



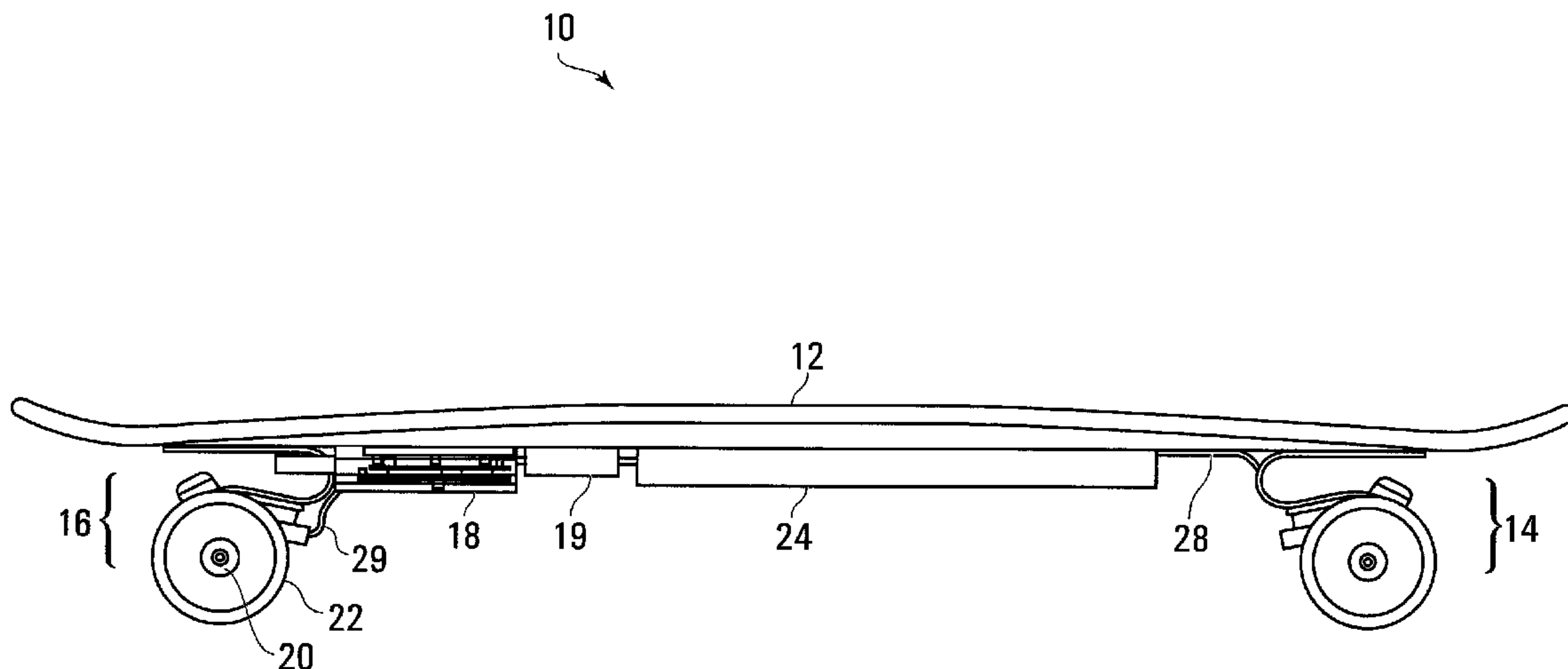
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(54) Title: WEIGHT SENSING SUSPENSION TRUCK FOR ELECTRIC SKATEBOARD



(57) **Abrégé/Abstract:**

An electric skateboard with a hands free control mechanism includes weight sensors embedded in the front and rear truck base plates to measure both the total weight of the rider as well as their weight distribution on the deck. An advanced skate control circuit uses these weight signals from the base plate to control the motor power, and includes the ability to detect when the rider is kicking the board. During these kicking events, the skate control algorithm changes to a mode which minimises any rapid changes to the skateboard velocity so that the rider will remain stable with just one foot on the deck.

ABSTRACT

An electric skateboard with a hands free control mechanism includes weight sensors embedded in the front and rear truck base plates to measure both the total weight of the rider as well as their weight distribution on the deck. An advanced skate control circuit uses these weight signals from the base plate to control the motor power, and includes the ability to detect when the rider is kicking the board. During these kicking events, the skate control algorithm changes to a mode which minimises any rapid changes to the skateboard velocity so that the rider will remain stable with just one foot on the deck.

WEIGHT SENSING SUSPENSION TRUCK FOR ELECTRIC SKATEBOARD

FIELD

This disclosure relates generally to electric skateboards, and more particularly to a weight sensing suspension truck that can be used with an electric skateboard.

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BACKGROUND

An early example of an electric skateboard design is disclosed in US patent no. 4,069,881. Since then, the capability and popularity of electric skateboards have grown rapidly with the advent of compact brushless motors and energy dense lithium batteries, with new products entering the market every year. Some of these electric skateboards include a handheld remote for the rider to
10 control the power and braking force on the motors, wherein the remote is tethered to the skateboard in some known designs, and wirelessly communicates with the skateboard in in other known designs.

While skateboards with handheld remotes are relatively popular, they have a number of drawbacks. One obvious drawback is that a rider's hand is occupied holding the remote thus
15 making it difficult for the rider to hold anything else with that hand. Further, the remote if wireless can be easily lost or misplaced. Also, the remote even if tethered to the skateboard presents a separate component that complicates storage and handling.

Other known electric skateboard designs have been proposed which use a rider's body position and/or foot placement to control the skateboard. For example, US patent no. 6,050,357 mentions
20 several methods of sensing rider weight and foot pressure, so that the skateboard can be accelerated by applying more weight with the front foot and slowed down by applying more weight with the rear foot. US patent no. 7,293,622 discloses another design wherein the entire deck is mounted on a tilting surface, and leaning forwards or backwards will cause a measured change in deck angle to regulate motor power. In US patent no. 9,004,213, a skateboard deck is disclosed
25 which includes a pressure sensitive pad that a user engages with his or her foot, similar in concept to a gas pedal on a car. Japanese patent no. 2003237670A discloses a skateboard with multiple sensors that detect a rider's center of gravity over the deck, regardless of where the rider's feet are located, while Japanese patent no. 20130081891A1 discloses pressure sensitive pads on a skateboard deck as a means of control input.

What is common in all of these foot based control devices is that the weight or pressure sensing is on or attached to the deck of the skateboard. This design approach presents certain limitations, including precluding the use of third party decks that are desirable but are not compatible with motorized or electric skateboards.

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SUMMARY

According to one aspect of the invention, there is provided an electric skateboard truck comprising: a base plate mountable to an underside of an electric skateboard deck and comprising a weight sensor positioned to directly or indirectly measure a force exerted on the base plate by the skateboard deck; and a hanger pivotably coupled to the base plate, and
10 comprising an axle for coupling to a pair of wheels.

The base plate can comprise a suspension spring, and the weight sensor can be a strain gauge mounted on a flexing portion of the suspension spring that flexes when the truck is subjected to a rider weight. In particular, the suspension spring can be a leaf spring in which case the strain gauge is positioned on a flexible surface of the leaf spring. Alternatively, the weight sensor can
15 be a displacement sensor mounted on a displacing portion of the suspension spring that displaces when the truck is subjected to a rider weight. The displacement sensor can be selected from a group consisting: an optical sensor, a magnet and Hall effects detector, a capacitive sensor, and an inductive sensor.

Alternatively, the base plate can comprise a planar section and a hanger mount section extending
20 downwardly from the planar section and configured to couple to the hanger. In this case, the weight sensor is a pressure sensitive resistor (FSR) sensor assembly mounted on top of the planar section and comprises a pair of plates sandwiching an FSR sensor. Optionally, the hanger mount section comprises a cut-out that causes a stress concentration in a location in the base plate when the truck is subjected to a rider weight; in this case, the weight sensor is a strain gauge
25 located at the stress concentration location of the base plate.

The electric skateboard truck can further comprise a pair of wheels coupled to the axle and at least one motor rotationally coupled to the pair of wheels. The at least one motor can be a motor mounted in a hub of each wheel of the pair of wheels.

According to another aspect of the invention, there is provided a truck kit for an electric skateboard comprising a front truck and a rear truck. The front truck comprises: a front base plate mountable to a front underside of an electric skateboard deck and comprising a front weight sensor positioned to directly or indirectly measure a force exerted on the front base plate by the skateboard deck; and a front hanger pivotably coupled to the front base plate, and comprising a front axle for coupling to a front pair of wheels. The rear truck comprises: a rear base plate mountable to a rear underside of the electric skateboard deck and comprising a rear weight sensor positioned to directly or indirectly measure a force exerted on the rear base plate by the skateboard deck; and a rear hanger pivotably coupled to the rear base plate, and comprising a rear axle for coupling to a rear pair of wheels. At least one of the front and rear pair of wheels is rotatably drivable by at least one motor, and the at least one motor is controlled by at least one controller that is communicable with the front and rear weight sensors.

The truck kit can further comprise at least one controller electrically communicative with the front and rear weight sensors, and for electrically coupling to a motor. The at least one controller can comprise at least one skate controller circuit electrically communicative with the front and rear weight sensors, and at least one motor controller electrically communicative with the least one skate controller circuit and for electrically coupling to the motor.

According to another aspect of the invention, there is provided an electric skateboard comprising: a deck; at least one motor; a battery electrically coupled to the at least one motor; a front truck assembly, a rear truck assembly, front and rear pairs of wheels, and at least one controller communicative with the front and rear weight sensors and the at least one motor. The front truck assembly comprises a front base plate mounted to a front underside of the deck and which comprises a front weight sensor positioned to directly or indirectly measure a force exerted on the front base plate by the skateboard deck, and a front hanger pivotably coupled to the front base plate and which comprises a front axle. The rear truck assembly comprises a rear base plate mounted to a rear underside of the deck and which comprises a rear weight sensor positioned to directly or indirectly measure a force exerted on the rear base plate by the skateboard deck, and a rear hanger pivotably coupled to the rear base plate and which comprises a rear axle. Each pair of wheels are mounted to the front and rear axles respectively, and at least one of the front and rear pairs of wheels is coupled to and rotatably driven by the at least one motor. The at least one controller can be communicative with the front and rear weight sensors and the at least one motor, and comprises a processor and a memory having encoded thereon program code

executable by the processor to operate the at least one motor in response to measurements received from the front and rear weight sensors.

According to another aspect of the invention, there is provided a method for controlling an electric skateboard comprising front and rear weight sensors mounted respectively to front and rear baseplates of the electric skateboard, and a motor rotatably coupled to drive wheels of the electric skateboard. The method comprises: repeatedly reading measurements taken by the front and rear weight sensors and determining a total weight and weight distribution of a rider on the electric skateboard; when the determined total weight is within a defined margin of a baseline weight, operating the motor to accelerate the skateboard when the weight distribution is higher on the front baseplate than on the rear baseplate, and operating the motor to decelerate the skateboard when the weight distribution is higher on the rear baseplate than on the front baseplate; and identifying a kick event when the determined total weight momentarily decreases beyond a defined kick threshold, and operating the motor to limit acceleration of the skateboard during the kick event, and operating the motor to sustain skateboard speed or to decelerate the skateboard for a selected time period after the kick event ends. The selected time period after the kick event ends can be between 0.5 and 3 seconds. Operating the motor to limit acceleration of the skateboard during the kick event can comprise operating the motor in a regenerative braking mode. Identifying the kick event can further comprise: detecting an acceleration of the skateboard when the total weight momentarily decreases below the defined kick threshold but is above a weight threshold indicating that a rider has one foot on the skateboard.

The method can further comprise detecting a bounce event, which comprises identifying a period of increased total weight followed by a period of reduced total weight with no associated acceleration of the skateboard during the period of reduced total weight, and filtering out detected bounce events from the step of identifying a kick event.

According to another aspect of the invention, there is provided a computer readable medium having encoded thereon program code executable by a processor to: repeatedly read measurements taken by the front and rear weight sensors and determine a total weight and weight distribution of a rider on the electric skateboard; when the determined total weight is within a defined margin of a baseline weight, operate the motor to accelerate the skateboard when the weight distribution is higher on the front baseplate than on the rear baseplate, and operate the motor to decelerate the skateboard when the weight distribution is higher on the rear baseplate

than on the front baseplate; and identify a kick event when the determined total weight momentarily decreases beyond a defined kick threshold, operate the motor to limit acceleration of the skateboard during the kick event, and operate the motor to sustain skateboard speed or to decelerate the skateboard for a selected time period after the kick event ends.

