



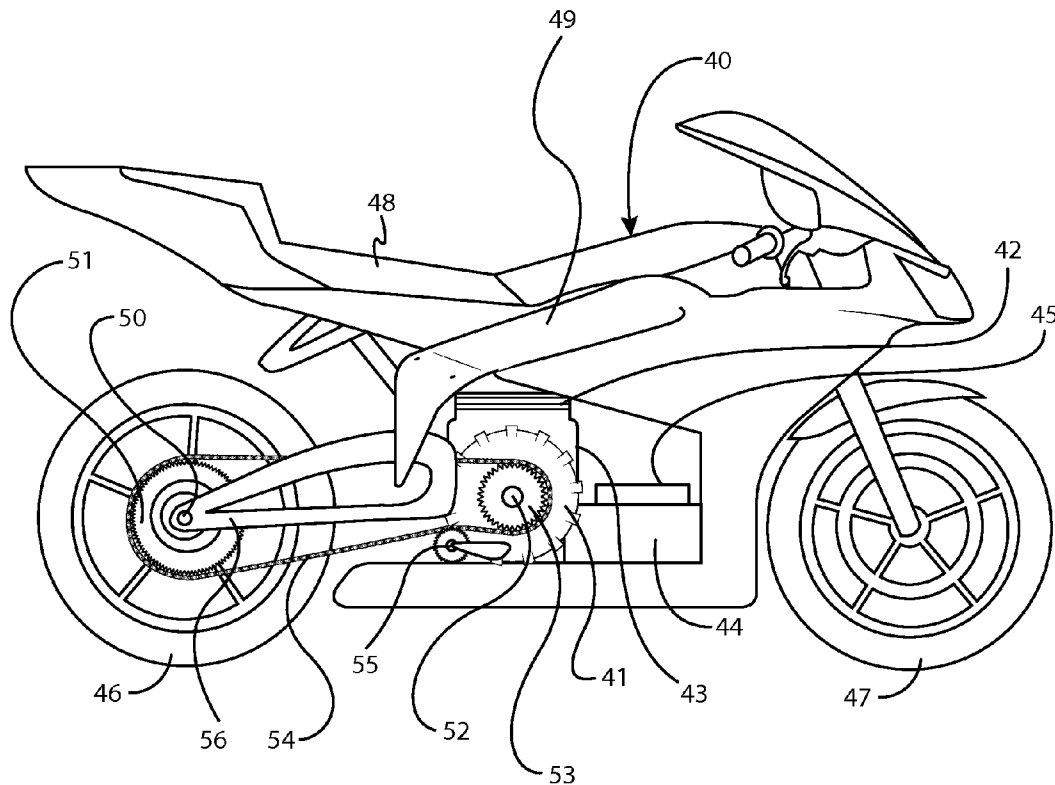
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(19) **United States**(12) **Patent Application Publication**
BUELL et al.(10) **Pub. No.: US 2013/0168171 A1**(43) **Pub. Date: Jul. 4, 2013**(54) **RIDDEN VEHICLE WITH HYBRID POWER SYSTEM**(71) Applicants: **ERIK BUELL**, MUKWONAGO, WI (US); **ANTHONY STEFANELLI**, ELKHORN, WI (US); **JOHN FOX**, Mukwonago, WI (US); **JONATHAN BUNNE**, ELKHORN, WI (US); **GIANCARLO BATTAGLINI**, EAGLE, WI (US); **CHAD ANTCZAK**, WAUKESHA, WI (US); **DEAN IWINSKI**, MUSKEGO, WI (US)(72) Inventors: **ERIK BUELL**, MUKWONAGO, WI (US); **ANTHONY STEFANELLI**, ELKHORN, WI (US); **JOHN FOX**, Mukwonago, WI (US); **JONATHAN BUNNE**, ELKHORN, WI (US); **GIANCARLO BATTAGLINI**, EAGLE, WI (US); **CHAD ANTCZAK**, WAUKESHA, WI (US); **DEAN IWINSKI**, MUSKEGO, WI (US)(21) Appl. No.: **13/731,073**(22) Filed: **Dec. 30, 2012****Related U.S. Application Data**

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Y10S 903/951 (2013.01)
USPC **180/220**; 180/65.245; 903/951(57) **ABSTRACT**

A motorcycle having at least one seat and at least two wheels, an internal combustion engine, a generator, and a rechargeable battery configured to be recharged by the internal combustion engine or generator, an electric motor electrically connected to the rechargeable battery and configured to drive at least one of a plurality of wheels of the vehicle, and an electronic controller configured to start the internal combustion engine based upon a monitored condition of the rechargeable battery.



