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(54) MATERIAL HANDLING VEHICLE

MATERIALHANDHABUNGSFAHRZEUG

VÉHICULE DE MANUTENTION DE MATÉRIAUX

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EP 3 521 235 B1

Description

[0001] The present disclosure is related to a material handling vehicle according to the pre-characterizing part of claim 1.

BACKGROUND

[0002] Warehouses are confined spaces which is constantly refined and being optimized for quickest possible material handling of goods. In order to achieve an effective operation of a warehouse it is important to utilise all possible surface for racks and goods. Thus it is desired to the smallest area possible for vehicles that operates in the warehouse. In order to achieve this it is important to have the smallest footprint possible of the vehicles operating in a warehouse.

[0003] One such vehicle is known from the document CN107473140 A. This vehicle discloses a relatively small footprint. However it is complex and has two horizontal beams that can move towards and distance themselves from each other. This document discloses the preamble of claim 1.

SHORT DESCRIPTION OF THE INVENTION

[0004] The present disclosure is related to a material handling vehicle comprising, a mast and auxiliary equipment. The auxiliary equipment comprises: a first and a second support leg each comprising at least one wheel. The material handling vehicle comprises at least two drive motors each comprising at least one wheel. The material handling vehicle further comprises an energy source device for powering the at least two drive motors. At least two of the wheels are independently steerable of the material handling vehicle. Further a load carrier is comprised and attached to the mast in a movable manner such that a load can be lifted up along the mast. The auxiliary equipment is fixedly attached to the mast.

[0005] One advantage with the above material handling vehicle is that it is very compact. Another advantage with the material handling vehicle is that it is very stable in its construction. Another advantage with the material handling vehicle is that it has a very small length. An especially important measure is the so called L2 measure. This is a well-known and accepted definition in this technical field and defines the length from the back end of the load carrier to the back end of the vehicle. A shorter L2 generally provides for a shorter turning radius and allows for a better manoeuvrability in confined spaces. To be more explicit the L2-measure is the definition for the measure of the horizontal length between the end of the material handling vehicle opposite the load carrier and the beginning of the load carrier in a direction from the end of the material handling vehicle and the load carrying back. Another advantage is that it is very simple in its construction; in particular as the mast itself is actually the central part of the vehicle. A further advantage is that by using the mast as the central main unit of the material handling vehicle a chassis is avoided and no longer necessary.

[0006] According to a further development a material handling vehicle is suggested in claim 2.

[0007] Hydraulics is particularly advantageous in order to achieve capability for heavy lifting operations. As preferred the attachment of the hydraulic pump to the mast makes the footprint of the material handling vehicle smaller. And also it provides for a stable attachment as the mast needs to be stable in itself for the higher levels of lifting that the material handling vehicle is intended for.

[0008] According to a further development a material handling vehicle is suggested in claim 3.

[0009] The material handling vehicle is preferred to be electric. As preferred the attachment of the energy source device to the mast makes the footprint of the material handling vehicle smaller. And also it provides for a stable attachment as the mast needs to be stable in itself for the higher levels of lifting that the material handling vehicle is intended for.

[0010] According to a further development a material handling vehicle is suggested in claim 4.

[0011] By arranging the drive motors on the support legs, the complexity of the material handling vehicle is further reduced. The support leg can then function as both support leg and also holder for both drive motors and wheels and gearing for the drive wheels that is powered by the respective drive motor.

[0012] According to the invention, by arranging all wheels with the respective support leg a very easily maintainable material handling vehicle is achieved. As an example wheels and drive motors/steering motors can be switched in a group operation, by detaching the respective support leg if desired. And still normal maintenance is possible as wheels and drive motor can easily be detached from the support leg itself.

[0013] According to a further development a material handling vehicle is suggested in claim 5.

[0014] With three steerable wheels it is possible for the material handling vehicle to move in very confined spaces and rotate in position. It is also possible to move in diagonal manner. If all wheels are individually steerable it is possible to control the path of the material handling vehicle very precisely. Also a redundancy can be achieved if a broken steering mechanism can be disengaged and thus it allows for the remaining steerable wheels to control the vehicle. Also diagonal movement will be made possible.

[0015] According to a further development a material handling vehicle is suggested in claim 6.

[0016] By introducing sensors it is possible to increase safety and avoid damages of the vehicle in operation.

[0017] According to a further development a material handling vehicle is suggested in claim 7.

[0018] Navigation equipment on the material handling vehicle makes the vehicle able to completely independently perform material handling tasks in a warehouse. A

fully automated material handling vehicle with the compactness of the present disclosure is of great advantage in a warehouse environment where all space that can be used for goods storage is of importance.

[0019] According to a further development a material handling vehicle is suggested in claim 8.

[0020] The stabilisation device will make the mast and also the complete vehicle more stable. It will also prevent view through the mast if an operator is operating in the warehouse and thus constitutes very important information for any person in the warehouse as the material handling vehicle is easily identified and any person in its operating area will be more aware where this particular material handling vehicle is.