- 5 According to another aspect of the invention, there is provided an electric skateboard comprising: a deck, at least one motor; a battery electrically coupled to the at least one motor; a front truck assembly comprising a front base plate mounted to a front underside of the deck and comprising a front weight sensor positioned to directly or indirectly measure a force exerted on the front base plate by the skateboard deck, and a front hanger pivotably coupled to the front base plate and
- 10 comprising a front axle; a rear truck assembly comprising a rear base plate mounted to a rear underside of the deck and comprising a rear weight sensor positioned to directly or indirectly measure a force exerted on the rear base plate by the skateboard deck, and a rear hanger pivotably coupled to the rear base plate and comprising a rear axle; front and rear pairs of wheels that are mounted to the front and rear axles respectively, wherein at least one of the front and
- 15 rear pairs of wheels is coupled to and rotatably driven by the at least one motor; and at least one controller communicative with the front and rear weight sensors and the at least one motor. The controller comprises a processor and a memory having encoded thereon program code executable by the processor to: repeatedly read measurements taken by the front and rear weight sensors and determine a total weight and weight distribution of a rider on the electric skateboard;
- 20 when the determined total weight is within a defined margin of a baseline weight, operate the at least one motor to accelerate the skateboard when the weight distribution is higher on the front baseplate than on the rear baseplate, and operate the at least one motor to decelerate the skateboard when the weight distribution is higher on the rear baseplate than on the front baseplate; and identify a kick event when the determined total weight momentarily decreases
- 25 beyond a defined kick threshold, operate the at least one motor to limit acceleration of the skateboard during the kick event, and operate the at least one motor to sustain skateboard speed or to decelerate the skateboard for a selected time period after the kick event ends.

According to another aspect of the invention, there is provided a truck base plate for an electric skateboard. The truck base plate is mountable to an underside of an electric skateboard deck and pivotably mountable to a truck hanger, and comprises a weight sensor positioned to directly

30 or indirectly measure a force exerted on the truck base plate by the skateboard deck.

BRIEF DESCRIPTION OF THE FIGURES

Figures 1 is a side elevation view of an electric skateboard having a pair of weight sensing suspension trucks according to one embodiment.

5 Figures 2A – 2C are respective perspective, side elevation and rear views of a weight sensing suspension truck having a strain gauge sensor mounted to a leaf type suspension spring in the truck's base plate, according to another embodiment.

Figures 3A – 3C are respective perspective, side elevation and rear views of a weight sensing suspension truck having an optical displacement sensor mounted to a leaf type suspension spring in the truck's base plate, according to another embodiment.

10 Figures 4A – 4C are respective exploded perspective, side elevation and rear views of a weight sensing suspension truck having a pressure sensitive resistor mounted on the truck's base plate according to another embodiment.

Figures 5A – 5C are respective perspective, side elevation and rear views of a weight sensing suspension truck having a strain gauge sensor mounted at a concentrated stress section of the truck's base plate according to another embodiment.

Figure 6 is a flowchart depicted a method performed by a motor controller to control the operation of the electric skateboard.

Figure 7 is a graph of weight detected by the front and rear suspension trucks over a time period.

DETAILED DESCRIPTION

20 Overview

Directional terms such as “top”, “bottom”, “upwards”, “downwards”, “vertically”, and “laterally” are used in the following description for the purpose of providing relative reference only, and are not intended to suggest any limitations on how any article is to be positioned during use, or to be mounted in an assembly or relative to an environment.

25 Additionally, the term “couple” and variants of it such as “coupled”, “couples”, and “coupling” as used in this description is intended to include indirect and direct connections unless otherwise

indicated. For example, if a first device is coupled to a second device, that coupling may be through a direct connection or through an indirect connection via other devices and connections. Similarly, if the first device is communicatively coupled to the second device, communication may be through a direct connection or through an indirect connection via other devices and connections.

Furthermore, the singular forms “a”, “an”, and “the” as used in this description are intended to include the plural forms as well, unless the context clearly indicates otherwise.

Embodiments of the invention disclosed herein relate generally to a weight sensing suspension truck for use in an electric skateboard. More particularly, a weight sensor is mounted in a base plate of each of a front and rear truck assembly of the skateboard, and is positioned to directly or indirectly measure a force exerted on each respective base plate by the skateboard deck, and is configured to output a measurement signal. One or more controllers are communicative with each truck assembly to receive their respective measurement signals. The controller(s) uses these measurement signals as inputs to control one or more electric motors that drives one or more wheels of the skateboard, such as the two rear wheels. The electric motor(s) in some embodiments is located in the hanger of one of the trucks, or in the hub of one of more wheels; in other embodiments, the motor(s) is mounted to the skateboard deck or elsewhere on the truck, and is rotatably coupled to the drive wheels, for example, by a drive chain.

In some embodiments, one of the controllers comprises a processor and a memory having encoded thereon a motor control program that is executable by the processor to control operation of the motor using the measurement signals received from the weight sensors. More particularly, the received measurement signals are used to determine the weight distribution of a rider on the skateboard, and the controller will operate the motor(s) in different modes based on the determined weight distribution. One operating mode is known as a kick assist control mode, which comprises using the received signals to determine whether a kick event has occurred, limiting acceleration of the motor(s) during a determined kick event, and sustaining speed or decelerating the motor after the kick event has finished.

In some embodiments, a kit is provided comprising the front and rear weight sensing suspension trucks for mounting to a skateboard deck; this kit can optionally include one or more of the controller(s), the motor(s), and a battery for powering the motor(s). In some other embodiments, an entire electric skateboard is provided comprising a deck, the front and rear weight sensing

suspension trucks mounted respectively to front and rear undersides of the deck, the one or more controllers which is communicative with the front and rear weight sensing suspension trucks, the motor(s) which is communicative with the one or more controllers and is mechanically coupled to drive wheels of the skateboard, and a battery that is electrically coupled to the motor. In some other embodiments, only the base plate of the weight sensing suspension truck is provided; this weight sensing base plate comprises the weight sensor and can be combined with third party hangers to form a complete truck assembly. By locating the weight sensor in the base plate of the truck assembly, end users can keep their original truck hangars, which optionally comprise an integrated motor and drive chain, thereby providing a broad use for aftermarket upgrades. Furthermore, the base plate is a stationary component of the truck and is relatively well protected and shielded from foreign objects encountered on the road, which should reduce the exposure risks compared to prior art electric skateboards which place sensors on other parts of the skateboard.

Apparatus

Referring now to Figure 1 and according to a first embodiment, an electric skateboard 10 generally comprises a deck 12, a front weight sensing suspension truck 14 mounted to a front underside of the deck 12, a rear weight sensing suspension truck 16 mounted to a rear underside of the deck 12, a pair of motor controllers 18, a skate controller circuit 19, a pair of motors 20 each integrated into a hub of each of the rear wheels 22, and a battery 24 that is electrically coupled to the motor controllers 18 to supply power thereto. The skate controller circuit 19 is communicative with weight sensors 26 (shown in Figures 2 to 5) in the front and rear weight sensing suspension trucks 14, 16 and with the motor controllers 18 via controller communication cables 28; alternatively, the skate controller circuit 19 can be communicative with the weight sensors 26 and motor controllers 18 by wireless means known in the art (not shown). The motor controllers 18 in turn are electrically coupled to the motors 20 by power cables 29.

Referring now to Figures 2A to 2C, each of the front and rear weight sensing suspension trucks 14, 16 comprise a base plate 30 fixedly mounted to the underside of the deck 12, and a hanger 32 pivotably mounted to the bottom of the base plate 30. The base plate 30 in this embodiment comprises a leaf spring, wherein one end ("top end") of the leaf spring is mounted to the underside of the deck 12, and another end ("bottom end") comprises a pivot cup for receiving a pivot arm 34 of the hanger 32. The leaf spring serves as a suspension means and is configured to flex by an

amount proportional to an applied force on the deck 12. The leaf spring can be selected to have a design stiffness that causes the leaf spring to deflect into a maximum flexed position where the top and bottom ends do not touch when a maximum design weight is applied to the deck 12.

In this embodiment, the weight sensor is a strain gauge 26 that is mounted on the inside surface of the leaf spring at around its midpoint. The strain gauge 26 measures the strain on the leaf spring when weight is applied to the base plate 30 from the deck 10 and the leaf spring flexes. The measured strain is then transmitted to the skate controller circuit 19 which then converts the measured strain into a force measurement in a manner well known in the art. In other words, the strain gauge indirectly measures the force exerted on the base plate 30.

The truck shown in Figures 2A-2C is the rear truck 16 and comprises the motors 20 each integrated into the hub of each of the rear wheels 22. Such "hub" motors are known in the art and thus are not described in detail here. The rear wheels 22 are attached to the hanger 32 via an axle 36. The hanger has an opening and is attached to the baseplate via a kingpin and pivot pushing as is standard in the art of truck design. A motor power cable extends from each motor 20 along the hangar and terminates at one of the motor controllers 18. These motor controllers 18 convert the fixed DC battery voltage into a variable voltage supply suitable for spinning the motors 20. The command signal for determining the motor power comes from the skate controller circuit 19, which is connected to both the front and rear weight sensors 26. This skate controller circuit has a memory having encoded thereon a motor control program for setting the desired motor power level based on what it measures from the front and rear weight sensors 26, as will be described in more detail below. The front truck 14 has the same design as the rear truck 16, with the exception that the front truck 14 does not comprise a hub motor. In particular, the front truck 14 has a base plate 30 featuring a leaf spring, and a strain gauge as the force sensor 26. A sensor communication port (not shown) is provided for connecting to the controller communication cable 28.

According to second embodiment, the front and rear trucks 14, 16 have the same design as in the first embodiment, except that the strain gauges are replaced by displacement sensors as the weight sensors 26. Referring now to Figures 3A to 3C, one suitable displacement sensor is an optical displacement sensor 26 that is positioned on the inner surface of the top end of the leaf spring, facing the inner surface of the bottom end of the leaf spring, such that the optical displacement sensor 26 can detect a change in the distance between the ends of the leaf spring

(“displacement measurement”). The optical displacement sensor 26 outputs a signal comprising the displacement measurement to the skate controller circuit 19, which then converts the displacement measurement into a force measurement in a manner well known in the art. In other words, the optical displacement sensor 26 indirectly measures the force exerted on the base plate 30. Suitable optical displacement sensors include commercially available optical displacement sensors well known in the art, such as triangulation sensors, intensity sensors, time of flight sensors and interferometer sensors.

Alternatively, other displacement sensors known in the art can be used as the weight sensor 26 instead of the optical displacement sensor, such as a magnet and Hall effects detector, capacitive sensors, and inductive sensors. The use of such sensor to measure displacement are well known in the art and thus not described in detail here.

In other embodiments, the front and rear trucks 14, 16 have a different suspension design than a leaf spring, but still comprise a weight sensor 26 in the base plate to directly or indirectly measure the force applied to the base plate 30. Referring now to Figures 4A to 4C and according to a third embodiment, the weight sensor 26 comprises a pressure sensitive resistor (FSR) sensor that allows for direct force measurement with minimal electrical signal conditioning. The base plate 30 comprises a planar section 50, and a hanger mount section 52 extending downwardly from the planar section and comprising a lower cup washer for engaging with a kingpin and a pivot cup for engaging with the hanger pivot. A FSR assembly 40 is fixedly mounted to the top of the base plate planar section 50, and comprises a FSR baseplate 42, an FSR boardplate 46, and the FSR sensor 26 sandwiched in between the FSR baseplate 42 and the FSR boardplate 46. The FSR assembly 40 is held together and mounted to the base plate 30 by a series of dowels 44 that extend through openings in the FSR baseplate 42, FSR boardplate 46, and the planar section of the base plate 30. A communication cable (not shown) is connected to the FSR sensor 30 and extends to a sensor port (not shown) at one end of the FSR assembly 40; the communication cable 28 couples to this port to enable the skate controller circuit 19 to receive measurement signals from the FSR sensor 26. The FSR boardplate is also provided with a set of bores 48 for receiving fasteners (not shown) for mounting the truck 14, 16 to the deck 12.

