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LeBlanc

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(54) ENDLESS TRACK CONVEYANCE MACHINES HAVING A TORQUE ASSIST SYSTEM FOR ENHANCING PERFORMANCE AND A BATTERY TEMPERATURE ASSIST

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B60L 7/10 (2006.01)
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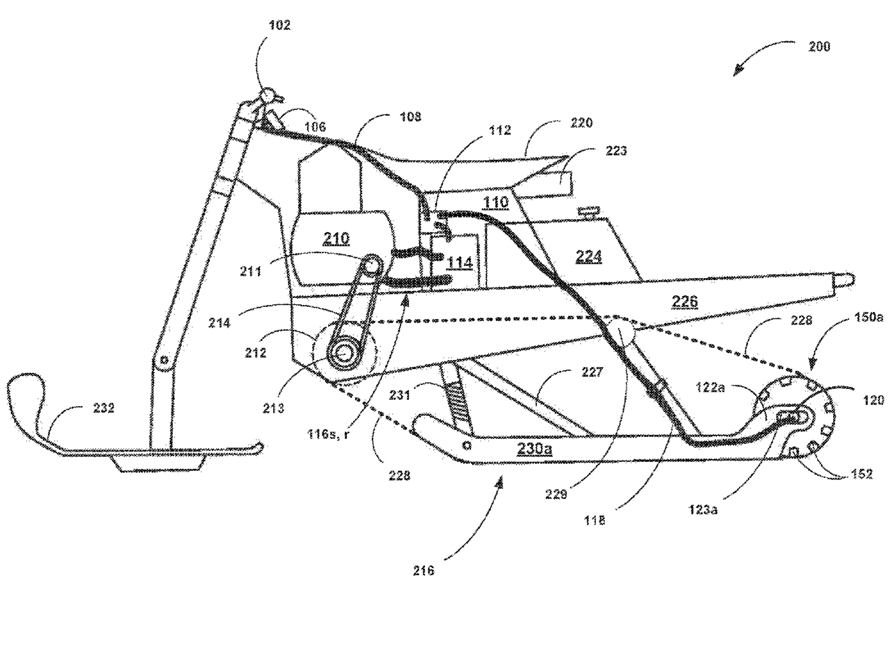
(57) **ABSTRACT**

Conveyance vehicles such as snow bikes and snowmobiles having an endless track system driven by a combustion engine are enhanced in performance with a torque assist system. The torque assist system includes an electric motor that is coupled to drive the track in parallel with the original internal combustion engine through either its own track drive, or through the drive system of the engine. The motor can be a spindle drive motor or hub motor. Torque assist is generated through a torque assist throttle input coupled to a motor controller. A battery temperature assist system diverts heated cooling fluid from the engine cooling system to heat the battery through its own heat exchanger. The controller is coupled to a processing device such as a smart phone that executes apps configured to provide parametric data to the controller and to receive parametric data from the controller through a user interface.

18 Claims, 11 Drawing Sheets



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H01M 10/625	(2014.01)
H01M 10/63	(2014.01)
H01M 10/6556	(2014.01)
H01M 10/6563	(2014.01)
H01M 10/6568	(2014.01)
H01M 10/663	(2014.01)

(52) **U.S. Cl.**

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CPC B62J 17/00; F01P 5/10; F01P 7/16; F01P 2007/146; F28F 27/02; H01M 10/46; H01M 10/625; H01M 10/63; H01M 10/6556; H01M 10/6563; H01M 10/6568; H01M 10/663; H01M 2220/20; H01M 10/617

See application file for complete search history.

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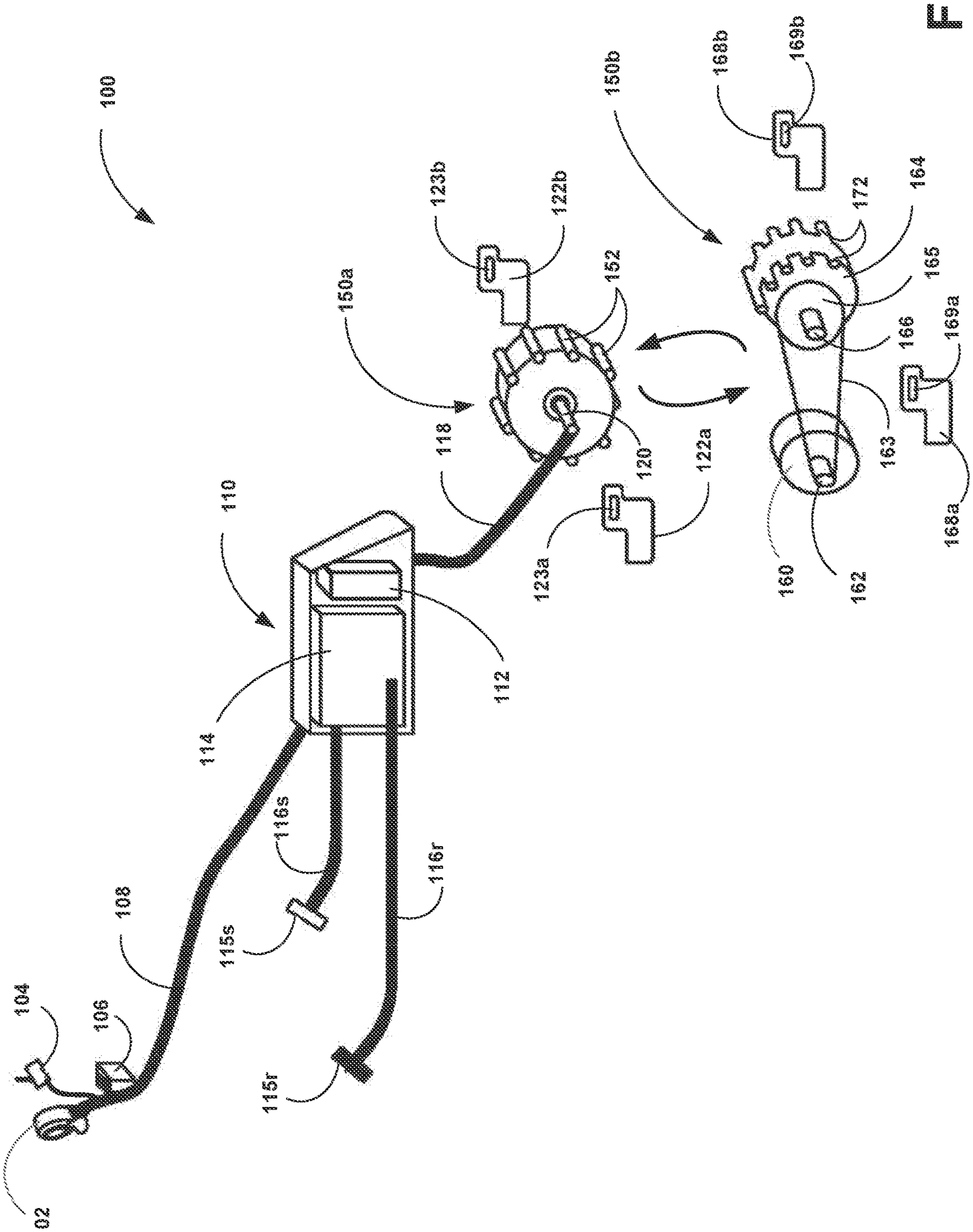
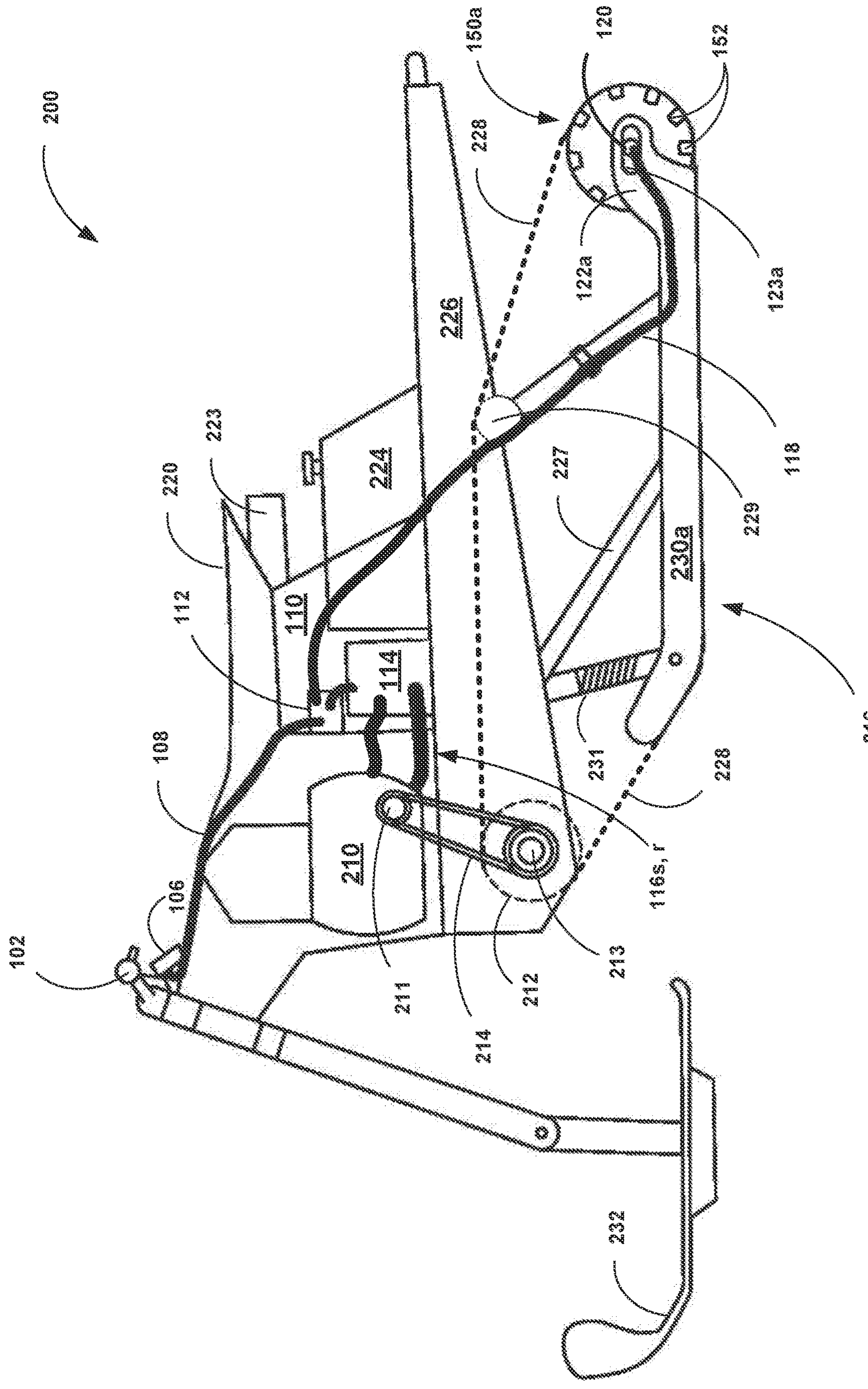

100
150b
168b
169b
123b
122b
150a
152
172
164
165
166
169a
163
168a
118
120
122a
123a
110
112
114
160
162
108
116s
116r
115s
115r
104
106
102

