



SYSTEM FOR STORING AND TRANSPORTING TRANSPORTING CONTAINERS

System for storing and transporting transport containers or the like of the generic type stated in the preamble of claim 1.

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There are very many different and diverse designs and constructions of storage and transport systems. For example, it is known to equip the aisles of high rack storage facilities with rails in each storage level, in order to provide container-transporting vehicles which can travel horizontally on these rails. Such solutions are disclosed e.g. in DE 39 07 623 A or DE 102 54 647 A to name just a few examples.

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Storage systems for removing containers from storage using satellite vehicles are disclosed e.g. in DE 10 2007 010 191 A1 or DE 20 2007 051 238 A1.

As described in these reference documents, systems of this type require the sequence, in which the respective containers are stored or discharged, to be determined in advance, wherein in particular discharge and receiving devices have to be provided upstream of the racking systems, in order to provide certain buffers or collecting or sorting lines, to name just a few disadvantages of these known systems. If the containers in such systems have to negotiate transverse and longitudinal paths in order to be discharged or removed, the transfer points of the respective path sections require particular machine elements which can transfer the containers, such as turning platforms or the like.

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Automatic picking storage facilities are confronted with partially conflicting requirements. In addition to efficiency which, where possible, is so high that the picking personnel are continuously utilised to capacity, there is a desire for a short reaction time within the system expressed as the number of containers taken out of / placed into storage per unit of time, i.e. orders should also be processed in the shortest time possible after they have been generated. It is also advantageous if the containers which have been removed from storage are discharged to the pre-zone in exactly the desired sequence, since otherwise sorting must take place, during which the goods delivered from the storage facility must be finally sorted either manually or with additional technical outlay.

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- On the one hand, it is known, for the lower range of efficiency, to use standard racking serving units having one or several load receiving means, the efficiency of which, however, is often not sufficient when a single device is used, multi-aisle systems are then installed with correspondingly complex conveyance technology in the pre-zone of the racks, on the other hand high-performance-container-storage systems are known which operate in accordance with the principle that a plurality of movements are performed in parallel with each other, e.g. Sistore (DE 39 07 623) or Rotastore. These systems are dependent on the fact that they select their storage-removal/storage-entry activities from the longest possible list of orders so that they can optimise their travelling paths and their stops. This is at variance with the requirement for a short reaction time. It is likewise not possible to directly generate the sequence desired at the picking station. High-performance storage systems of a conventional design are distinguished by the fact that relatively complex pre-zones are required in order to fulfil the required distribution functions. These pre-zones are cost-intensive, require space and after putting into service cannot be adapted very effectively, if at all, to changing boundary conditions. A frequent problem is also the ability to gain access to such complex conveyance systems in the event of a malfunction or for maintenance purposes.
- The object of the invention is to provide a transport and storage system which is highly flexible and can dispense with additional buffer lines, collecting lines and the like, as well as with structural elements which change the direction of container transportation.
- With a storage and transport system of the type stated in the introduction, this object is achieved in accordance with the invention by at least one vehicle which is equipped with a rail-compatible travelling mechanism and a floor-compatible travelling mechanism, and by a racking system having rail-mounted and floor-level travelling paths for the vehicle. In other words, the vehicles have separate travelling mechanisms for the rail-mounted and floor-level travelling paths.

With a corresponding storage and transport system it is thus possible to use both floor-level and rail-mounted travelling paths for the respective vehicles, which leads to a series of advantages.

By means of the invention, it is possible to produce e.g. storage systems which have a high storage-entry and removal-from-storage efficiency and which function without any fixed installation in the pre-zone of the storage facility and at the same time fulfil the requirement of short reaction times and correct removal-from-storage sequence to a significant extent. The transfer points can be disposed in a flexible manner and at any distance from the storage facility. High-performance picking warehouses are also possible, in which only a minimum of active mechanical equipment is installed within the rack and which are very compact in terms of construction owing to the use of flat transverse tunnels also provided in an embodiment of the invention.

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Embodiments of the invention are described in the subordinate claims. As already indicated briefly above, it can be provided that the racking system is equipped with tunnel-like floor travelling paths in particular transversely with respect to the rail-mounted travelling paths, wherein the rail-mounted travelling paths form in particular the rack aisles of the racking system. In other words, the front longitudinal beams of the multi-level racking system support or form the rail-mounted travelling paths.

