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(71) Applicant: **MIDTRONICS, INC.** [US/US]; 7000 Monroe Street, Willowbrook, IL 60527 (US).

(72) Inventor: **BERTNESS, Kevin, I.**; 1317 Mcclurg Drive, Batavia, IL 60510 (US).

(74) Agents: **CHAMPLIN, Judson, K.** et al.; Westman, Champlin & Koehler, P.A., 900 Second Avenue South, Suite 1400, Minneapolis, MN 55402-3319 (US).

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(54) Title: ALTERNATOR TESTER

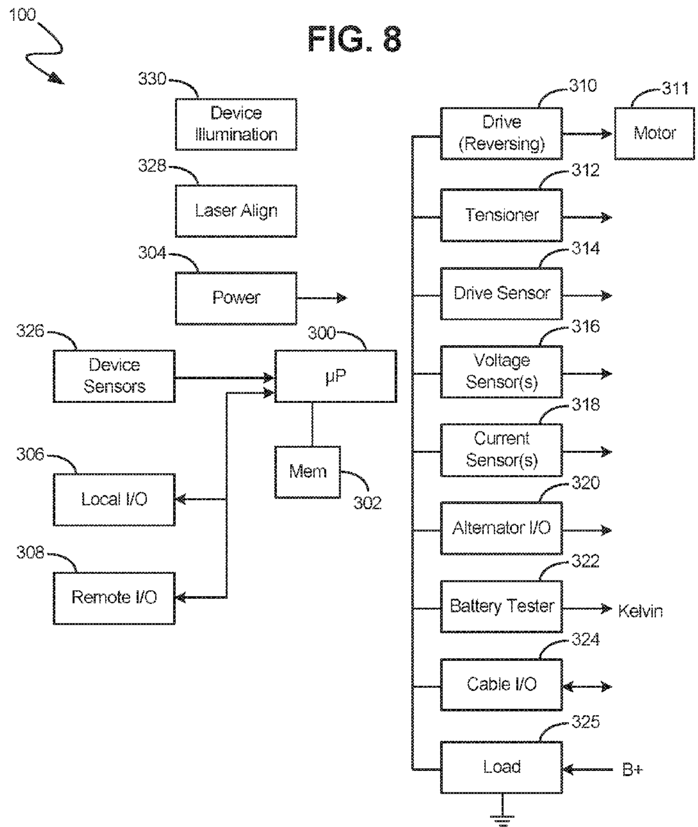

FIG. 8

(57) Abstract: An alternator tester (100) is configured to test an alternator (102) of a vehicle (104), the alternator (102) of the type which electrically couples to the vehicle through an alternator connector. The alternator tester (100) includes alternator test circuitry (300) and an alternator test connector or adapter (108) configured to electrically connect the test circuitry to the alternator. An optional vehicle connector is configured to electrically connect the test circuitry (300) to the vehicle (102) through the alternator connector (108). The test circuitry (300) is configured to interact with the alternator (102) through the alternator test connector (108) and thereby test operation of the alternator (102).

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ALTERNATOR TESTER

BACKGROUND

[0001] The present invention relates to automotive vehicles. More specifically, the present invention relates to testing of alternators in such vehicles.

[0002] Automotive vehicles include a storage battery for operating electronics in the vehicle and using an electric starter to start the vehicle engine. A battery charging system includes an alternator which is coupled to the engine and is powered by the engine when the vehicle is running. The charging system is used to charge the storage battery when the vehicle is operating.

[0003] Many techniques have been developed for testing the battery and related systems of the vehicle. Example techniques that have been pioneered by Dr. Keith S. Champlin and Midtronics, Inc. are shown and described in U.S. Patent No. 3,873,911, issued March 25, 1975, to Champlin; U.S. Patent No. 3,909,708, issued September 30, 1975, to Champlin; U.S. Patent No. 4,816,768, issued March 28, 1989, to Champlin; U.S. Patent No. 4,825,170, issued April 25, 1989, to Champlin; U.S. Patent No. 4,881,038, issued November 14, 1989, to Champlin; U.S. Patent No. 4,912,416, issued March 27, 1990, to Champlin; U.S. Patent No. 5,140,269, issued August 18, 1992, to Champlin; U.S. Patent No. 5,343,380, issued August 30, 1994; U.S. Patent No. 5,572,136, issued November 5, 1996; U.S. Patent No. 5,574,355, issued November 12, 1996; U.S. Patent No. 5,583,416, issued December 10, 1996; U.S. Patent No. 5,585,728, issued December 17, 1996; U.S. Patent No. 5,589,757, issued December 31, 1996; U.S. Patent No. 5,592,093, issued January 7, 1997; U.S. Patent No. 5,598,098, issued January 28, 1997; U.S. Patent No. 5,656,920, issued August 12, 1997; U.S. Patent No. 5,757,192, issued May 26, 1998; U.S. Patent No. 5,821,756, issued October 13, 1998; U.S. Patent No. 5,831,435, issued November 3, 1998; U.S. Patent No. 5,871,858, issued February 16, 1999; U.S. Patent No. 5,914,605, issued June 22, 1999; U.S. Patent No. 5,945,829, issued August 31, 1999; U.S. Patent No. 6,002,238, issued December 14, 1999; U.S. Patent No. 6,037,751, issued March 14, 2000; U.S. Patent No. 6,037,777, issued March 14, 2000; U.S. Patent No. 6,051,976, issued April 18, 2000; U.S. Patent No. 6,081,098, issued June 27, 2000; U.S. Patent No. 6,091,245, issued July 18, 2000; U.S. Patent No. 6,104,167, issued August 15, 2000; U.S. Patent No. 6,137,269, issued October 24, 2000; U.S. Patent No. 6,163,156, issued December 19, 2000; U.S. Patent No. 6,172,483, issued January 9, 2001; U.S. Patent No. 6,172,505, issued January 9, 2001; U.S. Patent No. 6,222,369, issued April 24, 2001; U.S. Patent No.

6,225,808, issued May 1, 2001; U.S. Patent No. 6,249,124, issued June 19, 2001; U.S. Patent No. 6,259,254, issued July 10, 2001; U.S. Patent No. 6,262,563, issued July 17, 2001; U.S. Patent No. 6,294,896, issued September 25, 2001; U.S. Patent No. 6,294,897, issued September 25, 2001; U.S. Patent No. 6,304,087, issued October 16, 2001; U.S. Patent No. 6,310,481, issued October 30, 2001; U.S. Patent No. 6,313,607, issued November 6, 2001; U.S. Patent No. 6,313,608, issued November 6, 2001; U.S. Patent No. 6,316,914, issued November 13, 2001; U.S. Patent No. 6,323,650, issued November 27, 2001; U.S. Patent No. 6,329,793, issued December 11, 2001; U.S. Patent No. 6,331,762, issued December 18, 2001; U.S. Patent No. 6,332,113, issued December 18, 2001; U.S. Patent No. 6,351,102, issued February 26, 2002; U.S. Patent No. 6,359,441, issued March 19, 2002; U.S. Patent No. 6,363,303, issued March 26, 2002; U.S. Patent No. 6,377,031, issued April 23, 2002; U.S. Patent No. 6,392,414, issued May 21, 2002; U.S. Patent No. 6,417,669, issued July 9, 2002; U.S. Patent No. 6,424,158, issued July 23, 2002; U.S. Patent No. 6,441,585, issued August 17, 2002; U.S. Patent No. 6,437,957, issued August 20, 2002; U.S. Patent No. 6,445,158, issued September 3, 2002; U.S. Patent No. 6,456,045; U.S. Patent No. 6,466,025, issued October 15, 2002; U.S. Patent No. 6,465,908, issued October 15, 2002; U.S. Patent No. 6,466,026, issued October 15, 2002; U.S. Patent No. 6,469,511, issued November 22, 2002; U.S. Patent No. 6,495,990, issued December 17, 2002; U.S. Patent No. 6,497,209, issued December 24, 2002; U.S. Patent No. 6,507,196, issued January 14, 2003; U.S. Patent No. 6,534,993; issued March 18, 2003; U.S. Patent No. 6,544,078, issued April 8, 2003; U.S. Patent No. 6,556,019, issued April 29, 2003; U.S. Patent No. 6,566,883, issued May 20, 2003; U.S. Patent No. 6,586,941, issued July 1, 2003; U.S. Patent No. 6,597,150, issued July 22, 2003; U.S. Patent No. 6,621,272, issued September 16, 2003; U.S. Patent No. 6,623,314, issued September 23, 2003; U.S. Patent No. 6,633,165, issued October 14, 2003; U.S. Patent No. 6,635,974, issued October 21, 2003; U.S. Patent No. 6,696,819, issued February 24, 20144; U.S. Patent No. 6,707,303, issued March 16, 2004; U.S. Patent No. 6,737,831, issued May 18, 2004; U.S. Patent No. 6,744,149, issued June 1, 2004; U.S. Patent No. 6,759,849, issued July 6, 2004; U.S. Patent No. 6,781,382, issued August 24, 2004; U.S. Patent No. 6,788,025, filed September 7, 2004; U.S. Patent No. 6,795,782, issued September 21, 2004; U.S. Patent No. 6,805,090, filed October 19, 2004; U.S. Patent No. 6,806,716, filed October 19, 2004; U.S. Patent No. 6,850,037, filed February 1, 2005; U.S. Patent No. 6,850,037, issued February 1, 2005; U.S. Patent No. 6,871,151, issued march 22, 2005; U.S. Patent No. 6,885,195, issued April 26, 2005;

