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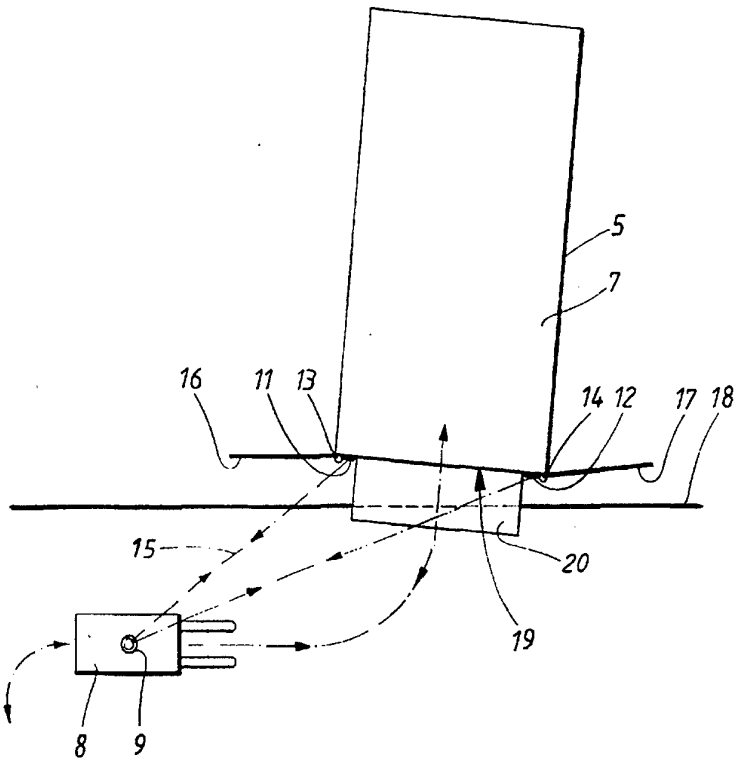
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(54) Title: METHOD AND DEVICE FOR AUTOMATIC VEHICLE GUIDANCE

(57) Abstract

A method and a device for controlling an AGV (8) for route selection upon transfer between different spaces (2, 7) within which said AGV is movable. The spaces are not fixedly related to each other with reference to their relative positions and are restricted from each other by means of area boarder lines (18). When AGV is present within a first of said spaces, it detects for the purpose of transfer of said spaces (7), the relative position of said space by means of two reference means (11, 12) belonging to the second space. Each of said reference means is fixedly related to the present space. The AGV will move over said area border lines (18) between said two spaces selecting route depending on calculating relative position.



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METHOD AND DEVICE FOR AUTOMATIC VEHICLE GUIDANCE

The present invention relates to a method and a device for controlling AGV according to the preamble of the enclosed claims 1 and 5 respectively.

There is a widespread demand for rationalization of e.g. cargo handling during trans-shipment from one means of transport to another. This applies to unloading and loading of ships, railway cars, lorrys, containers, aircraft etc. To this end, experiments have been made using Automatically Guided Vehicles, or AGV, which, so far, has demanded an adversely high precision in positioning of the mobile work area, onto which cargo is to be loaded or from which it is to be unloaded.

Generally, this is a problem comprising a number of as such known "spaces" with unknown relative positions, which has meant an obstacle when trying to automate activities to be performed within and between these spaces.

From e.g. WO 90/11561 it is previously known to use AGV for automatic loading and unloading of cargo-carrying vehicles, which are parked at a loading platform or other fixed loading space substantially level with the mobile loading space of the vehicle. As is evident from the known solution, it is necessary that the vehicle has been connected to the loading platform with a relatively high precision. This is because the known loading platform is quipped with photo detectors which sense that reflectors on the load-carrying vehicle are located at a fixed

longitudinal as well as angular position relative to the loading platform. The system indicates that the mobile loading area is in a predetermined position relative to the fixed loading area, in which case a "ready" signal is transmitted to the AGV for unloading of the mobile load area. Not until the AGV has passed to the mobile load area, will the navigation, including the position determination of the AGV, be achieved by means of a plurality of reference devices inside the loading area.

The known system has, for it's function, to consider the mobile work area or space as a part of the stationary work area or space, i.e. the mobile space must have an orientation which is fixed relative to the stationary space so that the mobile space forms a part of the stationary space.