[0021] According to a further development a material handling vehicle is suggested in claim 9.

[0022] By introducing telescopic forks the material handling vehicle is able to reach goods further away from the vehicle. Thus the material handling vehicle is configured to perform material handling tasks in an environment where a reach truck would normally be operating.

[0023] According to a further development a material handling vehicle is suggest in claim 10.

[0024] A telescopic mast provides for high lifting capacity. The material handling vehicle is thus able to position and handle loads that is positioned high above the floor of the warehouse.

[0025] According to a further development a material handling vehicle is suggest in claim 11.

[0026] A wireless interface for remotely controlling the vehicle can be useful if the vehicle needs to be moved by a remote operator, thus the operator need not operate in the vicinity of the vehicle but can reside in a control room elsewhere.

LIST OF DRAWINGS

[0027]

Figure 1 discloses from the side a material handling vehicle according to the disclosure where the drive motors are mounted to the support legs.

Figure 2 discloses from the side a material handling vehicle, not forming part of the invention, with separate drive motor holders.

Figure 3 discloses from above a material handling vehicle according to the disclosure where the drive motors are mounted to the support legs.

Figure 4 discloses from above a material handling vehicle , not forming part of the invention, with separate drive motor holders.

Figure 5 discloses the upper part of the first section of the mast of the material handling vehicle as disclosed, disclosing the stabilisation device.

DETAILED DESCRIPTION

[0028] The present disclosure is related to a high lifting material handling vehicle. With high lifting is to be understood a vehicle that in general can lift higher than a stacker material handling vehicle. A stacker in general can position a first load onto a second load. The high lifting material handling vehicle can lift much higher than this and position and fetch a load that is positioned in a rack that can be as high as 10 meters or more. In general this requires a mast that has several sections that can telescopically extend the mast with a load carrier for lifting high. In general the material handling vehicle has a load carrier. The load carrier is in generally a pair of forks that is optimal for lifting a load that is positioned on a pallet. The material handling vehicle in general comprises an energy source that can power a drive motor. The energy source may be a battery, and the drive motor an electric motor. Other energy sources are thinkable but not so common in a warehouse environment, such energy sources could be gas or fuel cells. The material handling vehicle is in general not a counter balance vehicle. The material handling vehicle is in general a reach material handling vehicle. This means that it can extend the load carrier in the longitudinal direction of the vehicle that is in the direction of the load carrier. Further the material handling vehicle has support legs that will bear the weight of a load such that the centre of gravity of the load itself is mainly positioned in the inner area of the wheels that bears the material handling vehicle.

[0029] Figure 1 discloses a high lifting material handling vehicle 1. The vehicle 1 comprises a mast 2. The mast 2 has a first vertical beam 2a. The mast 2 has also a telescopic element 3.

[0030] The material handling vehicle 1 further comprises auxiliary equipment. The auxiliary equipment is defined as equipment that is attached to the mast 2, in order for the mast to be able to move and perform a material handling task. The auxiliary equipment comprises a first support leg 4 and a second support leg 5, as seen in figure 1 and 3. The support legs 4, 5 have as function to carry weight. This is as opposed to a counter balance truck where the weight of a load is balanced by a counter balance weight. The support legs 4, 5 have a respective wheel 10, 13. The wheels 10, 13 are shown as a single wheel on respective support leg, but can be any type of wheel pair as a boogie or the like. All wheels of the material handling vehicle can be installed to the support legs 4, 5. It is important that the support legs 4, 5 are not movable in relation to each other and in particular in relation to the mast 2. The support legs 4, 5 are fixedly attached to the mast at any moment. This provides for a very stable material handling vehicle that also can be easily controlled without any differing angles to the wheels installed onto the support legs 4, 5. Also the material handling vehicle 1 will be very sturdy and will lover maintenance needs.

[0031] The material handling vehicle 1 has at least two

of its wheels steerable. This is preferred to be the drive wheels 7, 9 that are steerable by means of a respective servo motor. Individual steering of the drive wheels 7, 9 is preferred. This provides for a better control and adaptation to any movement of the vehicle.

[0032] The forward wheels 10, 13 of the support legs 4, 5 can be swivel wheels and only the drive wheels 7, 9 steerable. However one or both of the forward wheels 10, 13 may also be a steerable wheel. The steering is made possible by a respective servo motor. The steering is preferred to be individual for each wheel to allow very precise steering and avoid wear on the wheels in curves etc.

[0033] The material handling vehicle 1 comprises at least two drive motors 6, 8. The drive motors 6, 8 may be situated on the support legs 10, 13 and by means of these fixed to the mast 2 on each respective side of the mast 2, as seen in figures 1 and 3. The drive motors 6, 8 may also be fixed to the mast 2 by means of a separate holder 23, 24, as seen in figure 2 and 4, in embodiments which do not form part of the invention.