Referring now to Figures 5A to 5C, and according to a fourth embodiment, the weight sensor 26 is a strain gauge that is mounted on a concentrated stress part of the base plate 30. Like the third embodiment, the base plate 30 comprises a planar section 50 and a hanger mount section

extending downwardly from the planar section 50 and comprising a lower cup washer 53 and a pivot cup 54. Unlike the solid lower cup washer in the third embodiment, the lower cup washer 53 in the fourth embodiment comprises a cut-out 56 that results in a stress concentration to be located at the part of the lower cup washer 53 that connects to the planar section 50 of the base plate 30. The strain gauge 26 is located at this stress concentration location, and is effective to measure the strain at the location when a force is applied to the base plate 30.

In a fifth embodiment (not shown), the weight sensor 26 is a capacitive sensor, and the front and rear weight sensing truck 14, 16 comprises an elastomeric material in the base plate, wherein changing thickness of the elastomer material changes the separation distance of metal plates resulting in a measurable capacitance change by the capacitance sensor.

Motor Control Program

Referring back to Figure 1, the motor controller 18 can be a general purpose motor controller known in the art, such as known motor controllers which can convert DC power from the battery 24 to run a three-phase AC current for the hub motor 20 and to allow the modulation of the motor power. The skate controller circuit 19 is an interface circuit comprising a processor and a memory having encoded thereon the motor control program, and which has input ports communicative with the weight sensors 26 of the front and rear trucks 14, 16, and output ports communicative with the motor controllers 18. The skate controller circuit 19 operates to receive measurement signals from the weight sensors 26, executes the motor control program, and then sends out control signals to the motor controllers 18 for how much power or braking force should be provided by the motors 20.

Referring now to Figure 6 the motor control program when executed by the processor of the skate controller circuit 19 performs the following steps:

On start-up (step 100), the motor control program reads the front and rear weight sensors 26, converts each measurement to a force, and computes the sum of the two measured forces to establish a baseline weight for the rider currently on the deck 12 (step 102). This baseline weight can also be updated during the course of operation by looking at the time average weight over the trucks 14, 16.

During operation, the motor control program continuously or repeatedly reads the front and rear weight sensors 26 and determines the total summed weight applied to the deck 12. While the total summed weight remains within a defined margin of this baseline weight, the controller executes a weight sensing control mode (step 104). When the total summed weight is outside
5 the defined margin of the baseline weight, the controller 19 may prevent additional power to the motors 20 as a safety measure in case the rider has fallen off the board or one of the sensors 26 was damaged or the sensor signals compromised. . When the weight sensing control mode is executed, the controller 19 monitors the weight distribution over the front and rear trucks 14, 16 and will instruct the motor controller(s) 18 to increase or decrease operation of the motor(s) 20
10 based on the weight distribution. For example, when the weight distribution is higher over the front truck 14 than the rear truck 16, the controller 19 instructs the motor controller(s) 18 to drive the motor(s) 20 in a forward direction, with the amount of motor output being proportional to the percentage weight distribution over the front and rear trucks 14, 16. In contrast, when the weight distribution is higher over the rear truck 16 than the front truck 14 the controller 19 instructs the
15 motor controller(s) 18 to cause the motor(s) 20 to reverse torque thereby performing regenerative braking, with the amount of regenerative braking being proportional to the percentage weight distribution over the front and rear trucks 14, 16.

During operation, the motor control program continuously monitors for a kick event (step 106). Referring to Figure 7, a kick event is detected by a momentary reduction in the total weight
20 summed between the front and rear weight sensors 26, often accompanied by a simultaneous acceleration in the wheel velocity. A threshold for determining a kick event can be selected from a detailed analysis of multiple people riding and kicking skateboards with a high speed data logger recording the truck weight signals. For example, the kick threshold can be selected to be ~80% of the total weight, however, it is possible that the kick threshold can be between 50% to 90% of
25 total weight.

Thus, a kick event is logged whenever the controller 19 determines that a total weight on the deck is less than the selected kick threshold but still high enough to ensure that the rider has one foot on the deck, and a control mode kick assist sequence is executed (step 108).

Optionally and not shown, the motor controller program includes a bounce sensing module which
30 determines whether a rider is bouncing instead of kicking, and filters out rider bounce as potential false triggers to ensure that only actual kicks are detected as kick events. The bounce sensing

module distinguishes the difference between a rider kicking the skateboard and the rider bouncing on the deck, by identifying a bounce event as a period of high weight followed by a period of reduced weight, with no associated acceleration of the wheels while the weight is reduced. Such bounce events are filtered out from the kick event detection step.

- 5 When the control mode kick assist sequence is initiated, the motor control program may try to limit the motor acceleration by instructing the motor controller (s) 18 to cause the motor(s) 20 to switch into regenerative braking mode to put a drag force on the skateboard 10 in order to provide a resistance against which the rider is kicking so that the deck velocity does not increase too much during the kick event (step 110). That way, the rider's kicking energy can be converted and
10 stored as battery energy and then released more gradually during the period in between each kick, so that the board has a more steady velocity.

- Once the motor control program determines that the total weight has returned to within the defined margin of the original baseline value, the motor control program assumes that the rider no longer has one foot on the ground, the rider most likely still only has one foot on the deck, and the other
15 foot is freely swinging forwards and getting prepared for the next kick. During this time period, the rider is balancing with just one foot on the deck and any sudden acceleration or deceleration would be undesirable. Thus the motor controller program instructs the motor controller(s) 18 to operate the motor(s) 20 to sustain speed or slowly decelerate over a specified period (which can be user selectable) after the kick event (step 112). A possible default specified period can be
20 between 0.5 to 3 seconds. The motor control program then monitors for additional kick events (step 114) for a predetermined time period, and executes the control mode kick assist sequence 108 again if another kick event is detected during this time period. If no new kick events are detected during this time period, the motor control program assumes that the rider has planted both feet on the deck again, and reverts to the weight sensing control mode 104.

- 25 In an alternative embodiment, the skate controller circuit 19 can be provided with a different motor control program, including those in the art such as taught in US patent no. 6,050,357.

Operation

- With a rider standing in the center of the deck 10, both front and rear weight sensors 26 will output a similar weight and the skateboard 10 remains neutral. When the rider shifts more weight towards
30 the front truck 14, the skate controller circuit 19 will detect this and cause the motor controllers 18

to cause the motors 20 to accelerate forward. When the rider leans backwards and puts more weight on the rear truck 16, the skate controller circuit 19 will cause the motor controllers 18 to slow down the motors 20 for braking.

5 In the kick assist mode, the motor controllers 17 operate the motors 20 in a constant speed feedback loop in order to simulate the velocity profile that a regular non-electric skateboard experiences while being ridden. During the period when the rider is kicking, the skate controller circuit 19 instructs the motor controllers 18 to limit acceleration of the motors 20 in order to keep the skateboard 10 from running away. When the rider has his or her foot in the air, the skate controller circuit 19 instructs the motor controllers 18 to cause the motors 20 to maintain the
10 existing wheel velocity with a slight deceleration profile. This is intended to mimic the behavior of kicking a non-electric skateboard on flat ground.

The motor control program of the electric skateboard 10 allows for a seamless transition between electric-only power to human-powered kick assistance, and enables the electric skateboard to operate as an electric assist device rather than a fully powered electric vehicle. This feature is
15 expected to provide riders with the benefit of exercise, give them a sense of legitimacy and satisfaction from kicking a skateboard, and extend the range of the battery.

It is contemplated that any part of any aspect or embodiment discussed in this specification can be implemented or combined with any part of any other aspect or embodiment discussed in this specification.

20 While particular embodiments have been described in the foregoing, it is to be understood that other embodiments are possible and are intended to be included herein. It will be clear to any person skilled in the art that modifications of and adjustments to the foregoing embodiments, not shown, are possible.

CLAIMS

1. An electric skateboard truck comprising:

5 a base plate mountable to an underside of an electric skateboard deck and comprising a weight sensor positioned to directly or indirectly measure a force exerted on the base plate by the skateboard deck; and

a hanger pivotably coupled to the base plate, and comprising an axle for coupling to a pair of wheels.

2. The electric skateboard truck as claimed in claim 1, wherein the base plate comprises a suspension spring, and the weight sensor is a strain gauge mounted on a flexing portion
10 of the suspension spring that flexes when the truck is subjected to a rider weight.

3. The electric skateboard truck as claimed in claim 2 wherein the suspension spring is a leaf spring and the strain gauge is positioned on a flexible surface of the leaf spring.

4. The electric skateboard truck as claimed in claim 1 wherein the base plate comprises a suspension spring, and the weight sensor is a displacement sensor mounted on a
15 displacing portion of the suspension spring that displaces when the truck is subjected to a rider weight.

5. The electric skateboard truck as claimed in claim 4 wherein the displacement sensor is selected from a group consisting: an optical sensor, a magnet and Hall effects detector, a capacitive sensor, and an inductive sensor.

- 20 6. The electric skateboard truck as claimed in claim 1 wherein the base plate comprises a planar section and a hanger mount section extending downwardly from the planar section and configured to couple to the hanger, and the weight sensor is a pressure sensitive resistor (FSR) sensor assembly mounted on top of the planar section and comprising a pair of plates sandwiching an FSR sensor.

- 25 7. The electric skateboard truck as claimed in claim 1 wherein the base plate comprises a planar section and a hanger mount section extending downwardly from the planar section and configured to couple to the hanger, the hanger mount section comprising a cut-out that causes a stress concentration in a location in the base plate when the truck is

subjected to a rider weight, and wherein the weight sensor is a strain gauge located at the stress concentration location of the base plate.

5 8. The electric skateboard truck as claimed in any of claims 1 to 7 further comprising a pair of wheels coupled to the axle, and at least one motor rotationally coupled to the pair of wheels.

9. The electric skateboard truck as claimed in claim 8, wherein the at least one motor comprises a motor mounted in a hub of each wheel of the pair of wheels.

10. A truck kit for an electric skateboard, comprising:

(a) a front truck comprising:

10 a front base plate mountable to a front underside of an electric skateboard deck and comprising a front weight sensor positioned to directly or indirectly measure a force exerted on the front base plate by the skateboard deck; and

a front hanger pivotably coupled to the front base plate, and comprising a front axle for coupling to a front pair of wheels; and

15 (b) a rear truck comprising:

a rear base plate mountable to a rear underside of the electric skateboard deck and comprising a rear weight sensor positioned to directly or indirectly measure a force exerted on the rear base plate by the skateboard deck; and

20 a rear hanger pivotably coupled to the rear base plate, and comprising a rear axle for coupling to a rear pair of wheels;

wherein at least one of the front and rear pair of wheels is rotatably drivable by at least one motor, and the at least one motor is controlled by at least one controller that is communicable with the front and rear weight sensors.

25 11. The truck kit as claimed in claim 10, wherein the front and rear base plates comprise a front and rear suspension spring respectively, and the each of the front and rear weight

sensors is a strain gauge mounted on a flexing portion of the front and rear suspension spring respectively.

12. The truck kit as claimed in claim 11 wherein each of the front and rear suspension springs is a leaf spring and the each of the front and rear strain gauges is positioned on a flexible surface of the front and rear leaf spring respectively.

13. The truck kit as claimed in claim 12 wherein the front and rear base plates comprise a front and rear suspension spring respectively, and each of the front and rear weight sensors is a displacement sensor mounted on a displacing portion of the front and rear suspension spring respectively.

14. The truck kit as claimed in claim 13 wherein the displacement sensor is selected from a group consisting: an optical sensor, a magnet and Hall effects detector, a capacitive sensor, and an inductive sensor.

15. The truck kit as claimed in claim 10 wherein the front and rear base plates each comprises a planar section and a hanger mount section extending downwardly from the planar section and configured to couple to the hanger, and the front and rear weight sensors each is a pressure sensitive resistor (FSR) sensor assembly mounted on top of the planar section and comprising a pair of plates sandwiching an FSR sensor.

