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(71) Ansøger:
Driven Technologies Inc., 2840 Wilderness Place, Suite G, 80301 Boulder, Colorado, USA

(72) Opfinder:
Cameron Frazer, --, 80301 Boulder, Colorado, USA
Jason Smith, --, 80301 Boulder, Colorado, USA

(74) Fuldmægtig:
Patentgruppen A/S, Åboulevarden 31, 4., 8000 Aarhus C, Danmark

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A human-electric hybrid powertrain with a continuously variable transmission achieved with the use of a bevel planetacy gearset. Two electric motors are utilized to produce a hybrid powertrain with either a driveshaft, chain, or belt driveline. Tue electric motors combine to produce an infinitely variable range of gear ratios and power assistance to the operator.

Fortsættes...

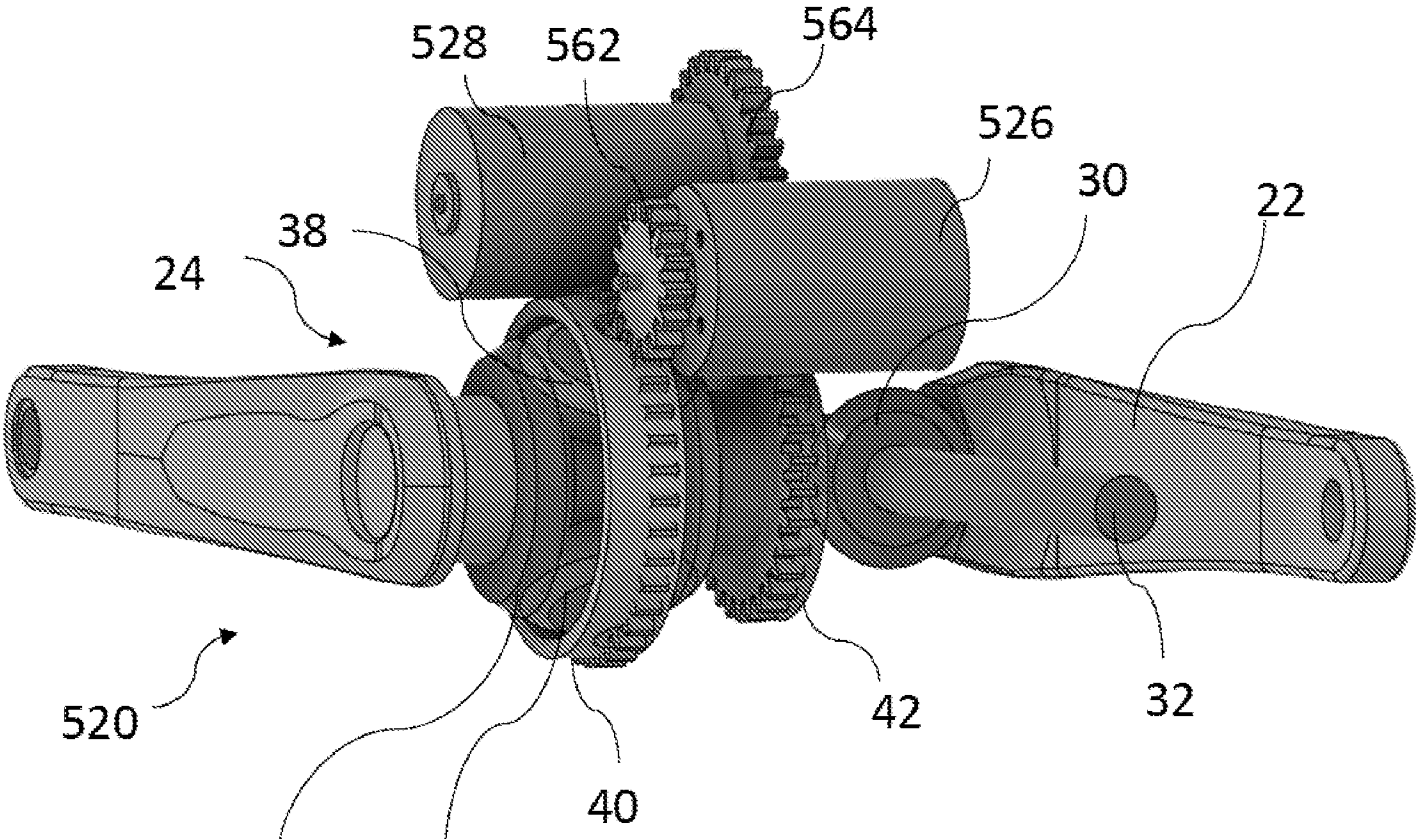

Fig. 5a

FIELD OF THE INVENTION

[0001] The present invention relates generally to an electric pedal assist bicycle transmission utilizing a continuously variable transmission.

BACKGROUND

[0002] An electric pedal assist bicycle powertrain is a type of hybrid drive where power provided by an electric motor and power provided by a human are combined in an additive fashion to mobilize a bicycle. Numerous types of electric pedal assist bicycle powertrains exist, but generally, traditional electric pedal assist bicycle powertrains are complicated due to the combination of new and legacy products to achieve a multispeed powertrain. An example of such a combined product is the use of a mid-drive electric motor with a derailleur and chain transmission. Other popular examples found in prior art include US10,137,954, US9,302,734, DE10,2018,130,377, US20,150,011,346, US9,777,774, and US10,773,771. The motors in these types of drives may utilize planetary gearsets to step the speed of the motor down to match rider cadence. Examples of these drives include US8,985,254 and US8,652,000.

SUMMARY

[0003] Described herein is an electric pedal assist powertrain for a bicycle. More specifically, the embodiments provided herein are continuously variable transmissions that can utilize either a driveshaft, belt, or a chain driveline. The continuously variable nature of the transmission is achieved through a bevel planetary gear train. The embodiments described herein may be used in any human powered vehicle that can utilize power assistance from an electric motor. The most common of those applicable vehicles is a bicycle for either on or off-road use. The powertrains described herein beneficially may be compact, high power, high efficiency continuous variable transmissions.

[0004] In some embodiments the gears within the bevel planetary gear train receive power from electric motors or from the rider depending on the driveline choice of either a driveshaft or a chain. The output direction of the bevel planetary gear train is opposite for each of these embodiments. In all embodiments the speeds of the sun gear, planet carrier, and ring gear are controlled either by an electronic control system or the rider through their application of power at the input of the bevel planetary gear train.

[0005] According to certain embodiments the bevel gears within the bevel planetary gear train and the bevel gears of the driveshaft may be of differing sizes to accommodate different applications. For example, on road bicycles travel at faster speeds than off road bicycles therefore each of these applications require a different range of and absolute values of gear ratios.

[0006] In some embodiments that require high efficiency, gears with rolling elements like lantern gears are utilized. This is possible because unlike in a standard planetary gear train where the sizes of the planet gears affect the gear ratio, this is not the case for a bevel planetary gear train.

[0007] In various embodiments the maximum speed of the vehicle is controlled by switching one of the motors into a regenerative brake to adhere to regulations surrounding the speeds of electric vehicles. This switching is required to maintain the same gear ratio being provided by the other motor.

[0008] Various other benefits and advantages may be realized with the devices and methods provided herein, and the aforementioned advantages should not be considered limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The principles of the embodiments described herein show the structure and operation of several examples used to illustrate the disclosure. It should be understood that the drawings are diagrammatic and schematic representations of such example embodiments and, accordingly, are not limiting the scope of the present invention, nor are the drawings necessarily drawn to scale.