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This design renders it possible to utilize, by means of the pre-set routes, which are generally provided for accessing the rack aisles in the racking unit and are arranged transversely with respect thereto, by means of their tunnel-like design, the air space above these routes completely from the first rack level as a racking unit, which results in a more compact construction whilst maintaining the same storage capacity of a racking unit.

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As is known *per se*, in accordance with the invention each vehicle is equipped with dedicated load receiving means and in an embodiment is also equipped with a control and drive unit linked to a computer, which means that the vehicles can be moved and activated completely automatically both on the floor-level and rail-mounted travelling paths. Therefore, AGV-functionality (Automated Guided Vehicle System) of the vehicles is provided.

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For the purpose of advancing movement within the rack-rail system and within the surface area (on the floor) the vehicle is equipped with two travelling mechanisms which on the drive side consist of two motors and associated power electronics. The two motors are connected to the right and left drive wheels of the two travelling

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mechanisms by a respective transmission. The motors can rotate independently of each other at the same or even different speed. For journeys within the rail system, the two motors will always rotate at the same rotational speed. For a journey on the floor, identical rotational speeds produce straight-ahead travel, whereas different
5 rotational speeds permit cornering ("differential steering").

In accordance with the invention, it is also provided that each vehicle is equipped with at least one sensor for detecting obstacles and/or for detecting position markers. Detection of obstacles can be performed e.g. by means of so-called laser scanners
10 which provide the angle and distance of located obstacles.

Fully automatic control procedures can be achieved by means of these sensor devices. With corresponding positionally fixed sensor markers it is e.g. possible to detect the centre of a lane or a preferred lane path by means of the corresponding
15 reflection, i.e. in order to permit automatic filtering from floor-level travel to rail-mounted travel.

The current position of the vehicle can be determined on the basis of a known starting position using coupled navigation algorithms. The information required for this
20 purpose relating to the distance travelled and the direction maintained is obtained by measuring the revolutions of the two motors. Since on account of various error influences the current vehicle position, which is calculated in this manner, has ever increasing deviations with respect to the real position as the travel distance increases, it is not possible by means of this method alone to carry out a longer journey over the
25 free surface area to the point of entry into rail system of the racking unit or a picking station with sufficient degree of accuracy. In this case, "sufficient" means that the vehicle arrives at the centre between the right and left rails with a degree of accuracy which is better than about $\pm 2\text{cm}$. A lateral offset (positioning error) in this order of magnitude can be compensated for by means of mechanical lead-in chamfers,
30 whereas larger deviations could result in the vehicle becoming stuck at the entrance or suffering mechanical damage. For this reason, at the end of a journey, i.e., at a distance of ca. 3 metres from the destination (e.g. entry into the rail system), a switch is made to a different - more accurate - relative locating method: with the aid of a laser scanner which is mounted on the end side of the vehicle, two reflector markers which
35 are mounted on the left- and right-hand side directly next to the entrance to the rails

are detected and their position relative to the vehicle is measured. From these measured values, which change constantly as the vehicle continues to move closer to the entrance, it is possible by means of suitable evaluation algorithms to perform a journey all the way to the centre of the entrance with a sufficient degree of accuracy.

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The distinctiveness of the method resides in the fact that, although the measured values of the laser sensor do not have the level of accuracy required for the task, skilled filtering of the measured values and fusion of the sensor measured values with the - likewise error-prone - movement information of the vehicle, which is based upon the measurement of the wheel revolutions, facilitate a sufficiently precise determination of position.

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Therefore in general terms, as the vehicle drives onto the rail, i.e., upon a change from the floor-compatible travelling mechanism to the rail-compatible travelling mechanism, it is possible to obtain position information, which is sufficiently accurate for the task, by means of suitable filter algorithms from in principle error-prone measured values of the path measurement and distance measurement devices, which means that the vehicle can drive onto said rail without becoming damaged.