[0034] The material handling vehicle 1 further has a load carrier 26 that is movably attached to the mast 2. The load carrier 26 comprises forks 19, 27. As disclosed in figure 1 the forks 19, 27 have an outer end element 19a, 27a and an inner element. The outer element 19a, 27a is extendable, for reach purposes. This is made possible as preferred by a hydraulic arrangement with hydraulic cylinders. This could also be achieved with an electric adjustment device.

[0035] The material handling vehicle 1 further has a hydraulic system comprising a motor 14 connected to a hydraulic pump 14a. The hydraulic system powers the lifting and lowering functions of the material handling vehicle 1. Hydraulics may also power the extension of forks 19, 27 if desired. A hydraulic cylinder 25 figure 3, 4 is pressurized from the pump 14a for lifting purposes. The hydraulic pump is fixedly attached to the mast 2, preferably by means of a holder 15. The motor 14 and the hydraulic pump 14a are preferred to be dimensioned such that lifting speeds without load can be reached in the excess of 3 m/s in vertical direction. It should be understood that there can be several lifting cylinders for performing lifting tasks. There can be one cylinder for lifting the load carrier 26 up to the top of the first mast element 2a, and a second hydraulic cylinder for lifting a further mast element 3.

[0036] The material handling vehicle 1 has an energy source device 16. The energy source device 16 comprises a battery pack 16a and a holder 17. The holder is fixedly attached to the mast 2. The battery pack is preferred to be constituted of Li-Ion battery cells.

[0037] The electric system of the material handling vehicle is preferred to be using above 300 Volt. This will be an advantage as the current values can be kept lower and cabling will be simplified. This is in contrast to prior art where much lower Volt values are in general used, for example 24, 36 or 48 Volts.

[0038] The material handling vehicle 1 comprises a control unit. The control unit has processor, memory and software to control the functions and operation of the vehicle.

[0039] All wheels 7, 9, 10, 13 may be steerable. This provides for a very excellent manoeuvrability and also provides for using narrow aisles in a warehouse. Thus the multi wheel steering improves efficiency of the warehouse material handling as a whole. In particular the vehicle 1 can move in diagonal direction and turn very narrowly of more wheels are steerable than one.

[0040] There are sensors 21, 22 provided on the material handling vehicle 1. The sensors provide for that the vehicle 1 can operate in very narrow environment of a warehouse. The sensors 21, 22 can be of a suitable type such as laser, ultra-sound or radio based sensors.

[0041] The material handling vehicle 1 also has navigating equipment 28 for navigating in a warehouse. This is realised in conventional manner.

[0042] So the control unit together with the sensors 21, 22 and the navigation equipment 29 provides for an automated material handling vehicle 1 that can perform tasks in the warehouse without interaction of an operator.

[0043] The material handling vehicle 1 does not comprise any normal operating or control means, such as steering wheel or tiller arm. The material handling vehicle comprises a remote interface, such that it can manually be controlled by a remote operator. The remote interface may comprise a radio receiver and radio emitter. This can be achieved by means of Wi-Fi, GSM or any other wireless interface. The material handling vehicle 1 is arranged such that it can store and perform tasks received over the remote interface. For this reason the material handling vehicle also comprises at least one camera that can send live video to a remote operator.

[0044] Further the mast 2 is the main element of the material handling vehicle 1. This means that no chassis is needed or present in the material handling vehicle 1.

[0045] A stabilization device 18 is preferred to be installed to the mast 2, figure 5 disclosing the upper section of the mast 2 for all described material handling vehicles. The stabilisation device is preferred to be a steel plate. The plate should not have holes for viewing through the mast as this would give lower stabilisation properties. And also as the material handling vehicle 1 shall not be operated directly by an operator at site in the warehouse the stabilisation device provides for detection of the vehicle at distance as being an automated vehicle.

[0046] The material handling vehicle 1 may be provided with a wireless interface 35 that provides for that the material handling vehicle can receive order for material handling but also for the possibility of remotely controlling the vehicle manually. This means that an operator that is not on board the vehicle can control the vehicle remotely. For this purpose the material handling vehicle can also be provided with at least one camera capable of sending live video to the operator. As an example, if the vehicle has stopped for any reason, for an example

due to an obstacle in its way, the remote operator can take over the control of the vehicle and manually do what is needed to start the vehicle again, for example, steer the vehicle around the obstacle.

Claims

1. Material handling vehicle (1), comprising, a mast (2) and auxiliary equipment, wherein the auxiliary equipment comprises:

   a first (4) and a second (5) support leg each comprising at least one wheel (10, 13),
   at least two drive motors (6, 8) each comprising at least one wheel (7,9),
   an energy source device (16) for powering the at least two drive motors (6, 8),
   wherein at least two of the wheels are independently steerable,
   and further a load carrier (19, 19a) is comprised and attached to the mast in a movable manner such that a load can be lifted up along the mast (2), whereby all wheels (7, 9, 10, 13) of the vehicle are arranged in or on, a first and a second support leg (4, 5)
   characterized in that
   the auxiliary equipment is fixedly attached to the mast (2).

