US 20190084364A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2019/0084364 A1**

LAGRANDCOURT et al. (43) **Pub. Date: Mar. 21, 2019**

(54) **VERSATILE URBAN ELECTRIC TRANSPORT DEVICE AND SYSTEM**

(71) Applicant: **Ford Global Technologies, LLC**, Dearborn, MI (US)

(72) Inventors: **Aurelien LAGRANDCOURT**, Preston (AU); **Navneet BHASIN**, Preston (AU)

(21) Appl. No.: **16/087,638**

(22) PCT Filed: **Sep. 9, 2016**

(86) PCT No.: **PCT/US16/50884**

§ 371 (c)(1),
(2) Date: **Sep. 22, 2018**

Related U.S. Application Data

(60) Provisional application No. 62/311,981, filed on Mar. 23, 2016.

Publication Classification

(51) **Int. Cl.**

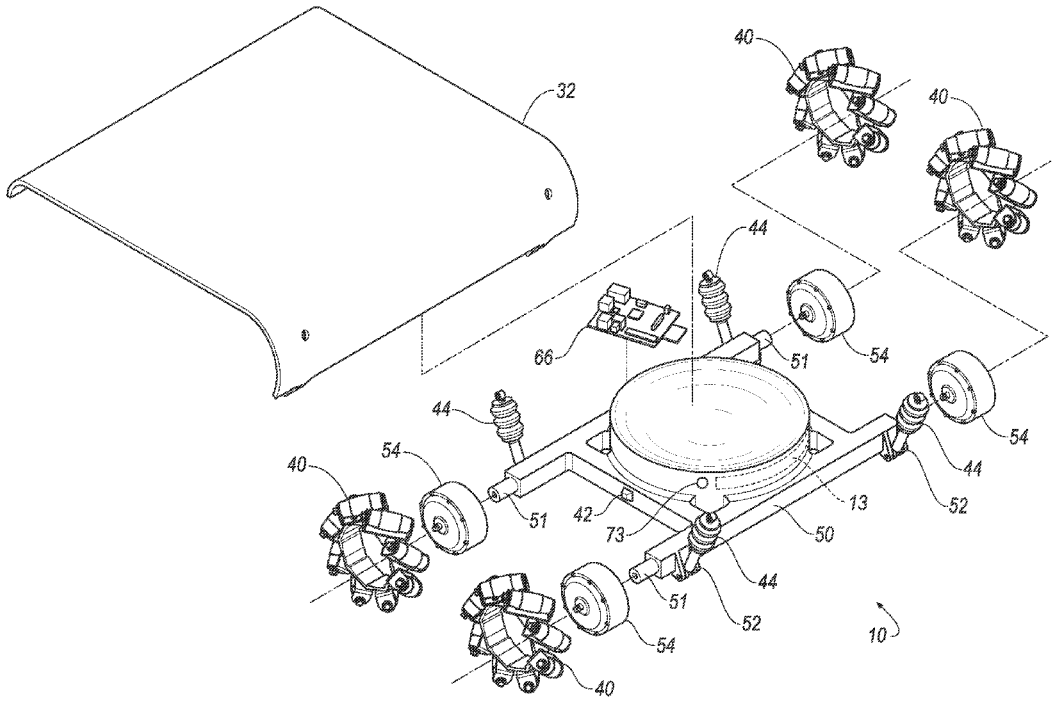
B60G 17/0165	(2006.01)
B62D 51/02	(2006.01)
B60B 19/00	(2006.01)
B60K 7/00	(2006.01)
B60K 1/04	(2006.01)

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

CPC ***B60G 17/0165*** (2013.01); ***B62D 51/02*** (2013.01); ***B60B 19/003*** (2013.01); ***B60K 7/0007*** (2013.01); *B60Y 2200/91* (2013.01); ***B60K 1/04*** (2013.01); *B60G 2800/019* (2013.01); *B60K 2001/0438* (2013.01); ***B60L 11/18*** (2013.01)

(57) **ABSTRACT**

Disclosed herein is a transport device with a platform that pivots relative to a frame of the transport device. A pivot angle of the platform is altered with an actuator controlled by a transport computer. The pivot angle is based, at least in part, on a predicted change in velocity, a determined change in ground surface, a determined ground slope, and a center of gravity of a user and of the transport device.