FIG. 1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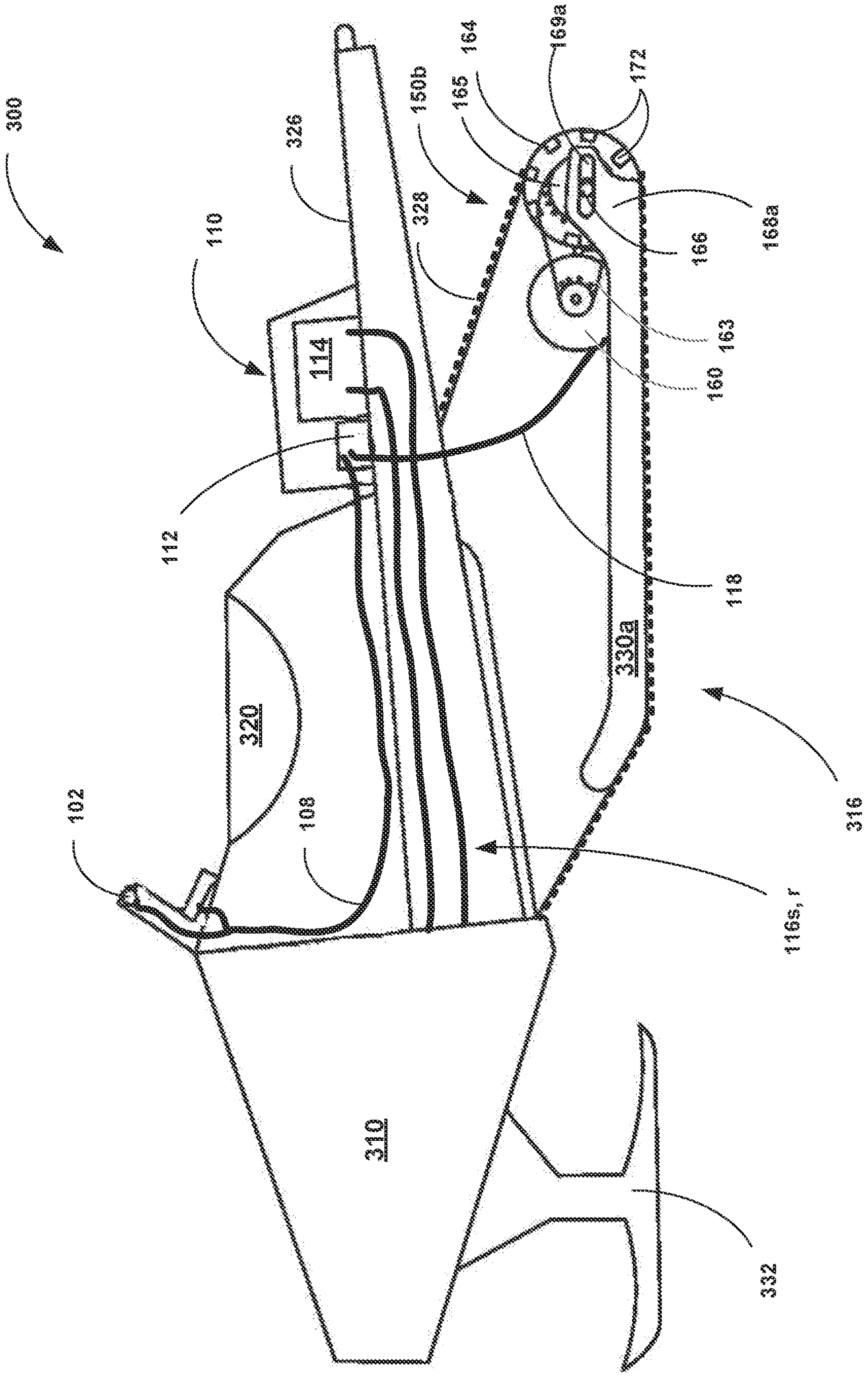
102
106
108
112
110
220
223
224
226
228
150a
120
152
122a
123a
118
229
227
230a
216
231
228
116s, r
210
211
214
212
213
232

FIG. 2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114
112
326
328
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172
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168a
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160
118
330a
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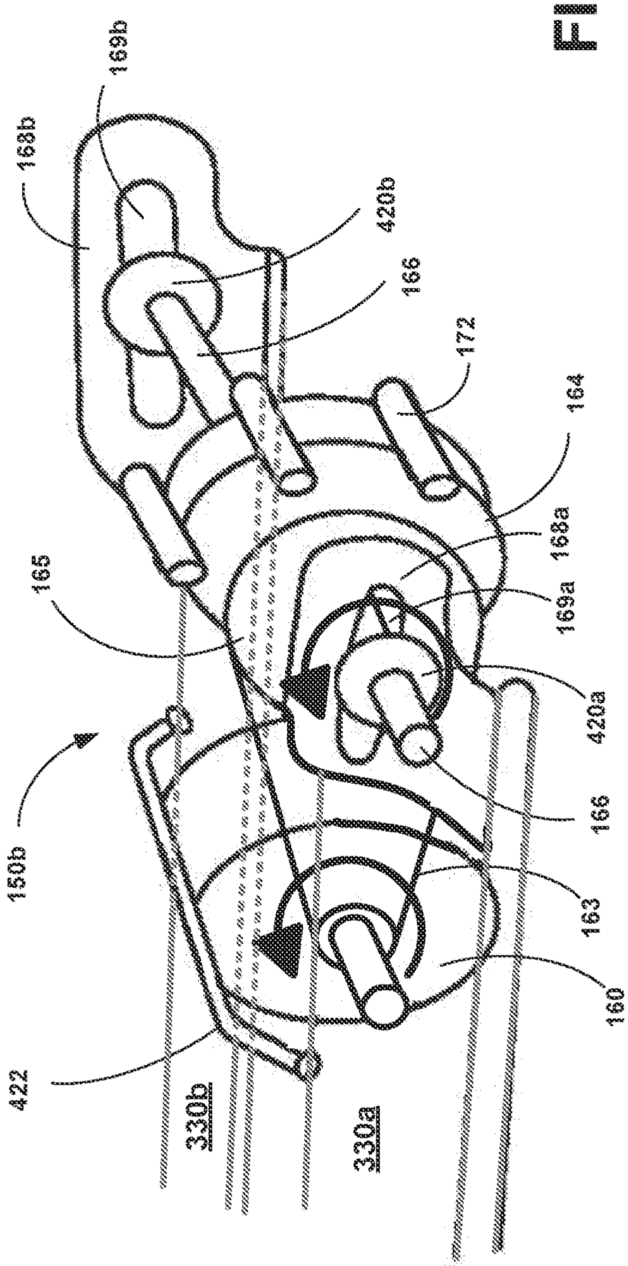
320
102
108
116s, r
310
332

FIG. 3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150b
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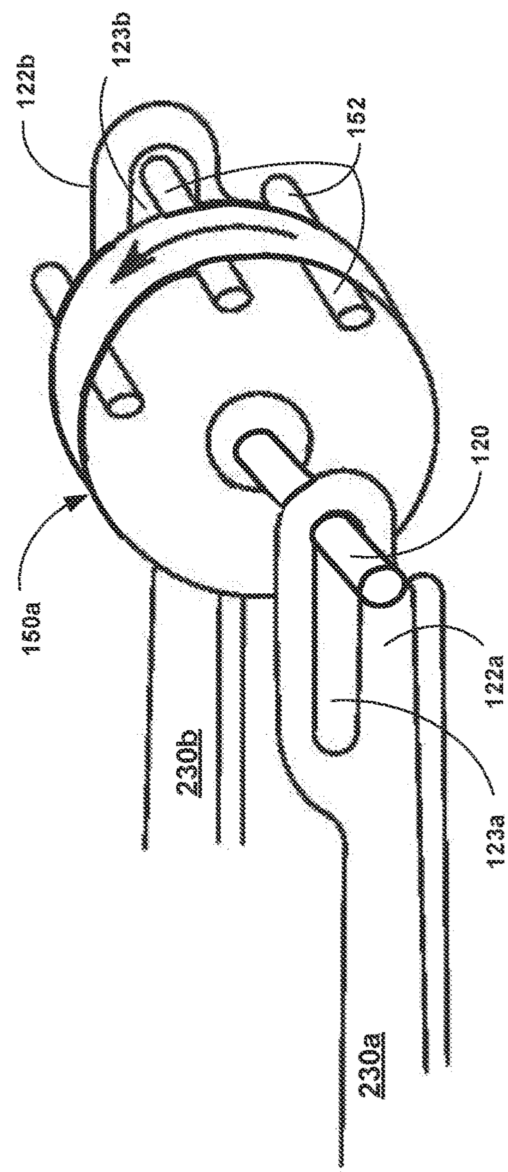
330b
330a

FIG. 4A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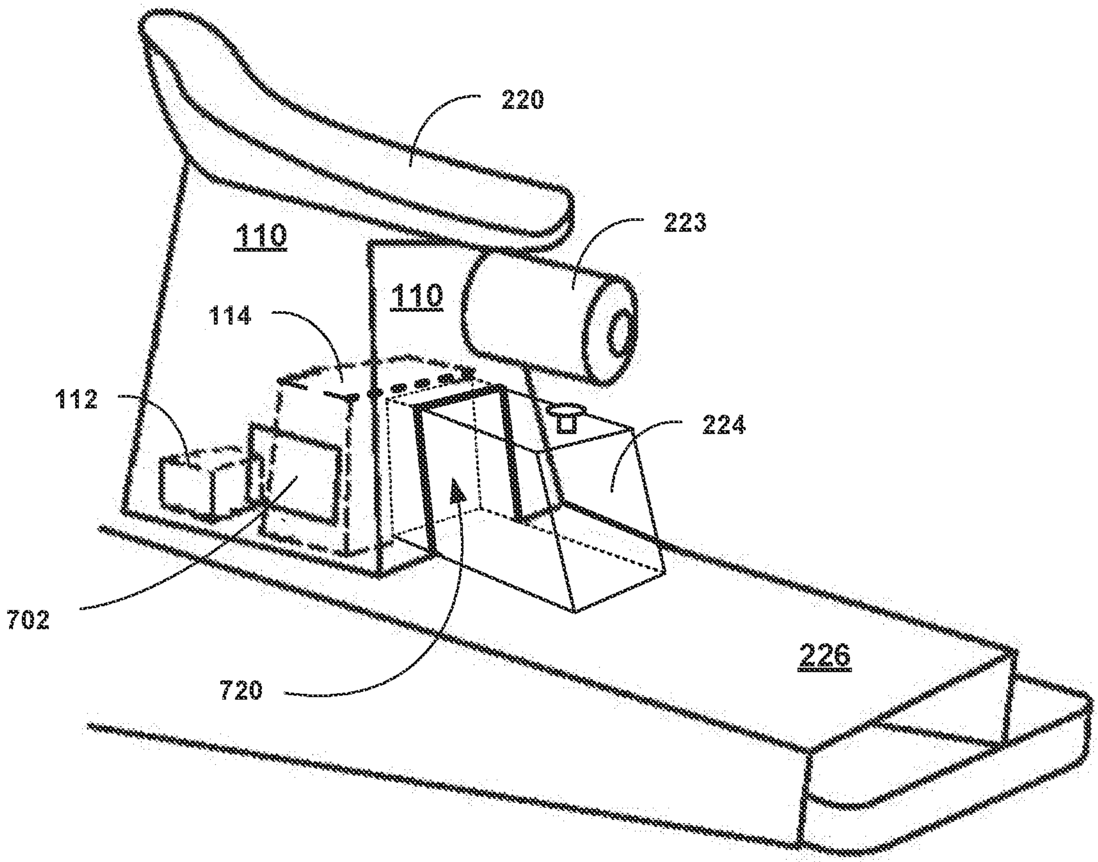
123b
152
120
150a
122a
123a
230b
230a

FIG. 4B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223
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114
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224
702
226
720

FIG. 5A

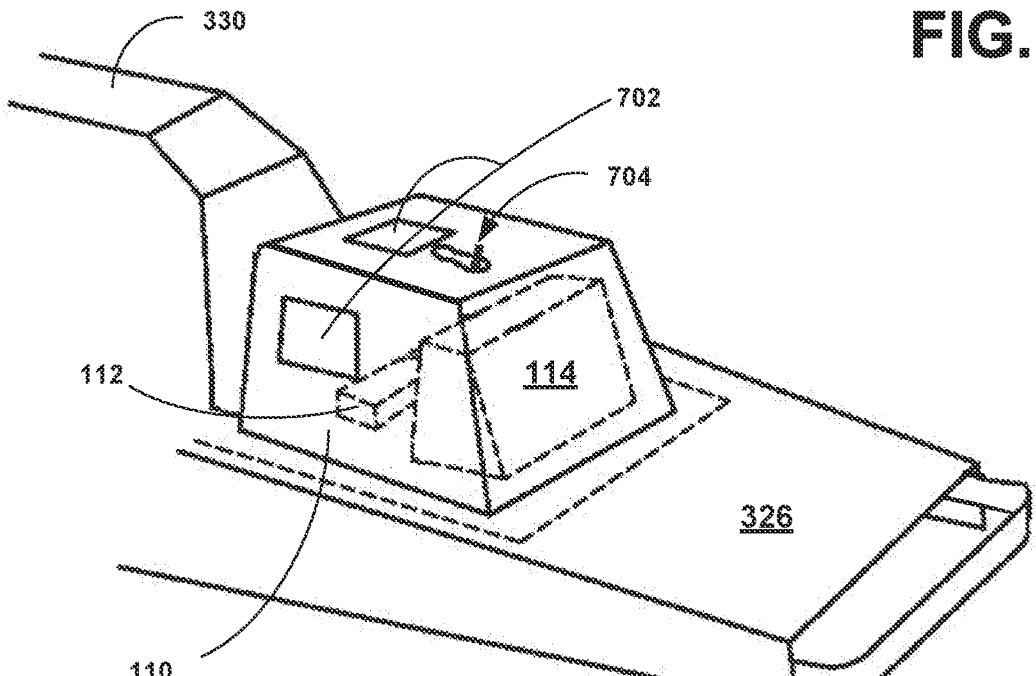
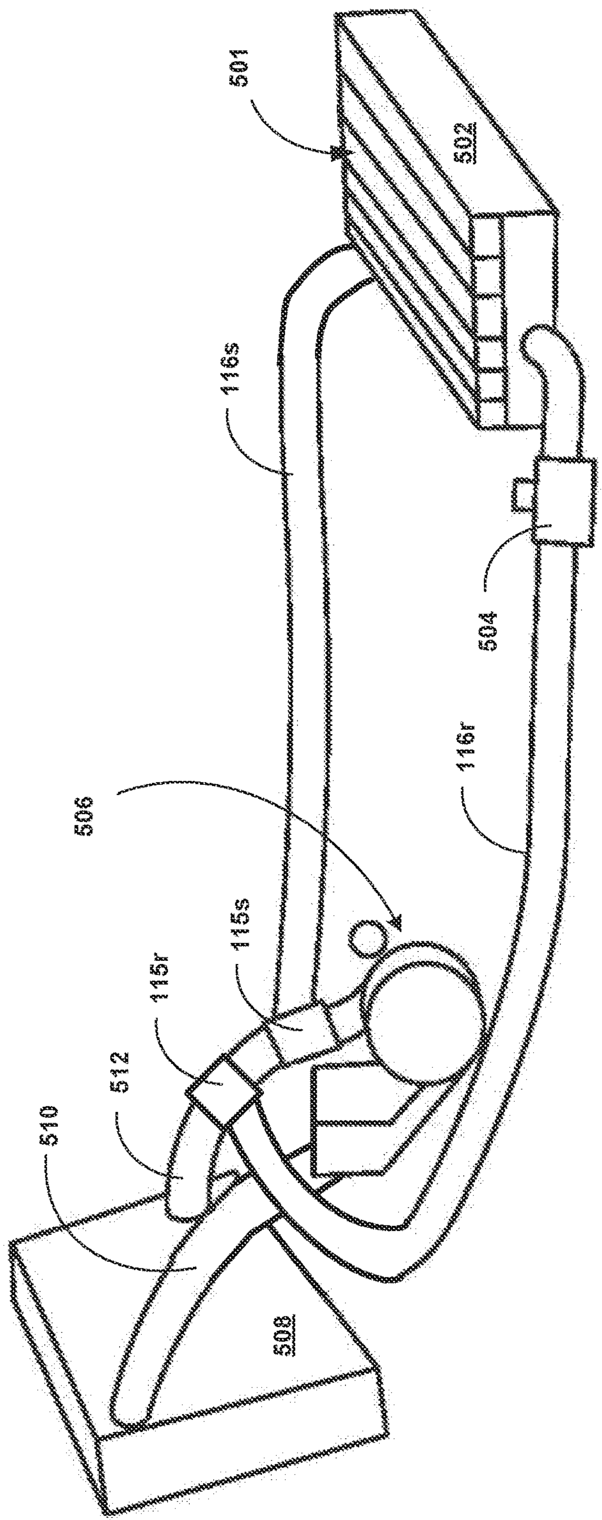