2. Material handling vehicle (1) according to claim 1, wherein further comprised is a hydraulic system comprising a pump motor (14) connected to a hydraulic pump (14a), preferably the hydraulic pump (14a) is attached to the mast (2) by means of a holder (15) fixedly attached to the mast (2).

3. Material handling vehicle (1) according to any of the claims above, wherein further comprised is an energy source device (16), wherein the energy source device comprises a battery pack (16a) and a holder (17) for the battery pack (16a), preferably the holder (17) is fixedly attached to the mast (2).

4. Material handling vehicle (1) according to any of the claims above, wherein each of the drive motors (6, 8) are arranged on or in the support legs (4, 5).

5. Material handling vehicle (1) according to any of the claims above, wherein at least three of the wheels (7, 9, 10, 13) are individually steerable, preferably all wheels (7, 9, 10, 13) of the material handling vehicle (1) are individually steerable.

6. Material handling vehicle (1) according to any of the claims above, wherein the material handling vehicle (1) further comprises sensors (21, 22) for detecting objects in the surrounding area of the vehicle (1).

7. Material handling vehicle (1) according to claim 6, wherein the vehicle (1) further is provided with navigation equipment (29) for navigating in a warehouse environment, preferably the vehicle (1) is an automated material handling vehicle that independently of direct input from an operator can handle goods in a warehouse environment.

8. Material handling vehicle (1) according to any of the claims above, wherein the mast (2) has a stabilisation device (18) mounted to the mast (2), preferably the mounted device (18) is a plate that at least partly covers the sight through the space that is defined by two main vertical mast beams (30, 31) of the mast (2).

9. Material handling vehicle (1) according to any of the claims above, wherein the load carrier (19, 19a) is arranged with a telescopic ability such that the load carriers (19, 19a) can be extended in a direction away from the mast (2) for reaching operations.

10. Material handling vehicle (1) according to any of the claims above, wherein the mast (2) comprises at least a first (2a) and a second (3) mast elements, thus arranging the mast as being telescopic for lifting loads to a higher level than the height of the first mast element (2a).

11. The material handling vehicle (1) according to any of the claims above, wherein the vehicle (1) is provided with a wireless interface (35) for manually remotely controlling the vehicle (1).

Patentansprüche

1. Materialhandhabungsfahrzeug (1), das einen Mast (2) und eine Zusatzausrüstung umfasst, wobei die Zusatzausrüstung Folgendes umfasst:

   einen ersten (4) und ein zweiten (5) Stützbein, die jeweils mindestens ein Rad (10, 13) umfassen,
   mindestens zwei Antriebsmotoren (6, 8), die jeweils mindestens ein Rad (7, 9) umfassen,
   eine Energiequelleneinrichtung (16) zum Versorgen der mindestens zwei Antriebsmotoren (6, 8) mit Strom,
   wobei mindestens zwei der Räder voneinander unabhängig lenkbar sind,
   und ferner einen Lastträger (19, 19a) umfasst ist, der angebracht verschiebbar an dem Mast derart ist, dass eine Last entlang des Mastes (2) angehoben werden kann, wobei alle Räder (7, 9, 10, 13) des Fahrzeugs in oder an einem ersten und einem zweiten Stützbein (4, 5) angeordnet sind,
   dadurch gekennzeichnet, dass die Zu-

satzausrüstung fest an dem Mast (2) angebracht ist.

2. Materialhandhabungsfahrzeug (1) nach Anspruch 1, wobei ferner ein Hydrauliksystem umfasst ist, das einen mit einer Hydraulikpumpe (14a) verbundenen Pumpenmotor (14) umfasst, wobei die Hydraulikpumpe (14a) vorzugsweise mittels einer fest am Mast (2) angebrachten Halterung (15) am Mast (2) angebracht ist.

3. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei ferner eine Energiequelleneinrichtung (16) umfasst ist, wobei die Energiequelleneinrichtung ein Batterieteil (16a) und eine Halterung (17) für das Batterieteil (16a) umfasst, wobei die Halterung (17) vorzugsweise fest am Mast (2) angebracht ist.

4. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei die Antriebsmotoren (6, 8) jeweils an oder in den Stützbeine (4, 5) angeordnet sind.

5. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei mindestens drei der Räder (7, 9, 10, 13) einzeln lenkbar sind, vorzugsweise alle Räder (7, 9, 10, 13) des Materialhandhabungsfahrzeugs (1) einzeln lenkbar sind.

6. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei das Materialhandhabungsfahrzeug (1) ferner Sensoren (21, 22) zum Erkennen von Objekten in der Umgebung des Fahrzeugs (1) umfasst.

7. Materialhandhabungsfahrzeug (1) nach Anspruch 6, wobei das Fahrzeug (1) ferner mit einer Navigationsausrüstung (29) zum Navigieren in einer Warenlagerumgebung versehen ist, wobei das Fahrzeug (1) vorzugsweise ein automatisiertes Materialhandhabungsfahrzeug ist, das in einer Warenlagerumgebung Waren unabhängig von einer direkten Eingabe durch einen Bediener handhaben kann.

8. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei der Mast (2) eine am Mast (2) angebrachte Stabilisierungsvorrichtung (18) aufweist, wobei die angebrachte Vorrichtung (18) vorzugsweise eine Platte, die zumindest teilweise die Sicht durch die durch zwei vertikale Hauptmasttragbalken (30, 31) des Mastes (2) begrenzte Lücke verdeckt.

9. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei der Lastträger (19, 19a) derart teleskopierbar angeordnet ist, dass die Lastträger (19, 19a) für Ausstreckvorgänge in eine vom Mast (2) wegführende Richtung ausgefahren werden können.

10. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei der Mast (2) mindestens ein erstes (2a) und ein zweites (3) Mastelement umfasst, wodurch der Mast zum Heben von Lasten auf ein höheres Niveau als die Höhe des ersten Mastelements (2a) teleskopisch ausgelegt ist.

11. Materialhandhabungsfahrzeug (1) nach einem der vorstehenden Ansprüche, wobei das Fahrzeug (1) mit einer drahtlosen Schnittstelle (35) zur manuellen Fernsteuerung des Fahrzeugs (1) versehen ist.

Revendications

1. Véhicule de manutention (1), comprenant, un mât (2) et un équipement auxiliaire, dans lequel l'équipement auxiliaire comprend :

une première (4) et une seconde (5) jambe de support comprenant chacune au moins une roue (10, 13),
au moins deux moteurs d'entraînement (6, 8) comprenant chacun au moins une roue (7, 9),
un dispositif de source d'énergie (16) pour alimenter les au moins deux moteurs d'entraînement (6, 8),
dans lequel au moins deux des roues sont orientables indépendamment,
et comprenant en outre un porte-charge (19, 19a) fixé au mât de manière mobile de sorte qu'une charge peut être soulevée le long du mât (2), moyennant quoi toutes les roues (7, 9, 10, 13) du véhicule sont agencées dans ou sur une première et une seconde jambe de support (4, 5),
caractérisé en ce que l'équipement auxiliaire est attaché de façon fixe du mât (2).

2. Véhicule de manutention (1) selon la revendication 1, comprenant en outre un système hydraulique comprenant un moteur de pompe (14) relié à une pompe hydraulique (14a), dans lequel la pompe hydraulique (14a) est de préférence fixée au mât (2) au moyen d'un support (15) attaché de façon fixe du mât (2).

3. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, comprenant en outre un dispositif de source d'énergie (16), dans lequel le dispositif de source d'énergie comprend un bloc de batterie (16a) et un support (17) pour le bloc de batterie (16a), le support (17) est de préférence attaché de façon fixe du mât (2).

4. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel chacun des moteurs d'entraînement (6, 8) est agencé sur ou dans les jambes de support (4, 5).

5. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel au moins trois des roues (7, 9, 10, 13) sont orientables individuellement, de préférence toutes les roues (7, 9, 10, 13) du véhicule de manutention (1) sont orientables individuellement.

6. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel le véhicule de manutention (1) comprend en outre des capteurs (21, 22) pour détecter des objets dans la zone environnante du véhicule (1).

7. Véhicule de manutention (1) selon la revendication 6, dans lequel le véhicule (1) est en outre doté d'un équipement de navigation (29) pour naviguer dans un environnement d'entrepôt, de préférence le véhicule (1) est un véhicule de manutention automatisé qui, indépendamment de l'entrée directe d'un opérateur, peut manipuler des marchandises dans un environnement d'entrepôt.

8. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel le mât (2) présente un dispositif de stabilisation (18) monté sur le mât (2), de préférence le dispositif monté (18) est une plaque qui couvre au moins partiellement la vue à travers l'espace qui est défini par deux poutres de mât verticales principales (30, 31) du mât (2).

9. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel le porte-charge (19, 19a) est agencé avec une capacité télescopique de sorte que les portes-charges (19, 19a) peuvent être étendus dans une direction s'éloignant du mât (2) pour les opérations d'atteinte.

10. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel le mât (2) comprend au moins un premier (2a) et un second (3) éléments de mât, agençant ainsi le mât comme étant télescopique pour soulever des charges à un niveau supérieur à la hauteur du premier élément de mât (2a).

11. Véhicule de manutention (1) selon l'une quelconque des revendications précédentes, dans lequel le véhicule (1) est doté d'une interface sans fil (35) pour commander manuellement à distance le véhicule (1).

