

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
8 July 2010 (08.07.2010)

(10) International Publication Number
WO 2010/077300 A2

- (51) International Patent Classification:
B62M 6/65 (2010.01) *B62M 6/90* (2010.01)
B62M 6/45 (2010.01)
- (21) International Application Number:
PCT/US2009/006535
- (22) International Filing Date:
14 December 2009 (14.12.2009)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/122,459 15 December 2008 (15.12.2008) US
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: ELECTRIC BICYCLE

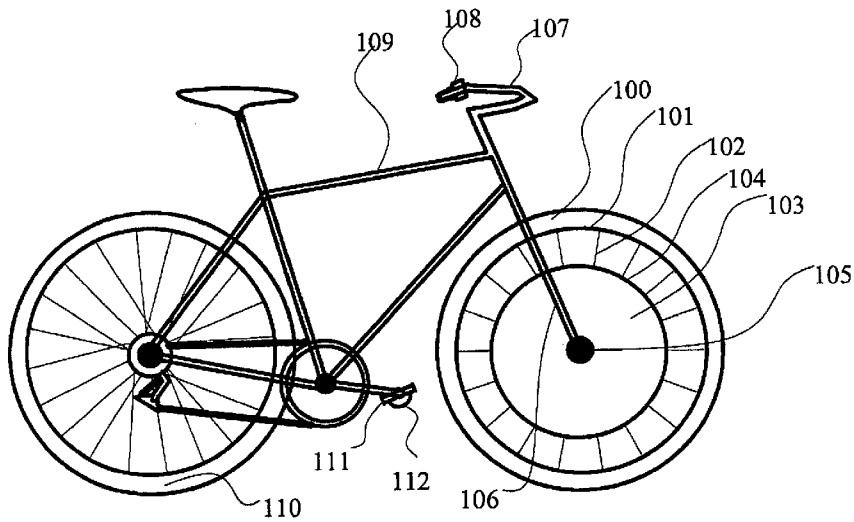


Fig. 1

[Continued on next page]



WO 2010/077300 A2

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
 - as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
 - of inventorship (Rule 4.17(iv))

Published:

- without international search report and to be republished upon receipt of that report (Rule 48.2(g))

Declarations under Rule 4.17:

(57) Abstract: A motorized wheel assembly for use in an electric bicycle is presented herein. An electric motor provides rotational force to the wheel assembly. An electronic circuit may communicate with the electric motor. The bicycle may include a control unit having a transmitter for emitting a wireless signal to a receiver that is in communication with the electronic circuit. In some cases, a battery for the motor of the wheel is located on a rotatable portion of the wheel.

ELECTRIC BICYCLE

RELATED APPLICATION

5 This application claims the benefit under 35 U.S.C. § 120 of U.S. Provisional Application Serial No. 61/122,459 , filed on December 15, 2008, which is herein incorporated by reference in its entirety.

TECHNICAL FIELD

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Aspects relate to a motorized wheel and an electric bicycle having the same. An electric motor embodied within the wheel of a vehicle (e.g., bicycle) serves to turn the wheel to achieve vehicle transport.

15 BACKGROUND

In vehicles, electric motors have been incorporated in the hub of their wheels. For bicycle wheels, there are two main categories of motors that are incorporated therein, brushed and brushless types. The structure of both these types of motors that are
20 employed in bicycle hubs is such that the electric field windings of the motor are attached rigidly to the axle while remaining static while permanent magnets are fixed to the outer rotating component of the motor. These permanent magnets are rigidly attached to the wheel body by means of spokes or other elements; these elements are in turn attached to the rim and thereby the tire of the wheel. In selecting appropriate
25 energizing methods of separate field coils, the attraction and repulsion of appropriate permanent magnet poles is the manner by which rotation of the wheel relative to the fixed axle is achieved. By virtue of the fixed non rotating field windings, it is possible to route the field winding electrical wires out through a hollow axle of the motor to which the field windings are rigidly attached. The field windings are then attached to the
30 wiring loom for control of the motor through various handlebar control systems and power supply connections such as batteries of various configurations. This arrangement necessitates positioning of other components, in particular the battery block, at another location on the vehicle frame. In the case of bicycle electric motor kits, this often entails

attaching wiring looms, making plug and receptacle connections as well as positioning battery systems with associated brackets and other hardware. Such motor kits can involve a considerable undertaking for an average person. A severe limitation of these current systems is that the wiring and connection of separate components leads to
5 unreliable electrical connections that are vulnerable to environmental factors such as salty water from roads leading to the corrosion and failure of exposed connection points. Another limitation of these systems is that the battery component is often a heavy package that is attached at some convenient place on the bicycle frame. Different models of bikes will have different places to attach this component and therefore a
10 number of different solutions need to be provided before a kit becomes universally adaptable to all bicycles. Often it turns out that the battery component is located at a high point in the bicycle frame, such as on a basket or cargo carrier located at the rear of the seat. In these instances the center of gravity of the bike is raised and makes the vehicle unstable when “walking” the bicycle alongside. In addition, a raised center of
15 gravity, such as in the case of employing a basket or cargo carrier, makes mounting the bike awkward as the battery may get in the way.

SUMMARY OF THE INVENTION

20 In one illustrative embodiment, a motorized wheel assembly for propelling a bicycle is provided. The assembly includes a fixed wheel portion and a rotatable wheel portion, the rotatable wheel portion adapted to rotate relative to the fixed wheel portion when the fixed wheel portion is mounted to a frame of the bicycle; an electric motor adapted to provide rotational force to the rotatable wheel portion; and at least one battery mounted
25 to the rotatable wheel portion, the at least one battery adapted to provide power to the electric motor.

In another illustrative embodiment, an electric bicycle is provided. The bicycle includes a frame; a wheel assembly attached to the frame; an electric motor adapted to provide
30 rotational force to the wheel assembly; an electronic circuit mounted on the wheel assembly and in communication with the electric motor, the electronic circuit having a receiver adapted to receive a wireless signal, the wireless signal providing an instruction to the electronic circuit for the electric motor to exert a rotational force to the wheel

assembly; and a control unit having a transmitter, the transmitter adapted to emit the wireless signal.

In a further illustrative embodiment, an electric bicycle is provided. The bicycle includes
5 a frame; a wheel assembly attached to the frame, the wheel assembly comprising a fixed wheel portion attached to the frame and a rotatable wheel portion that is rotatable relative to the fixed wheel portion; an electric motor adapted to provide rotational force to the wheel assembly; an electronic circuit mounted on the wheel assembly and in
10 communication with the electric motor, the electronic circuit having a receiver adapted to receive a wireless signal, the wireless signal providing an instruction to the electronic circuit for the electric motor to exert a rotational force to the wheel assembly; a control unit having a transmitter, the transmitter adapted to emit the wireless signal; and at least one battery adapted to provide the electric motor and the electronic circuit with power, the at least one battery being mounted to the rotatable wheel portion.

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In another illustrative embodiment, an electric bicycle is provided. The bicycle includes a frame; a wheel assembly attached to the frame; an electric motor adapted to provide rotational force to the wheel assembly; an electronic circuit mounted on the wheel assembly and in communication with the electric motor, the electronic circuit having: 1)
20 a receiver adapted to receive a wireless command signal, the wireless command signal providing an instruction to the electronic circuit for the electric motor to exert a rotational force to the wheel assembly, and 2) a transmitter adapted to transmit a wireless feedback signal; and a control unit having: 1) a transmitter adapted to emit the wireless command signal, and 2) a receiver adapted to receive the wireless feedback signal.

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Various embodiments of the present invention provide certain advantages. Not all embodiments of the invention share the same advantages and those that do may not share them under all circumstances.

Further features and advantages of the present invention, as well as the structure of
30 various embodiments of the present invention are described in detail below with reference to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

The accompanying drawings are not intended to be drawn to scale. In the drawings, similar features are represented by like reference numerals. For clarity, not every component is labeled in every drawing. In the drawings:

Fig. 1 shows a schematic side view of an exemplary bicycle with an electric motor and batteries and control system enclosed within a circular shell cover on the front wheel. An control module with wireless capability is shown attached to the handlebar. An additional wireless input is derived from an attachment to the base of the bicycle pedal to sense a bicycle rider's effort to propel the bicycle forward.

Fig. 2 shows a schematic side and cross sectional view of an exemplary bicycle wheel with stationary magnets and a rotating field winding type motor where a portion of the cover is shown to be cut away to reveal the internal components with hub motor and batteries and electronic control system including wireless receiving and transmitter system.

Fig. 3 shows a schematic side view of the construction of an electric motor with fixed permanent magnets connected by an armature to the axle and rotating field coils around the periphery.

Fig. 4 shows greater detail of one quadrant of the construction of the motor shown in Fig. 3 with fixed permanent magnets.

Fig. 5 shows a schematic side view of the construction of a motor with fixed permanent magnets mounted on the ring gear of a planetary gears system. Components of a planetary gear system may comprise a ring gear, planetary gears, a carrier to the output shaft, and a central sun gear. The carrier arms lever to the center from which is derived an output shaft that is stationary with respect to the bicycle fork.

Fig. 6 shows detail of one quadrant of the construction of a motor with permanent magnets mounted on planetary gears and arms from which is derived an output shaft that

is stationary with respect to the bicycle fork. Gear teeth of the planetary gear system are illustrated.

- 5 Fig. 7 shows a schematic side view of a disc motor formed into the hub of a bicycle wheel comprising batteries and electronic control system and with the outer cover removed. The disc motor is integrally formed into a planetary gear system. Some versions of these motors are also known as pancake motors but are not known to have been incorporated into the hub of a wheel.
- 10 Fig. 8 shows a schematic side view of a disc motor formed into the hub of a bicycle wheel in greater detail. A section of the field winding is shown cut away to reveal the disc portion of the motor that may comprise either a plurality of permanent magnets or composite magnets or a reactive field winding. Also shown in cross sectional view is detail of a planetary gear system where the non-rotating axle would be attached to the
- 15 bicycle fork. This illustration serves to show the connection of the carrier part of the planetary gear to the assembly ultimately attached to the wheel to affect rotation of the wheel with respect to a stationary axle, the output being reduced with respect to speed of rotation but increased with respect to torque.
- 20 Fig. 9 shows a schematic cross section of a portion of a disc motor formed into the hub of a bicycle wheel and a side view of the disc motor to show the arrangement of a planetary gear system.
- 25 Fig. 10 shows a schematic side and cross sectional view of a motor incorporated into the wheel of a bicycle with the cover removed to show the motor being offset from the central position and powering the wheel axle via a belt or chain system linked by a pulley and rotating shaft.
- 30 Fig. 11 shows a schematic side and cross sectional view of an offset motor in the wheel of a bicycle. The motor is shown mounted by a member to the inner rim or optionally to the wall of the cover in forming the enclosure.

