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(54) **Title:** ROBOTIC VEHICLE CHASSIS WITH INDEPENDENTLY CONTROLLABLE TRIANGULAR TRACKS AND TACTILE PERCEPTION OF TERRAIN SHAPE AND COMPLIANCE

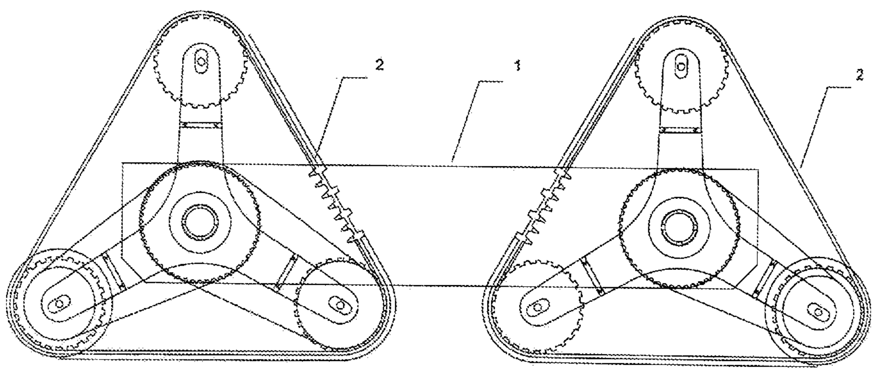

Fig. 1

(57) **Abstract:** A robotic vehicle chassis with independently controllable triangular tracks and tactile perception of terrain shape and compliance comprises a rigid structure main chassis body (1) provided with at least four independently controllable triangular track wheels (2). Each track wheel (2) is arranged to rotate its three-arm support frame (21) by means of a drive unit (29) and to drive an endless revolving track (25) on its circumference by means of a drive unit (26) of the endless revolving track. Each arm of the three-arm support frame (21) is further equipped with a 3-axis torque and force sensor (27) configured to provide information about the mechanical stress of each of the arms of the three-arm support frame (21) to calculate the estimate of the contact forces between the main chassis body (1) and the surrounding terrain.

WO 2024/251314 A1

Title: Robotic vehicle chassis with independently controllable triangular tracks and tactile perception of terrain shape and compliance

TECHNICAL FIELD

[0001] The invention relates to chassis for mobile vehicles, more specifically, tracked chassis for robotic mobile vehicles, wherein the chassis is provided with independently controllable triangular tracks. The individual parts of the triangular track or wheel are arranged in such a way that the endless revolving track wound around the vertices of the triangular arrangement of rotatable members can be moved forward and backward and at the same time the entire triangular track/wheel can rotate on its central axis. Furthermore, the independently controllable tracks are provided with means for tactile perception of terrain shape and compliance.

BACKGROUND ART

[0002] The solutions related to the use of triangular tracks on the vehicle chassis are well described in relevant prior art patent documents. For the purpose of further description, it is presumed that the triangular tracks and triangular tracked wheels have the same meaning.

[0003] For example, the document US8695735B2 describes a triangular continuous track device for direct replacement of a conventional tire and wheel combination found commonly on cars, trucks and other vehicles. A hub on the device is provided for direct bolt onto vehicles with a standard wheel bolt pattern. A track tensioning feature allows the track to be installed or repaired without removing the device from the vehicle. Grooves on the wheels are provided that engage with ribs on the inside of the track to efficiently transfer power from a power wheel in direct communication with the vehicle's axle to the two bottom idle wheels. The wheel according to the above-described document is not configured to rotate about its central axis passing through the shaft by which it is attached to the chassis, which is substantially disadvantageous for accurate passing through the complex terrain, and hence it has not tactile perception capability.

[0004] Another document WO2018035750A1 describes a robot having triangular crawler wheels. The robot includes a main body and four triangular crawler wheels disposed on the main body, and the main body includes an upper casing, a middle casing and a lower casing, and the upper casing and the lower casing are fixed on the middle casing, and the upper casing is provided with an image pickup mechanism. The middle frame has an external antenna at the end of the middle frame, and the middle frame includes a bracket plate having a hollow portion in the middle. The bracket plate is provided with an upward first convex edge and a downward second convex edge, and the upper side of the bracket plate is provided with a circuit board. The lower side of the bracket plate is fixedly connected to the driving motor and the gear set, and the upper shell and the lower shell are fixed on the middle frame for convenient installation, and the hollow part is arranged in the middle of the bracket plate, the weight is reduced, the fixing is convenient, and the fixing is firm. Similarly, as with regards to the previous state-of-the art document, the wheels of the robot are not configured to rotate about its central axis of the shaft. Moreover, the wheels according to said document are also not provided with means for tactile perception of the terrain shape and compliance.

[0005] In general, existing ground robots are usually equipped with a wheeled, tracked, or legged chassis. Robots with a wheeled chassis have a high speed of movement and are easy to control. Their main disadvantage is their small ability to overcome terrain obstacles. Robots with tracked chassis may have only main tracks or may be equipped with additional auxiliary tracks.