330
702
704
112
114
326
110

FIG. 5B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502
116s
504
116r
506
115s
115r
512
510
508

FIG. 6

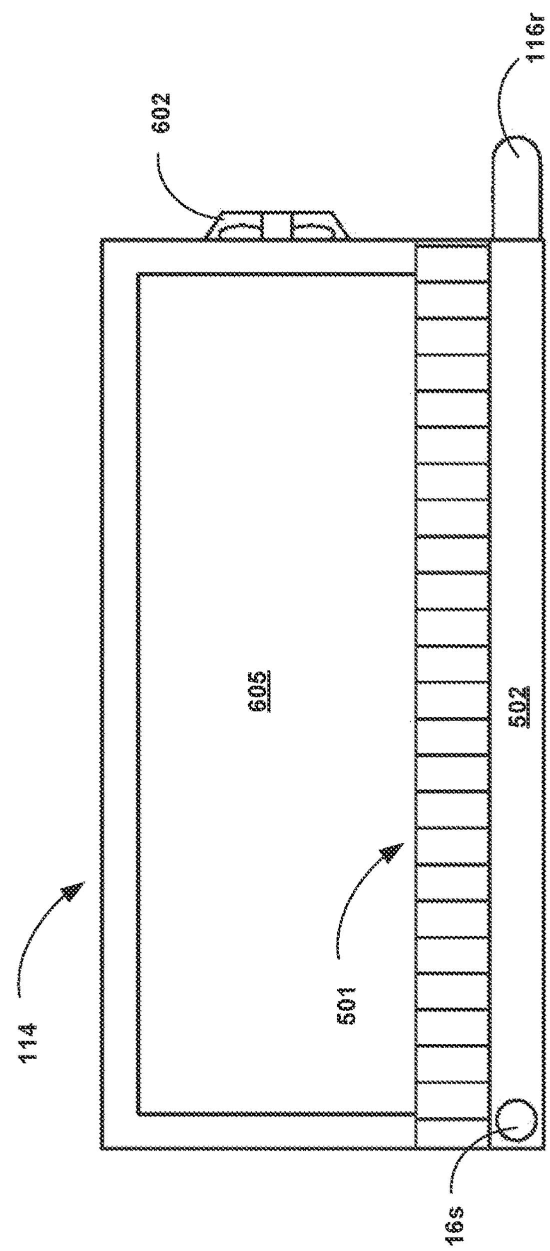

602
116r
605
502
501
114
116s

FIG. 7

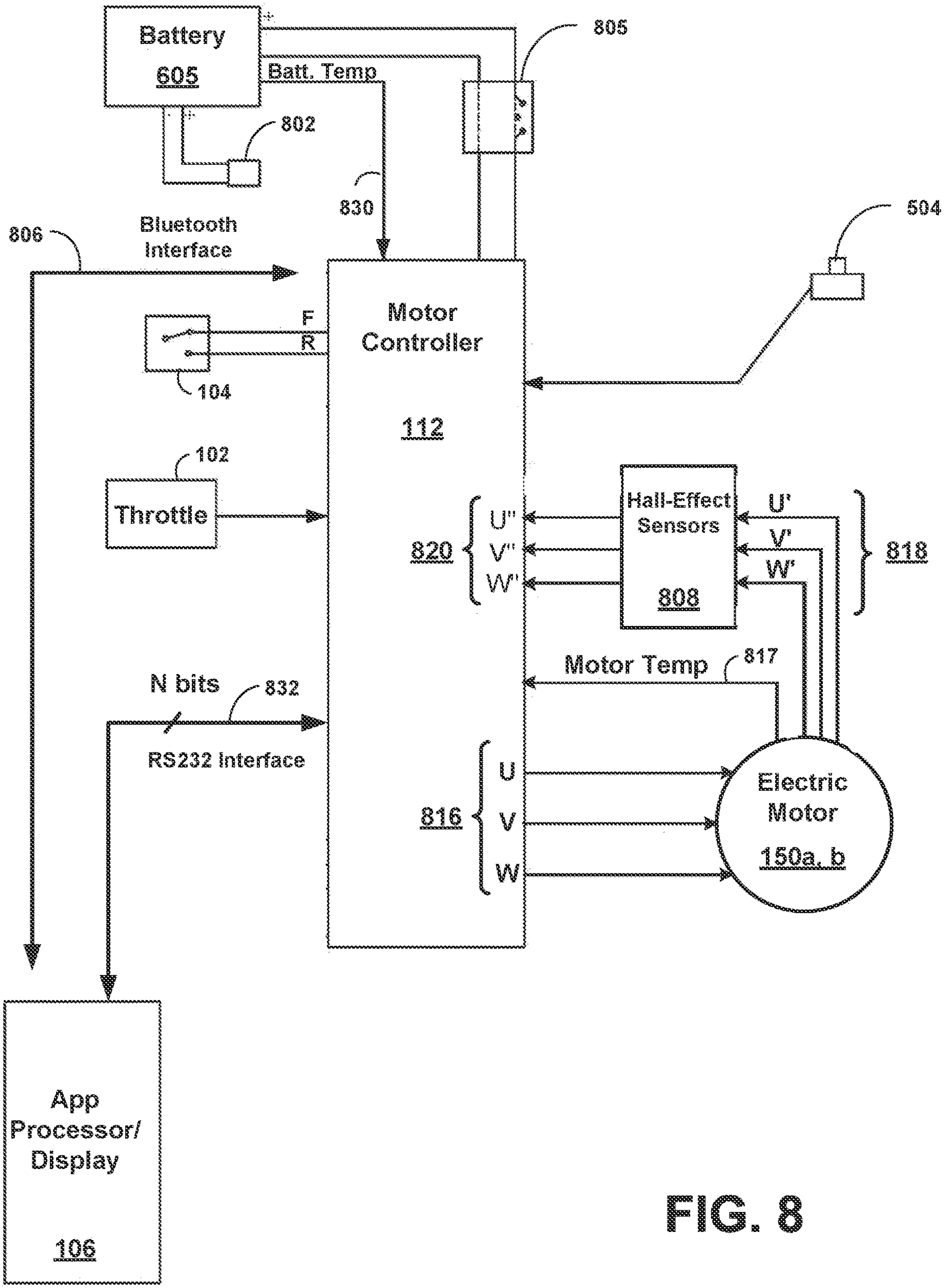
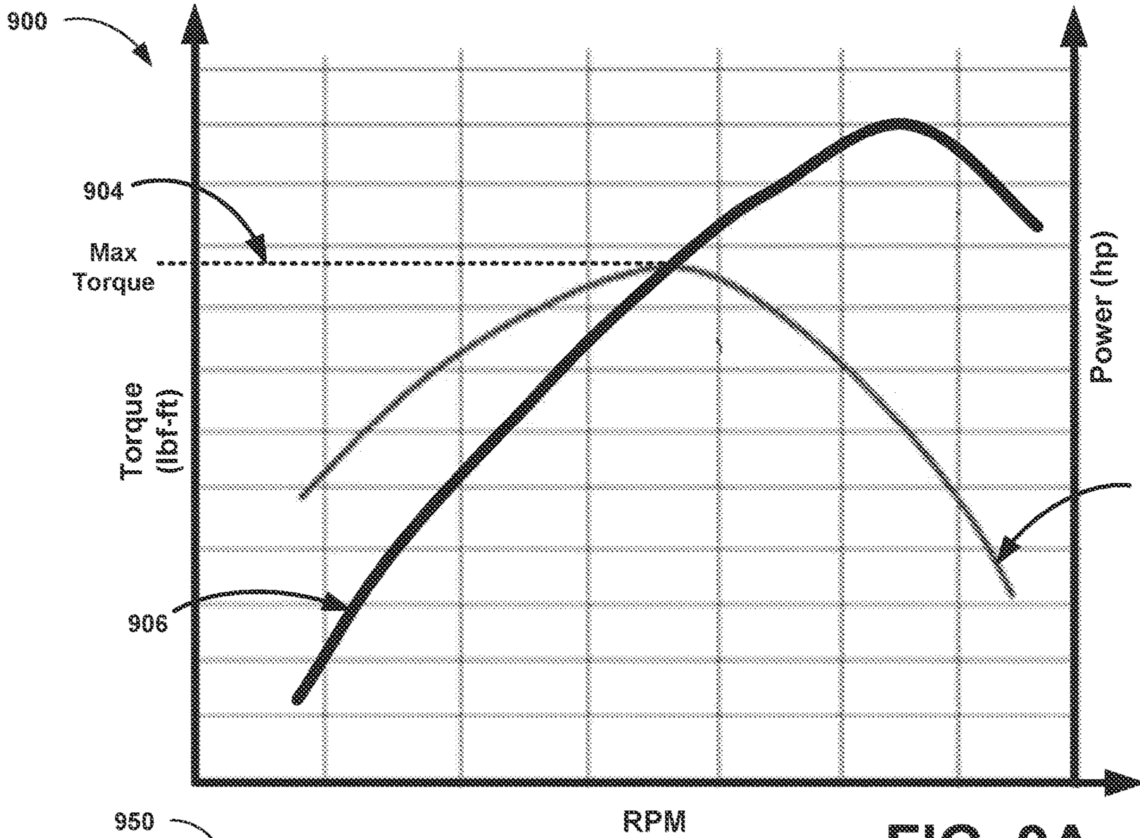

Battery
605
Batt. Temp
805
802
830
504
806
Bluetooth Interface
Motor Controller
112
F
R
104
102
Throttle
Hall-Effect Sensors
808
U''
V''
W''
820
U'
V'
W'
818
Motor Temp
817
N bits
832
RS232 Interface
U
V
W
816
Electric Motor
150a, b
App Processor/ Display
106

FIG. 8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904
Max
Torque
Torque
(lbf-ft)
Power (hp)
902
906
RPM