The known system described above will certainly tolerate some smaller deviations from an ideal position, but in practice demands that the mobile space is positioned with a high accuracy. A change in the position of the mobile space during on-going loading and unloading may bring about that said space will fall outside of the system tolerances. These disadvantages thus entail time needs for position adaptation and/or costs for special adaptation equipment.

The object of the present invention is to provide a method and a device, by which the above drawbacks are eliminated, so that considerably larger positional and angular deviations between different work areas or spaces for AGV are tolerated, whereby the needs for special devices in order to allow automatic loading and unloading are eliminated.

Said object is achieved by a method and a device according to the present invention, the characteristics of which will be apparent from the enclosed patent claims 1 and 2 respectively.

The invention will be further described by way of an embodiment example and with reference to the enclosed drawings, in which:

Fig. 1 depicts a schematical view of a cargo trans-shipment terminal at which the method and device according to the invention is utilized, and

Fig. 2 depicts, in an enlarged view, an AGV unit and a load-carrying unit during on-going loading or unloading.

The example shown in Fig. 1 is a cargo trans-shipment terminal which in the known way comprises a warehouse 1 for loading in or out of general cargo and, in front of the warehouse, preferably level with the warehouse floor, a fixed work area in the shape of a loading platform 2 and a loading ramp 20, on a level which is elevated relative to a parking area 3 for mobile load-carrying units 4, 5, 6, e.g. containers. The latter are parked so that the loading area 7 of each container is located substantially at the same level as the terminal work area 2. The plant comprises one ore more Automatically Controlled Vehicles (AGV) 8, which are arranged to move, without being manned, between the warehouse 1 and the appropriate load-carrying unit 5, to be loaded or unloaded. The AGV control and navigating system is of a kind generally known and is using reference points without identities in the vicinity of the AGV for its navigation of AGV within its activity area. One example of such a system is described in the Swedish Patent

Application with the publication No 451 770. The system utilizes for example a rotating laser 9 located on the AGV, sweeping across the work areas of the AGV substantially in a plane parallel to the AGV transportation plane, such as the fixed work area or space 2 or the mobile work area or space 7. Inside these work areas or spaces 2, 7, the AGV may thus move automatically and perform loading or unloading work or other activities. Adjacent to the fixed work area or space 2, for example inside and outside the wall 10 of the warehouse 1, reference instruments lacking identity, thus being void of any identity of their own, are located, e.g. in the shape of simple reflectors, aiding in the AGV navigation across the work area 2.

For the transfer of the AGV between the various work areas or spaces, i.e. the terminal loading area 2 and that mobile loading area 7 which is presently to be loaded or unloaded, a method and a device is provided according to the invention, consisting of the AGV itself determining the position and orientation of the other room relative to the room in which the AGV is located whilst still being inside its first work area 2, i.e the terminal loading area, with the help of at least two reference instruments 11, 12 without identity, belonging to the mobile load carrier 5, i.e being in fixed positions relative to the loading area 7. The selected example shows two reference instruments, which in principle will function, however, in practice, three or more reference instruments are recommended. As is more clearly seen from Fig. 2, the reference instruments 11, 12 may be arranged in connection with the hinges 13, 14 for the doors 16, 17 of the load carrier 5. When the doors are closed, the reference instruments 11, 12 are blanked off, so that the navigation device of the AGV 8

will not detect said instruments 11, 12. In the chosen example with an optical laser and reflectors as reference instruments, the laser 9 located on the AGV 8 emits a sweeping beam, whereby the detection occurs by reflection in the reference instruments 11, 12, which have a suitable location and extension in height such that the sweeping beam will hit the identity-less reflectors. The navigation system computer measures repeatedly, while in motion towards the mobile load carrier, the angles to the reflectors at the moment of reflection, from which data the position and orientation of the load carrier/space is determined at regular intervals and the AGV is controlled in relation to the now known position of the mobile load carrier.

Control of the AGV for transfer from the fixed work area or space 2 to the mobile work area or space 7 is based on a calculation by the navigation system of the position of the mobile work area 7 relative to the fixed work area 2 in regard to distance and angle. The system bases the AGV navigation within the fixed work area 2 on a fixed coordinate system, whereas the reference instruments 11, 12 define a different coordinate system, fixedly related to the mobile work area 7. Through the knowledge of the AGV about the position and angle of the load carrier unit 5 in the coordinate system of the fixed work area when said reference instruments 11, 12 are detected, the known relative position and angle entails that both coordinate systems may be fixed relative to each other and a driving route to the mobile work area 7 may be selected.