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It is apparent that the invention can ensure that the sequence of removed transport containers for final discharge and/or for sorting can also be random, since the control options of the floor-level and rail-mounted vehicles render it possible to effect a change in sequence without any problems, i.e., by overtaking a vehicle which is in front of a vehicle at a rear position in the sorting system.

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In accordance with the invention, it is also provided that with an identical drive a drive is effected such that the speed of the journey performed on rails is greater than the speed of the journey conducted on the floor. The steering kinematics can be achieved e.g. by means of differential steering, wherein in accordance with the invention other options are of course also incorporated.

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The supply of power is effected via power accumulators which are charged during travel in the racking unit via contact lines or in a contactless manner, e.g. by means of an inductive power transfer system, wherein other solutions are also possible, e.g. boost-charging at individual start-up positions or accumulator-change systems.

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The rail-compatible travelling mechanism permits not only direct serving of racking systems, rail-mounted sections can also be integrated into the travel route, in order to be able to cover individual distances e.g. at a higher speed or else in order to travel
 5 from rack sections to spatially separate rack sections, i.e., via suspended rails, which means that such rail systems can run at a corresponding height over e.g. sections of a production area which are located on the floor. It is thus possible e.g. to create a traffic system without any intersections, in that unused spaces above production plants are utilised or else in order to connect spatially separate rack sections via
 10 suspended rails. This type of rail system can also run at a corresponding height over sections of production areas which are located on the floor.

In order to move the vehicles to a different location, racking serving units or lift/distribution carriages can also be provided in the racking aisles or at corresponding
 15 locations. The vehicles are therefore vehicles which in each case serve only one level or individual racking bays in the racking unit from the rails. If required, they change levels by means of the aforementioned lifts which can be located at any position. These vehicles are also known as satellite vehicles.

20 In an expedient manner, at least two tunnel regions are provided within a racking unit in order to permit a circulating operation without two-way traffic. The tunnels can be designed to be very flat in accordance with the constructional height of the vehicles and can be of such a width that not only can buffer sections be formed in front of and behind the lifts, which means that by reason of the directed flow of the vehicles the
 25 lifts are used in double-cycle, i.e., while a vehicle coming from upper racking levels departs from the lift in the lower lift position, a vehicle wishing to travel upwards moves at the same time onto the lifting table on the other side. This enables the lifts to achieve high throughput rates.

30 The tunnels can also be designed in such a way that the aforementioned overtaking of the vehicles is possible, in order thus to be able to effect a certain amount of sorting at the same time.

In order to load and unload the transport vehicles, a transfer device can be provided
 35 which is allocated in particular to the rail-compatible travelling mechanism of the

vehicle and is adapted thereto. In other words, the load receiving means of the vehicles is used in the rail operation, since an accurate definition of the vehicle with respect to the transfer location is then possible.

- 5 Further features, details and advantages of the invention are apparent from the description hereinafter and with reference to the drawings, in which:

Figure 1 shows a top view of a part of a storage facility with vehicles travelling on the floor,

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Figure 2 shows a side view taken approximately along line II-II in Figure 1,

Figure 3 shows an enlarged illustration of a transport vehicle in a three-dimensional illustration prior to filtering into a rail system,

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Figure 4 shows a three-dimensional bottom view of the transport vehicle,

Figure 5 shows an enlarged filtering region for the vehicles from floor-level travel to rail-mounted travel, and

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Figure 6 shows a load-changing station for loading and unloading the vehicle, and

Figure 7 shows a further embodiment during the filtering procedure.

- 25 The storage and transport system which is designated in general by the reference numeral 1 is formed substantially by a racking unit, e.g. a high racking unit, which is designated in general by the reference numeral 2 and which is loaded by vehicles designated by the reference numeral 3, wherein in the top view in accordance with Figure 1 the vehicles designated by the reference numeral 3 use the floor level as a
- 30 travel level, whereas the vehicles designated by the reference numeral 3a are positioned so that they can travel in the rail system of the racking unit 2.

The vehicles 3 thus travel in the racking unit 2 itself on rails on the respective level in order to supply and remove products to and from the racking bays located on this

35 level, whereas for travel on the floor they travel on the ground. To this end, they have

separate travelling mechanisms.