Fig. 12 shows a schematic top view of a handlebar control system incorporating a battery and electronic transmitter circuitry together with receiving circuitry for indicators of the battery state and sensor for brake lever activation and other functions.

5 Fig. 13 shows a schematic side view of a handlebar control system incorporating a battery and electronic transmitter circuitry together with receiving circuitry for indicators of the battery state and other functions.

Fig. 14 shows a schematic arrangement of the electronic and electrical components in the
10 wheel and those in the operator control unit to affect the control of vehicle speed by wireless transmission.

DETAILED DESCRIPTION

15 The following detailed description is of an electric motor contained within the wheel of any form of vehicle for transportation of people and goods and all manner of articles including vehicles for transport.

For the purpose of this application, the definition of a non-rotating axle is an axle that is
20 attached to the frame of a vehicle, such as the fork of a bicycle, which remains relatively fixed in relation to a rotating portion of the wheel.

In one embodiment disclosed herein, an electric motor of the brushless type is incorporated into the hub of the wheel of a bicycle and structured such that the
25 permanent magnets, whether individual elements or composite type formed into a continuous cylindrical form, are rigidly attached to the non-rotating axle of the motor and the field coils are attached to the outer rotating enclosure of the hub motor. It becomes apparent that, upon reversing this position of the permanent magnets and of the field coils from that utilised in current hub motors, it is no longer necessary nor possible
30 to pass the electric current carrying wires of the field coils out through a hollow axle. Indeed, in some embodiments, associated control systems and electric power systems are placed within a wheel housing on and around the hub motor within the body of the wheel in a symmetrical and balanced configuration. Electric motors with field coils around the

periphery and permanent magnets attached to the rotating axle have not been applied to the hub of the bicycle wheel as it is necessary to provide power to the field coils which now rotate with the wheel. In addition, these types of motors are not commonly available with an axle that emerges from both ends of the motor body as there had not
5 been a requirement for it, until now. In some embodiments, a rotating field type hub motor is provided with associated control and battery power systems within the rotating wheel allowing direct connection of the power supply and control system and hub electric motor. It becomes apparent that this reversal of conventional wisdom requires external control of the motor and of its speed control which is an additional embodiment
10 that allows such control signal to be delivered to the rotating wheel containing the hub motor, the control and the power supply via radio transmission or infra red or other suitable telecommunication method within the electromagnetic spectrum that is wirelessly achievable. In some embodiments, it is possible to distribute and balance the components comprising the motor, battery and control systems within the wheel so as to
15 minimise vibrations during wheel rotation. In some embodiments, a durable and waterproof enclosure protects components within the inner rim from external ingress of water and corrosive elements. A similar housing specification may be utilized for the handlebar transmitter / receiver unit.

20 In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the motor is internally geared such as with planetary gears to provide increased torque output. Control of speed or change of gears may be provided by control circuitry from within the rotating wheel as well as being powered by the power supply also located within the rotating wheel. Such a wheel would also be provided with external control
25 signals delivered wirelessly.

In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the battery type may be of rechargeable chemistry. At the end of a discharge episode, a battery may be re-charged by connection at a suitable point to an external power source
30 of the type that is in common use in battery systems for electric vehicles and may include indicators for the state of charge of batteries. An additional method of re-charging battery elements may be to use inductance coils located in a transmitting unit received by

the wheel hub area where similar receiving coils would be deployed under the cover and composed of material through which magnetic fluxes can penetrate.

5 In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the battery power source may be substituted with other electric power generators such as compact fuel cells employing hydrogen and oxygen but is not limited to a particular type of source of electric current.

10 In another embodiment of a motor with rotating electric field coils in the hub of a wheel with rechargeable batteries, a charging current is maintained by the connection of photo voltaic cells or solar cell arrays affixed to the outer surface of the bicycle wheel cover where both sides of the wheel may be suitably covered for electric power generation in addition to the option of connection to an external power source as indicated above.

15 In another embodiment of a motor with rotating electric field coils in the hub of a wheel with rechargeable batteries, the state of the battery is relayed wirelessly to the operators handlebar control or to a separate unit with indicators of the state of charge of batteries or other indicators that may include but not limited to mileage covered from rotation counts, battery temperature, number of re-charges to date and so forth.

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In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided with appropriate step increments in speed change to affect the rate of rotation of the hub motor and therefore the wheel.

25 In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided with continuous increments in speed change to affect the rate of rotation of the hub motor and therefore the wheel.

30 In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided via a handlebar grip that by rotation registers either incremental or continuous control signals delivered to the rotating wheel hub by a wireless method.

In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided by a handlebar lever attachment with registers of either incremental or continuous control signals delivered to the rotating wheel hub by a wireless method.

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In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided by a handlebar wireless transmitter by registering increments or step changes in an optical encoder, the signals from which are transmitted for decoding with appropriate circuitry integrated within the rotating wheel and hub motor.

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In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided by a handlebar wireless transmitter by registering increments or step changes by means of a binary code decimal encoder, the signals from which are transmitted for decoding with appropriate circuitry integrated within the rotating wheel and hub motor.

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In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source are provided by a handlebar wireless transmitter that is securely coded and likewise securely received by a matched de-coding control receiver within the rotating wheel and hub motor.

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In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source include input from the brake lever to decelerate or if necessary disable functions transmitted to a matched control receiver within the wheel containing the hub motor. The brake lever is fitted with a small permanent magnet whose proximity to a Hall Effect sensor integrated into the handlebar control unit registers the application of brakes by the bicycle rider.

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In another embodiment, the motor includes rotating electric field coils in the hub of a wheel. The control signals from an external source include input from an electronic or electromechanical accelerometer to detect deceleration. Deceleration caused by application of the brakes on the bicycle initiates controlled slowing down of the motor

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speed or, in one embodiment, may disable functions transmitted to a matched control receiver within the wheel containing the hub motor.

5 In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source include input from an emergency stop actuator to disable functions transmitted to a matched control receiver within the wheel containing the hub motor. The lack of control signals transmitted to the wheel receiver assembly would also constitute the wheel with a state of disabled functions for reasons of safety.

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In another embodiment of a motor with rotating electric field coils in the hub of a wheel, the control signals from an external source include input from the bicycle pedal transmitted wirelessly to carry information relating to effort input from the bicycle rider indicating the start of motion or of pressure on the pedal to indicate the desire for electrical power assistance to the riding effort. A battery powered transmitter with input from pressure transducers located on the surface of the bicycle pedal serve to gather this information and transmit to the control center located on the handlebar and or the motorized wheel.

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20 In one embodiment, a motor with rotating electric field coils in the hub of a wheel is provided. In one embodiment, the control signals about the rider effort are derived from the wheel speed monitored at the hub motor. Wheel speed information relating to effort input from the bicycle rider is sent to the control circuitry. The rider's foot pressure on the pedal may produce two momentary speed changes for each pedal rotation. The speed changes may be sensed and used to activate controlled electrical power assistance in the riding effort. In one embodiment, this control information is integrated between the handlebar control unit and the electric motor speed control, and motor speed sense circuitry is located within the wheel hub.

25

30 In one embodiment, the electronic circuit mounted on the wheel assembly is in communication with the electric motor. The electronic circuit has a receiver adapted to receive a wireless command signal that provides an instruction to the electronic circuit for the electric motor to exert a rotational force to the wheel assembly, for example. A

transmitter of the electronic circuit may be adapted to transmit a wireless feedback signal. In one embodiment, a control unit is provided and has a transmitter adapted to emit the wireless command signal. The control unit also has a receiver adapted to receive the wireless feedback signal. In one embodiment, the feedback signal can
5 include a battery power level, battery temperature, and/or a speed of the bicycle, as well as other feedback information, as the present invention is not limited in this respect. In one embodiment, the feedback signal can include a rate of wheel rotation, electric current consumption as well as other feedback information to affect electric motor control in the event of brake application. The transmitter and the receiver of the electronic circuit and
10 of the control unit can be formed as a transceiver. In one embodiment, the transceiver of the electronic circuit and the transceiver of the control unit are adapted to provide a handshake communication between the control unit and the electronic circuit.

In another embodiment of a motor and battery and control system integrated within the
15 wheel, the motor is fully integrated into the hub of the wheel by a magnetized circular disc connected directly to the axle of the wheel and field coils arranged singularly to one side or paired to both sides of the magnetic disc for optimal field concentration. The magnetic disc may be formed from a plurality of magnetic segments or a composite magnetic disc formed of many magnetic elements formed into a disc. Batteries are
20 distributed evenly spaced around the outer magnetic disc and field coil area. This arrangement is not limited to discs composed of magnetic poles but also the disc may be composed of closed field windings to form reactive type electric motor with low mass. Furthermore this type of electric motor is built into a planetary gear into the hub of the wheel as this type of motor is capable of high speeds with low torque, the planetary gears
25 serve to translate the high operating speed into increased torque.

In another embodiment of a motor and battery and control system integrated within the wheel consists of a conventional, brushed or brushless, geared or direct drive motor incorporated within a wheel in an off-center position, the batteries are contained within
30 the wheel and positioned to counter the weight of the off-center motor so that the wheel remains balanced during rotation. This necessitates the balancing of all the components within the wheel to reduce vibrations during rotation. The power from the motor is transferred to a rotating shaft with respect to the wheel by means of either a pulley and

“V” belt drive or a sprocket and chain drive or direct gear meshing with toothed cogs. Hence the output pulley or Sprocket or cog is connected directly to the shaft that becomes the non-rotating axle attached to the bicycle fork. The off-center motor may be controlled in likewise manner to the foregoing with a remote control transmitter from a control system located at a convenient point on the bicycle frame.