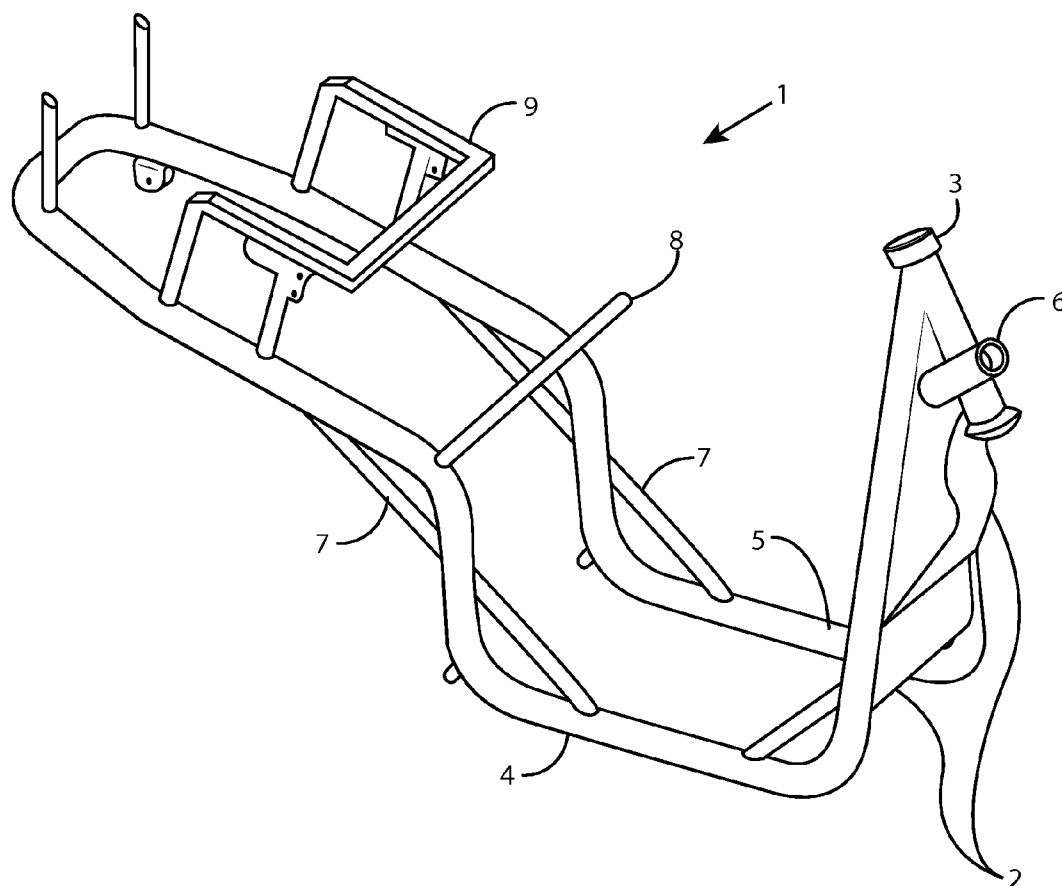


FIG. 1

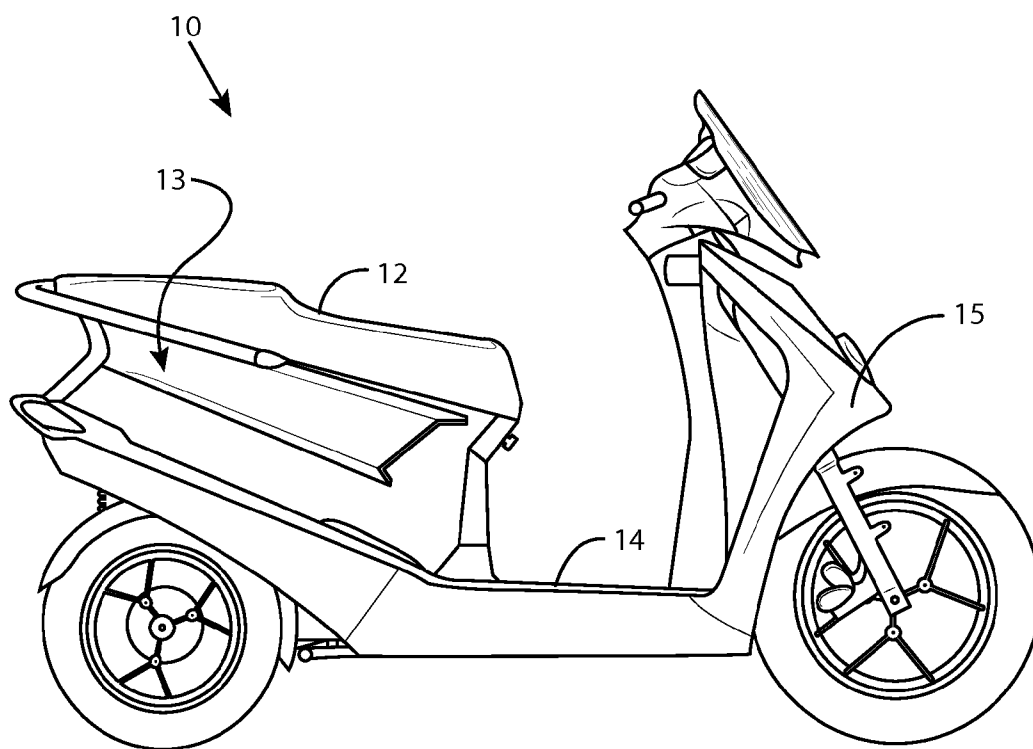


FIG. 2

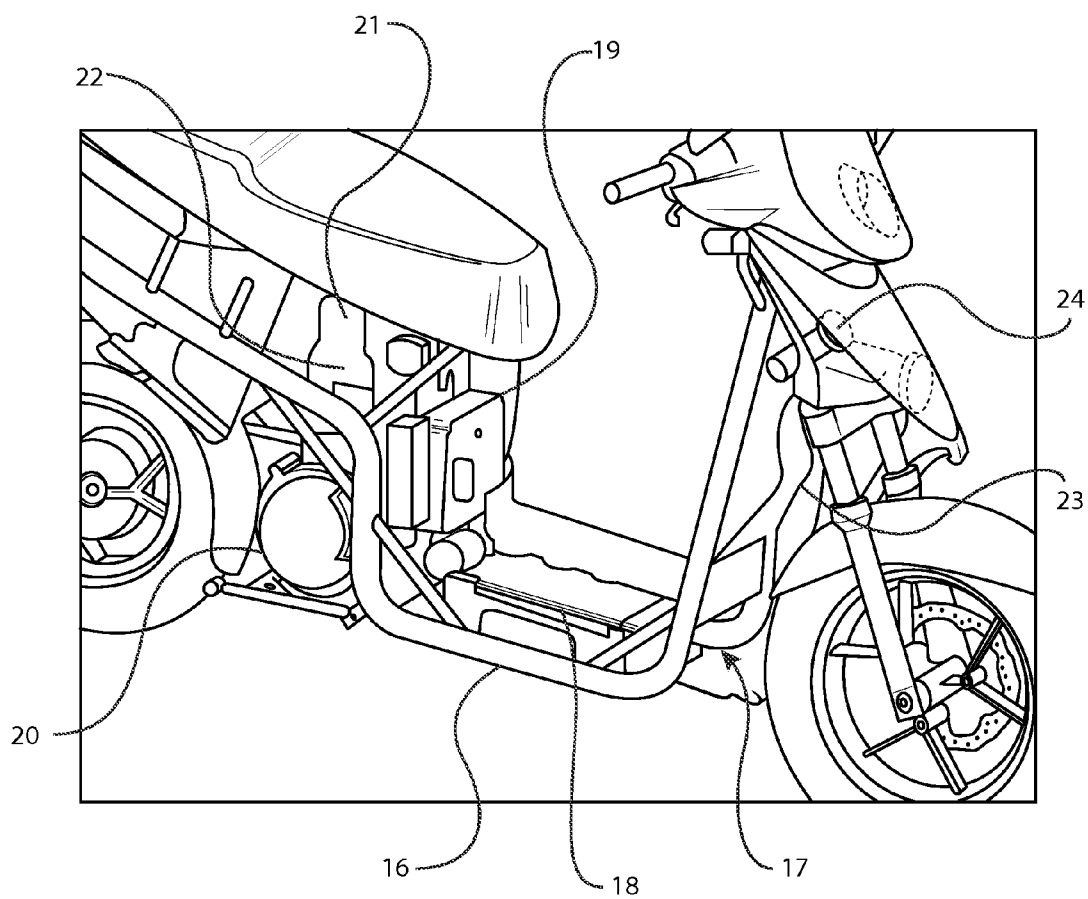


FIG. 3

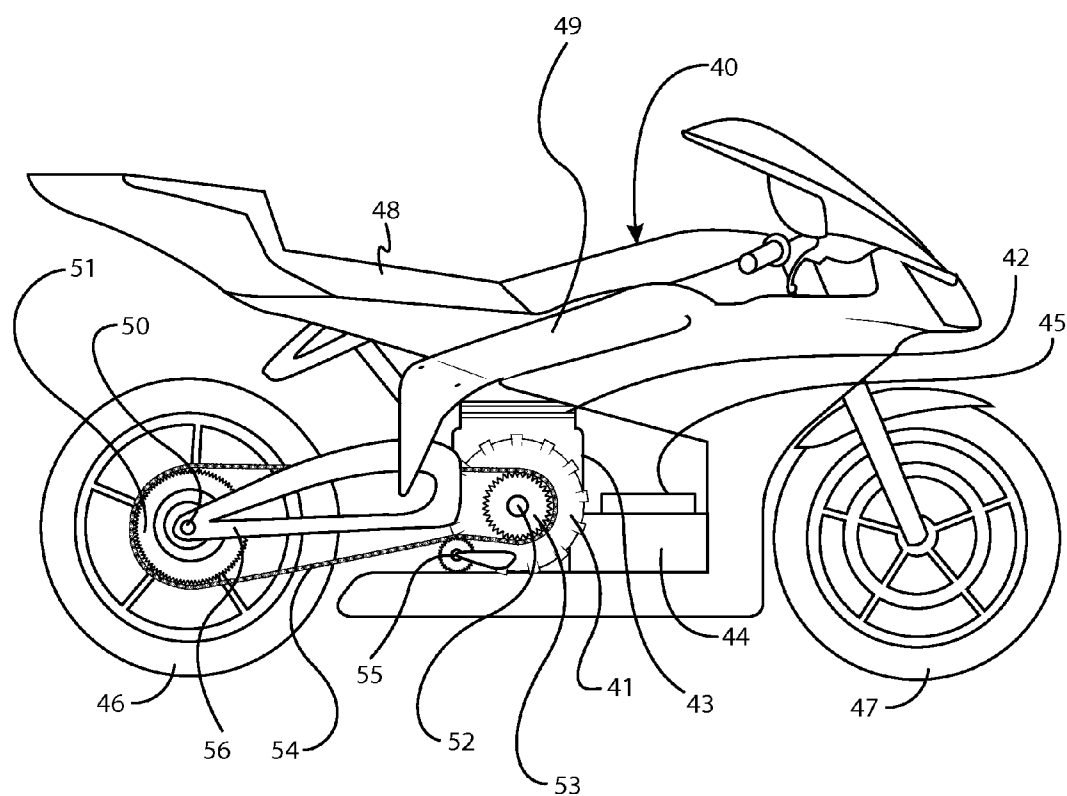


FIG. 4

RIDDEN VEHICLE WITH HYBRID POWER SYSTEM

RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Provisional Patent Application No. 61/582,816, filed on Jan. 3, 2012, and U.S. Provisional Patent Application No. 61/582,817, filed on Jan. 3, 2012, which are incorporated herein by reference.

BACKGROUND AND SUMMARY

[0002] The present disclosure relates to ridden vehicles, namely, motorized scooters, motorcycles, and other ridden vehicles, and more particularly to a ridden vehicle having a hybrid power system.

[0003] Vehicles to be ridden such as motorized scooters, motorcycles, three-wheeled vehicles, and four wheeled vehicles, such as all-terrain vehicles, have limited space to accommodate the components needed to power the vehicle. Efficient packaging of the vehicle's components is necessary to maintain the desired size of the ridden vehicle. In prior systems, placement of the fuel tank has been particularly challenging because of the need to connect the fuel tank to the engine, and the need to access the fuel tank for refueling.

[0004] Prior ridden vehicles having an electric or hybrid power system have utilized several different configurations each of which possess several drawbacks. In some prior designs, a low cost lead acid battery has been used; however, such batteries have limited power, extremely limited range and very limited battery durability. In other designs, higher cost chemistry batteries such as lithium-ion have been employed; however these batteries are expensive and may also have limited range. Yet other designs have employed an internal combustion engine and an electric motor to alternately drive the wheels; however these designs are complicated by double and integrated controls and transmissions necessary to transition the drive system between the two motor types, increasing the cost of manufacture. Electric ridden vehicles having a limited range and hybrid ridden vehicles having a complicated and costly power system have detracted from the adaption of ridden vehicles. There remains a need in the art for a ridden vehicle that is electrically powered, but reasonably priced and with a long range of travel. The presently disclosed ridden vehicle provides such a solution.

