US 20180148085A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2018/0148085 A1**

TAN et al. (43) **Pub. Date: May 31, 2018**

(54) **INTEGRATED AUTO-STEER SYSTEM FOR VEHICLE**

(71) Applicant: **AGJUNCTION LLC**, Hiawatha, KS (US)

(72) Inventors: **Jim TAN**, Cupertino, CA (US); **Alan Robert Joughin**, Union City, CA (US); **Jean-Marie Eichner**, Sunnyvale, CA (US); **Glen Sapilewski**, Emerald Hills, CA (US); **Andreas F. Sapilewski**, Woolloongabba (AU); **Husam Kal**, San Ramon, CA (US)

(73) Assignee: **AGJUNCTION LLC**, Hiawatha, KS (US)

(21) Appl. No.: **15/878,849**

(22) Filed: **Jan. 24, 2018**

Related U.S. Application Data

(63) Continuation-in-part of application No. 15/784,804, filed on Oct. 16, 2017.

(60) Provisional application No. 62/450,491, filed on Jan. 25, 2017, provisional application No. 62/409,210, filed on Oct. 17, 2016.

Publication Classification

(51) **Int. Cl.**

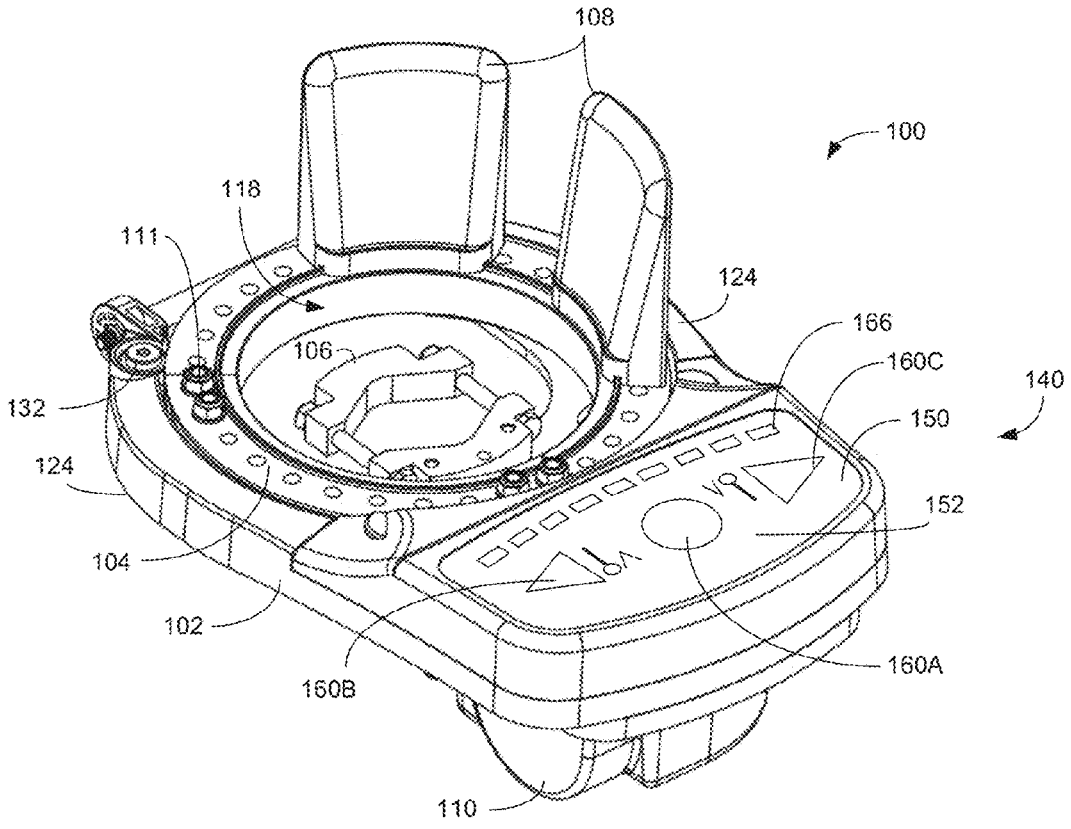
B62D 5/00	(2006.01)
B60W 40/10	(2006.01)
B60W 50/08	(2006.01)
B62D 1/28	(2006.01)
B62D 5/04	(2006.01)

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

CPC ***B62D 5/006*** (2013.01); ***B60W 40/10*** (2013.01); ***B60W 50/08*** (2013.01); *B60W 2050/146* (2013.01); ***B62D 5/0406*** (2013.01); ***B62D 5/0409*** (2013.01); ***B62D 1/28*** (2013.01)

(57) **ABSTRACT**

A steering wheel actuator is attached to a steering wheel column. The steering wheel actuator includes a gear assembly for turning a steering wheel on the steering wheel column, a motor for rotating the gear assembly, and an enclosure. A control system in the enclosure controls the motor to automatically steer the vehicle. The control system may receive global navigation satellite system (GNSS) signals from a GNSS antenna and GNSS receiver located in the enclosure and automatically steer the vehicle based on the GNSS signals. The control system also may receive inertial measurement unit (IMU) signals from an IMU located in the enclosure and automatically steer the vehicle based on the IMU signals. The control system also may receive user input signals from a user interface located on the enclosure and automatically steer the vehicle based on the user input signals.



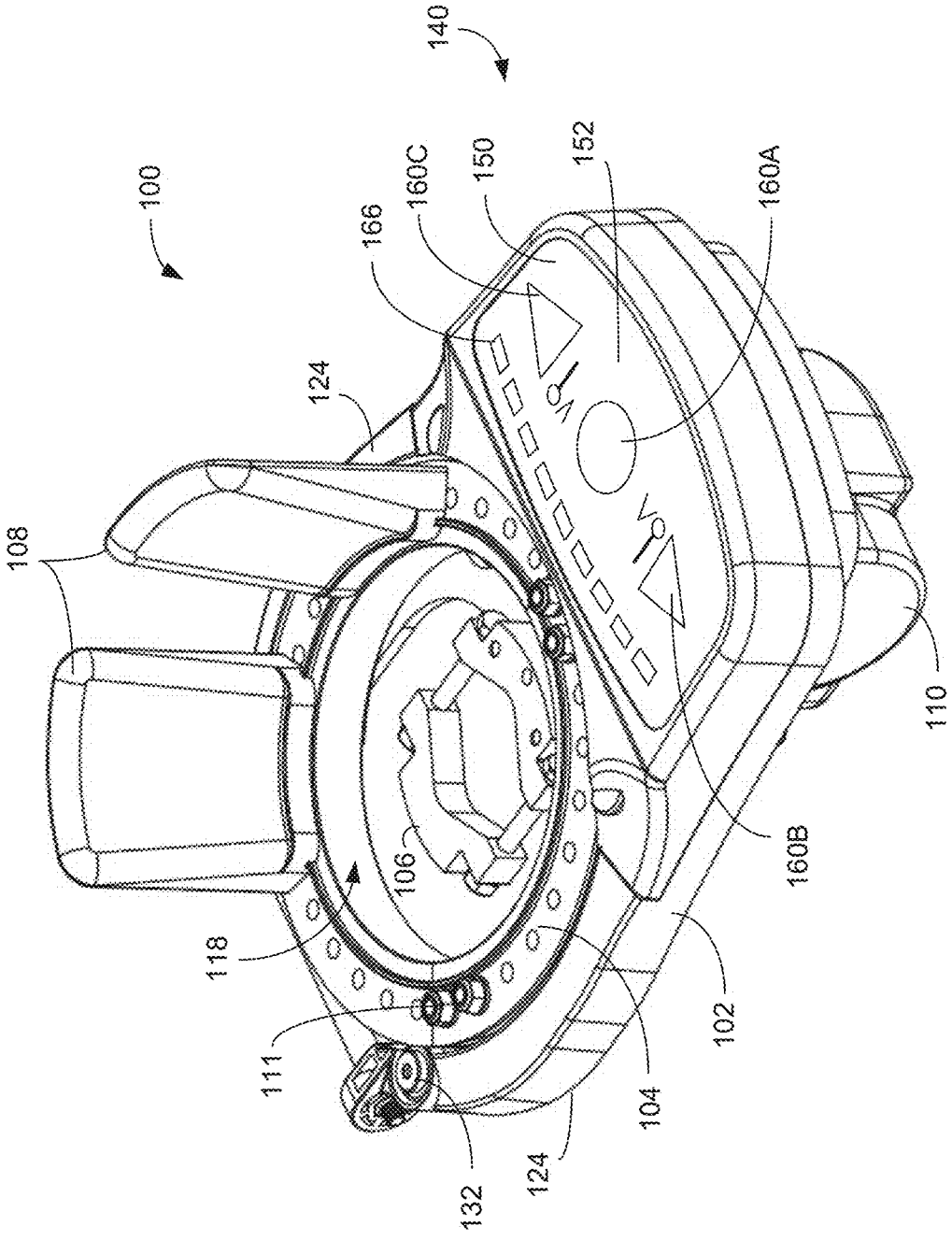

140
100
166
160C
150
152
160A
124
108
110
106
160B
118
102
111
104
132
124

FIG 1.