[0006] Compared to a wheeled robot, a tracked robot has more excellent terrain permeability and a larger contact area with the surface, but its control is more energy-demanding. Auxiliary tracks can increase the stability of the robot and improve the ability to pass through rugged terrain. Still, autonomous adjustment of the position of auxiliary tracks is not a simple task, and their incorrect position can lead to loss of stability and failure of the robot. Maintaining the desired position of the auxiliary tracks is energy-intensive in many cases, and the robot consumes energy even when it is not actively moving.

[0007] Robots with legged chassis have a very good ability to overcome obstacles. Still, they are often slow, and energy-intensive as they consume energy even when they are not actively moving, and their robustness depends entirely on the locomotion control algorithm.

[0008] The majority of the existing robotic chassis do not provide any information about their contact with the surrounding terrain and are therefore unable to respond adequately and in a timely manner to unexpected terrain changes.

[0009] For rescue and survey work, an energy-efficient chassis, resistant to control errors and with a good ability to pass through difficult terrain, which is able to actively respond to sudden and unexpected changes in the terrain such as landslides, subsidence, etc., is suitable.

[0010] Generally speaking, there are triangular wheel solutions which allow either forward and reverse movement of the revolving track via pivot members disposed anywhere along the circumference of the wheel in contact with the revolving track, or there are solutions where the entire wheel rotates on its axis, as is generally the case with standard circular wheels. However, no solution is yet known that combines these two modes of motion and simultaneously is capable of sensing the terrain characteristics to adjust the wheel movement in a most efficient manner.

SUMMARY OF THE INVENTION

[0011] Present invention relates to a robotic vehicle chassis with at least four independently controllable triangular tracks and tactile perception of terrain shape and compliance, wherein the individual elements of the wheel are formed in such a way that a revolving track wound around the vertices of the triangular arrangement of rotatable members can be moved forward and backward at the same time and furthermore the entire wheel can rotate on its central axis, which a major advantage addressing some of the problems of the state-of-the-art solutions.

[0012] The technical problem to be solved by the present invention is to provide a vehicle chassis with triangular track wheels. The proposed wheels offer high ability to overcome obstacles, inherent robustness, resistance to steering errors, and energy efficiency, providing information about the terrain on which it is located and the ability to respond to dynamic terrain changes quickly.

[0013] The goal of the present invention is achieved by the technical solution described in this section.

[0014] The robotic chassis with triangular tracked wheels comprises a fixed structure of the main body of the chassis equipped with at least and preferably exactly four independently actuated triangular tracked wheels. Each triangular tracked wheel is configured to rotate its three-arm support frame and drive the endless revolving track on its circumference.

[0015] The triangular tracked wheel comprises a three-arm support frame, each arm of which ends with a wheel adapted for guiding the endless revolving track and preventing sliding of the endless revolving track to the sides. One of the end wheels is mechanically coupled to the endless revolving track drive unit, which provides control of the endless revolving track movement with the possibility of setting the maximum allowed force for the endless revolving track movement. The track drive unit also provides information about the current position and speed of the endless revolving track, along with information about the electrical power applied to the drive unit's motor to achieve the desired motion.

[0016] Each arm of the three-arm triangular tracked wheel support frame is further equipped with a 3-axis torque and force sensor providing information about the mechanical stress of each of the arms of the three-arm triangular tracked wheel support frame. The information about the mechanical stress of each of the arms of the three-arm support frame of the triangular tracked wheel is used to calculate the estimate of the contact forces between the chassis and the surrounding terrain. Thanks to the actual measurement of the forces and torques acting on each of the arms of the three-arm support frame of the triangular tracked wheel, it is possible to immediately react to dynamic changes in the surrounding terrain, such as its subsidence, yielding, or sliding.

[0017] The triangular tracked wheel is attached to the main body by a hollow bracket with an inserted hollow shaft firmly connected to the three-arm support frame of the triangular tracked wheel. The hollow shaft is used to transmit torque from the driving unit of turning the three-arm support frame to the three-arm support frame and thus to control the angular position of the three-arm support frame of the triangular tracked wheel. The driving unit for rotating the three-arm triangular tracked wheel support frame is equipped with a locking mechanism, which eliminates the need to supply power to the unit to maintain the desired orientation of the three-arm triangular tracked wheel support frame. This locking mechanism yields significant energy savings and avoids the problems associated with position-controlled motors with significant load and zero speed, where a significant amount of heat is generated, which can lead to overheating and damage to the motor. The drive unit for turning the three-arm support frame of the triangular tracked wheel allows to precisely set the desired orientation of the three-arm support frame of the triangular tracked wheel. The drive unit also allows setting of the maximum allowable torque to achieve this angular position, providing feedback on the current orientation of the triangular tracked wheel and the torque needed to achieve it. A limitation of the locking mechanism of the drive unit is the absence of compliance of the angular position by the action of external forces, assuming a limited torque of the power unit. In the present solution, this limitation is eliminated due to i) the measurement of the external forces acting on the three-arm support frame of the triangular tracked wheel, and ii) the possibility to actively control the orientation of the three-arm support frame of the triangular tracked wheel based on the action of external forces, if desired.

