(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 June 2006 (15.06.2006)

PCT

(10) International Publication Number
WO 2006/062905 A2

(51) International Patent Classification:
B60K 26/00 (2006.01)

(21) International Application Number:
PCT/US2005/043949

(22) International Filing Date:
6 December 2005 (06.12.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/633,703 6 December 2004 (06.12.2004) US

(71) Applicant *(for all designated States except US)*: **AIR-TRAX, INC.** [US/US]; P.O. Box 1237, Hammonton, NJ 08037-1237 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **FENELLI, Nicholas, E.** [US/US]; 17 DeCou Avenue, Trenton, NJ 08628 (US). **MULLOWNEY, Robert, A.** [US/US]; 332 West Monument Avenue, Hatboro, PA 19040 (US).

(74) Agent: **PEQUIGNOT, Matthew, A.**; Hall, Vande Sande & Pequignot, Suite 200, 10220 River Road, Potomac, MD 20854 (US).

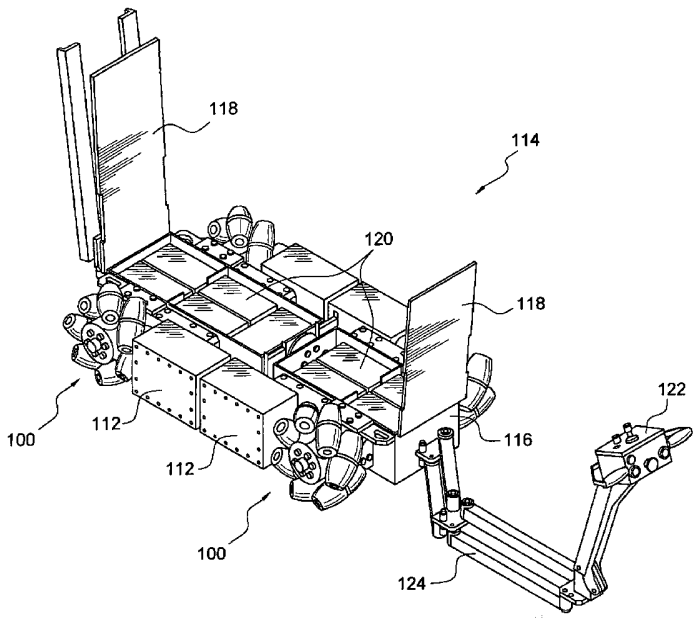
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** OMNIDIRECTIONAL WHEEL MODULES AND VEHICLES AND METHODS EMPLOYING SAME



(57) **Abstract:** Omni-directional wheel modules and methods for converting objects and non-omni-directional vehicles into omni-directional vehicles. In some embodiments, the modules are independently functional having an omni-directional wheel, an axle, a motor, a motor controller, transmission, and a brake assembled together. In other alternative embodiments, hybrid vehicles having a combination of omni-directional and non-omni-directional wheels.

WO 2006/062905 A2

OMNIDIRECTIONAL WHEEL MODULES AND VEHICLES AND METHODS EMPLOYING SAME

RELATED APPLICATION DATA

This application claims priority to United States Provisional Patent Application No. 60/633,703, filed December 6, 2004, which is hereby incorporated by reference in its entirety.

The following documents, in their entireties, are hereby incorporated by reference: U.S. Patent No. 6,394,203, filed December 6, 2001, issued to Donald Barnett Harris, entitled METHOD FOR DESIGNING LOW-VIBRATION OMNI-DIRECTIONAL WHEELS; U.S. Patent No. 6,340,065, filed January 22, 2002, issued to Donald Barnett Harris, entitled LOW VIBRATION OMNI-DIRECTIONAL WHEEL; U.S. Patent No. 6,547,340, filed December 6, 2001, issued to Donald Barnett Harris, entitled LOW VIBRATION OMNI-DIRECTION WHEEL; U.S. Patent No. 6,796,618, filed October 18, 2002, issued to Donald Barnett Harris, entitled METHOD FOR DESIGNING LOW VIBRATION OMNI-DIRECTIONAL WHEELS; U.S. Patent Application No. 20050045409, filed August 25, 2003, applied for by Nicholas Fenelli et al., entitled RELOCATABLE OPERATOR STATION; and U.S. Patent Application Nos. 20030034687; 20020057010; and 20020046888.

FIELD OF INVENTION

This invention relates to omni-directional wheel modules and vehicles employing same. In further embodiments, this invention relates to methods of converting objects and non-omni-directional vehicles into omni-directional vehicles or hybrids thereof. In preferred embodiments, such modules are independently functional

having an omni-directional wheel, an axle, a motor, a motor controller, a transmission, and a brake assembled together as a unitary assembly.

BACKGROUND OF INVENTION

Omni-directional vehicles capable of controlled motion in any direction have long been recognized as having many useful applications. A number of designs of omni-directional vehicles have been disclosed. Most omni-directional vehicle designs are similar in that they use wheels that feature a number of rollers positioned about the periphery of the wheel with the rollers permitting the wheels to support motion in directions at an angle to the wheel's plane of rotation. Omni-directional vehicles using such omni-directional wheels can move in any direction by rotating the wheels and rollers in an appropriate combination. Each omni-directional wheel's rotation is mechanically driven and servo controlled in a coordinated fashion to cause the vehicle to follow a desired path as previously disclosed by Ilon in U.S. Pat. No. 4,598,782. Three, four, or more omni-directional wheels are connected to a suitable chassis, suspension, wheel drives, and controls to form an omni-directional vehicle. Hereinafter, all uses of the words "roller" and "rollers" refer to the type of rollers used on or designed for omni-directional wheels for omni-directional vehicles.