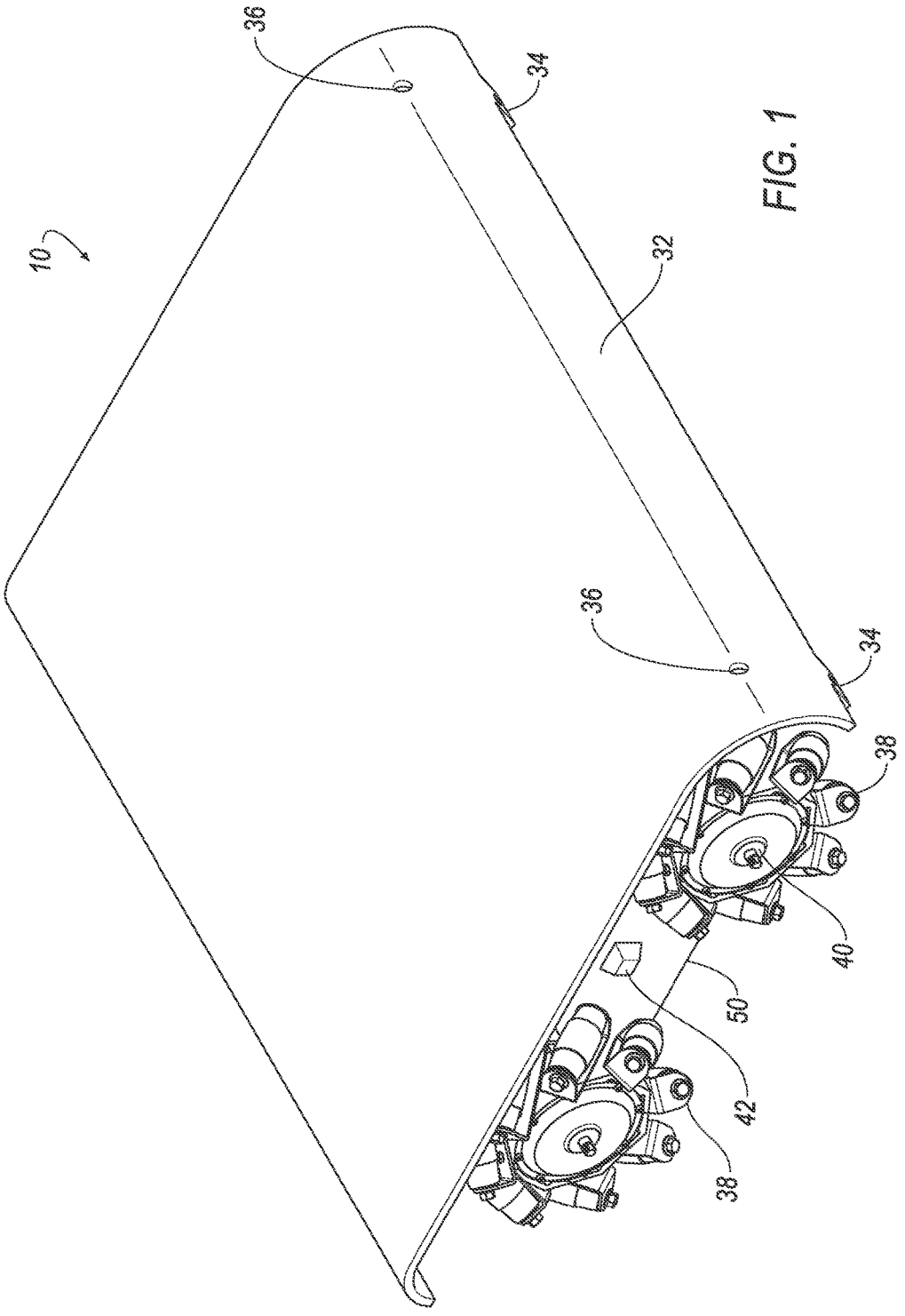


FIG. 1

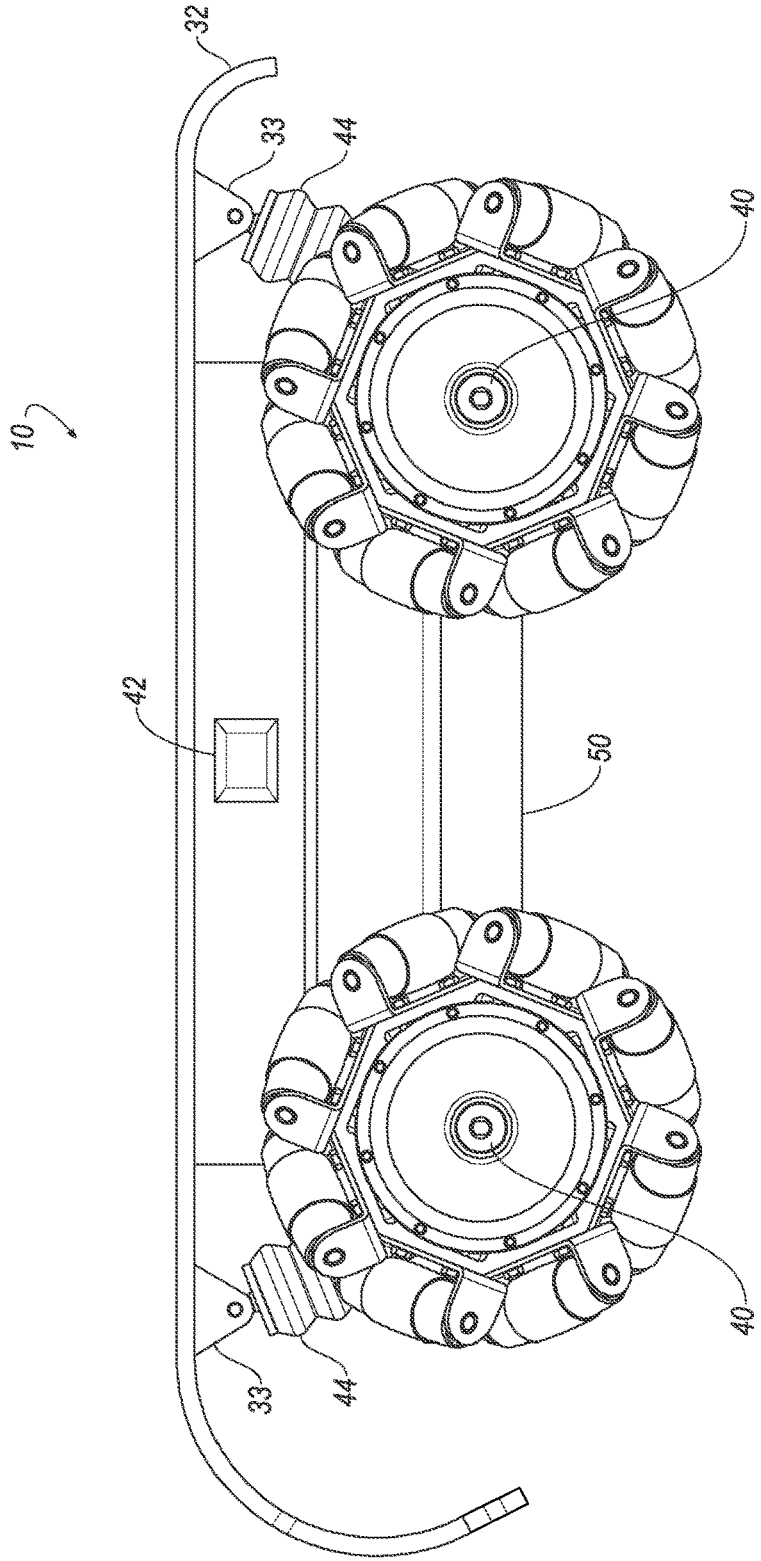


FIG. 2

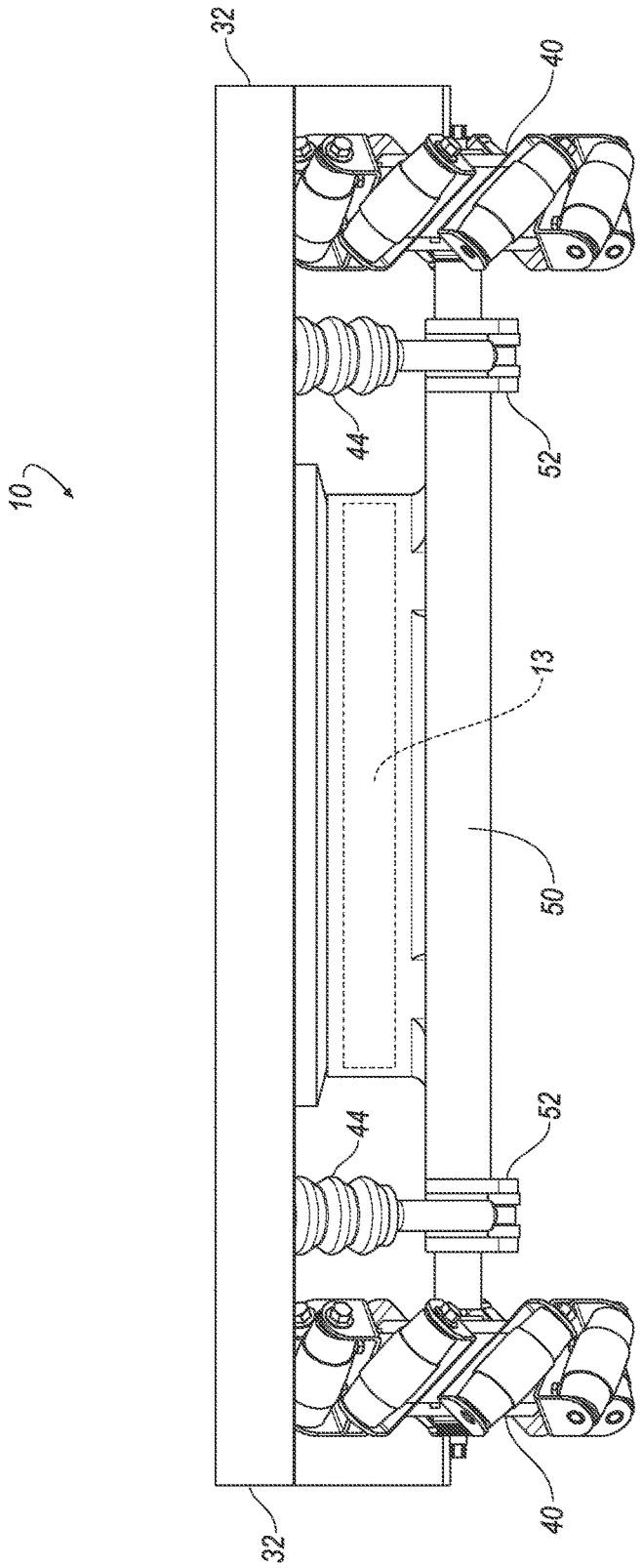