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STORAGE; U.S. Serial No. 10/174,110, filed June 18, 2002, entitled DAYTIME RUNNING LIGHT CONTROL USING AN INTELLIGENT POWER MANAGEMENT SYSTEM; U.S. Serial No. 10/258,441, filed April 9, 2003, entitled CURRENT MEASURING CIRCUIT SUITED FOR BATTERIES; U.S. Serial No. 10/681,666, filed October 8, 2003, entitled ELECTRONIC BATTERY TESTER WITH PROBE LIGHT; U.S. Serial No. 60/587,232, filed December 14, 2004, entitled CELLTRON ULTRA, U.S. Serial No. 60/653,537, filed February 16, 2005, entitled CUSTOMER MANAGED WARRANTY CODE; U.S. Serial No. 60/665,070, filed March 24, 2005, entitled OHMMETER PROTECTION CIRCUIT; U.S. Serial No. 60,694,199, filed June 27, 2005, entitled GEL BATTERY CONDUCTANCE COMPENSATION; U.S. Serial No. 60/705,389, filed August 4, 2005, entitled PORTABLE TOOL THEFT PREVENTION SYSTEM, U.S. Serial no. 11/207,419, filed August 19, 2005, entitled SYSTEM FOR AUTOMATICALLY GATHERING BATTERY INFORMATION FOR USE DURING BATTERY TESTER/CHARGING, U.S. Serial No. 60/712,322, filed August 29, 2005, entitled AUTOMOTIVE VEHICLE ELECTRICAL SYSTEM DIAGNOSTIC DEVICE, U.S. Serial No. 60/713,168, filed August 31, 2005, entitled LOAD TESTER SIMULATION WITH DISCHARGE COMPENSATION, U.S. Serial No. 60/731,881, filed October 31, 2005, entitled PLUG-IN FEATURES FOR BATTERY TESTERS; U.S. Serial No. 60/731,887, filed October 31, 2005, entitled AUTOMOTIVE VEHICLE ELECTRICAL SYSTEM DIAGNOSTIC DEVICE; U.S. Serial No. 60/751,853, filed December 20, 2005, entitled BATTERY MONITORING SYSTEM; U.S. Serial No. 60/751,853, filed December 20, 2005, entitled BATTERY MONITORING SYSTEM; U.S. Serial No. 11/356,443, filed February 16, 2006, entitled ELECTRONIC BATTERY TESTER WITH NETWORK COMMUNICATION; U.S. Serial No. 60/847,064, filed September 25, 2006, entitled STATIONARY BATTERY MONITORING ALGORITHMS; U.S. Serial No. 60/950,182, filed July 17, 2007, entitled BATTERY TESTER FOR HYBRID VEHICLE; U.S. Serial No. 60/973,879, filed September 20, 2007, entitled ELECTRONIC BATTERY TESTER FOR TESTING STATIONARY BATTERIES; U.S. Serial No. 60/992,798, filed December 6, 2007,entitled STORAGE BATTERY AND BATTERY TESTER; U.S. Serial No. 61/061,848, filed June 16, 2008, entitled KELVIN CLAMP FOR ELECTRONICALLY COUPLING TO A BATTERY CONTACT; U.S. Serial No. 12/697,485, filed February 1, 2010, entitled ELECTRONIC BATTERY TESTER;

U.S. Serial No. 12/712,456, filed February 25, 2010, entitled METHOD AND APPARATUS FOR DETECTING CELL DETERIORATION IN AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Serial No. 61/311,485, filed March 8, 2010, entitled BATTERY TESTER WITH DATABUS FOR COMMUNICATING WITH VEHICLE ELECTRICAL SYSTEM; U.S. Serial No. 61/313,893, filed March 15, 2010, entitled USE OF BATTERY MANUFACTURE/SELL DATE IN DIAGNOSIS AND RECOVERY OF DISCHARGED BATTERIES; U.S. Serial No. 12/769,911, filed April 29, 2010, entitled STATIONARY BATTERY TESTER; U.S. Serial No. 61/330,497, filed May 3, 2010, entitled MAGIC WAND WITH ADVANCED HARNESS DETECTION; U.S. Serial No. 61/348,901, filed May 27, 2010, entitled ELECTRTONIC BATTERY TESTER; U.S Serial No. 61/351,017, filed June 3, 2010, entitled IMPROVED ELECTRIC VEHICLE AND HYBRID ELECTRIC VEHICLE BATTERY MODULE BALANCER; U.S. Serial No. 12/818,290, filed June 18, 2010, entitled BATTERY MAINTENANCE DEVICE WITH THERMAL BUFFER; U.S. Serial No. 61/373,045, filed August 12, 2010, entitled ELECTRONIC BATTERY TESTER FOR TESTING STATIONARY STORAGE BATTERY; U.S. Serial No. 12/888,689, filed September 23, 2010, entitled BATTERY TESTER FOR ELECTRIC VEHICLE; U.S. Serial No. 61/411,162, filed November 8, 2010, entitled ELECTRONIC BATTERY TESTER; U.S. Serial No. 13/037,641, filed March 1, 2011, entitled :MONITOR FOR FRONT TERMINAL BATTERIES; U.S. Serial No. 13/098,661, filed May 2, 2011, entitled METHOD AND APPARATUS FOR MEASURING A PARAMETER OF A VEHICLE ELECTRICAL SYSTEM; U.S. Serial No. 13/152,711, filed June 3, 2011, entitled BATTERY PACK MAINTENANCE FOR ELECTRIC VEHICLE; U.S. Serial No. 61/558,088, filed November 10, 2011, entitled BATTERY PACK TESTER; U.S. Serial No. 13/357,306, filed January 24, 2012, entitled STORAGE BATTERY AND BATTERY TESTER; U.S. Serial No. 61/665,555, filed June 28, 2012, entitled HYBRID AND ELECTRIC VEHICLE BATTERY MAINTENANCE DEVICE; U.S. Serial No. 13/668,523, filed November 5, 2012, entitled BATTERY TESTER FOR ELECTRIC VEHICLE; U.S. Serial No. 13/672,186, filed November 8, 2012, entitled BATTERY PACK TESTER; U.S. Serial No. 61/777,360, filed March 12, 2013, entitled DETERMINATION OF STARTING CURRENT IN AN AUTOMOTIVE VEHICLE; U.S. Serial No. 61/777,392, filed March 12, 2013, entitled DETERMINATION OF CABLE DROP DURING A STARTING EVENT IN AN

AUTOMOTIVE VEHICLE; U.S. Serial No. 13/827,128, filed March 14, 2013, entitled HYBRID AND ELECTRIC VEHICLE BATTERY MAINTENANCE DEVICE; U.S. Serial No. 61/789,189, filed March 15, 2013, entitled CURRENT CLAMP WITH JAW CLOSURE DETECTION; U.S. Serial No. 61/824,056, filed May 16, 2013, entitled BATTERY TESTING SYSTEM AND METHOD; US Serial No. 61/859,991, filed July 30, 2013, entitled METHOD AND APPARATUS FOR MONITRING A PLURALITY OF STORAGE BATTERIES IN A STATIONARY BACK-UP POWER SYSTEM; U.S. Serial No. 14/039,746, filed September 27, 2013, entitled BATTERY PACK MAINTENANCE FOR ELECTRIC VEHICLE; U.S. Serial No. 61/915,157, filed December 12, 2013, entitled BATTERY TESTER AND BATTERY REGISTRATION TOOL; US Serial No. 61/928,167, filed January 16, 2014, entitled BATTERY CLAMP WITH ENDOSKELETON DESIGN; US Serial No. 14/204,286, filed March 11, 2014, entitled CURRENT CLAMP WITH JAW CLOSURE DETECTION; US Serial No. 14/276,276, filed May 13, 2014, entitled BATTERY TESTING SYSTEM AND METHOD; US Serial No. 62/024,037, filed July 14, 2014, entitled COMBINATION SERVICE TOOL; US Serial No. 62/055,884, filed September 26, 2014, entitled CABLE CONNECTOR FOR ELECTORNIC BATTERY TESTER; US Serial No. 14/565,689, filed December 10, 2014, entitled BATTERY TESTER AND BATTERY REGISTRATION TOOL; US Serial No. 14/598,445, filed January 16, 2015, entitled BATTERY CLAMP WITH ENDOSKELETON DESIGN; US Serial No. 62/107,648, filed January 26, 2015, entitled ALTERNATOR TESTER; US Serial No. 62/137,491, filed March 24, 2015, entitled BATTERY MAINTENANCE SYSTEM; US Serial No. 62/154,251, filed April 29, 2015, entitled CALIBRATION AND PROGRAMMING OF IN-VEHICLE BATTERY SENSORS; US Serial No. 62/155,045, filed April 30, 2015, entitled CALIBRATION AND PROGRAMMING OF IN-VEHICLE BATTERY SENSORS; US Serial No. 62/161,555, filed May 14, 2015, entitled ALTERNATOR TESTER, US Serial No. 14/799,120, filed July 14, 2015, entitled AUTOMOTIVE MAINTENANCE SYSTEM; US Serial No. 14/861,027, filed September 22, 2015, entitled CABLE CONNECTOR FOR ELECTRONIC BATTERY TESTER; US Serial No. 62/233,614, filed September 28, 2015, entitled KELVIN CONNECTOR ADAPTOR FOR STORAGE BATTERY; all of which are incorporated herein by reference in their entireties.

[0004] With the advent of accurate battery testing, it has become apparent that in some instances the battery in the vehicle may be good, and a problem related to the battery charging system is the cause of the perceived battery failure. A vehicle charging system generally includes the battery, an alternator, a regulator and an alternator drive belt. The role of the charging system is two fold. First, the alternator provides charging current for the battery. This charging current ensures that the battery remains charged while the vehicle is being driven and therefore will have sufficient capacity to subsequently start the engine. Second, the alternator provides an output current to power all of the vehicle electrical loads. In general, the alternator output, the battery capacity, the starter draw and the vehicle electrical load requirements are matched to each other for optimal performance. In a properly functioning charging system, the alternator will be capable of outputting enough current to drive the vehicle electrical loads while simultaneously charging the battery. Typically, alternators range in size from 60 to 120 amps.

[0005] There is a significant problem in the automotive industry with alternators that are replaced and subsequently determined to be in working condition. With alternators, this problem is even more significant than in the case of a storage battery which is replaced unnecessarily. This is because alternators may be much more expensive as well as much more difficult to replace than a storage battery.

[0006] Further, removing of an alternator from a vehicle, testing the alternator itself may be problematic. The alternator may be designed to communicate with a control system of the vehicle. Further, the complete testing of the alternator requires application of electrical loads while also applying a mechanical input to the alternator.

[0007] The difficulty in testing an alternator may result in an unnecessary warranty claims, expenses to vehicle owners, and a failure to identify a failure in a vehicle charging system.