[0005] Presently disclosed is a motorized ridden vehicle comprising at least one seat and at least two wheels; an electric motor adapted to drive at least one of the wheels of the ridden vehicle; at least one rechargeable battery electrically connected to the electric motor and adapted to power the electric motor; a generator adapted to charge the rechargeable battery; an internal combustion engine adapted to drive the generator; and an electronic controller adapted to control operation of the internal combustion engine based upon monitoring a condition of the rechargeable battery. In various embodiments, the motorized ridden vehicle may be a motorized scooter, a motorcycle, a three-wheeled ridden vehicle, a four-wheeled ridden vehicle, a snowmobile or any other ridden vehicle. In some embodiments, a ridden vehicle may be a vehicle adapted to be mounted by the rider or passenger, typically with one leg either side of the ridden vehicle, such as with a motorcycle, or, alternatively in a seated position above the engine, such as with a scooter.

[0006] Also disclosed is a motorcycle comprising a seat adapted to support at least one rider; a frame adapted to support the seat and the engine during operation of the motorcycle, the frame comprising a front frame portion having a steering head, a rear frame portion adapted to support the seat and the engine, and a connecting frame portion connecting the front frame portion and the rear frame portion and to support a foot rest for a rider; an electric motor positioned below the seat and adapted to drive at least one wheel of the motorcycle; at least one rechargeable battery electrically connected to the electric motor and adapted to provide power to the electric motor; a generator adapted to provide electrical charge to the rechargeable batteries; an internal combustion engine adapted to drive the generator, and a fuel tank integrated with the frame and adapted to store fuel for operation of the engine to drive a generator.