[0010] FIG. 1 illustrates a typical bicycle frame and the location of electric components for rider assistance.

[0011] FIG. 2 illustrates an electric pedal assist powertrain consisting of motors, bevel gears and a driveshaft.

[0012] FIG. 3 illustrates another perspective of an electric pedal assist powertrain to highlight internal details.

[0013] FIG. 4 illustrates the bevel planetary gearset which allows for a continuously variable transmission.

[0014] FIGS. 5a-b illustrate alternate embodiments of motors and their corresponding drives for an electric pedal assist powertrain.

[0015] FIG. 6 illustrates another embodiment of an electric pedal assist powertrain where the control motor and planet carrier have alternate power sources.

[0016] FIG. 7 illustrates a variation of the embodiment depicted in FIG. 6 for a chain driveline.

DETAILED DESCRIPTION

[0017] The subject matter of embodiments is described herein with specificity to meet statutory requirements, but this description is not necessarily intended to limit the scope of the claims. The claimed subject matter may be embodied in other ways, may include different elements or steps, and may be used in conjunction with other existing or future technologies. This description should not be interpreted as implying any particular order or arrangement among or between various steps or elements except when the order of individual steps or arrangement of elements is explicitly described. Directional references such as “up,” “down,” “top,” “bottom,” “left,” “right,” “front,” and “back,” among others, are intended to refer to the orientation as illustrated and described in the figure (or figures) to which the components and directions are referencing. All ranges disclosed herein are to be understood to encompass any and all subranges subsumed therein. For example, a stated range of “1 to 10” should be considered to include any and all subranges between (and inclusive of) the minimum value of 1 and the maximum value of 10; that is, all subranges beginning with a minimum value of 1 or more, e.g. 1 to 6.1, and ending with a maximum value of 10 or less, e.g., 5.5 to 10.

[0018] FIG. 1 illustrates an electric pedal assist bicycle 10 (hereinafter “bicycle 10”) that generally includes a frame 12 with a bottom bracket 12, seat tube 14, down tube 18, and rear hub 16. An assistance motor (not illustrated in FIG. 1 for simplicity of the figure) may be provided in or on various portions of the frame 12, such as but not limited to the bottom bracket 12 or rear hub 16. The electric pedal assist bicycle 10 may also have gear change systems at various locations such as but not limited to the bottom bracket 12 or rear hub 16. Batteries and auxiliary electronics (not illustrated) may be located within the down tube 18 and/or other locations as desired.

[0019] FIGS. 2-4 illustrate an example of an electric pedal assist powertrain 20 (hereinafter “hybrid powertrain 20”) for a bicycle such as the bicycle 10 according to embodiments. The hybrid powertrain 20 generally includes a bicycle crank 22, a bevel planetary gearset 24, a first motor 26, optionally a second motor 28, a bevel gear drive 30, and a driveshaft 32. A control system 46 may be used with the hybrid powertrain 20 in certain embodiments and as discussed in detail below. In used, the hybrid powertrain 20 delivers power to the rear hub 16 via the driveshaft 32.

[0020] The bicycle crank 22 includes a shaft 34. Pedals and/or other features or devices may be supported on the bicycle crank 22 for a rider to engage and thereby provide human power into the hybrid powertrain 20 as desired. The particular bicycle crank 22 illustrated should not be considered limiting.

[0021] The first motor 26 and the second motor 28 may be various types of framed or frameless motors as desired. In FIGS. 2-4, the motors 26, 28 illustrated are frameless motors. FIGS. 5a-b, discussed in detail below, illustrate examples of framed motors. In certain embodiments, the second motor 28 is a power motor for providing a steady state of output power to the system, and the first motor 26 may be a control motor providing speed matching between the second (power) motor 28 and the bicycle crank 22 so the rider can maintain a comfortable cadence. As non-limiting examples of motors, in FIGS. 2-4, the first motor 26 may be a direct drive brushless DC torque motor with a position feedback device, thereby making it a type of servo motor, and the second motor 28 may be a direct drive brushless DC torque motor. In another embodiment, the second motor 28 may be converted into a servo motor with a position feedback device. Examples of position feedback devices for direct drive motors include, but are not limited to, optical ring encoders, ring Hall-effect encoders, inductive encoders, combinations thereof, and/or other types of position feedback devices as desired. In further embodiments, the motors 26, 28 are brushed and may or may not be considered frameless.

[0022] The control system 46 includes a controller 56 and optionally includes an interface 58 and/or one or more sensors 60. The components of the control system 46 may be provided at various locations on the bicycle 10 as desired. The controller 56 is operatively coupled to the motors 26, 28, and may be various types of controllers as desired. As a non-limiting example, the controller 56 may include a processor and/or memory, although it need not in other embodiments, and other types of control devices for controlling the motors 26, 28 may be utilized.

[0023] When included, the interface 58 may be on the controller 56 itself or may be a component separate from the controller 56. The interface 58 may be various types of physical and/or virtual interfaces as desired for receiving an input from the rider. The interface 58 may be provided at various locations as desired, and in one non-limiting example may be provided on or proximate to handlebars of the bicycle 10. In certain embodiments, the controller 56 is operatively coupled to the motors 26, 28, and may control one or both motors 26, 28 based on the input from the rider. In various embodiments, the controller 56 receives wired or wireless signals from the interface 58 to modify characteristics of the motors 26, 28, such as but not limited to power and/or speed ratio.

[0024] Optionally, the control system 46 includes one or more sensors 60, and the controller 56 may receive information from the sensors 60 via wired or wireless communication. In certain embodiments, the controller 56 may control one or both motors 26, 28 based on information from the sensors (alone or in combination with input from the rider). Non-limiting examples of sensors 60 include but are not limited to strain gauges, accelerometers, gyroscopes, combinations thereof, and/or other types of sensors for detecting or measuring other information related or relevant to operation of the hybrid powertrain 20.

[0025] In certain embodiments, the hybrid powertrain 20 with the control system 46 may be capable of discrete gear ratios by utilizing software in combination with the onboard sensors. These gear ratios can be customized by the rider prior to and/or during the use of the hybrid powertrain 20 using the interface 58. These gear ratios may be selectable by the rider on the fly utilizing the interface 58. The continuously variable transmission also provides the ability for the powertrain 20 to be automatic in changing gear ratios to allow the rider to maintain a steady cadence regardless of the speed of the bicycle 10.

[0026] As best illustrated in FIGS. 3 and 4, the bevel planetary gearset 24 generally includes a bevel sun gear 36, one or more bevel planet gears 38, a planet carrier 40, and a bevel ring gear 42.

[0027] The bevel sun gear 36 may be centered to the bicycle crank 22 (e.g., on the shaft 34). In certain embodiments, a clutch 44 such as but not limited to a bearing (best illustrated in FIG. 3) acts as the mechanical linkage between the bevel sun gear 36 and the shaft 34. In one non-limiting embodiment, the clutch 44 is a one-way bearing clutch (e.g., configured to transmit torque between the sun gear 36 and the shaft 34 in one direction and free motion in the opposite direction), although in other embodiments, other types of clutches may be utilized as desired. In various embodiments, the clutch 44 may beneficially disconnect the rider / bicycle crank 22 from the bevel planetary gearset 24 to protect the rider in various situations. As a non-limiting example, the clutch 44 may disconnect the rider / bicycle crank 22 in the event the motors 26 and/or 28 cause the crank 22 to rotate faster than the rider cadence. Additionally, or alternatively, the clutch 44 beneficially may prevent the rider from back-driving the hybrid powertrain 20, which may confuse and/or otherwise cause issues with the control system 46.