FIG. 9A

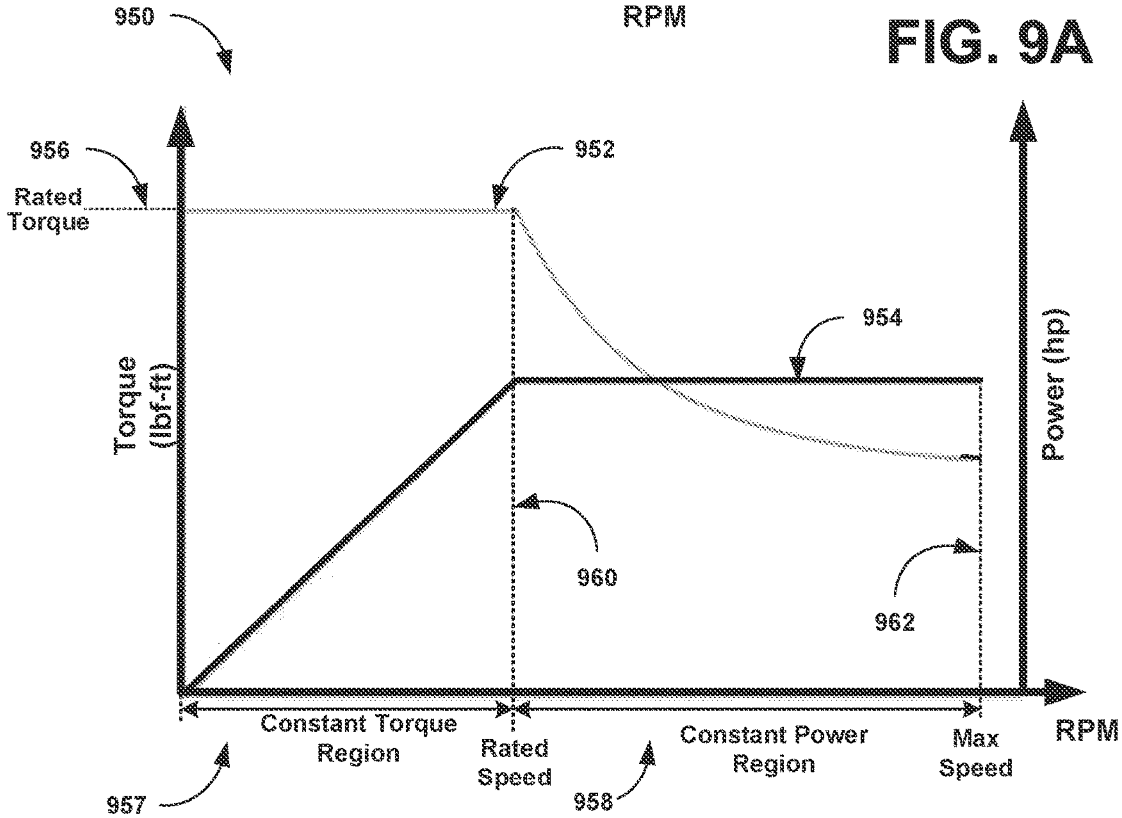

950
956
Rated
Torque
952
954
Torque
(lbf-ft)
Power (hp)
960
962
Constant Torque
Region
Rated
Speed
Constant Power
Region
Max
Speed
RPM
957
958

FIG. 9B

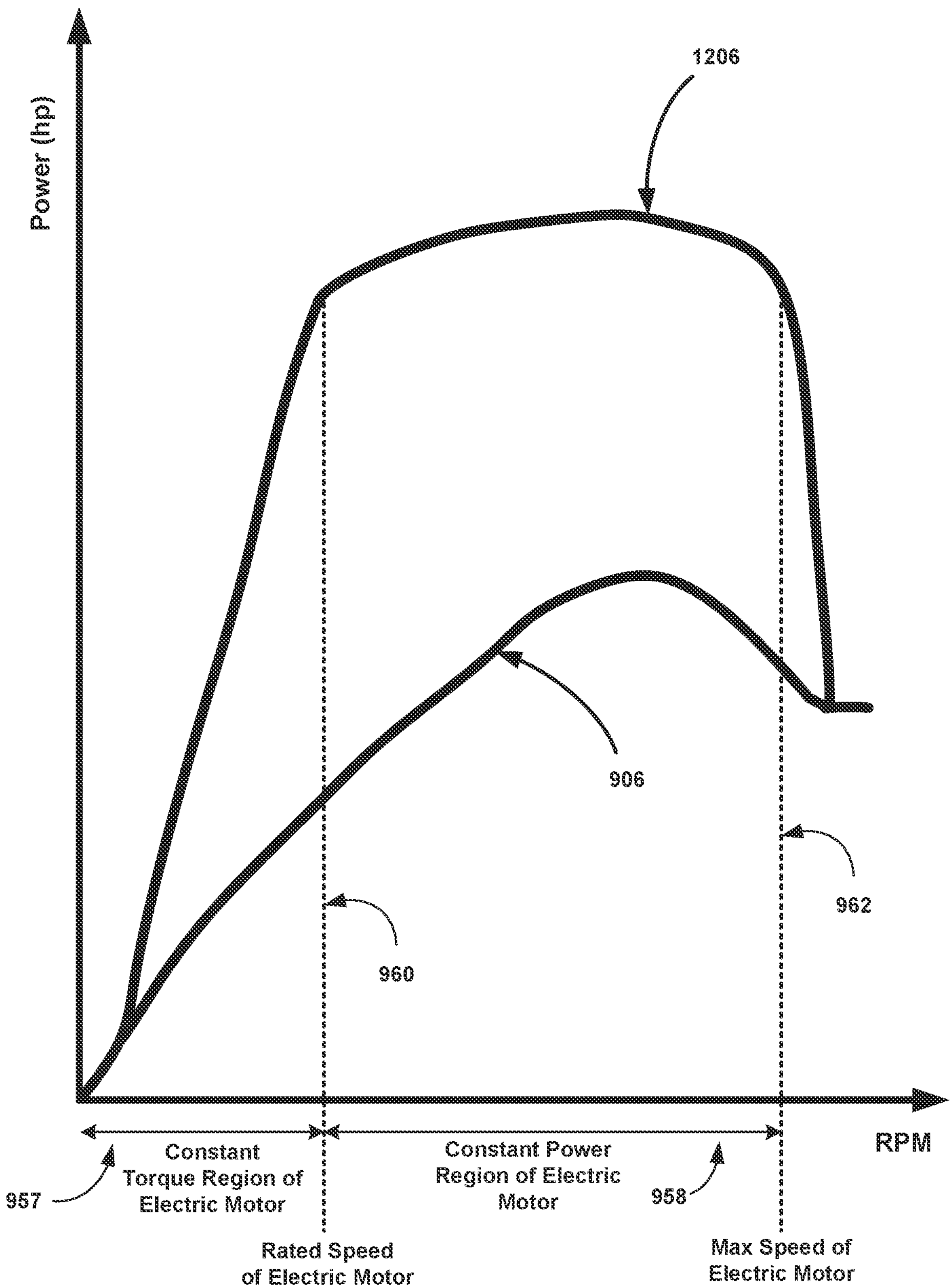
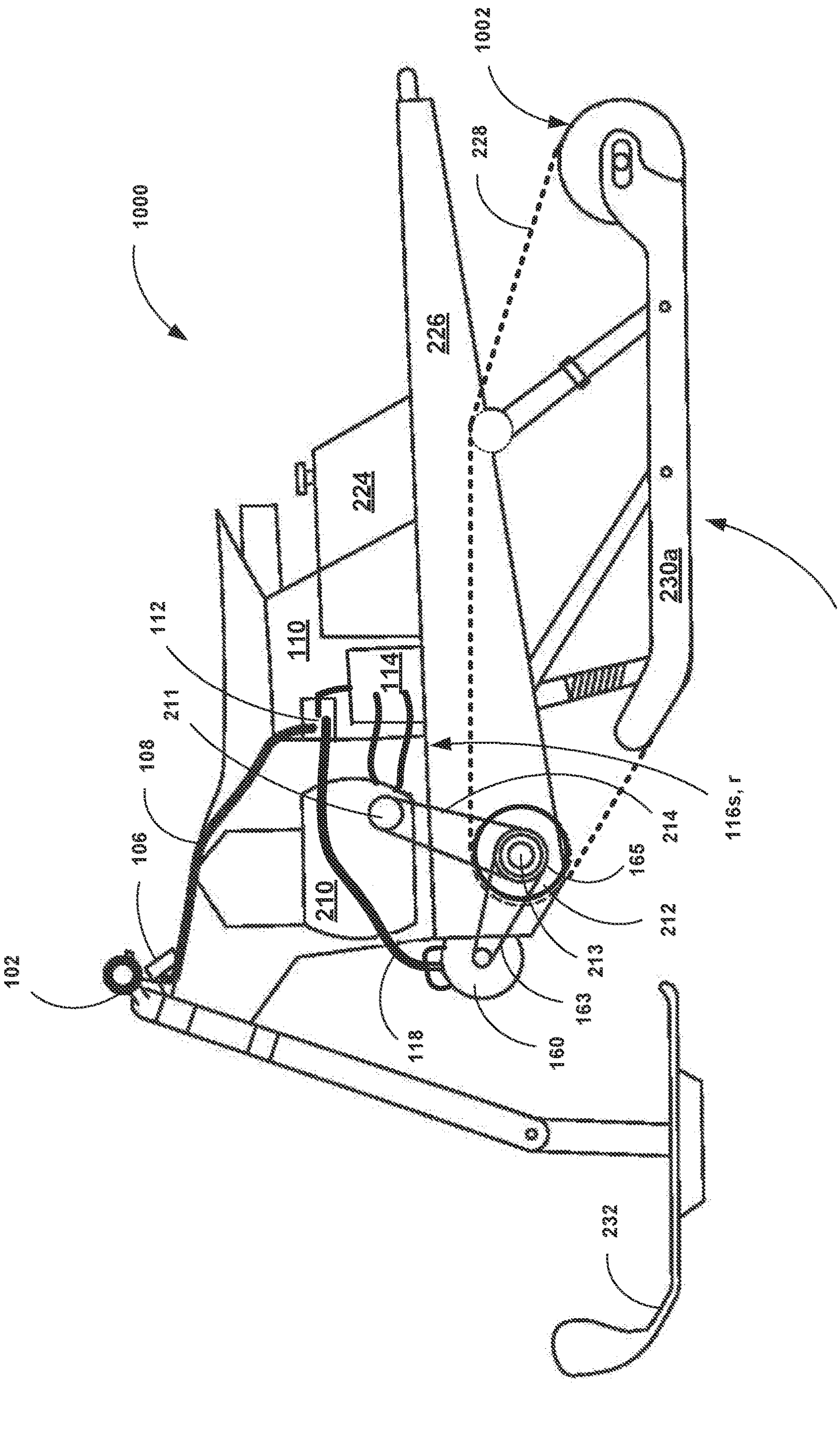

1206
Power (hp)
906
962
960
RPM
957
Constant Torque Region of Electric Motor
Constant Power Region of Electric Motor
958
Rated Speed of Electric Motor
Max Speed of Electric Motor

FIG. 9C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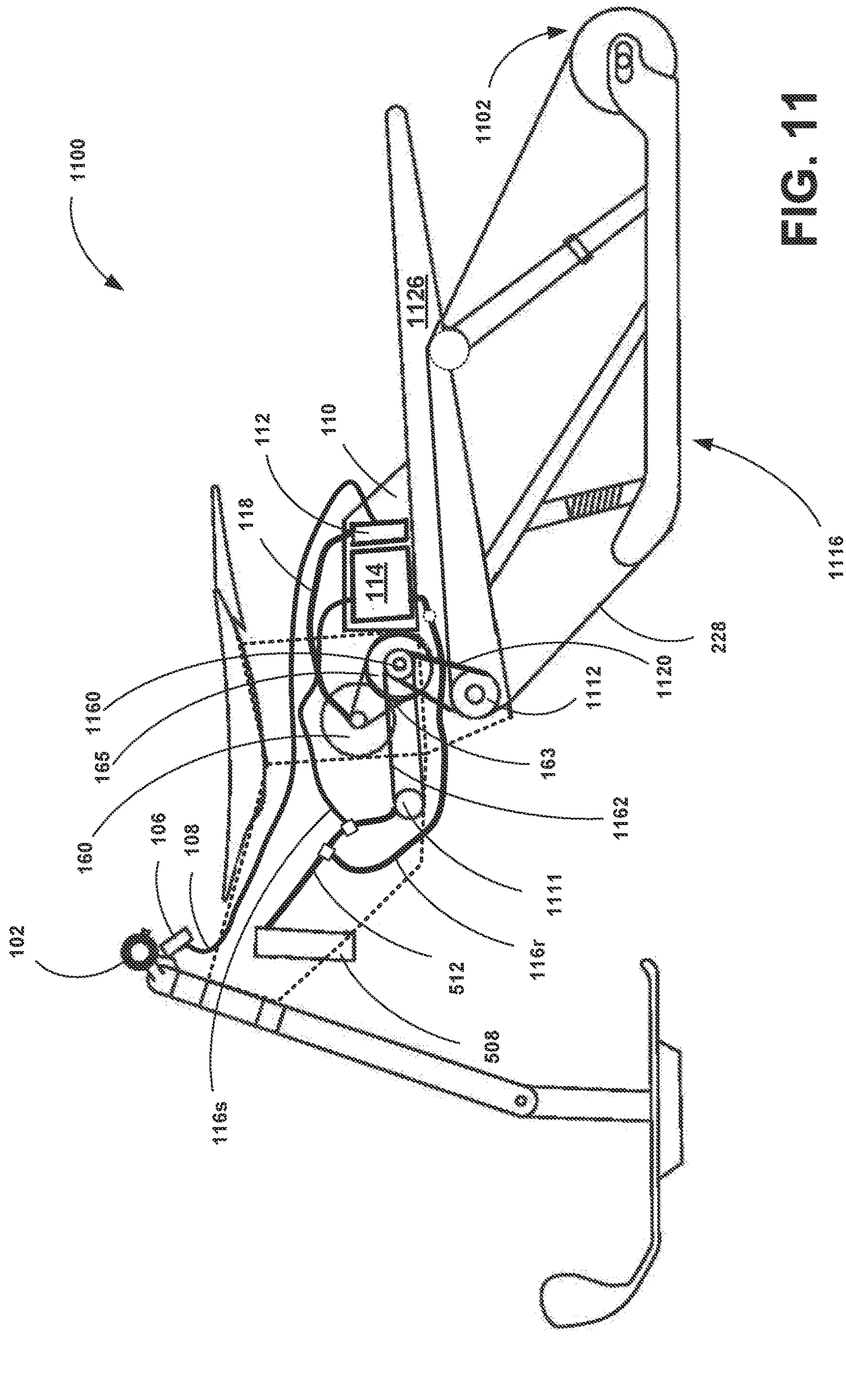
116s, r
216
230a
232

FIG. 10


1100
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1116
228
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1112
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1162
1160
165
160
106
108
102
1111
116r
512
508
116s

FIG. 11

ENDLESS TRACK CONVEYANCE MACHINES HAVING A TORQUE ASSIST SYSTEM FOR ENHANCING PERFORMANCE AND A BATTERY TEMPERATURE ASSIST

FIELD OF THE INVENTION

The invention relates generally to endless track conveyance machines, and more particularly to enhancing the performance of such conveyance machines.