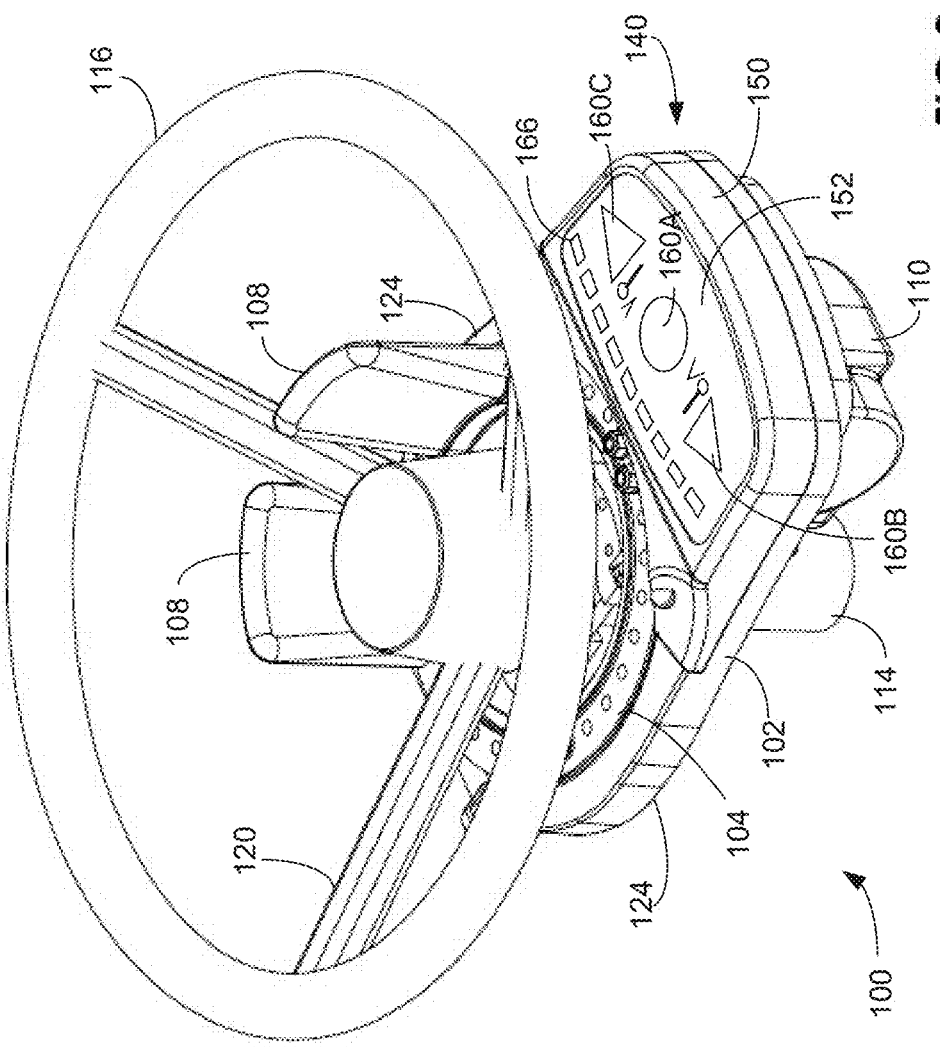

116
140
150
166
160C
152
160A
110
108
124
108
160B
114
102
104
120
124
100

FIG 2.

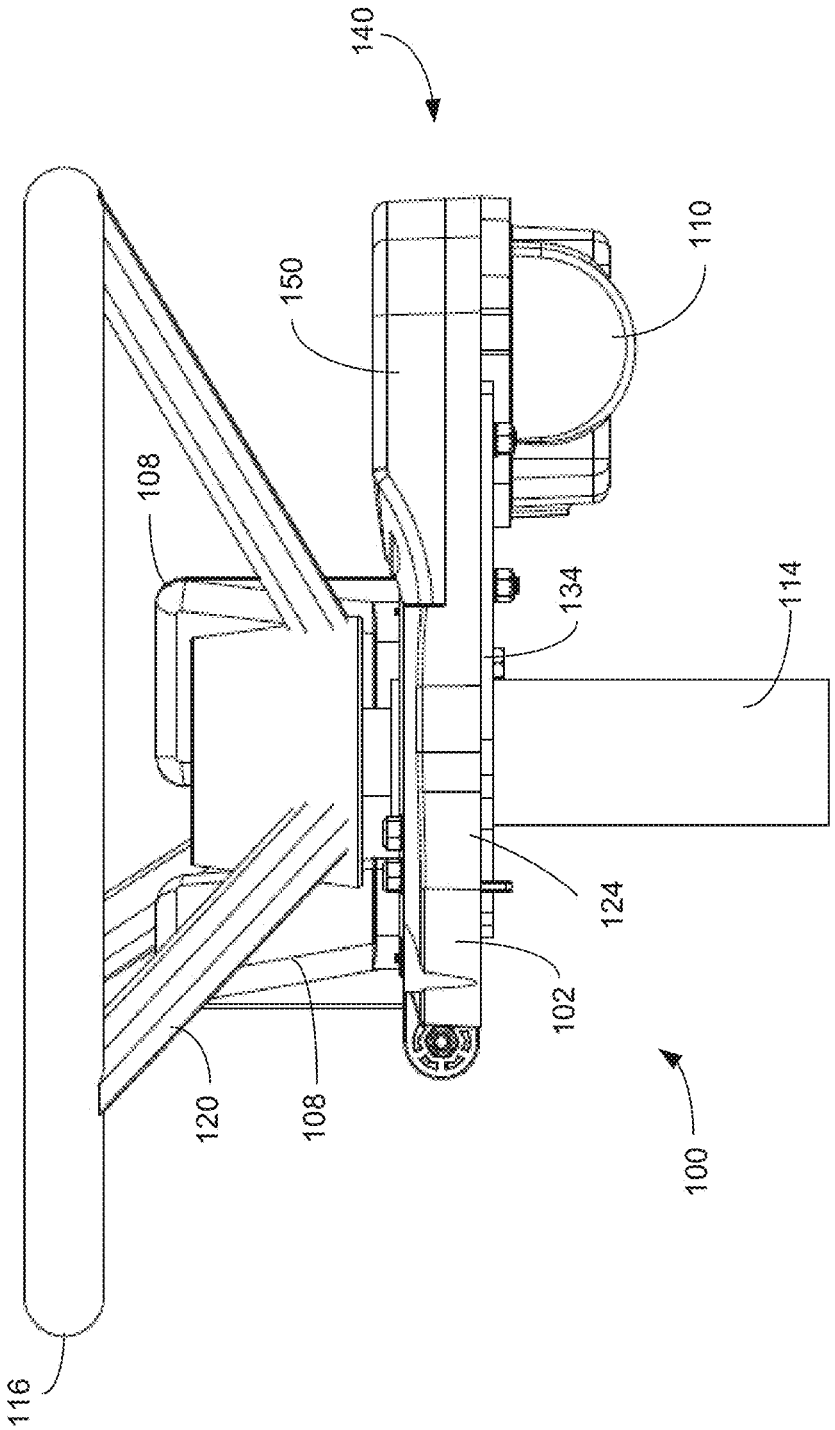


FIG 3.