Omni-directional wheels can be grouped into two general classifications. The first class of wheels is comprised of a rigid hub that supports a number of free spinning rollers around its periphery. The hub is rigidly coupled to an axle that, along with other omni-directional wheels and axles, supports the vehicle. The rollers are

mounted at an oblique angle to the wheel's axle and are free to rotate about their own axles. Omni-directional wheel roller mounting angles of ninety degrees have been disclosed by Blumrich in U.S. Pat. No. 3,789,947. The omni-directional wheel disclosed by Blumrich was mechanically driven to produce motion parallel to the axis of rotation of the wheel. Omni-directional wheel designs with a ninety-degree roller mounting angle and free-spinning rollers have been disclosed by Bradbury in U.S. Pat. No. 4,223,753; Hiscock in U.S. Pat. No. 4,335,899; Smith in U.S. Pat. No. 4,715,460; and Guile in U.S. Pat. Nos. D318,219 and D318,791. Omni-directional wheels with rollers mounted obliquely at roller mounting angles of approximately forty-five degrees with respect to the wheel shaft have been disclosed by Ilon in U.S. Pat. No. 3,876,255 and Amico in U.S. Pat. No. 5,701,966. U.S. Pat. Nos. 3,876,255 and 5,701,966 are hereby incorporated by reference in their entirety.

The second class of omni-directional wheels differ from the above described omni-directional wheel design concepts in that the rotational axes of the free spinning rollers intersect with the wheel's axis of rotation. Wheels of this class have been disclosed by Bradbury in U.S. Pat. No. 4,223,753, and by Pin, et al, in U.S. Pat. No. 5,374,879. In wheels of this class, two or more spherical rollers are mounted in fixed positions so as to constrain the vehicle's motion in the direction of wheel rotation, while being unconstrained in a direction that is orthogonal to the wheel's axis.

In known classes of omni-directional wheels, the axle supporting each roller may be mounted to the omni-directional wheel hub at both ends of the roller, as

disclosed by Blumrich, in the center, as disclosed by Ilon and Amico, or at intermediate locations, as disclosed by Smith. Typically, omni-directional wheel rollers are coated with an elastomer surface contact material to improve traction, as disclosed by Blumrich, Ilon and Smith.

The ability to move in any direction or rotate within the perimeter of the vehicle is advantageous for any industrial or commercial vehicle that must be maneuvered within confined spaces (e.g. warehouses) or with particular precision, including forklifts, scissorlifts, aircraft support and maintenance platforms, munitions handling vehicles, cranes, motorized dollies, and delivery trucks.

Although the functionality of many vehicles can be enhanced with omni-directional technology, forklifts are particularly improved when equipped with omni-directional capabilities. As is well known in the art, forklifts are vehicles with a hydraulically or mechanically powered liftforks that are used to lift, support and position a load.

Similarly, the ability to move laterally and rotate (e.g. within the vehicles own footprint) enables easy and precise positioning of omni-directional scissorlifts. As is well known in the art, a scissorlift is a vehicle that features a work platform suitable for supporting a worker that is hydraulically or mechanically raised or lowered to place the platform at the elevation where work is to be accomplished. Compared to a conventional scissorlift, an omni-directional capable scissorlift requires fewer operator maneuvers and less room to position it in a desired location or orientation.

Other vehicles that will benefit from omni-directional capability include wheelchairs, whether of self-propelled

or unpowered designs that are well known in the relevant art. Omni-directional capability permits the wheelchair operator to maneuver freely in confined spaces such as elevators and subway cars. The ability to move laterally at will is of particular value to wheelchair operators.

Omni-directional mobility is also of value for a wide variety of industrial and military uses including material transportation within a factory, aircraft maintenance, and any other use where precise, controlled omni-directional motion is desired.

Despite the known commercial need for omni-directional vehicles, initial omni-directional technologies did not achieve widespread commercial success due in part to the vibration and uneven ride produced by early omni-directional wheel designs. However, various improvements in omni-directional wheel designs have been made in recent years and are exemplified by the disclosures of U.S. Patent Nos. 6,340,065 and 6,547,340 owned by Airtrax, Inc. In particular, the improvements in omni-directional wheel technologies that have been made by Airtrax, Inc. have vastly improved their commercial viability. Such commercial usefulness has been principally improved by designing an omni-directional wheel which exhibits constant compliance while rotating under load. When such a wheel design is employed on a vehicle, the vehicle exhibits substantially constant ride height during directional operation thereby reducing vehicle vibration and allowing higher safe operational speeds. Other improvements in omni-directional wheels made by Airtrax, Inc. have increased the load carrying capacity of the wheels.

Although, as aforesaid, the commercial viability of omni-directional wheels has been improved dramatically by

various relatively recent Airtrax, Inc. innovations, the actual implementation of omni-directional wheels, much like the implementation of any major structural improvement in a given technology, can require substantial time and effort. In particular, using prior art technology and techniques in order to install omni-directional wheels on a conventional vehicle (e.g. an aircraft maintenance vehicle or a munitions handler) conventionally required making substantial structural and or design changes to the vehicle itself. Such changes required considerable mechanical and/or engineering skill as well as significant labor times and/or costs.

Taking into account the foregoing problems of vehicle conversion in the art, it would be beneficial to reduce the time and labor costs of converting vehicles to include omni-directional capabilities. Furthermore, it would be more cost effective to reduce the amount of skilled labor required to convert such a vehicle (e.g. because skilled labor typically receives higher wages).

In view of the above-enumerated drawbacks, it is apparent that there exists a need in the art for apparatus and/or methods which solve and/or ameliorate at least one of the above problems of prior art omni-directional technologies. It is a purpose of this invention to fulfill these needs in the art as well as other needs which will become more apparent to the skilled artisan once given the following disclosure.

SUMMARY OF INVENTION

Generally speaking, this invention addresses the above drawbacks by providing:

an omni-directional wheel module comprising:

an omni-directional wheel having a hub;

an axle carrying the omni-directional wheel so that the omni-directional wheel is capable of rotating about the axle;

a motor for powering rotation of the omni-directional wheel about the axle;

a transmission operatively interconnected between the motor and the omni-directional wheel; and

a brake for selectively inhibiting rotation of the omni-directional wheel; and

wherein the module components are assembled as a unitary, functional modular wheel assembly selectively installable and removable as an assembled unit.