BACKGROUND OF THE INVENTION

The torque generated by any motor has a peak level that is produced over a subset of the range of revolutions per minute (RPMs) that can be generated by the motor. There is always a trade-off in design between the peak level of torque that can be produced by a motor, and the range of RPMs over which that peak torque can be delivered. Motors are designed to have torque curves that serve the intended function for the motor.

Endless track conveyance machines such as snowmobiles and snow bikes are typically powered by internal combustion engines. These engines are often designed to deliver peak torque at higher ranges of RPMs to maximize power and thus acceleration at higher RPMs. As such, their torque performance at the lower end of the RPM range may leave much to be desired, as the engine will take longer to achieve the range of rotational speed at which the torque reaches its peak.

SUMMARY OF THE INVENTION

A torque assist system is provided that enhances the performance of any conveyance vehicle that employs an endless track system that is driven by an internal combustion engine. The torque assist system employs an electric motor that can be coupled in parallel with the combustion engine to drive the track system through its own dedicated driver, or it can be coupled into the drive system through which the engine drives the track system. The electric motor can be any electric motor that can be so coupled, and that has a torque profile that will provide greater torque over a desired predetermined range of RPM of the track than that of the engine to assist the engine in achieving more quickly the range of RPM where its torque and power are at a maximum. The electric motor chosen will be dictated by the purpose of the conveyance and thus the range of RPM for which torque enhancement best suits that purpose.

The torque assist system also necessarily includes a battery by which to power the electric motor. To provide the electric motor's maximum torque to the track in response to maximum throttle, the battery must be operated at or above a minimum temperature. Many applications of such conveyance machines can occur in cold weather. To ensure that the battery reaches a temperature that ensures it can provide a maximum current (especially from a cold start), the torque assist system can include a battery temperature assist subsystem that diverts cooling fluid that has been heated by the combustion engine to a heat exchanger in thermal communication with the battery.

In one aspect of the invention, a conveyance machine includes an internal combustion engine having a drive system coupled to a track. The engine is configured to apply rotational force to the track through the drive system to propel the conveyance machine in a forward direction along the ground. The engine is configured to produce torque

relative to its rotational speed in response to an engine throttle. The conveyance machine also includes an engine cooling system filled with cooling fluid. The cooling system pumps the cooling fluid through the engine during its operation to draw heat from the engine into the cooling fluid and then further through a first heat exchanger by which to transfer the heat from the cooling fluid to ambient air. The engine cooling system has a source coolant line to conduct heated cooling fluid exiting the engine to the first heat exchanger

The conveyance machine further includes an electric motor powered by a battery. The battery is coupled to the track through a motor driver. The electric motor is configured to apply rotational force to the track in parallel with the engine to propel the conveyance machine in either a forward or reverse direction. The motor is configured to produce peak torque relative to its rotational speed in response to a motor throttle.

A battery temperature assist system raises the temperature of the battery to a level that ensures maximum current availability. It includes a secondary source coolant line in fluid communication with the source coolant line of the engine cooling system to divert a fraction of the heated cooling fluid therefrom. It further includes a second heat exchanger in thermal communication with the battery, the second heat exchanger configured to receive the diverted fraction of the heated cooling fluid and to transfer the heat from the heated cooling fluid to the battery as it flows therethrough. It also includes a secondary return coolant line in fluid communication with the source coolant line of the engine cooling system to return the diverted fraction of the cooling fluid back to the engine cooling system.

The torque that can be produced by the electric motor peaks over a range of rotational speed of the track that is different than the range of rotational speed of the track at which the torque that can be produced by the engine peaks.

In an embodiment, the battery and the first heat exchanger are disposed in a heat isolating housing.

In another embodiment, the secondary return coolant line further includes a valve disposed therein to interrupt circulation of the diverted fraction of the cooling fluid through the second heat exchanging body when the diverted fluid exits the second heat exchanger at a temperature that exceeds a predetermined temperature.

In still another embodiment, the valve is a thermostatically controlled ball valve.

In yet another embodiment, the heat isolating housing further includes at least one thermostatically controlled fan for cooling the battery when the temperature inside the housing reaches or exceeds a predetermined temperature.

In a further embodiment, the conveyance machine further including a motor controller, the motor controller being coupled to the battery and the motor to control the magnitude of current being delivered from the battery to the motor in response to a signal provided from the motor throttle to the controller and in accordance with a specified torque profile file.

In a still further embodiment, the battery housing and the controller are surrounded by a fairing coupled to and supported by the conveyance machine, the fairing providing protection from at least weather related elements.

In yet another embodiment, the motor controller is coupled to a processing device. The processing device executes an app program that downloads the torque profile. The torque profile is selected from a plurality of torque profiles through a user interface.

In still another embodiment, the controller places the motor in a regenerative braking mode when the motor throttle is at a zero current position to cause the motor to generate current by which to re-charge the battery.

In another embodiment, the fairing includes snow filtered adjustable vents to allow cool air to moderate the temperature of the battery.

In another aspect of the invention, a conveyance machine includes an internal combustion engine coupled to a track through a drive system. The engine is configured to transfer rotational force to the track through the drive system to propel the conveyance machine in a forward direction when the track is in contact with the ground. The engine is configured to produce torque relative to its rotational speed in response to an engine throttle.

The conveyance machine also includes an electric motor that is powered by a battery and is coupled to the track through a motor driver. The electric motor is configured to apply rotational force to the track through the driver in parallel with the engine, to turn the track and thereby propel the conveyance machine in either a forward or reverse direction. The motor is configured to produce peak torque relative to its rotational speed in response to a motor throttle.

A motor controller is coupled to the battery and the motor and is configured to control the magnitude of the current being delivered from the battery to the motor at least in response to a signal provided from the motor throttle to the controller, and in accordance with a specified torque profile. A processing device, in communication with the motor controller, is configurable to run application programs that include a user interface through which parametric information may be input by a user to dictate to the controller how the motor performs. That parametric information includes the torque profile.

In an embodiment, when the motor throttle is at a zero current position, the controller places the motor in a regenerative braking mode to generate charging current to recharge the battery.

In another embodiment, a user specifies a braking level of the regenerative braking mode through an app executed by the processing device, causing the controller to establish a magnitude of EMF (electromotive force) generated by the motor that correlates to the specified braking level.

In still another embodiment, the electric motor is a hub motor, the hub motor having a fixed axle, the fixed axle being supported at both ends by a pair of suspension rails, the hub motor having teeth by which to engage with and drive the track.

In yet another embodiment, the conveyance machine is a snow bike, and the hub motor has been mounted in place of a rear track tensioner wheel of the snow bike.

In a further embodiment, the conveyance machine is a snowmobile, and the hub motor has been mounted in place of a rear track tensioner wheel of the snowmobile.

In a still further embodiment, the electric motor is a spindle motor having a spindle drive motor, a driver having a drive shaft, and a sprocket coupled to the drive shaft. The spindle drive motor is coupled through a chain to a sprocket to turn the drive shaft. The drive shaft is supported at both ends by one of a pair of suspension rails, the driver having teeth by which to engage with and drive the track.

In yet another embodiment, the conveyance machine is a snow bike and the drive of the spindle motor has been mounted in place of a rear track tensioner wheel of the snow bike.

In still another embodiment, the conveyance machine is a snowmobile, and the drive of the spindle motor has been mounted in place of a rear track tensioner wheel of the snow bike.

In another embodiment, the sprocket of the spindle motor is coupled directly to a sub-drive shaft of the engine drive system instead of a rear driver.

Thus, the torque assist system of the conveyance machine provides additional torque at lower ranges of the engine's available RPMs to assist it in reaching the range of higher RPMs over which the engine's torque is designed to peak, and can provide immediate supplemental torque in situations where the load on the internal combustion engine (ICE) is high at lower RPMs.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded view of the components of embodiments forming the torque assist system of the invention that can be installed to enhance the performance of a snow conveyance machine using an electric motor;

FIG. **2** is a side view of an embodiment of a snow bike that has been enhanced with installation of an embodiment of the torque assist system of FIG. **1**;

FIG. **3** is a side view of an embodiment of a snowmobile that has been enhanced with installation of an embodiment of the torque assist system of the invention of FIG. **1**;

FIG. **4**A is an embodiment of an electric spindle motor adapted to be used as part of an embodiment of the torque assist system of the invention of FIG. **1**;

FIG. **4**B is an embodiment of an electric hub motor adapted to be used as part of an embodiment of the torque assist system of the invention of FIG. **1**;

FIG. **5**A is a plan view of an embodiment of a fairing for a snow bike that houses the battery and a motor controller that controls the electric motor of the torque assist system of the invention;

FIG. **5**B is a plan view of an embodiment of a fairing for a snowmobile that houses the battery housing of FIG. **1** and a motor controller that controls the electric motor of the torque assist system of the invention;

FIG. **6** is a conceptual representation of an embodiment of a heating system for the battery that supplies the electric motor of the torque assist system of the invention;

FIG. **7** is a side view of an embodiment of a battery housing containing the battery and heat exchanger of the heating system of FIG. **5**;

FIG. **8** is a simplified conceptual diagram of an embodiment of the controller of the torque assist system of the invention;

FIG. **9**A is a graph depicting torque and power curves for a generic combustion engine that might be used as a component of the torque assist system of the invention;

FIG. **9**B is a graph depicting torque and power curves for a generic electric motor having permanent magnets that might be used as a component of the torque assist system of the invention;

FIG. **9**C is a graph depicting an approximation of the horsepower of a combination of the engine of FIG. **9**A and the motor of FIG. **9**B when combined as part of the torque assist system of the invention;

FIG. **10** is a side view of an embodiment of a snow bike illustrating an alternative technique for installation of the electric motor to engage the track of the snow bike; and

FIG. **11** is a side view of an embodiment of the snow bike employing a second alternative technique for installation of the electric motor to engage with the track of the snow bike.

DETAILED DESCRIPTION

Conveyance machines such as snow bikes and snowmobiles employ a spinning or endless track system that is rotationally driven by an internal combustion engine to engage with snow surfaces by which to propel the conveyance machine. Snow bikes are most commonly created using commercially available conversion kits configured to convert a motorcycle or dirt bike, intended to operate on surfaces with no snow, into a snow a machine that can operate on snow surfaces. These conversion kits typically include a steering ski that replaces the front tire of the motorcycle or dirt bike, and a rear track system that replaces the rear wheel to provide the propulsive force. The track system is provided with parts necessary to couple the track system to the combustion engine's drive system to provide the rotational force causing the track to spin. Snowmobiles are typically purpose built machines sold by an original equipment manufacturer (OEM) to operate on the snow. While the front steering skis and the track systems of snowmobiles and snow bikes are not identical, they are substantially analogous.

Disclosed herein are embodiments of a torque assist system **100** for enhancing the performance of conveyance machines such as snow bikes and snowmobiles. Embodiments of the system include an electric motor, which is coupled to the track system in parallel with an internal combustion engine, to provide a user discretionary boost in torque applied to the track of the conveyance machine over a range of RPMs of the track for which the torque of the internal combustion engine is low. Because they are both jointly coupled into the drive of the track system, the engine and the motor work synergistically to add their respective peak power available for any given throttle setting for each. The electric motor can enhance performance of the conveyance machine by reducing the time required for the RPMs of the track to reach a range over which the torque provided by the engine peaks, thereby reducing the time in which the engine reaches its maximum power and speed.