[0028] The planet gears 38 of the bevel planetary gearset 24 are connected to the planet carrier 30 via mechanisms such as but not limited to pins 48. In the embodiment illustrated there are three planet gears 38. However, the number of planet gears 38 should not be limiting, and in other embodiments, any number of planet gears 38 may be used as desired, including less than three planet gears 38 or more than three planet gears 38. In various embodiments, the first motor 26 is attached and/or engaged with the planet carrier 40 (optionally affixed rigidly), although it need not be in other embodiments.

[0029] As best illustrated in FIGS. 3 and 4, similar to the bevel sun gear 35, the bevel ring gear 42 is connected to the crank 22. In certain embodiments, a bearing 50 (best illustrated in FIG. 3) or other suitable devices or mechanisms connects the bevel ring gear 42 with the shaft 34. In one non-limiting embodiment, the bearing 50 is a ball bearing, although it need not be in other embodiments. The bevel ring gear 42 includes a first gear face 52 for engaging the plane gears 38 and a second gear face 54 for engaging the bevel gear drive 30. In certain embodiments, the bevel ring gear 42 is connected to the driveshaft 32 via the bevel gear drive 30, and as best illustrated in FIG. 3, the bevel gear drive 30 engages the second gear face 54 of the bevel ring gear 42. In use, the planet carrier 40 rotates in the opposite direction of the sun gear 36, but in the same direction as the bevel ring gear 42. Such rotation achieves the rotational direction of the driveshaft 32 required for the rear wheel to produce forward locomotion. The second motor 28 may be attached and/or engaged with the bevel ring gear 42.

[0030] The control motor 26 modifies the bevel planetary gearset 24 from a single speed gear train into a continuously variable transmission. The power motor 28 allows a steady state of output power to be provided to the rider. The control motor 26 provides speed matching between the crank 22 and power motor 28 so the rider can maintain a comfortable cadence. If the speed of the control motor 26 is increased, the amount of assistance from the control motor increases, and the power motor 28 may provide the difference.

[0031] The hybrid powertrain 20 with the bevel planetary gearset 24 provides an opportunity to optimize the gear ratio between the input and output of the driveshaft 32 for a bicycle. As one non-limiting example, the hybrid powertrain 20 may comfortably fit in and/or otherwise be supported at the bottom bracket 12 area of the bicycle 10, which has limited available space (e.g., due to the maximum comfortable spacing between the rider's feet). The hybrid powertrain 20 with the bevel planetary gearset 24 also allows for higher transmission ratios achievable in smaller spaces compared to traditional powertrains.

[0032] Another advantage of the hybrid powertrain 20 with the bevel planetary gearset 24 is the ability to significantly increase the size of the planet gears 38. The planet gears 38 in the powertrain 20 span a distance to mesh with two external gears (e.g., the sun gear 36 and the bevel gear ring 42), unlike a conventional planetary gear trains where the planet gears are confined to an internal gear, thereby reducing the maximum size of traditional planet gears. The increased size of the planet gears 38 allows for greater torque capacity, which may be advantageous when designing electric assist bicycles where the motors 26, 28 can produce more torque to the rider, and the rider is thereby capable of producing torque equivalent to an automobile (although it need not). The increased size of the planet gears 38 also allows for non-conventional tooth architectures to be utilized in other embodiments. As non-limiting examples, the planet gears 38 could be lantern bevel gears and/or similar rolling elements to increase the efficiency of the transmission.

[0033] In some embodiments, and as best illustrated in FIG. 4, the sun gear 36 optionally is a same size (e.g., same sized outer diameter) as the bevel ring gear 42. It should be evident that this layout would not be possible with a standard planetary gear train. In embodiments where the sun gear 36 is a same size as the bevel ring gear 42, if the control motor 26 was to hold the carrier stationary, the gear ratio of the embodiment illustrated is 1:1.

[0034] In other embodiments, the sun gear 36 and the bevel ring gear 42 may be different sizes. Utilizing a sun gear 36 and bevel ring gear 42 of differing sizes allows the control motor 26 and power motor 28 to be balanced in terms of their power assistance leading to motors of similar size and specification. As one non-limiting example, the sun gear 36 is larger than the bevel ring gear 42. Such embodiments may provide a step up in speed when the planet carrier 40 is held stationary. An arrangement where the sun gear 36 is larger than the bevel ring gear 42 may allow for a smaller control motor 26 to achieve the same output speed. Such an arrangement in turn would lower the torque contribution of the control motor 26 which may be compensated for by the power motor 28. In another non-limiting example, the sun gear 36 is smaller than the bevel ring gear 42.

[0035] As another non-limiting example, the hybrid powertrain 20 with the bevel planetary gearset 24 provides a continuously variable transmission with an infinite number of gear ratios within a fixed range. As mentioned, the hybrid powertrain 20 is capable of discrete gear ratios by utilizing software in combination with the onboard sensors, and such gear ratios can be customized by the user and/or selected as desired. The continuously variable transmission also provides the ability for the hybrid powertrain 20 to be automatic in changing gear ratios to allow the rider to maintain a steady cadence regardless of the speed of the bicycle.

[0036] There are many international, national, and regional regulations surrounding the speed electric assist bicycles are allowed to transit at. In such cases, the hybrid powertrain 20 described herein may achieve a wide range of gear ratios without exceeding the speed limits imposed by regulations surrounding electric assist bicycles. As non-limiting examples, the power motor 28 of the hybrid powertrain 20 may not only provide additional assistance, but when the control motor 26 is providing too much power to achieve a certain gear ratio (and therefore a transit speed that is too high), the power motor 28 may used as a regenerative motor. In such an example, utilizing the power motor 28 as a regenerative motor allows the hybrid powertrain 20 to achieve a wide range of gear ratios without exceeding the speed limits imposed by regulations surrounding electric assist bicycles.

[0037] In yet another embodiment of the powertrain 20, the power motor 28 is not utilized (either by deactivation, complete omission, disengagement, etc.). In embodiments where the power motor 28 is not utilized, the hybrid powertrain may create a single speed electric assist bicycle. In such an embodiment, as the rider speed increases, the amount of assistance increases. This embodiment could be utilized in a children’s bicycle or commuter bicycle and/or as otherwise desired.

[0038] As additional non-limiting examples, the bevel planetary gearset 24 within the hybrid powertrain 20 allows the additive torque of the power motor 28 and the rider input via the crank 22 to be delivered to the driveshaft 32. In certain embodiments, the control motor 26 provides speed matching between the crank 22 and power motor 28 so the rider can maintain a comfortable cadence.

[0039] FIGS. 5a and 5b illustrate additional embodiments of a hybrid powertrain 520 that is substantially similar to the hybrid powertrain 20 except that the hybrid powertrain 520 includes the motors 526 and 528. In this embodiment, the motors 526, 528 are framed motors and are used in place of frameless motors 26, 28. As best illustrated in FIG. 5a, spur gears 562 or bevel gears 564 are used to transmit the motor power to the planet carrier 40 and bevel ring gear 42, respectively. In further embodiments, chains and sprockets, belts and pulleys, and/or other features or mechanisms are used to transmit motor power to the planet carrier 40 and/or the bevel ring gear 42 are used. Framed motors might be used for either the control motor 526, power motor 528, or both. The advantage these embodiments present is for the use of motors of lower torque and power to achieve the same bicycle speeds.