In one embodiment, the omni-directional wheel employed by said module is so constructed such that a vehicle employing a plurality of such omni-directional wheels exhibits substantially constant ride height during directional operation.

In a preferred embodiment, the omni-directional wheel comprises:

a plurality of roller mounting brackets coupled to the hub; and

a plurality of rollers each rotatably coupled to at least one of the roller mounting brackets at a roller mounting angle, the rollers comprising;

a core rotatably coupled to the roller mounting bracket, the core having a first end and a second end; and

a contact surface of elastomeric material coupled to and radially disposed about the core with a volumetric shape such that the exterior profile of the contact surfaces of all the rollers forms a noncircular profile when viewed from a perspective laterally displaced from and coincident with the centerline of the hub.

In a further embodiment, therein is provided a vehicle comprising:

a vehicle frame;

a power storage device carried by the vehicle;

a plurality of omni-directional wheels operatively connected to the vehicle;

the power storage device being so connected to the motors of the plurality of omni-directional wheels such that the power storage device is capable of providing power to the motors to cause selective rotation of the plurality of omni-directional wheels.

In yet a further embodiment, there is provided:

a method of converting an object into an omni-directionally locomotable vehicle, the method comprising:

assembling a plurality of omni-directional wheel modules to the object.

In still a further preferred embodiment, therein is provided:

a method of converting a non-omni-directional vehicle into an omni-directional vehicle, the method comprising:

removing existing non-omni-directional wheels from a non-omni-directional wheeled vehicle;

connecting a plurality of omni-directional wheel modules to the vehicle to impart to the vehicle omni-directional functionality.

In still more preferred embodiments, there is provided:

a method of converting a non-omni-directional vehicle into an omni-directional vehicle, the method comprising:

connecting a plurality of omni-directional wheel modules to the vehicle to impart to the vehicle omni-directional functionality. In at least one form of this

embodiment, the omni-directional vehicle retains at least one non-omni-directional wheel. In at least a second form of this embodiment, the non-omni-directional vehicle is a four-wheeled vehicle having four non-omni-directional wheels, and two of the non-omni-directional wheels are removed from the vehicle; and two of the non-omni-directional wheels are retained on the vehicle.

In an alternative embodiment, it is an object of the invention to provide a hybrid powered vehicle in which a reformer is located onboard the vehicle for providing fuel to a fuel cell. In at least one of such alternative embodiments, the reformer is capable of converting a fossil fuel, such as jet fuel, into hydrogen.

In yet a further alternative embodiment, additional omni-directional wheel modules are employed to increase the load carrying capacity of a vehicle. In one such example, six modules are employed. In another example, six omni-directional wheel modules are installed on a crane-type vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates in diagrammatic, profile view an omni-directional wheel module according to one embodiment of the subject invention.

FIG. 2 illustrates a vehicle employing one embodiment of omni-directional wheel modules according to the subject invention.

FIG. 3 schematically illustrates a vehicle control system according to one embodiment of the subject invention.

FIG. 4 illustrates an overhead view of the vehicle and omni-directional wheel modules illustrated in FIG. 2 with

an alternate position of the operator station depicted by dotted lines.

FIG. 5 illustrates a profile view of the embodiment of the load carrying vehicle shown in FIG. 2 with an alternate position of the operator station depicted by dotted lines.

FIG. 6 illustrates a rear profile view of the embodiment of the load carrying vehicle depicted in FIG. 5.

FIG. 7 illustrates one embodiment of a crane employing a plurality of omni-directional wheel modules according to one example of the subject invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is generally directed to omni-directional wheel modules and vehicles employing the same. In some embodiments, the present invention is directed to methods of converting objects and non omni-directional vehicles into omni-directional vehicles or hybrids thereof (for example, having both non omni-directional and omni-directional wheels).

In preferred embodiments, such modules are independently functional and have an (1) omni-directional wheel, (2) an axle, (3) a motor, (4) a motor controller, (5) a transmission, and (6) a brake assembled together as a unitary assembly. In such embodiments, the independent and unitary assembly is readily implemented in desired applications, for example converting non omni-directional vehicles into vehicles with omni-directional capabilities. As discussed herein and as illustrated in the non-limiting embodiments shown in the Figures, vehicles of the present invention employing inventive wheel modules are capable of being used to load, transport, and unload heavy loads, due to the desirable load bearing characteristics of omni-directional wheels used in the inventive wheel modules.

In order to illustrate the present invention, Figures are provided which show certain non-limiting embodiments of the present invention. Turning to Figure 1, a diagrammatic, profile view of an omni-directional wheel module 100 according to one embodiment of the present invention is shown. As shown in Figure 1, a wheel module 100 of the present invention generally includes an axle 102 with mounts 104 for attachment of omni-directional wheels (not shown; as discussed below), a transmission system 106, a braking mechanism 108 and a motor 110. Various elements of

wheel module 100 may be enclosed in a housing 112 (Figure 2).

In the present invention, suitable omni-directional wheels include, for example, known omni-directional wheels which may be mounted on hub 102. For example, suitable omni-directional wheels include those described in US Patent Nos. 6,340,065 and 6,547,340, hereby incorporated by reference in their entirety, and other omni-directional wheels sold commercially, such as those sold by Airtrax Corporation. Transmission system 106 may be, for example, a 20:1 speed reducer transmission gearbox; braking mechanism 108 may be, for example, a spring-set electrically released brake; and motor 110 may be, for example, a modified AC induction motor. One of skill in the art will recognize that other suitable components may be used in wheel module 100, so long as wheel module 100 functions as desired.