FIG. 3

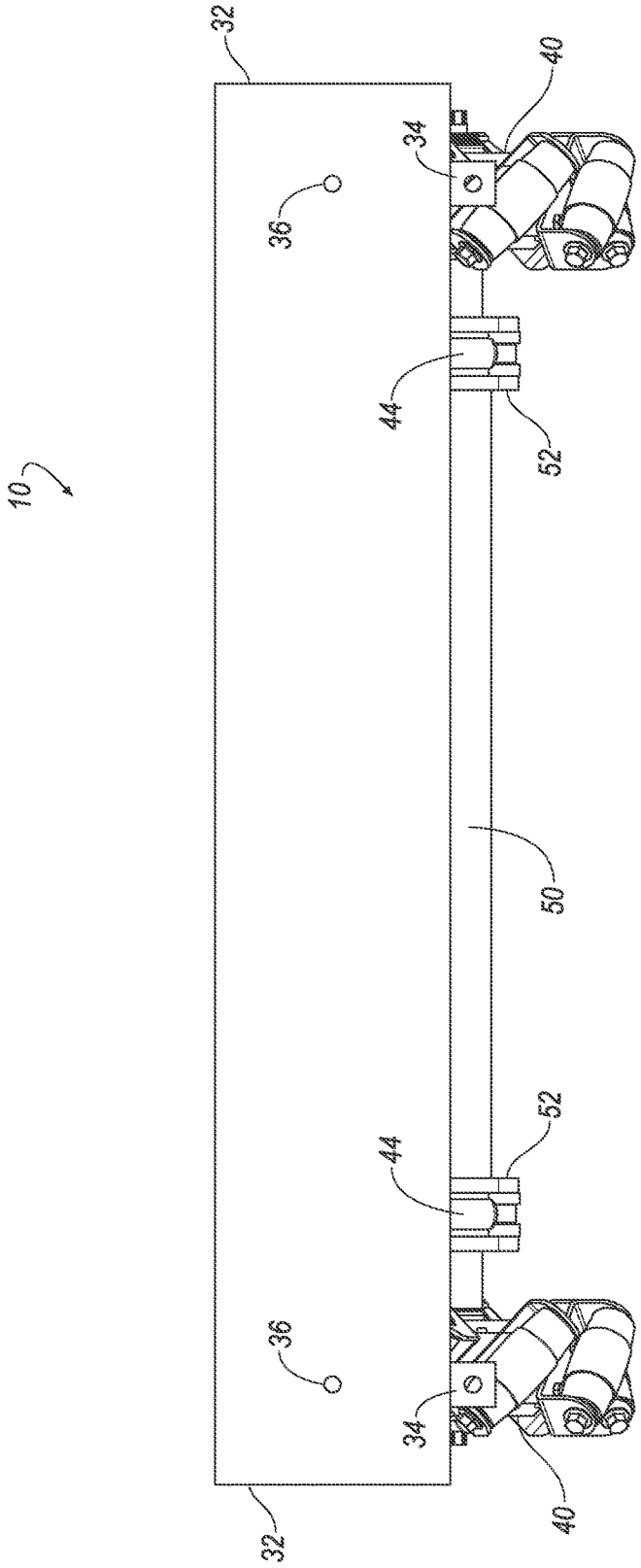


FIG. 4

FIG. 5

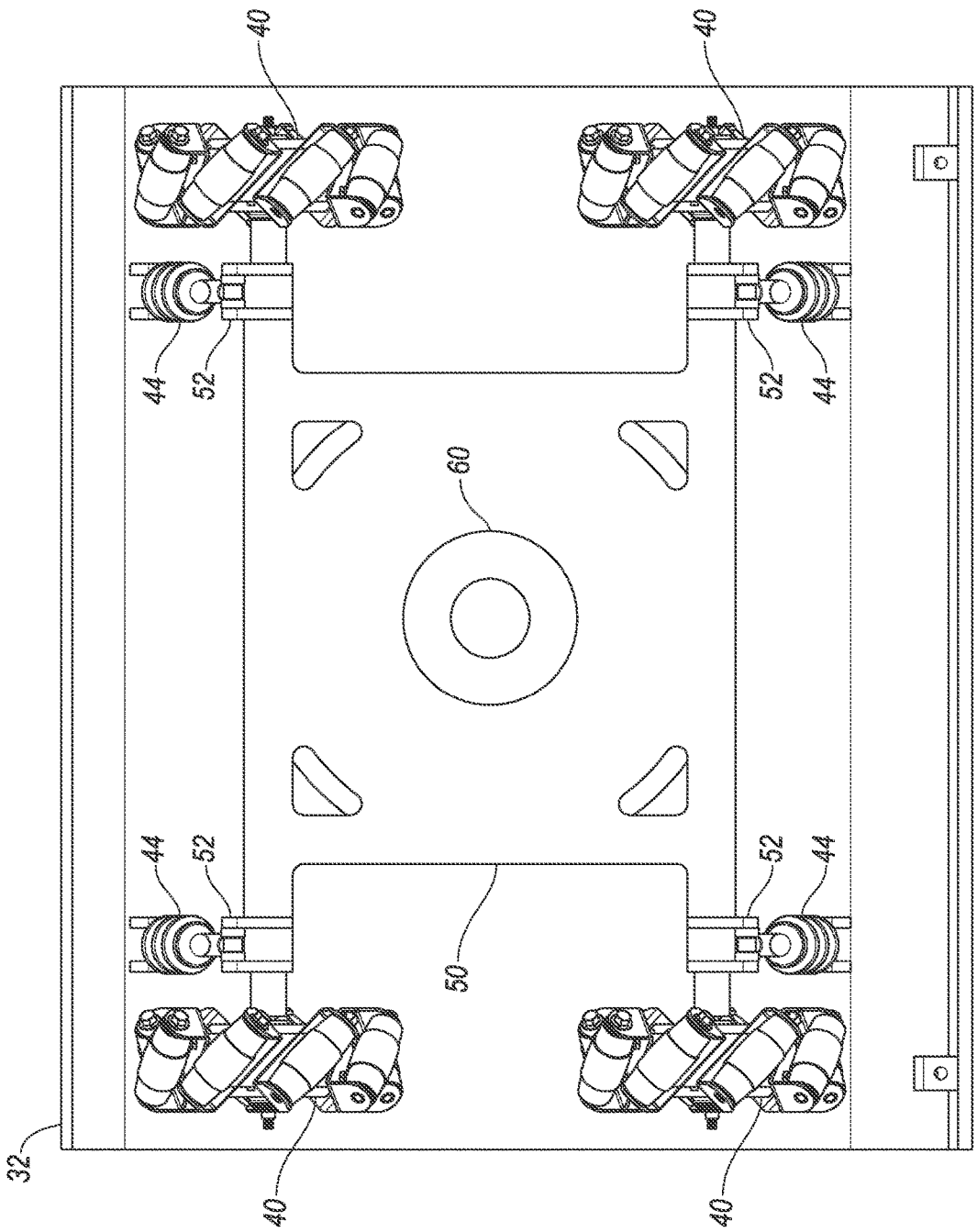
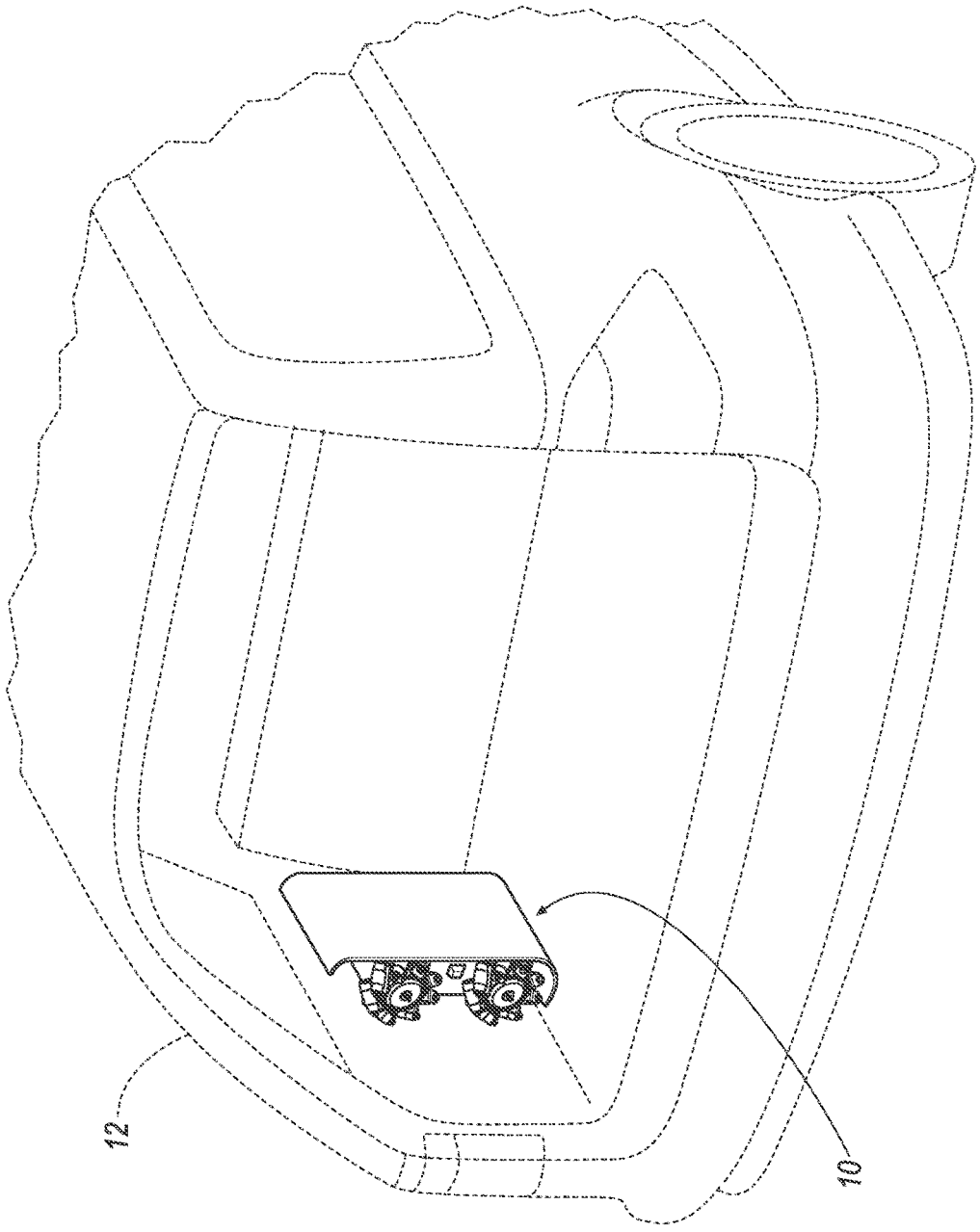