[0040] FIG. 6 illustrates another embodiment of a hybrid powertrain 620 according to embodiments. The hybrid powertrain 620 is substantially similar to the hybrid powertrain 20 except that the control motor 26 is rigidly affixed to the sun gear 36 rather than the planet carrier 40 as in the hybrid powertrain 20. In this embodiment, a spindle bearing 664 may isolate the sun gear 36 from the crank 22 input provided by the rider. In the hybrid powertrain 620, the crank 22 transmits torque to the planet pins 22 and planet carrier 40 through a unidirectional clutch 668 such as, but not limited to, a one way bearing or ratchet. The power motor 28 and bevel ring gear 42 arrangement is in unchanged compared to the hybrid powertrain 20, and therefore the direction of the bevel ring gear 42 is determined by the direction of the sun gear 36. In the hybrid powertrain 620, the direction of the sun gear 36 also determines the magnitude of gear ratio at a given power. In such embodiments, a second planetary stage may be utilized to achieve the direction of the bevel ring gear 42 and gear ratio required.

[0041] FIG. 7 illustrates a further embodiment of a hybrid powertrain 720 according to embodiments. The hybrid powertrain 720 is substantially similar to the hybrid powertrains 20, 520, 620 except that the hybrid powertrain includes a direction change planetary gearset 770. The direction change planetary gearset 770 optionally enables the ability to utilize a chain 772 driveline in addition to aiding an embodiment for a driveshaft 32 mated with a bevel ring gear 42 rotating in the wrong direction. The direction change planetary gearset 770 includes of a sun gear 774, one or more planet gears 776, a planet carrier 780, and a ring gear 778. In the case of a chain 772 driveline, the sprocket teeth could be machined directly into the exterior of the bevel ring gear 42, and/or could also be done for a bevel gear 30 with driveshaft 32. In the embodiment with the hybrid powertrain 720, to get the direction change, the planet carrier 780 of the planet gears 776 may be rigidly affixed to a static element of the powertrain 720, such as but not limited to the case of the power motor 28 and/or the bottom bracket 12 of the frame.

[0042] The above-described aspects are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the present disclosure. Many variations and modifications may be made to the above-described embodiment(s) without departing substantially from the spirit and principles of the present disclosure. All such modifications and variations are intended to be included herein within the scope of the present disclosure, and all possible claims to individual aspects or combinations of elements or steps are intended to be supported by the present disclosure. Moreover, although specific terms are employed herein, as well as in the claims that follow, they are used only in a generic and descriptive sense, and not for the purposes of limiting the described embodiments, nor the claims that follow.

[0043] Illustration 1: A human-electric hybrid powertrain with a continuously variable transmission comprising:

a bevel planetary gear train having a planet carrier, a bevel sun and a bevel ring gear that is rotatably mounted to an input crank shaft;

a plurality of bevel planet gears rotatably mounted to a crank shaft;

a bevel output gear meshing with a driveshaft connected to the driving wheel

a first and second motor engaged with the planet carrier and bevel ring gear, respectively, providing drive power or speed control

a one way clutch rotatably connecting the crank shaft to the sun gear

a controller connected to said first and second motors to maintain power and speed ratio

wherein said controller receives wired or wireless signals from the operator interface device to modify either power or speed ratio.

[0044] Illustration 2: The human-electric hybrid powertrain of claim 1 wherein the first motor is engaged with the bevel sun or the planet carrier.

[0045] Illustration 3: The human-electric hybrid powertrain of Illustration 1 wherein a one way clutch is rotatably connecting the crank to the planet carrier.

[0046] Illustration 4: The human-electric hybrid powertrain of Illustration 1 wherein a secondary planet gearset connects the bevel ring gear with the output.

[0047] Illustration 5: The human-electric hybrid powertrain of Illustration 1 wherein a chain or belt is utilized to transfer power to the driving wheel.

[0048] Illustration 6: A hybrid powertrain comprising:

a drive shaft;

a bevel planetary gearset comprising a bevel sun gear, at least one bevel planet gear, a planet carrier, and a bevel ring gear, wherein the sun gear and the bevel gear ring are each on the drive shaft, and wherein the at least one planet gear is engage with both the sun gear and the bevel gear ring; and

a first motor and a second motor connected to the bevel planetary gearset.

[0049] Illustration 7: The hybrid powertrain of Illustration 6, wherein the first motor is affixed to the bevel sun gear or the planet carrier.

[0050] Illustration 8: The hybrid powertrain of Illustration 6, wherein the second motor is connected to the bevel ring gear.

[0051] Illustration 9: The hybrid powertrain of Illustration 6, further comprising a one-way clutch connecting the drive shaft with the bevel sun gear.

[0052] Illustration 10: An electric pedal assist powertrain comprising a bevel planetary gearset.

[0053] Illustration 11: An electric pedal assist powertrain comprising a crank, an electric motor, and a bevel planetary gearset configured to receive power from the crank and/or the electric motor.

[0054] Illustration 12: An electric pedal assist powertrain comprising a bevel planetary gearset comprising a sun gear, a planet carrier, and a ring gear, and wherein speeds of the sun gear, the planet carrier, and the ring gear are controlled either by an electronic control system or the rider through their application of power at the an input of the bevel planetary gearset.

[0055] Illustration 13: An electric pedal assist powertrain comprising a bevel planetary gearset comprising a sun gear, a planet carrier, and a ring gear, wherein a size of the sun gear is different from a size of the ring gear.

[0056] Illustration 14: An electric pedal assist powertrain comprising a bevel planetary gearset comprising a sun gear, a planet carrier, and a ring gear, wherein a size of the sun gear is the same as a size of the ring gear.

[0057] Illustration 15: An electric pedal assist powertrain for a human-powered vehicle comprising a bevel planetary gearset, a first motor, and a second motor, wherein a maximum speed of the vehicle is controlled by switching one of the motors into a regenerative brake to adhere to regulations surrounding the speeds of electric vehicles.

[0058] Illustration 16: An electric pedal assist powertrain, wherein the powertrain is a continuously variable transmission.

[0059] Illustration 17: A bicycle comprising the powertrain of any preceding illustrations.

[0060] Illustration 18: A human-powered vehicle that can utilize power assistance from an electric motor comprising the powertrain of any preceding illustrations.

CLAIMS

Claim 1: A human-electric hybrid powertrain with a continuously variable transmission characterized by:

a bevel planetary gear train having a planet carrier, a bevel sun and a bevel ring gear that is rotatably mounted to an input crank shaft;

a plurality of bevel planet gears rotatably mounted to a crank shaft;

a bevel output gear meshing with a driveshaft connected to the driving wheel

a first and second motor engaged with the planet carrier and bevel ring gear, respectively, providing drive power or speed control

a one way clutch rotatably connecting the crank shaft to the sun gear

a controller connected to said first and second motors to maintain power and speed ratio

wherein said controller receives wired or wireless signals from the operator interface device to modify either power or speed ratio.

Claim 2: The human-electric hybrid powertrain of claim 1 wherein the first motor is engaged with the bevel sun or the planet carrier.

Claim 3: The human-electric hybrid powertrain of claim 1 wherein a one way clutch is rotatably connecting the crank to the planet carrier.

Claim 4: The human-electric hybrid powertrain of claim 1 wherein a secondary planet gearset connects the bevel ring gear with the output.

Claim 5: The human-electric hybrid powertrain of claim 1 wherein a chain or belt is utilized to transfer power to the driving wheel.

Claim 6: The human-electric hybrid powertrain of claim 1 wherein the sun gear and the bevel gear ring are each on the driveshaft, and wherein the at least one planet gear is engaged with both the sun gear and the bevel gear ring.