Figure 2 shows a vehicle employing one embodiment of omni-directional wheel modules according to the present invention. Specifically, Figure 2 shows a multi-purpose mobility platform 114 which is useful for the transport of equipment, for example in military and industrial environments. Such a multi-purpose mobility platform 114 is highly configurable for various applications (for example, various wheelbase widths and wheel tread widths are possible depending on the desired application) and allows equipment to be moved easily and with precision, particularly in confined spaces

As shown in Figure 2, a housing 116 includes a load bearing platform 118 and a compartment therebelow, which contains energy modules 120 for providing the necessary energy to power wheel modules 100. Platform 118 is preferably hinged to allow ready access to energy modules 120. Energy modules 120 may be any suitable energy source for powering wheel modules 100 and may

include, for example, conventional lead acid batteries or an air cooled diesel motor/battery hybrid. In a preferred embodiment, an operator interface module 122 is attached to housing 116 by a hinged arm 124 (shown in greater detail in Figures 4-6) and permits operation of multi-purpose mobility platform 114 in a walk-behind manner. Figure 3 is a schematic diagram generally showing the control of the multi-purpose mobility platform 114 of Figure 2.

Figures 4, 5 and 6 respectively show an overhead view, a side view and a rear view of the multi-purpose mobility platform 114 of Figure 2. As shown in various perspectives in each of Figures 4-6, operator interface module 122 is preferably attached to housing 116 by an arm 124 which is capable of both horizontal and vertical movement, allowing an operator great flexibility in walking behind multi-purpose mobility platform 114 while in operation.

The provided figures diagrammatically show a unitary assembly of a wheel module of the present invention (Figure 1) and a multi-purpose mobility platform embodiment of the present invention (Figures 2-6). However, it will be apparent to one of skill in the art that the inventive wheel modules are suitable for use in numerous applications, both for converting objects and non omni-directional vehicles into omni-directional vehicles or hybrids thereof (for example, having both non omni-directional and omni-directional wheels). Such vehicles are within the scope of the present invention.

For example, the inventive wheel modules may be provided as an independently functioning unitary assembly in a kit for such applications, allowing any suitable object or vehicle to be retrofitted with a wheel module of the present invention. In such a kit, the wheel modules may be entirely self-contained, such that

they may be attached to any suitable object or vehicle, wherein such object or vehicle does not require any particular equipment to accommodate such wheel modules. One such embodiment is a forklift, which are often used in industrial environments with confined spaces (e.g., warehouses) where maneuvering equipment is challenging. Other embodiments include, for example, scissorlifts, aircraft support and maintenance platforms, munition handling vehicles, motorized dollies, delivery trucks and wheelchairs. Moreover, the inventive wheel modules may attach to such objects and vehicles in any conventional manner and have, for example, a wiring harness capable of being connected to an operator control module for operating the omni-directional wheels.

Figure 7 illustrates an embodiment of a crane 126 employing a plurality of omni-directional wheel modules 100 of the present invention. As illustrated in Figure 7, the crane's arm 128 is capable of swinging in both horizontal and vertical directions such that a load 130 may be placed on and removed from platform 132. Wheel modules 100 permit crane 126 to be positioned with great precision for this purpose, as well as for moving crane 126 for transporting load 130 to a desired location. The use of omni-directional wheels on wheel modules 100 permits crane 126 to transport, load and unload heavy loads even in confined spaces.

Once given the above disclosure, many other features, modifications, and improvements will become apparent to the skilled artisan. Such other features, modifications, and improvements are therefore considered to be part of this invention, the scope of which is to be determined by the following claims:

We claim:

1. An omni-directional wheel module comprising:

an omni-directional wheel having a hub;

an axle carrying said omni-directional wheel so that said omni-directional wheel is capable of rotating about said axle;

a motor for powering rotation of said omni-directional wheel about said axle;

a transmission operatively interconnected between said motor and said omni-directional wheel; and

a brake for selectively inhibiting rotation of said omni-directional wheel; and

wherein said module components are assembled as a unitary, functional modular wheel assembly selectively installable and removable as an assembled unit.

2. An omni-directional wheel module according to claim 1 further comprising:

a motor controller for controlling operation of said motor.

3. An omni-directional wheel module according to claim 2 wherein said motor controller selectively communicates to said motor to operate said motor at a selected motor output value.

4. An omni-directional wheel module according to claim 3 wherein said motor controller, by controlling operation of said motor, controls speed and direction of omni-directional wheel rotation.

5. An omni-directional wheel module according to claim 4 wherein said transmission comprises a primary gear reduction assembly and a secondary gear reduction assembly.

6. An omni-directional wheel module according to claim 5 wherein:

said primary gear reduction assembly comprises spur gears; and

said secondary gear reduction assembly comprises planetary gears.

7. An omni-directional wheel module according to claim 6 wherein said spur gears are helical spur gears.

8. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, wherein:

said omni-directional wheel is so constructed such that a vehicle employing a plurality of such omni-directional wheels exhibits substantially constant ride height during directional operation.

9. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, wherein said omni-directional wheel further comprises:

a plurality of roller mounting brackets coupled to said hub; and

a plurality of rollers each rotatably coupled to at least one of said roller mounting

brackets at a roller mounting angle, said rollers comprising;

a core rotatably coupled to said roller mounting bracket, said core having a first end and a second end; and

a contact surface of elastomeric material coupled to and radially disposed about said core with a volumetric shape such that the exterior profile of said contact surfaces of all said rollers forms a noncircular profile when viewed from a perspective laterally displaced from and coincident with the centerline of said hub.

10. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, wherein:

said contact surface of said rollers is disposed about said core with a radial diameter near said first end of said core that exceeds the radial diameter that would result in a circular profile when viewed from a perspective laterally displaced from and coincident with the centerline of said hub.

11. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, wherein:

said rollers are further comprised of: a roller segment, wherein said contact surface of said roller segment is disposed about said core with a radial diameter near an end of said roller segment that exceeds the radial diameter that would result in a circular profile when viewed from a perspective laterally displaced from and coincident with the centerline of said hub.

12. An omni-directional wheel module according to any one of the preceding
or following claims, or any combination thereof, wherein:

said contact surface of said rollers further comprises:

a first zone of elastomeric material disposed about said core, said first zone positioned between said first and second ends of said core; and

a second zone of elastomeric material disposed about said core, said second zone positioned between said first zone and said first end of said core and having a material stiffness that is different from the material stiffness of said first zone.

13. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, wherein:

said roller mounting angle is selected from substantially between 20 and 90 degrees.

14. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, wherein:

said hub of said omni-directional wheel is so constructed so as to allow free wheel rotation of said wheel.

15. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, further including:

an integrated power storage device for providing power to said motor.

16. An omni-directional wheel module according to any one of the preceding or following claims, or any combination thereof, further including:

a mount means for mounting said omni-directional wheel module to a vehicle.

17. A vehicle comprising:

a vehicle frame;

a power storage device carried by said vehicle;

a plurality of omni-directional wheels operatively connected to said vehicle, said omni-directional wheels each comprising an omni-directional wheel according to any one of the preceding or following claims, or any combination thereof;

said power storage device being so connected to said motors of said plurality of omni-directional wheels such that said power storage device is capable of providing power to said motors to cause selective rotation of said plurality of omni-directional wheels.

18. A vehicle comprising:

a vehicle frame;

a power storage device carried by said vehicle;

a plurality of omni-directional wheels operatively connected to said vehicle, said omni-directional wheels each comprising an omni-directional wheel according to any one of the preceding or following claims, or any combination thereof;

each said motor controller of said plurality of omni-directional wheels being communicably connected between said power storage device and said respective motor of said plurality of omni-directional wheels such that said power storage device is capable of providing power to said motors, via said passage through said motor controllers, to cause selective rotation of said plurality of omni-directional wheels.

19. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein:

said power storage device comprises at least one battery.

20. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein:

said at least one battery includes a quick connect/disconnect connector for connecting said at least on battery to at least one motor controller.

21. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein:

said vehicle further includes a power generation device.

22. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein:

said power generation device is so constructed and connected such as to be capable of providing power to at least one of said motors.

23. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein:

said power generation device is so constructed and connected such as to be capable of providing power for storage by said at least one battery.

24. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein:

said power generation device is a fuel cell.

25. A vehicle according to any one of the preceding or following claims, or any combination thereof, further including:

an operator controller for controlling directional motion of said vehicle, said operator controller comprising:

a first directional control mechanism capable of controlling translational locomotion of said vehicle; and

a second directional control mechanism capable of controlling rotational locomotion of said vehicle.

26. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein said first and second directional control mechanisms comprise joystick controls.

27. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein said operator controller further includes:

an on/off switch, a deadman switch, and an emergency stop switch.

28. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein said vehicle further includes a power gauge.

29. A vehicle according to any one of the preceding or following claims, or any combination thereof, wherein said vehicle further includes a wiring harness interoperatively connecting said operator controller, said power storage device, said motor controller, and said motor.

30. A method of converting an object into an omni-directionally locomotable vehicle, said method comprising:

assembling a plurality of omni-directional wheel modules to said object, said omni-directional wheels modules being selected from the modules according to any one of the preceding claims, or any combination thereof.

31. A method of converting a non-omni-directional vehicle into an omni-directional vehicle, said method comprising:

removing existing non-omni-directional wheels from a non-omni-directional wheeled vehicle;

connecting a plurality of omni-directional wheel modules to said vehicle to impart to said vehicle omni-directional functionality, said modules comprising omni-directional wheel modules according to any one of the preceding or following claims, or any combination thereof.

32. A method of converting a non-omni-directional vehicle into an omni-directional vehicle, said method comprising:

connecting a plurality of omni-directional wheel modules to said vehicle to impart to said vehicle omni-directional functionality, said modules comprising omni-directional wheel modules according to any one of the preceding or following claims, or any combination thereof.

33. A method according to claim 32 wherein said omni-directional vehicle retains at least one non-omni-directional wheel.

34. A method according to claim 32 wherein said non-omni-directional vehicle is a four-wheeled vehicle having four non-omni-directional wheels, said method further comprising:

removing two of said non-omni-directional wheels from said vehicle; and

retaining two of said non-omni-directional wheels on said vehicle.

35. A method according to claim 34 wherein said two retained non-omni-directional wheels are so located and oriented on said vehicle such that said vehicle can be towed with said two retained non-omni-directional wheels in ground engagement.