16. The truck kit as claimed in claim 10 wherein the front and rear base plate each comprises a planar section and a hanger mount section extending downwardly from the planar section and configured to couple to the front and rear hanger respectively, each hanger mount section comprising a cut-out that causes a stress concentration in a location in the front and rear base plate respectively when the truck is subjected to a rider weight, and wherein each of the front and rear weight sensor is a strain gauge located at the stress concentration location of the front and rear base plate respectively.

17. The truck kit as claimed in claim 10 further comprising at least one controller electrically communicative with the front and rear weight sensors, and for electrically coupling to a motor.

18. The truck kit at claimed in claim 17 wherein the at least one controller comprises at least one skate controller circuit electrically communicative with the front and rear weight

sensors, and at least one motor controller electrically communicative with the least one skate controller circuit and for electrically coupling to the motor.

19. An electric skateboard, comprising:

(a) a deck;

5 (b) at least one motor;

(c) a battery electrically coupled to the at least one motor;

10 (d) a front truck assembly comprising a front base plate mounted to a front underside of the deck and comprising a front weight sensor positioned to directly or indirectly measure a force exerted on the front base plate by the skateboard deck, and a front hanger pivotably coupled to the front base plate and comprising a front axle;

(e) a rear truck assembly comprising a rear base plate mounted to a rear underside of the deck and comprising a rear weight sensor positioned to directly or indirectly measure a force exerted on the rear base plate by the skateboard deck, and a rear hanger pivotably coupled to the rear base plate and comprising a rear axle;

15 (e) front and rear pairs of wheels, each pair of wheels mounted to the front and rear axles respectively, wherein at least one of the front and rear pairs of wheels is coupled to and rotatably driven by the at least one motor; and

20 (f) at least one controller communicative with the front and rear weight sensors and the at least one motor, and comprising a processor and a memory having encoded thereon program code executable by the processor to operate the at least one motor in response to measurements received from the front and rear weight sensors.

25 20. A method for controlling an electric skateboard comprising front and rear weight sensors mounted respectively to front and rear baseplates of the electric skateboard, and a motor rotatably coupled to drive wheels of the electric skateboard, the method comprising:

- (a) repeatedly reading measurements taken by the front and rear weight sensors and determining a total weight and weight distribution of a rider on the electric skateboard;
- 5 (b) when the determined total weight is within a defined margin of a baseline weight, operating the motor to accelerate the skateboard when the weight distribution is higher on the front baseplate than on the rear baseplate, and operating the motor to decelerate the skateboard when the weight distribution is higher on the rear baseplate than on the front baseplate; and
- 10 (c) identifying a kick event when the determined total weight momentarily decreases beyond a defined kick threshold, and operating the motor to limit acceleration of the skateboard during the kick event, and operating the motor to sustain skateboard speed or to decelerate the skateboard for a selected time period after the kick event ends.
- 15 21. The method as claimed in claim 20, wherein the selected time period after the kick event ends is between 0.5 and 3 seconds.
22. The method as claimed in claim 20 wherein operating the motor to limit acceleration of the skateboard during the kick event comprises operating the motor in a regenerative braking mode.
- 20 23. The method as claimed in claim 20, wherein identifying the kick event further comprises: detecting an acceleration of the skateboard when the total weight momentarily decreases below the defined kick threshold but is above a weight threshold indicating that a rider has one foot on the skateboard.
- 25 24. The method as claimed in claim 20, further comprising detecting a bounce event, comprising identifying a period of increased total weight followed by a period of reduced total weight with no associated acceleration of the skateboard during the period of reduced total weight, and filtering out detected bounce events from the step of identifying a kick event.
25. A computer readable medium having encoded thereon program code executable by a processor to:

- (a) repeatedly read measurements taken by the front and rear weight sensors and determining a total weight and weight distribution of a rider on the electric skateboard;
- 5 (b) when the determined total weight is within a defined margin of a baseline weight, operate the motor to accelerate the skateboard when the weight distribution is higher on the front baseplate than on the rear baseplate, and operate the motor to decelerate the skateboard when the weight distribution is higher on the rear baseplate than on the front baseplate; and
- 10 (c) identify a kick event when the determined total weight momentarily decreases beyond a defined kick threshold, and operate the motor to limit acceleration of the skateboard during the kick event, and operate the motor to sustain skateboard speed or to decelerate the skateboard for a selected time period after the kick event ends.
26. An electric skateboard, comprising:
- 15 (a) a deck;
- (b) at least one motor;
- (c) a battery electrically coupled to the at least one motor;
- 20 (d) a front truck assembly comprising a front base plate mounted to a front underside of the deck and comprising a front weight sensor positioned to directly or indirectly measure a force exerted on the front base plate by the skateboard deck, and a front hanger pivotably coupled to the front base plate and comprising a front axle;
- 25 (e) a rear truck assembly comprising a rear base plate mounted to a rear underside of the deck and comprising a rear weight sensor positioned to directly or indirectly measure a force exerted on the rear base plate by the skateboard deck, and a rear hanger pivotably coupled to the rear base plate and comprising a rear axle;
- (e) front and rear pairs of wheels, each pair of wheels mounted to the front and rear axles respectively, wherein at least one of the front and rear pairs of wheels is coupled to and rotatably driven by the at least one motor; and

(f) at least one controller communicative with the front and rear weight sensors and the at least one motor, and comprising a processor and a memory having encoded thereon program code executable by the processor to:

(i) repeatedly read measurements taken by the front and rear weight sensors and determining a total weight and weight distribution of a rider on the electric skateboard;

(ii) when the determined total weight is within a defined margin of a baseline weight, operate the at least one motor to accelerate the skateboard when the weight distribution is higher on the front baseplate than on the rear baseplate, and operate the at least one motor to decelerate the skateboard when the weight distribution is higher on the rear baseplate than on the front baseplate; and

(iii) identify a kick event when the determined total weight momentarily decreases beyond a defined kick threshold, and operate the at least one motor to limit acceleration of the skateboard during the kick event, and operate the at least one motor to sustain skateboard speed or to decelerate the skateboard for a selected time period after the kick event ends.

27. A truck base plate for an electric skateboard, the truck base plate being mountable to an underside of an electric skateboard deck and pivotably mountable to a truck hanger, the truck base plate comprising a weight sensor positioned to directly or indirectly measure a force exerted on the truck base plate by the skateboard deck.

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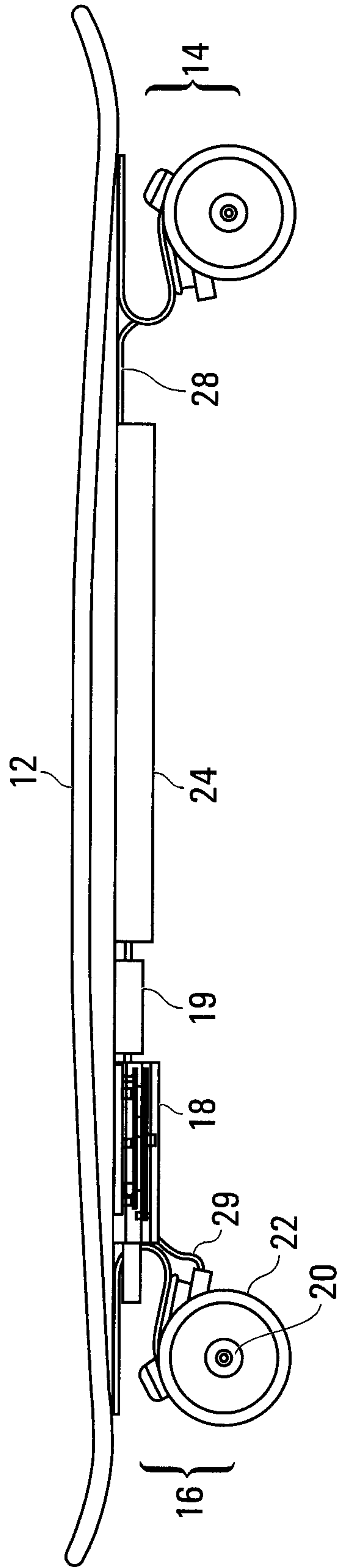


FIG. 1

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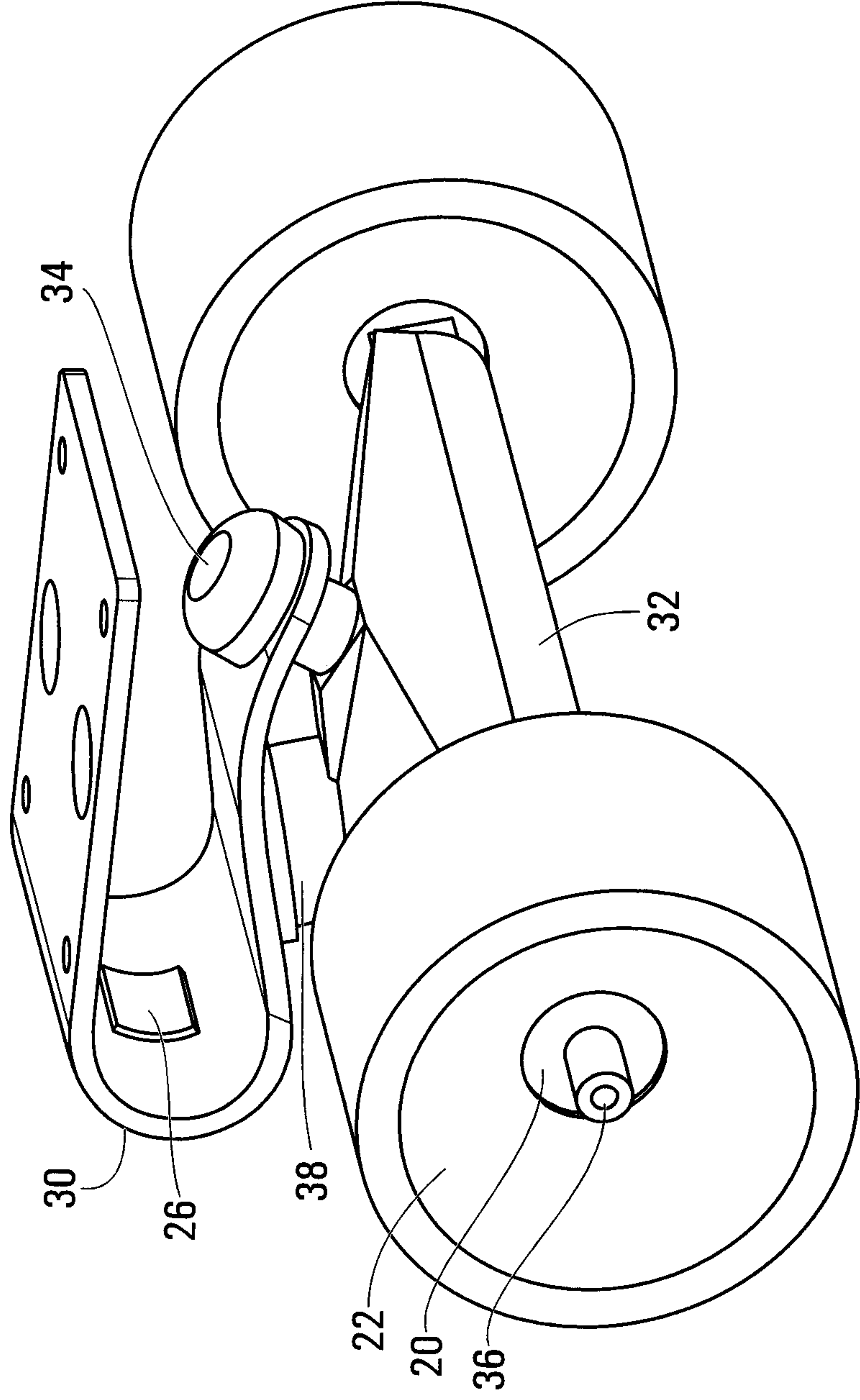