[0018] The proposed chassis with triangular tracked wheels is primarily intended for overcoming obstacles in urban or industrial environments (stairs, curbs). In addition to that, thanks to the continuous rotation of the triangular tracked wheels and simultaneous movement of their endless revolving tracks, it can traverse more difficult terrain than a wheeled robot of comparable size, even in natural unpaved terrain.

[0019] In contrast to crawler chassis with auxiliary tracks, the proposed chassis is far more robust and resistant to inaccurate control of the orientation of the triangular tracked wheels. By measuring the moments and forces acting on each of the arms of the three-arm support frames of each triangular tracked wheel, the chassis provides detailed information about contact with the surrounding terrain that conventional mobile robot chassis are unable to provide. Information about contact with the surrounding terrain is then further used to estimate the type and properties of the terrain and to react to sudden changes in the terrain (e.g., subsidence, yielding, or damage to the supporting surface). In conjunction with vision sensors and suitable algorithms, it is then possible to predict the characteristics of the terrain that the robot is about to enter and, on this basis, to choose more suitable parameters for the control algorithm of the robot's movement.

[0020] Each triangular tracked wheel unit is preferably equipped with an electronic control and sensor processing unit (not shown) that provides control of the motors and reading and processing data from sensors located on the unit such as motor current sensors, absolute and incremental encoders and 3-axis torque and force sensor. The electronic control and sensor processing unit executes commands from a superior control system which is responsible for control of the whole robot and provides real time information of the state of the triangular tracked wheel (positions, velocities, currents, forces, torques) to the superior control system. The inner control loop of the electronic control and sensor processing unit can directly react on sensor data without involving the superior control system and inferring non-trivial information about the acting forces, it can for example mimic mechanical compliance of the triangular tracked wheel when desired. The electronic control and sensor processing unit can thus offer more advanced high-level control commands than usual motor control units used for mobile robots. Using the data from all triangular tracked wheel units, the superior control system can run common high-level control and state estimation algorithms such as factorgraph-based localization or linear-quadratic regulator control.

[0021] One guiding wheel of each triangular tracked wheel is preferably provided with an additional wheel attached to its side. When moving on a flat surface and with a corresponding orientation of the three-arm support frame of the triangular tracked wheel, the additional wheel eliminates the vibrations formed by the profile of the endless revolving track and facilitates smooth movement on a flat paved surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Figure 1 shows a side view of robotic vehicle chassis according to this invention provided with triangular tracks;

Figure 2 shows a side view triangular track wheel having three-arm support frame, each arm of which ends with a wheel adapted for guiding the endless revolving track and preventing sliding of the endless revolving track and each arm is provided with 3-axis torque and force sensor;

Figure 3 shows top view of triangular track wheel coupled with drive unit of the endless revolving track and drive unit for turning the three-arm support frame;

Figure 4 shows top view of robotic vehicle chassis (according to this invention provided with four triangular tracks;

DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention is further described by the following examples, which should not be construed as limiting the scope of the invention.

[0024] The vehicle chassis on Figs. 1 to 4 with triangular tracked wheels consists of rigid structure main chassis body 1 provided with four independently actuated triangular tracked wheels 2. Each triangular tracked wheel 2 is arranged to rotate its three-arm support frame 21, as well as drive the endless revolving track 25 on its circumference.

[0025] The triangular tracked wheel 2 comprises a three-arm support frame 21, each arm of which ends with a wheel 22 adapted for guiding the endless revolving track 25 and preventing sliding of the endless revolving track 25 to the sides.

[0026] One of the end wheels 22 is mechanically coupled by means of a chain transmission 23 to the inner hollow shaft 24, which transmits torque from the endless revolving track drive unit 26. The endless revolving track drive unit 26 consists of an electric motor 261 equipped with a shaft angular position sensor, a gearbox 262 made up of gear wheels, and a motor control unit enabling control of the motor 261 for torque, position, and speed. The drive unit 26 of the endless revolving track provides control of the speed of movement of the endless revolving track 25 with the possibility of setting the maximum allowed force for the endless revolving track 25 and provides information on the current position and speed of the endless revolving track 25 along with information on the energy supplied to the electric motor 261 required to move the endless revolving track 25.

[0027] Each of the arms of the three-arm support frame 21 is provided with a 3-axis force and torque sensor 27, providing information about the mechanical stress of each of the arms. The 3-axis force and torque sensors 27 are connected by means of rotary connectors (slip rings) and wires leading through the inner hollow shaft 24 to the control unit of the 3-axis torque and force sensors 27 located in the main chassis body 1.

[0028] Information on the mechanical stress of each of the arms of the three-arm support frame 21 is used to calculate an estimate of the contact of the chassis with the surrounding terrain. Compared to the common estimation of the forces acting on the arms of the three-arm support frame 21 from the magnitude of the current flowing through the motor 291 of the drive unit 29 for turning the three-arm support frame 21 of the triangular tracked wheel 2, this method of direct measurement of forces and torques is significantly more accurate and provides more information about the stress on each of the arms of the three-arm supporting frame 21, leading to a more accurate estimate of the contact of the chassis with the surrounding terrain. Thanks to the actual measurement of the forces acting on each of the arms of the three-arm support frame 21, it is possible to immediately react to dynamic changes in the surrounding terrain, such as its subsidence, yielding, or sliding.