It is apparent that the vehicles on the floor surface can also overtake one another (see vehicles 3b and 3c in Figure 1 above). The racking system 2 has inter alia tunnel-like floor-level travelling paths, designated in general by the reference numeral 4, as well as rail-mounted travelling paths, designated in general by the reference numeral 5, wherein the rail-mounted travelling paths 5 provide access to the racking locations 6 in the racking unit for the containers which are transported on the vehicles and are designated in general by the reference numeral 7.

As shown in Figure 2, the floor-level, tunnel-like travelling paths 4 render it possible for the air space located thereabove having further racking locations 6 to be used for receiving the corresponding containers 7.

Located at some preferred locations, into which rail-mounted travelling paths are integrated, are lift systems which are designated by the reference numeral 8 and enable the vehicles to change levels.

Details of the vehicles 3 are indicated in Figures 3 and 4. For example, the wheels 9 provided for travel on rails and the wheels 10 and 10a provided for floor-level travel and separate therefrom, wherein in this case the common drives are not illustrated in greater detail.

Figures 3 and 4 also illustrate load receiving means 11 which are indicated merely symbolically and which render it possible to receive the containers 7, either empty or filled, and to deposit them in the racking locations 6 or at another location.

Figure 3 also indicates rails 5a of the rail-mounted travel regions as well as lateral guide wheels 12, in order to facilitate filtering and travel on the rails.

The slightly enlarged illustration of Figure 5, as an extract of Figure 1, indicates that the vehicles 3 are equipped with sensors 13 which can detect e.g. reflective, positionally fixed control markers 14 and 14a, in order to reach the centre position of a rail-mounted travel lane, designated in Figure 5 by the reference numeral 15, between these markers by means of a corresponding computing operation.

The control computers of the vehicles 3 having sensors 13 providing data for filtering purposes can also be used to provide other controls, which means that the floor-level travel of the vehicles can also be established accordingly via calculated virtual travelling paths (lanes). By means of these sensors, it is also possible to determine the distances between individual vehicles next to one another and in front of one another, which is illustrated by dotted lines in Figure 5, wherein the beams which determine the target point are designated by the reference numeral 16.

10 In the variant shown in Figure 7, the current position of the vehicles 3' is determined on the basis of a known starting position S (cf. direction of travel arrow in Figure 7) using coupled navigation algorithms. The information required for this purpose relating to the distance travelled (cf. direction of travel arrow in Figure 7) and the direction maintained is obtained by measuring the revolutions of the two motors of the floor-compatible travelling mechanism or of the wheels 10 and 10a.

Since on account of various error influences the current vehicle position, which is calculated in this manner, has ever increasing deviations with respect to the real position as the travel path increases, it is not possible by means of this method alone to carry out a longer journey over the free surface area to the point of entry into the rail system 5 of the racking unit 2 or a picking station or load-changing station (cf. Figure 6) with a sufficient degree of accuracy. In this case, "sufficient" means that the vehicle arrives at the centre between the right and left rails with a degree of accuracy which is better than about $\pm 2\text{cm}$. A lateral offset (positioning error) in this order of magnitude can be compensated for by means of mechanical lead-in chamfers (cf. Figure 3), whereas larger deviations could result in the vehicle becoming stuck in the entrance during filtering into the racking aisle 15 or when driving to the rail ends 5a at this location, or in the vehicle suffering mechanical damage.

30 For this reason, at the end of a journey, i.e., at a distance of ca. 3 metres in front of the entrance into the rail system 5 or the racking aisle 15 (or another corresponding destination) a switch is made to another - more precise - relative locating method.

With the aid of a laser scanner 21 which is mounted on the end side of the vehicle 3' and which "monitors" the region (shaded in Figure 7) in front of the vehicle, two

reflector markers 14, 14A, which are mounted on the left- and right-hand side directly next to the entrance to the rails are detected and their position relative to the vehicle 3' is measured. The laser scanner 21 provides the control computer of the vehicles with the angle and distance of obstacles, in this case the reflector markers 14, 14A.

5 From these measured values, which change constantly as the vehicle 3' continues to move closer to the entrance of the racking aisle 15, a journey is conducted, by means of suitable evaluation algorithms, all the way to the centre of the entrance (indicated by a dot-dash line) with a sufficient degree of accuracy.