This latter embodiment serves to illustrate an approach presented herein where the power and control system together with the motor are integrated into the rotating wheel entirely, and that control of the system is through externally powered, wirelessly transmitted control signals.

Fig. 1 shows an exemplary bicycle with an electric motor, battery and control system contained within the wheel of a bicycle. Here is shown a front wheel consisting of tire *100*, rim *101* and spokes *102* attached to an inner rim *104* the inside of which contains components of the electric motor, batteries and control system all contained within a protective and waterproof cover *103*. The output of the motor axle *105* is shown attached to the bicycle fork *106* preferably by means of quick release locks on the threaded portion of the axle. The front wheel is attached to a bicycle frame *109*. Another component of the bicycle may be a control unit *108* attached to the bicycle handlebars *107* in close proximity to the bicycle brake operating levers. In one embodiment, a control signal derived from an accelerometer contained within the control unit *108* may be used either alone or in addition to a sensed brake activation and be used to initiate motor speed control. Although the electric powered wheel is shown attached to the front wheel, it also possible to replace the rear wheel *110* with the same or even attach two independent wheels, one to the front and one to the rear with independent and coordinated control systems. An additional input of force applied by the foot of the rider from the pedal *111* is measured and transmitted by a transmitter *112* to the control unit *108* on the handle bar *107* in addition to the control system contained within the motorized wheel.

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Fig. 2 shows an electric motor of the brushless type integrated into the wheel of a bicycle with a protective cover *103* partially removed to reveal the construction. The inner rim *104* contains entirely the batteries *201*, arranged around the body of the electric motor

202 and electronic circuitry 203 to integrate the control of power from batteries 201 to the motor 202 for allowing the axle 105 of the motor to rotate in a set of bearings 204. When the axle 105 is rigidly attached to the forks (Fig 1, 106) of a bicycle and the electric motor is activated, the wheel rotates and propels the bicycle. The bearings 204 of the motor being either of roller, pin or other suitable type also becomes the wheel bearings upon which the weight of the front portion of the bicycle ultimately rests. Batteries 201 are distributed evenly spaced and weighted around the peripheral area enclosed by the outer rim so as to minimize imbalance and reduce vibrations during rotation.

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Fig. 3 shows an exemplary brushless direct current motor of the type that is proposed for deployment in this type of electric powered bicycle wheel. The construction shows permanent magnets rigidly attached to the armature 304 and in turn to a non-rotating axle 105 in the context of being attached firmly to the forks (Fig 1, 106) of a bicycle. An outer rotating member is depicted on which are attached field coils that include an outer yoke 301 from which are formed separate magnetic poles 300 on account of being energized by an electric current supplied to a field winding 302. The field winding generates attraction and repulsion forces against the counterpart permanent magnets 303. Various configurations of such electric motors are available and currently may or may not be adapted for slow rotations suitable for direct integration into the wheel of a bicycle hub. In some configurations the magnets 303 are formed from a continuous composite ceramic material or rare earth magnets have been employed. Magnetic materials with high flux densities capable of providing high torque with corresponding high strength electromagnet poles may be incorporated as well.

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Fig. 4 shows in greater detail the construction of an exemplary brushless direct current motor with a quadrant enlarged. The yoke 301 is profiled in multiple wafer sections to form a pole 300 that is energized by an electric field winding 302 to generate a magnetic flux which is either attracted or repelled by the permanent magnetic poles of the magnets 303 arranged around an armature 304 connected to an output axle 105. The output axle 105 extends to protrude from both ends of the body of the motor such that it can be engaged and rigidly fixed to the forks (Fig. 1, 106) of a bicycle. The electric field windings are controlled by circuitry (Fig. 2, 203) and energized within the rotating wheel

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by batteries (Fig 2, *201*) and the control and monitoring signals are transmitted and received by an attached control unit typically on the handlebars *107* of the vehicle close to the braking system.

5 Fig. 5 shows another exemplary brushless direct current motor of the type that is proposed for use in this type of electric powered bicycle wheel. The electric drive mechanism is as described above for Fig. 3 and Fig. 4. The difference in construction is the inclusion of a planetary gear system within the armature *500* such that the armature now forms the ring gear. Within the armature *500* of the motor, the ring gear engages
10 with a plurality of planetary gears *502* which in turn rotate around a central sun gear *503*. In some embodiments, the sun gear *503* is rigidly connected to the yoke *301* and forms a rotating portion with respect to the bicycle fork. The planetary gear system in this instance is used to increase the torque output to the axle *105* which is linked to the orbital rotation of the planetary gears *501* by carrier arms *502*. In order to produce the increase
15 in torque, the high rotational speed of the armature *500* is converted to slow rotation by the planetary gears *501* and carried to the output axle *105* by the carrier arms *502*.

Fig. 6 shows the construction of an exemplary brushless direct current motor of Fig. 5 containing planetary gears. The armature *500* has an internal surface composed of ring
20 gear teeth *600* that intermesh with the planetary gear *501* having teeth *601*. Clockwise rotation of the armature *500* results in clockwise rotation of planetary gear *501*. This planetary gear rotates and intermeshes with sun gear teeth *602* of a fixed sun gear *503*. Resultant motion of planetary gear *501* is imparted into a plurality of carrier arms *502* connected to a central rotating element which forms the wheel axle *105*.

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Fig. 7 shows an exemplary view of a bicycle wheel motorized by brushless rotating magnetic disc armature *700* with integral planetary gears linking to a non-rotating axle
105. In this configuration, an inner rim *104* completely contains batteries *201* around a hub motor which has a rotating permanent magnet disc armature *700*. A planetary gear
30 system for which the ring gear *701* becomes the non-rotating axle *105* of the wheel is attached to the bicycle fork (Fig. 1, *106*). Electronic circuitry *203* for control of power to the motor and for wireless communication with an external control unit is housed completely within the inner rim *104*.

Fig. 8 shows the construction of an exemplary brushless rotating magnetic disc motor of Fig. 7 in an enlarged view. The rotating magnetic disc **700** is comprised of shaded magnetic poles or a plurality of discrete permanent magnets and is shown in close proximity between field coils **800** that surround the disc from either one or both sides. The field coil **800** is shown partly removed to show the position of the magnetic disc **700**. The rotating magnetic disc has a hollow axle and also forms the sun gear of a planetary gear system and will be described in the description to follow. The ring gear component **701** of this planetary gear is non-rotating by virtue of being fixed rigidly to the fork of the bicycle at the axle **105**. The planetary gears **801** are linked by carriers **802** to the wheel structure carrying the other components namely electric field windings **800** and batteries **201** distributed evenly spaced around the hub motor section.

Fig. 9 shows further details of the planetary hub gear system components contained in the brushless rotating disc type motor described in Fig. 8. The planetary gear system is present on both sides of the rotating magnetic disc but for clarity only one side is illustrated. Here is shown a magnetic disc **700** with a hollow axle through which a linking shaft **804** with bearing surfaces projects through the entire axle. A portion of the rotating magnetic disc is formed into a sun gear **803** which intermeshes with a plurality of planetary gears **801**. The ring gear **701** of this planetary gear arrangement forms the stationary axle attached to the bicycle fork. Carrier arms **802** pivot from the planetary gears **801** by way of spindles **901** and in turn this carrier structure links to the outer rim (Fig. 8, **104**) which is fixed to the spokes and rim of the wheel. The carrier arm structure **802** has a bearing **900** that allows free rotation on the hollow axle formed from the rotating magnetic disc **700** and sun gear **803**. The linking shaft **804** through the hollow axle serves to keep the entire structure assembled and may have machined screw portions for assembly. The functioning of this system can be described by viewing the illustration to the right in Fig. 9. When electric field windings (Fig 8, **800**) are energized appropriately the magnetic disc **701** rotates clockwise and this turns the sun gear **803** connected to it directly in the same direction. Clockwise rotation of the sun gear **803** causes a plurality of planetary gears **801** which mesh with it to turn counter-clockwise. Since one side of planetary gear **801** also meshes with the internal surface of the ring gear **701** which is stationary on account of being attached to the bicycle fork, the

planetary gear bearing **901** position moves in a clockwise direction. Since the planetary gear bearing **901** is attached to the carrier arm **802**, this also rotates in a clockwise direction. The carrier arm **802** is ultimately connected to the inner rim, (Fig. 8, **104**) spokes, (Fig. 8, **102**) and wheel rim (Fig. 8, **101**) of the bicycle wheel which now also
5 turns in a clockwise direction. This motion is relative to the fixed, ring gear **701** which also forms the bicycle wheel axle **105** attached rigidly to the bicycle forks.

Fig. 10 shows a view of a bicycle wheel motorized by an off center electric motor **1001** mounted on the inside of the inner rim **101** by a motor support member **1000** and the
10 motor output shaft is linked by an electric motor spindle **1002** and belt **1005** to a driven pulley **1003** connected directly to an axle **105** that is rigidly attached to the bicycle fork. Batteries **201** may be distributed and balanced in a way to counter the mass of the electric motor **1001** such that wheel rotation does not result in undesirable vibrations. Electronic control and wireless communication circuitry **203** may be located within the
15 inner rim **104** for motor control and the wheel inner rim may be entirely covered with a protective and waterproof cover.

Fig. 11 shows a quadrant view of the bicycle wheel with an off-center electric motor as described in Fig. 10 above. The driven pulley **1003** is connected directly to the axle **105**
20 which has a bearing surface **1004** and therefore forms the rotating part of the wheel.

Fig. 12 shows a view of a handlebar control system **108** incorporating a battery and electronic transmitter circuitry together with receiving circuitry for indicators of the battery state and other functions. The bicycle handlebar **107** is used to mount the control
25 unit **108** via a suitable clamping arrangement with the object of replacing the existing handlebar grip on the bicycle or, in one embodiment, as an additional unit mounted next to the existing handlebar grip. An integral thumb control lever may be employed to serve as command input. The control system comprises an integral grip **1200** with a rotatable selector collar **1203** with pointer **1202** and register **1201** whereby different
30 functions **1204** such as system start and speed may be selectable. The main body of the control system **108** includes the electronic circuitry for transmitting and receiving wireless communications from the motorized bicycle wheel and includes display functions such as illuminated indicators for battery state, system status, start and stop

functions and so forth. In addition, operation of the brake lever *1205* used by the bicycle rider to slow down or to stop may be sensed by a Hall Effect device contained within the body of the control unit by sensing the proximity of a permanent magnet *1206* attached to the brake lever *1205*. In one embodiment, an accelerometer contained within the body of the control unit *108* is mounted on the handlebar and serves to provide signals relating to brake application on the bicycle and/or providing appropriate control to the hub motor.