FIG. 6



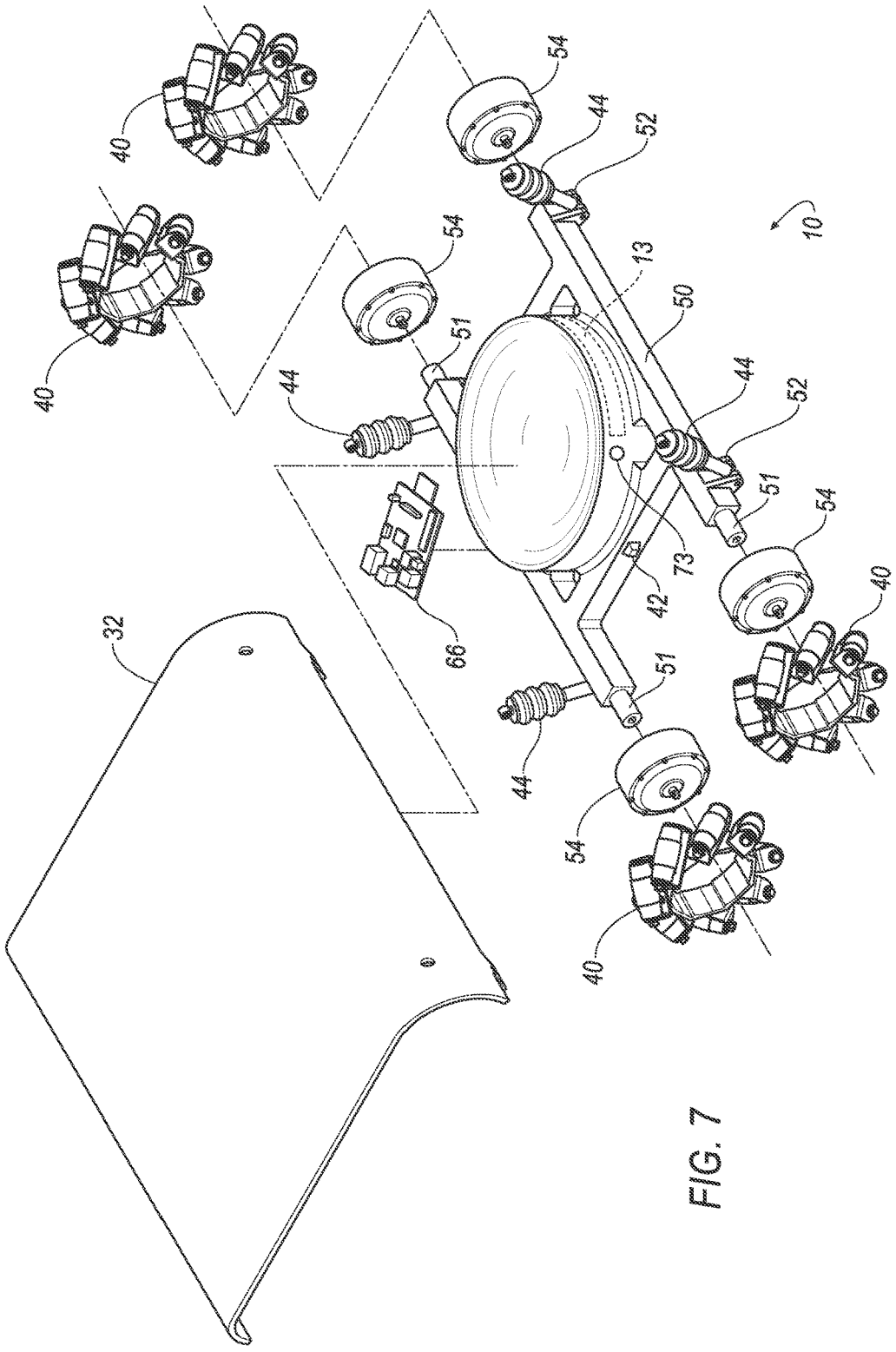


FIG. 7

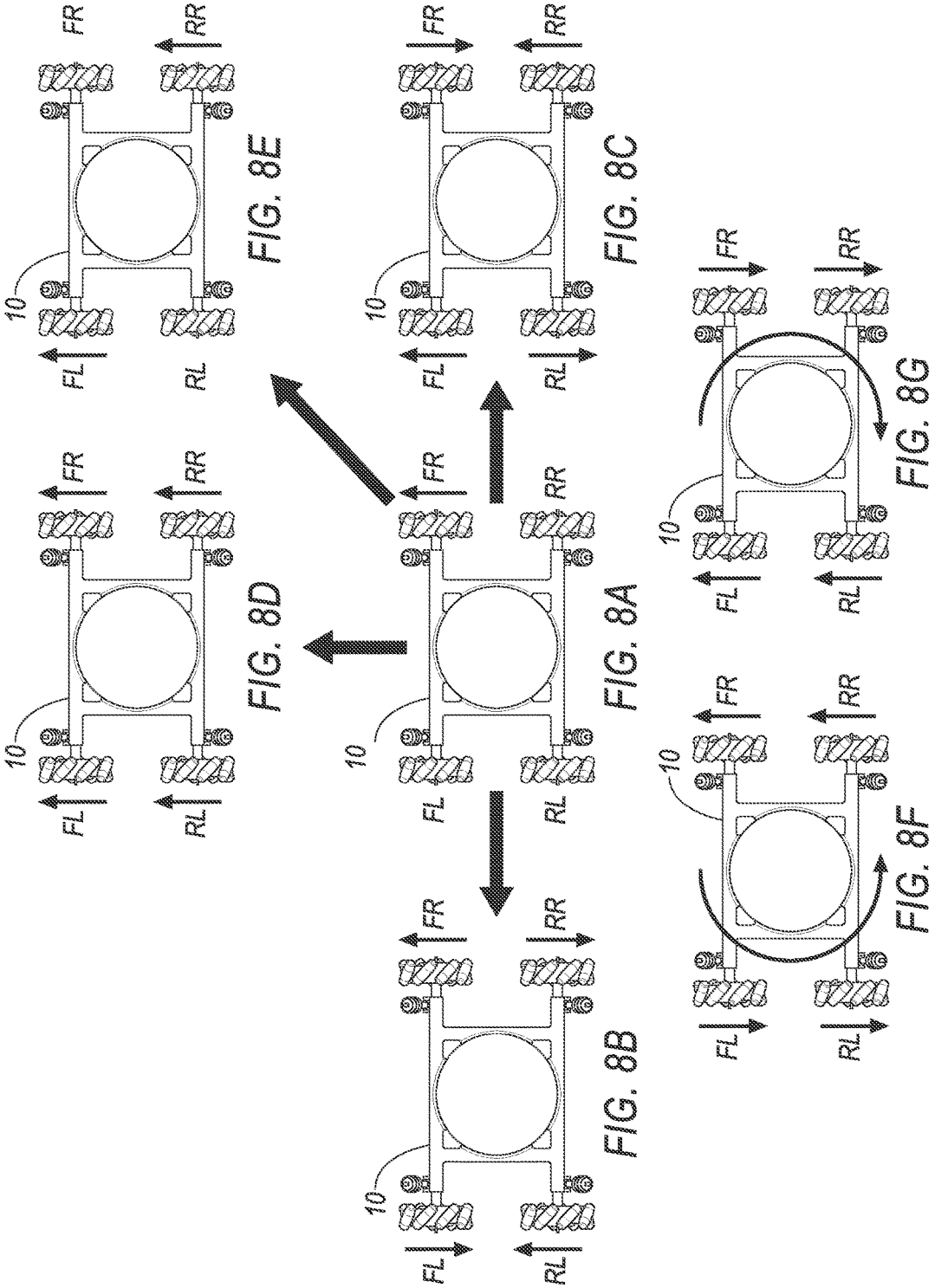


FIG. 8A

FIG. 8B

FIG. 8C

FIG. 8D

FIG. 8E

FIG. 8F

FIG. 8G

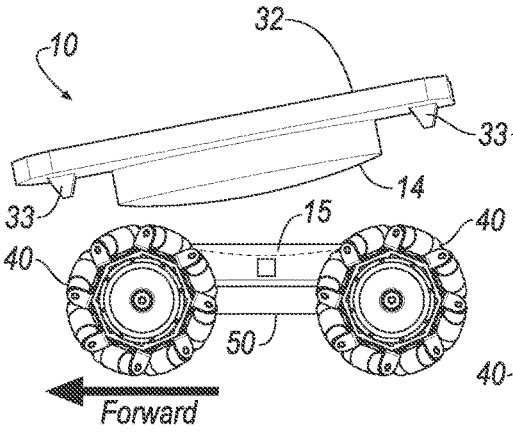


FIG. 9A

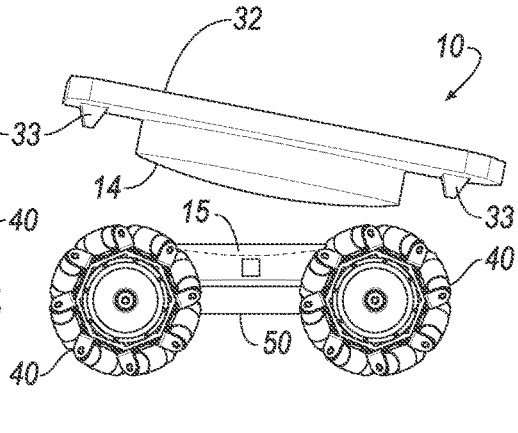


FIG. 9B

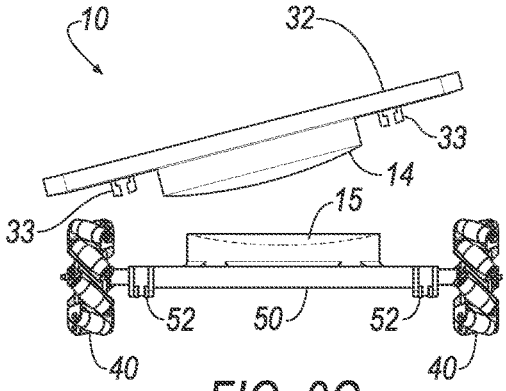


FIG. 9C

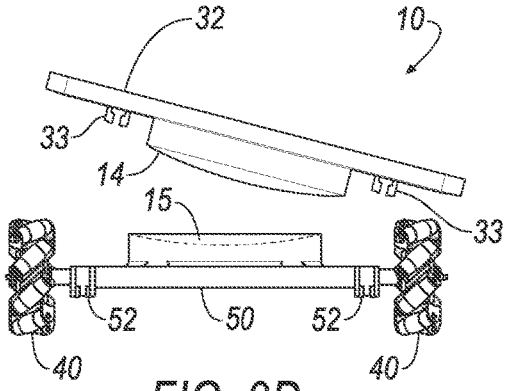


FIG. 9D

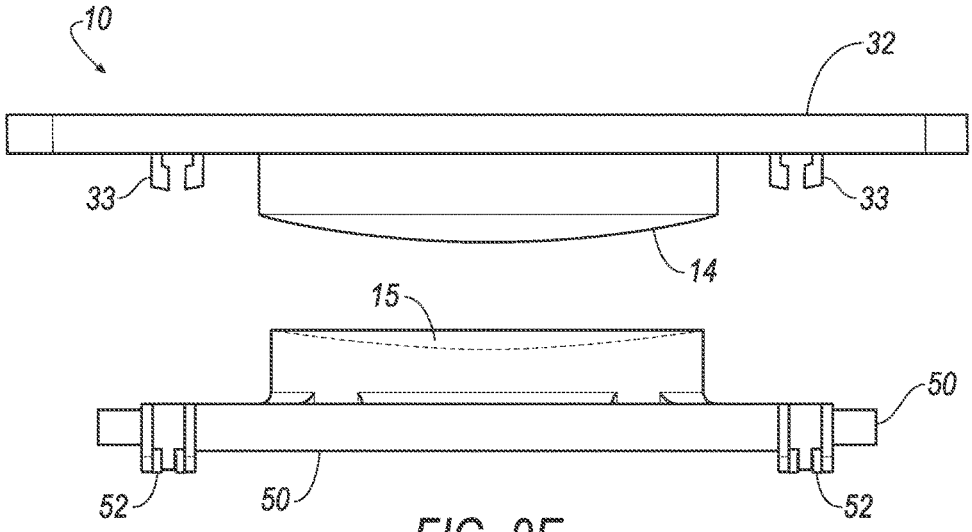


FIG. 9E

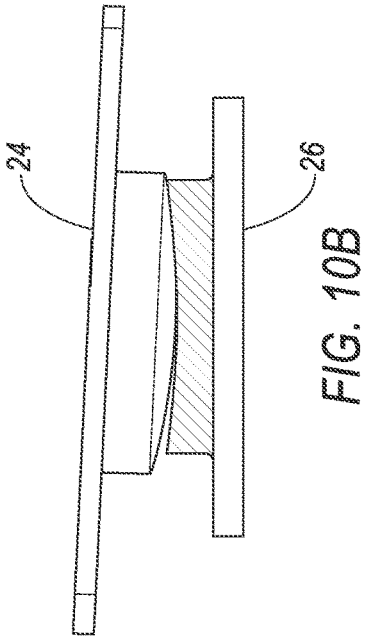


FIG. 10B

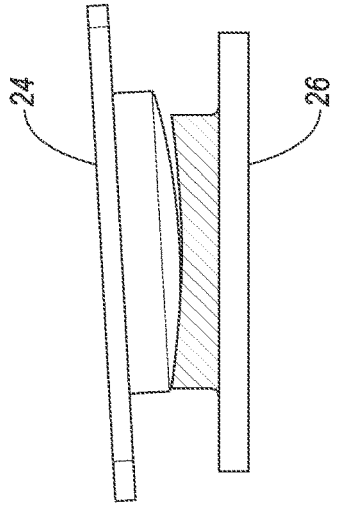


FIG. 10D

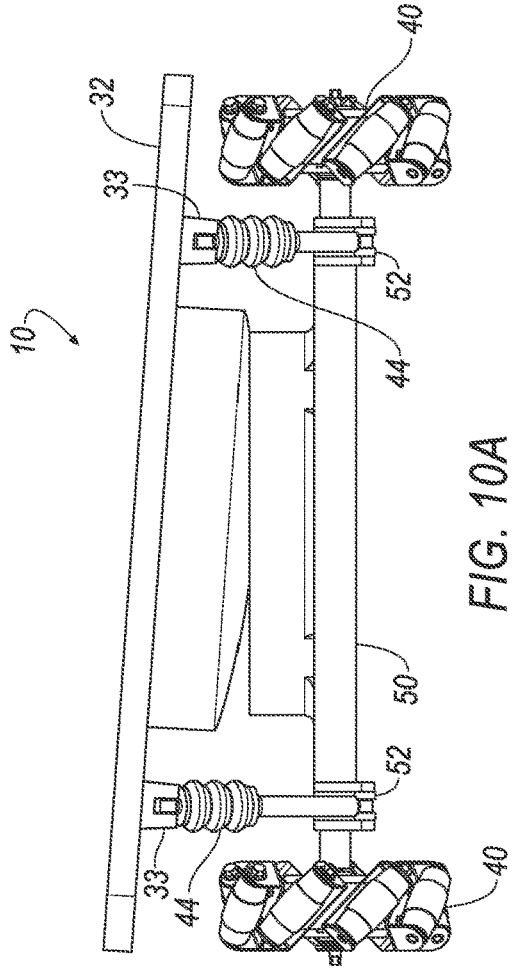


FIG. 10A

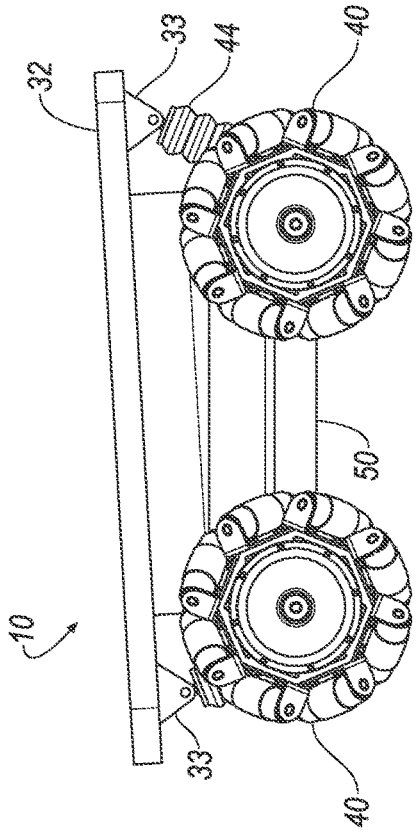


FIG. 10C

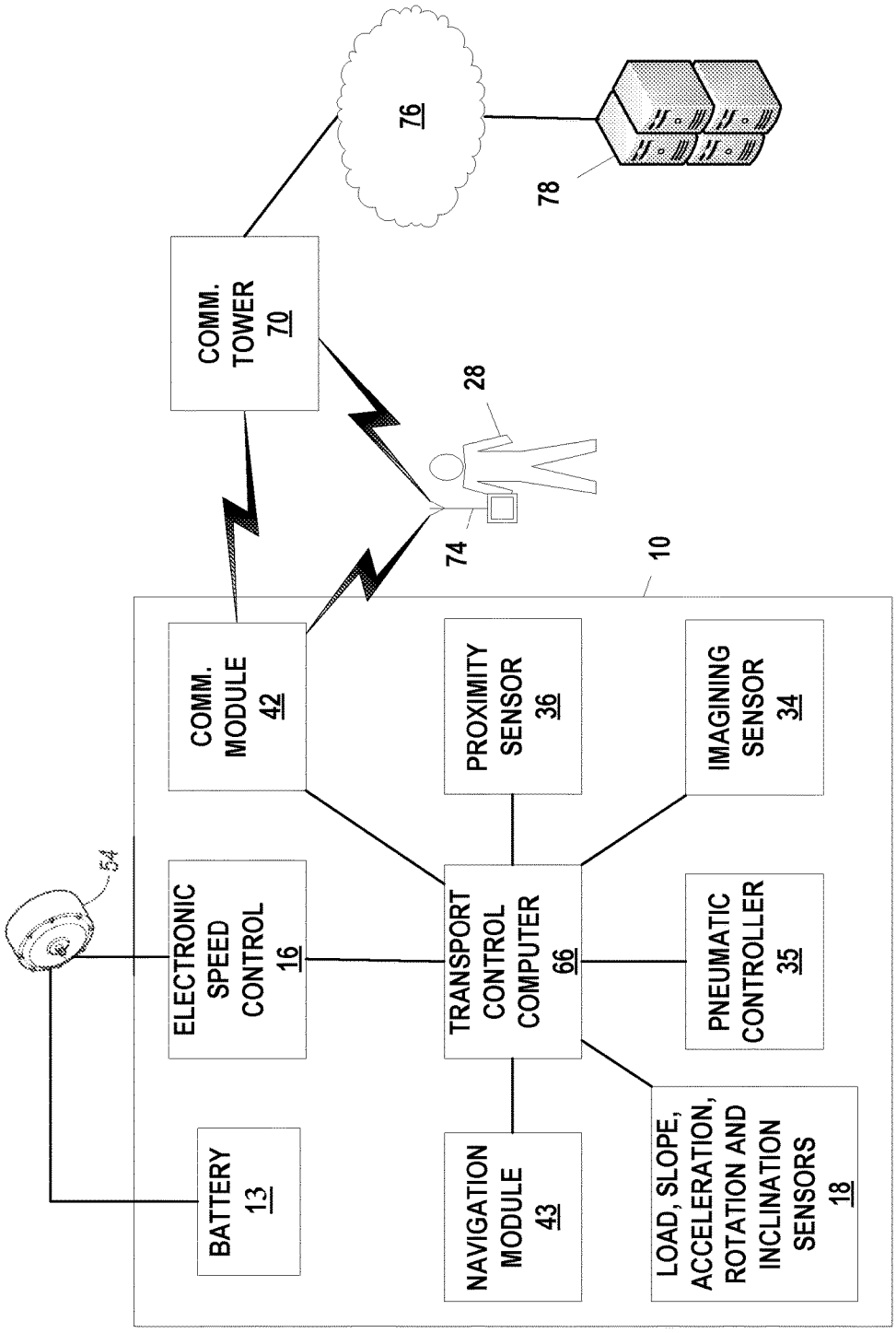

76
78
COMM. TOWER 70
28
74
10
COMM. MODULE 42
PROXIMITY SENSOR 36
IMAGINING SENSOR 34
54
ELECTRONIC SPEED CONTROL 16
TRANSPORT CONTROL COMPUTER 66
PNEUMATIC CONTROLLER 35
BATTERY 13
NAVIGATION MODULE 43
LOAD, SLOPE, ACCELERATION, ROTATION AND INCLINATION SENSORS 18