In addition, because the electric motor requires a battery as its source of power, some embodiments also include a battery temperature-assist system for boosting the temperature of the battery, particularly on a cold start. The battery temperature-assist system uses heat initially generated by the internal combustion engine to ensure that the battery is able to source maximum current when demanded by a user after a cold start of the snow conveyance machine in winter climates.

FIG. **1** shows an exploded view of an embodiment of a set of enhancement components **100** of the invention without the conveyance machine. These components **100** can be either provided as a kit by which to modify and thereby enhance the performance of an aftermarket OEM snow conveyance machine, or they could be included in the original set of components purpose built into an OEM snow conveyance machine to provide the enhanced performance.

In one embodiment, the set of enhancement components **100** of the invention includes an electric hub motor **150***a*. Hub motor **150***a* is installed to rotate around a fixed axle **120** and includes features such as involute or extrovert teeth **152** configured to engage with features of a track (not shown in FIG. **1**) of a snow conveyance machine. These features can be similar to the same types of features as those used to couple the combustion engine with the track of the snow conveyance machine, which is driven by its internal combustion engine. Those of skill in the art will appreciate that the features such as teeth **152** are well known in the art for engaging with conveyance tracks such as those used in snow bikes and snowmobiles.

The hub motor **150***a* is thereby configured to engage with the conveyance track to assist the internal combustion engine in turning the track to propel the snow conveyance machine. The hub motor **150***a* is configured to be conveniently installed in place of a track tensioner wheel that is originally installed on such conveyance machines to maintain tension on the track as it turns. Brackets **122***a, b* are designed to support the hub motor **150***a* and its fixed axle **120** through openings **123***a, b*. They are designed to replace the originally installed brackets that are designed to hold the track tensioner wheel in place. Installation of the hub motor **150***a* and brackets **122***a, b* will be illustrated and described in more detail below. Those of skill in the art will appreciate that any electric motor having a fixed axle where the housing of the motor itself rotates such as, for example, an outrunner Halbach array motor.

In an alternate embodiment, an electric spindle motor **150***b* can be used in lieu of the hub motor **150***a* to assist the conveyance machine's engine in turning the track. Spindle motor **150***b* consists of a spindle driver motor **160** that turns spindle drive axle **162**, which engages with and drives chain **163**. Chain **163** engages with sprocket **163**, which then turns rear driver **164**. Rear driver **164** includes track engagement features **172**, which can be, for example, involute teeth or extrovert teeth designed to engage with features of the track that permit the rear driver to apply rotational force to the track. Brackets **168***a, b* are configured to support the live axle **166** of the rear driver in openings **169***a, b*. Installation of the spindle motor **150***b* will be illustrated and described in more detail below.

Those of skill in the art will appreciate that the two electric motors **150***a, b* can be driven by a control circuit **112**, which is disposed within a fairing **110** and configured to control the magnitude of the current drawn from a battery by the motor **150***a, b*. The battery (See **605**, FIG. **6**) is disposed in a battery housing **114** that is also enclosed within fairing **110**. Fairing **110** serves to protect the control circuit and the battery box or housing **114**, by preventing their exposure to snow and weather related moisture and particulate matter.

The magnitude of the current drawn from the battery **605** and supplied to the motor through electrical wiring harness **118** is dictated by the user through a torque assist throttle **102** that provides an electrical signal output that is coupled to the controller **112** through wiring harness **108**. The magnitude of the current supplied to the electric motor **150***a, b* is related to the amount of torque generated by the motor **150***a, b* in accordance with its torque curve. Wiring harness **118** delivers current to the phases of the electric motor **150***a, b* and returns feedback information to the controller **112**, including the amount of current being drawn by each phase of the electric motor **150***a, b*.

Wiring harness **108** can be further coupled to an input device such as a toggle switch that permits the electric motor to be switched between (and thereby operate in) forward and reverse modes. Wiring harness **108** can provide additional control inputs to the controller **112** from a data processing device **106** such as a smart phone or other forms of PDAs, providing a user interface by which to control other aspects of the motor's **150***a, b* operation. This can include downloading various torque profiles to the controller **112** by which to selectively alter the torque curve of the motor **150***a, b*, prior to or even during operation of the snow conveyance machine. In addition, the controller **112** can be programmed through the user interface of the processing device **106** to set the regenerative braking level of the electric motor when the motor is in regenerative braking mode (e.g. when the torque assist motor throttle **102** is set to a zero position). Finally, wiring harness **108** can also receive parametric output from the controller **112** for display by the user interface of the processing device **106**.

Because snow conveyance machines such as snow bikes and snowmobiles are used in cold weather, cold starts of these machines require that the engine first warm up so that the lubricant for the engine can be properly circulated. Adding an electric motor **150***a, b* to provide torque assistance presents an issue regarding cold weather as well. The battery that is used to supply current to any electric motor cannot supply full current to the motor when it is cold. Thus, the battery must also be warmed up so that full current can be delivered to the motor on demand from a user.

Thus, the embodiment of the set of components **100** of FIG. **1** also provides a battery temperature-assist system for using the heat generated by the internal combustion engine to warm the battery **605** as the engine heats up so that it is able to provide full current on demand from a user. Snow conveyance machines require a cooling system to cool the engine. Such a system typically includes cooling fluid that is pumped into the engine to draw heat from the engine, and which upon exit from the engine, is further pumped through a heat exchange device such as a radiator, a tunnel cooler or the like, to transfer the heat absorbed by the cooling fluid to the ambient environment.

Source and return coolant conducting lines **116***s, r* (respectively) are provided with termination means **115***s, r* that are configured to be coupled in sealable fluid communication with the coolant line through which the cooling fluid is pumped as it exits the engine on its way to the heat exchanging device of the cooling system for the engine. Thus, battery supply line **115***s* is configured to divert a portion of the cooling fluid that has exited the engine and has therefore been heated by the engine, to the battery housing **114**. As will be discussed in more detail below with reference to FIGS. **5** and **6**, the heated coolant is pumped through a heat exchange element that is located in physical proximity to the battery **605** by which heat is transferred to the battery.

FIG. **2** illustrates an embodiment of a snow bike **200** that has been enhanced with an embodiment of the enhancement components illustrated in FIG. **1**. The snow bike **200** has an internal combustion engine **210** that is coupled to a rear track system **216** and has a steering ski **232** in communication with handlebars (not shown). The crankshaft of engine **210** has been coupled to the jack drive **212** of the rear track system, by way of drive chain **214**, which is coupled to the jackshaft **213** of jack drive **212**. Track engagement features of jack drive **212** are received by features in the track **228** to exert turning force (i.e. torque) on track **228** to linearly propel the snow bike **200** over terrain preferably covered with snow. The rear track system **216** further includes parallel suspension rails **230***a* and **230***b* (not shown), that are coupled with tunnel **226** through one or more shocks **231** and support arms **227**. Track **228** is supported over idler wheels **229** as it travels through the tunnel **226**.

The performance of the snow bike **200** is enhanced by the components **100** of the invention to provide torque assist through the hub motor **150***a*. The hub motor **150***a* physically occupies the location once occupied by the original tensioner wheel (not shown) that was provided as part of the rear track system. Brackets **122***a* and **112***b* (not pictured) are configured to support the hub motor **150***a* at its fixed axle **120** through opening slots **123***a* and **123***b* (not shown) and replace the brackets originally provided as part of the rear track system to support the track tensioner wheel.

Electrical harness **118** couples the electric motor with the controller **112**. The controller **112** controls the amount of current supplied to the hub motor **150***a* for a given position of the torque assist throttle **102**, and the torque curve used by the controller **112**. Electrical harness **108** provides various signals to the controller **112**, including the position of the torque assist throttle, the position of the forward/reverse toggle switch **104**, the regenerative braking level and parametric information provided by the processing device **106** to the controller **112**, as well as parametric data from the controller **112** to be displayed on the processing device **106**.

Battery temperature-assist system supply and return hoses **116***s, r* are coupled into the coolant line of the cooling system that conducts heated cooling fluid leaving the engine **210** to the radiator or tunnel cooler (not shown). The supply line or hose **116***s* diverts a portion of the heated cooling fluid to the battery housing and through a heat exchanger in close proximity to the battery **605** and return line **116***r* returns the cooling fluid back to the line and downstream from the supply line **116***s*.

Controller **112** and battery housing **114** are preferably located under the seat **220** as illustrated, to center the additional weight of the battery **605** beneath a rider. In some snow bike designs, the gas tank **224** is often located under the seat **220**, which may require the gas tank to be shifted rearwardly to accommodate the controller **112** and battery housing **114**. A fairing **110** is provided to surround the controller **112** and batter box **114** to protect them from snow and other forms of precipitation, wind, and particulate matter. The fairing **110** can also include an opening to accommodate part of the gas tank **224** that remains under the seat. The faring **110** may also have to have an opening to accommodate the exhaust pipe **223**, which also commonly runs under the seat for dirt bikes that have been converted to snow bikes.

FIG. **3** illustrates snowmobile **300**, which has been performance enhanced by the components **100** of the invention. In the case of an OEM snowmobile, the engine and drive mechanism are located forward of the seat and are covered by a fairing **310**. The internal combustion engine, the engine drive system and cooling system are all obscured by the fairing **310** but are similar to the that of the snow bike of FIG. **2**. The snowmobile also has a steering ski **332** (usually a pair of them) and a track system that also includes a tunnel **326**, a track **328**, and suspension rails **330***a* and **330***b* (not shown).

In this embodiment of the enhancement components **100**, the electric motor is a spindle motor **150***b*. The spindle motor includes a spindle drive motor **160** with an axle **162**, a rear drive **165** having a live axle **166**, and a sprocket **165** that is coupled to the spindle motor through chain **163**. The rear drive and its axle are turned by the spindle drive motor **160** and chain **163** through sprocket **164**. Brackets **168***a* and **168***b* (not shown) are configured to support the live axle **166** of rear driver **164** through slotted openings **169***a* and **169***b* (not shown). They replace brackets originally configured to support the track tensioner originally provided with snowmobile **300**. The controller **112** and batter housing **114** are located behind the seat and surrounded by fairing **110**. They are supported by the track system **316**.

Battery temperature-assist coolant lines are coupled to the equivalent cooling line to that of the snow bike of FIG. **2**, which carries cooling fluid that is exiting the engine and has therefore been heated by the engine of the snowmobile **300**. Electrical harnesses **108** and **118** are coupled in the same manner as described for the snow bike **200** of FIG. **2**. In this embodiment, harness **118** is coupled to the spindle drive motor **160**.

FIG. **4**A is an elevated view of the spindle motor **150***b*. In this view, both suspension rails **330***a, b* are shown, as well as both brackets **168***a, b* supporting live axle **166** coupled to rear drive **164** in slots **169***a, b*. In addition, bearings **420***a, b* are shown that facilitate the spinning of live axle **166**. In an embodiment, the spindle motor is mounted to suspension rail **422**, that itself is supported at each end by suspension rails **330** *a, b*. Those of skill in the art will appreciate that track engaging features **172** can be of any form required to properly engage with the track **328** of snowmobile **300**. They will also span the entire circumference of the rear drive **164** but have been limited in this view for ease of illustration.

FIG. **4**B illustrates an elevated view of the hub motor **150***a*, that also illustrates both suspension rails **230***a, b* and both replacement brackets **122***a, b* supporting the fixed axle **120** in slots **123***a, b*. Those of skill in the art will appreciate that track engaging features **152** can be of any form required to properly engage with the track **228** of snow bike **200**. They will also span the entire circumference of the hub motor **150***a* but have been limited in this view for ease of illustration.

FIG. **5**A illustrates a closer view of the fairing **110** enclosing the controller **112** and the battery housing **114** for the enhanced snow bike **200** of FIG. **2**. If the fuel tank **224** is originally located under the seat **220**, it may need to be shifted rearwardly along the tunnel **226** to accommodate the controller **112** and the battery housing **114**. Given that the weight of a snow bike (as with any dirt bike or motorcycle) should be centered under the rider to promote balance, the fuel tank **224** may be moved only just enough to fit the controller **112** and the battery housing **114**.

Those of skill in the art will appreciate that fairings are common to motorcycles and dirt bikes. They come in many forms and materials and are typically designed to cover and isolate components of these machines, primarily for aesthetics and aerodynamics. They are often custom made to fit particular brands and models of such machines because the component arrangements are often substantially different between brands as well as models of even the same brand.

In the example of snow bike **200**, the fairing serves another purpose which is important in snow conveyance machine applications. It also prevents snow and other forms of precipitation from building up under the seat and impacting the integrity of the controller **112** and batter box **114**. Because fairings are typically customized for each configuration of bike brand and model, fairing **110** may be differently formed or located, but it is configured to enclose the controller **112** and battery housing **114** to isolate it from snow and the elements.