Fig. 13 shows another view of a handlebar control system *108* from the side to illustrate the compartment containing battery and electronic control systems

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Fig. 14 shows a schematic arrangement of the electronic and electrical components in the wheel and those in the operator control unit to affect the control of vehicle speed by two way wireless transmission. Wheel components include the hub motor, control unit, transmitter, receiver and a battery. The handlebar control unit components include the display, brake lever position sensor, control unit, transmitter, receiver and battery. An additional component is a sensor with wireless transmission from the bicycle pedal to indicate foot pressure exerted on the pedal by the rider that is transmitted wirelessly to the handle bar control unit for information relating to the riders requirement.

This invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” “having,” “containing,” or “involving,” and variations thereof herein, is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

Having thus described several aspects of at least one embodiment of this invention, it is to be appreciated various alterations, modifications, and improvements will readily occur to those skilled in the art.

30

CLAIMS

1. A motorized wheel assembly for propelling a bicycle, the assembly comprising:
a fixed wheel portion (105) and a rotatable wheel portion (100, 101, 102, 104),
5 the rotatable wheel portion adapted to rotate relative to the fixed wheel portion when the
fixed wheel portion is mounted to a frame (109) of the bicycle;
an electric motor (202) adapted to provide rotational force to the rotatable wheel
portion ; and
at least one battery (201) mounted to the rotatable wheel portion, the at least one
10 battery adapted to provide power to the electric motor.
2. The wheel assembly of claim 1, further comprising an electronic circuit (203) in
communication with the electric motor, the electronic circuit mounted to the rotatable
portion and electrically coupled to the motor.
15
3. The wheel assembly of claim 1, wherein the at least one battery comprises a
plurality of batteries electrically coupled together, the plurality of batteries mounted to
the rotatable wheel portion in a circumferentially spaced configuration about the fixed
wheel portion.
20
4. The wheel assembly of claim 2, further comprising a waterproof enclosure (103)
adapted to protect the electronic circuit and the at least one battery.
5. The wheel assembly of claim 1, wherein the electric motor comprises a plurality
25 of permanent magnets (303) arranged on a disc (304, 500, 700).
6. The wheel assembly of claim 1, wherein the electric motor comprises a plurality
of permanent magnets (303) mounted on the fixed wheel portion and a plurality of
electro-magnets (302) mounted on the rotatable wheel portion.
30
7. The wheel assembly of claim 1, further comprising a planetary gear set (501)
adapted to transmit power from the motor to the rotatable wheel portion.

8. The wheel assembly of claim 2, wherein the electronic circuit has a receiver adapted to receive a wireless signal, the wireless signal providing an instruction to the electronic circuit for the electric motor to exert rotational force.

5 9. The wheel assembly of claim 8, further comprising a control unit (108) having a transmitter, the transmitter adapted to emit the wireless signal.

10. The wheel assembly of claim 1, in combination with the bicycle, wherein the wheel assembly is attached to a frame of the bicycle.

10

11. An electric bicycle, comprising:

a frame (109);

a wheel assembly (100, 101, 102, 104, 105) attached to the frame;

an electric motor (202) adapted to provide rotational force to the wheel assembly;

15 an electronic circuit (203) mounted on the wheel assembly and in communication with the electric motor, the electronic circuit having a receiver adapted to receive a wireless signal, the wireless signal providing an instruction to the electronic circuit for the electric motor to exert a rotational force to the wheel assembly; and

20 a control unit (108) having a transmitter, the transmitter adapted to emit the wireless signal.

12 The electric bicycle of claim 11 further comprising a brake sensor for initiating an instruction for the electric motor to decrease the rotational force provided to the wheel assembly.

25

13. The electric bicycle of claim 12, wherein the brake sensor comprises a Hall effect sensor (1206).

14. The electric bicycle of claim 12, wherein the brake sensor comprises an accelerometer sensor contained within the handlebar controller (108) for initiating an instruction for the electric motor to decrease the rotational force provided to the wheel assembly.

30

15. The electric bicycle of claim 11, further comprising a pedal sensor for initiating an instruction for the electric motor to increase the rotational force provided to the wheel assembly in accordance with rider effort measured as a force acting on the pedals.

5 16. The electric bicycle of claim 15, wherein a signal of the pedal sensor is transmitted wirelessly to the handlebar control unit.

17. The electric bicycle of claim 11, wherein the control unit is located at a position that is remote from the wheel assembly.

10

18. The electric bicycle of claim 17, wherein the frame comprises a handle bar (107), wherein the control unit is mounted to the handle bar.

19. The electric bicycle of claim 18, wherein the wheel assembly comprises a fixed
15 wheel portion (105) attached to the frame and a rotatable wheel portion (100, 101, 102, 104) that is rotatable relative to the fixed wheel portion, wherein the electric bicycle further comprises at least one battery (201) adapted to provide the electric motor and the electronic circuit with power, the at least one battery being mounted to the rotatable
wheel portion.

20

20. The electric bicycle of claim 18, wherein the electronic circuit is attached to the rotatable wheel portion.

21. The electric bicycle of claim 18, wherein the electric motor comprises a plurality
25 of permanent magnets (303) mounted on the fixed wheel portion and a plurality of electro-magnets (302) mounted on the rotatable wheel portion.

22. The electric bicycle of claim 18, further comprising a planetary gear set (801) adapted to transmit power from the motor to the rotatable wheel portion.

30

23. The electric bicycle of claim 11, wherein the electronic circuit further comprises a transmitter and the control unit further comprises a receiver, wherein the electronic circuit is adapted to wirelessly transmit a feedback signal to the control unit.

24. The electric bicycle of claim 23, wherein the feedback signal comprises at least one of a battery power level, battery temperature, and a speed of the bicycle.

5 25. An electric bicycle, comprising:
a frame (109);
a wheel assembly (100, 101, 102, 104, 105) attached to the frame, the wheel
assembly comprising a fixed wheel portion (105) attached to the frame and a rotatable
wheel portion (100, 101, 102, 104) that is rotatable relative to the fixed wheel portion;
10 an electric motor (202) adapted to provide rotational force to the wheel assembly;
an electronic circuit (203) mounted on the wheel assembly and in communication
with the electric motor, the electronic circuit having a receiver adapted to receive a
wireless signal, the wireless signal providing an instruction to the electronic circuit for
the electric motor to exert a rotational force to the wheel assembly;
15 a control unit (108) having a transmitter, the transmitter adapted to emit the
wireless signal; and
at least one battery (201) adapted to provide the electric motor and the electronic
circuit with power, the at least one battery being mounted to the rotatable wheel portion.

20 26. An electric bicycle, comprising:
a frame (109) ;
a wheel assembly (100, 101, 102, 104, 105) attached to the frame;
an electric motor (202) adapted to provide rotational force to the wheel assembly;
an electronic circuit (203) mounted on the wheel assembly and in communication
25 with the electric motor, the electronic circuit having: 1) a receiver adapted to receive a
wireless command signal, the wireless command signal providing an instruction to the
electronic circuit for the electric motor to exert a rotational force to the wheel assembly,
and 2) a transmitter adapted to transmit a wireless feedback signal; and
a control unit (108) having: 1) a transmitter adapted to emit the wireless
30 command signal, and 2) a receiver adapted to receive the wireless feedback signal.

27. The electric bicycle of claim 26, wherein the feedback signal comprises at least one of a battery power level, battery temperature, and a speed of the bicycle.

28. The electric bicycle of claim 26, wherein the feedback signal comprises at least one speed of the bicycle to provide the control unit a way to gauge the level of pedal assist required to be given by the electric motor.

5

29. The electric bicycle of claim 26, wherein the feedback signal comprises at least one rate of wheel rotation as a way to gauge the application of brakes and to affect motor control.

10 30. The electric bicycle of claim 26, wherein the feedback signal comprises at least electric current consumption as a way to gauge the application of brakes and to affect motor control.

15 31. The electric bicycle of claim 26, wherein the transmitter and the receiver of the electronic circuit comprises a transceiver.

32. The electric bicycle of claim 31, wherein the transmitter and the receiver of the control unit comprises a transceiver.

20 33. The electric bicycle of claim 32, wherein the transceiver of the electronic circuit and the transceiver of the control unit are adapted to provide a handshake communication between the control unit and the electronic circuit.