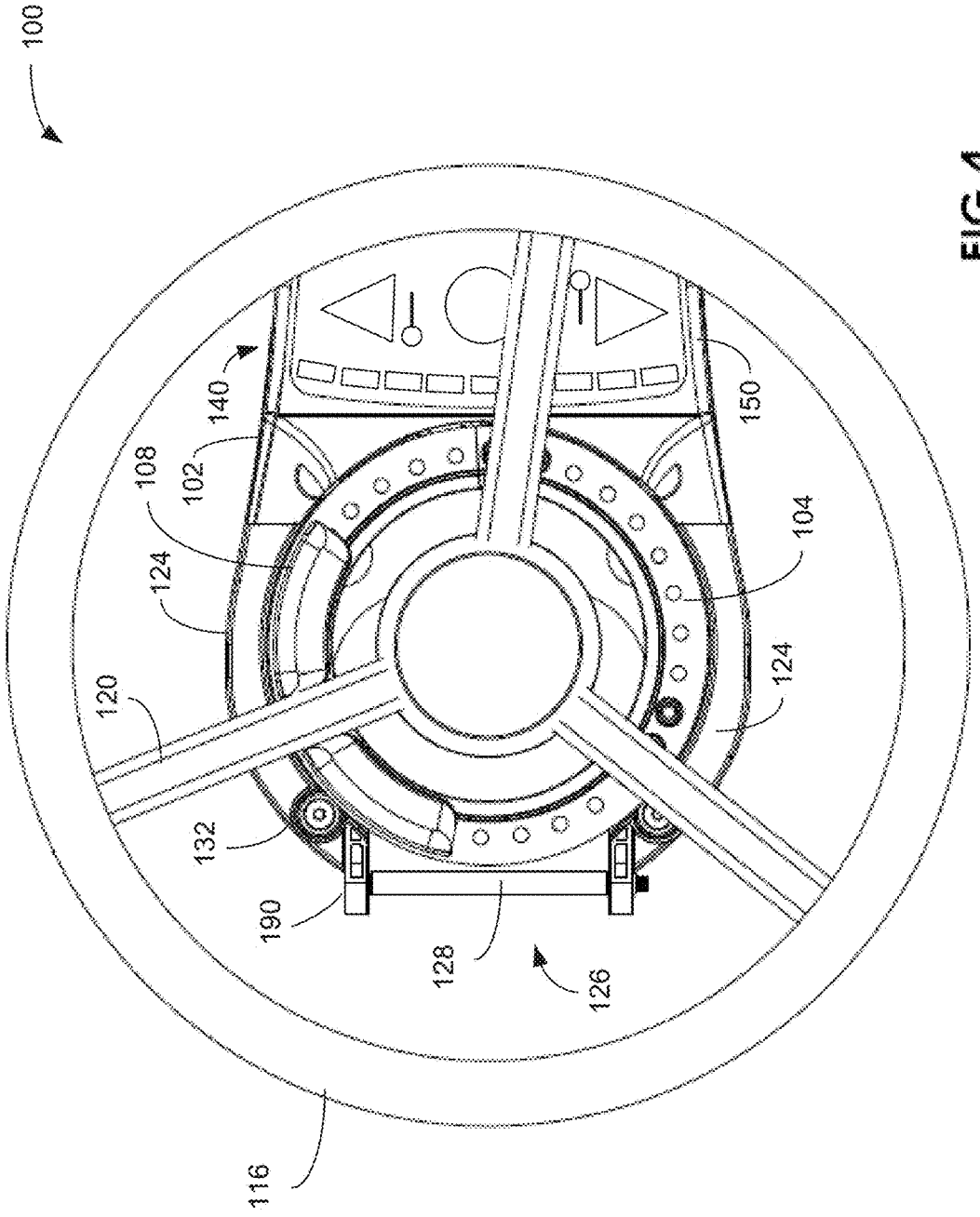


FIG 4.

