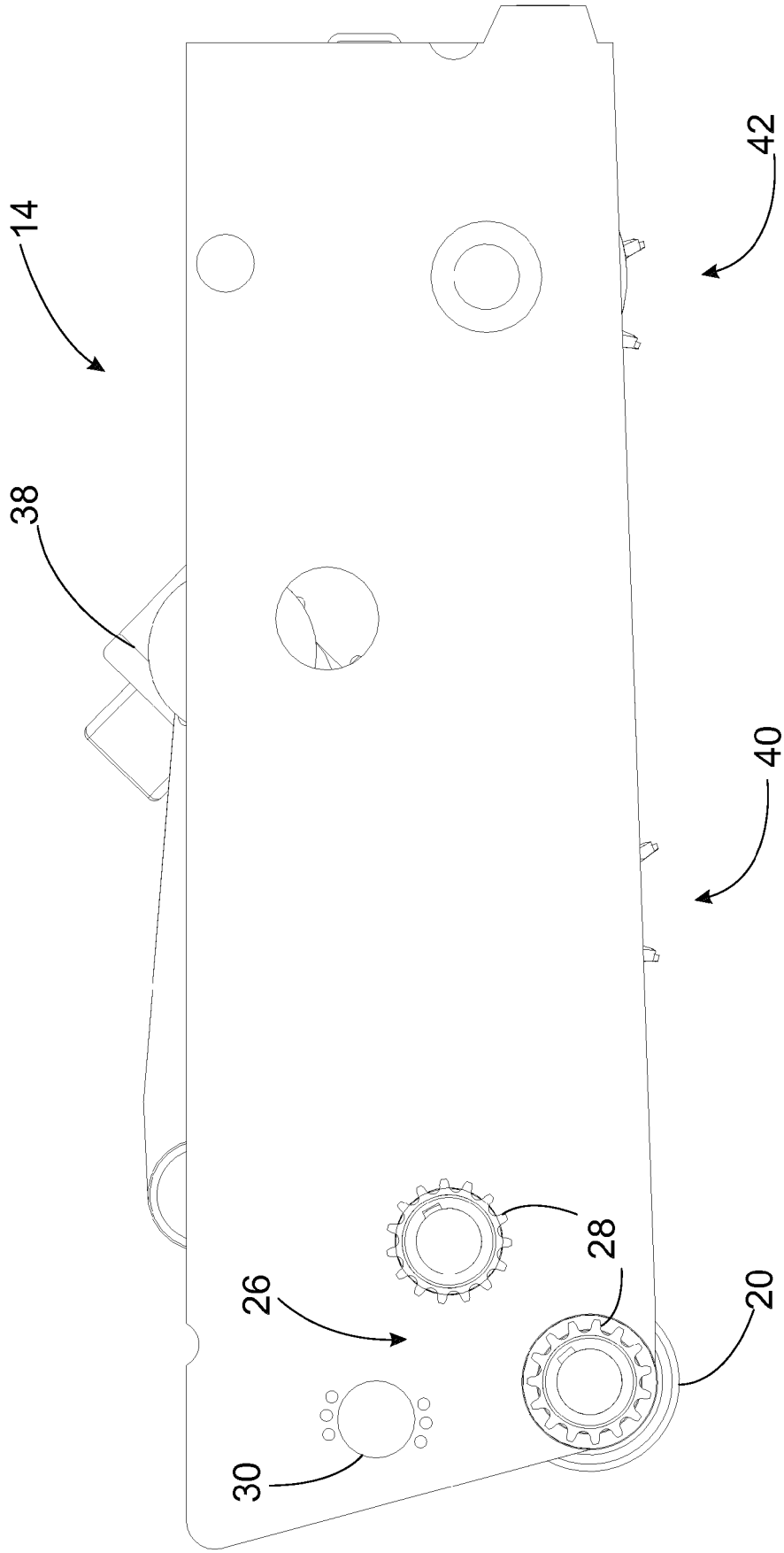

Fig. 2f

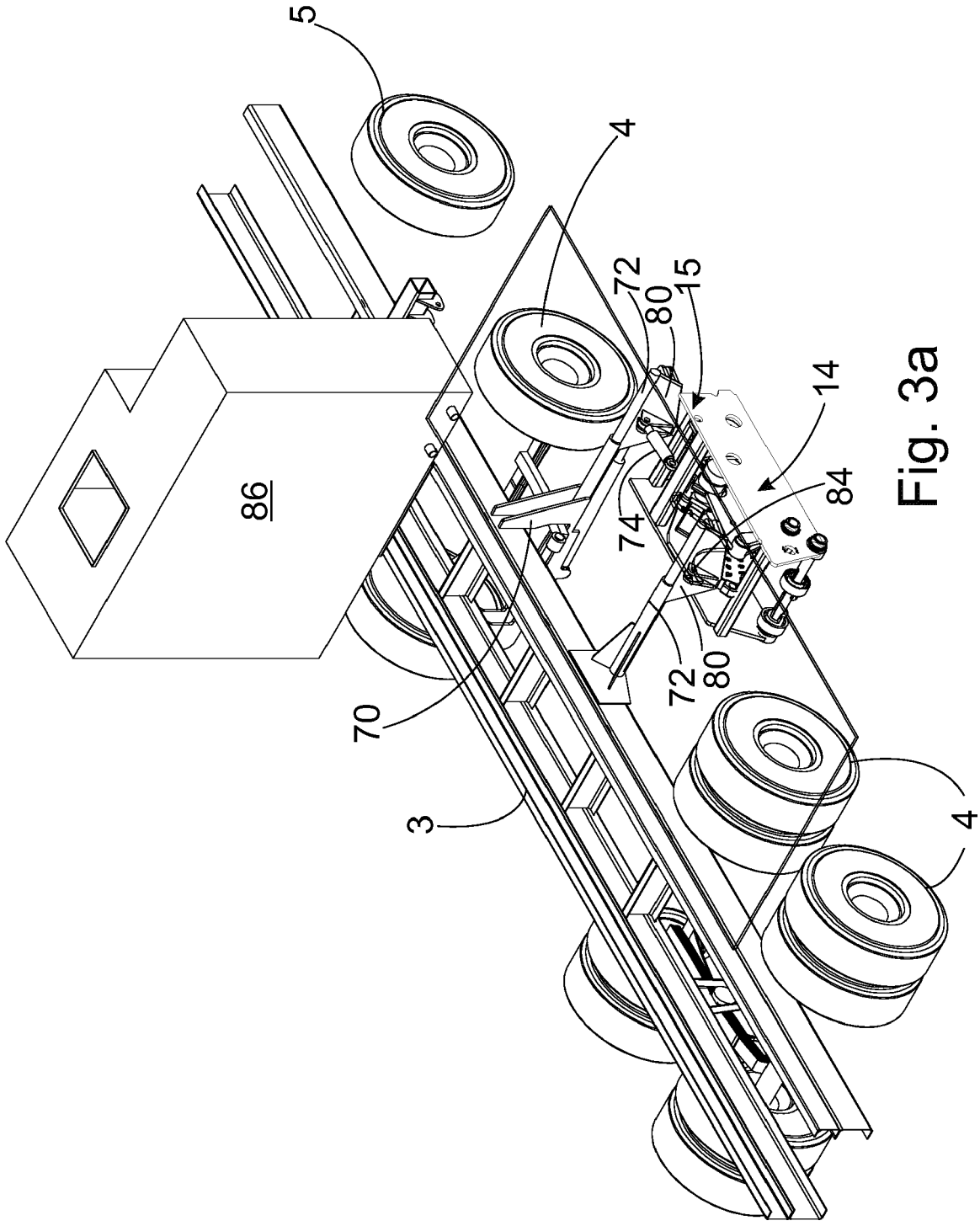

Fig. 3a

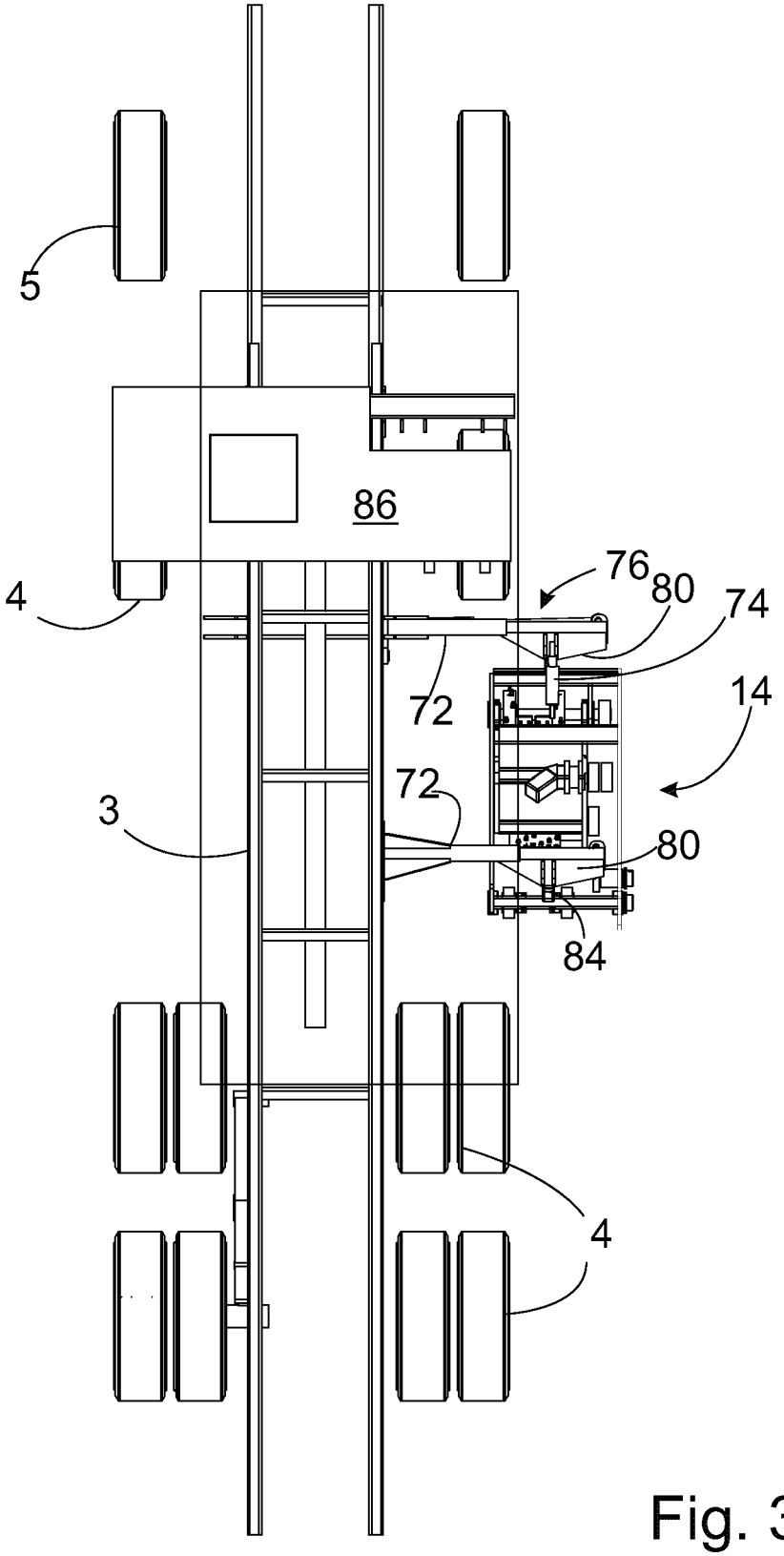

Fig. 3b

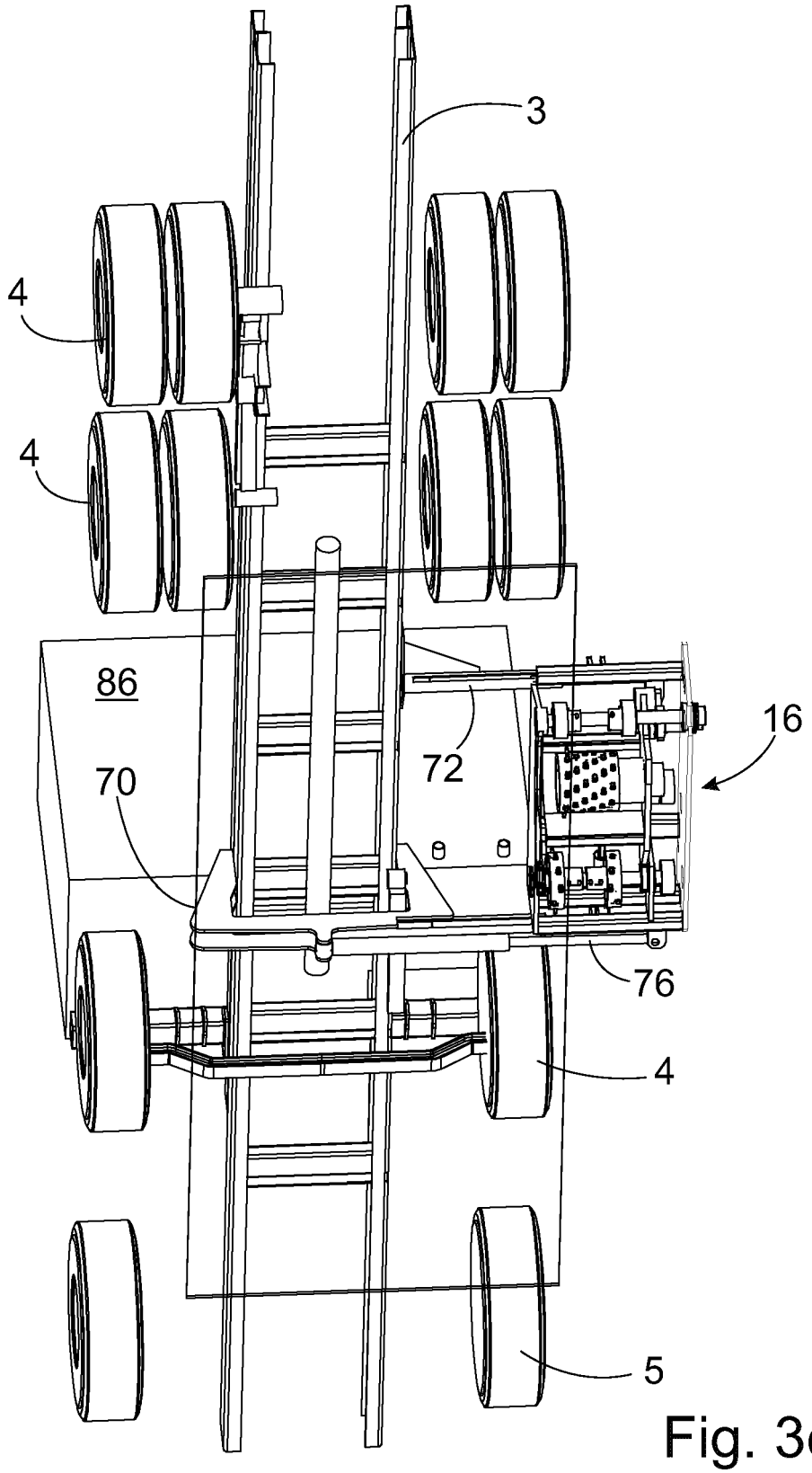

Fig. 3c

Prior art