SUMMARY

[0008] An alternator tester is configured to test an alternator of a vehicle, the alternator of the type which electrically couples to the vehicle through an alternator connector. The alternator tester includes alternator test circuitry and an alternator test connector or adapter configured to electrically connect the test circuitry to the alternator connector. An optional vehicle connector is configured to electrically connect the test circuitry to the vehicle through the alternator connector. The test circuitry is configured to interact with the alternator through the alternator test connector and thereby test operation of the alternator. A configuration for testing an alternator out of a vehicle is also provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a simplified block diagram showing an alternator tester having an adapter plug electrically coupled between an alternator and other components of an automotive vehicle.

[00010] FIG. 2 is a perspective view of an alternator tester in accordance with one example configuration.

[00011] FIG. 3 is a perspective view of an alternator secured by a belt.

[00012] FIG. 4 is a top perspective view of the alternator tester of FIG. 2 in which a perspective cover is opened.

[00013] FIG. 5 is a side plan view of an alternator mounted in the alternator tester of FIG. 4.

[00014] FIG. 6 illustrates a laser to align a belt.

[00015] FIG. 7 is a side plan view illustrating belt tensioners used to tension a belt used to drive an alternator.

[00016] FIG. 8 is a simplified block diagram of an alternator in accordance with one example embodiment.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[00017] In various aspects, the present invention provides an alternator or starter motor tester which includes alternator test circuitry which is electrically coupled between an alternator and other components of an automotive vehicle. An optional clamp on amp meter (amp clamp) or other current sensor can be configured to electrically couple to an alternator output B+ cable. The clamp on amp meter can communicate wirelessly, for example through a Bluetooth® connection, to other equipment. Further, the tester can be configured to work with an alternator or starter motor that has been removed from a vehicle.

[00018] Alternators are used in automotive vehicles to provide power to the electrical system of the vehicle as well as charge a battery of the vehicle. There are many types of alternator configurations and they vary between vehicles as well as manufacturers. In general, an alternator has at least two outputs, a ground and a powered output which is sometimes referred to as the B+ connection. The alternator acts as an electrical generator and is typically rotated by an internal combustion engine in the vehicle. Other typical connections to an alternator include a connection to an ignition switch as well as connections for an external voltage regulator. Additionally, some alternators include an internal voltage regulator and/or diodes for rectifying an AC charge signal generated by the alternator. Further still, some more complex alternators may include internal sensors for use in diagnostics as well as a databus connection for coupling to a databus of a vehicle. Some alternators also include connections for connecting to external sensors such as a voltage or current sensor located proximate the vehicle battery. Similarly, starter motors in vehicles vary greatly in their configuration. A typical starter motor has at least two electrical connections, one to electrical ground and a switchable power connection used to power an electrical motor of the alternator and thereby crank the internal combustion engine of the vehicle. The power connection is typically controlled by an electrical relay connected to the key switch of the vehicle. Closing this relay completes an electrical circuit with the vehicle battery. Some starter motors include additional connections including connections to external sensors, connecting to internal sensors of the starter motor, and may even include a connection for coupling to a databus of the vehicle. The variability between various alternator and starter motor configurations makes it difficult to test the performance of more than one specific configuration.

[00019] A universal connector system may be implemented which includes one or more specific adapter cables that are configured to be plugged into particular vehicle types and/or alternator types. This allows the alternator test circuitry to be placed between the vehicle and the alternator to thereby monitor signals which are exchanged therebetween as well as send commands or other information over this connection. The cable can also be used to control and monitor operation of the alternator for bench (out of vehicle) testing.

[00020] The communication may occur using any appropriate technique including communicating with vehicle circuitry over an OBDII module. This allows the device to query the VIN number as well as other information from the vehicle including determining specifics vehicle type, control, RPM, particular loads of the vehicle, etc.

[00021] The alternator tester may also communicate with other equipment including a battery tester such as those in accordance with the various techniques set forth herein as well as a charger which can monitor battery voltage, apply loads, etc. The communication with the OBDII system may be directly or also may also be routed through the tester, etc.

[00022] FIG. 1 shows a simplified schematic diagram of an adapter cable 108 for use alternator tester 100 (shown in Figure 2) connected between the alternator 102 and the vehicle 104. For example, the alternator and vehicle may be coupled together through electrical plugs or other connectors. These connections can be separated and the alternator tester plugged therebetween. This allows communication and control over the system through the various connectors including a sense connector, a pulse width modulated (PWM) connection, CAN, LIN, etc. The various physical connectors and communication protocols are chosen for a specific vehicle and alternator under test. Alternator 102 also includes a B+ connection which provides a charging output to the battery of the vehicle. A current sensor (not shown in FIG. 1) such as an amp clamp or other type of sensor, may be coupled to the B+ output or electrical ground and used to monitor the amount of current provided by the alternator 102 as well as the waveform of this current. Additionally, voltage sensors may also be employed.

[00023] In operation, a technician electrically couples the amp clamp to the alternator 102 B+ cable. The electrical connections/cables which extend between the alternator and the vehicle are unplugged and the technician plugs the adapter cable 108 of the alternator 104 into these connections. The alternator test circuitry 100 may than monitor a communication that occurs between the vehicle 104 and the alternator 102 and simply pass signals therebetween. Such information and communication could include commands sent from the vehicle 104, particular responses or commands from the alternator 102, responses of the vehicle 104 to particular events or communications from the alternator 102, loading of the electrical system, changes in the RPM of a motor of the vehicle 104, etc. When used during bench testing, the cable 108 can be used to control operation of the alternator 102 as well as monitor its operation.

[00024] After observing communication between the alternator 102 and the vehicle 104 during normal operation, the test circuitry 100 may than break the electrical connection and insert itself into the communication. This allows the test circuitry 100 to operate as if it was the vehicle sending commands to the alternator and observing responses including changes in the charge signal from the alternator 102. Similarly, the test circuitry 100 may operate as if it was the alternator 102 sending and receiving commands and information from the vehicle 104 and observing such operation.

[00025] This allows a determination to be made as to the root cause of a problem. The cause of a charging problem may be isolated as between a problem within an alternator 102 itself, a problem related to the vehicle 104 including engine control or commands or other information communicated with the alternator 102, electrical wiring, sensed leads, etc. The use of an optional battery test may also be implemented to further isolate problems in the electrical system.

[00026] If Bluetooth® or other communication circuitry 110 is provided, a technician may be able to remotely monitor the test circuitry 100 or communicate with cable 108, including communicating with the adapter cable 108 while the technician operates the vehicle 104. The technician can communicate with the adapter cable using remote unit 120. The test circuitry and/or adapter cable 108 may also include a local input or output including a display or command buttons for use by the technician. Further, data collected during monitoring or testing may be logged in a memory 112 of the cable adapter 108 for subsequent examination.

[00027] The device 100 may optionally be coupled to the vehicle for long-term operation. For example, a customer may be instructed to use their vehicle 104 for the period of time with the cable adapter 10 monitoring operation and performing diagnostics.

[00028] The cable adapter 108 may include other communication circuitry as well as other sensors or sense circuitry as appropriate for the various vehicles 104 and/or alternators 102 which may be tested. An optional internal power supply may be used or the device may be powered with power received from the vehicle itself. A remote wireless display and/or input or other control 120 may be used to allow the operator to monitor and control the cable adapter 108 or the test circuitry 100. Collected information including test results, type of vehicle, VIN number, type of alternator, etc. may also be collected and communicated to a remote location such as a remote database, a manufacturer or warranty service location, etc.

[00029] The databus connections to the cable 110 can also be used to provide additional functionality. For example, a microprocessor or other logic may be added to the cable 108 by a user, for example in the field. This allows additional features or upgrades to be provided to the cable 108 after an initial sale or installation. In such a configuration, a module containing the additional functionality is coupled to the cable 108 and interfaced to the databus. This module may be powered internally, or may receive power from the cable 108 itself, including, for example, through a connection to the vehicle 104. Further, additional relay logic or other functionality including additional sensors, connectors for additional communications, etc. may be provided.

[00030] The alternator tester system 100 discussed herein may also be configured to function and test an alternator which has been removed from a vehicle. In such a configuration, the alternator tester 100 includes a motor or other actuator to rotate the alternator causing the alternator to function. In such a configuration, the vehicle interface discussed above is not required. The alternator tester may include a storage battery or a load configured to simulate a storage battery for performing diagnostics. In such a configuration, the battery itself may also be tested using the techniques discussed herein.

[00031] A universal drive system may be provided in which a groove/V-belt is configured to couple to the alternator and cause the alternator to be rotated. An arrangement is provided in which an alternator is mounted in a test fixture, a belt connected to the alternator, and the belt tension so that the alternator is caused to rotate by movement of the belt. This configuration can be held in place on the pulley of a motor by belt tensioners or the like. The alternator can be placed in a linear actuator that can be configured to lift or otherwise move the alternator with respect to the motor pulley on the drive belt to thereby tension the drive belt. A strap or other attachment mechanism can be used to fasten the alternator to the linear actuator on a temporary basis. A lifting lever or the like applies compression against the cost rate spring to the linear actuator to thereby take up slack and provide belt tension. Variations in travel due to different sized alternators can then be absorbed by the springs. The locking and positioning of the alternator 102 within the tester 100 can be performed manually by an operator, or may be performed automatically by the tester 100.

[00032] The alternator, belt and drive pulley can be enclosed in an enclosure for safety purposes. The enclosure may include safety cover with a window and include mechanical interlocks that can be pulled over the device. The safety cover can also latch the lifting lever into place to thereby ensure belt tension during testing. Optional lifting mechanisms may be employed to accommodate different alternator configurations.