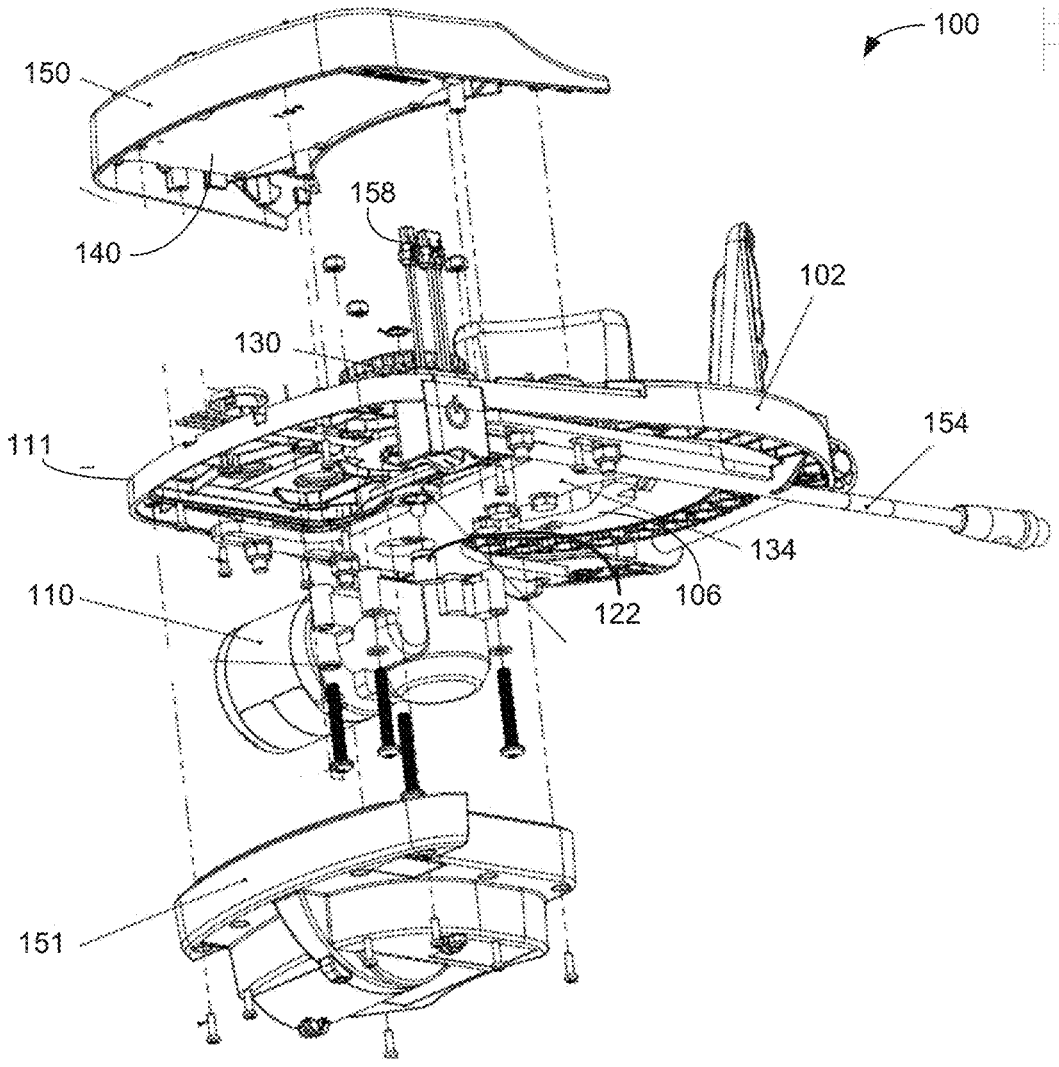


FIG. 5

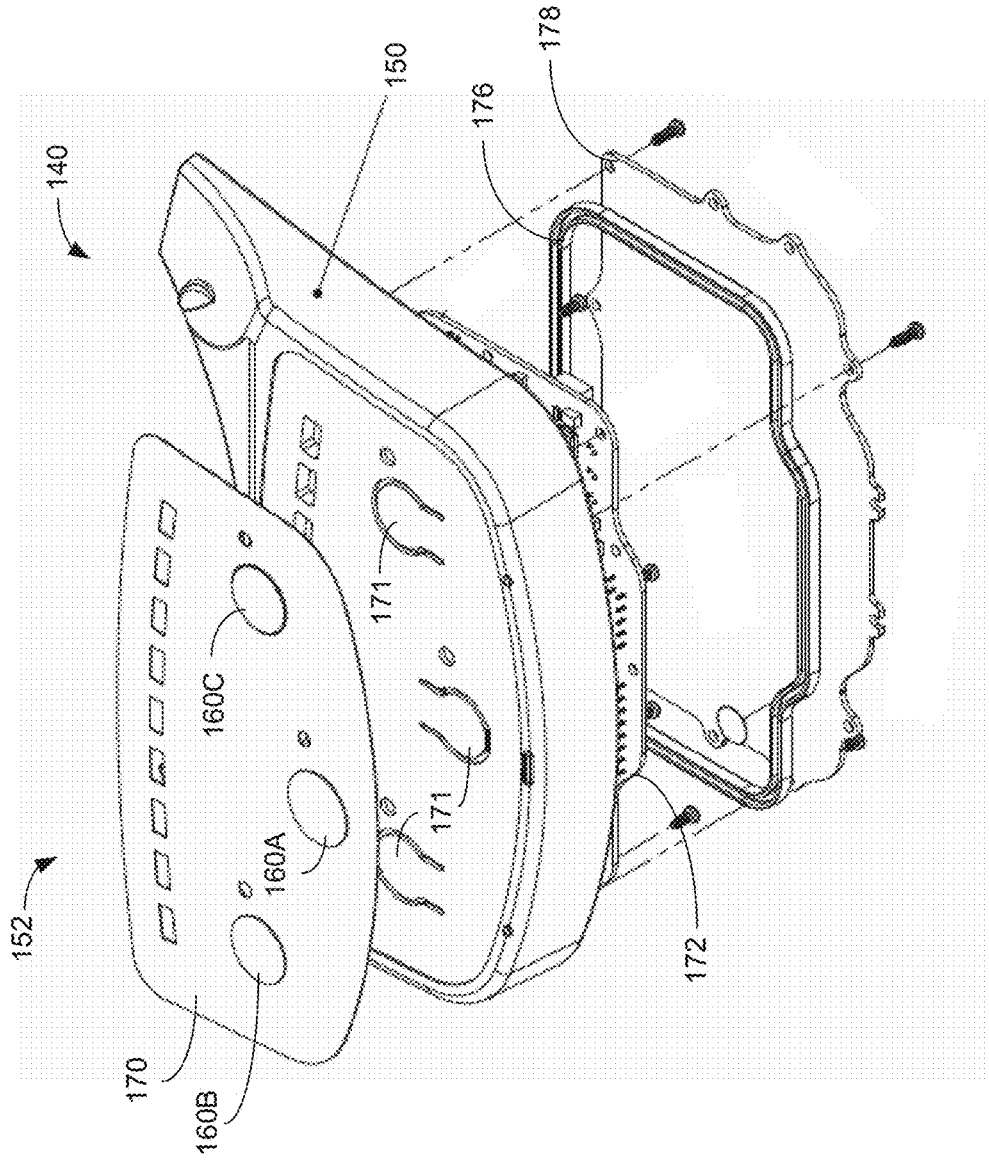


FIG. 6

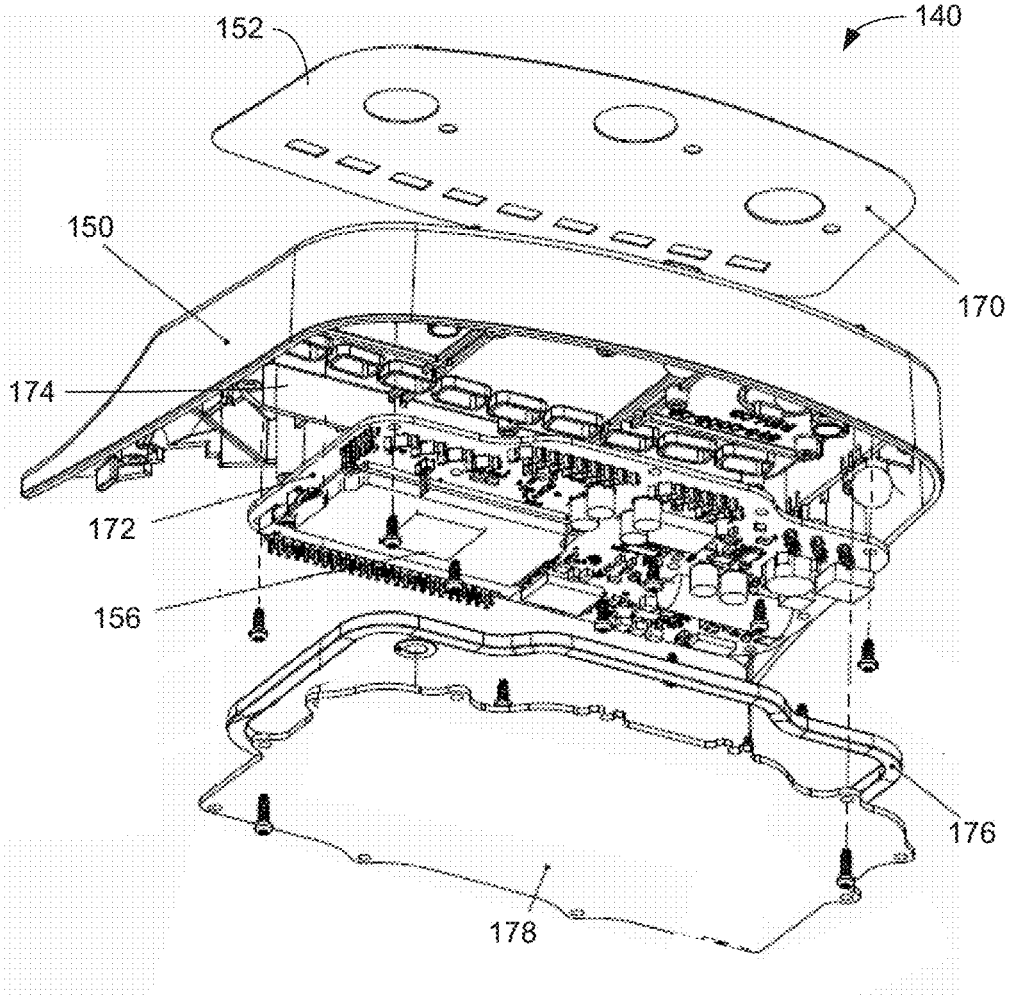


FIG. 7

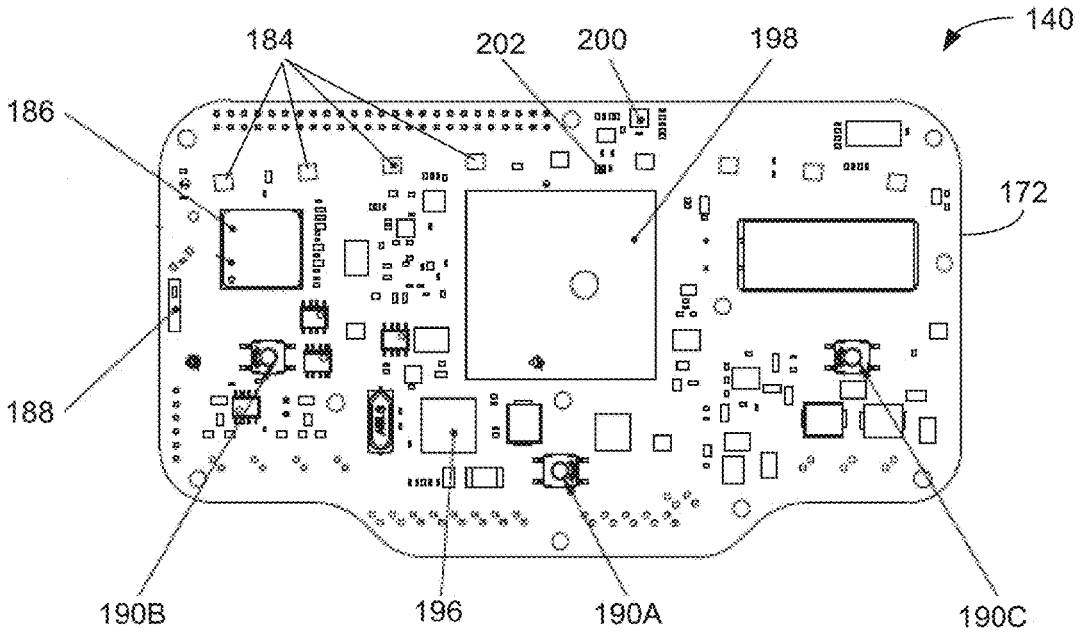

140
184
202
200
198
186
172
188
190B
196
190A
190C

FIG. 8A

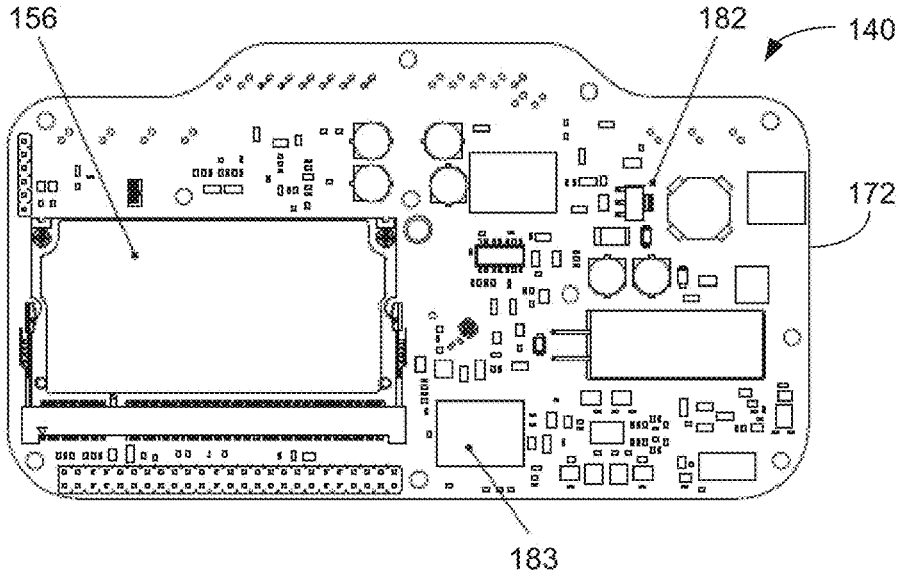

156
182
140
172
183

FIG. 8B

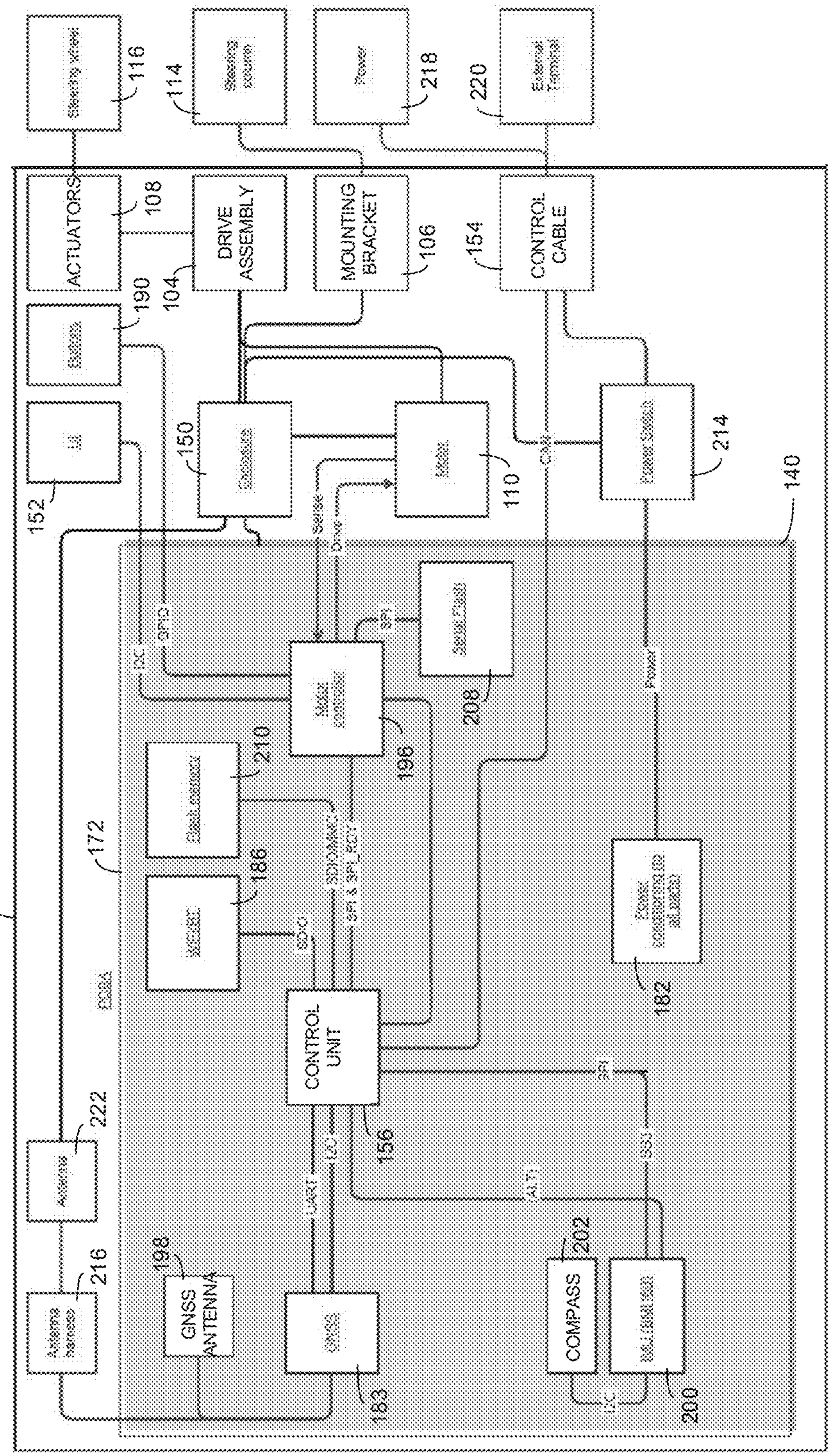

100
ACTUATORS
108
DRIVE ASSEMBLY
104
MOUNTING BRACKET
106
CONTROL CABLE
154
116
114
218
220
190
152
150
110
214
140
172
210
186
198
208
CONTROL UNIT
156
182
222
216
GNSS ANTENNA
183
COMPASS
202
200

FIG. 9

INTEGRATED AUTO-STEER SYSTEM FOR VEHICLE

[0001] The present application claims priority to U.S. Provisional Patent Application Ser. No. 62/450,491 filed on Jan. 25, 2017, entitled: METHOD AND APPARATUS FOR AN INTEGRATED AUTO STEERING SYSTEM FOR VEHICLE which is herein incorporated by reference in its entirety. The present application is also a continuation-in-part of U.S. patent application Ser. No. 15/784,804 filed Oct. 16, 2017, entitled AN ACTUATOR FOR TURNING A STEERING WHEEL IN AUTOMATIC STEERING SYSTEMS which claims priority to U.S. Provisional Patent Application Ser. No. 62/409,210 filed on Oct. 17, 2016, entitled: SYSTEM FOR TURNING A STEERING WHEEL IN AUTOMATIC STEERING SYSTEM which are all herein incorporated by reference in their entireties.