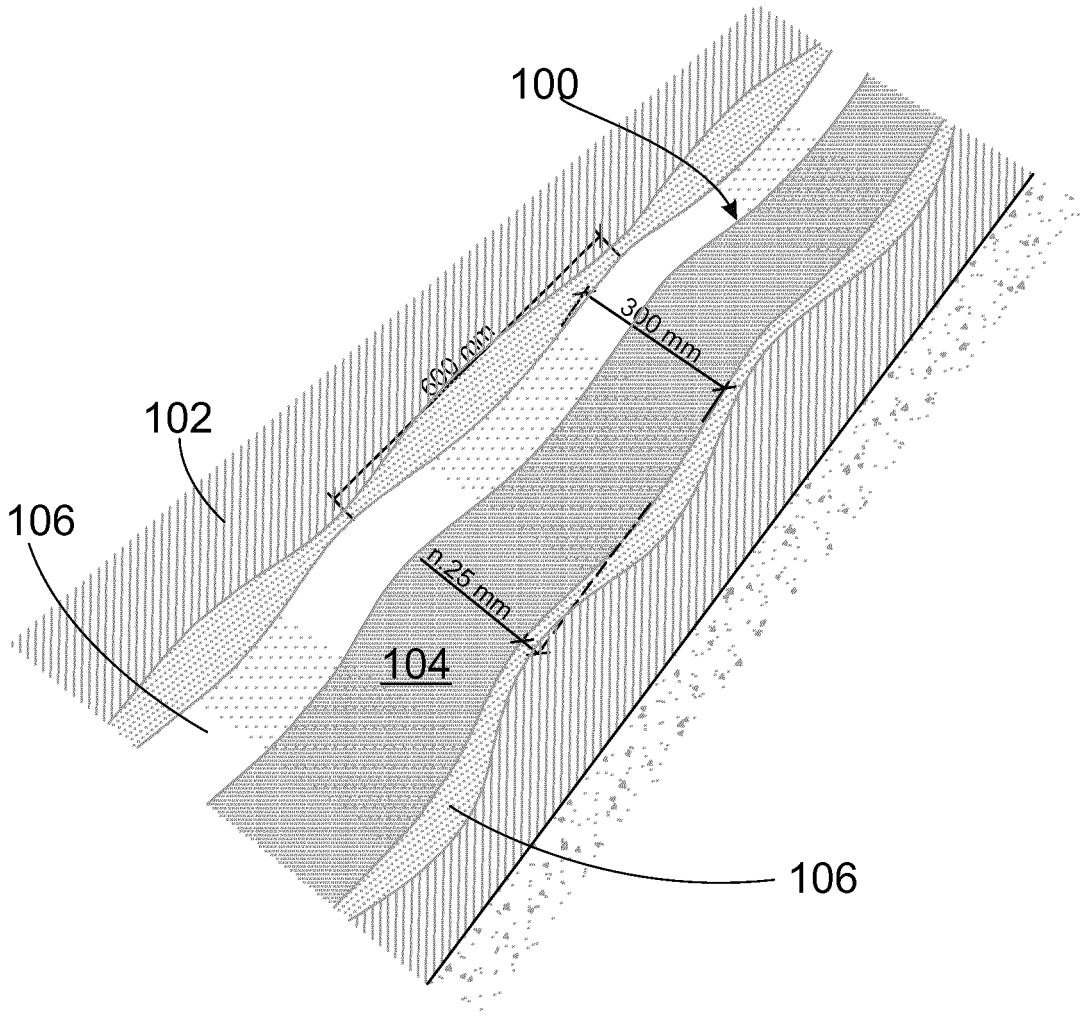

Fig. 4

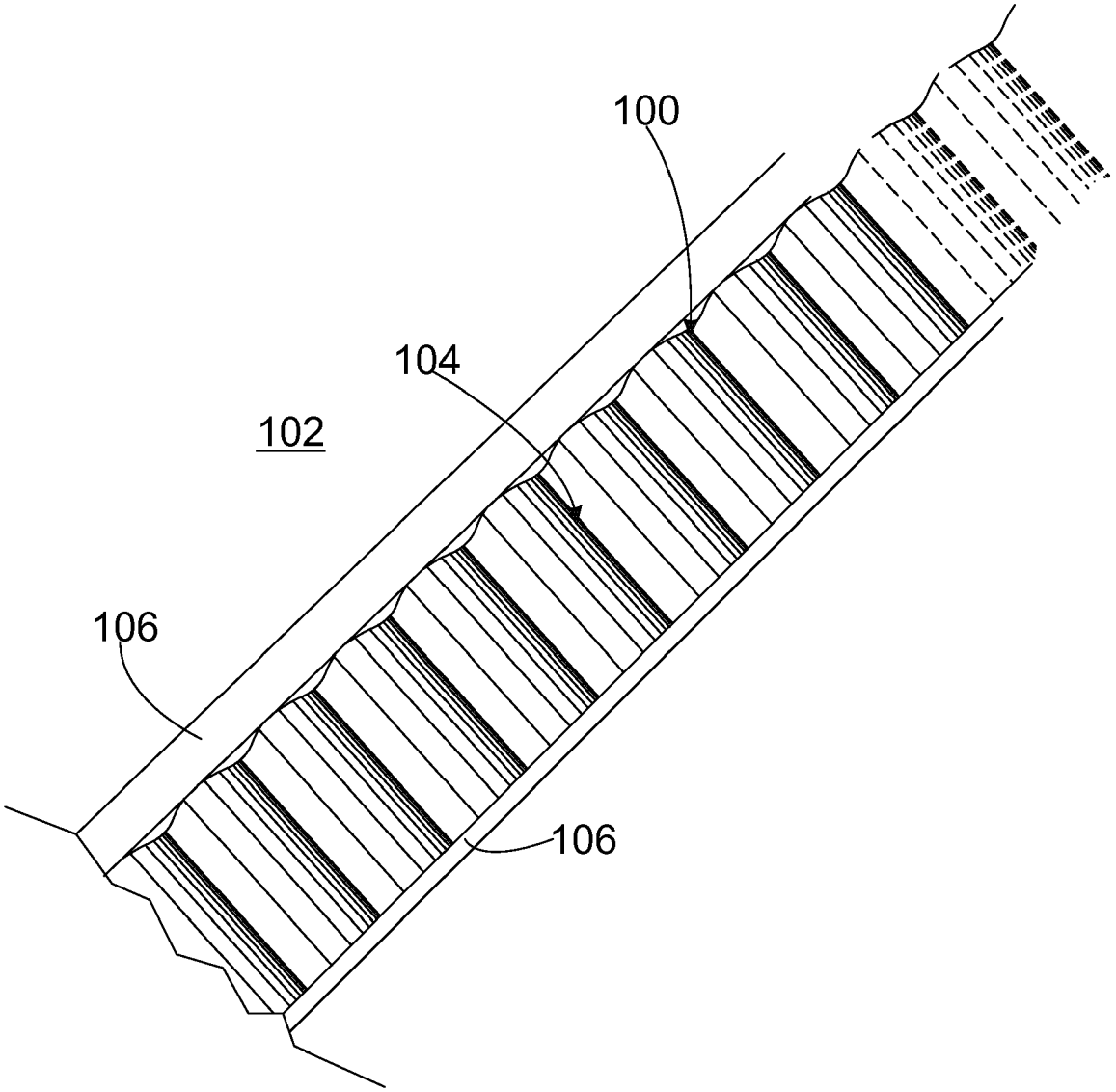

Fig. 5

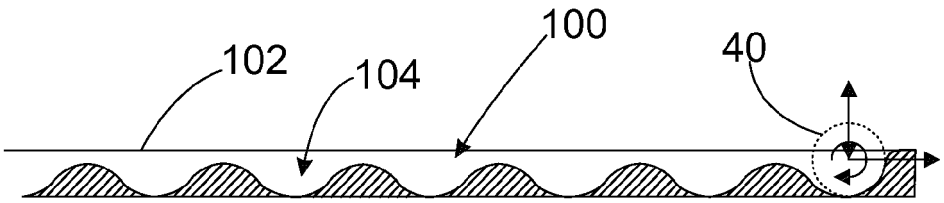

Fig. 6

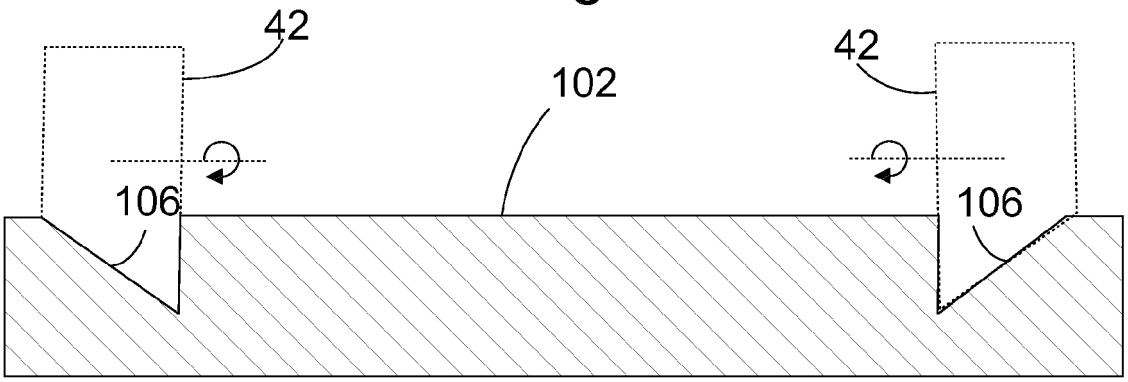

Fig. 7a

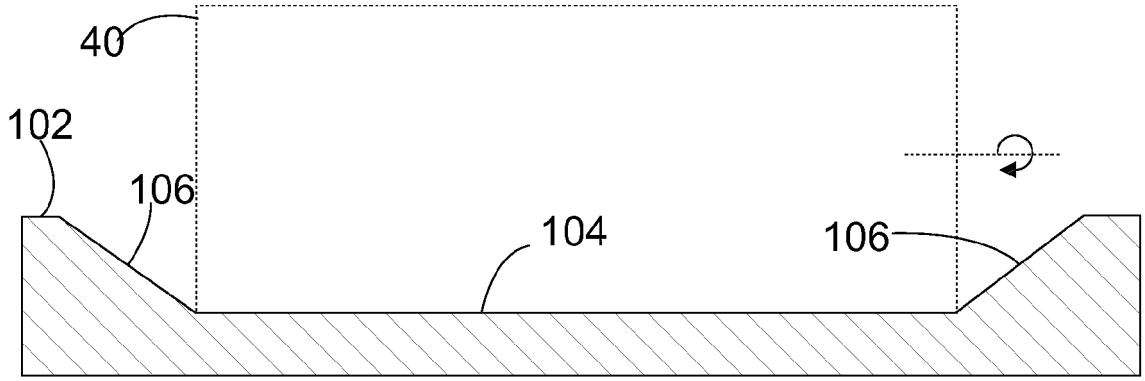