FIG. 11

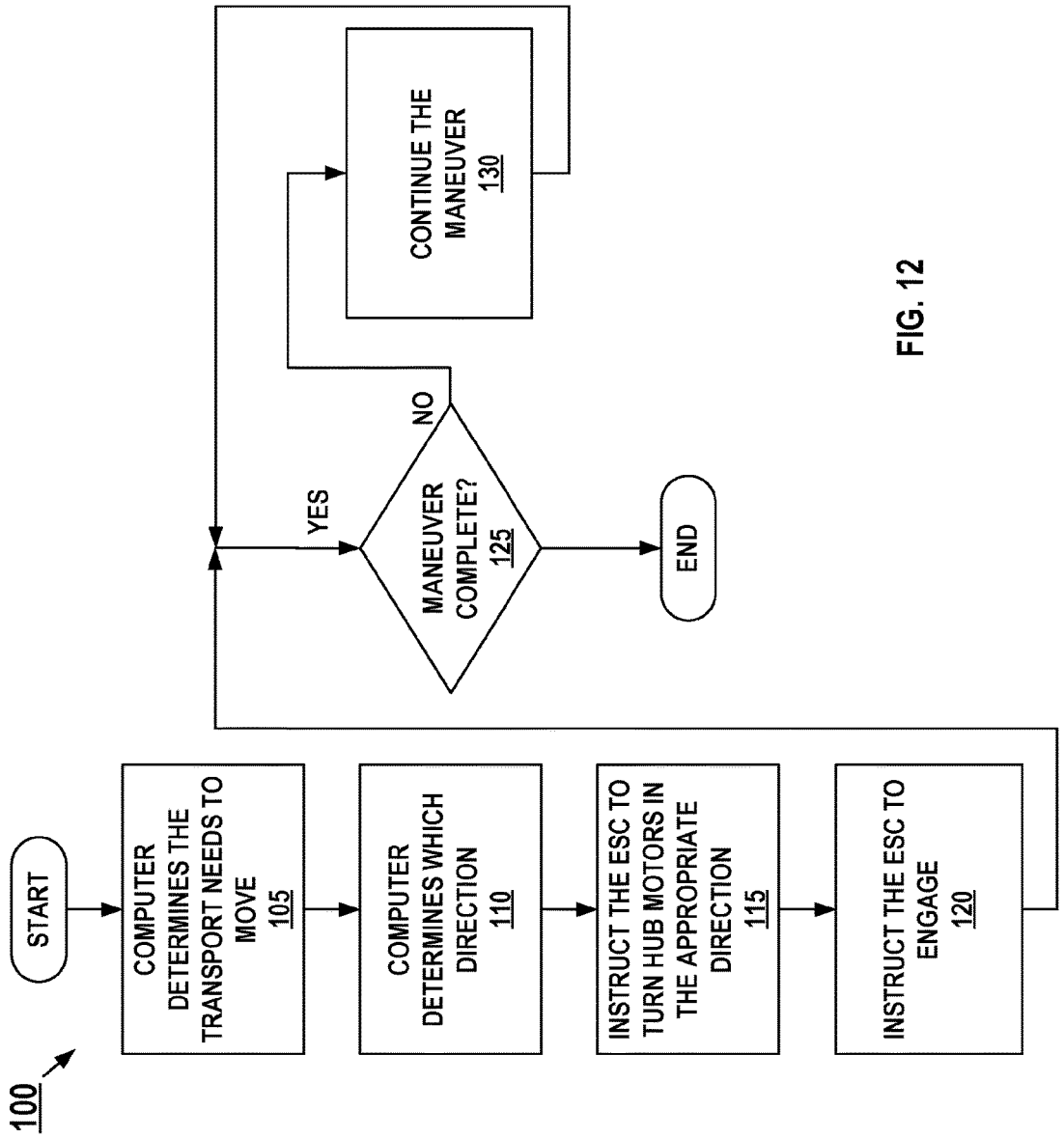

100
START
COMPUTER DETERMINES THE TRANSPORT NEEDS TO MOVE 105
COMPUTER DETERMINES WHICH DIRECTION 110
INSTRUCT THE ESC TO TURN HUB MOTORS IN THE APPROPRIATE DIRECTION 115
INSTRUCT THE ESC TO ENGAGE 120
MANEUVER COMPLETE? 125
YES
NO
CONTINUE THE MANEUVER 130
END

FIG. 12

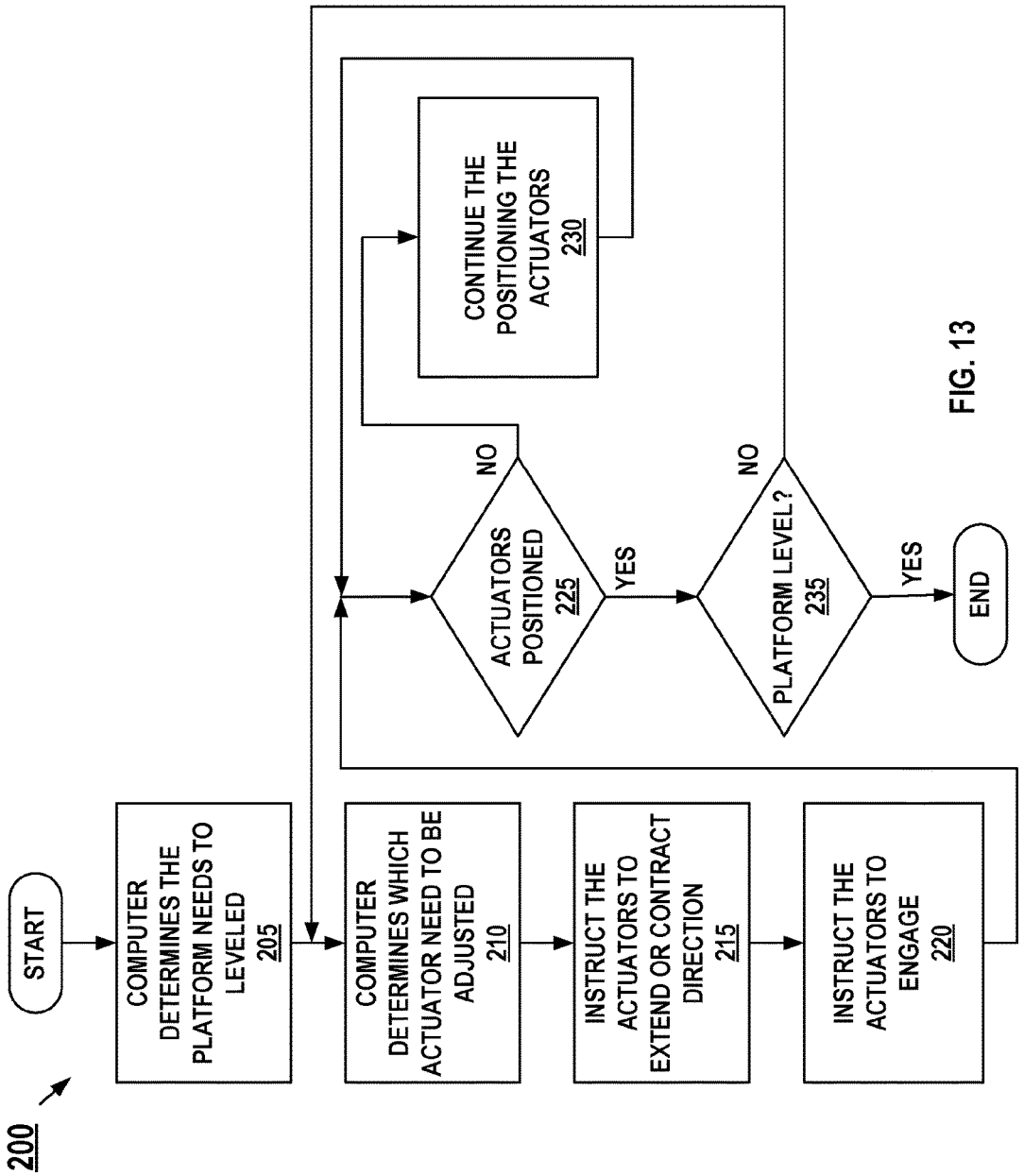

200
START
COMPUTER DETERMINES THE PLATFORM NEEDS TO LEVELED 205
COMPUTER DETERMINES WHICH ACTUATOR NEED TO BE ADJUSTED 210
INSTRUCT THE ACTUATORS TO EXTEND OR CONTRACT DIRECTION 215
INSTRUCT THE ACTUATORS TO ENGAGE 220
ACTUATORS POSITIONED 225
NO
YES
CONTINUE THE POSITIONING THE ACTUATORS 230
PLATFORM LEVEL? 235
NO
YES
END

FIG. 13

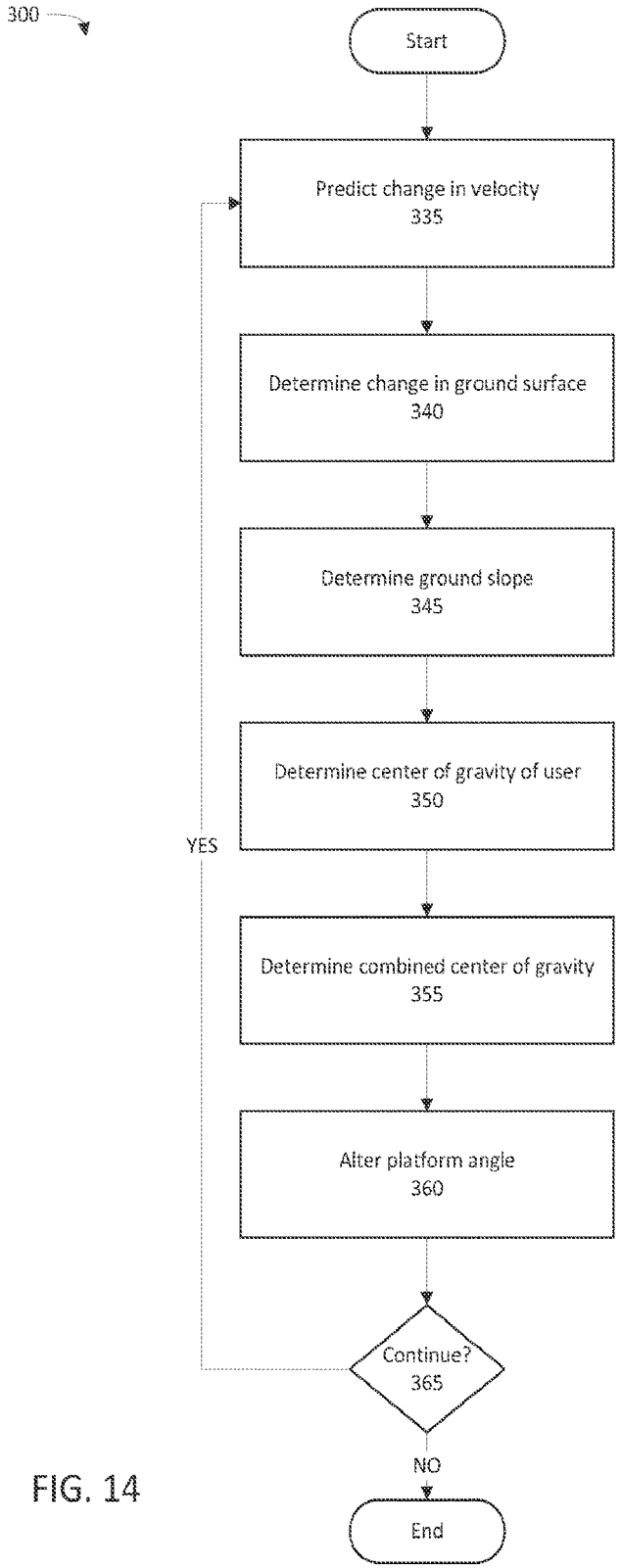

300
Start
Predict change in velocity
335
Determine change in ground surface
340
Determine ground slope
345
Determine center of gravity of user
350
YES
Determine combined center of gravity
355
Alter platform angle
360
Continue?
365
NO
End