[0029] The triangular tracked wheel 2 is attached to the main body 1 by means of a hollow bracket 11 in which the inserted hollow shafts 24, 28 are placed concentrically. The inner hollow shaft 24 serves to transmit the torque from the drive unit 26 of the endless revolving track 25 to the endless revolving track 25, while the outer hollow shaft 28 firmly connected to the three-arm support frame 21 serves to transmit the torque from the drive unit 29 for turning the three-arm support frame 21 to the three-arm support frame 21 and thus to control the position and rotation of the three-arm support frame 21.

[0030] The drive unit 29 for turning the three-arm support frame 21 is, in contrast to the commonly used drive units consisting of an electric motor with a conventional gearbox, equipped with a self-locking gearbox, and therefore there is no need to supply energy to the drive unit 29 for turning the three-arm support frame 21 to maintain the set position of the three-arm support frame 21. This achieves significant energy savings and avoids the problems associated with motors driven into position at load and zero speed, where a significant amount of heat is generated, which can lead to overheating and damage to the motor.

[0031] The drive unit 29 for turning the three-arm support frame 21 consists of two electronically coupled electric motors 291 equipped with shaft angular position sensors, a self-locking gearbox made of a worm gear with two worms 292 and one worm wheel 293, and a motor control unit enabling the control of motors 291 for torque, position, and speed. The driving unit 29 for turning the three-arm support frame 21 allows setting the angular position of the three-arm support frame 21 or the continuous rotation of the three-arm support frame 21 at a specified speed with the possibility of setting the maximum allowed force for the rotation of the three-arm support frame 21 and provides information about the current position and speed of the three-arm support frame 21 together with information about the energy supplied to the motors 291.

[0032] Each triangular tracked wheel 2 unit is provided with an electronic control and sensor processing unit (not shown) that provides control of the motors 261, 291 and reading and processing data from sensors located on the wheel 2 unit such as motor current sensors, absolute and incremental encoders and 3-axis torque and force sensor 27.

[0033] A limitation of the self-locking drive used is the absence of mechanical compliance, due to which the angular position can be changed by the action of external forces if the drive unit's torque is limited. In the presented solution, this limitation is eliminated thanks to the measurement of external forces acting on the chassis and the possibility of active angular positioning of the three-arm support frame 21 based on the measurements. In addition, it is possible to achieve mechanical compliance of the self-locking drive by cyclic bidirectional torque excitation at the limit of static friction.

INDUSTRIAL UTILIZATION

[0034] The present invention is industrially utilizable particularly in the field of mobile robotic systems with chassis that require high and efficient traversability over various types of terrain with minimal or reduced energy demands or prolonged working time.

CLAIMS

1. A robotic vehicle chassis with independently controllable triangular tracks and tactile perception of terrain shape and compliance, **characterized in that** it comprises a rigid structure main chassis body (1) provided with at least four independently controllable triangular track wheels (2),

wherein each track wheel (2) is arranged to rotate its three-arm support frame (21) by means of a drive unit (29) and to drive an endless revolving track (25) on its circumference by means of a drive unit (26),

wherein each arm of the three-arm support frame (21) is provided at its end with a wheel (22) adapted for guiding the endless revolving track (25) and preventing sliding of the endless revolving track (25) to the sides,

wherein one of the end wheels (22) is mechanically coupled to the endless revolving track drive unit (26) to control the endless revolving track movement and preferably to set the maximum allowed force for the endless revolving track movement,

wherein the drive unit (26) is configured to provide information about the current position and speed of the endless revolving track (25) and/or information about the electrical power applied to the drive unit's motor (261) to achieve the desired motion,

wherein each arm of the three-arm support frame (21) is further equipped with a 3-axis torque and force sensor (27) configured to provide information about the mechanical stress of each of the arms of the three-arm support frame (21) to calculate the estimate of the contact forces between the main chassis body (1) and the surrounding terrain,

wherein each triangular tracked wheel (2) is attached to the main body (1) by a hollow bracket (11) in which the inserted hollow shafts (24, 28) are placed concentrically in such a manner that

- the inner hollow shaft (24) is firmly connected to the three-arm support frame (21) of the triangular tracked wheel (2) and is adapted to allow transmission of torque from the drive unit (26) to the endless revolving track (25) and
- the outer hollow shaft (28) is firmly connected to the three-arm support frame (21) and the shaft (28) and is adapted to transmit the torque from the drive unit (29) to the three-arm support frame (21), thereby providing control of the angular position and rotation of the three-arm support frame (21).

2. The robotic vehicle chassis according to claim 1, **characterized in that** the drive unit (26) is provided with a locking mechanism adapted to eliminate the need to supply power to the unit (26) to maintain the desired orientation of the three-arm support frame (21).