Claim 7: The human-electric hybrid powertrain of claim 1 wherein the second motor is connected to the bevel ring gear.

Claim 8: The human-electric hybrid powertrain of claim 1, further comprising a one-way clutch connecting the drive shaft with the bevel sun gear.

Claim 9: The human-electric hybrid powertrain of any of the proceedings claims, wherein the powertrain is mounted on a bicycle.

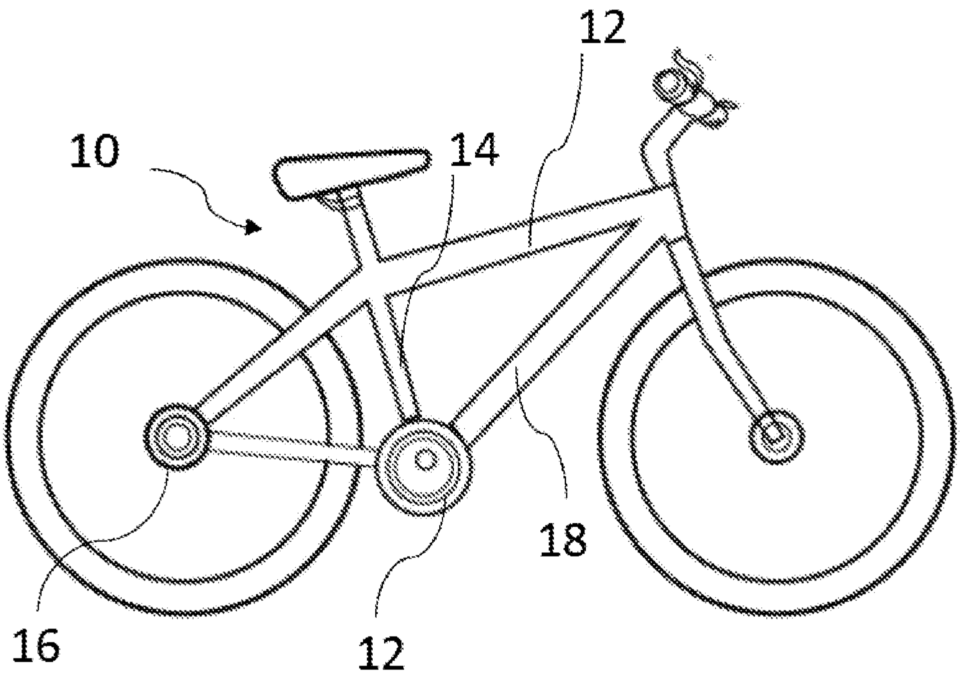

Fig. 1

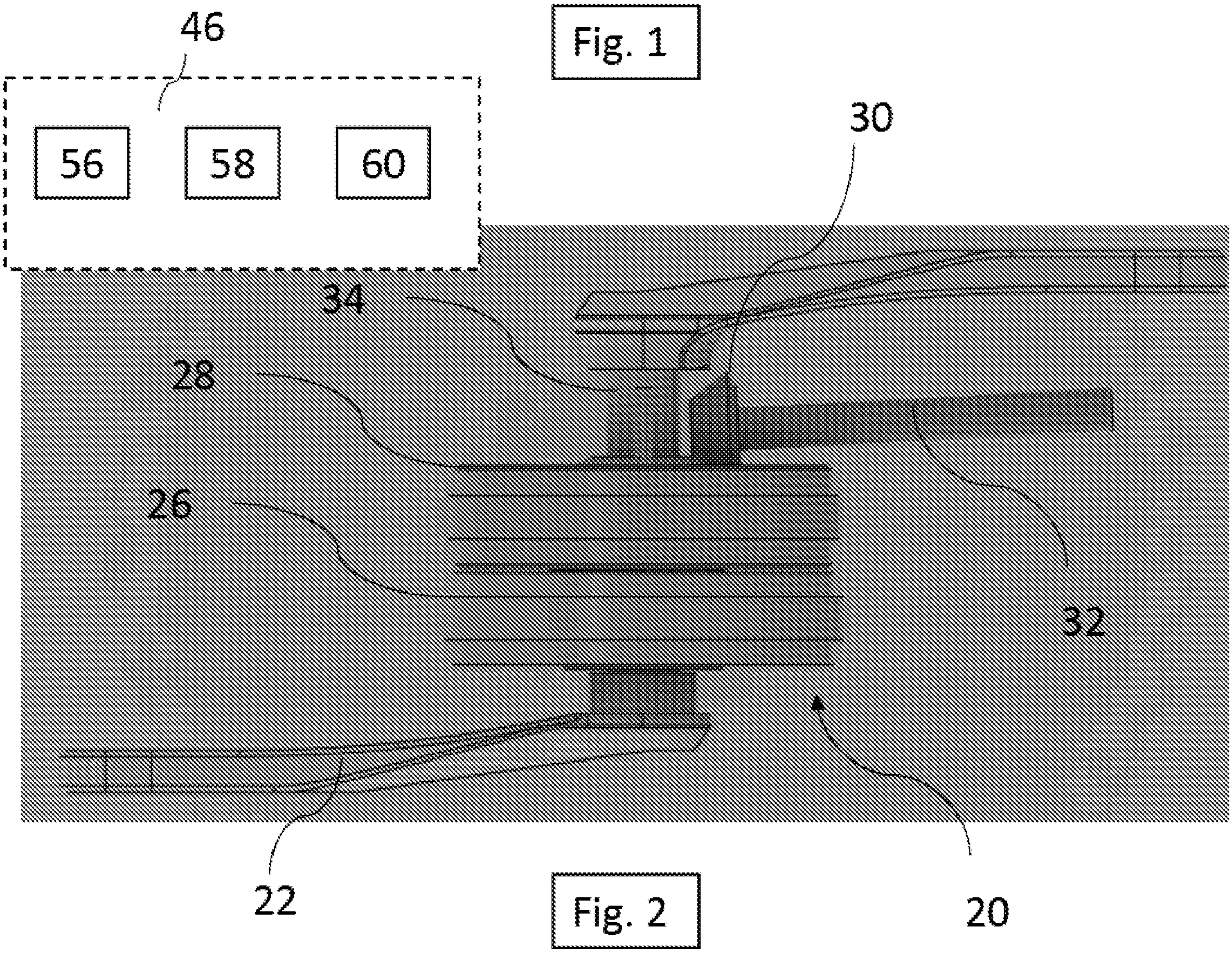

Fig. 2

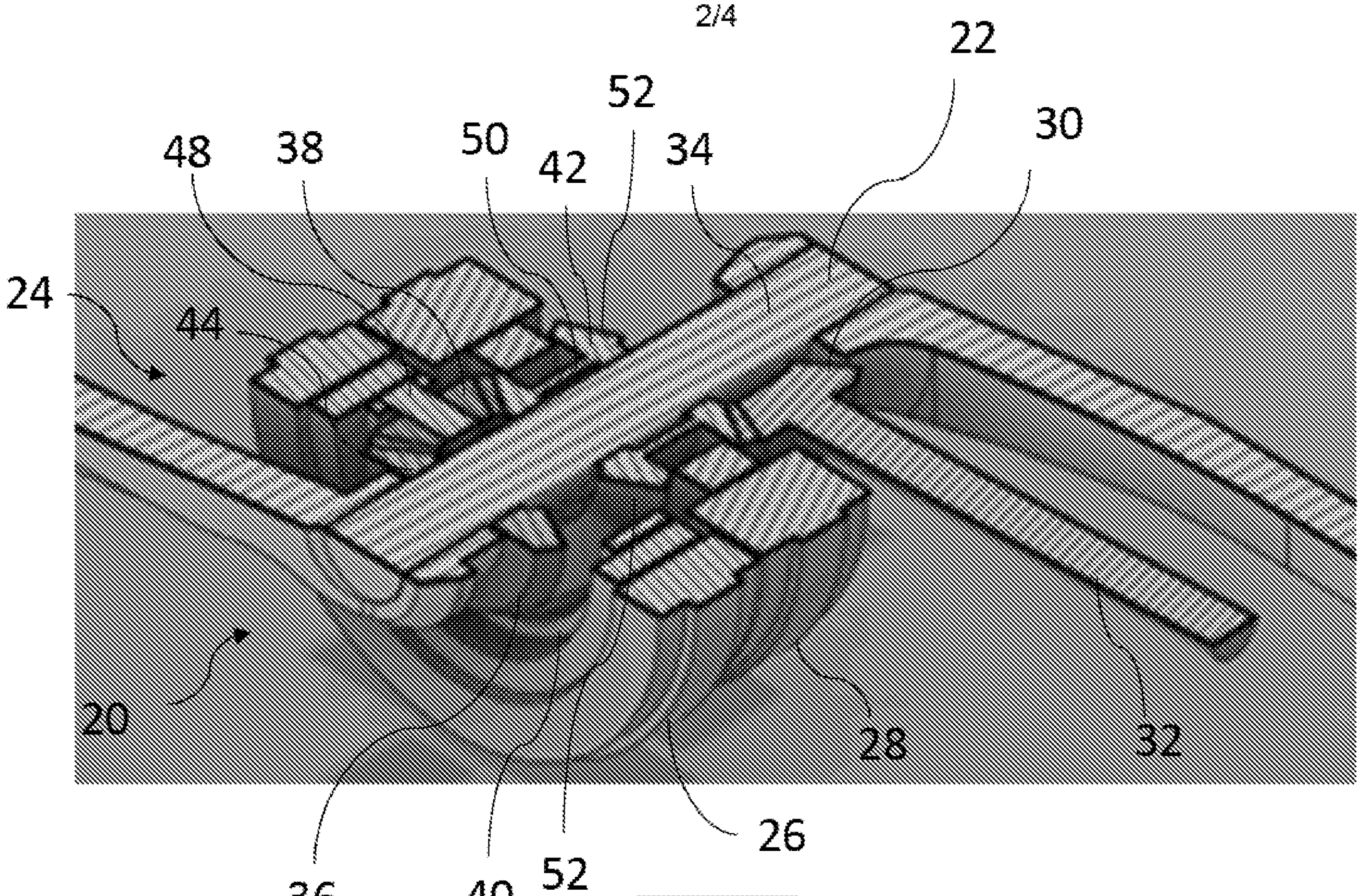
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Fig. 3

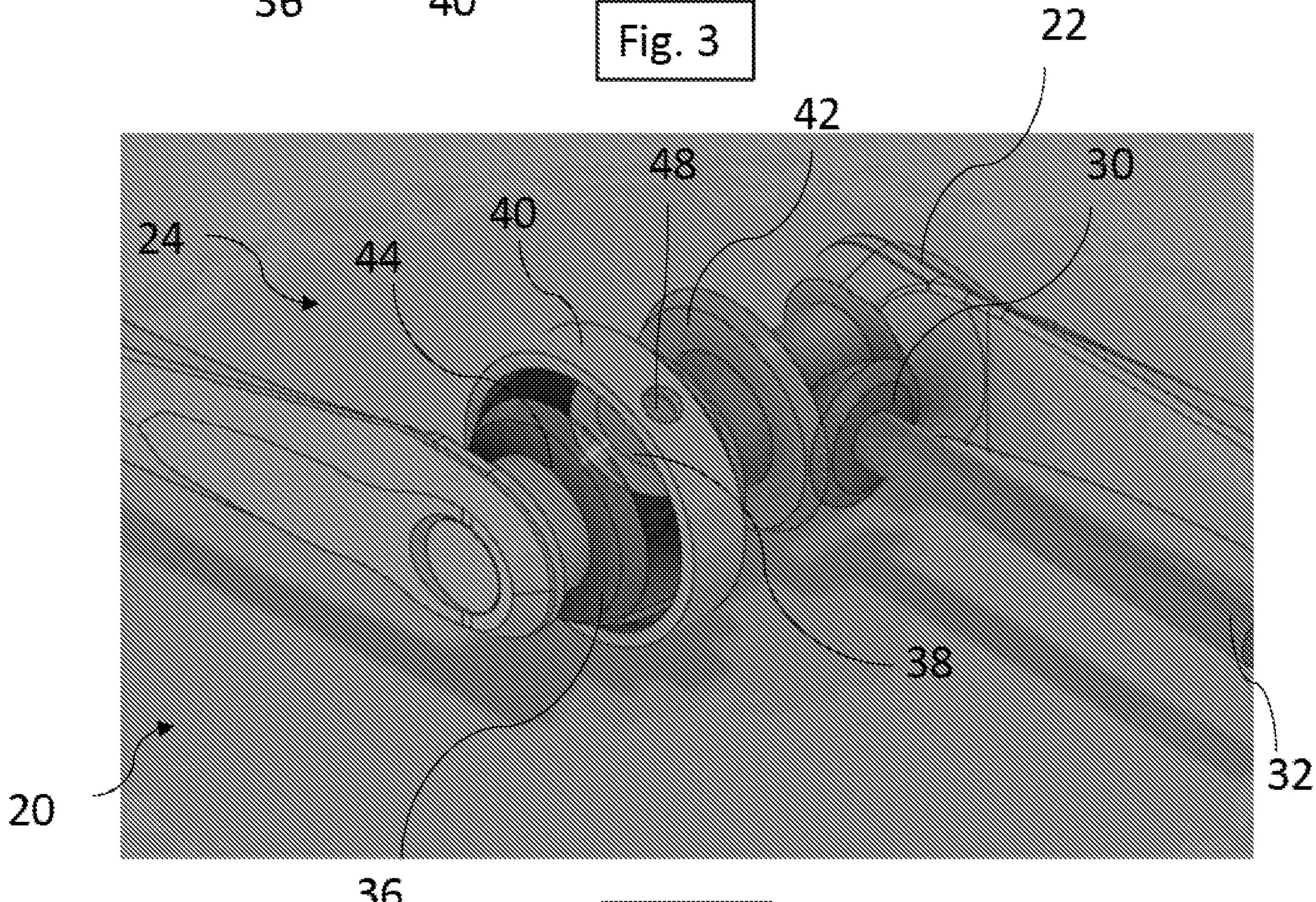
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Fig. 4