FIG. 2A

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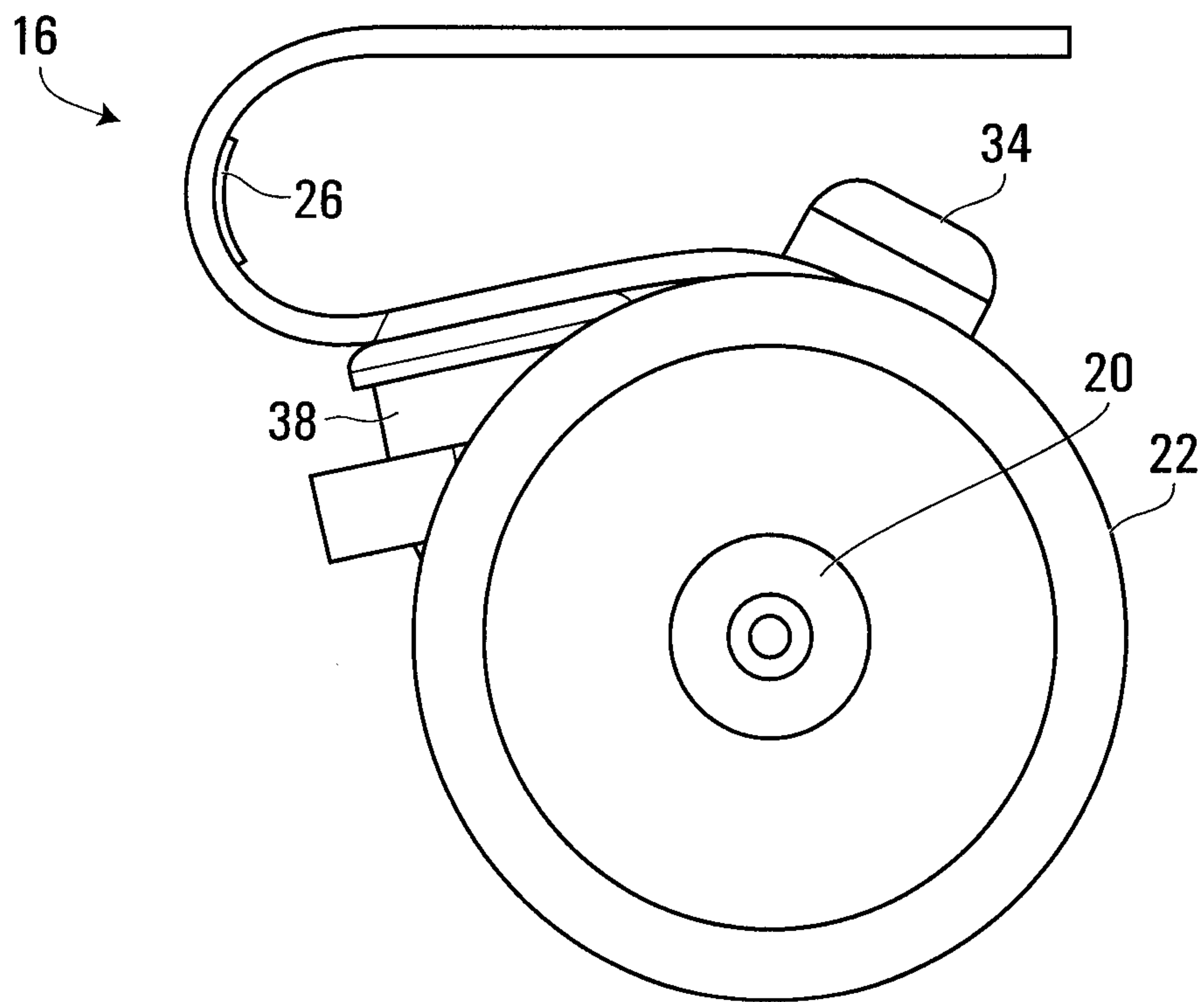


FIG. 2B

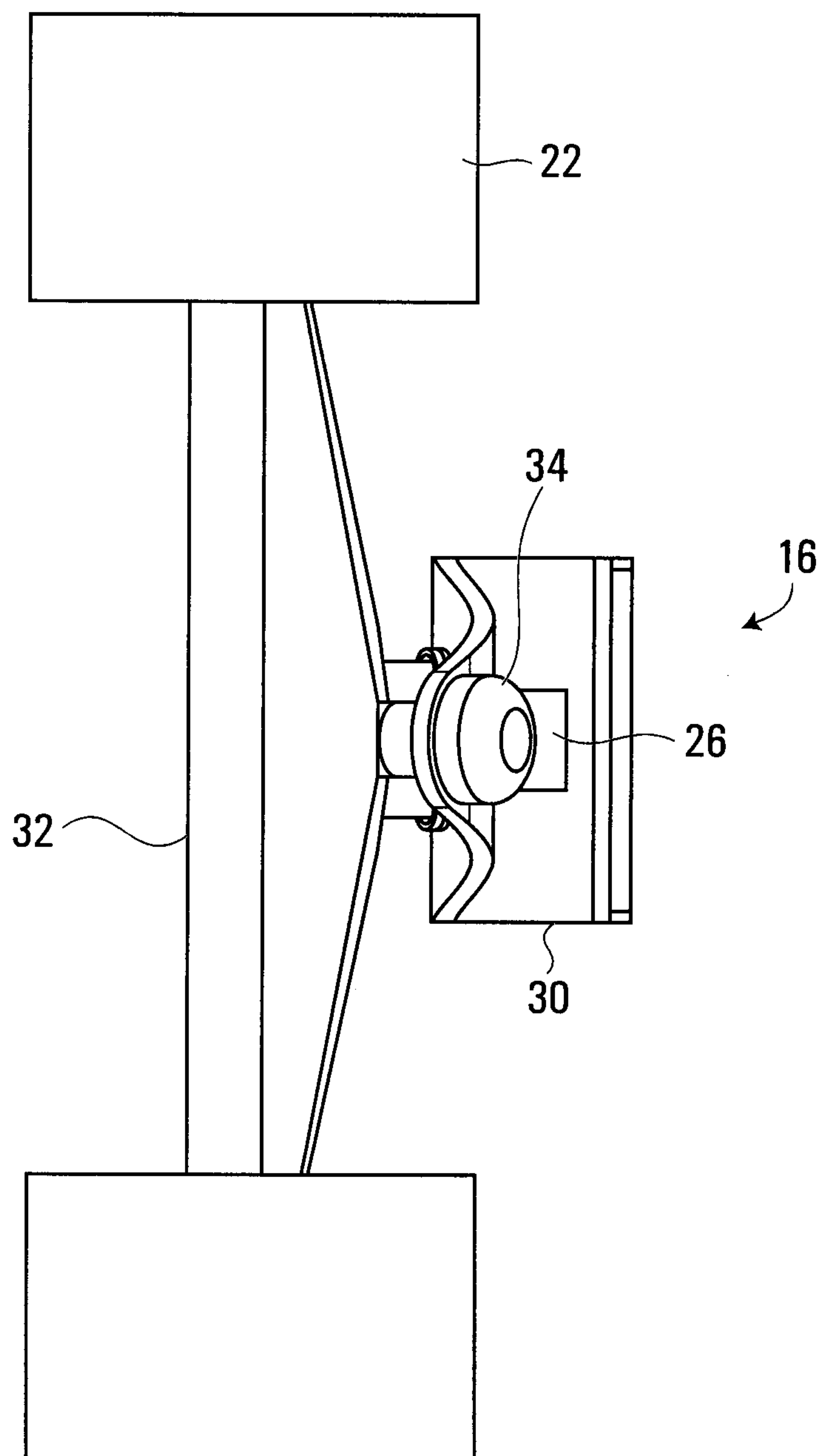


FIG. 2C

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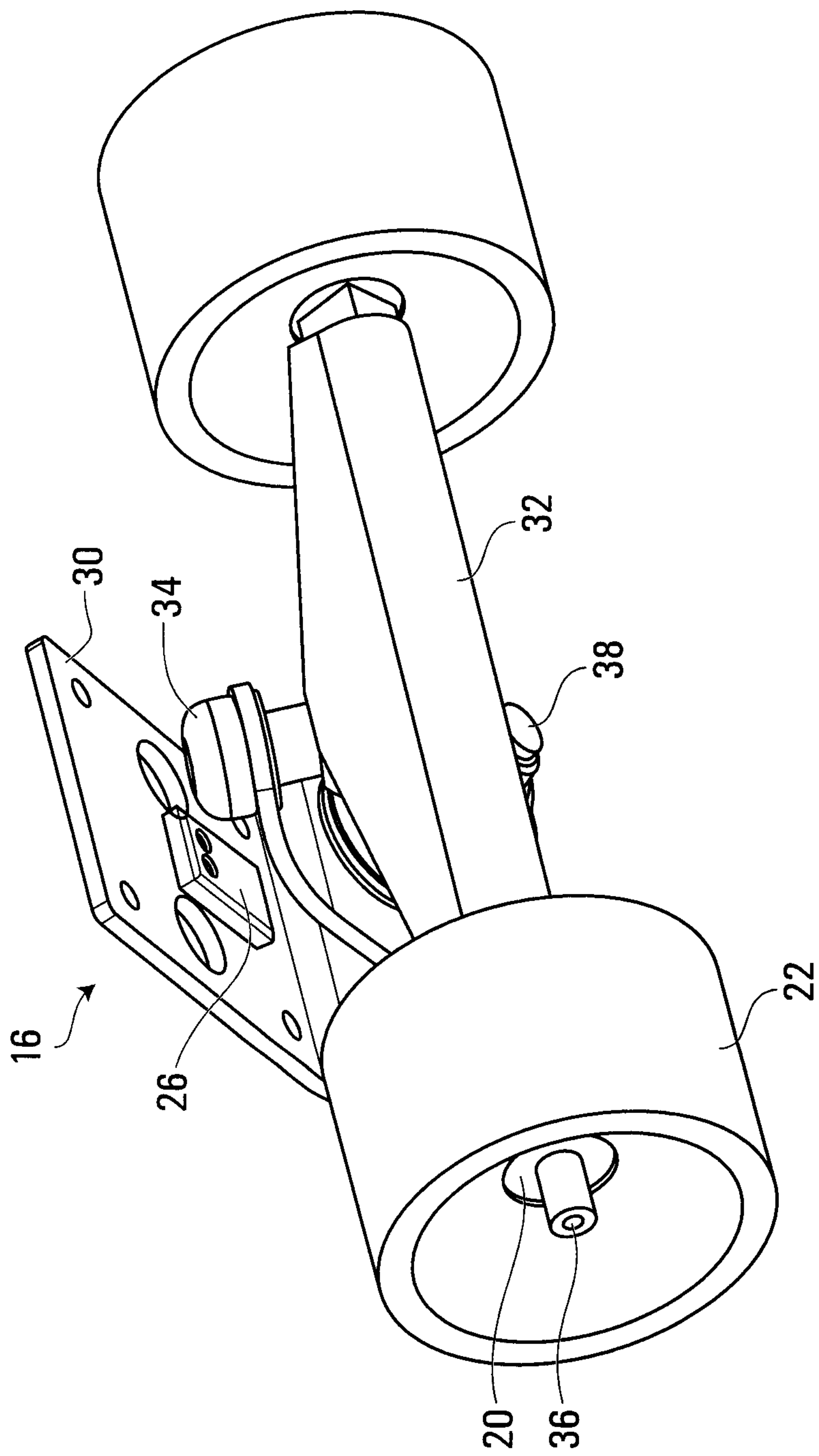