[0007] In the various embodiments, the internal combustion engine may be controlled to maintain operation of the engine in an efficiency range for the engine. In other embodiments, the rotational velocity of the internal combustion engine may vary, as desired, to provide additional electric power to operate the motorcycle in response to a monitored condition of the rechargeable battery. In further embodiments, when additional power is desired to operate the motorcycle, the electric motor draws power from the electric battery in addition to the internal combustion engine and generator. The rechargeable battery may comprise of a single rechargeable battery or may be comprised of multiple rechargeable batteries disposed through the ridden vehicle.

[0008] In some embodiments, the ridden vehicle may further comprise an electronic controller adapted to start the internal combustion engine based upon a condition of the rechargeable battery, such as a charge level, or rate of discharge, of the rechargeable battery. In other embodiments, when the rechargeable battery is depleted to a predefined level, the electronic controller may be adapted to detect that the rechargeable battery has been depleted to the predefined level and also adapted to start the internal combustion engine which is configured to power a generator adapted to recharge the battery and additionally, or alternatively, provide power to the electric motor. In further embodiments, the ridden vehicle may comprise an electronic controller adapted to start the internal combustion engine based upon a rate of discharge of the rechargeable battery. The controller may be adapted to determine when the charge in the battery is being discharged in excess of a predefined rate indicating that the battery is under an increased load. In response to detecting that the battery is being discharged in excess of the predefined rate, the controller may further be adapted to start the internal combustion engine configured to drive a generator adapted to charge the rechargeable battery and additionally, or alternatively, provide power to the electric motor.

[0009] Where the ridden vehicle comprises an electric motor and an internal combustion engine, the electric motor and internal combustion engine may be stacked below the seat of the motorcycle. In some embodiments the internal combustion engine may be positioned above the electric motor. Additionally, or in the alternative, the rechargeable battery may be positioned below the seat of the motorcycle.

[0010] In some embodiments the ridden vehicle may comprise a fuel tank integrated with the frame and adapted to store fuel for operation of the engine. The frame may further comprise at least one tubular portion housing a fuel line extending from the fuel tank through the at least one tubular portion to

the engine, and the frame may be adapted to provide torsional support for the frame. The fuel storage capacity of the integrated fuel tank may be between 2 and 15 liters. In other embodiments the fuel storage capacity of the integrated fuel tank may be in excess of 15 liters.

[0011] In some embodiments, the ridden vehicle may have an electric motor producing in excess of 200 horsepower, or 400 horsepower. In other embodiments the electric motor may produce in excess of 150 horsepower. In further embodiments the electric motor powered by both the internal combustion engine and generator, and the rechargeable battery may produce in excess of 200 horsepower.

[0012] In some embodiments, the fuel tank may provide torsional support for the frame. The frame of the ridden vehicle may also include at least one hollow section, and the fuel tank is in fluid communication with the internal combustion engine, here preferably, through at least one hollow section of the frame. In addition, the hollow section of the frame may be configured to store fuel for the internal combustion engine and may be adapted to be in direct fluid communication with the internal combustion engine. In some embodiments, the frame has at least one tubular portion housing a fuel line extending from the fuel tank through the at least one tubular portion to the engine.

[0013] The internal combustion engine, of embodiments described herein, may be adapted to provide a drive for the ridden vehicle, and the engine may have a displacement of at least 100 cubic centimeters or at least 150 cubic centimeters. In other embodiments, the engine may have a displacement between 100 and 500 cubic centimeters. In further embodiments, the internal combustion engine may have a displacement of 300 cubic centimeters.

[0014] In another embodiment, the ridden vehicle includes a rechargeable battery configured to be supported by the frame and to be recharged by generated power by the internal combustion engine, and an electric motor electrically supported by the frame and connected to the rechargeable battery and adapted to provide a drive for the ridden vehicle. The internal combustion engine used to recharge the rechargeable battery may have a displacement of no more than 1,000 cubic centimeters, between 50 and 250 cubic centimeters, or approximately 2 cubic centimeters in various embodiments. The rechargeable battery may be a lithium-ion battery.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Reference is made to the accompanying drawings in which particular embodiments and further benefits of the invention are illustrated as described in more detail in the description below, in which:

[0016] FIG. 1 is a perspective view of a frame for a ridden vehicle, being a scooter;

[0017] FIG. 2 is a side view of a ridden vehicle, being a scooter; and,

[0018] FIG. 3 is a partial perspective view of a ridden vehicle, being a scooter;

[0019] FIG. 4 is a side view of another embodiment of a ridden vehicle, being a motorcycle, having a hybrid drive system.

DETAILED DESCRIPTION OF THE DRAWINGS

[0020] Embodiments of a ridden vehicle having a fuel tank integrated with the vehicle frame are presently disclosed. The integrated fuel tank is illustrated in the context of a motorized

scooter, however, the ridden vehicle with integrated fuel tank may also be used with other ridden vehicles such as motorcycles, mopeds, three-wheeled vehicles, four-wheeled vehicles, such as all-terrain vehicles, and other vehicles configured to be ridden, such as snow mobiles or personal watercraft (i.e. jet skis).

[0021] In the various embodiments, a vehicle includes a seat configured to be ridden and an internal combustion engine. The vehicle also includes a frame configured to support the seat and the engine during operation of the vehicle. The frame includes a front frame portion having a steering head, a rear frame portion configured to support at least the seat and the internal combustion engine, and a lower frame portion connecting the front frame portion and the rear frame portion. The vehicle also includes a fuel tank integrated with the frame configured to store fuel for the vehicle. In an embodiment, the fuel tank is disposed within the front frame portion below the steering head.

[0022] Referring to FIG. 1, a frame for a ridden vehicle in the form of a motorized scooter is illustrated. In one embodiment, the frame 1 is constructed of hollow tubes that provide structural support for the components, such as the seat, engine and steering mechanism, of a motorized scooter. Additionally or alternatively, the frame may include one or more structural members other than hollow tubes, such as struts 7 which may provide diagonal bracing for portions of the frame. The frame 1 may include one or more seat mounts, such as first seat mount 8 and second seat mount 9, for securing one or more seats to the frame for the rider and a passenger. The shape and configuration of the frame 1 may be selected for the specific configuration of the ridden vehicle and may include additional portions for storage compartments or the attachment of peripheral devices as is known. In an embodiment, the frame 1 for a motorized scooter may include a triangular front frame portion connecting a steering head 3 to the lower frame tubes 4, 5. The lower frame tubes 4, 5 connect the front frame portion to the rear frame portion which supports the passenger seat and engine. A motorized scooter may also have floorboards (not shown) supported above the lower frame tubes 4, 5, on which a passenger's feet may rest when riding the vehicle.