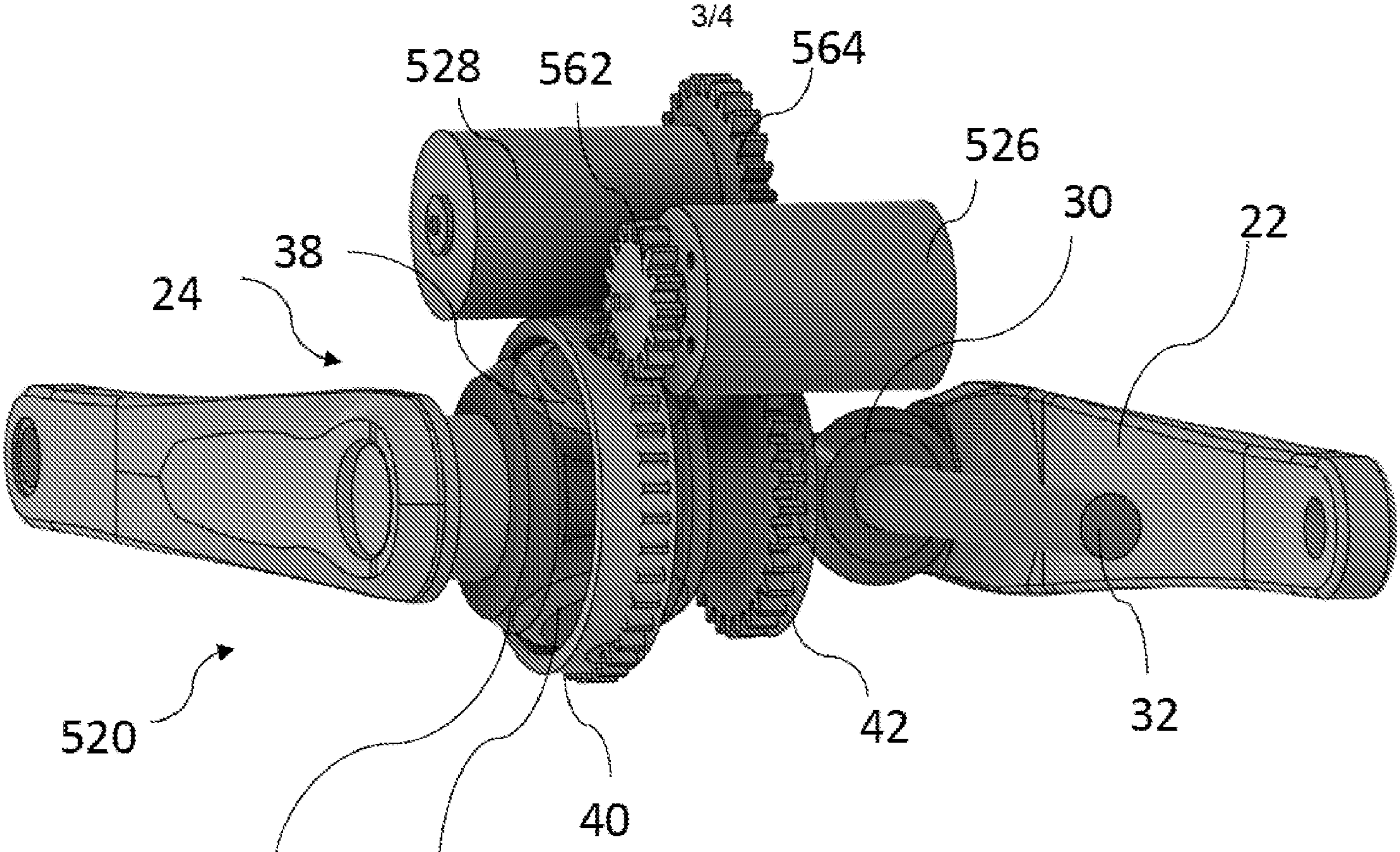
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Fig. 5a

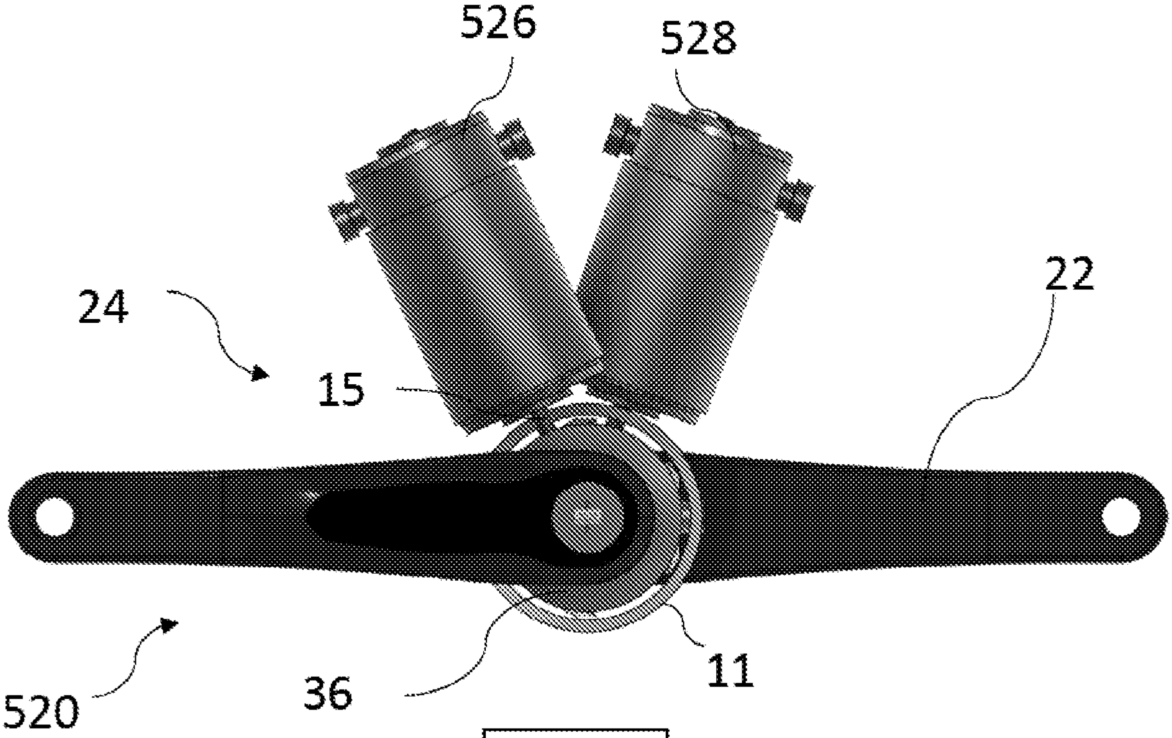
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Fig. 5b