FIG. 14

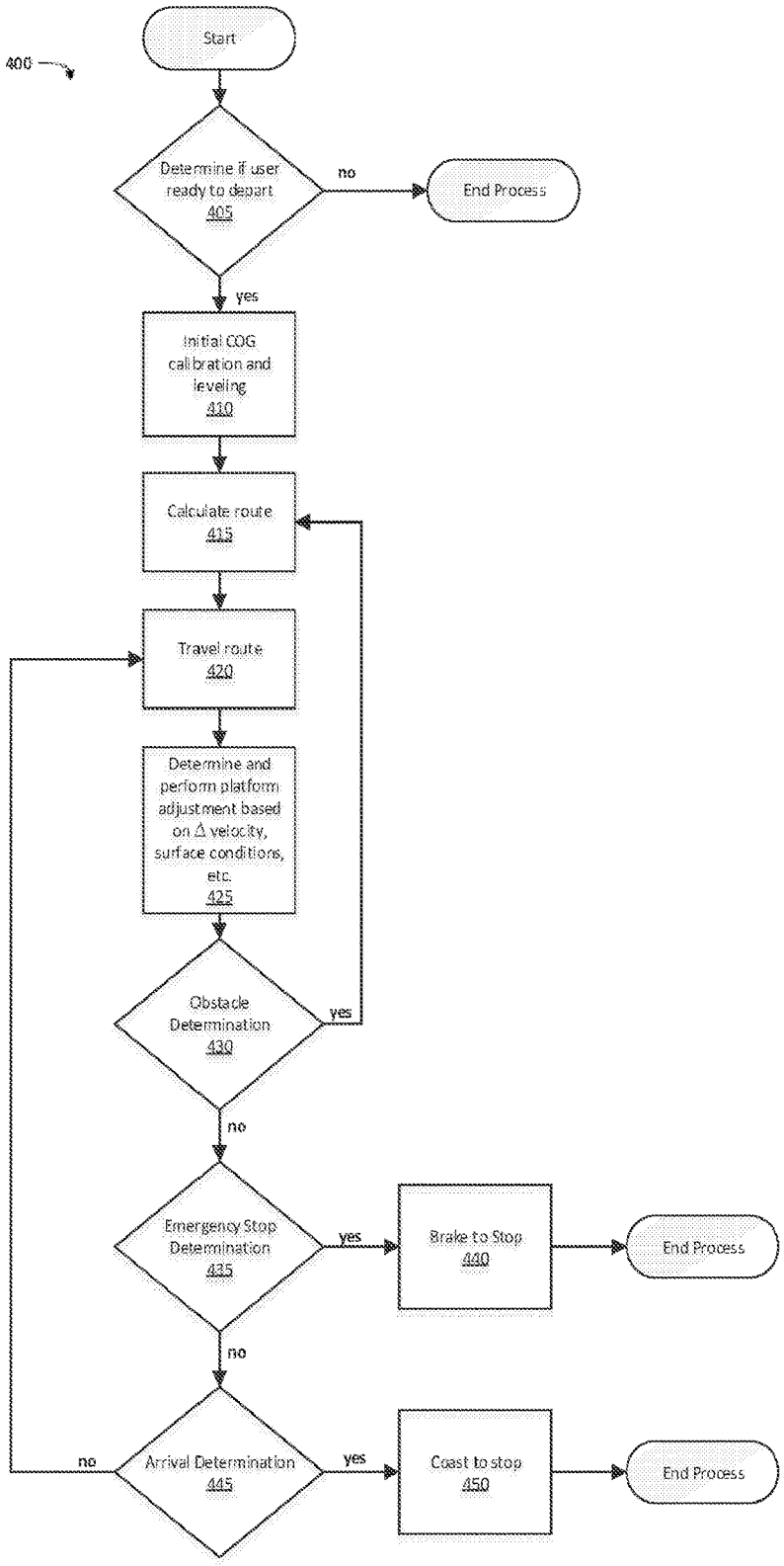

400
Start
Determine if user ready to depart 405
no
End Process
yes
Initial COG calibration and leveling 410
Calculate route 415
Travel route 420
Determine and perform platform adjustment based on Δ velocity, surface conditions, etc. 425
Obstacle Determination 430
yes
no
Emergency Stop Determination 435
yes
Brake to Stop 440
End Process
no
Arrival Determination 445
no
yes
Coast to stop 450
End Process

FIG. 15

VERSATILE URBAN ELECTRIC TRANSPORT DEVICE AND SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The subject patent application claims priority to and all the benefits of U.S. Provisional Patent Application No. 62/311,981 filed on March **23**, **2016**, which is herein incorporated by reference in its entirety.

BACKGROUND

[0002] Today fifty-four percent of the world's population is living in urban areas. In the next three decades, that portion is expected to increase to sixty-six percent. Projections show that urbanization combined with the overall growth of the world's population could add another 2.5 billion people to urban populations by 2050. With this rise in population density, it will become increasingly difficult for commuters, residents, tourists, elderly and disabled people to get around, even over short distances. Even when using personal transportation, i.e., an automobile, a bicycle or the like, it can often mean facing horrific traffic jams and long parking queues due to limited roadway infrastructure and space available to park. Yet further, public transportation presents problems, e.g., overcrowding, inconvenient schedules, etc. Even further, the financial cost of travelling a short distance often cannot be justified.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** is a perspective view of an exemplary versatile electric transport device.

[0004] FIG. **2** is a side perspective view of the versatile electric transport device of FIG. **1**.

[0005] FIG. **3** is a rear perspective view of the versatile electric transport device of FIG. **1**.

[0006] FIG. **4** is a front perspective view of the versatile electric transport device of FIG. **1**

[0007] FIG. **5** is a bottom perspective view of the versatile electric transport device of FIG. **1**.

[0008] FIG. **6** is a perspective view of the versatile electric transport device stored in a storage area of a vehicle of FIG. **1**.

[0009] FIG. **7** is a fragmentary exploded perspective view of the versatile electric transport device of FIG. **1**.

[0010] FIGS. **8**A to **8**G are views illustrating the driving principle of Mecanum wheels of the versatile electric transport device of FIG. **1**.

[0011] FIGS. **9**A to **9**E are perspective views of a tilting mechanism deployed in the versatile electric transport device of FIG. **1**.

[0012] FIGS. **10**A and **10**B are additional perspective views of the tilting mechanism.

[0013] FIGS. **10**C and **10**D are rudimentary representative views of the tiling mechanism.

[0014] FIG. **11** is a block diagram of a transport system including the device of FIG. **1**.

[0015] FIG. **12** is a flowchart of an exemplary process that may be implemented in a transport control computer and associated hardware components of the system of FIG. **11**.

[0016] FIG. **13** is a flowchart of an exemplary process that may be implemented in a transport control computer and associated hardware components of the system of FIG. **11**.

[0017] FIG. **14** is a flowchart of an exemplary process that may be implemented in a transport control computer and associated hardware components of the system of FIG. **11**.

[0018] FIG. **15** is a flowchart of an exemplary process that may be implemented in a transport control computer and associated hardware components of the system of FIG. **11**.

DETAILED DESCRIPTION

[0019] A smart and versatile electric transport **10** can carry a full size adult over a reasonable distance, e.g., about five miles in one example, and can be deployed in a dense urban environment. The transport is equipped with a set of positional sensors **18** to monitor the transport's status, e.g., the transport's load, slope, acceleration, rotation and inclination. The transport can also be furnished with obstacle and avoidance sensors, i.e., cameras, radars, lidars, sonars and the like to avoid obstacles. The transporter can be fitted with an array of communication/navigation devices, i.e., a Global System for Mobile Communications (GSM) module, a General Packet Radio Service (GPRS) module, a Wi-Fi module, a WiMax module, a Long-Term Evolution (4G LTE) module, a Bluetooth module and a Global Navigation Satellite System (GNSS) receiver. The exemplary transport is outfitted with Mecanum wheels that enable omnidirectional movement and further includes a suspension system which controls a hemispherical tilting mechanism to provide comfort as well as to keep a user balanced during movement in particular acceleration, deceleration and curves.

[0020] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a versatile electric transport device **10** is generally shown in FIGS. **1**-**4** and **11**. The transport device **10** includes a platform **32** mounted to a frame **50**. The platform **32** and the frame **50** can be any light and durable material, for example, aluminum, carbon fiber, plastic, etc. The platform includes one or more of each of an imaging sensor **34** and a proximity sensor **36** mounted thereto and/or disposed therein. The imaging sensor **34** can be, for example, a camera imaging system to provide vision guidance for the versatile electric transport device **10**. Alternatively, the imaging sensor can be a lidar system. The proximity sensor **36** can be an ultrasonic device that emits high-frequency sound waves and that as is known to detect a presence of a nearby object by evaluating an echo from the emitted sound waves. Other types of proximity sensor **36** which can be utilized include capacitive, Eddy-current, inductive, laser rangefinder, charge-coupled, passive thermal infrared, photocell, radar and sonar, just to name a few.

[0021] A hub motor **54** is mounted to an axle **51** on the frame **50**. The hub motor **54** is fitted into an omnidirectional wheel such as a Mecanum wheel **40**. The Mecanum wheel, as is known, is a wheel that can move a vehicle in any direction by deploying a series of rollers **38** attached to a wheel circumference. The rollers **38** typically each have an axis of rotation at 45° to the plane of the wheel **40** and at 45° to a line through the center of the roller parallel to the axis of rotation of the wheel **40**. In order to improve the operational time of the transport device **10**, different roller **38** angles can be utilized, for example, a smaller roller **38** angle can increase the transport device **10** efficiency when moving forward and backward. An electronic speed controller (ESC) **16** can be used to control the motor **54**. The ESC **16** is an electronic circuit which varies an electric motor's speed,

direction and dynamic braking. The ESC **16** is connected to the transport computer **66** via a transport device network.

[0022] The frame **50** also provides an attachment point for a communications module **42** and/or a navigation module **43**. The communications module **42**, for example, can be a telematics unit to provide radio frequency communications via a Global System for Mobile Communications (GSM) connection, a General Packet Radio Service (GPRS) connection, Wi-Fi connection, a WiMax connection, Bluetooth connection or a Long-Term Evolution (4G LTE) connection. The navigation module **43** can be equipped with a Global Navigation Satellite System (GNSS) receiver, for example to receive a satellite global positioning system (GPS) signal.

[0023] Additionally, a rechargeable battery **13** can be mounted to the frame **50** and can be of any type of rechargeable battery, including and not limited to a lead-acid battery, a lithium cobalt oxide battery, a lithium iron phosphate battery, a lithium manganese oxide battery, a lithium nickel cobalt aluminum oxide battery, a lithium nickel manganese cobalt oxide battery, a low self-discharge nickel-metal hydride battery, a nickel-cadmium, a nickel-hydrogen, a nickel-iron, a nickel-metal hydride, a nickel-zinc and a rechargeable alkaline battery. The rechargeable battery **13** provides energy to the hub motors **54**, the positional sensors **18**, the transport computer **66** and all other electrical systems of the transport device **10**. In some configurations, each hub motor **54** can have its own dedicated reachable battery **13**. The transport computer **66** can monitor a status rechargeable battery **13** and determine its available range. Charging of the rechargeable battery **13** can be achieved by a direct plug-in connection or with an induction charging system.

[0024] The versatile electric transport device **10** is highly transportable and, as shown in FIG. **6**, can be stowed in a hatchback or a trunk of a vehicle **12**. This permits the user **28** to park at a parking facility, retrieve the versatile electric transport device **10** from his or her vehicle and finish his or her commute on the versatile electric transport device **10**. Further, the user **28** can use the versatile electric transport device **10** to carry, for example, luggage or their groceries. In addition to be highly transportable, versatile electric transport device can be upgrade and/or reconfigured with extensions, for example, a wheel chair extension permitting the versatile electric transport device **10** to be a stable highly maneuverable non-ambulatory patient transport.

[0025] An actuator **44** controls and stabilizes the platform **32** of the versatile electric transport device **10** as shown for example in FIGS. **2-3**. The actuator **44** can be an electric actuator, a hydraulic actuator, a pneumatic actuator or any controllable mechanical device that converts energy into motion. In addition, the actuator **44** can also absorb and damp shock impulses, for example, when the versatile electric transport device **10** encounters a pothole. The actuator **44** can be further combined with a spring mechanism to improve stability.

[0026] A first end of the actuator **44** is attached to the frame **50** with a pin joint at a pin joint mounting location **52** and a second end of the actuator **44** is attached to the platform **32**. A weight senor in communication with the transport computer may be secured proximate the mounting location **52** of each actuator **44**. The actuator **44** is controlled by signals from a transport computer **66**, as shown in FIG. **7** to keep the platform **32** level, e.g., a plane defined by a top surface of the platform **32** may be maintained within a predetermined tolerance, e.g., three degrees, five degrees, etc., of deviation from a plane that is parallel to a ground surface on which the device **10** is situated. The position of the actuator **44** can be sent to the transport computer **66**. The actuator **44** can reduce sudden changes to the ground surface, for example, a rut or a pot hole. The actuator **44** can also adjust the platform **32** tilt when the versatile electric transport device **10** is about to change velocity, examples of changes in velocity include accelerating, decelerating, and turning. A change in velocity can be predicted according to an input to, or a determination by, the computer **66** to accelerate or brake the transport device **10**. The transport device **10** is "about to" change velocity after such input or determination is detected, and before it is applied. For example, implementation of a change in velocity could be delayed for a short period of time, e.g., **500** milliseconds, to allow for movement of the platform **32**. The transport computer **66** uses inputs from various sensors along with a desired course to adjust the positioning of the actuator **44**, for example, using an inverted pendulum algorithm such as is known to be applied to balance control systems associated with objects having a center of gravity above a pivot point.