[0023] The steering head 3 is configured to connect to a steering mechanism for the ridden vehicle. In various embodiments, the steering mechanism (not shown) is rotated by the rider to steer the vehicle. The steering mechanism may include handle bars, such as commonly used on scooters and motorcycles, but may also include a steering wheel or other device for steering the vehicle. In each configuration, the steering mechanism is supported by steering head 3, which is supported by the frame 1 of the vehicle.

[0024] The ridden vehicle further includes a fuel tank 2 supported or integrated with the frame 1 for storing fuel, such as gasoline. In an embodiment, the fuel tank 2 is a hollow structure connecting the steering head 3 to the lower frame portion. The fuel tank 2 includes a filler tube 6. The filler tube 6 may be a short section of tube extending from the tank 2 or may be internal to the tank. In each embodiment, the removable cap or cover may be provided to seal the filler tube 6 when the ridden vehicle is in operation. The filler tube 6 is positioned to enable the ridden vehicle to be refueled from the front portion of the vehicle while a rider remains on the vehicle. In contrast, prior systems have placed the fuel tank

and filler tube under the seat or between the rider's legs requiring the rider to dismount the vehicle during refueling operations.

[0025] In each embodiment, the fuel tank **2** may be integrated with the frame **1** such that the fuel tank **2**, itself, provides structural support to the frame and supports the steering head **3**. In some embodiments, the fuel tank occupies substantially the entire triangular front portion of the frame of a ridden vehicle such as a motorized scooter. In an embodiment, the fuel tank provides torsional support to the front frame portion of the vehicle to inhibit twisting or turning the front frame portion. The fuel tank may also provide lateral support to the lower frame tubes **4,5**. In addition or alternatively, the frame may include a lattice, webbing or other cross bracing to further support the front portion of the frame connecting the steering head to the lower frame tubes **4,5**.

[0026] The capacity of the supported or integrated fuel tank may be selected based upon the specifications of the ridden vehicle. For many light weight vehicles, such as motorized scooters, a fuel capacity of between two liters and six liters will be sufficient to provide a desired operating range for the ridden vehicle. In an embodiment, the integrated fuel tank has a storage capacity of four liters (or approximately one gallon). In other embodiments, of the ridden vehicle being a scooter, the capacity of the fuel tank may be increased by extending the fuel tank under the floorboards and along the lower frame tubes **4,5**. In an embodiment, the fuel tank, of a ridden vehicle being a scooter, is substantially L-shaped extending down the front portion of the frame and transitioning approximately 90 degrees to extend along at least a portion of the lower frame tubes **4,5**. The portion of the fuel tank under the floorboards may be secured to the lower frame tubes **4,5**, or may be integrally formed with the tubes **4,5**. In this manner, the capacity of the fuel tank may be increased.

[0027] In such embodiments, the fuel tank **2** may be integrated with the frame **1** such that the fuel tank provides structural support for the vehicle. The frame and integrated fuel tank may be formed in a variety of methods. In one example, the frame and integrated fuel tank are formed of multiple discrete pieces and welded together to complete the frame assembly. In another embodiment, the frame and fuel tank are constructed separately and then joined together during the manufacturing process to form the integrated fuel tank presently disclosed. In yet another embodiment, the frame may be constructed of a plurality of tubes as previously discussed. The fuel tank may comprise one or more enlarged sections of the tubes forming the frame of the vehicle. As such, the fuel may be stored in the fuel tank and/or within hollow sections of the frame as desired. In one embodiment, the frame includes at least one hollow section and the fuel tank is in fluid communication with the at least one hollow section of the frame such that the fuel tank and the at least one hollow section cooperate to store fuel for the vehicle. As illustrated in FIG. **1**, the hollow section of the frame may include one of the pair of lower frame tubes **4,5**, and the lower frame tube may further include a port configured to receive a fuel line to transfer fuel from the lower frame tube to the engine.

[0028] In some embodiments, the steering head **3** of the frame is connected to the lower frame rails **4,5** by tubes extending diagonally downwardly from the steering head to form the triangular front portion of the frame. A fuel tank may be affixed between the diagonally extending tubes using conventional fastening techniques for securing a fuel tank to a

vehicle frame. In this embodiment, a preexisting frame may be modified to integrate a fuel tank in the front portion of the frame to allow for refueling the vehicle without displacing the vehicle's rider.

[0029] In various embodiments, the ridden vehicle includes an internal combustion engine secured to the frame. In some embodiments, the internal combustion engine may be secured to the rear portion of the frame. In some embodiments, the internal combustion engine provides the drive for the vehicle, such as by powering one or more drive wheels of the vehicle to move the vehicle. The internal combustion engine may have a displacement of at least 100 cubic centimeters, at least 150 cubic centimeters, or more, as desired, depending upon the weight and other requirements of the vehicle. In some embodiments, the internal combustion engine may have a displacement of 250 cubic centimeters or 500 cubic centimeters. As discussed further below, the internal combustion engine may be used to drive a generator to generate electricity which is then used to drive an electric motor that turns the drive wheel of the vehicle. In such embodiments, a smaller engine may be used. Fuel from the fuel tank must be transferred to the internal combustion engine.

[0030] As previously discussed, the fuel tank may include a hollow structure connecting the steering head **3** to the lower frame tubes **4,5**. In some embodiments, the hollow structure forming the fuel tank may open directly into one of the lower frame tubes, such as tube **4**, allowing fuel to flow from the tank through the lower frame tube to the engine in the rear portion of the frame. In this manner, the lower frame tube, such as tube **4**, provides additional fuel storage capacity and forms a portion of the integrated fuel tank. The integrated fuel tank may thus be understood as the space in which fuel may be stored regardless of what other purpose or purposes the component holding the fuel may serve. In an embodiment, the lower frame tube may have a port or connection configured to receive a fuel line connecting the lower frame tube carrying the fuel to the internal combustion engine. Alternatively, the lower frame tube may have a port configured to directly supply fuel from the tube to the engine without the use of a separate fuel line further reducing the number of components in the vehicle assembly.