In the chosen example, the detection of the reference instruments 11, 12 is only taking place with a load carrier present, and, furthermore, only with open doors

16, 17, whereby it is guaranteed that the container 5 is in place.

In accordance with the invention, the AGV 8 is thus detecting the position of the mobile work area relative to the fixed work area before entry into the mobile area, whereby the AGV entry can be prepared depending on the container position and the character of the task. Consequently, this means that there will be no higher demands on the position of the mobile work area 7 relative to the fixed work area than for manually controlled loading. In the shown example, the transfer of the AGV to the container 5 during loading and unloading takes place across the loading edge 18 of the fixed work area, i.e across its boundary, in the direction of the opening 19 of the container 5, whereby the position of the mobile work area is detected in sequence, i.e continuously or at close intervals, by means of the reference instruments 11, 12, for directing the AGV along a suitably selected route 21 so that the AGV is able to calculate an optimal movement across the mobile work area 7. The AGV thus moves into and out of the load carrier unit 5 along a route determined by a control program in dependence of the relative positions of the two spaces.

When moving from the mobile area 7 to the fixed work area 2, the AGV 8 is able, according to an advantageous embodiment, to make a verifying calculation of the relative positions of the work areas when in position within the mobile area, by detecting also those reference instrument without identity which belong to the fixed area. In this way, the route of the AGV may be adapted to any change in relative position of the mobile work area while the work is in progress.

The invention is not limited to the embodiment example described above and depicted by the drawings, but may be varied within the scope of the enclosed patent claims. For example, distance measurements to at least two reference instruments without identity may be made, or, alternatively, a combination of angle and distance measurement. As an example, the invention may principally be applied to any field of application, where an AGV is performing an activity during which a transfer is necessary between different spaces, work areas or structures, which have no fixed relationship to each other regarding longitudinal, lateral and angular position. The activity may for example be surveillance, operating in dangerous environments and all kinds of load handling in harbours, railway terminals, road transport terminals, air terminals etc. The number of spaces may vary from two up to a substantial number of fixed and mobile spaces. The number of AGV may vary from a minimum of one to a plurality of AGV. The work areas or spaces do not necessarily have to be located at a distance from each other, but may overlap, or the second work area (or areas) may be located completely within the boundaries of the first one. As stated above, the system will in principle be able to operate with two reference instruments, but in practice an improved precision is achieved by using three or more reference instruments for each work area. For the sake of clarity, we have schematically shown a simple straight-edged loading platform in the drawings. In practice, extendable bellows type ramps are often used, having an individual loading edge for each loading bay, a design to which the example shown may easily be adapted.

Claims

1. Method for control of an AGV (8) for selection of route when passing between different work areas or spaces (2, 7), within which areas said AGV is mobile, said work areas or spaces not being fixedly related to each other regarding their mutual positions, and being separated from each other by means of area boundaries (18), which at least temporarily are located so as to enable said passing of the AGV, characterized in that said AGV (8), when inside a first one of said work areas or spaces (2), detects, for its passage to a second one of said work areas or spaces (7), the relative position of the second space by means of at least two reference instruments (11, 12), belonging to said second work area or space, each of said reference instruments being fixed relative to its appurtenant work area or space, and in that the AGV passes across said area boundaries (18) between said two work areas or spaces while selecting a route (21) depending on their calculated relative positions.

2. Method according to claim 1, characterized in that for said route selection, the AGV position relative on one hand to said first work area or space (2) and on the other to said second work area or space (7) is calculated, from which data the position of the second work area or space is measured both regarding translation and rotation relative to the first work area or space.

3. Method according to claim 2, characterized in that for route selection when the AGV is passing from the second work area or space (7) to the first work area or space (2), a verifying determination of the AGV position and accordingly the relative positions of the two work areas or spaces is made, whereby the AGV route for said passage may be adjusted.

4. Method according to any one of claims 1 or 4, characterized in that also the first work area or space (2) has at least two reference instruments for the position determination of the AGV.

5. Device for realization of a method for control of an AGV (8) for selection of route when passing between different work areas or spaces (2, 7), within which said AGV is mobile, said work areas or spaces not being fixedly related to each other regarding their mutual positions, and being separated from each other by means of area boundaries (18), which at least temporarily are located so as to enable said passing of the AGV, whereby the AGV has a position detection and control device (9) for automatic control of the AGV position relative to at least two reference instruments (11, 12), characterized in that said two reference instruments (11, 12) each have a fixed position relative to a second one (7) of said work areas or spaces and in that the AGV (8) is deviced, when inside a first one (2) of said work areas or spaces, to detect, for its passage to said second work area or space (7), the relative position of the second space by means of said two reference instruments and to select, when passing across the area boundaries (18), a route depending on the calculated relative position.