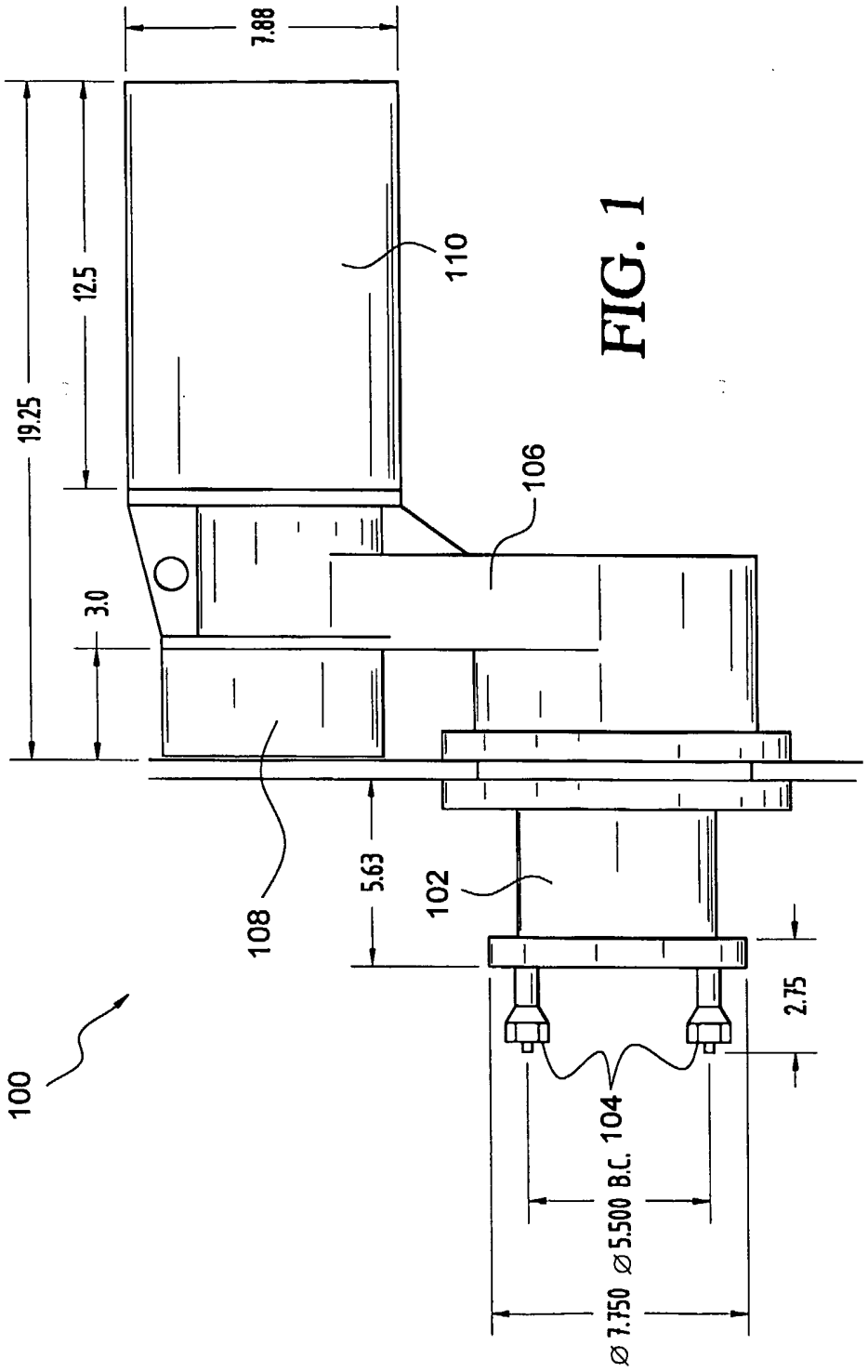


FIG. 1

FIG. 2