[00033] A selectable electrical load can be applied to the alternator during testing. For example, 5, 10, 15 and 20 amp load currents can be drawn from the alternator and using resistive loads that are digitally actuated and combined in various combinations to achieve loads which draw from between 5 amps up to 50 amps. A motor can be powered by standard wall current for example, 115 VAC such as a 1.5 hp motor, which is used to power the alternator up to its maximum output. The motor can include a start capacitor for assisting in startup. The amp clamp discussed above can be used with a B+ output from the alternator passing through a wire and to the load. The amp clamp can be placed around the wire to monitor current flow. In one configuration, the B+ and grounding cables are implemented with low cost weld connectors. A separate or integral battery tester can also be employed. In one configuration, the battery tester docks with the alternator base to perform battery testing and communicate with internal control circuits in the tester 100. Wireless communication may also be implemented. The alternator tester 100 may also provide other communication techniques including WiFi, Ethernet, Bluetooth(TM), cellular, etc. Specific cables may be employed for specific types of alternators and may include identification information stored either visually and/or using other techniques such as RFID or NFC tags or using other storage techniques. Similarly, a memory or the like may be used to store information in the cable connector, including resistors which can be programmed as desired. The alternator tester may include an optional output such as a video display screen to show connection diagrams, instructions videos, test results, etc. The information may be stored in memory or provided live from an external source such as the internet, data cloud, etc.

[00034] FIG. 2 is a perspective view showing alternator tester 100 including a base 202 and a protective cover 204. The alternator 102 may be mounted on the base 202 at an operator protected during operation by protective cover 204. FIG. 2 also shows an input/output counsel 206 including a display 208 and a manual input such as a keypad 210. A battery tester 212 is also illustrated as mounted in the base 202. FIG. 3 is a perspective view showing alternator 102 mounted within the base 202 and secured by a mounting strap 220 having an adjustable buckle 222. As illustrated in FIG. 3, alternator 102 includes an alternator body 228 and mounting apertures 230. Mounting apertures 230 are configured to be mounted using bolts or the like to the engine of the vehicle. The alternator 102 also includes a pulley 232 arranged to couple to a drive belt in the vehicle. In one configuration, the mounting strap 220 and adjustable buckle are configured to manually or automatically clamp and secure the alternator 102. For example, a drive motor or other actuator may be connected to the belt 220 to apply the desired tension.

Additionally, a rubber mount or other compliant component can be arranged to support the base of the alternator.

[00035] FIG. 4 is a view of the tester 100 with the lid 204 opened. As illustrated in FIG. 4, a shaft 250 is arranged to be received through the mounting apertures 230 of the alternator 102. The alternator body 228 rests in a support 252 and a drive belt 254 is placed around the pulley 232. The support 252 and shaft 250 are carried on a support plate 256 which can be adjusted laterally with respect to the belt 254 using horizontal actuator handle 258. Probe clips 260 and 262 are provided and can be used, for example, to connect to the ground and B+ connection of the alternator 102. An amp clamp 264 may also be provided for measuring current flow. A vertical actuator handle 264 is provided and arranged to raise the support plate 256 as illustrated in FIG. 5. Prior to testing, the alternator 102 is raised using actuator handle 264 whereby the pulley 232 is tightly pressed against the drive belt 254.

[00036] As illustrated in FIG. 4, a laser light source 270 is provided and arranged to project a linear beam 268 onto the drive belt 254. As illustrated in FIG. 6, the drive belt 254 includes an alignment mark 272. The horizontal actuator handle 258 can be used to move the alternator 102 horizontally whereby the alignment mark 272 is brought into alignment with the linear beam 268. This ensures that the alternator 102 can be operated at high speed without any lateral offset with between the alternator pulley and the belt 254.

[00037] As illustrated in FIG. 7, the drive belt 254 is driven by a drive wheel 280 within the tester 100. A tensioning mechanism 282 is provided in which armatures 284 rotate about pivots 286 to apply a desired tension to the belt 254 through rollers 288. The tensioning mechanism 282 may be driven manually by an operator or the tester 100 may automatically actuate the tensioners 282 to provide the desired tension. A linear actuator, rotary gear motor, or the like may be employed to actuate the tensioning mechanism 282. The appropriate tension level can be determined by, for example, by monitoring the voltage or current output from the alternator 102 as well as monitoring the amount of torque required to rotate the drive wheel 280.

[00038] FIG. 8 is a simplified block diagram of alternator tester 100 showing various components of the system. Alternator tester 100 includes a microprocessor 300 or other controller which operates in accordance with instructions stored in a memory 302. Memory 302 can also be used to store other information including information regarding the alternator under test, test criteria, test rules, test measurements, test results, information related to an operator or a location, instructions which may be provided to an operator, etc. Test system 100 also includes a power supply 304 used to power the various components of the device. A local I/O 306 is provided and may comprise, for example, a user output such as a display as well as a user input such as a keyboard, touchpad, touchscreen, etc. The local I/O may also include other types of input/output circuitry including a barcode scanner, local Bluetooth® communication circuitry, RF communication circuitry, etc. Remote I/O circuitry 304 is also provided as a way to communicate with the remote location using wireless or wired communication protocols including, for example, WiFi, Ethernet, cellular technologies, etc. as well as the remote user interface 120 shown in FIG. 1.

[00039] The system 100 includes any number modules for sensing and/or controlling various aspects of the testing procedure. A drive circuit 310 is used to drive a motor 311 which turns the drive wheel 280. The motor 311 can be a capacitor start/capacitor run motor in order to provide for maximum horsepower using power from a standard AC outlet. The drive wheel 280 may be driven at different speeds as well as optionally reversed in accordance with some alternator configurations, such as clutched alternators. A tensioner actuator 312 is provided. A drive sensor 314 can be used to sense the amount of resistance applied by the drive motor 311. This can be used as feedback for tensioning the drive belt using tensioner actuator 312 as well as use to identify problems with a particular alternator such as a failing bearing. Voltage sensors 316 are used for connecting to various voltage points in the alternator such as the B+ connection, ground connection, control connections, etc. Current sensors 318 may also be provided and may include the amp clamp discussed herein. The current sensors may be Hall Effect sensors, amp clamp sensors, as well as shunt based sensors or other configurations. Alternator I/O circuitry 320 is provided for use in sending control signals to the alternator 102 as well as sensing output data provided by the alternator. An optional battery tester 322 may be provided for connecting to a battery of the vehicle. The battery tester 322 may include Kelvin connections for use in measuring a dynamic parameter of the battery or other components of the vehicle. A cable I/O module 324 may be provided to communicate with a cable, such as cable 108 shown in Figure 1. The cable is used to provide the data and sensor connections to the alternator. Various different cables may be employed and the cable I/O module 324 is used to interrogate the cables to identify the particular cable which is in use as well as any information stored in the cable. Additionally, information may be sent to a memory in the cable for storage and subsequent use. Various modules illustrated in Figure 8 maybe embodied in cable 108. Further, the modules may be used in interface with an alternator and a vehicle while the alternator is in the vehicle, and may also be used in configurations in which the alternator is removed from the vehicle for bench testing.

[00040] The drive belt 254 shown in Figure 4 can include a v-groove or other universal groove which is capable of driving many types of different alternators. The tensioners 282 may be driven by in a linear manner using a linear actuator or through using a rotary gear technique, or other manner. An over traveled spring can be provided to assist in applying the desired tension. The tensioners 282 may be controlled using an over travel spring. Further, using the drive sensor 314, the motor 311 current and/or voltage may be monitored and used as a feedback mechanism. The current applied to motor 311 may be monitored and used as feedback mechanism to control the tensioning. A load 325 may be connected to the current output from the alternator 102, for example, between the B+ and ground connections, in order to load the alternator. The load may be controlled by microprocessor and may be variable whereby different loads may be applied to the alternator 102 and performance of the alternator monitored.

[00041] The memory 112 of cable 108 may store various types of information related to the cable itself. For example, the information may indicate a type of cable, a serial number of the cable, a date the cable was placed into service, the number of tests performed using the cable, statistics related to tests performed using the particular cable such as pass, fail, etc., or other information. A cable may be identified using data stored in a memory such as an EEPROM, a RFID chip or other type of communication device, a flash memory, a mechanical switch which may be set, programmable resistors, etc. Further, the cable can be left connected to a vehicle so that data can be collected during normal operation. Additionally, circuitry within the cable 108 can be used to perform soft diagnostics. For example, dual leads may be used to for an in vehicle testing configuration of the cable 108. In such a configuration, the normal communication between the vehicle and the alternator can be monitored as-is, or can be interrupted for detailed diagnostics. In the as-is mode, the tester can observe the command and response as provided by the vehicle. In the interrupted mode, the tester can pretend to be the alternator performing in different modes, and observing the vehicle response to verify correct operation. Alternatively, the tester can pretend to be the vehicle operating in different modes, and observe the alternator response to verify correct operation. With a single lead version, biased terminals can be provided for connector and alternator since it can be automatically detected if the correct loading is placed on the electrical terminals when the connector is fitted to the alternator. The various data buses provided by cable 108 illustrated in FIG. 1 may be used to add an additional microprocessor or providing additional functionality at a future date. Similarly, relay logic may be implemented.

[00042] During a bench test, an operator mounts alternator 102 in tester 100. The drive belt 254 is placed on pulley 232, aligned using laser 270, and tensioned using tensioners 282. Voltage sense connections are coupled to the B+ ground, or other connections to the alternator 102. Current sensors are used to sense the current generated by alternator 102 and control connections are provided for use in controlling operation of alternator 102. The alternator 102 is rotated using motor 311 and the output current and voltage are monitored. Various electrical loads are applied using load 325. The rate of rotation can be controlled as desired. A determination is made as to the condition of the alternator based upon the speed of rotation, the measured voltage and/or current, and the specifications of the alternation under test. These specifications may be input manually, stored in a database and selected based up on information received to identify the type of alternator under test or received using some other means. Data may also be received through a connection to a databus of the vehicle, for example using OBDII or some other technique. For example, when a certain resistive load is connected to alternator 102, and the alternator rotated at a particular RPM, the alternator 102 may be specified to output a minimum current and/or or voltage level. Further, the waveform of the current and/or voltage can be monitored, including monitoring under various speeds or loads, to ensure that there are no ambiguities such as excessive ripple. The torque required to rotate the alternator can also be measured to ensure that there are no mechanical problems with the alternator. Electrical parameters of the alternator 102 can also be measured, for example resistance, inductance, capacitance, or others, using the connections, including using the Kelvin connections provided by the batter tester module 322 or some other sensor. Based upon the measurements, a diagnostic output is provided, for example to an operator. The output can provide absolute measurements as well qualitative results such as pass, fail, or impending failure. The information may also be sent to a remote location using the techniques discussed herein.