[0031] In other embodiments, the fuel tank **2** may have a port or connection configured to receive a fuel line, and the fuel line may extend from the fuel tank along at least a portion of the frame to the engine. A fuel line may be secured to one of the lower frame tubes as necessary. In yet another embodiment, the frame may provide protection for a fuel line extending through one of the lower frame tubes. In one example, a fuel line may exit the fuel tank disposed in the front portion of the frame and enter one of the lower frame tubes through an opening near the front portion of the frame. The fuel line may extend through the lower frame tube such that the tube protects the fuel line from damage as may be caused by road debris. The fuel line may exit the lower frame tube through an opening in the rear portion of the frame and extend to the internal combustion engine.

[0032] In some embodiments, the position of the fuel tank in the front portion of the frame reduces the airflow reaching the engine as the vehicle moves. In such embodiments, the engine may be provided with air inlets positioned to capture air flowing around or under the fuel tank so as to maintain a desired air flow to the engine for cooling. In yet other embodiments, the fuel tank may be provided with an aperture extending through the fuel tank in the direction of travel of the ridden

vehicle such that air may pass through the aperture and flow to the engine. As will be appreciated, the fuel tank may be configured in a variety of shapes to accommodate air flow requirements and provide an aerodynamically desirable configuration for the vehicle.

[0033] As previously noted, the internal combustion engine may be used to drive a generator to generate electricity for an electric motor, and/or charge the rechargeable battery.

[0034] FIG. 3 is a partial perspective view of a ridden vehicle, in particular a motorized scooter, with its front fairing and other coverings partially removed. Referring now to FIGS. 2 and 3, an embodiment of a motorized scooter is illustrated, which includes a rechargeable battery configured to be recharged by an internal combustion engine to power a generator adapted to power an electric motor electrically connected to the rechargeable battery and configured to provide a drive for the ridden vehicle by powering at least the rear wheel of the scooter. As shown, the motorized scooter vehicle 10 includes a seating area 12, a storage area 13 under the seating area, a footboard 14, and a front fairing 15. The rechargeable battery 18 is disposed underneath footboard 14 between lower frame rails 16, 17. The rechargeable battery 18 may be a lithium-ion battery, however, other battery chemistries may also be used. Operation of the rechargeable battery and electric motor may be managed by an electronic controller 19. In one configuration, the electronic controller 19 may be positioned centrally behind the rider's leg position to avoid interfering with the rider during operation of the ridden vehicle. The electric motor 20 is secured to the rear portion of the frame. As illustrated, the electric motor 20 may be bolted to a vertical section of the frame, and an internal combustion engine 21 and generator 22 or alternator may also be secured to the frame above the electric motor. The position and orientation of the electric motor and internal combustion engine may be selected to balance the weight distribution on the vehicle and to conform to the desired dimensions of the assembled vehicle. The ridden vehicle also includes a fuel tank 23 to store fuel for the internal combustion engine. The fuel tank 23 may be supported or integrated into the front portion of the frame beneath the steering head and behind front fairing 15 as previously discussed. The fuel tank also includes a filler tube 24 which extends through the front fairing 15 communicating with the fuel tank for refueling the fuel tank without displacing the vehicle's rider. In some embodiments, as shown, the filler tube communicating with the fuel tank may be disposed in the vehicle to provide an entrance to the fuel tank in front of the steering head.

[0035] During operation, the ridden vehicle being a motorized scooter, illustrated in FIGS. 2 and 3, is operated by the electric motor 20 drawing power from the battery 18. In one embodiment, the charge level of the battery 18 is monitored. When the charge level of the battery falls below a predetermined charge level, such as 25%, 50% or 60% of full charge, the electronic controller activates the internal combustion engine 21 to power a generator recharging the battery. In other embodiments, the electronic controller may activate the internal combustion engine based upon a monitored condition of the rechargeable battery, such as the rate of discharge or load applied to the rechargeable battery. In this manner, the internal combustion engine may be activated and deactivated to maintain the desired charge level in the battery or to provide additional power under high load conditions, such as rapid acceleration or traveling up a steep hill. The internal combustion engine 21 powers a generator to recharge the battery 18

and as such may be operated at a substantially constant speed to optimize the generator output with minimum fuel consumption. In an embodiment, a substantially constant speed of operation is understood by those of skill in the art as distinguished from a variable speed operation, and entails control of the engine to a determined operating condition. In some embodiments, the internal combustion engine is operated at a power setting that yields the engine's minimum brake specific fuel consumption. For recharging the rechargeable battery, a smaller internal combustion engine may be utilized on the ridden vehicle, such as an internal combustion engine having a displacement of no more than 500 cubic centimeters, or between 50 and 190 cubic centimeters, or in excess of 500 cubic centimeters, as desired. In one embodiment, a 35 cubic centimeter displacement internal combustion engine provides adequate electrical power generation for a motorized scooter application. Once the battery 18 is recharged to a predetermined charge level, such as 95%, 98% or 100% of full charge, the internal combustion engine is shut down and the vehicle operates solely on the electric motor and battery as previously discussed. The vehicle rider may select the power output of the electric motor using a throttle to control the vehicle's speed.

[0036] FIG. 4 is a side view of an embodiment of a ridden vehicle being a motorcycle 40, having a hybrid drive system. The motorcycle 40 includes a hybrid drive system comprising an electric motor assembly 41, an internal combustion engine 42, generator 43, and a rechargeable battery 44. The internal combustion engine 42 may be used as a motor to power a generator 43 adapted to generate electricity for the electric motor 41 and/or rechargeable battery 44. The internal combustion engine 42, electric motor assembly 41, and rechargeable battery 44 may form an integrated drive system for a hybrid motorcycle 40, configured to be installed and removed as a single unit. In other embodiments, the internal combustion engine 42, generator, electric motor assembly 41 and the rechargeable battery 44 may be separate components, configured to be installed and removed separately.

