

Transport device for moving heavy loads

The invention relates to a transport device for moving heavy loads, in particular an automated maintenance device for large, substantially vertical surfaces, for example ship hulls, along a movement direction on a freely installable monorail system, wherein a chassis having a longitudinal axis extending substantially parallel to the movement direction is provided, on which the heavy load can be arranged.

WO 2012/080448 A1 describes an automated maintenance device having a carrier tower that can be moved, for example, on a rail system. Since this carrier tower has a considerable height, depending on the requirements, and at the same time is to be moved quickly along the rails at, for example, 25-30 m/min, additional measures for stabilizing the maintenance device are regularly required. These requirements are particularly given if the maintenance device is to be moved on a monorail system as shown, for example, in AT 518 744 B1.

Due to its own weight as well as the supply units also arranged on the chassis, the maintenance device has a low center of gravity so that tipping over is impossible under normal operating conditions, but swinging of the tower can occur especially when moving the maintenance device along the rails or also due to windy weather.

Therefore, in order to stabilize the carrier tower described in WO 2012/080448 A1, additional supporting devices are provided in the upper area of the carrier tower, which are supported against the surface to be processed during operation. However, such support is often undesirable because of the fear of damage to the surface.

It is therefore the object of the invention to provide a transport device of the type mentioned at the beginning, which has an improved driving behavior and enables additional stabilization.

This object is solved according to the invention in that a supporting device is arranged on the chassis, the longitudinal axis of which extends at an angle, preferably at an angle of 90°, to the longitudinal axis of the chassis in the position of use. The supporting device moves the center of gravity of the transport device with the heavy load located thereon outside the rail and thus provides greater stability. Here, in automated devices, it is provided that the

entire system is sensed by means of sensors, wherein leveling sensors are used in particular to monitor the vertical alignment of the maintenance device.

It is particularly preferably provided that the supporting device has an extension arm, the first proximal end of which can be arranged in a rigidly or articulated manner on the chassis, and at the second distal end of which a wheel device is arranged.

If the transport system according to the invention is now moved along the rails, which are designed, for example, as a monorail system, the supporting device is also moved in this direction essentially transversely to its longitudinal axis, wherein the wheel device moves essentially parallel to the movement direction of the chassis in normal operation. This results in additional support of the transport system according to the invention with heavy load thereon and consequently a shift of the overall center of gravity of the system along the extension arm of the supporting device, so that a part of the load is shifted away from the rail towards the wheel device.

The heavy load arranged on the transport device according to the invention, in particular a maintenance device, usually has a high weight of 40 to 100 t, so that corresponding forces act on the wheel device. Therefore, in a particularly preferred embodiment of the invention, the wheel device is designed as a support wheel, preferably with twin tires.

Repair and maintenance, especially inspection and renewal of paint layers on ship hulls, often takes place in a floating dock. This floating dock has a sheet metal floor arranged on a water surface, which is arranged on frames attached at regular intervals. The sheet metal floor has a wavy structure caused by the frames. As a result, vehicles moving on a rail system laid on this sheet metal floor exhibit resonance behavior at certain speeds. This resonance behavior is particularly problematic when high tower structures, such as are common in maintenance equipment in particular, start to vibrate as a result.

In a further embodiment of the invention, it is therefore provided that the wheel device is designed as a double wheel, wherein two support wheels are arranged on a preferably length-adjustable arm system with two pendulum arms. These two support wheels, with their two pendulum arms, act as damping elements, wherein the distance between the two support wheels is preferably a multiple of half the frame distance, in order to compensate for the unevenness of the ground.

It is particularly preferably provided that the extension arm of the supporting device consists of at least two extension elements that are telescopically

displaceable relative to one another in the longitudinal axis, wherein preferably the at least two extension elements are movable relative to one another via at least two heavy load linear guides. This allows the length of the extension arm to be changed as required, whereby the overall center of gravity of the transport system with the heavy load located thereon can be shifted as required.

In a first embodiment of the invention, the extension can be effected via actuating cylinders. In a particularly preferred embodiment of the invention, it is provided that the wheel device is steerable. By deflecting the wheel device during the displacement of the chassis along the rails, the second extension element is pulled out of the first extension element or pushed into it, depending on the position of the support wheel. The wheel unit can be steered by hydraulic steering cylinders, for example.

In a further embodiment variant of the invention, it is provided that the wheel device is additionally adjustable in height, which results in an additional stabilization possibility of the overall system. Likewise, this height adjustment permits a change in the distance of the extension arm of the supporting device from the ground in order to guide it over obstacles lying on the ground, for example.