FIG. 3A

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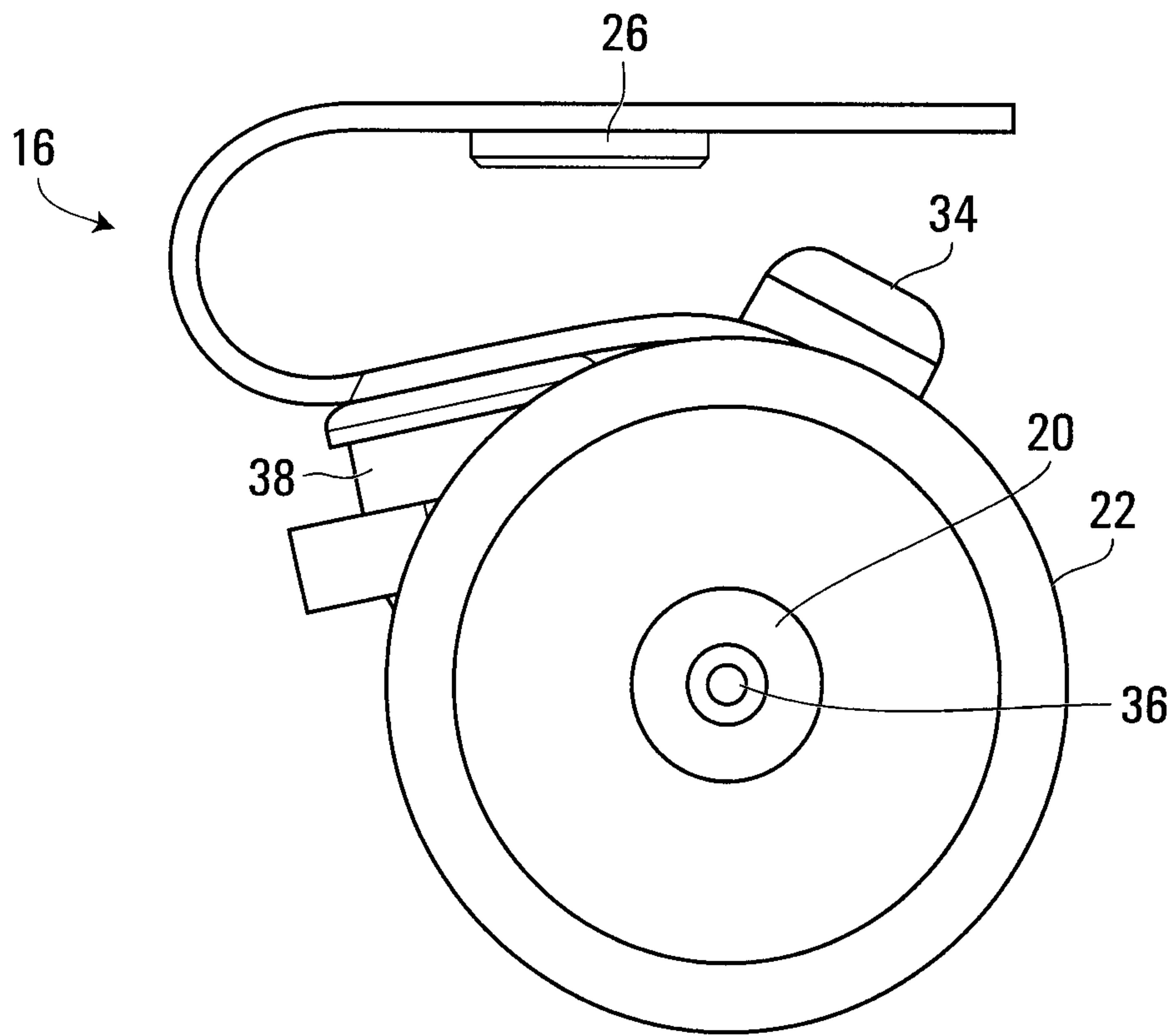