[0037] In the embodiment of FIG. 4, the motorcycle has at least one seat 48, attached to a frame 49. Also attached to the frame 49 is an internal combustion engine 42, generator 43, an electric motor assembly 41 and a rechargeable battery 44. The motorcycle 40 also has two wheels, 46 and 47. The axle 50 of the rear wheel 46 comprises a sprocket 51, fixedly engaged to the axle 50. The output shaft 52 of the motor assembly 41 also has a sprocket 53 fixedly engaged to the motor assembly output shaft 52. A drive chain or belt 54 is disposed between the wheel axle sprocket 51 and the motor assembly output shaft sprocket 53, such that the chain or belt 54 operatively engages the two sprockets 51 and 53. The chain or belt 54 transmits the power produced from the motor assembly 41, to the rear wheel 46. In some embodiments, a chain tensioner 55 (or belt tensioner) may be disposed on the motorcycle 40 to impart a tension on the chain, or belt, 54. The tension on the chain, or belt, 54 ensures that the chain or belt maintains sufficient traction with the two sprockets 51, 53 as the rear wheel 46 moves up and down with the changing ground conditions. The movement of the rear wheel 46 changing the distance between the motor sprocket 53 and the rear axle sprocket 51. In other embodiments, the swing arm 56, which supports the rear wheel 46 and the suspension, may be pivotably attached to the motorcycle 40 such that the pivot point of the swing arm 56 is aligned with the output shaft of the electric motor assembly 41. In such embodiments, as the

rear wheel **46** moves up and down with changing ground conditions the distance between the rear axle sprocket **51** and the motor assembly sprocket **53** remains substantially constant, therefore, forgoing the requirement for a chain, or belt, tensioner.

[0038] The internal combustion engine **42**, generator **43**, electric motor **41** and the rechargeable battery **44** may be arranged in parallel electrical connection with each other. In this manner electricity may be supplied to the electric motor **41** by either the rechargeable battery **44** and/or the internal combustion engine **42**. The internal combustion engine **42** may be configured to an optimal operating condition to drive the generator **43** to provide electricity to the rechargeable battery **44** to charge the rechargeable battery **44**.

[0039] To maintain a motorcycle **40** at motorway speeds requires less power from the motor assembly **41** than when the motorcycle **40** is accelerating or travelling at very high speeds. The internal combustion engine **42** and generator **43** may be configured to provide sufficient electrical power to the electric motor assembly **41**, and/or battery **44**, to maintain the motorcycle at highway speeds while also providing electricity to the rechargeable battery **44** to recharge the rechargeable battery **44**. When the rider wishes to accelerate or travel at high speeds the rechargeable battery **44** may be adapted to provide the required increase in electrical charge to the electric motor assembly **41** necessary to propel the motorcycle **40** at higher speeds or accelerate the motorcycle. When the rider decelerates or travels at certain speeds the internal combustion engine **42** and the generator **43** may be configured to provide sufficient electrical power to the motor **41**, while also providing sufficient electrical charge to simultaneously recharge the rechargeable battery **44**. In some embodiments, the internal combustion engine **42** and generator **43** may provide electrical charge to the electric motor **41** through the rechargeable battery **44**. In other embodiments, the electrical charge may be provided directly to the electric motor **41**.

[0040] The rechargeable battery **44** may be disposed within the frame **49** of the motorcycle **40**. Additionally, or in the alternative, embodiments the electric motor assembly **41**, the internal combustion engine **42**, and generator **43**, may be stacked below the seat of the motorcycle **40**. In some embodiments, the internal combustion engine is positioned above the electric motor. To reduce the center of gravity the rechargeable battery **44** may be positioned at a lower point within the frame **49** of the motorcycle **40**. The battery **44** may be a lithium-ion battery; however other battery chemistries may be used in the alternative. Operation of the rechargeable battery **44** may be controlled by an electronic controller **45**. The electronic controller **45** may be the motorcycle's central computer, or it may be a stand-alone system, specifically configured to control the operation of the rechargeable battery **44**. The electronic controller **45** may also be configured to control the operation of the internal combustion engine **42** and the electric motor assembly **41**.

[0041] The presently disclosed ridden vehicle in form of a motorcycle may be capable of having electric motors **41** producing in excess of 200 horsepower while having improved fuel efficiency due to the internal combustion engine **42** optimized to drive a generator **43** to generate electricity to charge the rechargeable battery **44**. In some embodiments, the internal combustion engine may be configured to operate at a desired single speed, or a desired set of speeds, for

maximum efficiency. In other embodiments, the electric motor assembly **41** may be configured to produce in excess of 400 horse power.

[0042] The motorcycle **40** may also comprise a fuel tank. The fuel tank may be supported by or disposed within the frame **49** such that the frame **49** of the motorcycle **40** houses the fuel for the internal combustion engine **42**. A fuel line may connect the frame **49** housing the fuel to the internal combustion engine **42**, or the frame, housing the fuel, may be configured to be directly connected to the fuel intake valve of the internal combustion engine **42**. In some embodiments, the motorcycle **40** may comprise a fuel tank located on top of the frame **49** forward of the seat **48** as with traditional motorcycles. In other embodiments, the fuel tank may be disposed within the confines of the frame **49** to provide fuel to the internal combustion engine **42**. The motorcycle **40** having a hybrid drive system, comprising an electric motor assembly **41**, an internal combustion engine **42**, a generator **43**, and a rechargeable battery **44**, would typically comprise an internal combustion engine **42** of smaller size than a conventional motorcycle powered solely by an internal combustion engine. A smaller engine requires less fuel, therefore, the presently disclosed hybrid motorcycle **40** typically comprises a fuel tank having a reduced capacity compared to conventional motorcycles. In other embodiments, the fuel tank may provide torsional support for the frame **49**.

[0043] In some embodiments, during operation, the motorcycle **40** illustrated in FIG. 4 is operated by the electric motor **41** drawing electricity from the rechargeable battery **44**. In embodiments, the charge level of the battery **44** is monitored. When the charge level of the battery falls below a predetermined charge level, for example 25%, 50%, or 75% of full charge, or any desired level of charge, the electronic controller **45** activates the internal combustion engine **42** to drive the generator **43** adapted to provide electrical charge to recharge the rechargeable battery **44**. In other embodiments, the electronic controller **45** may activate the internal combustion engine based upon a monitored condition of the rechargeable battery **44**, such as the rate of discharge or load applied to the rechargeable battery **44**. In this manner, the control of the internal combustion engine may be activated and deactivated to maintain the desired charge level in the battery **44** or to provide additional power under high load conditions, such as rapid acceleration or travelling up a steep hill or at high speed.