[0027] Using the inverted pendulum algorithm, the system helps a user to maintain balance by angling the platform **32** towards the predicted change in velocity. To keep the user balanced during acceleration, the front actuators **44** compress and the rear actuators **44** expand to tilt the platform **32** forward. To keep the user balanced during deceleration, the rear actuators **44** compress and the front actuators **44** expand to tilt the platform **32** rearward. To keep the user balanced during a right turn, the right hand side actuators **44** compress and the left hand side actuators **44** expand to tilt the platform **32** inboard and compensate for centrifugal force. Similarly, for a left turn, the left hand side actuators **44** compress and the right hand side actuators **44** expand.

[0028] As shown in FIG. **5**, an inductive charging port **60** is positioned on the bottom (closest to the ground) of the versatile electric transport device **10**. The inductive charging port **60** uses an electromagnetic field to transfer energy between a charging station and the inductive charging port **60**. Energy is sent through inductive coupling of the charging station to the inductive charging port **60** to charge the rechargeable battery **13** of the versatile electric transport device **10**.

[0029] As shown in FIG. **7**, an electric motor **54** is attached to the frame **50** and to each of the Mecanum wheels **40**. The transport computer **66**, as well as any other computers discussed herein, has at least one processor and typically has a memory, e.g., comprising various types of permanent and transient memory such as are known to store computer instructions, register values, and temporary and permanent variables. Further, the transport computer **66** can generally include instructions for sending and/or receiving vehicle control data, e.g., from and to a user **28** or an operator of the versatile electric transport device **10**, for example via a mobile device, a smartphone and a portable computer. The vehicle control data can be, for example, instructions sent from a smartphone along with the smartphone' s geolocation commanding the transport device **10** to navigate its way to the smartphone's geolocation. Another example of vehicle control data is another set of commands sent by the smartphone and the transport device **10** acknowledgement of those commands, for example, the smartphone can continually send the smartphone's geolocation to the transport device **10** along with a command to follow the

smartphone, causing the transport device **10** to follow the smartphone. The vehicle control data can be used by the transport computer **66** to predict a change in velocity of the transport device **10**. For example, the computer **66**, and/or other controllers such as the electronic speed controller **16**, receives (or determines) instructions to transport device **10** motors **54** and/or brakes to control changes in velocity.

[0030] The versatile electric transport device **10** transport computer **66** is typically connected to other computers, for example, to the electronic speed controller (ESC) **16** to control the motor **54** via a transport device network. The ESC **16** is also connected to a power source, i.e., the rechargeable battery **13** and to the motor **54**. Additionally, the transport device **10** communications may occur, i.e., over a Serial Peripheral Interface (SPI) bus, an Inter-Integrated Circuit (I^2C) bus or a Controller Area Network (CAN) bus such as is known. Other wired and wireless communications can be included in the versatile electric transport device **10** network, e.g., Ethernet, Wi-Fi®, Bluetooth®, etc. Further, the vehicle can communicate with other networks or vehicles as described below, and may include wireless networking technologies, e.g., cellular, Wi-Fi®, Bluetooth®, Near Field Communication (NFC), wired and/or wireless packet networks, etc.

[0031] The movement of versatile electric transport device **10** using the Mecanum wheels **40** is shown in FIGS. **8**A to **8**G. FIG. **8**A is the versatile electric transport device **10** at rest and no Mecanum wheels are turning. FIG. **8**B illustrates the versatile electric transport device **10** moving to the left. The arrows shown indicate the rotation of the wheels, for example, the front left (FL) wheel, is turning relatively clockwise, the right rear (RR) wheel is turning relatively counterclockwise, the front right (FR) wheel is turning relatively counterclockwise and the right rear (RR) wheel is turning clockwise. FIGS. **8**C, **8**D and **8**E illustrate the versatile electric transport device **10** moving to the right, forward and diagonally forward to the right. FIGS. **8**F and **8**G illustrate how the versatile electric transport device **10** can rotate to the left and to the right, respectively.

[0032] The inclination or tilt of the platform **32** of the versatile electric transport device **10** is illustrated in FIGS. **9**A-**9**E. The platform **32** has a convex face **14** which abuts a concave face **15** of the frame **50** permitting the platform **32** to pivot about the frame **50**. FIGS. **9**A and **9**B illustrate a forward and a backward tilting of the platform **32** on the frame **50** as realized by the actuator **44**. FIGS. **9**C & **9**D illustrate a left and a right tilting of the platform on the frame **50** as realized by the actuator **44**. FIG. **9**E is a close up view of the convex face **14** of the platform **32** and the concave face **15** of the frame **50**.

[0033] As discussed above, the actuator **44** tilts the platform **32** upon the frame **50** and is illustrated in FIGS. **10**A and **10**C. FIGS. **10**B and **10**D illustrate a simplified schematic of the tilting illustrated in FIGS. **10**A and **10**C. The forward and back tilting of the platform **32** along with its side to side tilting enables the transport device **10** to help the user **28** maintain their balance. The transport device **10** determines the combined center of gravities of the transport device **10** and that of the user **28** and manages their combined inertias, which results in the user **28** balance being maintained. The center of gravity determination is based at least in part on the information received by transport computer **66** from the weight sensors that are proximate the actuators, and levelling sensors, such as gyroscopic sensors, in the platform **32** and frame **50**.

[0034] The versatile electric transport device **10** is highly transportable and as shown in FIG. **6**, it can be stowed in a hatchback or a trunk of a vehicle **12**. This permits the user **28** to park at a parking facility, retrieve the versatile electric transport device **10** from their vehicle and finish their commute on the versatile electric transport device **10**. Alternatively, the user **28** can use the versatile electric transport device **10** to carry cargo, for example, luggage or groceries.

[0035] A block diagram of the versatile electric transport device connection to communication and navigation devices is illustrated in FIG. **11**. The versatile electric transport device **10** is communicatively coupled to a communications tower **70**, a geolocation satellite **72** and a communications device **74**. The communication tower **70** can provide a connection to a cloud network **76**, for example, the Internet via a GSM or 4G. The cloud network **76** is further communicatively connected to a server **78**.

[0036] The server **78** is one or more computer programs and a computing device on which the programs are executable. The server **78** provides operations for other programs or devices, called "clients." Operations provided by the server **78** are often called "services", and can include sharing data or resources among multiple clients, or performing computation for a client. The server **78**, for example, can execute a transport request program that processes the user **28** request for a transport and forwards the request to the versatile electric transport device **10** over the network **76**. The transport request program, for example, can handle the initial request for transport and all additional communications exchanges between the user **28** and the versatile electric transport device **10**.

[0037] The server **78** can include or be connected to a database that stores information regarding the transport devices in the area, local and regional maps, traffic and weather information. This information permits the server **78** or the transport computer **66** to calculate the fastest or the most economical route for battery life when requested, for example, when the transport computer **66** determines that the status of the rechargeable battery **13** is low, the transport computer **66** can request routing information from the server permitting the transport device **10** to traverse via the most economical route. In a worst case scenario, the transport computer **66** can detect that the rechargeable battery **13** of the transport device **10** is near depletion or a system fault. The transport computer **66** can then request a backup transport device to rendezvous with the transport device **10** and exchange the passenger or the payloads and continue the journey on the backup transport device.

[0038] The geolocation satellite **72** can be a Global Navigation Satellite System (GNSS) which transmits a precise location along with a time signal allowing the navigation module **43** to determine the geolocation of the versatile electric transport device **10**. The geolocation of the versatile electric transport device **10** can be expressed as geo-coordinates such as are known, e.g., latitude and longitude coordinates.

[0039] The communications device **74** can be a smartphone, a portable computer or a wearable device which allows the user **28** to communicate with the versatile electric transport device **10**. The communications device **74** can control the movement of the versatile electric transport device **10** along a desired path or alternatively instruct the

transport device **10** to follow the user **28** who placed their groceries on the transport device **10**. In one scenario, a user **28** can use a communications device **74** to request the versatile electric transport device **10** to come to their location from a fleet of versatile electric transport devices **10** which are placed throughout various neighborhoods in a city.

[0040] The transport device **10** can have a speaker or a piezo device to communicate with a user **28** an aural warning of a potential system failure or fault of the transport device **10**, for example, a low battery condition, an emergency stopping of the transport device **10**, a potential loss of balance of the user **28**, etc. In addition to the aural warning, the transport device **10** can provide a haptic feedback through the platform **32** or to the user **28** communications device **74**.

[0041] Process Flows

[0042] FIG. **12** is a flow chart illustrating an exemplary process **100** that can be executed according to programming in a versatile electric transport device **10** transport computer **66** to move the versatile electric transport device **10** in response to a request from a user **28**.

[0043] The process **100** begins in a block **105**, in which the transport computer **66** determines that the versatile electric transport device **10** needs to move from its current location.

[0044] Next, in a block **110**, the transport computer **66** determines in which direction the versatile electric transport device **10** needs to go, for example, to the right as shown in FIG. **8**C.

[0045] Next, in the block **115**, the transport computer **66** sends programming instructions to the appropriate electronic speed controller (ESC) **16**, for example, to move the versatile electric transport device **10** to the right, the, the front left (FL) wheel will be programmed to turn counterclockwise looking at the versatile electric transport device **10** side where the wheel **40** is located. The right rear (RR) and the rear left (RL) wheels needs to be programmed to turn clockwise and the front right (FR) wheel needs to be programmed to turn counterclockwise. The ESC **16** programming also includes the speed at which each wheel will turn.

[0046] Next, in a block **120**, the transport computer **66** instructs the ESC **16** to engage and begin turning the wheel **40**

[0047] Next, in a block **125**, which can also be entered into from in a block **130**, the transport computer **66** determines if the maneuver is complete. If the maneuver is complete, the process **100** ends, else next in the block **130** is executed.

[0048] Next, in the block **130**, the transport computer **66** continues to send commands to the ESC **16** to continue the wheel **40** rotations and the process **100** returns to in the block **125**.

[0049] FIG. **13** is a flow chart illustrating an exemplary process **200** that may be executed simultaneously with the process **100** according to programming in a versatile electric transport device **10** transport computer **66** to keep the platform **32** level using the actuator **44**.

[0050] The process **200** begins in a block **205**, in which the transport computer **66** determines that the platform **32** needs to be leveled.

[0051] Next, in a block **210**, which can also be entered from in the block **235**, the transport computer **66** determines which actuator **44** needs to be extended, retract or left in its current position. For example, the weight distribution on the platform **32** is greater on the right side of the platform **32** and the platform is listing to the right. Therefore, the actuator **44** on the right side of the versatile electric transport device **10** will need to be extended raising the platform **32**.

[0052] Next, in the block **215**, the transport computer **66** sends programming instructions to the appropriate actuator **44** to extend, retract or remain in its current position to get the platform **32** level.

[0053] Next, in a block **220**, the transport computer **66** instructs the actuator **44** to engage and begin extending or retracting.

[0054] Next, in a block **225**, which can also be entered into from in a block **230**, the transport computer **66** determines if the actuator **44** have completed their extension or retraction be receiving feedback from the actuator **44**. If the extension or retraction is not complete, next in the block **230** is executed, else next a block **235** is executed.

[0055] Next, in the block **230**, the transport computer **66** continues to send commands to the actuator **44** to continue the activating the actuator **44** and the process **100** returns to in the block **225**.

[0056] Next, in the block **235**, the transport computer **66** determines if the platform **32** is level, for example, from the gyroscopic sensor on the platform **32**. If the platform is level, the process **200** ends, else next the block **210** is executed.

[0057] FIG. **14** is a flow chart illustrating an exemplary process **300** that may be executed simultaneously with the process **100** and the process **200** according to programming in a versatile electric transport device **10** transport computer **66** to control the tilt angle of the platform **32** using the actuator **44**.

[0058] The process begins in block **335** after the transport device **10** is turned on, in which the transport computer **66** predicts a change in velocity of the transport device **10**, e.g., as discussed above. The change in velocity can be a positive or negative change in speed such as an acceleration or deceleration, a change in direction such as a turn, or a combination thereof.