Fig. 6

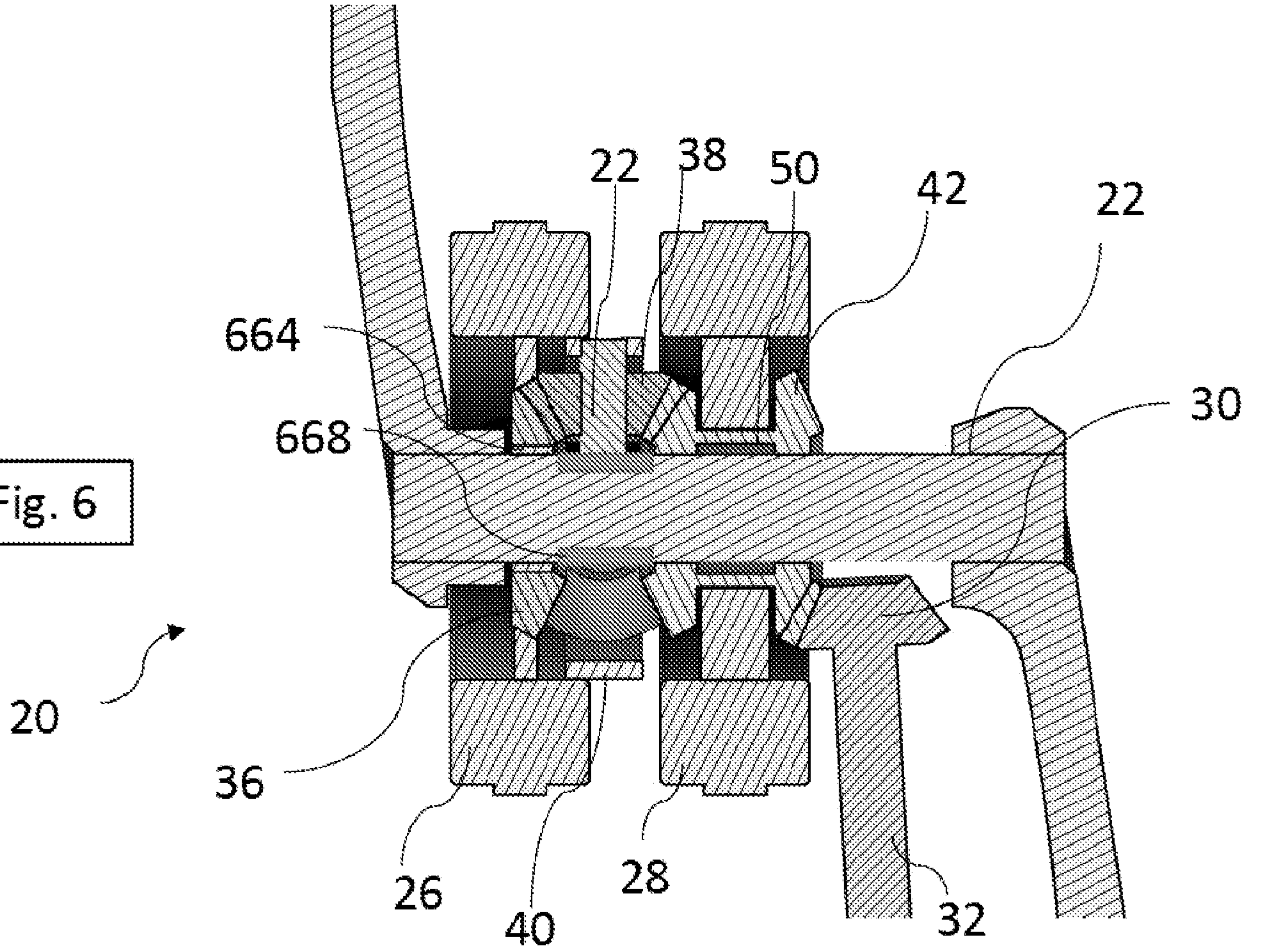
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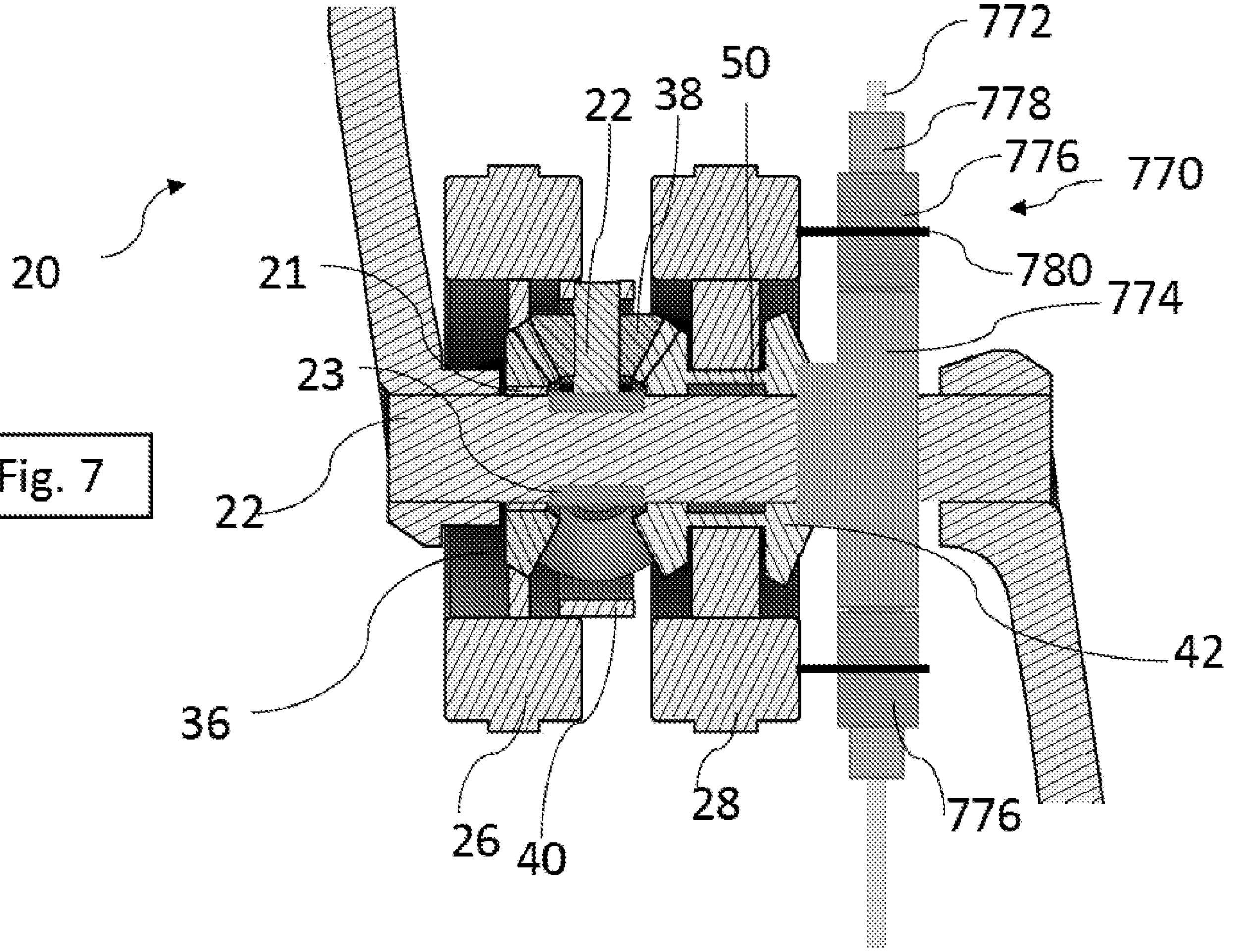
Fig. 7


772
22
38
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778
776
770
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780
774
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42
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776
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DANISH PATENT AND TRADEMARK OFFICE

Additional search report - patent

Application No.
PA 2023 00065

A. Classification

B62M 6/ 55 (2010.01); B62M 11/ 14 (2006.01); B62M 11/ 18 (2006.01)

According to International Patent Classification (IPC)

B. Fields searched

PCT-minimum documentation searched (classification system followed by classification symbols)

IPC&CPC: B62M

Documentation searched other than PCT-minimum documentation

DK, NO, SE, FI: IPC-classes as specified in Box A above

Electronic database consulted during the search (name of database and, where practicable, search terms used)

EPODOC, WPI, FULL TEXT: ENGLISH, GERMAN, FRENCH

C. Documents considered to be relevant

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
A	DE 102018212584 B3 (CONTI TEMIC MICROELECTRONIC GMBH) 24/12/2019 Fig. 1-3a and paragraphs [0010, 0020-0025]	1-9

☐ Further documents are listed in the continuation of Box C

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Danish Patent and Trademark Office

Helgeshøj Allé 81
DK-2630 Taastrup
Denmark

Tel.: +45 43 50 80 00

Date of completion of the search report

15/05/2023

Authorized officer

Jesper Peis
Tel.: +45 43 50 84 69

Additional search report - patent

Application No.
PA 2023 00065

C. Documents considered to be relevant (continuation)		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.