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Differential Dual Drive Bicycle Assembly.5 Field of Invention:

This invention relates to a differential dual drive assembly for use in transmission of differential power to bicycles and in particular to motorized bicycles that can be used for recreational purposes like cross-country biking, mountain biking and the likes. The invention, when adapted into a bicycle construction provides for a variety of advantages.

Background to the Invention:

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A conventional bicycle uses foot pedal power to propel the bicycle and the rider forward. A number of practical modifications have been patented since then, more particularly to the mechanization of the conventional bicycle. However, a practical and cost-effective dual wheel driven bicycle has not been available commercially yet.

For example, there is a bicycle that has two wheels driven synchronously by conventional pedal power where the pedal means is linked to the driven wheel by means of a chain and sprocket to the rear driven wheel. This in turn is linked to a front wheel pulley by a continuous belt. The disadvantage is that the power generated is split in a given ratio between the rear wheel and the front wheel. A further disadvantage is that the speed is not variable for a given configuration of gears and pulleys and wheel diameters.

Another disadvantage of such a dual drive system is that it fails

to effectively address the different rotational speeds between the front wheel and the rear wheel which cause power loss and tire wear. Further, some inventions use a ratchet and pawl mechanism to the front wheel to reduce tire scrubbing but lose the advantage of a dual driven bicycle.

In another form of bicycle, a dual wheel driven mechanism is provided wherein the pedaled power is transmitted to the rear wheel by conventional pedaling means. The rear wheel power is then divided in a fixed gear ratio to the two wheels by a ring and pinion gear mechanism. A designed ratio of power is therefore transmitted to the front wheel by means of an elongated flexible transmission shaft. To this front wheel is attached a similar ring and pinion gear drive mechanism as provided for in the rear. In such a dual drive bicycle, in a first operational mode, in which the front and rear wheels are driven in a speed ratio equal to their gear ratios and wheel diameters; to a second mode in which the front wheel drive is decoupled to allow only rear wheel drive.

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The disadvantage to the existing form of dual drive bicycles is that slippage of wheels occur due to the speed range being fixed for the rear and front wheels.

25 A further disadvantage is apparent when riding on slippery surfaces such as wet roads, on mud or snow when it is desirable to perform differential two wheel drive for powering both the front and rear wheels even in the event if slippage occurs in one of the wheels.

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Existing dual drive bicycles are designed very precisely for a given wheel configuration. Factors such as tire elasticity, varying ground conditions and manufacturing defects will cause

tire scrubbing and premature tire wear as there is no differential capability when fixing gear ratios.

These disadvantages can be overcome with the present invention described by the use of a power transmission means comprising epicyclic gear assembly attached rotationally to the wheels to allow for transmission of power to either both wheels or to the rear wheel only or to the front wheel only, differentially.

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Summary of the Invention:

According to the first aspect of the invention, there is provided a power transmission means to a bicycle where the power transmission is able to provide both front wheel drive and rear wheel drive with differential torque distribution depending on operating conditions.

By use of the invention, both the rear wheel and the front wheel can be driven at different rotational speeds without any loss of power.

Preferably, when both wheels are engaged to rotate together, the torque is increased instead of the rotational speed. This aspect of the invention allows the rider to traverse soft terrain and ascend steep inclines. It also provides safer riding in wet and slippery road conditions.

Another aspect of the invention allows the bicycle to be driven with a rear or front wheel drive only.

Rear wheel only drive means allows increased speed at the expense of torque without loss of power. This mode of drive is preferred

on flat or even terrain where the rolling resistance is low.

Front wheel drive only is preferable for straight steering stability during higher speeds on the bicycle.

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The invention provides automatic speed compensating means if the bicycle uses different sizes of wheels for the front and rear; or if wear and tear causes different diameters on the wheels or while negotiating bends.

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Advantageously, with the speed compensating means, the cyclist need not apply corrective braking to compensate the speed change between wheels as the power transmission system will automatically compensate such that both the wheels will be in
15 full contact with the ground without any slippage.

Another important aspect of the invention is that it allows speed to torque interchangeability under different ground conditions. Torque is inversely proportional to speed. For example, when the
20 front wheel is in contact with a dry and tractive terrain whilst the rear is spinning in a wet terrain, by braking on the front wheel, more torque is given to the rear wheel to extricate the bicycle out of the situation.

25 This causes less wear on the tires and there is less slipping of the wheels.

The invention provides a differential dual drive assembly as a power transmission means for a standard pedal bicycle that can be
30 easily and cheaply retrofitted. It is also provided that the assembly is also economical to manufacture and to fit on to a new bicycle.

Brief Description of the Drawings:

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The present invention will now be described by way of example only, with reference to the accompanying drawings wherein:

10 Figure 1 shows the rear perspective view of a bicycle having attached thereto a form of drive assembly according to the invention.

Figure 2 is front perspective view from the right of the bicycle illustrating the front drive means (30) with flexible shaft (40)

15 Figure 3 is the side elevation view of the differential dual driven bicycle.

Figure 4 is a plan view of Figure 3.