3. The robotic vehicle chassis according to claim 1 or 2, **characterized in that** it comprises at least one vision sensor to predict the characteristics of the terrain.

4. The robotic vehicle chassis according to any of claims 1 to 3, **characterized in that** the main chassis body (1) is provided with four independently controllable triangular track wheels (2).

5. The robotic vehicle chassis according to any of claims 1 to 4, **characterized in that** the drive unit (26) consists of at least one electric motor (261) provided with a shaft angular position sensor, a gearbox (262) made up of gear wheels, and a motor control unit enabling control of the motor (261) for torque.

6. The robotic vehicle chassis according to any of claims 1 to 5, **characterized in that** the drive unit (29) consists of two electronically coupled electric motors (291) provided with shaft angular position sensors, a self-locking gearbox made of a worm gear with two worms (292) and one worm wheel (293), and a motor control unit adapted to control motors (291) for torque, position, and speed.

7. The robotic vehicle chassis according to any of claims 1 to 6, **characterized in that** the 3-axis force and torque sensors (27) are connected by means of rotary connectors or slip rings and wires leading through the inner hollow shaft (24) to the control unit of the 3-axis torque and force sensors (27) located in the main chassis body (1).

8. The robotic vehicle chassis according to any of claims 1 to 7, **characterized in that** one guiding wheel (22) of each triangular tracked wheel is provided with an additional wheel (221) externally attached to its side to eliminate the vibrations formed by the profile of the endless revolving track (25).

9. The robotic vehicle chassis according to any of claims 1 to 8, **characterized in that** the guiding wheel (22) is mechanically coupled to the drive unit (26) by means of a chain transmission (23) connected to the inner hollow shaft (24).

10. The robotic vehicle chassis according to any of claims 1 to 9, **characterized in that** each track wheel (2) comprises an electronic control and sensor processing unit to provide control of the motors (261, 291) and for reading and processing data from sensors located on the wheel (2) unit such as motor current sensors, absolute and incremental encoders and 3-axis torque and force sensor (27).

LIST OF REFERENCE MARKS

1	- rigid structure main chassis body
11	- hollow bracket
2	- triangular tracked wheel
21	- three-arm support frame
22	- wheel adapted for guiding the endless revolving track
23	- chain transmission
24	- inner hollow shaft
25	- endless revolving track
26	- drive unit of the endless revolving track
261	- electric motor
262	- gearbox made up of gear wheels
27	- 3-axis torque and force sensor
28	- outer hollow shaft
29	- drive unit for turning the three-arm support frame
291	- electric motors
292	- worms
293	- worm wheel
221	- externally attached additional wheel

AMENDED CLAIMS
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1. A robotic vehicle chassis with independently controllable triangular tracks and tactile perception of terrain shape and compliance, **characterized in that** it comprises a rigid structure main chassis body (1) provided with at least four independently controllable triangular track wheels (2),
wherein each track wheel (2) is arranged to rotate its three-arm support frame (21) by means of a drive unit (29) and to drive an endless revolving track (25) on its circumference by means of a drive unit (26),
wherein each arm of the three-arm support frame (21) is provided at its end with a wheel (22) adapted for guiding the endless revolving track (25) and preventing sliding of the endless revolving track (25) to the sides,
wherein one of the end wheels (22) is mechanically coupled to the endless revolving track drive unit (26) to control the endless revolving track movement and preferably to set the maximum allowed force for the endless revolving track movement,
wherein the drive unit (26) is configured to provide information about the current position and speed of the endless revolving track (25) and/or information about the electrical power applied to the drive unit's motor (261) to achieve the desired motion,
wherein each arm of the three-arm support frame (21) is further equipped with a 3-axis torque and force sensor (27) configured to provide information about the mechanical stress of each of the arms of the three-arm support frame (21) to calculate the estimate of the contact forces between the main chassis body (1) and the surrounding terrain,
wherein each triangular tracked wheel (2) is attached to the main body (1) by a hollow bracket (11) in which the inserted hollow shafts (24, 28) are placed concentrically in such a manner that

- the inner hollow shaft (24) is firmly connected to the three-arm support frame (21) of the triangular tracked wheel (2) and is adapted to allow transmission of torque from the drive unit (26) to the endless revolving track (25) and
- the outer hollow shaft (28) is firmly connected to the three-arm support frame (21) and the shaft (28) is adapted to transmit the torque from the drive unit (29) to the three-arm support frame (21), thereby providing control of the angular position and rotation of the three-arm support frame (21).

2. The robotic vehicle chassis according to claim 1, **characterized in that** the drive unit (26) is provided with a locking mechanism adapted to eliminate the need to supply power to the unit (26) to maintain the desired orientation of the three-arm support frame (21).

3. The robotic vehicle chassis according to claim 1 or 2, **characterized in that** it comprises at least one vision sensor to predict the characteristics of the terrain.

4. The robotic vehicle chassis according to any of claims 1 to 3, **characterized in that** the main chassis body (1) is provided with four independently controllable triangular track wheels (2).