Fig. 7b

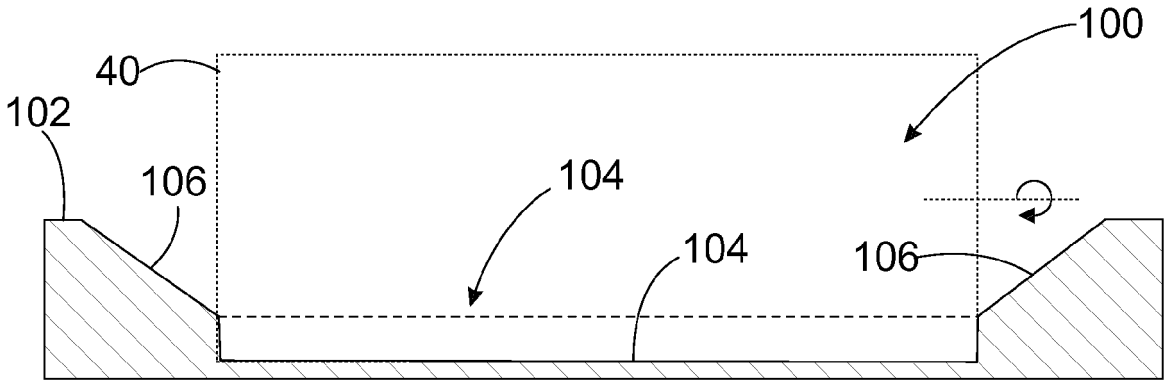

Fig. 7c

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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 2447

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2018/371711 A1 (CROCKER JAMES P [US]) 27 December 2018 (2018-12-27) * figures 1-14 * * paragraphs [0028], [0033] - [0036], [0041] * * the whole document * -----	1-4,6-9, 11-15 5,10	INV. E01C23/09
Y,D	EP 3 266 935 A1 (PYYKKÖ TOMMI [FI]) 10 January 2018 (2018-01-10) * figures 2-10 * * the whole document * * paragraphs [0055], [0056] * -----	5,10	
			TECHNICAL FIELDS SEARCHED (IPC) E01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 September 2024	Klein, A

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 17 2447

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05-09-2024

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EP 3266935 A1	10-01-2018	EP 3266935 A1	10-01-2018
		ES 2896478 T3	24-02-2022
		LT 3266935 T	10-12-2021

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

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