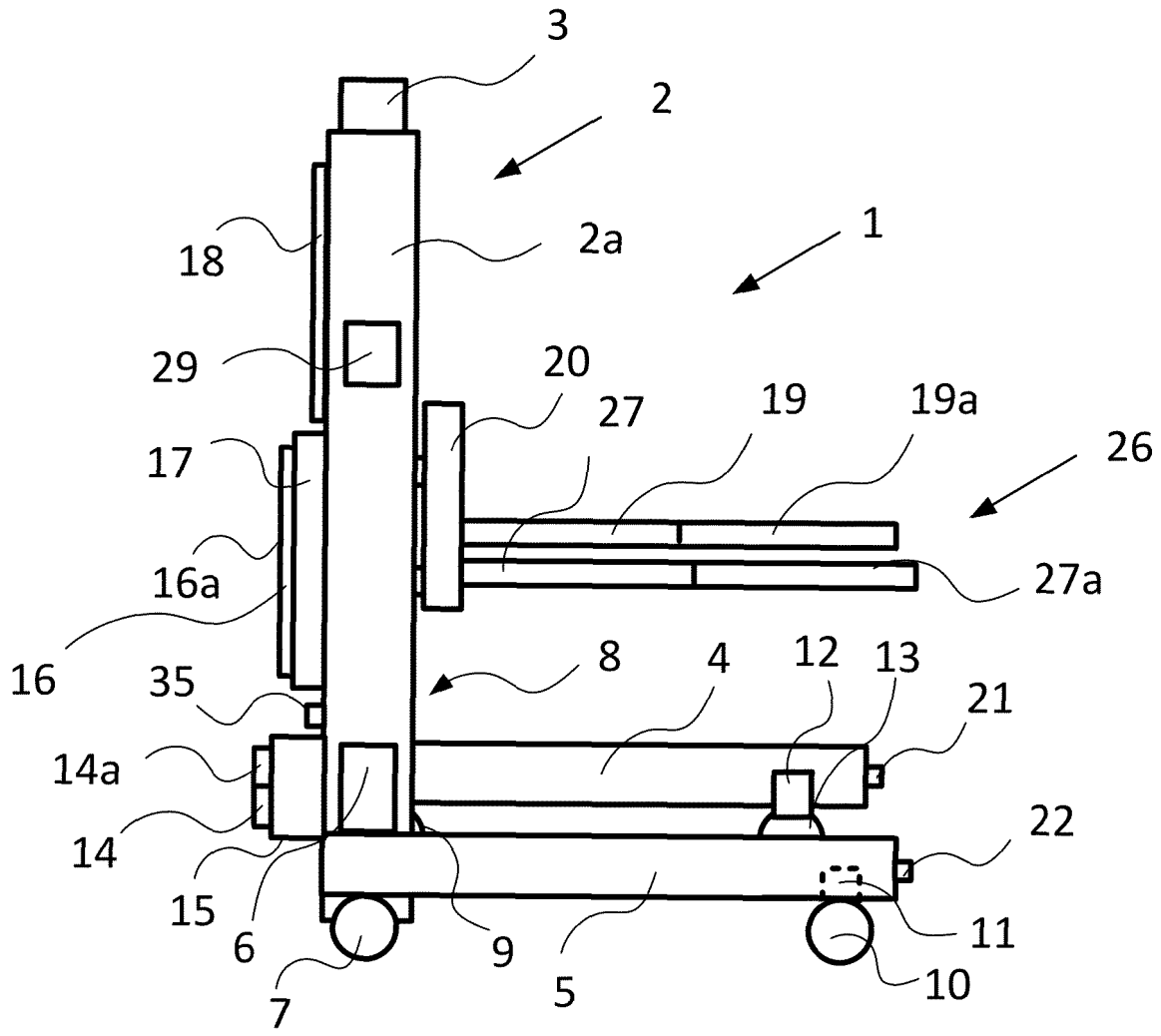

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Figure 1

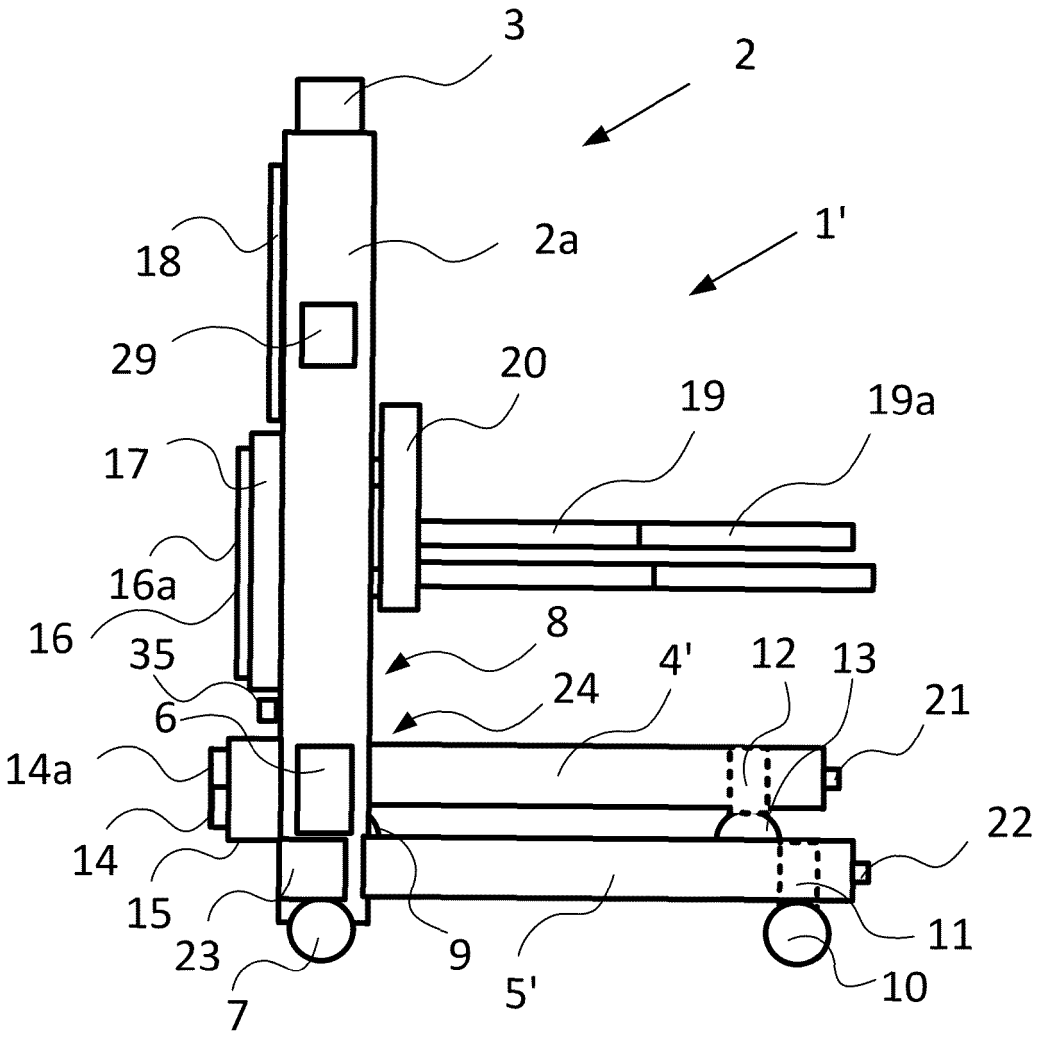