5. The robotic vehicle chassis according to any of claims 1 to 4, **characterized in that** the drive unit (26) consists of at least one electric motor (261) provided with a shaft angular position sensor, a gearbox (262) made up of gear wheels, and a motor control unit enabling control of the motor (261) for torque.

6. The robotic vehicle chassis according to any of claims 1 to 5, **characterized in that** the drive unit (29) consists of two electronically coupled electric motors (291) provided with shaft angular position sensors, a self-locking gearbox made of a worm gear with two worms (292) and one worm wheel (293), and a motor control unit adapted to control motors (291) for torque, position, and speed.

7. The robotic vehicle chassis according to any of claims 1 to 6, **characterized in that** the 3-axis force and torque sensors (27) are connected by means of rotary connectors or slip rings and wires leading through the inner hollow shaft (24) to the control unit of the 3-axis torque and force sensors (27) located in the main chassis body (1).

8. The robotic vehicle chassis according to any of claims 1 to 7, **characterized in that** one guiding wheel (22) of each triangular tracked wheel is provided with an additional wheel (221) externally attached to its side to eliminate the vibrations formed by the profile of the endless revolving track (25).

9. The robotic vehicle chassis according to any of claims 1 to 8, **characterized in that** the guiding wheel (22) is mechanically coupled to the drive unit (26) by means of a chain transmission (23) connected to the inner hollow shaft (24).

10. The robotic vehicle chassis according to any of claims 1 to 9, **characterized in that** each track wheel (2) comprises an electronic control and sensor processing unit to provide control of the motors (261, 291) and for reading and processing data from sensors located on the wheel (2) unit such as motor current sensors, absolute and incremental encoders and 3-axis torque and force sensor (27).