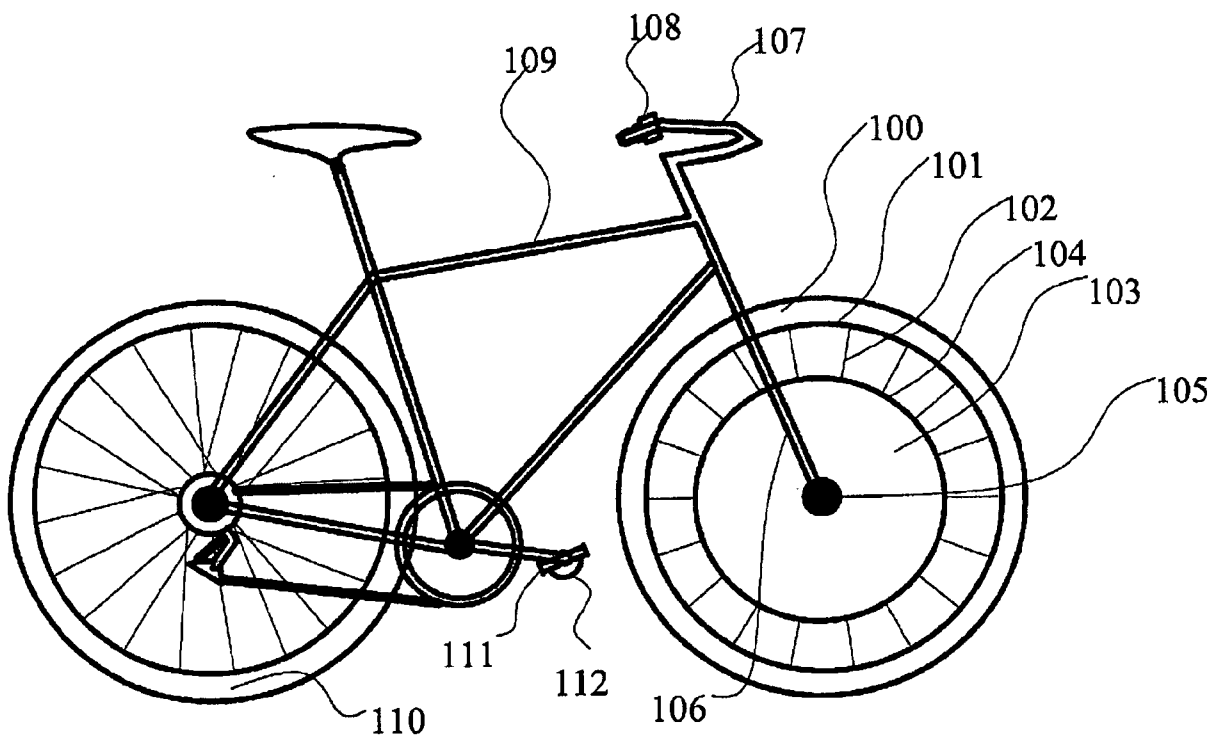


Fig. 1

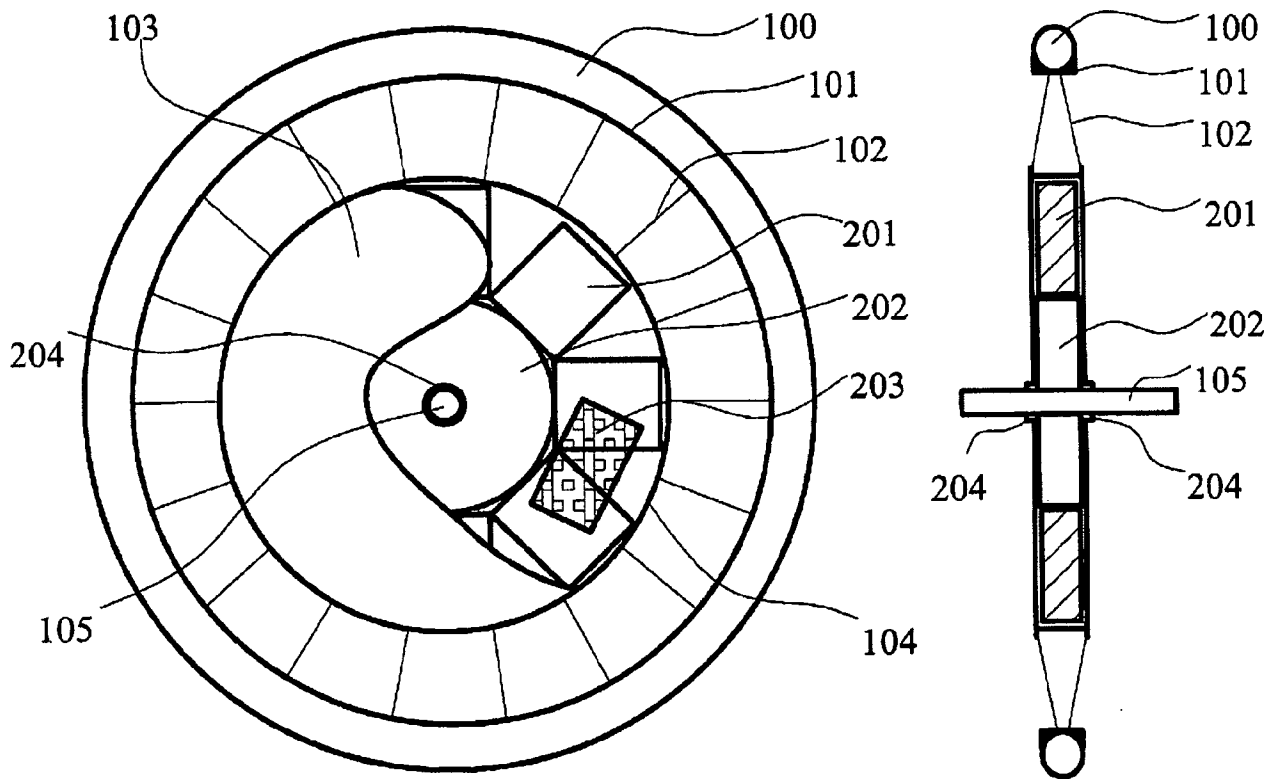


Fig.2

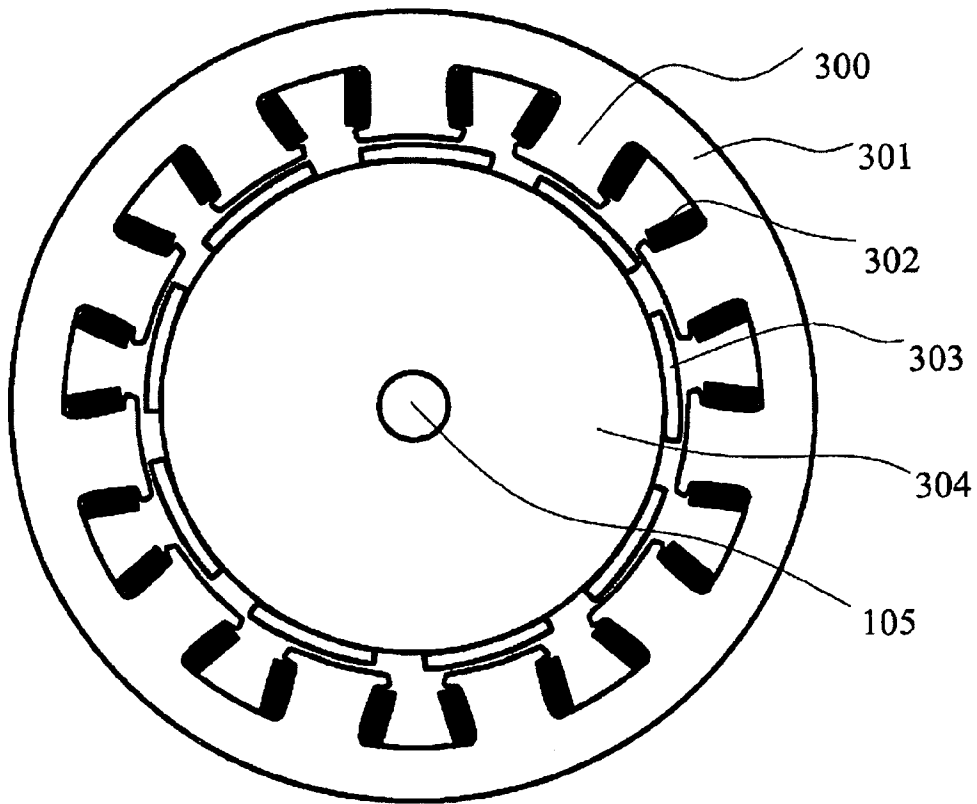


Fig.3

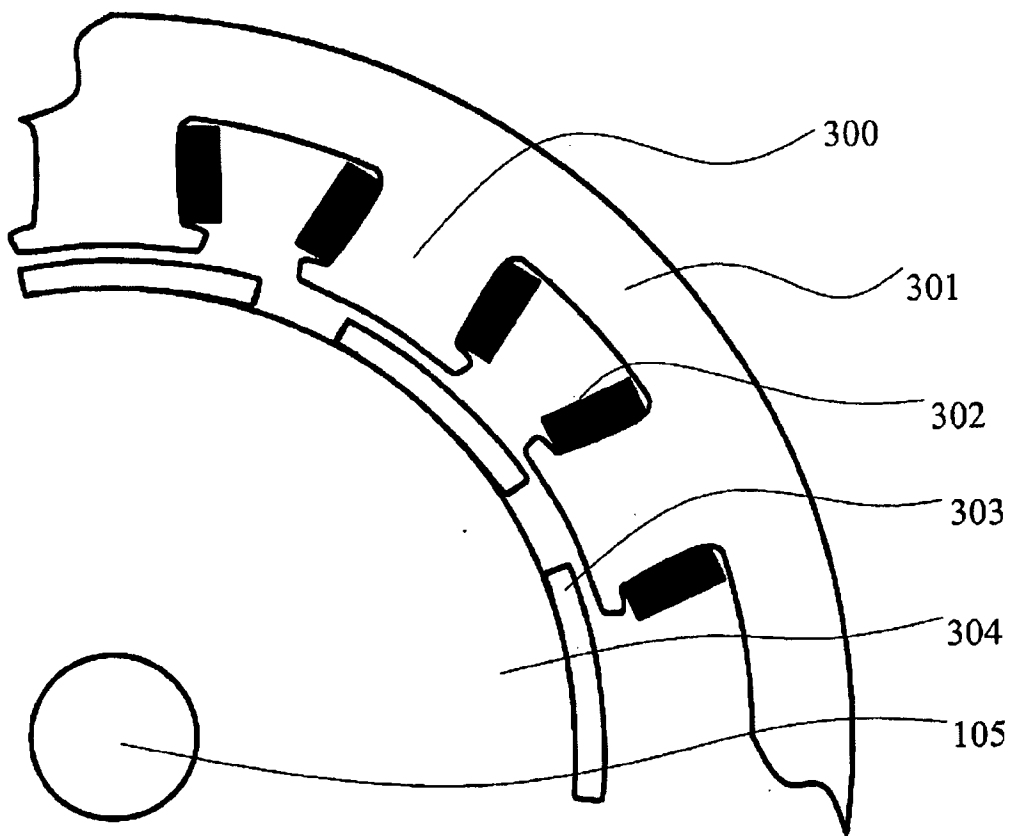