The fairing **110** of FIG. **5**A is configured to use the underside of the seat **220** and the surface of the tunnel **226** as natural boundaries of the enclosure formed by the fairing **110**. Fuel tank **224** is illustrated from under the seat **220** and thus exceeds the upper and lower boundaries of the fairing **110**. Thus, an opening **720** is provided in fairing **110** to permit the fuel tank **224** reside partially inside of fairing **110**. See also FIG. **2**. Exhaust pipe **223** also originally runs through the space enclosed by the fairing **110**, and this also has an opening through it protrudes to vent the exhaust to the ambient environment. Adjustable vents **702** are also provided in the fairing **110** to permit cooler ambient air to be vented into the area enclosed by the fairing **110** if desirable. These vents can be equipped with snow filters to prevent ingress of snow through the vents **702**, while permitting the ingress and egress of air therethrough. The vents **702** can be louvered to permit opening and closing them using a lever for example.

FIG. **5**B illustrates a fairing **110** for the snowmobile **300** of FIG. **3**. In the case of the snowmobile **300**, weight distribution is not so critical and thus it is easier to place controller **112** and battery box **114** into fairing enclosure **110** configured in the form of a box that can be fixedly coupled to the top surface of the tunnel **326**. A levered catch **704** and hinges can make for easy access to the components in the interior of the fairing **110**.

FIG. **6** illustrates an embodiment of the battery temperature-assist system of the invention, and one configuration for coupling the components thereof into the cooling system of engine **506**. During normal operation, engine **506** receives cooling fluid pumped through the heat exchanging means **508** and through engine coolant supply line **510**. Heat exchanging means **508** can be suitable form of heat exchanger such as a radiator, tunnel cooler or the like. As the cooling fluid passes through the engine **506**, heat generated by the engine is transferred to the cooling fluid to cool the engine. As the heated cooling fluid exits the engine and into coolant return line **512**, the heated cooling fluid is pumped to back to the radiator **508**, which serves to transfer the heat from the cooling fluid passing therethrough to the ambient air. The coolant lines **510**, **512** of the engine cooling system of a snow conveyance system are typically ¾" in diameter.

The source coolant line **116***s* of the battery temperature-assist system can be coupled into the engine coolant return line **512** using T fitting **115***s*. The diameter of source coolant line can be for example, half of the diameter size engine coolant return line **512** so that half of the cooling fluid is diverted to assist the battery temperature. The diverted cooling fluid is pumped through heat exchanger **502** and out into battery temperature assist return line **116***r*. A thermostatically controlled valve **504** (e.g. a ball valve) is disposed within return coolant line **116***r* that is configured to close off further circulation of the cooling fluid if the coolant fluid exiting the heat exchanger **502** exceeds for example, 100 degrees F. Such an exit temperature for the cooling fluid will indicate that the temperature requires no further temperature assistance. Return coolant line **116***r* of the battery temperature-assist system is then coupled back into the engine coolant return line **512** using T fitting **115***r*, down stream from where the source coolant line **116***r* is coupled into the engine coolant return line **512**.

Those of skill in the art will appreciate that some engine cooling systems have a bypass line between the engine coolant return line **512** and the engine coolant supply line **510** that permits bypassing of the heat exchanging means **508** on a cold start to help the engine warm up faster. The cooling fluid is diverted to the bypass line by a thermostatically controlled valve that diverts the fluid into the bypass line until the cooling fluid exiting the engine reaches a predetermined temperature. If the engine cooling system has such a bypass, coolant supply line **116***s* to the battery **605** can be coupled into the engine coolant return line **512** at or upstream from the valve controlling the bypass.

FIG. **7** illustrates a plan view of the battery box or housing **114**. Battery pack **605** rests on, or in proximity with, the fins **501** of heat exchanger **502**. The heated fluid enters heat exchanger **502** via supply coolant line **116***s* and transfers heat from the cooling fluid to the fins **501** of the heat exchanger **502** as the cooling fluid flows through the base of the heat exchanger, out through return coolant line **116***r* and back to the engine cooling system. The heat exchanger **502** can be made of any material having suitable heat transfer characteristics, such as aluminum. The housing can be made of any thermal insulating material such as thermal insulating plastic to hold in the heat provided by the heat exchanger as well as the heat ultimately generated by the battery. Electrostatically controlled fan **662** is configured to turn on when the internal temperature exceeds a predetermined temperature, such as 100 degrees F.

FIG. **8** illustrates a simplified block diagram for controller **112**. Those of skill in the art will appreciate that there are many commercially available motor controllers designed for brushless DC motors such as hub **150***a* and spindle motor **150***b*. Many of them are purpose designed for controlling such motors for vehicular applications. A few examples include the BAC8000 Controller by Accelerated Systems™ Inc. and the KHB 14401 BLDC motor controller by Kelly Controls, Inc.

Controller **112** essentially provides a fixed DC voltage (e.g. 12 volts) to energize each pole of the electric motor **150***a, b* and controls the current delivered to each pole (U, V, W) in accordance with the position of the torque assist throttle **102**, which thereby controls the torque produced by the motor to assist the engine in turning the tack. The speed at which the shaft of the motor turns, and thus the speed at which can turn the track of the snow conveyance machine is dictated by the torque and the load on the motor.

Controller **112** is therefore coupled to the battery **605**, and to the motor to source current to the poles through outputs U, V and W **816**. Outputs U', V and W' **818** provide positional information for the rotor that is sensed by hall effect sensors **808** and are provided as feedback signals as inputs U", V", W" **820** to tell the controller **112** which phase or pole should be energized. A Motor Temp sensor signal **817** is provided as an input to controller **112** to enable the controller **112** to monitor the temperature of the motor **150***a, b*. This enables the controller **112** to cease driving the motor **150***a, b* if, for example, the motor **150***a, b* exceeds a predetermined temperature, such as 100 degrees F. These signals are provided between the controller **112** and the motor **150***a, b* through electrical harness **118**.

Those of skill in the art will appreciate that the size of the battery **605** and the power provided by the electric motor **150***a, b* should be determined based on the type of performance sought to be achieved. In an embodiment, the battery **605** can discharge between 8,000 and 60,000 watts of phase power to the electric motor **150***a, b*. A circuit breaker **805** is placed across the terminals of the battery **605** and is rated for between 100 and 600 amps of current from the battery **605** and provides a main power switch for turning on the torque assist system of the invention on startup of the enhanced snow conveyance machine.

The choice of what type of motor **150***a, b* for a given application is also a consideration that depends upon the type of performance enhancement one seeks in employing the torque enhancement system of the invention **100**, and that determination is influenced by the performance curves of the internal combustion engine (ICE) with which the electric motor is to be paired. FIG. **9**A illustrates a typical torque **902** and power **906** vs. track speed (RPM) graph **900** for a generic ICE. As will be appreciated by those of skill in the art, a combustion engine typically produces its maximum torque **904** (and power **906**)) at higher ranges of engine RPM. This is why the drive systems of ICEs are typically geared, so that they can get to the range of track RPMs where they produce their peak torque and power, even when the speed of the vehicle itself is still low.

FIG. **9**B illustrates a typical torque **952** and power **954** vs. track speed (RPM) graph **950** for a generic brushless DC (BLDC) motor. It will be appreciated by those of skill in the art, that an electric motor such as a BLDC motor is able to produce virtually instant torque from zero track RPMs, unlike the ICE. By coupling an electric motor such as a BLDC motor to drive the track system of a track driven vehicle in parallel with the ICE, it will be appreciated that the electric motor can be used to provide rated torque **956** at 100% of maximum throttle, which remains substantially constant over a range (the Constant Torque Range **957**) of track RPM up to the point at which the Rated Speed **960** of the motor is reached. After that, the power **954** is constant (Constant Power Range **958**) of track RPM as the torque **952** decreases. The torque **952** will decrease until the net voltage across the magnets of the BLDC motor reaches zero, due to the increasing back EMF generated by the motor as the motor speed increases. At this tack RPM, the torque **952** will be zero and the motor will stall at its maximum speed **962**.

Thus, depending upon the values of peak or maximum torque of the ICE, a specific motor design can be chosen to provide its rated torque over a range of RPMs starting substantially at zero as shown in FIG. **9**B, and that spans some or all of the gap in torque generating performance of the ICE illustrated by FIG. **9**A. For example, hub motors **150***a* typically deliver higher rated torque over a smaller range of RPM (e.g. to about 1800) RPMs of the track and the motor **150***a*. This makes hub motor **150***a* advantageous for supplementing available torque when the engine is loaded at lower RPMs of the track, such as hill climbing, low speed off trail operation (e.g. boondocking) or hauling heavier loads.

FIG. **9**C illustrates a power curve **1206** that reflects the synergistic power generated by the parallel combination of both the ICE and the electric motor **150***a, b* as a combination of the ICE power curve **906** of FIG. **9**A and the power curve **954** of the electric motor. The power curve for the electric motor is not shown in FIG. **9**C for the sake of simplicity, but the regions of constant torque (or linear power) **957** and constant power **958** ranges of track speed in RPMs are shown as delineated by the motor first reaching its rated speed **960** and finally its maximum speed. Those of skill in the art will appreciate that these curves show the power curves individually and as combined for a given throttle position and a given gear ratio. But regardless of the throttle level, the peak power of both the ICE and electric motor at the given throttle level are made available and additively combined to turn the track as illustrated.

By coupling both the ICE and the electric motor in parallel to the track, they are free to generate their own available power to the task of turning the track. Thus, if the graph of FIG. **9**C shows a combined output power for the ICE and the electric motor with both at full throttle, the combined power curve **1206** represents the additive combination of the maximum available power that can be supplied by each for the given track RPM up to a maximum track RPM that can be achieved through the combination. For a snow bike, the user could apply full throttle to both the electric motor and the ICE, with the snow bike in third gear, and the electric motor will initially dominate the generated power generated until the track RPM causes the ICE in third gear to reach a level of RPM at the crankshaft at which the ICE can generate significant torque, and therefore the power, to significantly add to the overall power produced to turn the track. In this way, the time it takes to achieve the level of RPM for the ICE is significantly reduced from how long it would take to get there by itself. Those of skill in the art will appreciate that the electric motor can also be geared to either increase or decrease the range of track RPM over which torque is delivered before reaching the motor's maximum speed. As the range is increased, the rated or maximum torque will decrease, and as the range is decreased, the rated or maximum torque will increase.

Spindle motors **150***b* are capable of producing less rated torque and power, but operate up to a higher RPM (e.g. 6400-7500 RPM). This may render spindle motors **150***b* more advantageous for high-speed applications (45-120 MPH), such as trail and flat track racing of snow conveyance machines. Thus, the spindle motor **150***b* produces its lower rated torque, but that can be generated to a range of RPMs more useful to aiding acceleration just before the ICE is in range of producing its own peak torque. The hub motor achieves its higher rated torque over a narrower range of RPMs and adds more weight because of the extra components required to install it.

Controller **112** can further include a bus or a serial data interface that enables data to be downloaded to the microprocessor of the controller **112** from the processing device and display **106**. For example, a Bluetooth coupling **806** between the processing device **106** and a serial bus input of the controller **112** would enable interchangeable processing devices **106** to be used. A more robust coupling may be accomplished through a hard-wired bus interface of n bits between them such as an RS232 interface **832**. This capability enables the torque profile of motor **150***a, b* to be altered, thereby enhancing its ability to assist in providing additional torque to better achieve the desired performance for the current use of the snow conveyance machine. The torque profile may also be changed to simply reflect the personal preferences of a given user. Apps can be installed on the processing device **106** that can provide a choice of profiles for selection through the user interface of the processing device. These choices can be dictated by the specific configuration of the torque enhancement system **100**.

Additional inputs can also be provided to the controller **112** from the torque enhancement system **100** of the invention to aid the controller **112** in providing additional features and protective functions. The thermostatic control of the ball valve **504** residing in the battery temperature assist system can provide additional information regarding the temperature of the battery. Likewise, the thermostatic control of the fan in the battery housing can provide battery temperature signal **830** to the controller **112** to limit the current so that the battery **605** does not overheat. In addition, a signal supplied to the controller by forward/reverse toggle switch **104** will cause the controller **112** to operate in either a forward or reverse mode.

In addition, those of skill in the art will appreciate that a DC brushless motor produces a back EMF (electromotive force) that is overcome by the applied voltage when driving the motor. When the motor **150***a, b* is rotated by application of an external force against the back EMF (i.e. by coasting downhill due to gravity or because the engine is turning the track, current is generated that is supplied back to the battery **605** and therefore recharges the battery. This is known as regenerative braking. Controller **112** can be configured to place the motor **150***a, b* in regenerative braking mode whenever the torque assist throttle **102** is at zero. In addition, the back EMF can be increased or decreased to increase or decrease the level of recharging that takes place. Thus, a user can adjust the braking level by increasing the back EMF. This can be adjusted directly through a switch to produce as braking level input to the controller **112**, or it can be input or selected though the user interface of the processing device and display **106** and over harness **108** or by way of Bluetooth interface **806**. A charging port **802** is provided by which to externally charge the battery **605** should it be required.