FIG. 3B

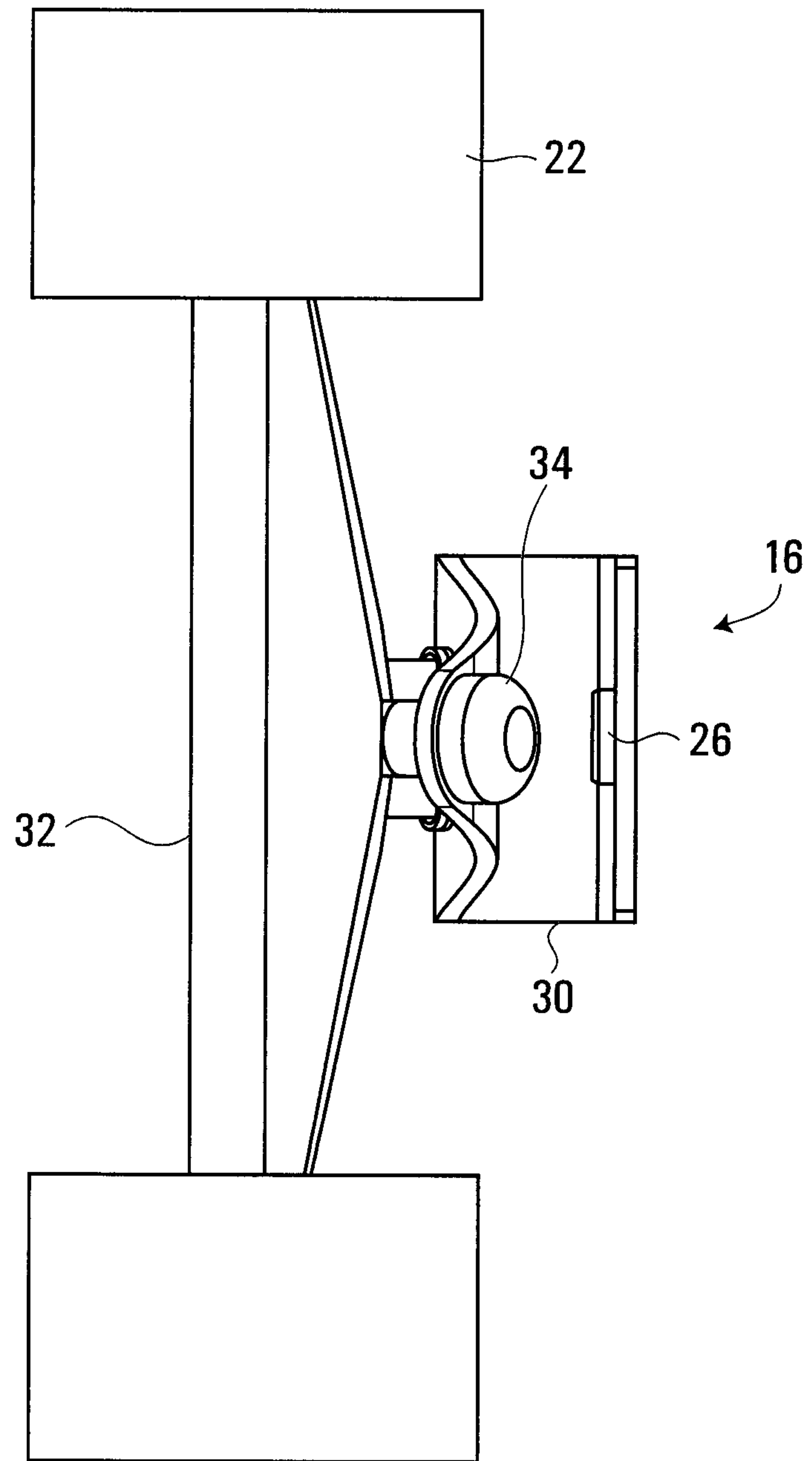


FIG. 3C

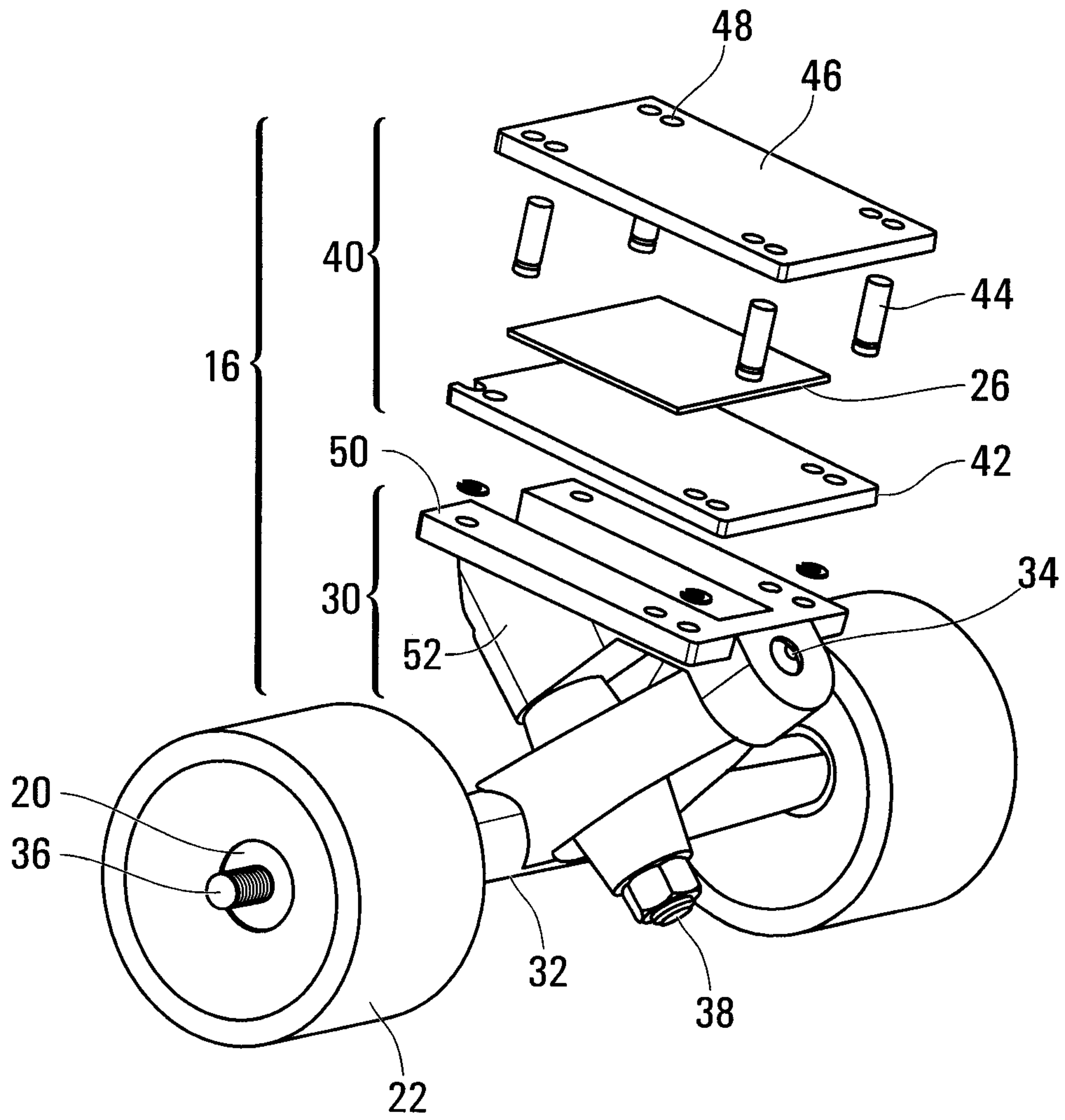


FIG. 4A

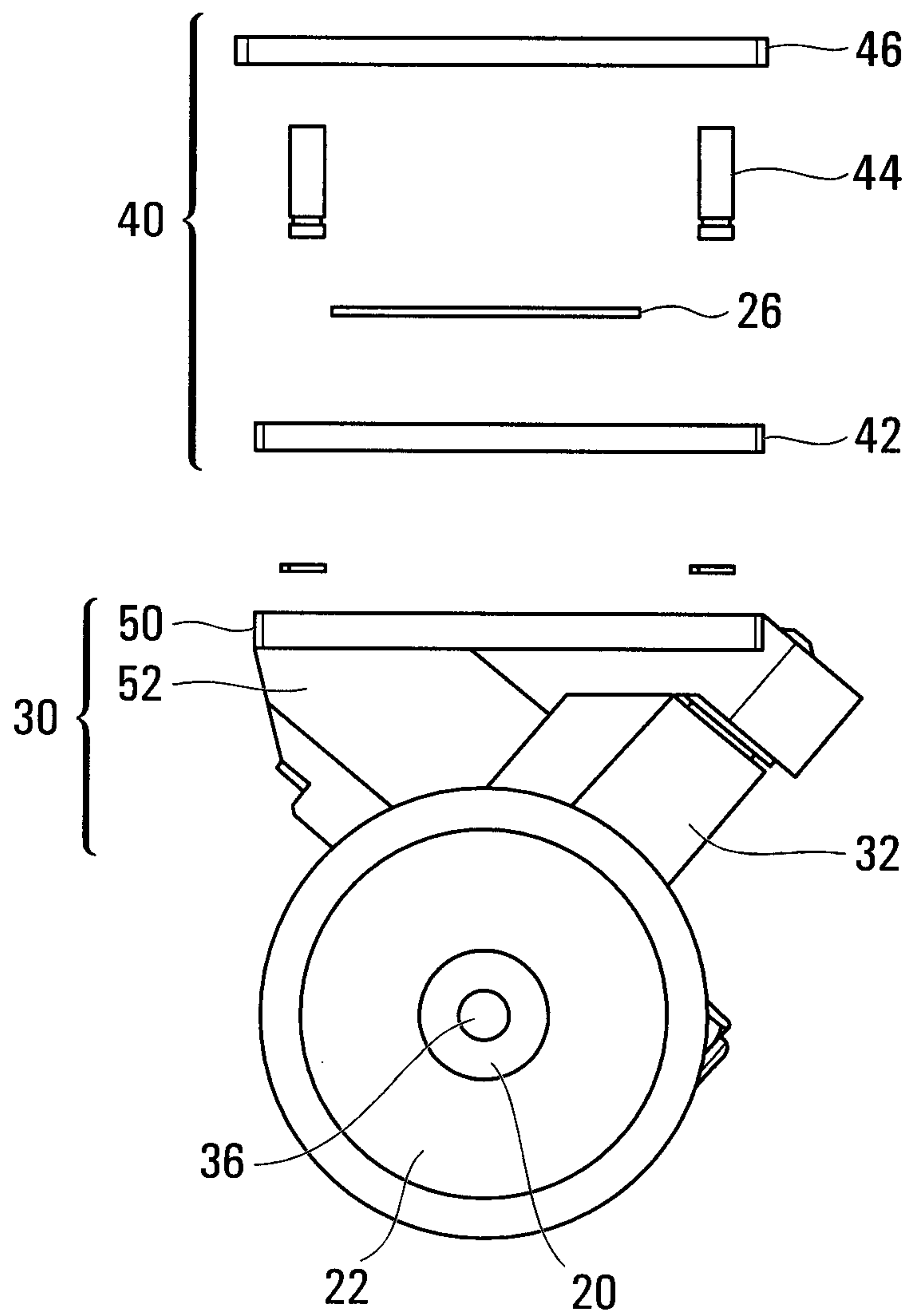


FIG. 4B

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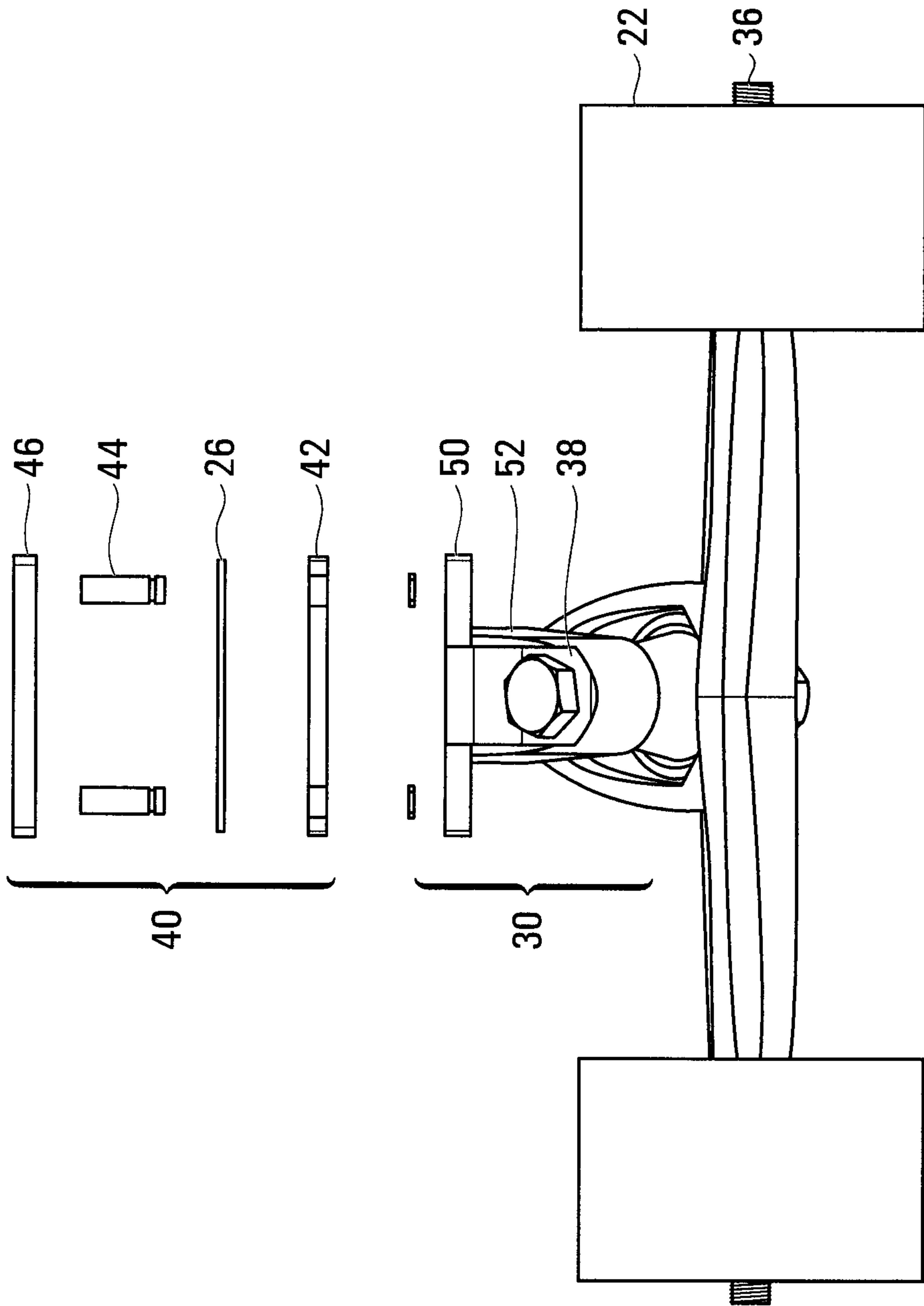


FIG. 4C

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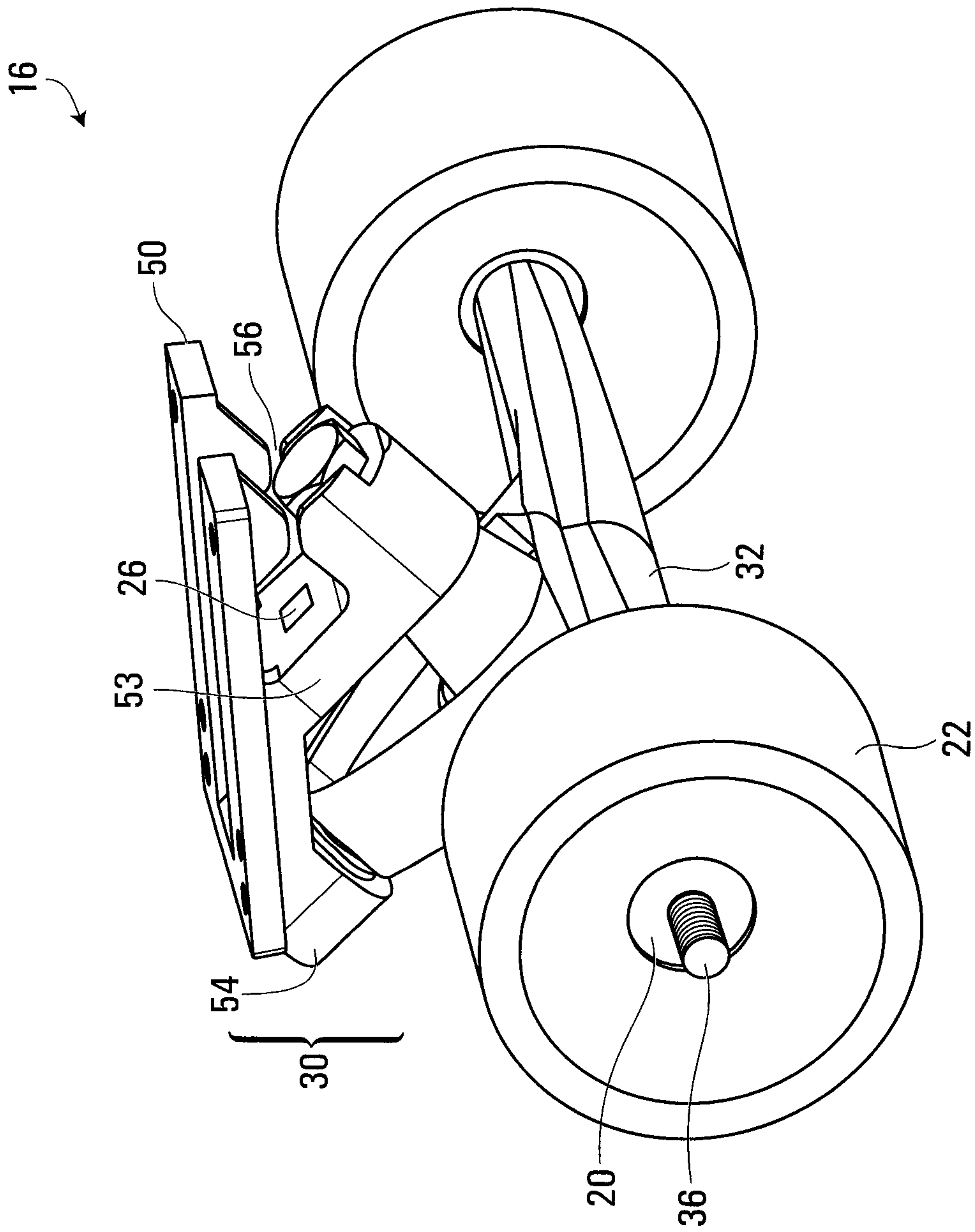


FIG. 5A

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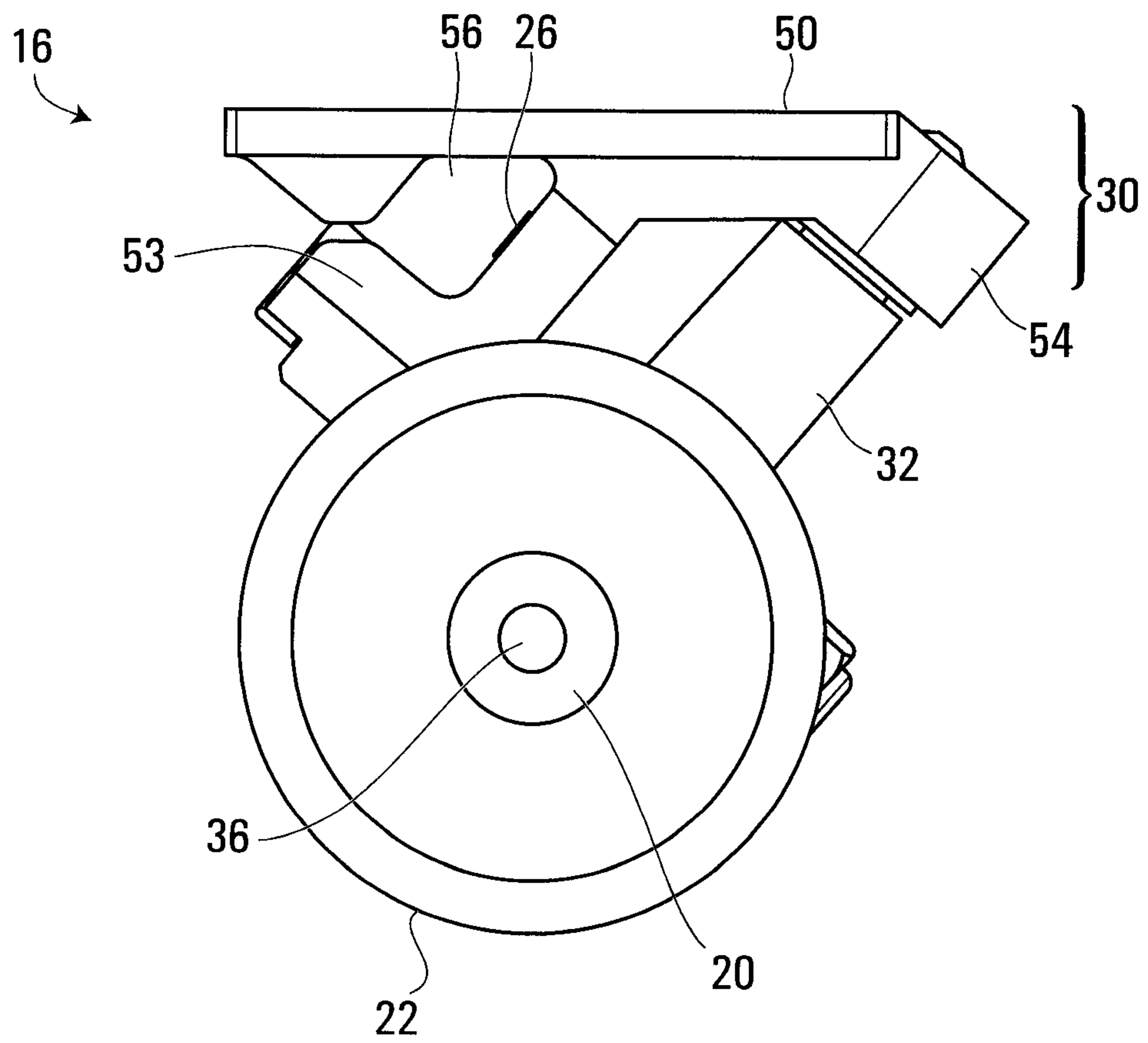