Figure 5 is a detail drawing of the front wheel (50) incorporating flexible drive shaft (40), front transmission
20 roller unit (31), holding bracket (30) attached to the extended front wheel spindle through retaining nuts.

Figure 6 shows the rear wheel drive (100) attached to the rear wheel (60) using holding bracket (70) to the back wheel spindle.

Figure 7 is a perspective view of the epicyclic gear (100)
25 showing the drive roller (108), annular gear (106), sun gear (105), planet gear (104), and attached to the sun gear, the flexible shaft (40).

Figure 8 is an exploded view of the epicyclic gear drive mechanism and the electric motor (101).

30 Figure 9 shows an elevation of a mounted gear assembly (101) to the rear wheel (60) together with reaction roller (109).

Figure 10 shows a plan view of the bracket arrangement of Figure 9.

Figure 11 shows a schematic of the all wheel drive arrangement.
Figure 12 shows a schematic of the rear wheel drive arrangement.
Figure 13 shows a schematic of pedal power only detached from the drive mechanism.

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Detailed Description of the Invention:

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The present invention will now be described with reference to the preferred embodiments thereof and with reference to the drawings. The differential dual drive bicycle (1) has a power transmission means comprising an epicyclic gear assembly compartment (20) containing the differential power transmitting device (100) of a planetary gear wheel type for providing differential action between the front and rear wheel driven by a primary power source input motor (101). A battery compartment (10) is also provided at the rear wheel (60). The gear assembly compartment (20) and the battery compartment (10) are supported by a spring loaded bracket attachment (70) which is in turn securely attached to the rear wheel spindle (71) together with the rear dropout (2) by retaining nuts (72). In the preferred embodiment the bicycle is a conventional bicycle in which the pedal sprocket , endless chain and the rear sprockets are supplemented with the drive arrangement of the invention. There are provided left and right pedals (3) with cranks (7). When the drive arrangement is in use the pedals (3) can be cranked but this provides no advantage.

Alternatively, in a further embodiment, a conventional bicycle gear train with pedals (3), cranks, a pedal sprocket , an endless gear chain , and a flexible transmission shaft (40) with differential fitted as described in the preferred embodiment and

can be used to provide the mechanical power in lieu of electric power.

The power transmission means (100) and the transmission shaft
5 (40) will now be described in detail as shown in exploded Figure
8. The power transmission means (100) is driven by an electric
powered motor (101) and comprises an epicyclic gear train
assembly having carrier plate (103), with preferably three, but
not more than five planet gears (104) on pins (111). Central to
10 these planet gears (104), is positioned the sun gear (105) which
meshes into the planet gears (104). Externally, the planet gears
(104) are meshed into a ring gear (106) with internal teeth. The
outside of the annular ring gear is suitably prepared to receive
the rubber roller (108) which will be in contact with the
15 sidewall of the rear tire (60) (supplied with the bicycle). The
rubber roller (108) is replaceable upon wear and is made from a
similar material to the tire. The entire assembly is then capped
on either end with a front retainer (107) and a rear retainer
(102). The retainers also provide protection to the gear assembly
20 (100) from the outdoor elements. The carrier plate with the
planet gears (104) can rotate around the sun gear (105) and the
ring gear (106) allowing the sun gear (105) and the ring gear
(106) to rotate at different speeds.

25 Attached rigidly to the sun gear (105) and exiting coaxially from
the epicyclic gear train is a suitable sized flexible torque
transmitting shaft or cable (40) of predetermined length to reach
the front wheel (50). The rotational speed of the sun gear (105)
is transmitted through the shaft (40) to the front wheel (50) to
30 the front wheel end of the shaft (40) is attached a front wheel
drive roller (31) which translates the sun gear (105) output
torque to the front wheel drive. The roller of the front wheel
attachment is similar to the roller provided on the rear wheel

attachment (108). In addition and preferably there is provided reaction rollers (32) opposite to the front wheel roller (31). Similarly, there is provided reaction rollers (113) opposite to the rear wheel roller (108). This is advantageous to the stability of the bicycle during use.

The rear and front wheel drive assemblies can be mounted on the respective wheel spindles by bracket attachments (70) and (30) respectively, in the same way that bicycle forks (2) and (4) are attached.

The operation of the gear train will now be described. The input power is derived from a electric motor (101) operated by a rechargeable battery, housed in a battery compartment (10). The output shaft (102) of the motor is fitted into the carrier arm (103) within the epicyclic gear (100). When the motor (101) is operated, the motor torque will be transmitted to the carrier plate (103). This arm carries planet gears (104) and the planet gears (104) rotate with a common rotational velocity as they are carried on common arm (103) driven by the motor (101) and mounted on pins (111) extending from the common plane (103). They also are free to rotate on their own axis. The planet gears (104) are in turn meshed with the internal teeth of the ring gear (106), causing the ring gear (106) to rotate, which is integrally attached with the rear drive roller (108). The drive roller (108) provides traction to rotate the rear wheel (60) of the bicycle (1) independently from the front wheel (50).