Fig.4

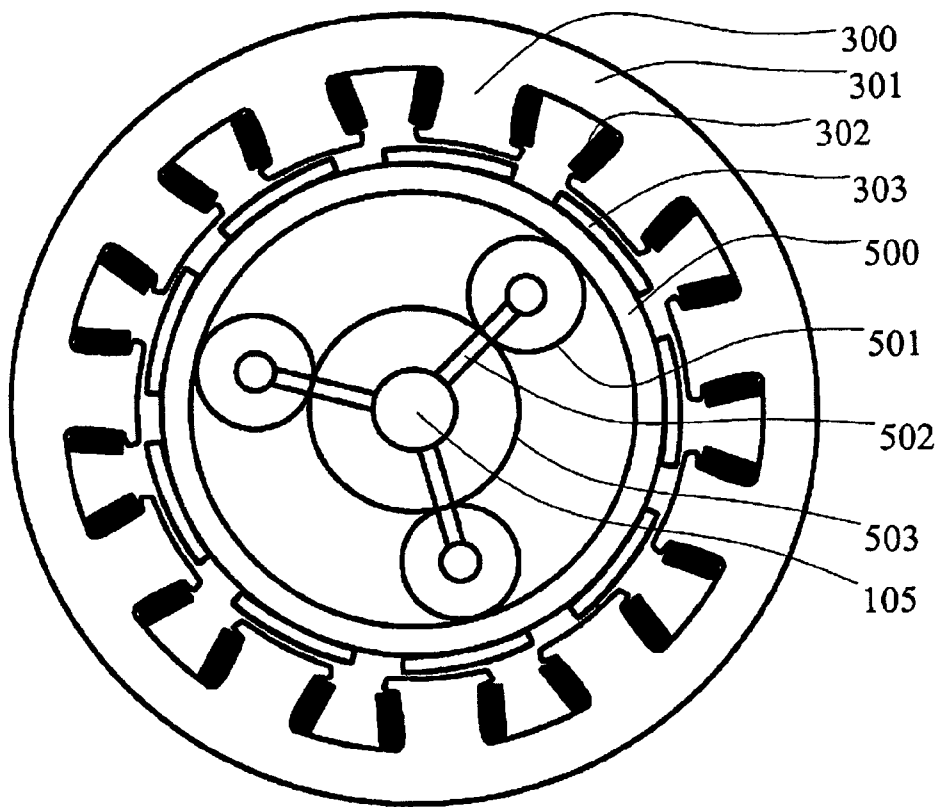


Fig.5

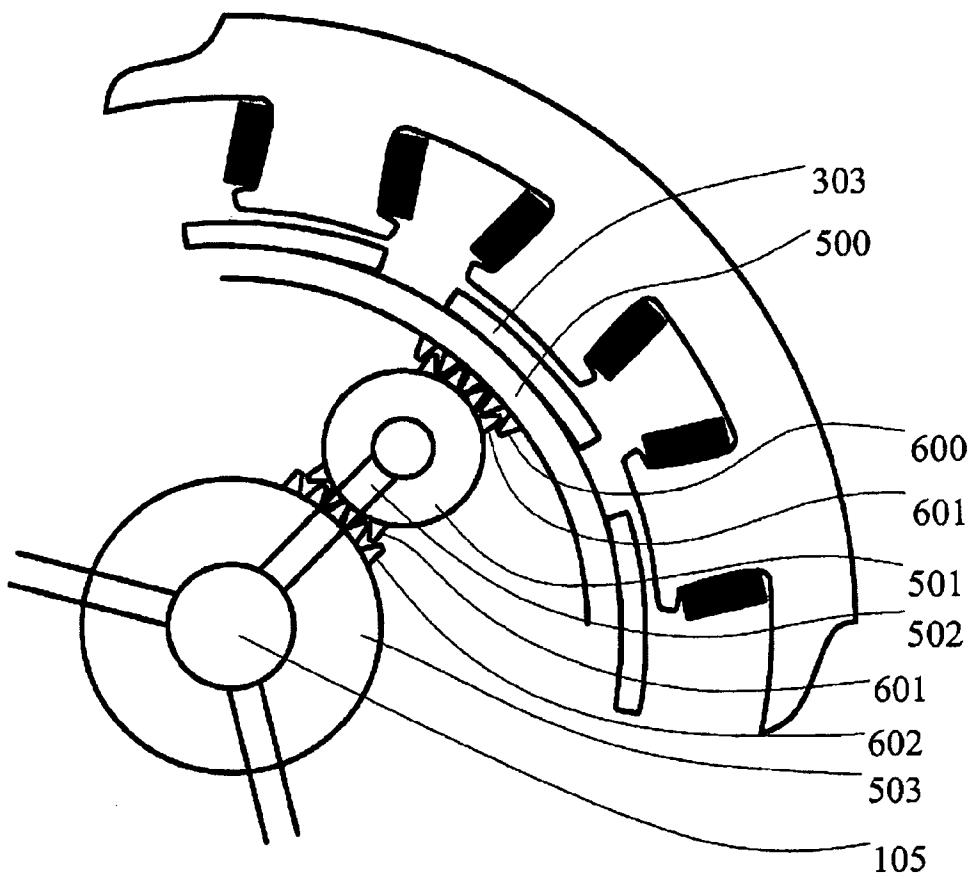


Fig.6

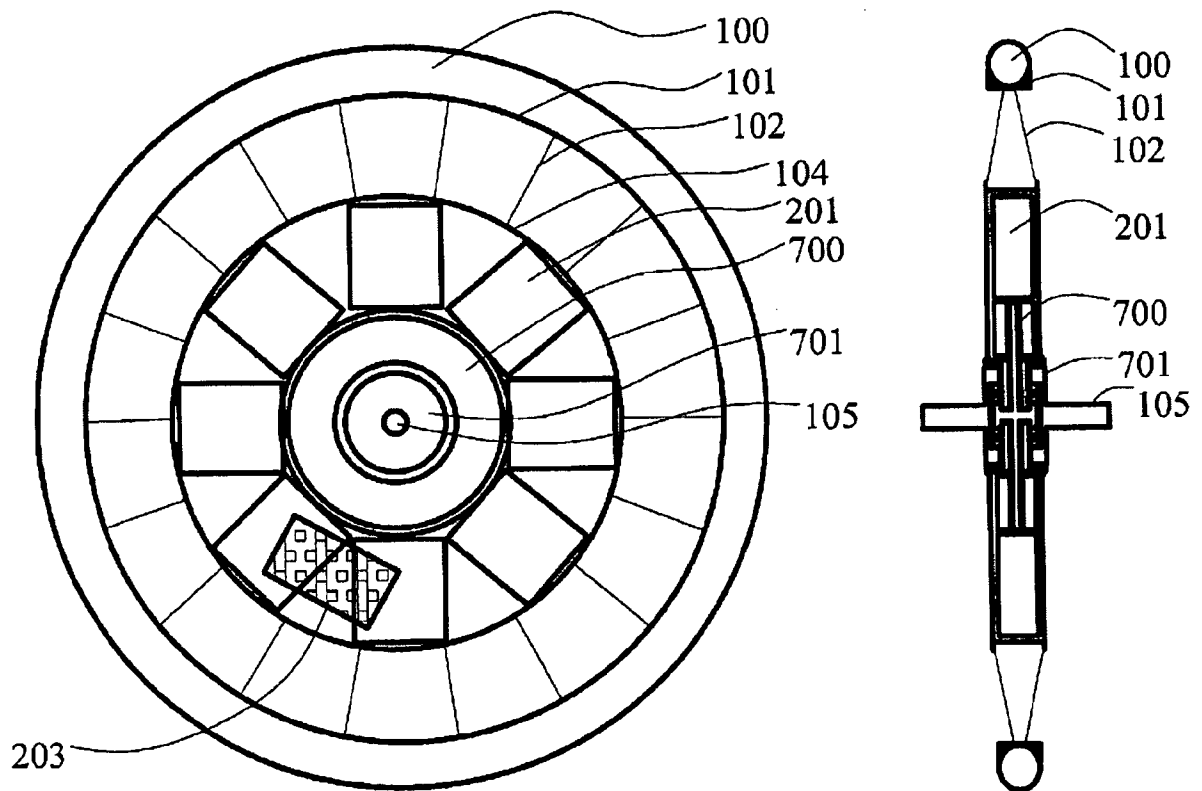
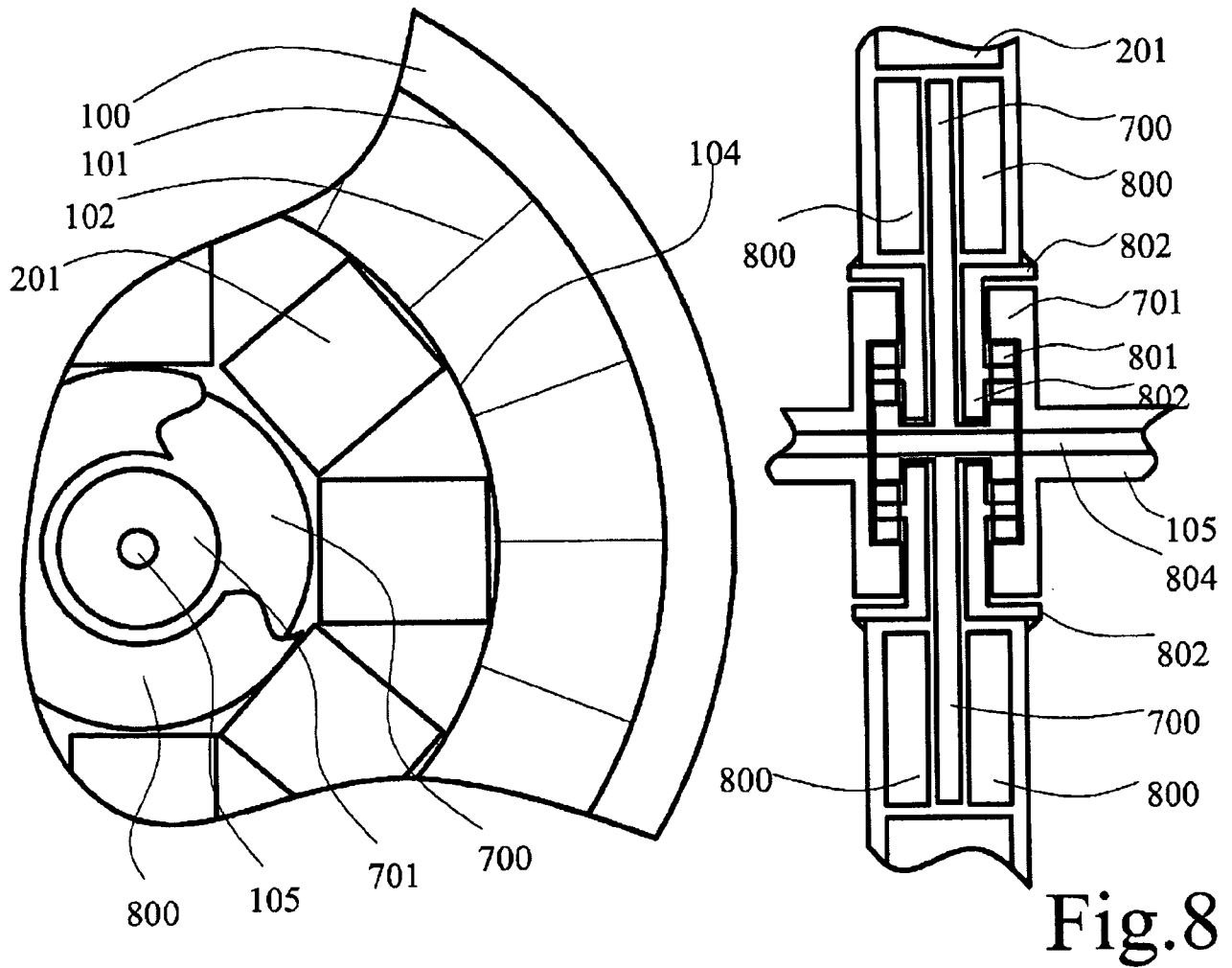