6. Device according to claim 5, characterized in that said reference instruments (11, 12) are void of any identity.

7. Device according to claim 5 or 6, characterized in that said reference instruments (11, 12) are located at predetermined unique positions within the second work area or space (7).

8. Device according to claim 7, characterized in that said reference instruments (11, 12) are three or more in number.

9. Device according to claim 8, characterized in that said work areas comprise a fixed first work area (2) and one or more mobile second work areas.

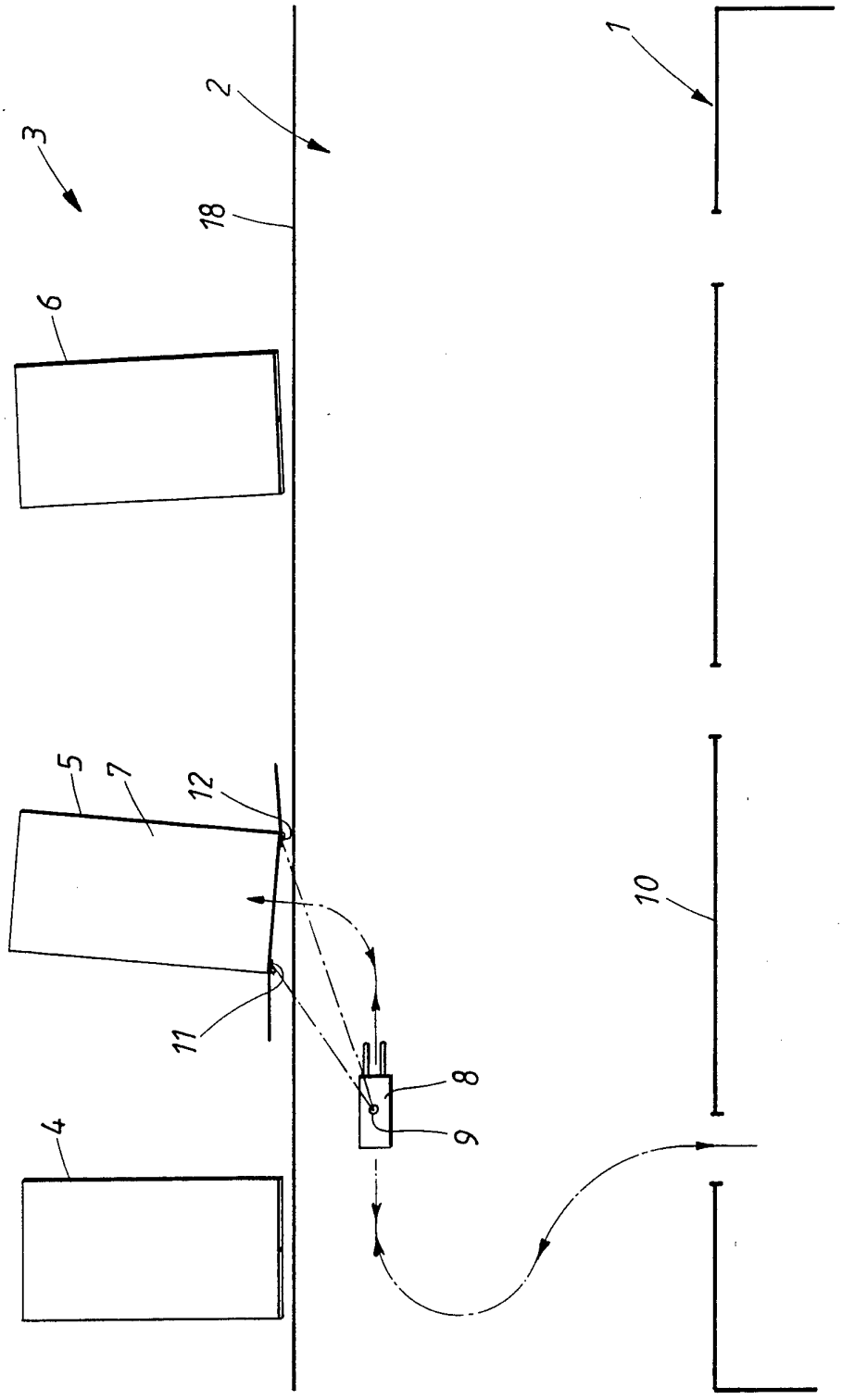


FIG.1

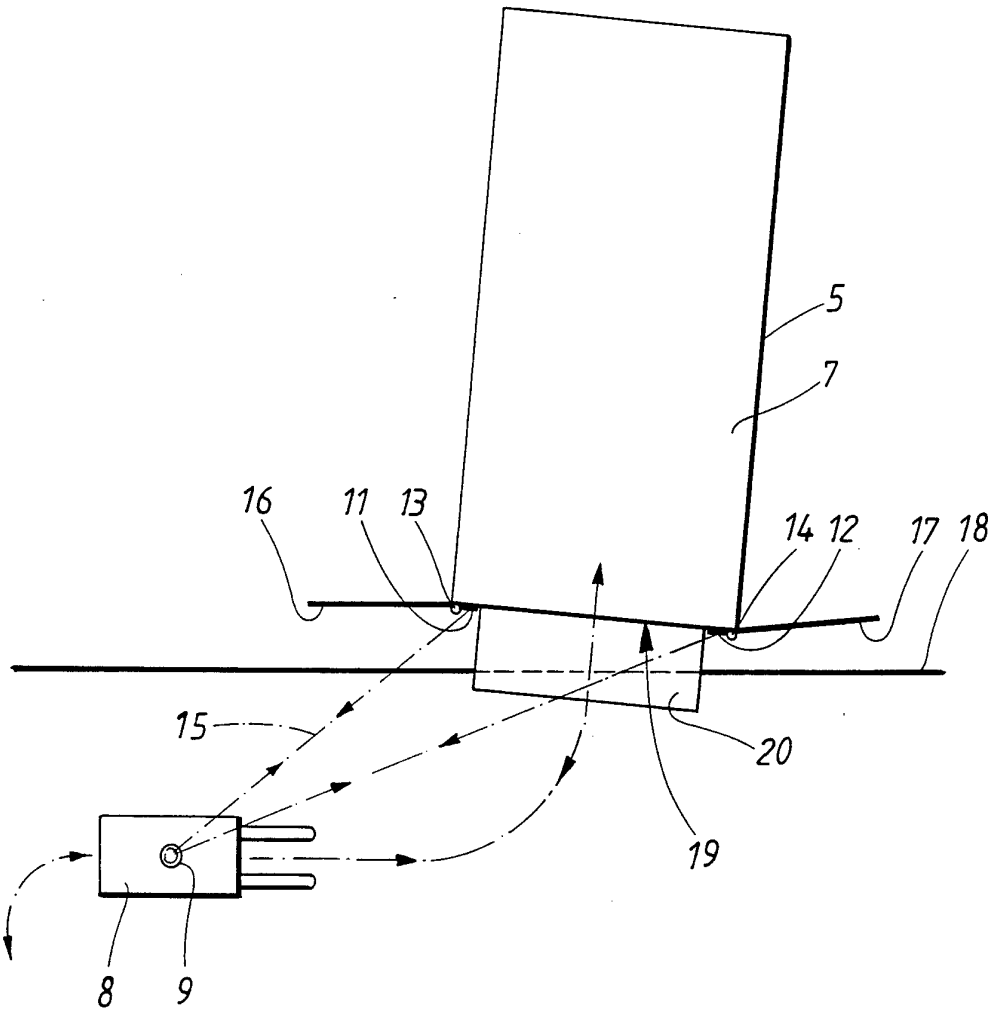


FIG.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00696

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G05D 1/02
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)

IPC6: G05D

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

SE,DK,FI,NO classes as above

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DIALOG

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO, A1, 9011561 (CATERPILLAR INDUSTRIAL INC.), 4 October 1990 (04.10.90), See the whole document cited in the application	1-9
A	SE, B, 412 653 (SAAB-SCANIA AB), 10 March 1980 (10.03.80), abstract	1-9
A	WO, A1, 9002987 (CATERPILLAR INDUSTRIAL INC.), 22 March 1990 (22.03.90), abstract	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

01/10/94

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 9011561	04/10/90	US-A- 4950118	21/08/90
SE-B- 412 653	10/03/80	NONE	
WO-A1- 9002987	22/03/90	EP-A- 0389555	03/10/90
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		US-A- 4918607	17/04/90