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Figure 2

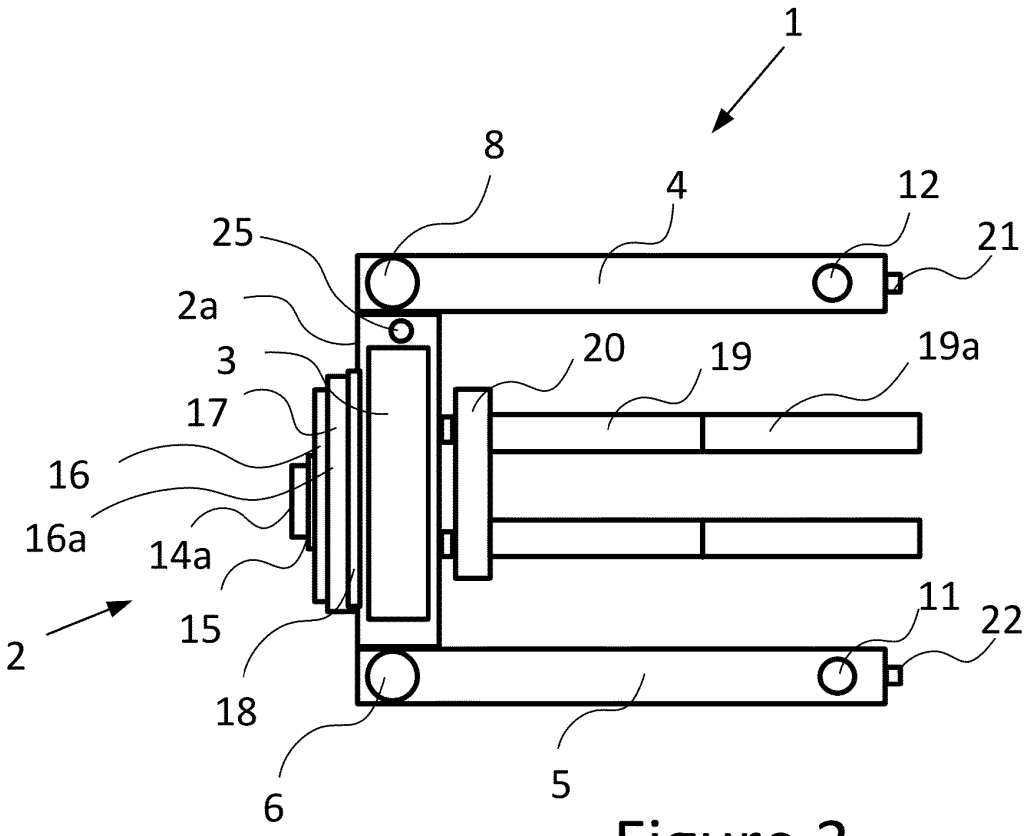


Figure 3

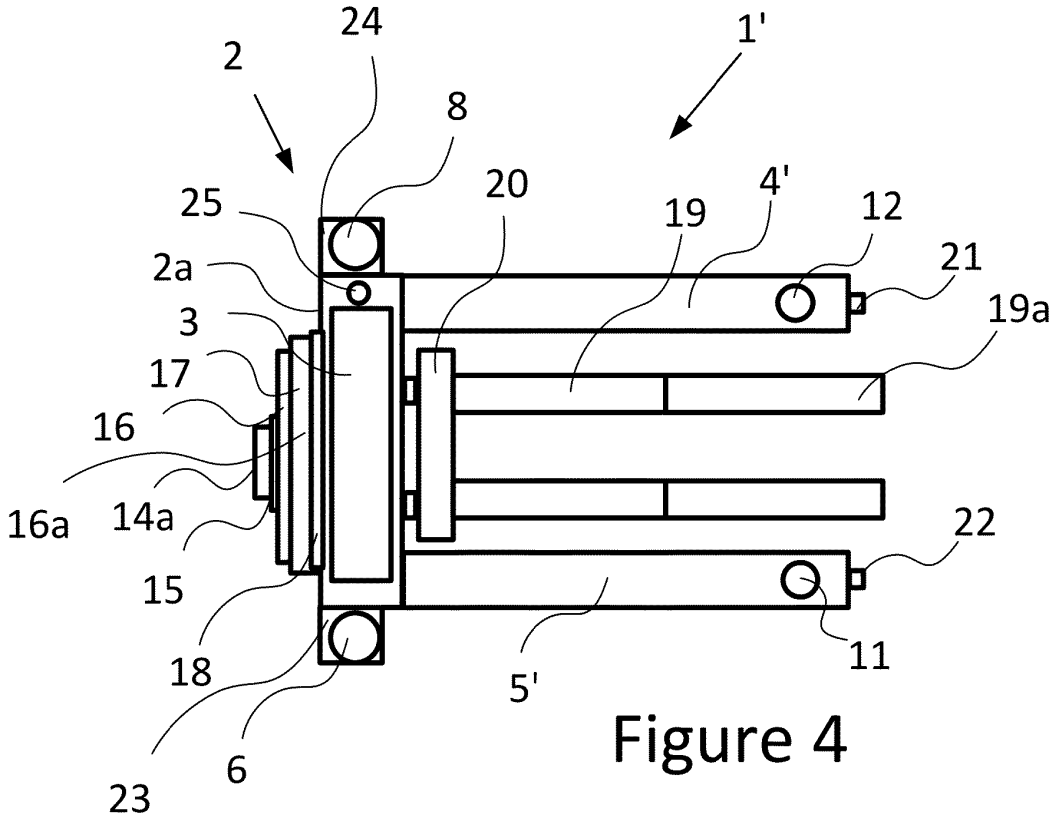


Figure 4