[00043] During an in-vehicle test, the cable 108 is coupled between the vehicle 104 and the alternator 102 as illustrated in Figure 1. Using the connections to the alternator, current and/or voltage generated by the alternator can be measured. Information related to alternator RPM can be retrieved from the vehicle databus. Further, the vehicle databus can be used to control loads applied to the alternator through the vehicle electrical system. The remote 120 can be used by an operator to communicate with the cable 108, including receiving data collected by the cable 108 and controlling the vehicle using a connection to the vehicle databus. The diagnostics and modules discussed above can be implemented in the cable. In another configuration, memory 112 in the cable 108 is used to store collected information for subsequent use in performing diagnostics. These may be performed using a computer, or other device such as tester 100. Further, if the cable can communicate information to a remote location, for example using a cellular data connection.

[00044] This configuration can also be used to test starters. For example, a starter can be mounted in the lift mechanism and a power supply used to provide energy to the starter motor. The output torque provided by the started can be measured using the belt 254 to drive a generator or the like, Further, if the power supply used to power the starter is sufficiently filtered, any ripple measured on the starter motor can be identified as being due to the starter itself and not from an external source.

[00045] Various aspects of configurations of the present invention are discussed herein and further identified below:

[00046] Electronic Battery Tester

- Advanced Battery Diagnostics
    - Conductance Profiling
        - for newer vehicles with advanced electrical systems
- Communication Channels
    - Base / Gateway Channel
        - Bluetooth LE
            - Pathway to the cloud for test data and updates

    - Diagnostic Clamp Channel
        - Bluetooth LE
            - Simplified tangle-free connection to vehicle touch points
    - OBDII Channel
        - Bluetooth LE
            - Simplified connection to vehicle networks
- Dynamic Customer Experience
    - TFT Color Screen
        - High resolution display for graphical user interface
    - Strong glass
        - Most robust system for workshop application
    - Capacitive Multi-Touch
        - Enables intuitive user interface
- Vehicle Identification
    - Bar Code Scanning (1D and 2D)
        - Future proof system concept
        - Automatically obtains VIN
            - Used to tie service records to tests
            - Identifies system specifications
- Battery Registration
    - Required for certain newer vehicle battery replacement
- Battery Reset Database
    - User guide to restore vehicle settings following battery replacement
- Combined or split operation
    - Control module can be remotely used
- In or Out of Vehicle Testing
    - Consistent, repeatable results

[00047] Charger Base/Gateway:

- Communication Channels
    - Battery Tester

        - Bluetooth LE uplink connection point
    - Cloud
        - Options
            - Ethernet
            - Wi-Fi
            - Cellular Modem
        - Future proof with plug-in USB adapters
- Data Flash Storage Standard
    - Upgradeable
- Automatic charging of battery tester

[00048] Motor Drive:

- Capacitor Start, Capacitor Run
    - Maximum amps at desired voltage
        - Current sensing on AC line input
    - Reversing motor drive
        - Compatible for CW / CCW alternators

[00049] Alternator Loads:

- Digital Loads
    - 5, 10, 15, 20 amp discrete loads
        - Loading in 5 amp increments from 5 amps to 50 amps
            - Enables appropriate current for each alternator type

[00050] Starter Power Supply

- Low-ripple regulated supply
    - Ensures data represents starter condition

[00051] **Positioner / Tensioner**

- Simple lever actuation
    - Quick and easy alignment
- Universal belt system
    - Works with serpentine pulleys
    - Works with V-belt pulleys

- Spring-loaded over-travel
    - o Maintains correct belt tension regardless of alternator size or position
- Laser belt centering guide

[00052] Instructional Photos / Videos Displayed to Operator

- TFT Color
- Content Source
    - o Flash Based
    - o Cloud Based

[00053] Diagnostic Clamp

- Bluetooth LE wireless connectivity
- Alternator B+ current measurement
- Automatically recharges when parked in base
- Auxiliary voltmeter
- Connects to alternator communication and vehicle
    - Isolates alternator for pinpoint diagnostics
    - Isolates vehicle for pinpoint diagnostics
    - Isolates battery for pinpoint diagnostics
    - Verifies total system performance

[00054] OBDII Connection Module

- OBDII connectivity
    - o Captures VIN
    - o Captures relevant specifications
    - o Monitors engine RPM
    - o Monitors relevant DTCs

[00055] Control Cable Interface

- Alternator Specific
- Error Proofing
    - o Digital Tag Verification
- Diagnostic Clamp Connector
    - o cycle rated

- Alternator Connector
    - Cycle rating per alternator connector specification
        - Optionally can custom tool high cycle design
            - Consider for high usage cables
- Dual Mode Cables
    - In Vehicle
    - Out of Vehicle
- Future-proof
    - Unforeseen alternator interfaces
        - Microcontroller and specific interfaces can be embedded in new cable type

[00056] Power Cable Interface

- High Current Welding Connector
- Unlimited cycle life
- Automatically captures B+ current

[00057] Safety Systems

- Simple to use
- High visibility
- Lighted interior
- Mechanical and electrical safety interlocks
- Emergency Stop Button

[00058] Cable Storage

- Smart Storage Cabinet
    - Individual cable pockets
    - LED indicator for cable selection
    - Magnet retention lock

[00059] The remote I/O circuitry 308 can be used for wireless communication with the test device 100. For example, a wireless diagnostic interface can be provided using remote 120 shown in FIG. 1 for in-vehicle testing. In such a configuration, an operator can connect the device to the alternator (or starter) and enter the vehicle to operate the vehicle. Monitoring of the device 100 can be provided using the remote 120. Such a configuration can also be used when bench testing a component using the arrangement illustrated in FIG. 4.

[00060] In one configuration, different types of cables 108 are stored within the device 100 for use in connecting to different types of alternators. For example, various cables may be stored in the compartments of protective cover 204 illustrated in FIG. 4. The system can identify particular cables for use by an operator by illuminating that cable (or compartment) as desired. An interior cabinet light may also be provided for operator convenience.

[00061] In one configuration, local I/O 306 provides a communication interface for an OBDII interface for interfacing with a vehicle under test. Such an interface can be used to monitor engine RPM, control the speed of the vehicle engine, monitoring an optional clearing diagnostic trouble codes (DTC), registering or identifying a particular alternator or starter motor in the vehicle, as well as vehicle identification. By identifying a particular vehicle, information related to the service requirements for that vehicle may be identified as well as relevant testing parameters or other information.

[00062] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. Although element 102 has been described above as an alternator, in one configuration element 102 is a starter motor of a vehicle whereby the test circuitry can be used to operation of the starter motor. In such a configuration, the test may be performed in-vehicle without removing the starter as well as out of vehicle. For example, the belt 254 can be used to apply a mechanical load to the starter and measure the torque provided by the starter motor. The various components discussed herein can be replaceable modulates such that they can be added as features to the system 100, or easily repaired/replaced as needed. Examples include the motor assembly, belt tensioner, controller, user interface, cabinet electronics, starter power supply, etc. As used herein, the term “alternator connector” refers to one or more of the electrical connections to an alternator including the connections which are used to provide an electrical output from the alternator as well as other connections including control connections and databus connections. Similarly, a starter motor connector includes one or more of the electrical connections used to power a starter motor, control a starter motor, or communicate with a starter motor. A capacitor start/capacitor run motor configuration for use in rotating the alternator ensures that maximum horse power is available on a standard AC outlet. Further, the term “alternator test connector” or “alternator test adapter” refers to the cable discussed herein. In one configuration, the same remote control unit can be used for performing bench testing as well as for in-vehicle testing. This allows for a consistent/uniform testing protocol to be applied in various settings for more consistent test results. Further diagnostics can be performed by connecting the adapter cable to a loop back connection ensuring that a voltage is detected or that there is continuity therebetween. In a single lead configuration, the lead can be biased, for example to six volts and connected to an alternator. Depending upon the connection, the six volt bias will be pulled high or low (for example to 12 volts or to electrical ground) when connected to the alternator thereby indicating continuity.

WHAT IS CLAIMED IS:

1. An alternator tester configured to test an alternator of a vehicle, the alternator of the type which electrically couples to the vehicle through an alternator connector, the alternator tester comprising:

alternator test circuitry;

an alternator test connector or adapter configured to electrically connect the test circuitry to the alternator connector; and

wherein the test circuitry is configured to interact with the alternator through the alternator test connector and thereby test operation of the alternator.

2. The alternator tester of claim 1 wherein the test circuitry is configured to monitor communication between a vehicle and the alternator through the alternator connector.

3. The alternator tester of claim 1 including an amp clamp configured to couple to an alternator output B+ cable.

4. The alternator tester of claim 1 including Bluetooth® communication circuitry.

5. The alternator tester of claim 1 including electronic battery test circuitry.

6. The alternator tester of claim 1 including a vehicle connector configured to connect to an electrical connection of the vehicle.

7. The alternator tester of claim 6 wherein the electrical connection comprises a databus of the vehicle.

8. The alternator tester of claim 7 wherein the databus comprises an OBDII databus.

9. The alternator tester of claim 6 wherein the vehicle connector interrupts a connection between the vehicle and the alternator.

10. The alternator tester of claim 6 wherein the alternator test circuitry monitors communication between the vehicle and the alternator.

11. The alternator tester of claim 1 including a drive motor configured to drive the alternator.

12. The alternator tester of claim 11 wherein the drive motor is connected to an alternator through a belt.

13. The alternator tester of claim 12 including a tensioner configured to apply tension to the belt.

14. The alternator tester of claim 1 including a load configured to electrically connect to the alternator and apply an electrical load to the alternator.

15. The alternator tester of claim 14 wherein the load comprises a variable load for drawing selectable current from the alternator.

16. The alternator tester of claim 1 wherein the alternator test connector includes a memory.

17. The alternator tester of claim 16 wherein the memory identifies a type of alternator connector.

18. The alternator tester of claim 16 wherein the memory includes a serial number of the connector.

19. The alternator tester of claim 18 wherein the memory includes a date of service of the connector, number of tests performed using the connector and/or statistics regarding test results obtained using the alternator test connector.