COPYRIGHT NOTICE

[0002] A portion of the disclosure of this patent document contains material which is subject to copyright protection. The copyright owner has no objection to the facsimile reproduction by anyone of the patent document or the patent disclosure, as it appears in the United States Patent and Trademark Office patent file or records, but otherwise reserves all copyright rights whatsoever.

TECHNICAL FIELD

[0003] One or more implementations relate generally to an integrated auto steering system for a vehicle.

BACKGROUND

[0004] Electric actuators have been developed for automatically turning a steering wheel of an autonomous vehicle. These systems use electric motors and drive mechanisms to turn the steering wheel through friction wheels, gears, belt drives and direct drive motors installed under the steering wheel.

[0005] A quick connect system includes a sleeve concentrically received around a steering shaft of the vehicle and a hub concentrically received around and releasably secured to the sleeve by one or more fasteners. Mating non-rotary interfaces are provided between the shaft and sleeve and the hub and the sleeve when the shaft, sleeve, and hub are concentrically arranged relative to one another. The hub is releasably secured by a number of fasteners to a rotatable output member of an auto-steer motor of the steering wheel system. The steering wheel system includes an auto-steer motor that can be installed on the steering shaft of a vehicle not originally equipped with an auto-steer motor.

[0006] Another integrated automatic electrical steering system includes a global navigation satellite system (GNSS) receiver and antenna for determining the vehicle's instantaneous position, a guidance CPU, and an automatic steering subsystem integrated with the vehicle electrical power system. The automatic steering subsystem can be interfaced with the steering column of the vehicle. The steering subsystem mechanically activates the steering column steering the vehicle according to instructions received from the CPU based upon the vehicle position and a predetermined path. An interrupt element, such as a wheel movement sensor or a slip gear, will allow manual steering override of the automatic steering control.

[0007] Another hydraulic primary steering system includes a guidance module with a GPS receiver and a microprocessor adapted to process and store global positioning system (GPS) data defining travel paths, which can be associated with a cultivated field in an agricultural vehicle application. An automatic steering module is connected to the guidance module and to a steering valve control block, which provides pressurized hydraulic fluid in parallel with the vehicle primary hydrostatic steering system.

[0008] All of these steering actuators need several separate components or housings for GPS data reception, GPS based data control, and a user interface with display and keypad.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The included drawings are for illustrative purposes and serve to provide examples of possible structures and operations for the disclosed inventive systems, apparatus, methods and computer-readable storage media. These drawings in no way limit any changes in form and detail that may be made by one skilled in the art without departing from the spirit and scope of the disclosed implementations.

[0010] FIG. **1** shows a perspective view of an integrated steering wheel actuator.

[0011] FIG. **2** is a perspective view of the steering wheel actuator of FIG. **1** mounted under a steering wheel.

[0012] FIG. **3** is a side view of the steering wheel actuator of FIG. **1** mounted under a steering wheel.

[0013] FIG. **4** is a top view of the steering wheel actuator of FIG. **1** mounted under a steering wheel.

[0014] FIG. **5** is a bottom exploded perspective view of the steering wheel actuator of FIG. **1**.

[0015] FIG. **6** is a top exploded perspective view of a control system integrated into the steering wheel actuator.

[0016] FIG. **7** is a bottom exploded perspective view of the control system and user interface.

[0017] FIG. **8**A is a top plan view of a printed circuit board for the control system.

[0018] FIG. **8**B is a bottom plan view of the printed circuit board for the control system.

[0019] FIG. **9** is a schematic diagram of the control system.

DETAILED DESCRIPTION

[0020] An all-in-one auto-steer system steers a farm tractor or any other vehicle along a predetermined path. The auto-steer system integrates processing components into a single unit rather than connecting several separate components together with cables. The end result is overall system simplicity, easy installation, and lower overall system cost.

[0021] The auto-steer system may include a steering wheel actuator attached to a steering wheel column. The steering wheel actuator includes a gear assembly for turning a steering wheel on the steering wheel column, a motor for rotating the gear assembly, and an enclosure. A control system operates in the enclosure to control the motor and automatically steer the vehicle.

[0022] The control system may receive global navigation satellite system (GNSS) signals from a GNSS antenna and GNSS receiver located in the enclosure and automatically steer the vehicle based on the GNSS signals. The control system also may receive inertial measurement unit (IMU) signals from an IMU located in the enclosure and automati-

cally steer the vehicle based on the IMU signals. The control system also may receive user input signals from a user interface located on the enclosure and automatically steer the vehicle based on the user input signals. In other example systems, the user interface, IMU and/or GNSS may be installed externally to the enclosure and main control unit.

[0023] FIG. **1** shows an isolated perspective view of integrated steering actuator **100**. FIG. **2** is a perspective view of actuator **100** mounted under steering wheel **116**, FIG. **3** is a side view of actuator **100** mounted under steering wheel **116**, FIG. **4** is a top view of actuator **100** mounted under steering wheel **116**, and FIG. **5** is an exploded bottom perspective view of steering wheel actuator **100**.

[0024] Referring to FIGS. **1-5**, steering wheel actuator **100** includes an annular frame assembly **102** that supports a round rotating gear assembly **104**. A clamp **106** may attach to a steering wheel column **114** and hold frame assembly **102** and gear assembly **104** below steering wheel **116**. Actuators **108** are bolted to gear assembly **104** and extend vertically up between spokes **120** in steering wheel **116**.

[0025] An enclosure **150** is integrally formed with frame assembly **102** and also may extend underneath steering wheel **116**. Enclosure **150** may house a control system **140** that automatically steers the vehicle containing steering wheel **116**. Control system **140** may control a motor **110** that rotates gear assembly **104** causing attached actuators **108** to turn steering wheel **116**.

[0026] Frame assembly **102** may include oppositely opposing semi-circular arms **124** forming a circular center region **118** and a front opening **126** for receiving steering wheel column **114**. A spacer **128** is located in opening **126** in between opposite front ends of arms **124**. Gear assembly **104** seats into center region **118** and is rotationally held in-between arms **124** by bearings **132** that are located in four opposing quadrants of frame assembly **102**.

[0027] Motor **110** may be a DC electric motor that includes a shaft **122** that extends up through a hole formed in a back section **111** of frame assembly **102** and couples to a gear **130**. Gear **130** sits in frame assembly section **111** and engages with teeth that extend around the lower outside perimeter of gear assembly **104**.

[0028] A bracket **134** is bolted to the bottom of frame assembly **102** and attaches to clamp **106**. Bracket **134** can be aligned so gear assembly **104** is concentrically aligned with steering wheel column **114**. In one example, clamp **106** may be substantially co-planer with teeth in the lower layer of gear assembly **104**. Recessing clamp **106** up into opening **130** reduces the overall depth of steering wheel actuator **100**.

[0029] In one embodiment, actuator **100** is made fully out of plastic to reduce cost. In at least one embodiment, gear assembly **104** consists of a two-piece split design that allows installation without removing steering wheel **116**. Operation and assembly of frame assembly **102** and actuators **108** is described in more detail in co-pending U.S. patent application Ser. No. 15/784,804 which has been incorporated by reference in its entirety.

[0030] Gear assembly **104** is just one example drive assembly that may couple motor **110** to an actuator **108** that turns steering wheel **116**. It is understood that other types of drive assembly can be used to connect motor **110** to actuator **108** and/or steering wheel **116**. For example, motor **110** may be coupled to a belt drive assembly or chain drive assembly that connects to a pulley or sprocket connected to actuators **108** or connected directly to the steering wheel shaft. In another example, the drive assembly may be a direct drive motor coupled directly to the steering wheel or steering wheel shaft.