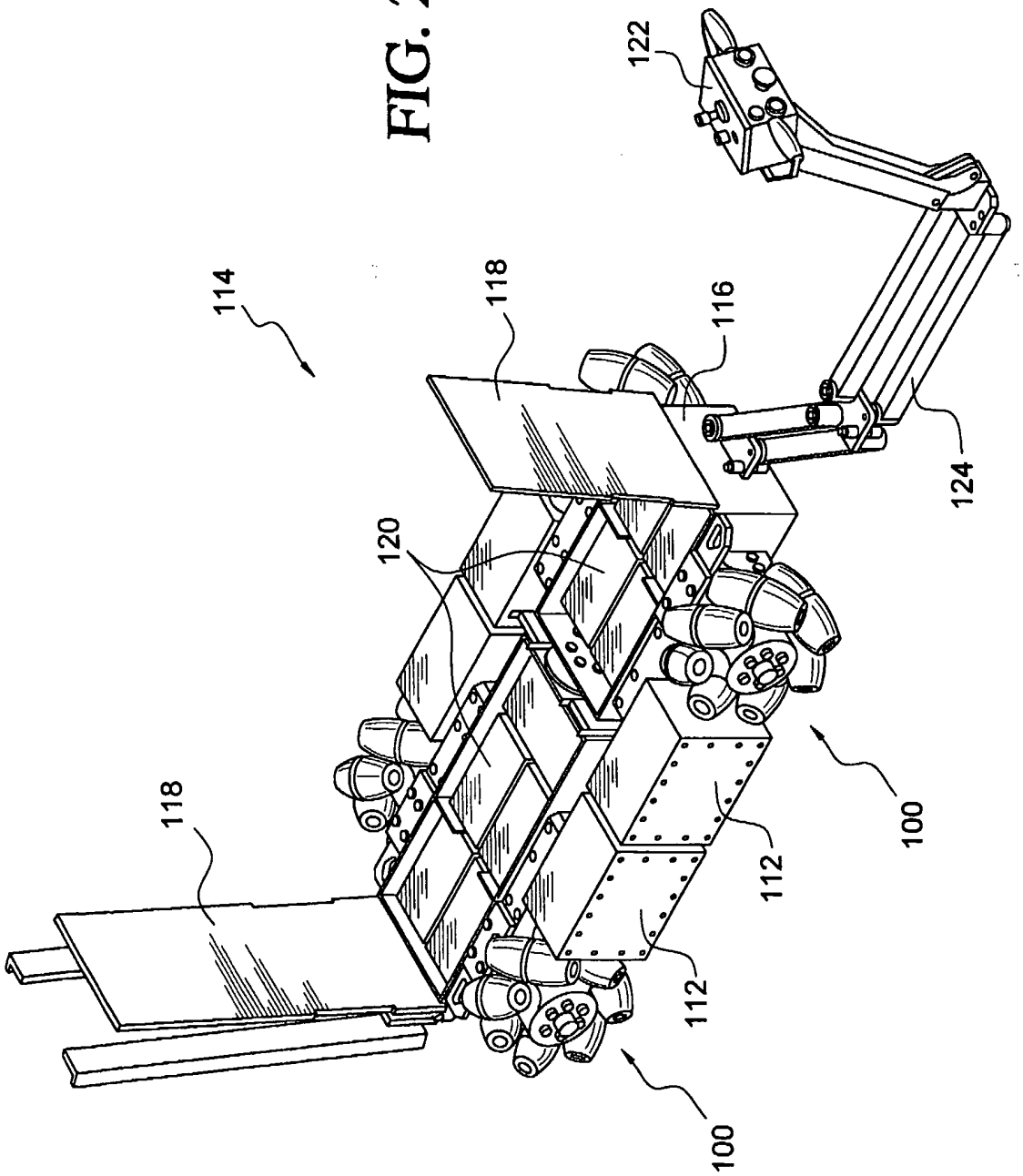
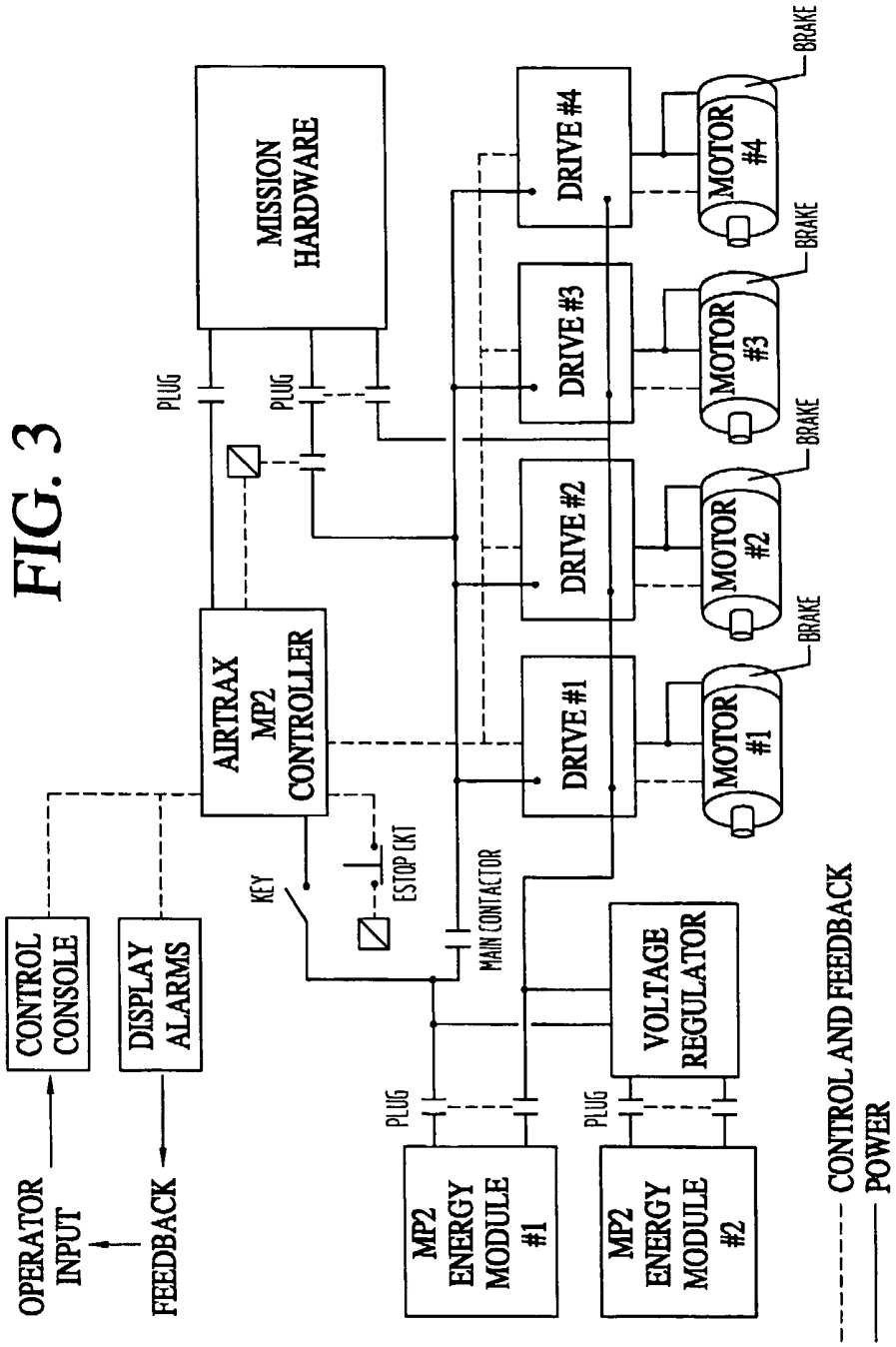