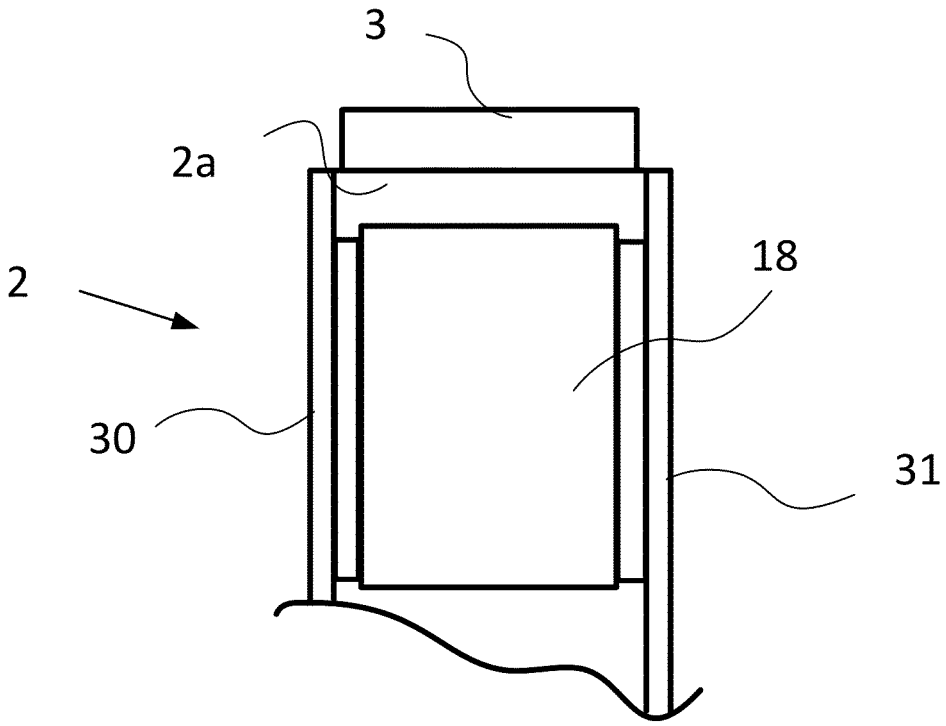


Figure 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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