Integrated Auto-Steer Control System

[0031] Control system **140** includes enclosure **150** that sits over the top of back section **111** and contains electronics and electrical connections for controlling motor **110** and operating a user interface **152**. A bottom cover **151** sits over motor **110** and attaches to the back side of frame assembly back section **111**. A power and control cable **154** includes the control and power lines used for powering and controlling motor **110** and control system **140**. Connectors **158** in cable **154** plug into a printed circuit board contained in enclosure **150** that holds the electrical components of control system **140**. Control system **140** contains a central processing unit, a motor controller, an inertial measurement unit (IMU), a global navigation satellite system (GNSS) receiver, and a GNSS antenna all integrated together inside of enclosure **150**.

[0032] User interface **152** includes a center engage button **160**A, a left set A button **160**B, a right set B button **160**C, and a light bar **166**. Integrated buttons **160**A-**160**C and light bar LEDs **166** form a simple user interface **152** for controlling actuator **100**. Buttons **160**A-**160**C engage auto-steering, disengage auto-steering, and set the starting point and end point of a new wayline in a field. Light bar **166** may indicate system status, power, error codes, and steering error relative to the desired ideal wayline in the field. The functionally of LEDs in light bar **166** is fully programmable and other modes of operations can be added.

[0033] Pressing middle button **160**A may engage auto-steering transferring vehicle control to control system **140** so the operator can let go of steering wheel **116**. Pressing button **160**A again disengages the auto-steering. An operator presses set A button **160**B to set the start coordinates for a a desired path for the vehicle (wayline) and presses the set B button **160**C to set the ending coordinates of the wayline.

[0034] A and B buttons **160**B and **160**C, respectively, are also used during auto-steer to nudge the vehicle in the left or right direction when the vehicle is drifting off the set wayline. For example, a farm implement may pull the vehicle to the left off of the wayline. The operator may press set B button **160**C to move the vehicle and towed implement slightly to the right.

[0035] The operator may grab the steering wheel at any time to disable auto-steer. For example, at the end of the wayline, the operator may grab the steering wheel and manually perform a U-turn to realign the vehicle with a next row on a field. The operator then presses center engage button **160**A to re-engage auto-steer.

[0036] Light bar **166** may provide diagnostics identifying power status, GPS status, motor faults, IMU status, etc. Light bar **166** also may indicate how far the vehicle is off the current wayline. For example, light emitting diodes (LEDs) in light bar **166** are activated on the left or right of a center LED to indicate how far the vehicle is off the wayline to the left or right, respectively.

[0037] FIG. **6** is an exploded top perspective view of control system **140** and FIG. **7** is an exploded bottom perspective view of control system **140**. Referring to FIGS. **6** and **7**, in one example, user interface **152** may include a flexible mat or screen **170** that lays on top of button actuators **171** formed on the top surface of enclosure **150**. Different

locations on mat **170** operate as buttons **160**A, **160**B, and **160**C and are located over associated actuators **171**.

[0038] A printed circuit board (PCB) **172** seats up inside of a wall **174** that extends down from the top surface of enclosure **150**. A gasket **176** is shaped to extend around the perimeter of printed circuit board (PCB) **172** and seat up into a bottom end of wall **174**. A cover **178** attaches to enclosure **150** pressing up against gasket **176** and providing a water-tight seal around PCB **172**. The entire enclosure **150** may be waterproof and drive assembly **104** may be the only exposed moving element.

[0039] FIG. **8**A shows a top plan view of PCB **172** and FIG. **8**B shows a bottom plan view of PCB **172**. The top side of PCB **172** includes multiple LEDs **184** that form light bar **166** shown above in FIG. **1**. Multiple push button switches **190**A, **190**B, and **190**C are mounted on PCB **172** and activate in response to depressed buttons **160**A, **160**B, and **160**C, respectively, on user interface **152** as shown above in FIG. **6**.

[0040] Liquid crystal diodes (LCDs), an LCD screen, a touch screen, or any other type of display and input device may be used instead of LEDs **184**. Other types of switches or input devices may be used based on the type of user interface. For example, user interface **152** may use a touch screen with capacitive sensors instead of switches **190**.

[0041] Wi-Fi and Bluetooth® transceivers **186** operate within a same integrated circuit and are coupled to a Wi-Fi and Bluetooth® antenna **188**. A GNSS antenna **198** is coupled to a GNSS receiver **183** mounted on the back side of PCB **172**. GNSS is alternatively referred to as global positioning system (GPS). An inertial measurement unit (IMU) IC **200** and compass IC **202** are also mounted to the top of PCB **172**. IMU **200** may include an integrated accelerometer and gyroscope. A power conditioning circuit **182** generates, conditions, and filters the voltages used by the ICs mounted on PCB **172**.

Control unit **156** is connected to substantially all of the ICs on PCB **172** and is alternatively referred to as a main central processing unit (CPU). CPU **156** operates as a steering controller for automatically steering the vehicle based on a stored destination path, and inputs from GNSS receiver **183**, compass **202**, IMU **200**, Bluetooth/Wi-Fi **186**, and push button switches **190**A, **190**B, and **190**C. Control unit **156** sends commands to a motor controller **196** for controlling motor **110** and steering wheel **116**. The CPU **156** may use control software to determine the vehicle position for controlling the motor and automatically steering the vehicle.

[0042] Steering control systems that automatically steer vehicles using GPS/IMU technology over defined paths are described in U.S. Pat. No. 7,142,956, issued Nov. 28, 2006, entitled: AUTOMATIC STEERING SYSTEM AND METHOD; U.S. Pat. No. 7,689,354, issued Mar. 30, 2010, entitled ADAPTIVE GUIDANCE SYSTEM AND METHOD; U.S. Pat. No. 7,835,832, Nov. 16, 2010, entitled: VEHICLE CONTROL SYSTEM; and U.S. Pat. No. 7,437,230, issued Oct. 14, 2008, entitled: SATELLITE BASED VEHICLE GUIDANCE CONTROL IN STRAIGHT AND CONTOUR MODES, which are all herein incorporated by reference in their entireties.

[0043] Normally a user interface is a separate expensive touchscreen display connected by cables to the steering wheel actuator. Electronic control units (ECUs) with inertial sensors are also usually sold as a separate expensive devices that connect to steering actuators with electrical harnesses.

[0044] Control system **140** and user interface **152** are uniquely integrated into steering wheel actuator **100** to achieve a lower overall system cost. Control system **140** uses a same enclosure **150** to hold CPU **156**, GNSS receiver **183**, and the accelerometers and gyros of IMU **200** used for terrain compensation and closed loop steering control. Control system **140** integrates the ECU/steering controller **156** into steering actuator **100** providing an easy to install and use cost effective design.

[0045] In one example, control system **140** is integrated on a single PCB **172**. In other examples, multiple PCBs located within enclosure **150** may retain different components of control system **140**. Other components of actuator **100** are connected to PCB **172** via wires, cables or alternative physical attachments.

[0046] FIG. **9** is a schematic diagram showing how different devices in steering wheel actuator **100** are connected together on a vehicle. As described above, steering wheel actuator **100** includes a mounting bracket and clamp **106** that attaches enclosure **150** to steering column **114**. Actuators **108** are connected to drive assembly **104** and extend up in-between the spokes of steering wheel **116** to steer the vehicle. As explained above, drive assembly **104** may be a gear assembly, belt drive assembly, chain drive assembly, or a direct dive motor.

[0047] Control and power cable **154** in actuator **100** is coupled to a power supply **218**, such as the vehicle battery. Control cable **154** may include a wiring harness that runs down steering column **114** to the vehicle floorboard to connect to an external terminal **220**. A power switch **214** connects power from control cable **154** to power conditioning circuit **182** located on PCB **172**.

[0048] Enclosure **150** retains control system **140**, and buttons **190** of user interface **152**. Enclosure **150** also may retain motor **110** and power switch **214**. Enclosure **150** is also attached via frame assembly **102** in FIG. **1** to mounting bracket **106**, gear assembly **104**, actuators **108**, and control cable **154** as shown above.