Sun ring (105) is mounted to output shaft (102) by means of locking screw (110). A flexible torque transmitting shaft or cable (40) of a sufficient length to reach the front wheel (50) is attached centrally to the sun wheel (105). The shaft (40) or cable, for example a Bourden cable, is a commonly available item

but must be sized suitably for the aspects of withstanding torque and torsional deflection under the required maximum load to be transmitted. To the other end of the shaft (40) is attached the front wheel roller (31) which translates the shaft (40) torque to the rotational velocity of the front wheel (50).

During normal operation of the epicyclic gear, the bicycle is dual wheel driven but differentially. The torque generated by the motor (101) can be split advantageously between the rear wheel (60) and the front wheel (50) to traverse soft terrain or ascend steep inclines. The output torques at the rear wheel (60) and the front wheel (50) are determined by the number of teeth on the sun gear (105) and the ring gear (106). If the symbol R_g is used to represent the ratio of number of teeth on the sun gear (105) to the number of teeth on the ring gear (106), then this value of R_g will be naturally between unity and greater than zero since the ring gear (106) has more teeth than the sun gear (105). The torque distribution ratio for the rear wheel (60) will equal to $1 / (1 + R_g)$ and that of the front wheel (50) will be $R_g / (1 + R_g)$. It can be seen therefore that the drive torque distribution amount for the rear wheel (60) is naturally higher than the drive torque distribution amount for the front wheel (50) of the bicycle in its preferred embodiment.

Upon locking the front wheel roller (31), the bicycle is a complete rear wheel drive bicycle. There is no power loss when the mechanism is in this mode and the torque completely shifts to the rear wheel (60) and front wheel (50) in the ratio of 100% to 0% respectively.

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Therefore, in this rear wheel drive mode, the bicycle is powered only at the rear wheel (60) which is advantageous for climbing inclines such as slopes and for starting off from rest.

Alternatively, as the front wheel (50) can be driven in the same mode as the rear wheel (60) only drive mode that is, in the ratio of 0% - 100% respectively for the rear wheel (60) to front wheel 5 (50). This is achieved by locking the ring gear (106) or disengaging ring gear from rear wheel contact and allowing the sun gear (105) to rotate. The described front wheel only drive mode is a suitable torque distribution for normal riding because it provides for good straight riding stability.

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Speed compensation can also be possible. This is necessary when the bicycle wheels are not of the same diameter or if wear and tear is present in the tires or when it is negotiating a bend. Usually, speed is compensated for torque and vice-versa.

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The power transmission means described above is relatively simple in construction and is readily available as commercially available parts. Therefore, it is relatively inexpensive to assemble and manufacture as a complete assembly for retrofitting 20 to older bicycles or to be fitted as an option to newly manufactured bicycles.

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Claims:

- 5 1. A drive assembly for a bicycle for driving both wheels of the bicycle and comprising inter-connected driving means for the rear wheel of the bicycle and for the front wheel of the bicycle and a differential, whereby the wheels can be driven at dissimilar speeds.
- 10 2. A drive assembly according to Claim 1, wherein the differential incorporates epicyclic gearing.
- 15 3. A drive assembly according to Claims 1 or 2 incorporating a power source for powering the driving means for the rear and the front wheel.
- 20 4. A drive assembly according to Claim 3, wherein the power source is an electric motor.
- 25 5. A drive assembly according to any one of Claims 1 to 4, wherein the drive means of the front and rear wheels each incorporates at least one roller for engagement with the tire on the respective wheels, with the drive for the rear wheel being provided from the ring gear of the epicyclic gearing and the drive for the front wheel being provided direct from the power source by a flexible shaft or cable which passes centrally through the sun gear.
- 30 6. A drive assembly according to any one of Claims 1 to 5, wherein the drive means for at least one of the wheels is provided with means for locking or disengaging from its driving position.

7. A differential dual drive bicycle assembly for providing tractive power to both wheels of a bicycle using an epicyclic gear train comprising planet gears mounted on a carrier and attached to a power generating source, a ring gear to which is attached a driven roller means which can engage with a sidewall of the rear wheel of the bicycle and a sun gear which is centrally disposed of the gear train and to which is attached a transmission shaft or cable; the other end which can be engaged with a sidewall of the front tire of the bicycle whereby the two wheels can be driven at dissimilar speeds.
8. A differential dual drive bicycle assembly according to Claim 7, wherein the front wheel roller can be locked to slow the speed of the front wheel thereby increasing the speed of the rear wheel to near synchronous speed with the front wheel.
9. A differential dual drive bicycle assembly according to any one of Claims 1 to 8 wherein the said drive assembly is releaseably attached to the rear of the bicycle.
10. A bicycle fitted with a drive assembly according to any one of the preceding Claims.