Fig.7



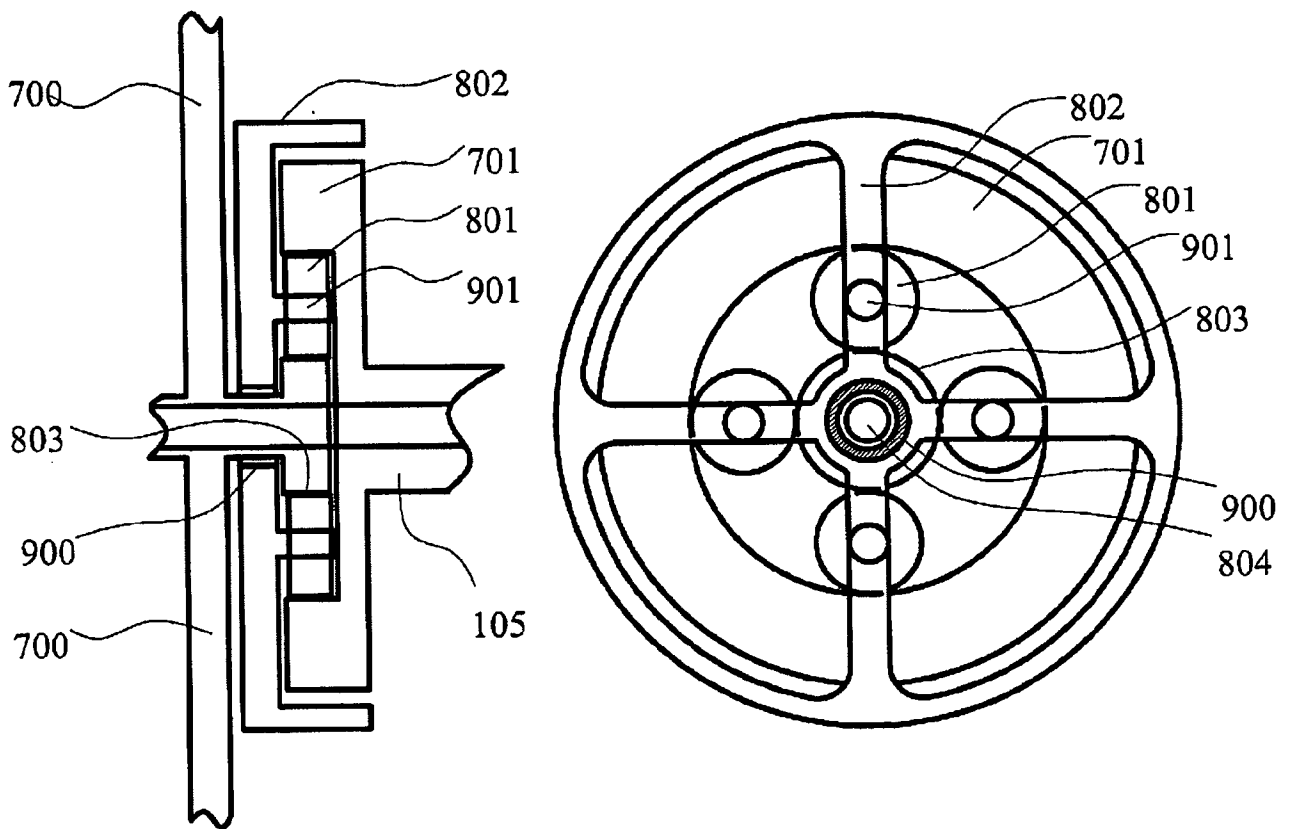


Fig.9

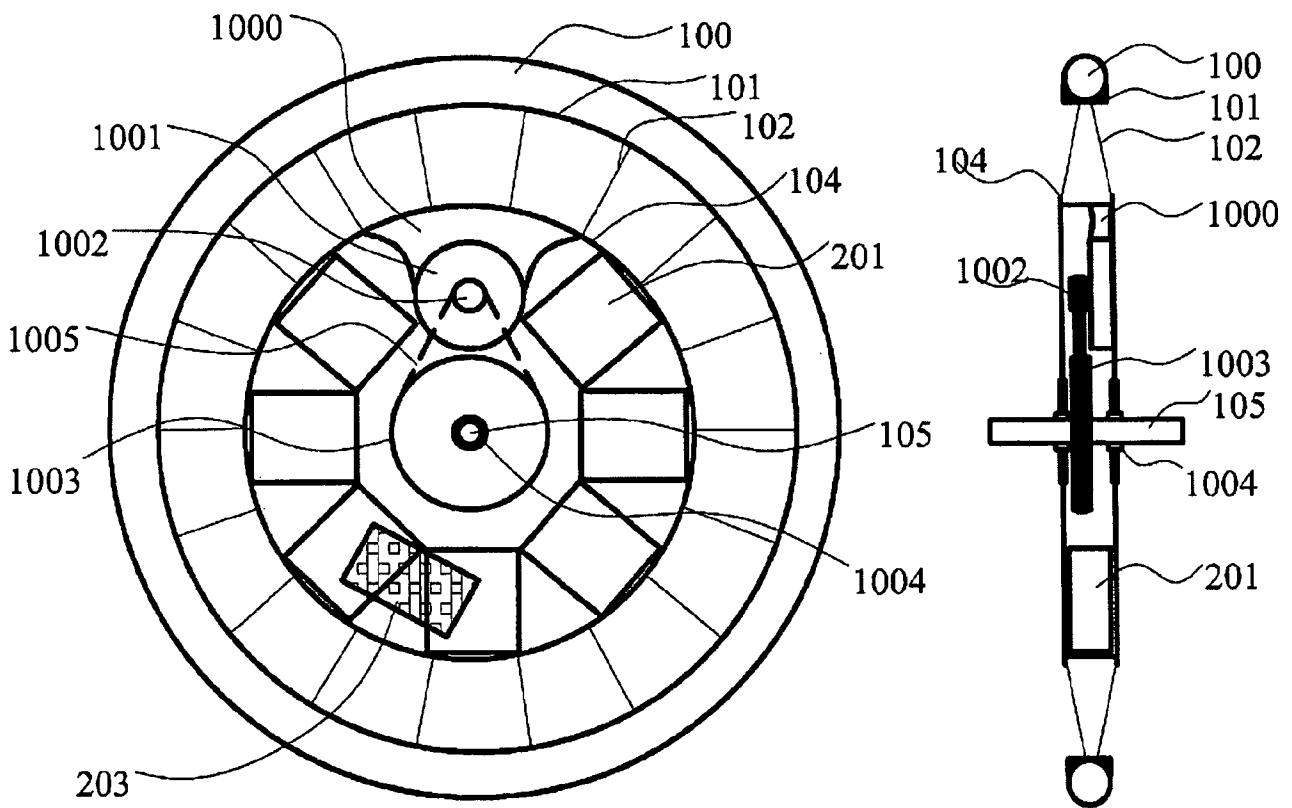


Fig.10

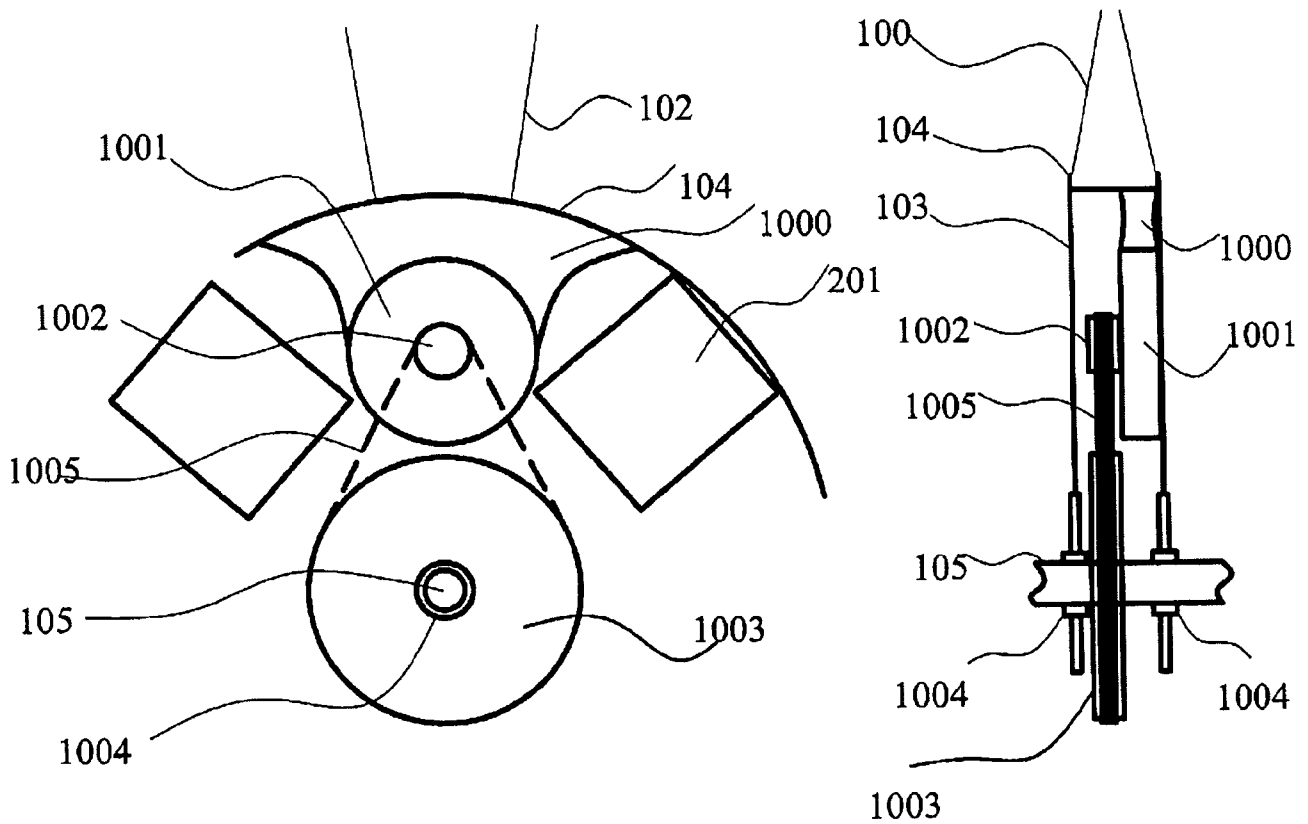