[0049] Control unit **156** receives position, speed, heading, yaw, roll, pitch, etc. from GNSS receiver **183**, compass **202**, and IMU **200**. GNSS antenna **198** is connected to GNSS receiver **183** and is mounted directly on PCB **172**. Mounting GNSS antenna **198** on PCB **172** may improve strength of GNSS signals received by GNSS receiver **183**. An antenna harness **216** may connect an external antenna **222** located outside of enclosure **150** to GNSS receiver **183**.

[0050] Control unit **156** may store configuration data, location data, and selected waylines in Flash memories **210** and **208**. Control unit **156** reads the position and heading data from GNSS receiver **183**, compass **202**, and IMU **200** and reads the wayline coordinates in memories **210** and **208** to determine where the vehicle is currently located and where the vehicle needs to be located. Control unit **156** sends signals to motor controller **196** to turn the vehicle to the right or left based on the current vehicle location relative to the stored wayline.

[0051] Motor controller **196** controls motor **110** and actuates the LEDs in user interface **152** based on inputs received from buttons **190** and the inputs received from control unit **156**. In a simplified configuration, motor **110** and user interface **152** may be operated only by motor controller **196** without the auto-steer functionality provided by control unit

156. Control unit **156** also may be controlled by a wireless device, such as a smart phone, IPAD, PC, etc. via Wi-Fi/Bluetooth® transceivers **186**.

[0052] Thus, auto-steer components are integrated into a same enclosure **150** within steering wheel actuator **100**. For example, GNSS antenna **198**, GNSS receiver **183**, IMU **200**, control unit **156**, and user interface **152** are all located within enclosure **150** mounted on steering column **114** instead of in separate enclosures located on separate vehicle locations. Thus, steering wheel actuator **100** with integrated control system **140** provides a complete auto-steer system that is less expensive to manufacture and easier to install.

[0053] For the sake of convenience, operations may be described as various interconnected or coupled functional blocks or diagrams. However, there may be cases where these functional blocks or diagrams may be equivalently aggregated into a single logic device, program or operation with unclear boundaries.

[0054] Some of the operations described above may be implemented in software and other operations may be implemented in hardware. One or more of the operations, processes, or methods described herein may be performed by an apparatus, device, or system similar to those as described herein and with reference to the illustrated figures.

[0055] It will be apparent to one skilled in the art that the disclosed implementations may be practiced without some or all of the specific details provided. In other instances, certain process or methods also referred to herein as "blocks," have not been described in detail in order to avoid unnecessarily obscuring the disclosed implementations. Other implementations and applications also are possible, and as such, the following examples should not be taken as definitive or limiting either in scope or setting.

[0056] References have been made to accompanying drawings, which form a part of the description and in which are shown, by way of illustration, specific implementations. Although these disclosed implementations are described in sufficient detail to enable one skilled in the art to practice the implementations, it is to be understood that these examples are not limiting, such that other implementations may be used and changes may be made to the disclosed implementations without departing from their spirit and scope. For example, the blocks of the methods shown and described are not necessarily performed in the order indicated in some other implementations.

[0057] Having described and illustrated the principles of a preferred embodiment, it should be apparent that the embodiments may be modified in arrangement and detail without departing from such principles. Claim is made to all modifications and variation coming within the spirit and scope of the following claims.

1. A steering wheel actuator for mounting on a steering wheel column and turning a steering wheel of a vehicle, comprising:

an enclosure formed onto the steering wheel actuator;

a central processing unit (CPU) located in the enclosure configured to automatically steer the vehicle; and

a user interface located on the enclosure configured to control the CPU.

2. The steering wheel actuator of claim **1**, further comprising:

a global navigation satellite system (GNSS) antenna located in the enclosure; and

a GNSS receiver located in the enclosure and coupled to the GNSS antenna and the CPU.

3. The steering wheel actuator of claim **2**, further comprising an inertial measurement unit (IMU) including an accelerometer and a gyroscope located in the enclosure and coupled to the CPU.

4. The steering wheel actuator of claim **3**, wherein the CPU, GNSS antenna, GNSS receiver, and IMU are all mounted on one or more printed circuit boards located in the enclosure.

5. The steering wheel actuator of claim **1**, wherein the user interface includes one or more buttons, light emitting diodes (LEDs), a liquid crystal display (LCD), or a touch screen located on the enclosure and operably coupled to the CPU to control engagement and disengagement of the steering wheel actuator with a steering wheel.

6. The steering wheel actuator of claim **5**, wherein the user interface includes a mat or screen located on the top face of the enclosure.

7. The steering wheel actuator of claim **1**, further comprising:

a frame assembly that attaches around the steering wheel column;

a drive assembly that rotates within the frame assembly;

a motor configured to rotate the gear assembly based on control signals generated by the CPU and user interface.

8. The steering wheel actuator of claim **7**, further comprising a motor controller located in the enclosure and coupled between the CPU and the motor, the motor controller configured to send control signals to the motor based on the control signals generated by the CPU and the user interface.

9. The steering wheel actuator of claim **7**, wherein the enclosure extends back from the frame assembly underneath the steering wheel.

10. An apparatus for controlling a steering wheel, comprising:

a frame assembly configured to attach to a steering wheel column;

a drive assembly located in the frame assembly;

a motor coupled to the drive assembly; and

a control system attached to the frame assembly including a user interface and a motor controller, the motor controller sending commands to the motor to turn the steering wheel based on inputs received from the user interface.

11. The apparatus of claim **10**, including an enclosure extending from the frame assembly retaining the user interface and an internal space housing the motor controller.

12. The apparatus of claim **10**, wherein the control system includes:

a global navigation satellite system (GNSS) antenna;

a GNSS receiver coupled to the GNSS antenna; and

a central processing unit (CPU) coupled to the motor controller and the GNSS receiver.

13. The apparatus of claim **12**, wherein the control system includes an inertial measurement unit (IMU) coupled to the CPU.

14. The apparatus of claim **13**, including an enclosure extending from the frame assembly and containing one or more printed circuit boards coupled to the control system.

15. The apparatus of claim **13**, wherein the CPU sends commands to the motor controller to control the motor based on signals received from the GNSS receiver and the IMU.

16. The apparatus of claim **15**, wherein the control system includes a memory to store wayline coordinates, the CPU sending the commands to the motor controller based on a position and heading signals received from the GNSS receiver and the IMU relative to the wayline coordinates.

17. The apparatus of claim **10**, wherein the drive assembly includes at least one of a gear assembly, belt drive assembly, chain drive assembly, or direct dive motor.

18. The apparatus of claim **10**, wherein the user interface includes one or more buttons, light emitting diodes (LEDs), a liquid crystal display (LCD), or a touch screen.

19. The apparatus of claim **10**, including a wireless transceiver for wireless communication with an external device.

20. The apparatus of claim **19**, wherein the wireless transceiver comprises a WiFi, Bluetooth, or cellular phone transceiver.

21. A method for steering a vehicle, comprising:

attaching a steering wheel actuator to a steering wheel column, the steering wheel actuator including a motor for rotating the steering wheel and an enclosure; and

operating a control system in the enclosure to control the motor and automatically steer the vehicle.

22. The method of claim **21**, wherein the steering wheel actuator includes a drive assembly coupled to the motor for rotating the steering wheel.

23. The method of claim **21**, further comprising:

receiving global navigation satellite system (GNSS) signals from a GNSS antenna and GNSS receiver located in the enclosure; and

automatically steering the vehicle based on the GNSS signals.

24. The method of claim **21**, further comprising:

receiving inertial measurement unit (IMU) signals from an IMU located in the enclosure; and

automatically steering the vehicle based on the IMU signals.

25. The method of claim **21**, further comprising:

receiving user input signals from a user interface located on the enclosure; and

automatically steering the vehicle based on the user input signals.

26. The method of claim **25**, wherein the user interface includes one or more buttons, light emitting diodes (LEDs), a liquid crystal display (LCD), or a touch screen.

27. The method of claim **21**, including using a central processing unit and control software in the control system to control the motor and automatically steer the vehicle.

* * * * *