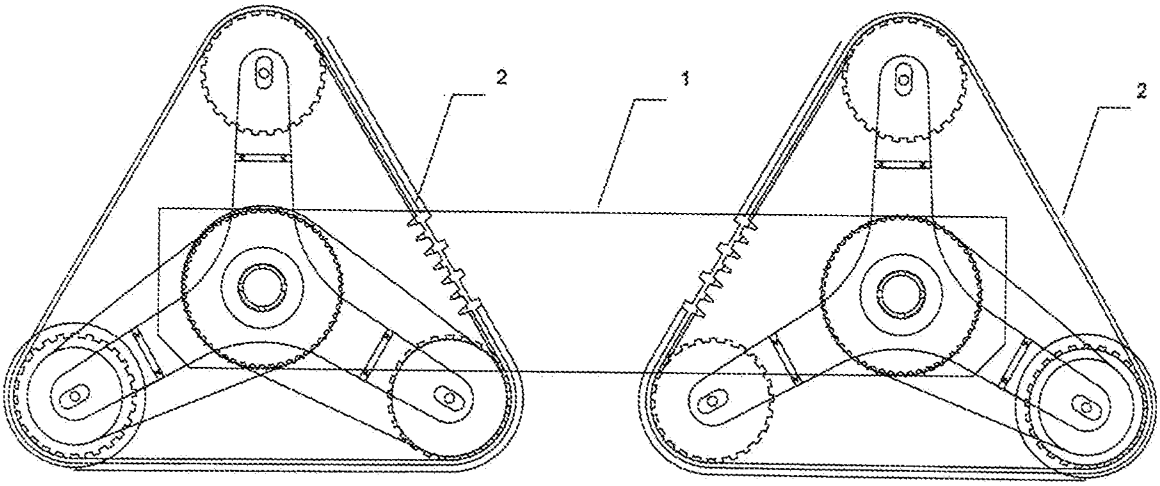


Fig. 1

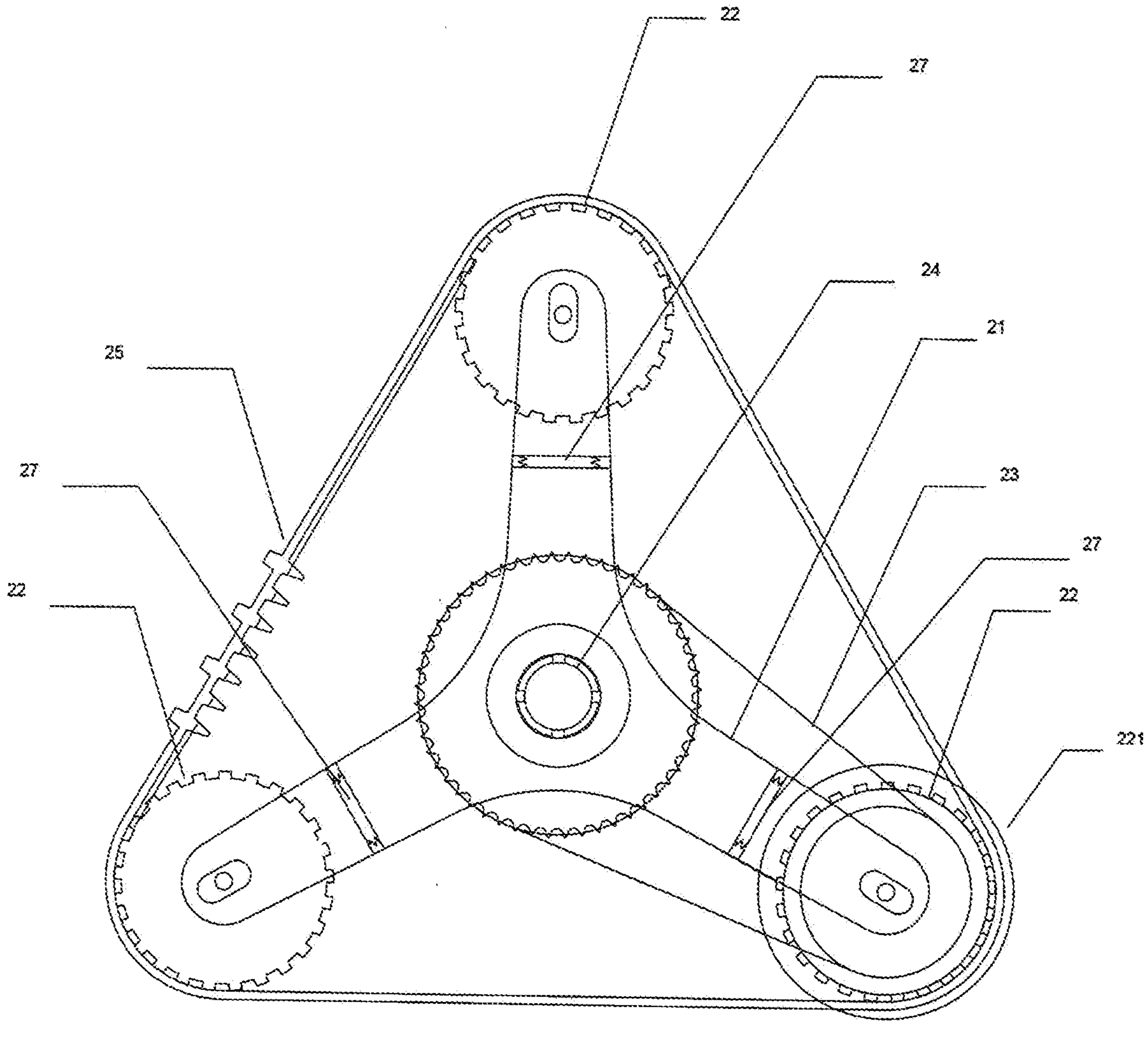
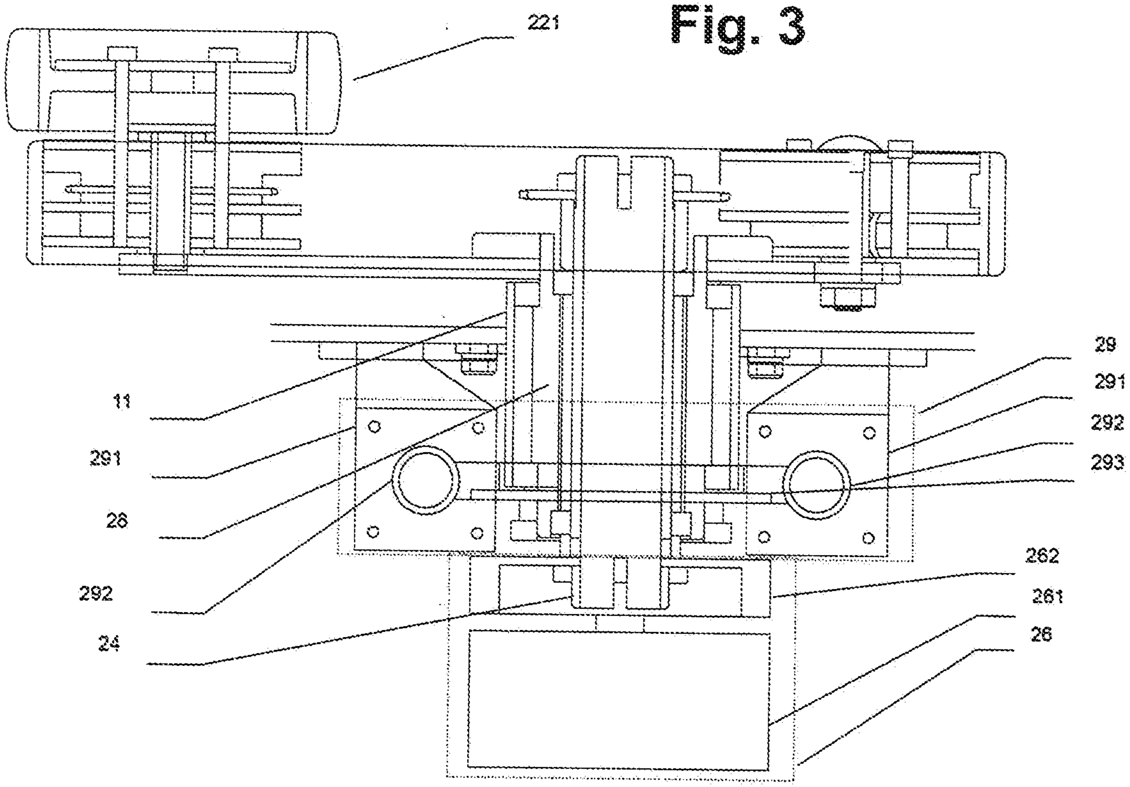