[0044] The internal combustion engine **42** and generator **43** are operated to recharge the battery **44**, and as such, may be operated at a substantially constant speed to optimize the generated output with minimum fuel consumption. A substantially constant speed operation may be distinguished from a variable speed operation, and entails control of the engine to a determined operating condition. In some embodiments, the internal combustion engine is operated at a power setting that yields the engine's minimum brake specific fuel consumption. Once the battery **44** is charged to a predetermined level, for example, 95%, 98%, or 100% of full charge, the internal combustion engine **42** may be shut down and the ridden vehicle may operate solely with the battery **44** providing all of the electric power to the electric motor assembly **41**.

[0045] In other embodiments, the internal combustion engine **42** may be controlled to maintain operation of the engine in an efficiency range for the engine unless additional electric power is desired to operate the motorcycle. In such embodiments, if additional electric power is desired to operate the motorcycle the internal combustion engine **42** may be

operated to produce more electrical energy, such as by increasing the rotational speed of the internal combustion engine 42 to provide increased power to drive the generator 43. Under certain conditions, as desired, electrical power may be provided to the electric motor from the internal combustion engine 42 and generator 43, as well as the rechargeable battery 44. During operation the rider may select the power output of the electric motor assembly 41 using a throttle to control the vehicle's speed and acceleration.

[0046] In some embodiments, the ridden vehicle being a motorcycle, as illustrated, may be capable of being powered solely by the electricity produced by the internal combustion engine 42 and generator 43. However, when the rechargeable battery is depleted, the internal combustion engine may function as a range extender for the motorcycle, allowing, for operation of the motorcycle, if at somewhat reduced performance, thus allowing the rider to travel home or to a maintenance control if the battery should malfunction or run out of charge.

[0047] Other methods of charging the vehicle battery, of any of the aforementioned vehicles, may also be employed. The vehicle may have an electrical connector configured to recharge the battery from an external electrical source, such as a generator or utility power. The vehicle may include an AC/DC converter allowing the vehicle to be charged from a standard alternating current source; however, in other embodiments, an AC/DC converter may be required to provide the necessary charging voltage to the battery.

[0048] In other embodiments, the decision to start or stop the internal combustion engine to recharge the battery may be based upon a measured rate of change of the charge level of the battery or on other operating parameters of the battery. The internal combustion engine may also be activated by the rider to recharge the battery even if the predetermined charge condition has not been reached. In some embodiments, the internal combustion engine 42 and generator 43 will recharge the battery 44 during operation of the ridden vehicle provided that the generator output exceeds the load on the battery. If the generator output does not exceed the load on the battery the rate of depletion of the battery will be reduced and the battery recharged when the load is reduced, such as when the ridden vehicle stops or when the throttle setting is reduced. As a result, the electric motor may at times be powered solely by the battery, solely by the internal combustion engine and generator, or by both the battery and generator depending upon the operating conditions of the vehicle. The terms "generator" and "alternator" are used interchangeably herein (however, it is recognized that one term or the other may be more appropriate depending on the application).

[0049] This written description uses examples to disclose the invention, including the best mode, and also to enable one of ordinary skill in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to one of ordinary skill in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

What is claimed is:

1. A motorized ridden vehicle comprising:
at least one seat and at least two wheels;

an electric motor adapted to drive at least one of the wheels of the ridden vehicle;
at least one rechargeable battery electrically connected to the electric motor and adapted to power the electric motor;
a generator adapted to charge the rechargeable battery;
an internal combustion engine adapted to drive the generator; and
an electronic controller adapted to control operation of the internal combustion engine based upon monitoring a condition of the rechargeable battery.

2. The motorized ridden vehicle as claimed in claim 1 where the internal combustion engine is controlled to maintain operation of the engine in an efficiency range for the engine.

3. The motorized ridden vehicle as claimed in claim 1 further comprising:

an electronic controller adapted to start the internal combustion engine based upon a charge level of the rechargeable battery.

4. The motorized ridden vehicle as claimed in claim 1 further comprising:

an electronic controller adapted to start the internal combustion engine based upon a rate of discharge of the rechargeable battery.

5. The motorized ridden vehicle as claimed in claim 1 where the electric motor and the internal combustion engine are stacked below the seat of the motorcycle.

6. The motorized ridden vehicle as claimed in claim 5 where the internal combustion engine is positioned above the electric motor.

7. The motorized ridden vehicle as claimed in claim 5 where the rechargeable battery is positioned below the seat of the motorcycle.

8. The motorized ridden vehicle as claimed in claim 1, further comprising a fuel tank integrated with the frame and adapted to store fuel for operation of the engine.

9. The motorized ridden vehicle as claimed in claim 1, where the frame further comprises at least one tubular portion housing a fuel line extending from the fuel tank through the at least one tubular portion to the engine.

10. The motorized ridden vehicle as claimed in claim 8 where the fuel tank is integrated into the frame such that the frame houses the fuel for the internal combustion engine.

11. The motorized ridden vehicle as claimed in claim 8, where the fuel storage capacity of the integrated fuel tank is between 1 and 15 liters.

12. The motorized ridden vehicle as claimed in claim 1, where the electric motor is capable of producing in excess of 200 horse power.

13. The motorized ridden vehicle as claimed in claim 1, where the internal combustion engine has a displacement in excess of 300 cubic centimeters.

14. A motorcycle comprising:

a seat adapted to support at least one rider;

a frame adapted to support the seat and the engine during operation of the motorcycle, the frame comprising a front frame portion having a steering head, a rear frame portion adapted to support the seat and the engine, and a connecting frame portion connecting the front frame portion and the rear frame portion and to support a foot rest for a rider;

an electric motor positioned below the seat and adapted to drive at least one wheel of the motorcycle;

at least one rechargeable battery electrically connected to the electric motor and adapted to power to the electric motor;

a generator adapted to charge the rechargeable batteries;

an internal combustion engine adapted to drive the generator; and,

a fuel tank integrated with the frame and adapted to store fuel for operation of the generator.

15. The motorcycle as claimed in claim **14** comprising in addition an electronic controller adapted to control operation of the internal combustion engine based upon monitoring a condition of the rechargeable battery.

16. The motorcycle as claimed in claim **14** the generator is controlled to maintain operation of the internal combustion engine in an efficiency range for the internal combustion engine.

17. The motorcycle as claimed in claim **14** where the electric motor and the internal combustion engine are stacked below the seat of the motorcycle.

18. The motorcycle as claimed in claim **17** where the internal combustion engine is positioned above the electric motor.

19. The motorcycle as claimed in claim **14** where the rechargeable battery is positioned below the seat of the motorcycle.

20. The motorcycle as claimed in claim **14**, where the fuel storage capacity of the integrated fuel tank is between 2 and 15 liters.

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