10 The laser scanner 21 can also be used to detect and drive round obstacles. The obstacles can appear unexpectedly in particular during floor-level travel, since e.g. persons or further vehicles can move on the ground.

Figure 6 illustrates one possible load-changing station 20, in order to load the vehicles
15 3 with corresponding containers 7' or in order to receive containers 7 therefrom.

Positioned within a frame 18 is a double lift 17, wherein in the illustrated example the right-hand part of the double lift is designated by the reference numeral 17 and the left-hand part is designated by the reference numeral 17a. Connected to the upper lift
20 positions of the lift 17 or the lift 17a, are roller conveyors 19 and 19a, wherein the front roller conveyor 19 on the right-hand side in Figure 6 is inclined so as to descend towards the lift 17, whereas the slightly more highly positioned rear roller conveyor 19a is inclined so as to descend to a sorting and loading region 21 such that the containers designated by the reference numeral 7' can run off to the left, whereas the
25 containers designated by the reference numeral 7 can run off to the right in the illustrated example.

In the respectively lower position, the lifts 17 and 17a are aligned with the loading region of the vehicle 3, so that containers 7 can be discharged and containers 7' can
30 be received respectively.

At this juncture, it should be noted that the station illustrated in this case can also be designed in a different manner. The illustrated example represents an option for integration into the existing rail system with the running rails 5a for the vehicles 3
35 which are then rail-mounted.

Of course, the described exemplified embodiment of the invention can also be modified in many respects, without departing from the basic idea.

Claims:

1. Storage and transport system (1) for transport containers (7) or the like,
characterised by
 - 5 at least one vehicle (3), which is equipped with a rail-compatible travelling mechanism and a separate floor-compatible travelling mechanism, and a racking system (2) having rail-mounted and floor-level travelling paths (5, 4) for the vehicle (3), wherein the vehicle (3) is equipped with a sensor and control system such that it can move autonomously on the rail-mounted and floor-level travelling paths (5, 4) and can
 - 10 change travelling paths.
2. Storage and transport system as claimed in claim 1,
characterised in that
 - 15 the racking system (2) is equipped with tunnel-like floor-level travelling paths (4) in particular transversely with respect to the rail-mounted travelling paths (5), wherein the rail-mounted travelling paths (5) form in particular the racking aisles of the multi-level racking system (2), wherein the rails of the rail-mounted travelling paths (5) are formed by the racking unit (2) on each level.
- 20 3. Storage and transport system as claimed in claim 1 or 2,
characterised in that
 - each vehicle (3) is equipped with dedicated load receiving means (11).
4. Storage and transport system as claimed in any one of the preceding claims,
25 characterised in that
 - each vehicle (3) is equipped with a control and drive unit linked to a computer.
5. Storage and transport system as claimed in any one of the preceding claims,
characterised in that
 - 30 each vehicle (3) is equipped with at least one sensor (13, 21) for detecting obstacles and/or for detecting position markers (14).
6. Storage and transport system as claimed in any one of the preceding claims,
characterised by
 - 35 a common drive for floor-level or rail-mounted travel, wherein a drive is effected such

that the speed of the rail-mounted travel is higher than the speed of the floor-level travel.

7. Storage and transport system as claimed in any one of the preceding claims,
5 characterised in that
the steering kinematics are achieved by means of differential steering.

8. Storage and transport system as claimed in any one of the preceding claims,
characterised in that
10 the supply of power is effected via power accumulators which are charged during
travel in the rail (5a) e.g. via contact lines.

9. Storage and transport system as claimed in any one of the preceding claims,
characterised in that
15 racking serving units or lift/distribution carriage systems (8) are provided in the racking
aisles or at corresponding locations.

10. Storage and transport system as claimed in any one of the preceding claims,
characterised in that
20 at least two tunnel regions (4, 4a) are provided inside a racking unit (2).

11. Storage and transport system as claimed in any one of the preceding claims,
characterised in that a transfer device is provided for loading and unloading the
vehicles (3).
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12. Storage and transport system as claimed in claim 11,
characterised in that
the transfer device is allocated in particular to the rail-compatible travelling
mechanism of the vehicle (3) and is adapted thereto.
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