[0059] Next, in block **320**, the transport computer **66** determines a change in the ground surface on which the transport device **10** is based. The change in ground surface may be a positive anomaly from the surface such as a speed bump or rock, it may be a negative anomaly from the surface such as a divot or pothole, or it may be a change in elevation of the surface such as a curb or ledge. Techniques for making such a determination using senor data, e.g. cameras, LIDAR, and/or ultrasound, etc. are known.

[0060] Next, in block **345**, the transport computer **66** determines a slope angle of the ground on which the transport device **10** is traveling. The slope angle of the ground may be determined via known techniques for detecting inclination of a travel path, e.g., a gyroscope sensor mounted on the frame **50**, the gyroscope sensor in communication with the transport computer **66**.

[0061] Next, in block **350**, the transport computer **66** determines a center of gravity of the user on the platform **32**.

[0062] Next, in block **355**, the transport computer determines a combined center of gravity of the transport device **10** and the user of the transport device **10**.

[0063] Next, in block **360**, the transport computer **66** controls the actuators **33** to alter the tilt angle of the platform **32** based on the various predictions and determinations of blocks **335** through **355**. As few a one, and as many as all,

of the various predictions and determinations of blocks **335** through **355** may be used by the transport computer **66** when altering the tilt angle of the platform **32**. The process ends when the transport device **10** is turned off.

[0064] FIG. **15** is a flow chart illustrating an exemplary process **400** that may be executed simultaneously with the process **100**, the process **200** and the process **300** according to programming in a versatile electric transport device **10** transport computer **66** to control the transport device **10**.

[0065] The process **400** begins when the device is powered on, or transitioned to a ready mode from a standby mode. The standby mode is a known power saving mode of a computing device where various programs and applications are paused, and only a few basic functions are provided with power. For example, in the standby mode the transport computer **66** might pause various calculations and input monitoring used for the process **300** described above, while continuing to run other instructions and monitor other inputs, such as receiving various communications. The ready mode may be requested by a user of the transport device **10**, the transport computer **66**, and/or another computer communicating with the transport computer **66**.

[0066] At a block **405**, the transport computer **66** determines that a user has boarded the transport device **10** and is ready to depart. Such determination is made, for example, by the transport computer **66** receiving information from the weight sensors proximate the mounting location **52** of each actuator **44** indicating that the user is on the platform **32**. When the user steps off the transport device **10**, as may be identified by the weight sensor information, before a predetermined amount of time has lapsed, **10** seconds for example, the process **400** ends and the transport computer **66** returns to the standby mode. When the user stays on the platform **32** longer than the predetermined amount of time, the transport computer **66** determines that the user is ready to depart.

[0067] Next, at a block **410**, the transport computer **66** uses the weight information from the weight sensors and determines the center of gravity of the user on the platform **32**. For example, known calculations may be used to compare the values of the weight sensors relative to each other. Based on the determined center of gravity, the transport computer **66** performs an initial adjustment of the actuators **44** to angle the platform **32**.

[0068] At a block **415** the transport computer **66** calculates a route to be traveled by the transport device **10** to arrive at a specific destination. To calculate the route, the transport computer determines the current location of the transport device **10**, such as with the navigation device, the navigation module **43**, and/or known GNSS systems, as discussed above. In further example, the navigation device, the navigation module **43**, and/or known GNSS systems are then used along with the current location information and the specific destination information to calculate the route to be traveled by the transport device **10**. When calculating the route, the transport computer **66** may take into consideration travel conditions, such as surface type, congestion, speed limits, road closures, construction, obstacles, etc.

[0069] Next, at a block **420**, after the user has boarded in the block **405** and the route has been calculated in the block **415**, the transport computer **66** instructs the transport device **10** to travel to the specific destination via the calculated route. For example, to travel along the route process **100** may be used along with the navigation device, the navigation module **43**, and/or known GNSS systems.

[0070] Next, at a block **425**, as the transport device **10** travels the calculated route, the transport computer **66** adjusts the platform **32** angle based on predicated changes in velocity, detected surface conditions and angles, etc., as disused above. For example, the process **200** and the process **300** may be used. After adjustment, the transport computer **66** returns to block **420**, instructing the transport device **10** to continue to travel to the specific destination via the calculated route in a looped manner until the process **400** ends.

[0071] Next, at a block **430**, also as the transport device **10** travels along the calculated route, the transport computer **66** determines if an obstacle exist along the calculated route. Obstacles may be determined based on information about the route received by the transport computer **66**, for example from the navigation device, the navigation module **43**, and/or known GNSS systems, and/or may be detected by the various sensors in communication with the transport computer **66**, such as proximity sensors, LIDAR, image devices etc. Exemplary obstacles include closed roads, unexpected physical objects blocking the route, etc. When an obstacle is determined to exist along the route, the transport computer **66** returns to block **415** to re-calculate the route based in part on the determined obstacle. After the route has been recalculated, the process **400** continues from block **415** in a looped manner until the process **400** ends.

[0072] Next, at a block **435**, also as the transport device **10** travels to the specific destination, the transport computer **66** determines when an emergency stop is necessary. The emergency stop determination is made by the transport computer **66** based on the information received from the various sensors in communication with the transport computer **66**. One exemplary situation requiring the emergency stop determination exists when a sudden and unexpected object is detected in the travel path the transport device **10** by proximity sensors and the like, such as when a pedestrian walks in front the of transport device **10**. Another exemplary situation requiring the emergency stop determination exists when there is a sudden and unexpected shift in the measurement value of the weight sensors, such as when the user prematurely vacates the transport device **10**. When the determination is made that the emergency stop is necessary, the transport computer **66** moves to a block **440** and instructs the transport device **10** to stop in a manner that prioritizes bringing the transport device **10** to a halt quickly, such as by applying brakes of the transport device **10**. Once the transport device **10** stops, the process **400** ends. When no emergency stop is determined to be necessary the process **400** continues from block **420** in a looped manner until the process **400** ends.

[0073] Next, at a block **445**, the transport computer **66** determines the transport device **10** has arrived at the specific location. The determination that the transport device **10** has arrived at the destination may be based on information received from the navigation device, the navigation module **43**, and/or known GNSS systems, as discussed above. When the transport device **10** is determined to be at the specific destination, the transport computer **66** moves to a block **450** and brings the transport device to a stop prioritizing efficiency and/or user comfort. For example, the transport device **10** may be stopped using known regenerative braking techniques, and/or, may be instructed to coast to a stop. Once

the transport device **10** has stopped, the process **400** ends. When no arrival at the destination is determined, the process **400** continues from block **420** in a looped manner until the process **400** ends.

[0074] Conclusion

[0075] As used herein, the adverb "substantially" modifying an adjective means that a shape, structure, measurement, value, calculation, etc. may deviate from an exact described geometry, distance, measurement, value, calculation, etc., because of imperfections in the materials, machining, manufacturing, sensor measurements, computations, processing time, communications time, etc.

[0076] Computing devices such as those discussed herein generally each include instructions executable by one or more computing devices such as those identified above, and for carrying out blocks or steps of processes described above. Computer executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java™, C, C++, C#, Visual Basic, Python, Java Script, Perl, HTML, PHP, etc. In general, a processor (e.g., a microprocessor) receives instructions, e.g., from a memory, a computer readable medium, etc., and executes these instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions and other data may be stored and transmitted using a variety of computer readable media. A file in a computing device is generally a collection of data stored on a computer readable medium, such as a storage medium, a random access memory, etc.

[0077] A computer readable medium includes any medium that participates in providing data (e.g., instructions), which may be read by a computer. Such a medium may take many forms, including, but not limited to, non-volatile media, volatile media, etc. Non-volatile media include, for example, optical or magnetic disks and other persistent memory. Volatile media include dynamic random access memory (DRAM), which typically constitutes a main memory. Common forms of computer readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD ROM, DVD, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH EEPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

[0078] With regard to the media, processes, systems, methods, etc. described herein, it should be understood that, although the steps of such processes, etc. have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words, the descriptions of systems and/or processes herein are provided for the purpose of illustrating certain embodiments, and should in no way be construed so as to limit the disclosed subject matter.

[0079] The disclosure has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described.

What is claimed is:

1. A controller comprising a processor and a memory, the memory storing instructions executable by the processor, the instructions including instructions for:
- predicting a change in velocity of a transport device; and
- then altering a tilt angle of a riding platform of the transport device based at least in part on the predicted change in velocity.

2. The controller of claim **1**, wherein the instructions further comprise instructions for:
- determining a change in a ground surface on which the transport device is traveling; and
- then altering the tilt angle of the platform based at least in part on the change in the ground surface.

3. The controller of claim **2**, wherein the instructions further comprise:
- determining a slope angle of the ground on which the transport device is traveling; and
- then altering the tilt angle of the platform based at least in part on the slope angle of the ground on which the transport device is traveling.

4. The controller of claim **3**, wherein instructions for altering the tilt angle of the platform based at least in part on the slope angle of the ground on which the transport device is traveling include instructions to maintain the platform within a predetermined tolerance of deviation from the slope angle of the ground.

5. The controller of claim **1**, wherein the instructions further comprise using an inverted pendulum algorithm to determine the altered tilt angle of the platform.

6. The controller of claim **1**, wherein the instructions further comprise:
- determining a center of gravity location of a user of the transport device; and
- then altering the tilt angle of the platform based at least in part on the determined center of gravity location.

7. The controller of claim **1**, wherein the instruction further comprise:
- determining a combined center of gravity location of a user of the transport device and the transport device; and
- then altering the tilt angle of the platform based at least in part on the determined combined center of gravity location.

8. A transport device comprising:
- a frame;
- a platform pivotally mounted on the frame;
- an actuator fixed to the platform and the frame; and
- a controller in communication with the actuator, the controller comprising a processor and a memory, the memory storing instructions executable by the processor, the instructions including instructions for:
  - predicting a change in velocity of the transport device; and
  - then controlling the actuator to alter a tilt angle of the platform based at least in part on the predicted change in velocity.

9. The transport device of claim **8**, wherein the instructions further comprise:
- determining a change in a ground surface on which the transport device is traveling; and

then controlling the actuator to alter the tilt angle of the platform based at least in part on the determined change in the ground surface on which the transport device is traveling.

10. The transport device of claim **9**, wherein the instructions further comprise:

determining a slope angle of the ground on which the transport device is traveling; and

then controlling the actuator to alter the tilt angle of the platform based at least in part on the determined slope angle of the ground on which the transport device is traveling.

11. The transport device of claim **10**, wherein controlling the actuator to alter the tilt angle of the platform based at least in part on the slope angle of the ground on which the transport device is traveling is performed such that the platform is maintained within a predetermined tolerance of deviation from the slope angle of the ground.

12. The transport device of claim **8**, wherein controlling the actuator to alter the tilt angle of the platform based at least in part on the predicted change in velocity uses an inverted pendulum algorithm.

13. The transport device of claim **8** further comprising:

the platform having opposing first and second surfaces, the second surface being convex; and

the frame having a concave surface mateable to the convex second surface of the platform.

14. The transport device of claim **8**, wherein the instructions further comprise:

determining a center of gravity location of a user of the transport device; and

then controlling the actuator to alter the tilt angle of the of the platform based at least in part on the determined center of gravity location.

15. The transport device of claim **8**, wherein the instructions further comprise:

determining a combined center of gravity location of a user of the transport device and the transport device; and

then controlling the actuator to alter the tilt angle of the platform based at least in part on the determined combined center of gravity location.

16. A method for controlling a tilt angle of a riding platform of a transport device, the method comprising:

predicting a change in velocity of the transport device; and

then altering the tilt angle of the platform of the transport device based at least in part on the predicted change in velocity.

17. The method of claim **16** further comprising:

determining a change in a ground surface on which the transport device is traveling; and

then altering the tilt angle of the platform based at least in part on the change in the ground surface.

18. The method of claim **17** further comprising:

determining a slope angle of the ground on which the transport device is traveling; and

then altering the tilt angle of the platform based at least in part on the slope angle of the ground on which the transport device is traveling.

19. The method of claim **16** further comprising using an inverted pendulum algorithm to determine the altered tilt angle of the platform.

20. The method of claim **16** further comprising:

determining a center of gravity location of a user of the transport device; and

then altering the tilt angle of the platform based at least in part on the determined center of gravity location.

* * * * *