FIG. 3


MISSION HARDWARE
PLUG
PLUG
AIRTRAX MP2 CONTROLLER
DRIVE #4
DRIVE #3
DRIVE #2
DRIVE #1
MOTOR #4
MOTOR #3
MOTOR #2
MOTOR #1
BRAKE
BRAKE
BRAKE
BRAKE
CONTROL CONSOLE
DISPLAY ALARMS
KEY
ESTOP CKT
MAIN CONTACTOR
VOLTAGE REGULATOR
PLUG
PLUG
MP2 ENERGY MODULE #1
MP2 ENERGY MODULE #2
OPERATOR INPUT
FEEDBACK
CONTROL AND FEEDBACK
POWER

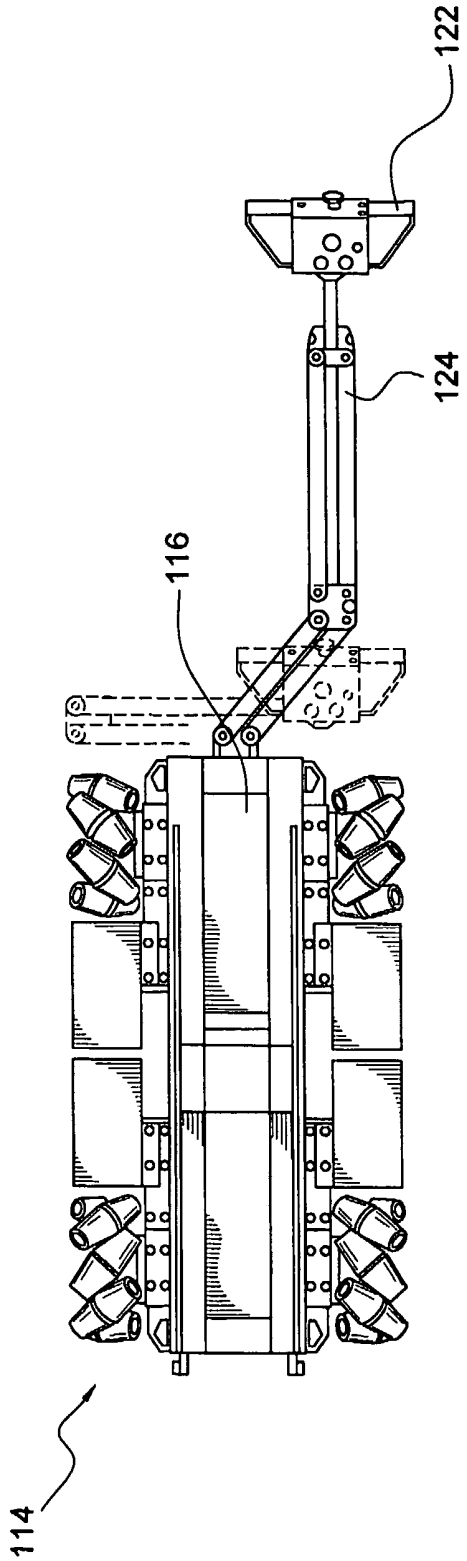


FIG. 4

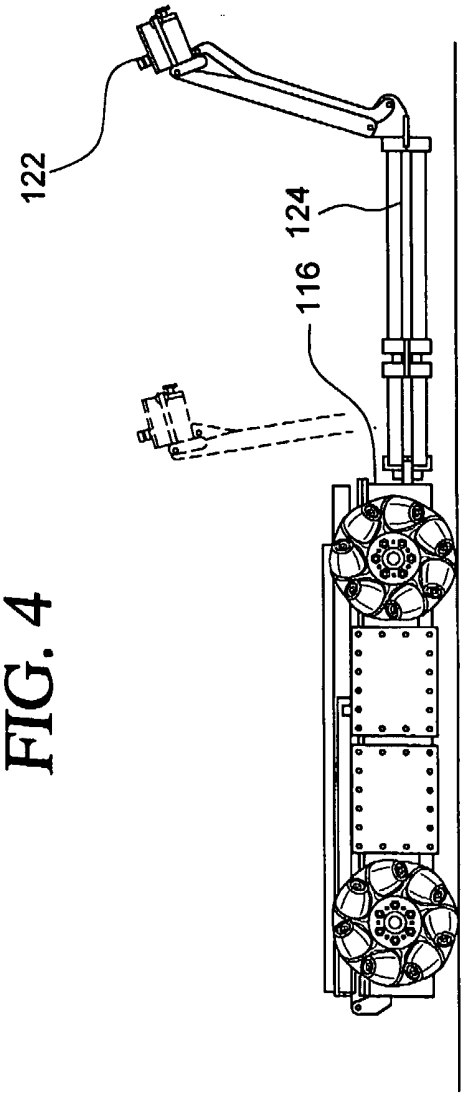


FIG. 5

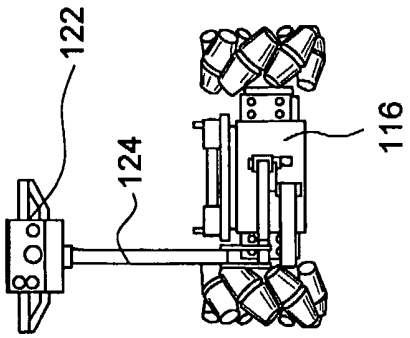


FIG. 6

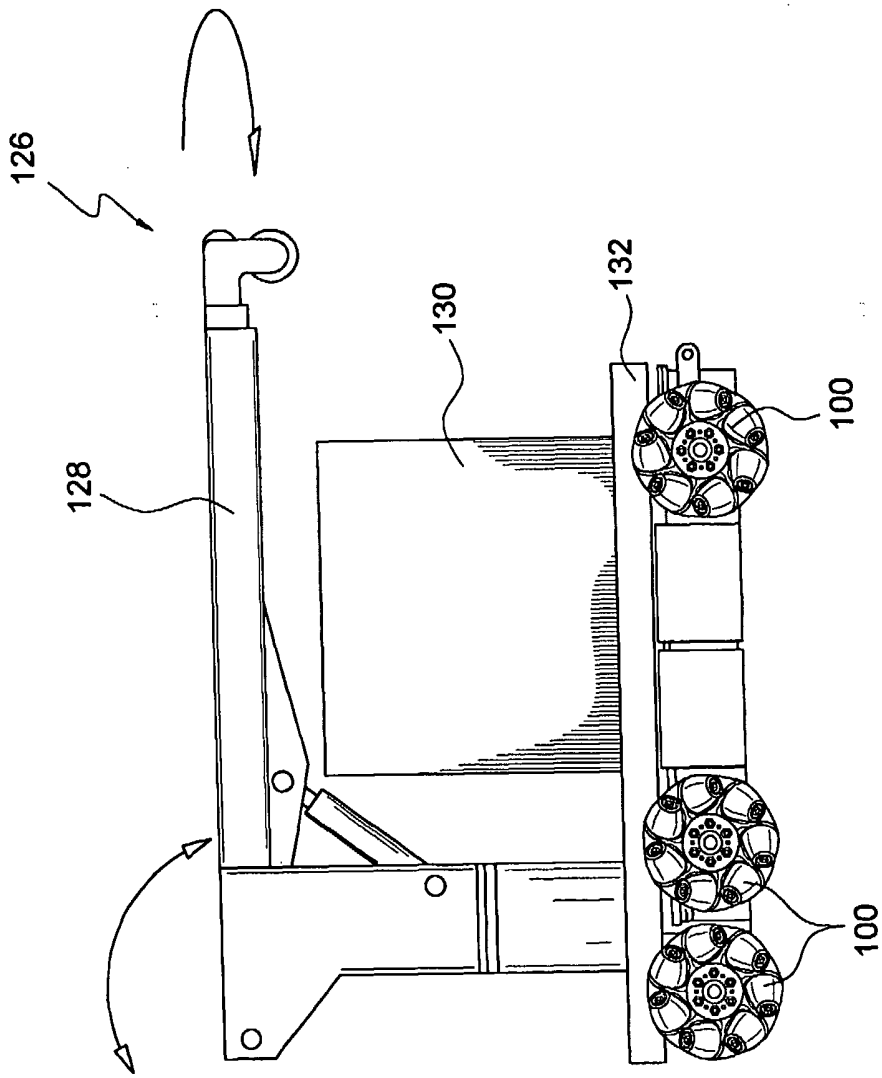


FIG. 7