Fig. 2

Fig. 3



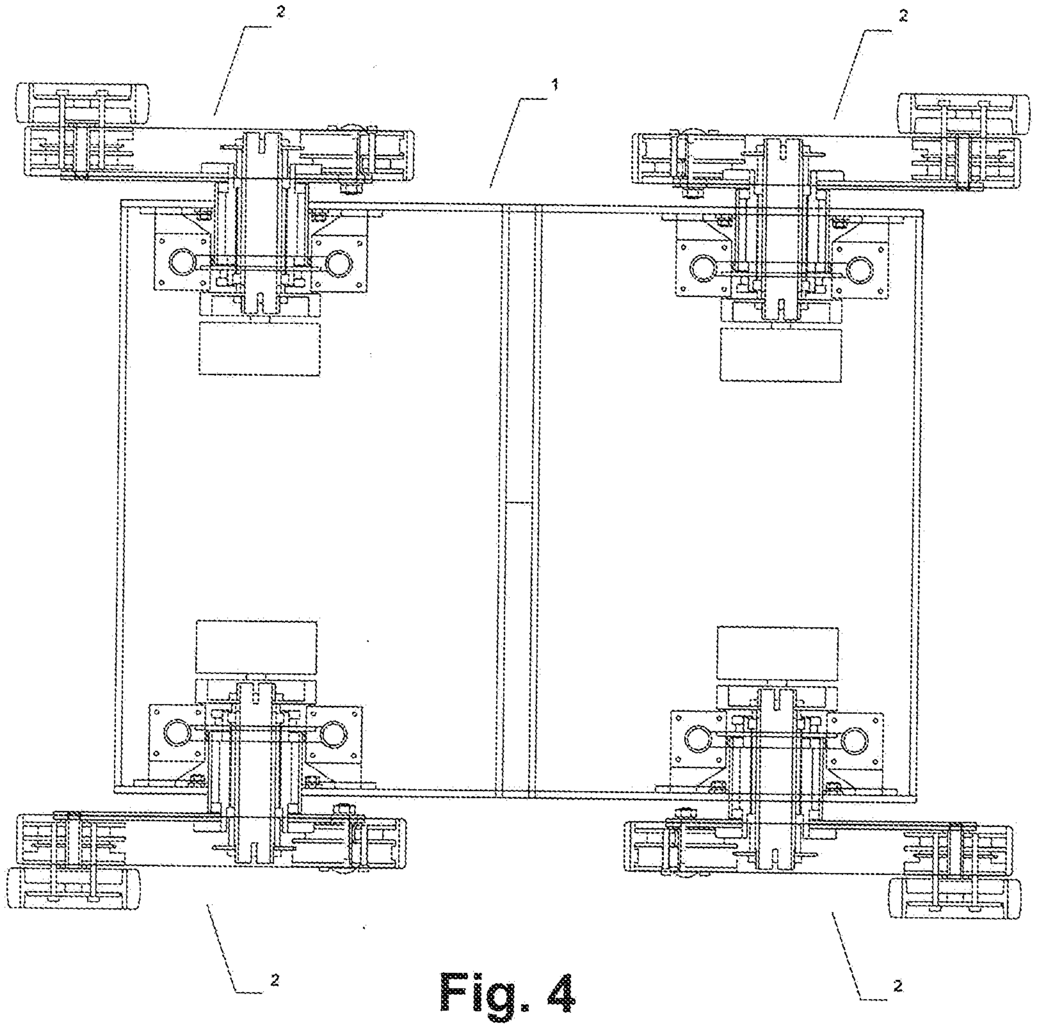


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/CZ2023/000021

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D55/065 B62D55/084 B62D55/10 B62D55/12 B62D55/14
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B62D

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/060743 A1 (ATLAS COPCO ROCK DRILLS AB [SE]; LIEBERT ALEXANDER [SE] ET AL.) 10 May 2012 (2012-05-10) figures 1-5 page 11, line 23 - page 12, line 9 -----	1-10
A	CN 110 466 631 A (UNIV JIANGSU) 19 November 2019 (2019-11-19) claims 1,2,3; figures 1-4 paragraph [0035] -----	1
A	EP 1 832 501 A2 (NAT INST OF ADVANCED IND SCIEN [JP]) 12 September 2007 (2007-09-12) figures 1-10 paragraph [0039] -----	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 November 2023	14/12/2023

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/CZ2023/000021

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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			WO	2012060743	A1	10-05-2012
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EP 1832501	A2	12-09-2007	AT	E489279	T1	15-12-2010
			EP	1832501	A2	12-09-2007
			JP	4635259	B2	23-02-2011
			JP	2007237991	A	20-09-2007
			US	2007209844	A1	13-09-2007