A user can apply torque generated by the electric motor **150***a, b* manually by simply advancing the electric motor torque assist throttle **102** in various circumstances in which there is a benefit in performance to be derived. For example, the ICE of a snow bike can be roll-started on a substantially flat surface by first using the motor to get the snow bike rolling with the clutch engaged, and then popping the clutch to start the ICE. The more efficient way to manually apply torque to a snow bike with an already running ICE is to place the snow bike in low gear to get it rolling, and then to advance the torque assist throttle **102** to add torque to the snow bike.

When such vehicles (including snowmobiles) are being operated at lower track RPMs, such as while boondocking in the trees, a sudden drop in ICE performance because of sudden increases in load from heavy snow or steep inclines can be overcome by advancing the torque assist throttle **102** to increase the torque applied to the track to offset the increase in load. If the vehicle becomes bogged down in the snow, a user can advance both throttles to ensure enough torque to advance the track. When racing a snowmobile, for example, the user can wait to advance the torque assist throttle **102** until the speed of the track is approaching the range of RPM's for which the ICE can generate maximum torque and power. This would be the functional equivalent of giving the ICE a boost of nitrous oxide.

Torque assist throttle **102** can produce a 0-5V that is received by the controller. A value of 0 volts can represent zero torque assist, and a 5V value can represent maximum available torque assist. While this output can be manually generated by a manually actuated throttle that actuates a potentiometer, the torque assist throttle **102** can also be automatically generated in accordance with a torque assist app that receives inputs from the ICE controller that indicates when the ICE may be experiencing an increase in load at an RPM and in a gear that would benefit from torque boost from the electric motor **150***a, b*. The app can then determine an appropriate percentage of maximum torque assist throttle to send to the controller **112**. This would permit a user who does not wish to operate a separate torque assist throttle to settle for an automatically generated torque assist. The app can be executed on the processing device **106**, that would generate the torque assist throttle **102** output through calculations executed by the software based on the parametric information received from the engine controller. The app could also be used to determine from the parametric data when to enter the regenerative braking mode as well.

Controller **112** can also provide parametric feedback to the user through the user interface of processor and display device **106**. This information can include the current regenerative braking level, the current torque profile selected, battery temperature, motor temperature, Forward/Reverse mode, torque assist level, system voltage, etc. All of these signals can be transmitted over individual pin connections, RS232 bus **832** or Bluetooth interface **806**.

FIG. **10** illustrates an alternate embodiment **1000** of the snow bike **200** of FIG. **2** that has been enhanced with the torque assist system **100** of the invention. In this embodiment, the drive system is substantially the same as in FIG. **2** and is coupled to the rear track system **216** by coupling the crankshaft **211** of engine **210** to the jack drive **212** of the ear track system **216** through a chain **214**. However, instead of installing a hub drive motor **150***a* at the back of the rear track system **216** in lieu of the track tensioning wheel **1002**, a spindle drive motor **160** is mounted on the frame of the snow bike **1000** at the opposite side of the track **228** from the jack drive **212**. The spindle drive motor **160** is then coupled to a sprocket **165** through chain **163**, sprocket **165** being proximal to the spindle drive motor **160** that is coupled to the jack shaft **213** at the opposite end of the jack shaft from the jack drive **212**. Because the spindle drive motor **160** is directly coupled to the jack shaft **213**, no rear driver (**164**, FIGS. **1** and **5**A) is required to drive the track. This renders installation simpler and eliminates the weight of the rear track driver. The spindle driver motor **160** does not have to be mounted on the parallel suspension rails **230***a* and **230***b* as shown in FIG. **5**A.

Every other aspect of the torque assist system **100** of the invention is virtually the same. The harness **118** is coupled between the motor controller **112** and the spindle drive motor **160**. Harness **108** is couples the controller **112** to various control inputs such as the forward/reverse toggle switch **104**, torque assist throttle **102** and the processing and display device **106**. The battery temperature assist coolant supply and return lines **116***s, r* are still coupled between the engine coolant return line **512** and the heat exchanger **502** in battery housing **114**. The controller **112** and the battery housing **114** are still located in the same place and protected by fairing **110**.

FIG. **11** illustrates another embodiment of a snow bike **1100**, wherein a spindle motor **150***b* is used as part of the torque assist system **100** of the invention, where like in the embodiment of snow bike **1000** of FIG. **10**, it is directly incorporated into the drive system of the snow bike rather than being installed at the back of the rear track assembly **236**. Snow bike **1100** is a different model with a drive system that includes crank shaft **1111** (the full engine is omitted for simplicity) that turns a drive shaft **1160** through chain **1162** that in turn drives jack drive **1112**. Jack drive **1112** engages with track **228** of lower track system **1116** to propel the snow bike **1100**.

Spindle drive motor **160** is coupled into the drive system by adding sprocket **165** to the drive shaft **1160**. Spindle drive motor **160** is thereby able to also turn drive shaft **1060** by way of chain **163** turning sprocket **165**. Once again, as in the embodiment **1000** of FIG. **10**, the spindle motor **150***b* of the torque assist system **100** of the invention eliminates the need for a rear drive component **164**, FIG. **5**A to separately engage with the track **228**. The rear track system **1116** is able to remain intact, including track tensioning wheel **1102**, and the spindle drive motor **160** can be coupled directly into the drive system of the snow bike **1100**. It should be noted that not all models of snow bikes (or the dirt bike/motorcycle from which the snow bike was converted) can accommodate the addition of sprocket **165** to the main drive shaft. As can be seen from FIG. **11**, all other components of the torque assist system **100** of the invention are coupled into the snow bike **1100** as previously discussed with other embodiments of snow conveyance machines.

While the same reference numbers for the primary components of the torque assist system **100** of the invention have been maintained throughout, it should not be interpreted to mean that they may not be modified in minor ways to accommodate their installation into various makes and models of snow conveyance machines. For example, the lengths, diameters and T fittings **115***s, r* illustrated herein for the coolant lines **116***s, r* may very as various components may be located differently between such makes and models. Further, while the drive systems generally use chains, they may also use belts or other types of drive couplings that fall within the intended scope of the invention. Likewise, electrical harnesses and other forms of electrical interconnect can also vary depending upon the interconnects provided by various commercially available motor controller circuits.

It will be appreciated that while the embodiments described herein are examples of conveyance machines that are configured for snow terrain, it is will be appreciated that the invention is not limited to snow conveyance machines. The performance of any conveyance machine that uses an endless track for its propulsion can potentially be enhanced through the torque assist system **100** of the invention. It will also be appreciated that the hub and spindle motors can be interchangeably used for any type of conveyance machine. The hub motor is motor and driver in one, and thus would be required to engage the track independently of the engine's drive system as illustrated in the embodiment of FIG. **2**. The spindle motor can be coupled independently as well, as shown in the embodiment of FIG. **3**, or it can be coupled to into the drive system of those that can accommodate such an implementation, as illustrated in FIGS. **10** and **11**.

Finally, it will be further appreciated by those of skill in the art that the torque assist system **100** of the invention can be implemented as an aftermarket upgrade package of components that have been customized for installation on various makes and models of such conveyance machines, the torque assist system **100** of the invention can also be built into an OEM purpose built conveyance machine as well.

What is claimed is:

1. A conveyance machine comprising:

an internal combustion engine having a drive system coupled to a track, the engine being configured to apply rotational force to the track through the drive system to propel said conveyance machine in a forward direction along the ground, the engine being configured to produce torque relative to its rotational speed in response to an engine throttle;

an engine cooling system filled with cooling fluid, the cooling system for pumping the cooling fluid through the engine during its operation to draw heat from the engine into the cooling fluid and further through a first heat exchanger by which to transfer the heat from the cooling fluid to ambient air, the engine cooling system having a source coolant line to conduct heated coolant fluid exiting the engine to the first heat exchanger;

an electric motor powered by a battery and being coupled to the track through a motor driver, the electric motor configured to apply rotational force to the track through the driver, in parallel with the engine, to turn the track and thereby propel the conveyance machine in either a forward or reverse direction, the motor being configured to produce peak torque relative to its rotational speed in response to a motor throttle, the battery and the first heat exchanger disposed in a heat isolating housing;

a motor controller, the motor controller being coupled to the battery and the motor to control the magnitude of current being delivered from the battery to the motor in response to a signal provided from the motor throttle to the controller and in accordance with a specified torque profile and a battery temperature assist system including:

a secondary source coolant line in fluid communication with the source coolant line of the engine cooling system to divert a fraction of the heated cooling fluid therefrom;

a second heat exchanger in thermal communication with the battery, the second heat exchanger configured to receive the diverted fraction of the heated cooling fluid and to transfer the heat from the heated cooling fluid to the battery as it flows therethrough; and

a secondary return coolant line in fluid communication with the source coolant line of the engine cooling system to return the diverted fraction of the cooling fluid back to the engine cooling system,

wherein the torque that can be produced by the electric motor peaks over a range of rotational speed of the track that is different than the range of rotational speed of the track at which the torque that can be produced by the engine peaks.

2. The conveyance machine of claim **1**, wherein the secondary return coolant line further includes a valve disposed therein to interrupt circulation of the diverted fraction of the cooling fluid through the second heat exchanging body when the diverted fluid exits the second heat exchanger at a temperature that exceeds a predetermined temperature.

3. The conveyance machine of claim **2**, wherein the valve is a thermostatically controlled ball valve.

4. The conveyance machine of claim **1**, wherein the heat isolating housing further includes at least one thermostatically controlled fan for cooling the battery when the temperature inside the housing reaches or exceeds a predetermined temperature.

5. The conveyance machine of claim **1**, wherein the battery housing and the controller are surrounded by a fairing coupled to and supported by the conveyance machine, the fairing providing protection from at least weather related elements.

6. The conveyance machine of claim **1** wherein the motor controller is coupled to a processing device, the processing device executing an app program that downloads the torque profile when selected from a plurality of torque profiles through a user interface.

7. The conveyance machine of claim **5**, wherein the controller places the motor in a regenerative braking mode when the motor throttle is at a zero current position to cause the motor to generate current that re-charges the battery.

8. The conveyance machine of claim **5**, wherein the fairing includes snow filtered adjustable vents to allow cool air to moderate the temperature of the battery.

9. A conveyance machine comprising:

an internal combustion engine having a drive system coupled to a track, the engine being configured to apply rotational force to the track through the drive system to propel said conveyance machine in a forward direction along the ground, the engine being configured to produce torque relative to its rotational speed in response to an engine throttle;

an electric motor powered by a battery and being coupled to the track through a motor driver, the electric motor configured to apply rotational force to the track through the driver, in parallel with the engine, to turn the track and thereby propel the conveyance machine, in either a forward or reverse direction, the motor being configured to produce peak torque relative to its rotational speed in response to a motor throttle;

a motor controller coupled to the battery and the motor, the motor controller configured to control the magnitude of the current being delivered from the battery to the motor at least in response to a signal provided from the motor throttle to the controller and in accordance with a specified torque profile; and

a processing device, in communication with the motor controller, which is configurable to run application programs that include a user interface through which parametric information may be input by a user to dictate to the controller how the motor performs, the parametric information including the torque profile.

10. The conveyance machine of claim **9**, wherein when the motor throttle is at a zero current position, the controller places the motor in a regenerative braking mode to generate charging current to re-charge the battery.

11. The conveyance machine of claim **10**, wherein a user specifies a braking level of the regenerative braking mode through an app executed by the processing device, causing the controller to establish a magnitude of EMF (electromotive force) generated by the motor that correlates to the specified braking level.

12. The conveyance machine of claim **9**, wherein the electric motor is a hub motor, the hub motor having a fixed axle, the fixed axle being supported at both ends by a pair of suspension rails, the hub motor having teeth by which to engage with and drive the track.

13. The conveyance machine of claim **12**, wherein said conveyance machine is a snow bike, and the hub motor has been mounted in place of a rear track tensioner wheel of the snow bike.

14. The conveyance machine of claim **12**, wherein said conveyance machine is a snowmobile, and the hub motor has been mounted in place of a rear track tensioner wheel of the snowmobile.

15. The conveyance machine of claim **9**, wherein the electric motor is a spindle motor having a spindle drive motor, a driver having a drive shaft, and a sprocket coupled to the drive shaft, the spindle drive motor being coupled through a chain to a sprocket to turn the drive shaft, the drive shaft being supported at both ends by one of a pair of suspension rails, the driver having teeth by which to engage with and drive the track.

16. The conveyance machine of claim **15**, wherein said conveyance machine is a snow bike, and the drive of the spindle motor has been mounted in place of a rear track tensioner wheel of the snow bike.

17. The conveyance machine of claim **15**, wherein said conveyance machine is a snowmobile, and the drive of the spindle motor has been mounted in place of a rear track tensioner wheel of the snowmobile.

18. The conveyance machine of claim **15**, wherein the sprocket of the spindle motor is coupled directly to a sub-drive shaft of the engine drive system.

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