20. The alternator tester of claim 16 wherein the memory is selected from the group of memories consisting of an EEPROM, RFID tag, flash memory, mechanical switch, and resistor programming.

21. The alternator tester of claim 11 wherein the drive motor is reversible.

22. The alternator tester of claim 12 including a laser for use in aligning the belt.

23. The alternator tester of claim 11 including a strap configured to secure the alternator.

24. The alternator tester of claim 1 wherein components of the tester are modular.

25. The alternator tester of claim 1 including wireless communication circuitry.

26. The alternator tester of claim 25 wherein the wireless communication circuitry is used to wirelessly communicate with a remote unit.

27. The alternator tester of claim 1 wherein the alternator test circuitry is configured to identify an improper alternator test connector coupled to the alternator.

28. The alternator tester of claim 1 including a light configured to illuminate the alternator tester to assist an operator.

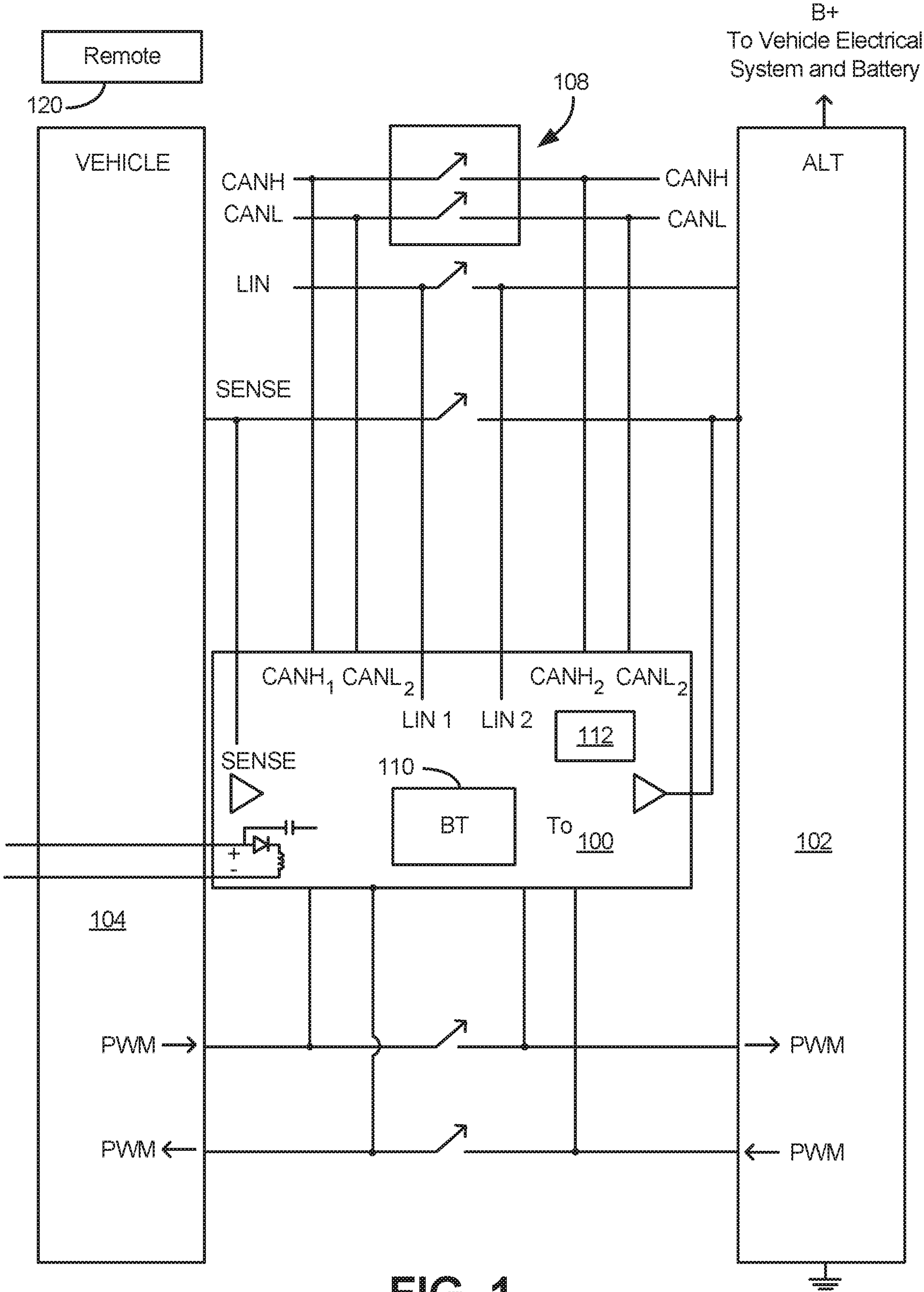
29. The alternator tester of claim 1 including a connector configured to couple to a databus of a vehicle, the connector for use in at least one of monitoring engine RPM, controlling engine

speed, monitoring diagnostic codes, clearing diagnostic codes, identifying an alternator and identifying a vehicle.

30. The alternator tester of claim 29 wherein an identified vehicle is used by the alternator test circuitry to identify specific service requirements of an alternator.

31. The alternator tester of claim 29 wherein the identified vehicle is used by the alternator test circuitry to identify test parameters for use in testing an alternator.

32. The alternator tester of claim 1 wherein the alternator test circuitry is further configured to test a starter motor.



Remote
120
VEHICLE
B+
To Vehicle Electrical
System and Battery
108
ALT
CANH
CANL
LIN
CANH
CANL
SENSE
CANH1 CANL2
LIN 1
LIN 2
CANH2 CANL2
112
SENSE
110
BT
To 100
102
104
PWM
PWM
PWM
PWM