Fig.11

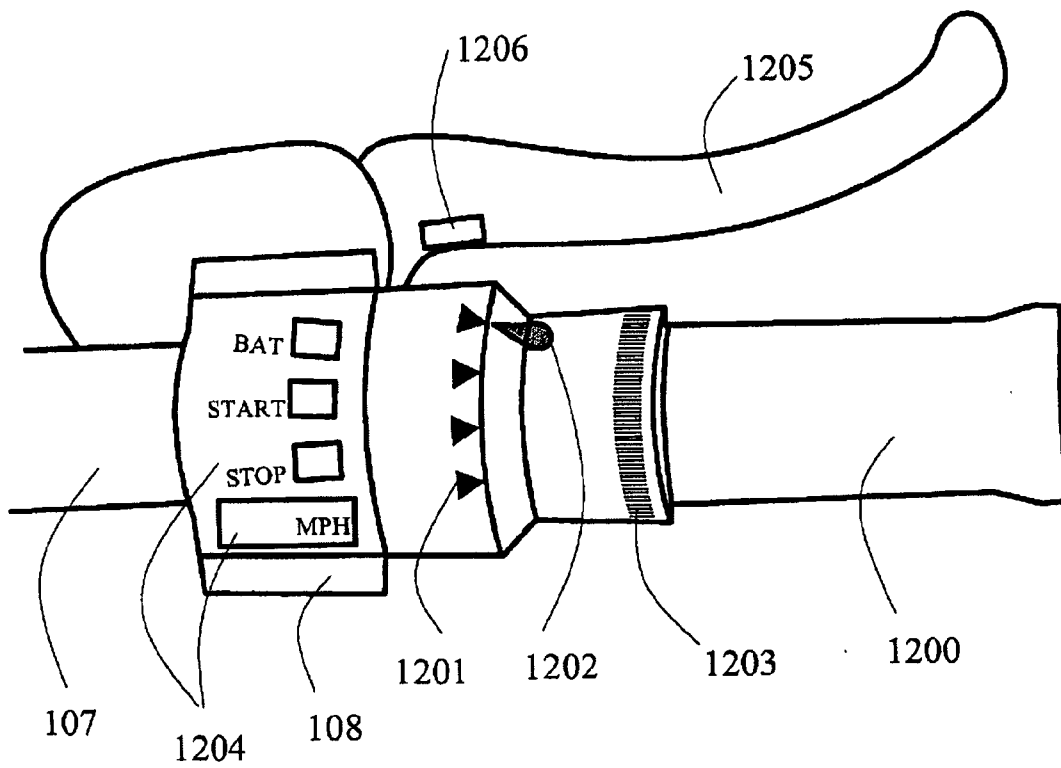


Fig.12

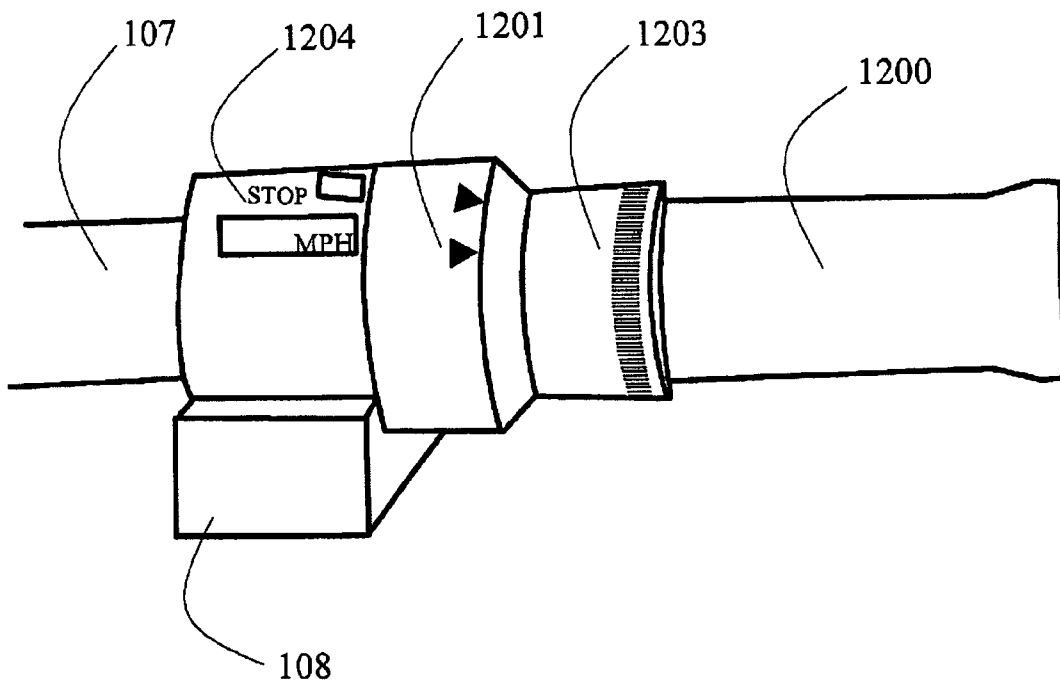


Fig.13

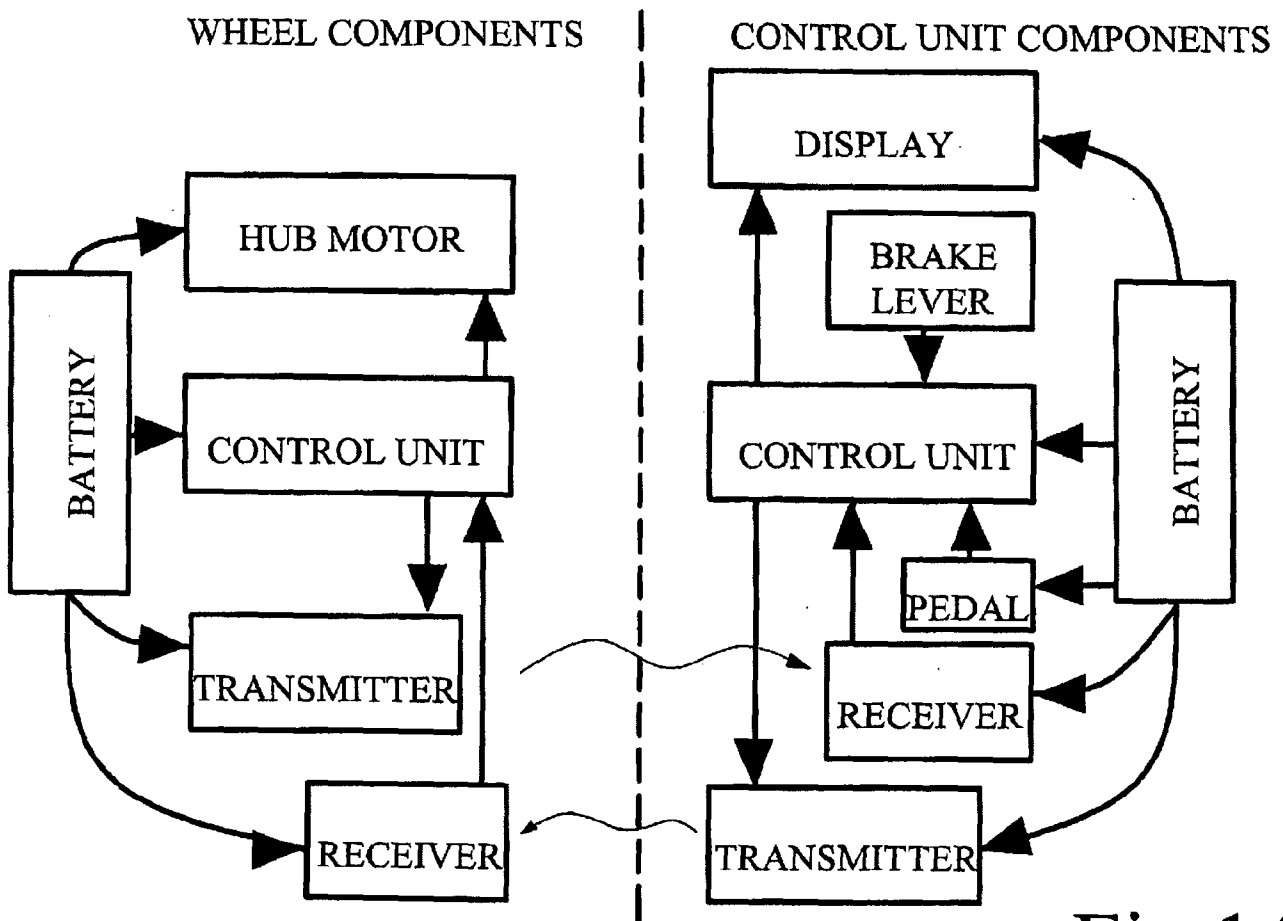


Fig.14