FIG. 5B

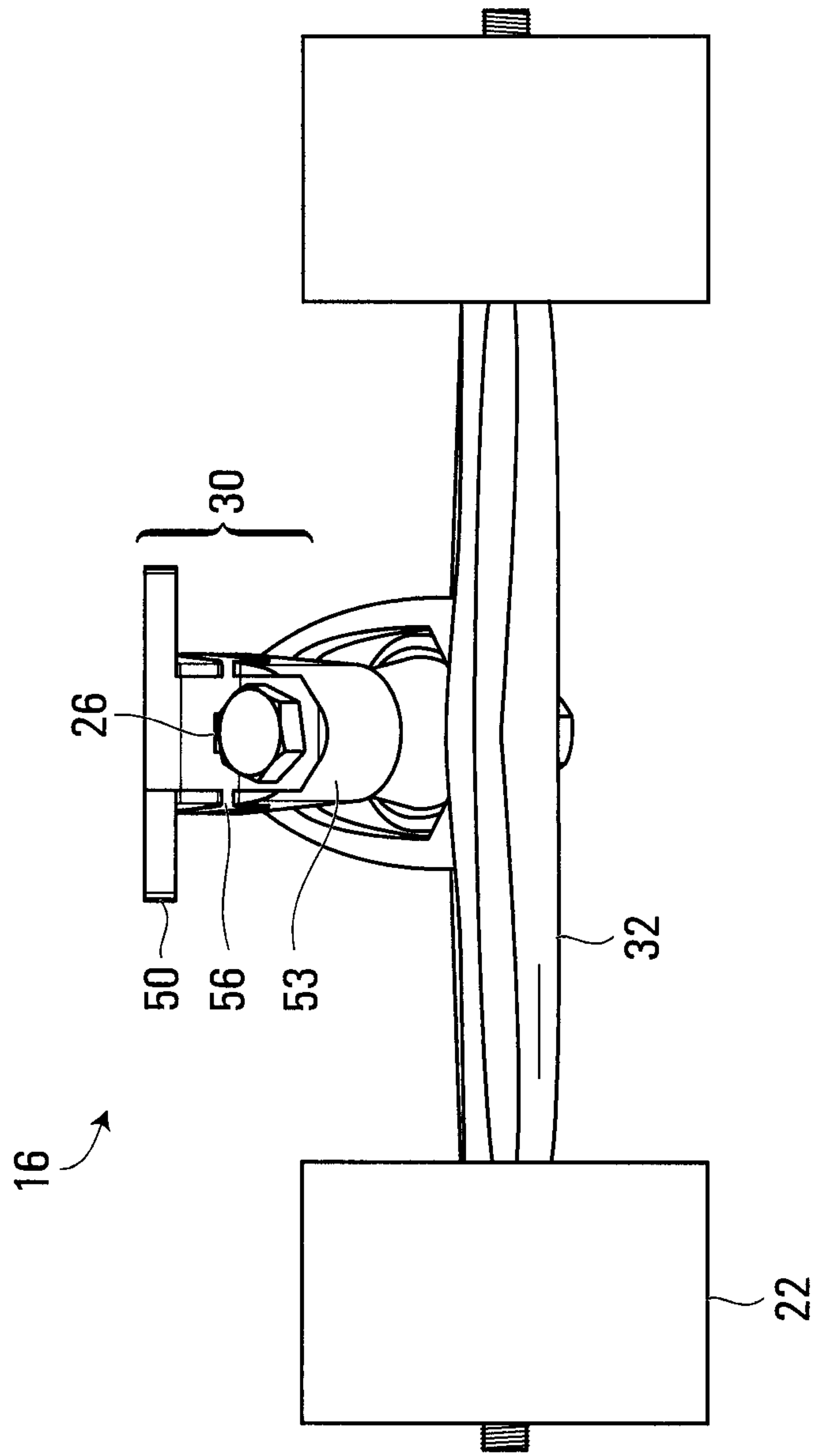
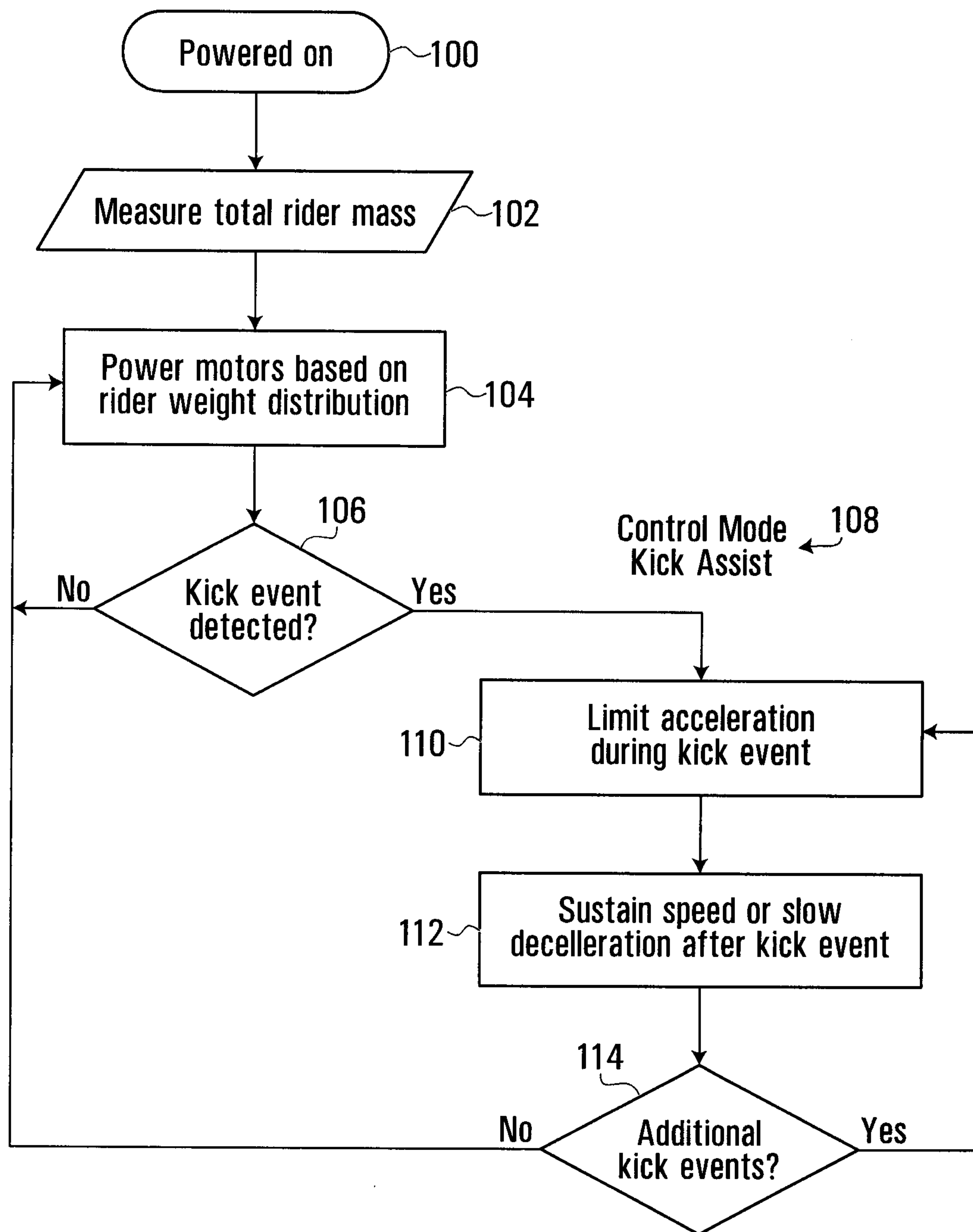


FIG. 5C

**FIG. 6**

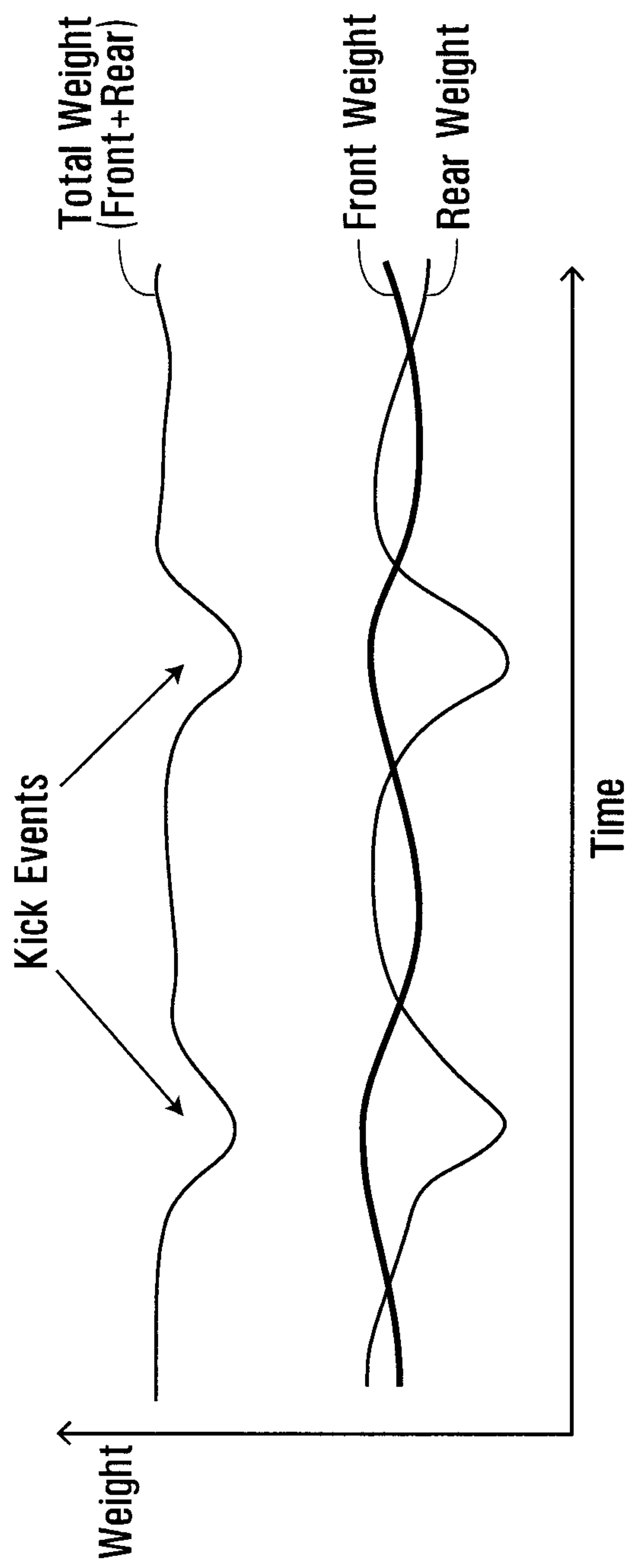


FIG. 7