FIG. 1

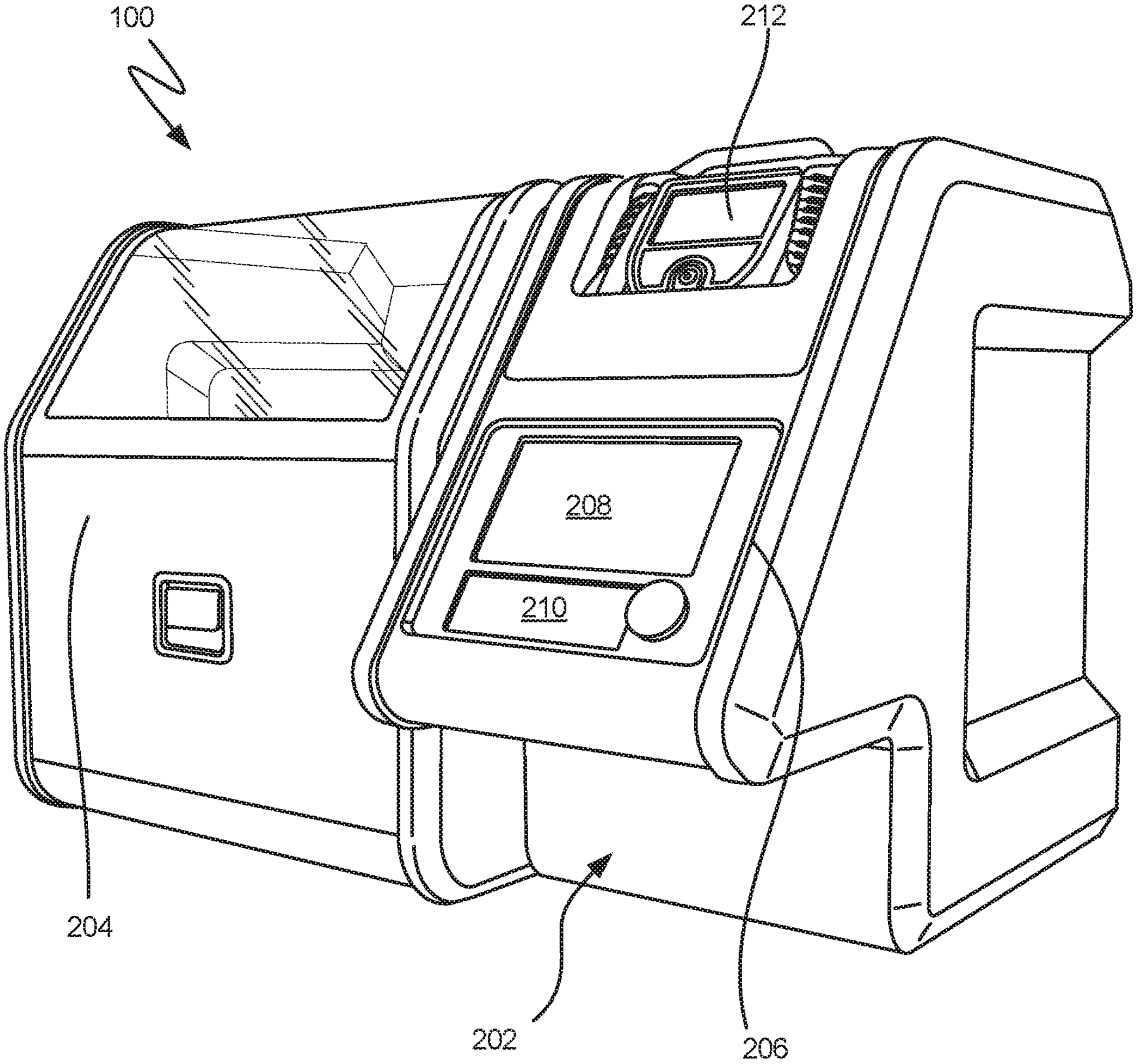


FIG. 2

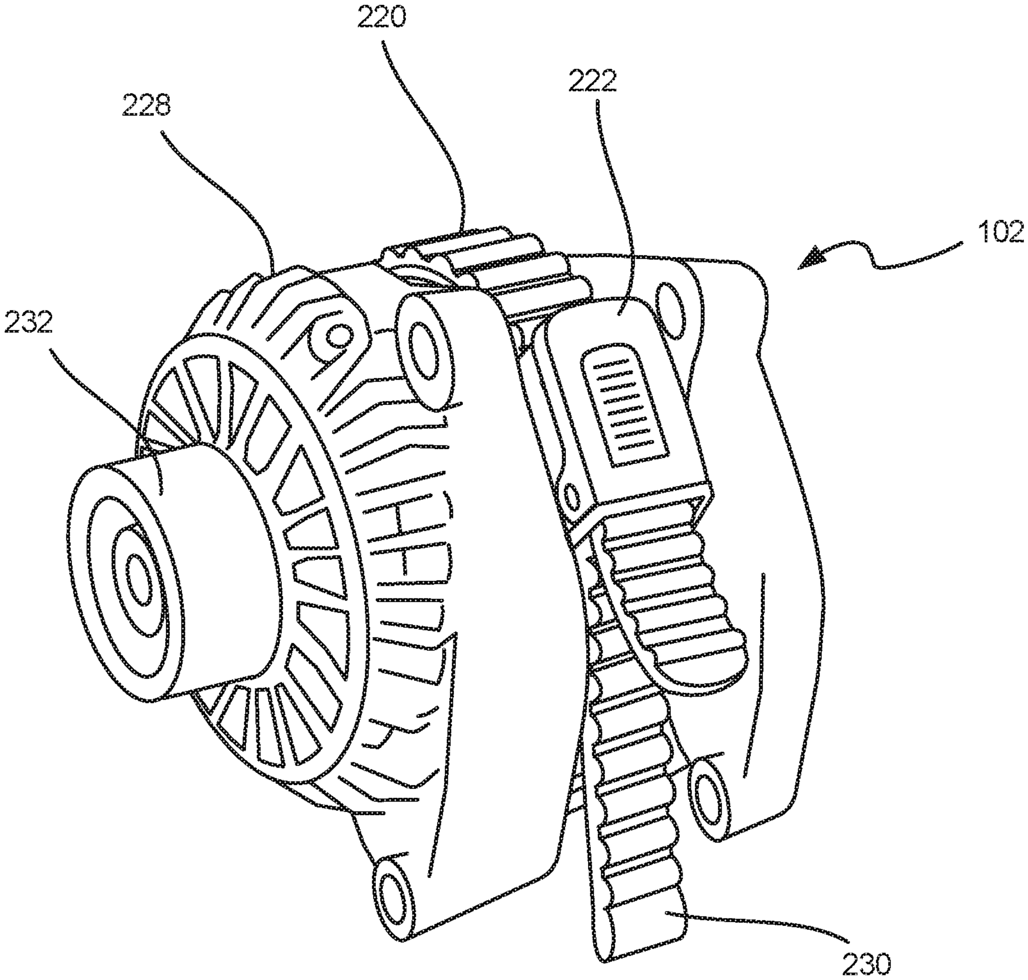


FIG. 3

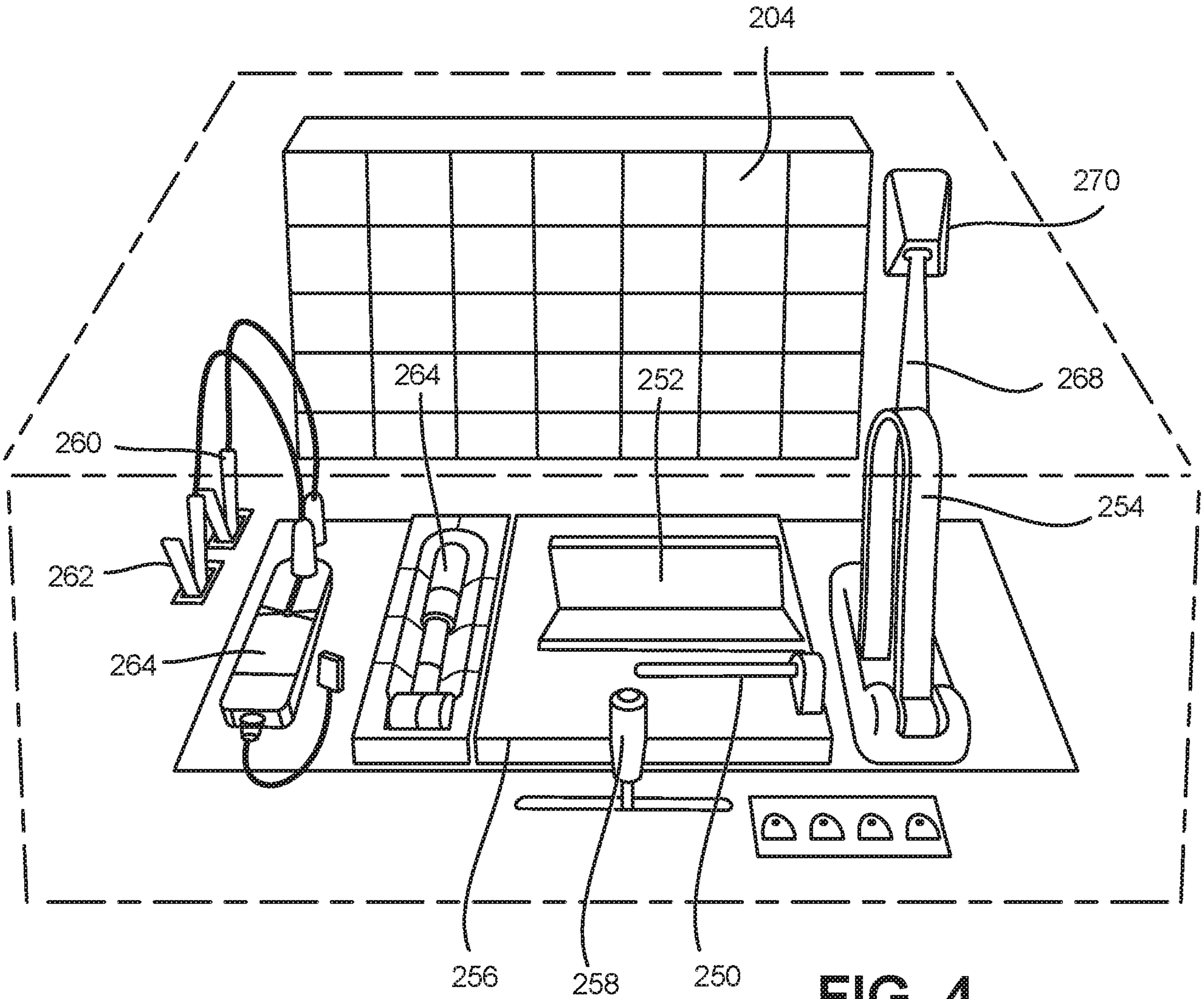


FIG. 4

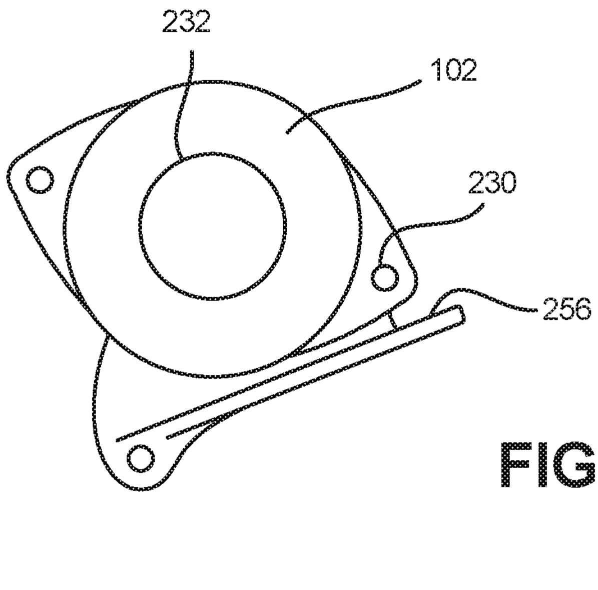


FIG. 5

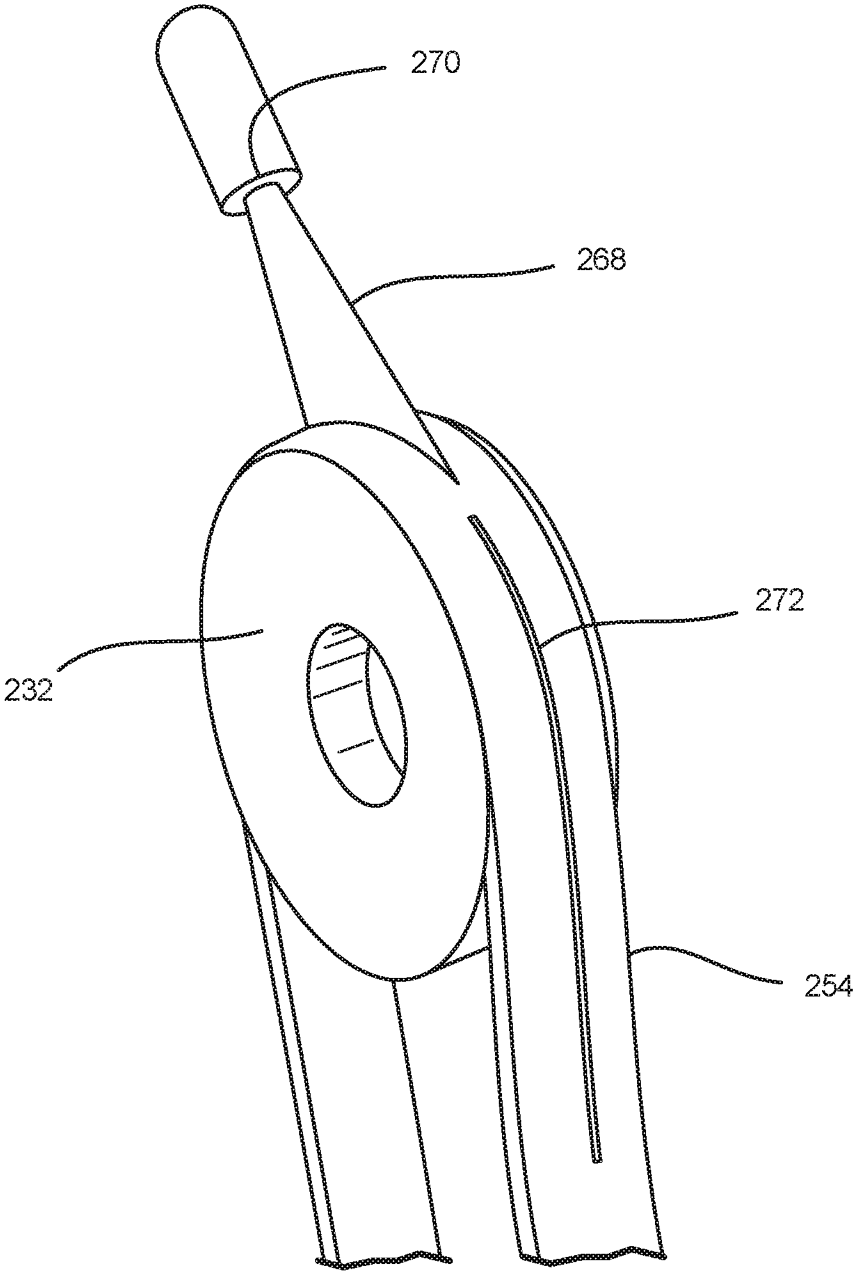


FIG. 6

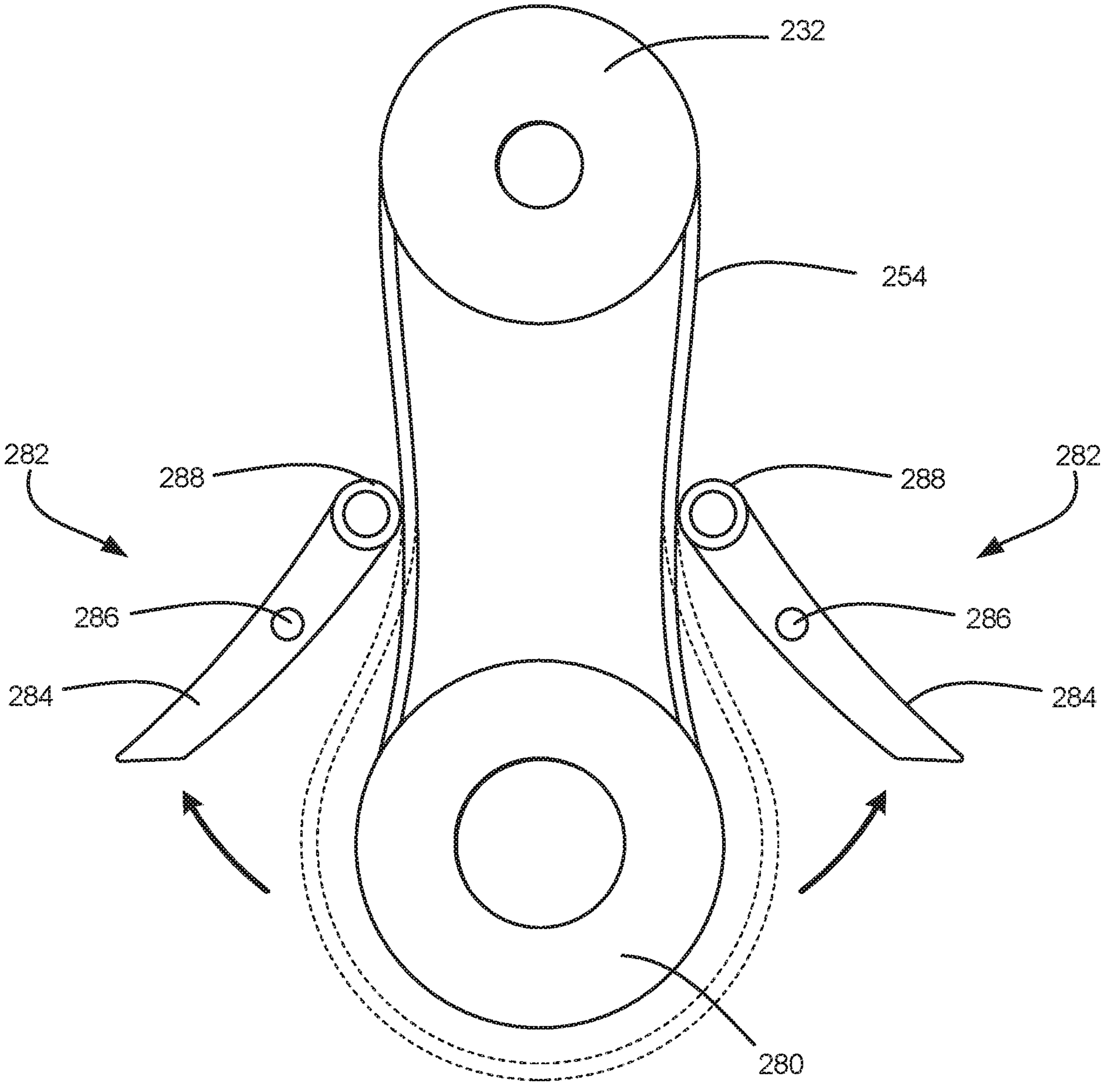


FIG. 7

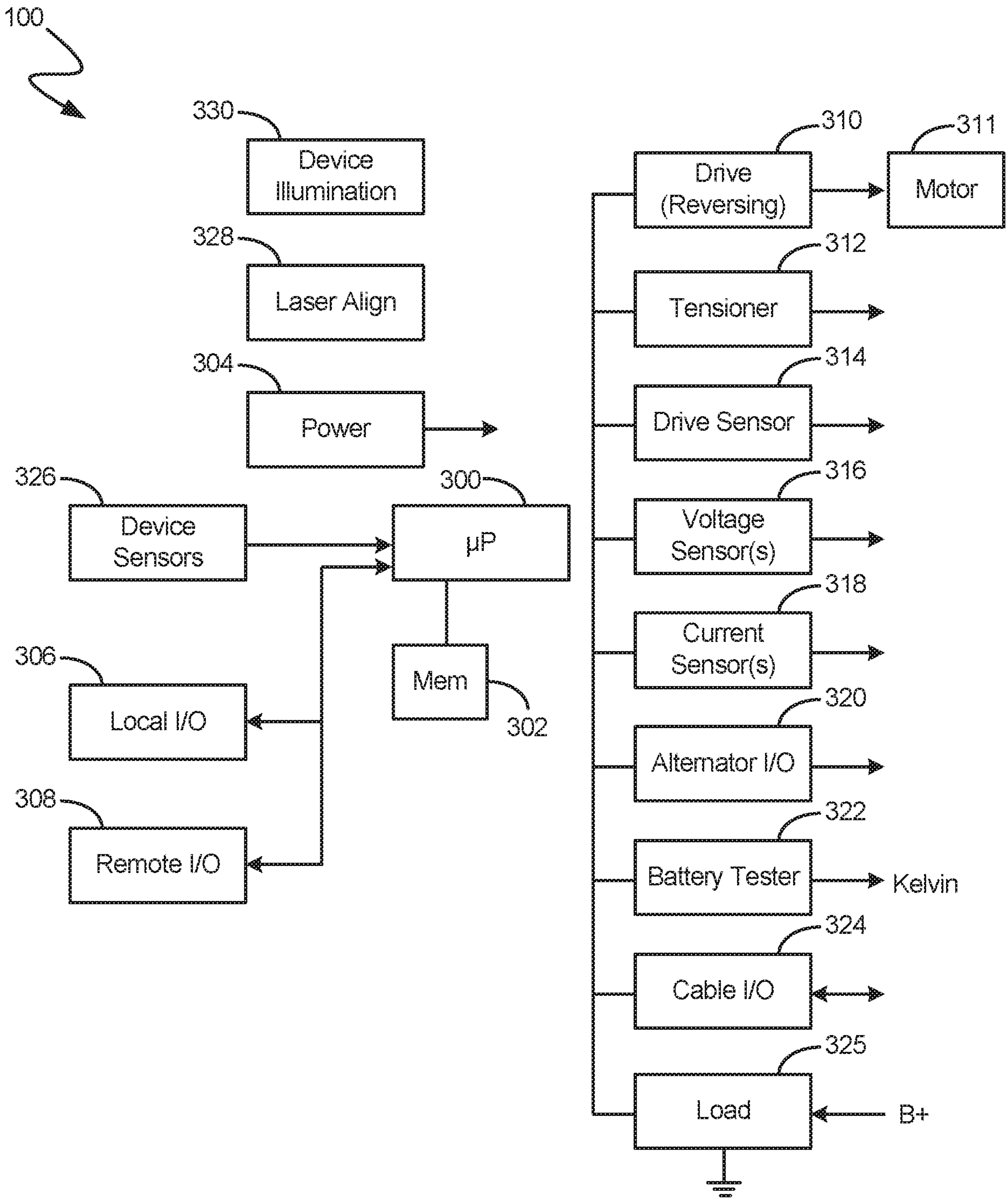

100
330
Device Illumination
328
Laser Align
304
Power
326
Device Sensors
300
µP
Mem
302
306
Local I/O
308
Remote I/O
310
Drive (Reversing)
311
Motor
312
Tensioner
314
Drive Sensor
316
Voltage Sensor(s)
318
Current Sensor(s)
320
Alternator I/O
322
Battery Tester
Kelvin
324
Cable I/O
325
Load
B+

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/014867

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01R31/34
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 550 485 A (FALK DEAN A [US]) 27 August 1996 (1996-08-27) abstract; figures 2A-2C,4A-4C column 1, lines 10-12 column 4, lines 7-8 -----	1-32
X	US 2008/023547 A1 (RAICHLE KURT [US] ET AL) 31 January 2008 (2008-01-31) the whole document -----	1-32
X	US 2004/108855 A1 (RAICHLE KURT [US]) 10 June 2004 (2004-06-10) the whole document -----	1-32
X	US 5 701 089 A (PERKINS CLIFTON G [US]) 23 December 1997 (1997-12-23) the whole document ----- -/--	1-32

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 May 2016	03/06/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dogueri, Ali Kerem

1

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/104728 A1 (BERTNESS KEVIN I [US] ET AL) 3 June 2004 (2004-06-03) the whole document -----	1-32

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/014867

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			US	5701089	A	23-12-1997
			WO	9714046	A1	17-04-1997
US 2004104728	A1	03-06-2004	NONE			