The control of the length of the extension arm by changing the extension as well as the height adjustment of the wheel device is carried out with the inclusion of a complete sensor monitoring of the entire system, in particular the maintenance device as well as the chassis. In particular, the travel speed, the extension of the extension arm, the height and the deflection of the wheel device are monitored and controlled in order to ensure optimum alignment of the maintenance device located on the chassis, in particular its tower element.

In the following, the invention is explained in more detail by means of non-limiting exemplary embodiments with associated figures, wherein:

Figs. 1A and 1B show a transport system according to the invention with chassis and maintenance device located thereon;

Fig. 2A shows the transport system of Fig. 1 in a first perspective view;

Fig. 2B shows the transport system of Fig. 2A in a second perspective view;

Fig. 2C shows the transport system of Fig. 2A in a third perspective view;

Fig. 3 shows the extension arm of Fig. 2A in a first, retracted position;

Fig. 3B shows the extension arm of Fig. 2A in a second, extended position;

Fig. 3C shows the extension arm of Fig. 2A in an exploded view;

Fig. 4A shows the wheel device of Fig. 2A in a first, lowered position;

Fig. 4B shows the wheel device of Fig. 2A in a second, raised position;

Fig. 4C shows the wheel device of Fig. 2A in a side view;

Fig. 5A shows a second embodiment of the transport system according to the invention;

Fig. 5B shows a frontal view of the wheel assembly of the transport system of Fig. 5A; and

Fig. 5C shows a perspective view of the wheel assembly of the transport system of Fig. 5A.

In Figs. 1A and 1B, a maintenance device 2000 having a tower 2010 is shown, wherein the maintenance device 2000 has two tool arms 2020 that can be moved along the tower 2010, which are provided for machining ship walls, for example.

This maintenance device 2000 is arranged on a first embodiment of the transport device 1000 according to the invention, which has a chassis 100 via which the transport device 1000 can preferably be moved along a monorail system. For this purpose, two running wheel devices 110 are preferably provided, wherein at least one of the two running wheel devices 110 is driven, for example, by means of an electric motor 115.

Access platforms 1010 are also provided on the transport device 1000 for the operation and maintenance of the maintenance device 2000 arranged on the transport device 1000 or the supply units 2030 required for its operation, such as a diesel unit, energy unit, compressed air unit, water reservoir, paint reservoir, etc.

According to the invention, a supporting device 200 is arranged on the chassis 100, with its proximal end 201 being rigidly connected to the chassis 100 in this embodiment variant by means of a flange connection 210 (Figs. 2A to 2C). In this case, the supporting device 200 has an extension arm 220 which is adjustable in length along its longitudinal axis A and at the distal end 202 of which a wheel device 230 is arranged.

In Figs. 3A to 3C, the supporting device 200 according to the invention is shown in the retracted or extended state. For this purpose, the extension arm 220 in this embodiment variant comprises a first extension element 221, which is fixed to the chassis 100 via the flange connection 210. This first extension element 221 is essentially formed as a square tube, in which a second extension element 222 is displaceably arranged. At the distal end 202 of the second extension element 222, the wheel device 230 is arranged in this embodiment of the invention. The displacement of the second extension element 222 in relation to the first extension element 221 along the longitudinal axis A of the extension arm 220 is preferably effected via heavy-duty linear guides.

The wheel device 230 is connected to the second extension element 222 via a vertical guide 240. In this embodiment, the support wheel 231 is designed as a twin wheel with solid rubber tires. In the exploded view of Fig. 3C, this vertical guide 240 is shown in detail. The vertical guide 240 is fixed to the second extension element 222 by a rigid bolt connection 241, which allows the connection to be quickly released if necessary.

A support wheel 231 is arranged on the vertical guide 240 via an axial bearing 242, wherein the support wheel 231 can be steered via a steering cylinder 232. In Figs. 4A to 4C, this vertical guide 240 is again shown in detail, with Fig. 4A showing the support wheel 231 in a first, raised height position, in which the extension arm 220 is arranged closer to the ground. In Fig. 4B, the support wheel 231 is shown in a lowered height position such that the extension arm 220 extends at a greater distance from the ground. Furthermore, a control device 250 is arranged on the vertical guide, via which the height adjustment as well as the steering of the support wheel 231 takes place.

The extension of the extension arm 220, namely the extent to which the second extension element 222 is pulled out of the first extension element 221, is performed by the wheel device 230. During operation, the chassis 100 with the heavy load thereon, namely the maintenance device 2000, is moved in a first direction along the rails. Here, the support wheel 231 moves essentially along a straight line parallel to the direction of travel. If the support wheel 231 is now deflected, the direction of travel of the support wheel 231 is no longer parallel but at an angle to the direction of travel of the chassis 100 and the second extension element 222 is pushed into or pulled out of the first extension element 221 depending on the angular position. Thus, the length of the extension arm 220 can be varied by steering the support wheel 231.

Another variant of the invention is shown in Figs. 5A to 5C. Here, the supporting device 230 has a double-wheel support 233 with a first support wheel 231A and

a second support wheel 231B, which are connected to the axial bearing 242 and the vertical guide 240, respectively, via two length-adjustable pendulum arms 234A, 234B. The two support wheels 231A, 231B are in turn separately steerable, thereby allowing the actual length of the extension arm 220 to be varied in the manner previously described.

The double wheel support 233 is used in particular on floating docks. Floating docks usually have frames that are covered with sheet metal. This sheet metal covering causes uneven floors in the area of the frames, which occur at regular intervals due to the distance between the frames. If a rail system is laid on this floor and a heavy load is moved on it, resonance effects can occur. Such resonance effects are particularly disturbing in the case of high superstructures, as in the case of the maintenance device 2000 shown in Figs. 1A and 1B with an exemplary 12 m high tower 2010. In this case, the double wheel support 233 with its arm system consisting of two pendulum arms 234A, 234B is capable of mitigating the vibrations caused by the resonance effect, wherein the distance between the two support wheels 231A, 231B is adapted to the distance between the frames of the floating dock.

In the illustrated embodiment of the double wheel support 233 according to Fig. 5B, this length adjustability is carried out by means of specified fixing points 235. Alternatively, adjusting cylinders can also be provided which continuously adjust the distance between the support wheels 234A, 234B. However, it is essential for the damping property of the double wheel support that the distances of the respective support wheels 234A, 234B from the axis of the axial bearing 241 are the same, so that the double wheel support 233 acts similar to a rocker in the area of ground unevenness.

It is understood that the present invention is not limited to the described embodiment variants. For example, the supporting device may have an extension arm comprising more than two extension elements. Similarly, a variant may be provided in which the extension arm is not rigidly connected to the chassis but, for example, is connected thereto in an articulated manner so that, for example, it can be folded parallel to the chassis when the support element is not required. Likewise, the wheel device can be designed in a variety of ways, but a significant advantage is seen in the steerable and height-adjustable wheel device. It is essential to the invention that the transport device has a crash device which serves to stabilize the heavy load arranged on the transport device. In particular, a wide variety of sensors are used here to monitor the position of the heavy load, in particular the maintenance device, and, if necessary, to influence the driving behavior by changing the length and/or height of the support element.

CLAIMS

1. Transport device (1000) for moving heavy loads, in particular an automated maintenance device (2000) for large, substantially vertical surfaces, for example ship hulls, along a movement direction on a freely movable monorail system, wherein a chassis (100) having a longitudinal axis extending substantially parallel to the movement direction is provided, on which the heavy load can be arranged, wherein a supporting device (200) is arranged on the chassis (100), the longitudinal axis (A) of which supporting device, in the position of use, extends at an angle not equal to 180°, preferably at an angle of 90° to the longitudinal axis of the chassis (100), and the supporting device (200) has an extension arm (220), via the first, proximal end (201) of which the supporting device (200) can be arranged on the chassis (100) in a rigid or articulated manner, **characterized in that** a wheel device (230) is arranged at the second, distal end (202) of said extension arm (220), wherein the extension arm (220) of the supporting device (200) consists of at least two extension elements (221, 222) telescopically displaceable relative to one another in the longitudinal axis (A).
2. Transport device (1000) according to claim 1, **characterised in that** the wheel device (230) is designed as a support wheel (231), preferably with twin tires.
3. Transport device (1000) according to claim 1, **characterised in that** the wheel device (230) is designed as a double wheel, wherein two support wheels (231A, 231B) are arranged on a wheel support system having one, preferably two, pendulum arms (234A, 234B).
4. Transport device (1000) according to one of claims 1 to 3, **characterised in that** the wheel device (230) is steerable.
5. Transport device (1000) according to claim 4, **characterised in that** the wheel device (230) is steerable via at least one preferably hydraulic steering cylinder (232).
6. Transport device (1000) according to one of claims 1 to 5, **characterised in that** the wheel device (230) is adjustable in height.
7. Transport device (1000) according to one of claims 1 to 5, **characterised in that** the at least two extension elements (221, 222) are movable relative to one another via at least one heavy-load linear guide.