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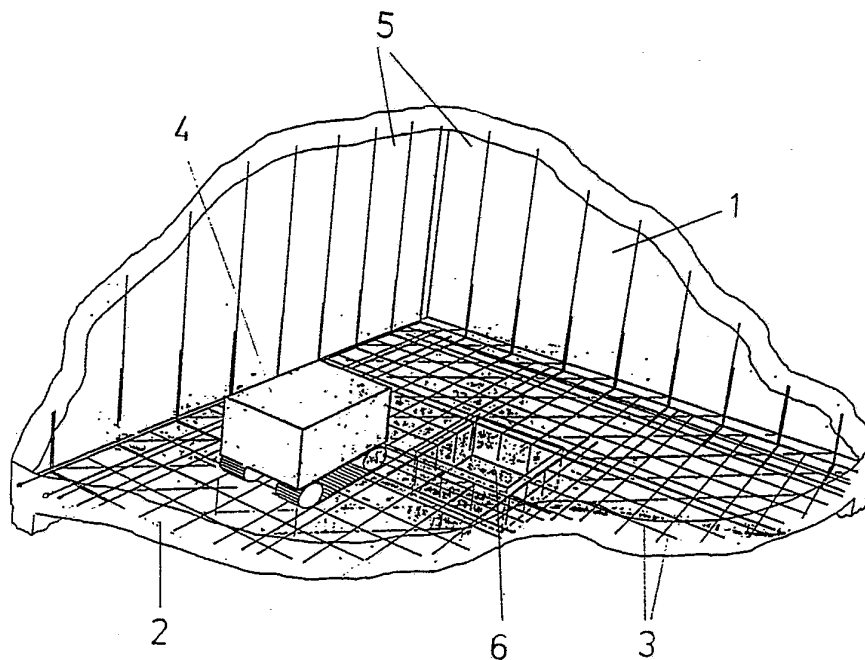
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(54) Title: A METHOD AND A SYSTEM FOR NAVIGATION OF UNMANNED VEHICLES



(57) Abstract

A method for navigation of unmanned vehicles (4), preferably mobile robots within a predetermined area over a surface of reinforced concrete (2), whereby the vehicle is equipped with driving means for propelling and with steering means for steering the vehicle, and by using as reference for the navigation, a geometric structure (3) present within the area, which geometric structure is constituted by the reinforcement of the reinforced concrete surface.

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A METHOD AND A SYSTEM FOR NAVIGATION OF UNMANNED VEHICLES

The present invention refers to navigation of unmanned vehicles particularly mobile robots, and it more exactly
5 refers to a method and a system for determining the position of such a vehicle within a predetermined area over a surface of reinforced concrete, such as e.g. the floor plane of a building.

10 Older known systems of this type are based either on that the vehicle is caused to follow a fixedly installed guide loop, or on that it receives position references from external so called beacons or markers. Genuine navigation systems use either a compass or inertial navigation.

15 For shifting the route of travel for a vehicle guided by fixedly installed guide loops it is required that new grooves are cut in the concrete floor, in which grooves new guide loops thereupon are to be embedded. Another drawback
20 at such guide loops embedded in the concrete floor is that the concrete floor of the building must be constructed thicker than what is required from purely strength technical reasons, as it is necessary thereupon to cut down grooves in the floor, which reduce the carrying thickness of the
25 floor. This will increase the cost for the very building. Genuine navigation systems are furthermore expensive.

The purpose of the present invention is to provide a method for navigation of initially described vehicles, which method
30 proffers a simple and efficient navigation, which eliminates the above mentioned drawbacks, and this has been achieved with the features defined in claim 1.

35 The invention is based on the basic concept of using, instead of navigation in accordance with a particularly positioned fixed guide loop or the like, a geometric structure already present in the building, which is constituted

by the reinforcement of the reinforced concrete surface. It must be possible to follow this structure directly from the vehicle in such a manner that a track reference is obtained, which may be stored and repeated an unlimited number of times. With this method and system there shall be no need for mounting and trimming any additional external reference points.

The invention furthermore refers to a navigation system for accomplishing this method and this system is characterized by the features defined in claim 2.

The invention hereinafter will be further described with reference to solutions shown in the accompanying drawings.

Fig. 1 shows in a schematical perspective view a portion of a room in which there is an unmanned vehicle equipped with the navigation system according to the invention.

Fig. 2 is a perspective view, which schematically illustrates an embodiment of the fitting of detectors to the schematically shown vehicle.

Fig. 3 intimates an alternative method of application of the detectors for the schematically intimated vehicle.

Fig. 1 shows schematically a portion of a room, e.g. an industry hall 1. Each concrete surface, i.e. particularly the floor 2 has a reinforcement incorporating a specific pattern of reinforcing irons 3, often in the shape of a bar pattern. The reinforcing irons 3 are made from a standardized ferromagnetic material.

All reinforcement is made in accordance with especially established rules and its positions may not vary outside approved tolerances. This shall be controlled prior to the pouring of the concrete. The reinforcement thus forms an ferromagnetic system of coordinates, which according to the present invention is utilized as a navigational basis for an unmanned vehicle 4, which can be driven on the floor within

the space limited by the walls. In the vicinity of adjacent walls 5 and holes 6 made in the floor and also at possible pillars, the reinforcing irons are furthermore provided closer to each other, whereby a more strong ferromagnetic field is obtained in the vicinity of such objects 5,6 et-cetera, impeding the motion of the vehicle 4, and which can be utilized for the orientation of the vehicle, whereby collisions furthermore may be avoided and the manoeuvrability may be improved, particularly at corners.

By means of the present invention thus is obtained a system, which is based upon the utilization of an existing geometric structure. This structure can be followed directly from the vehicle and then is obtained a track reference, which may be stored and repeated. No especial external references have to be installed and trimmed.

However it may be advantageous that the starting point for each memorized track is a ferromagnetic reference marking of particular geometry, which is embedded in the concrete.

In Fig. 2 is shown in perspective the configuration of detectors 7,8,9,10 applied on the intimated vehicle 4, and which might be four Hall-elements, or other types of magnetic field detectors or other detectors for contact-free measurement of the presence of metal, arranged in pairs opposed to each other and adapted to detect the pattern formed by the reinforcing irons 3x and 3y resp., arranged in x and y directions. The distance 7-8 between the pairs of opposed detectors 7, 8 thereby is distinctly bigger than the distance 9-10 between the detectors 9, 10. On a concrete surface having a substantially symmetrical bar pattern reinforcement in this manner is obtained a possibility of measuring at least four parameters, such as direction, speed, density and level in relation to the base.

In Fig. 3 is illustrated schematically in perspective a vehicle 4 wherein it is illustrated how the separate detector elements - here shown as lines 7a, 8a, 9a and 10a - are positioned at the outer border angles of the vehicle and are positioned outwardly from the vehicle under an angle α bigger than 90° whereby the detector will be facing obliquely outwards/downwards, whereas its angle β is substantially equal to 90° . In this manner the outer boundaries of the detecting area 11 will be situated outside the limiting surfaces 4a of the vehicle, thus that particularly the measurement of the density increase can take place without risk for collision, whereby perpendicularly adjoining surfaces, e.g. walls, pillars, etcetera, will partly form part of the measuring area.

In the concrete may preferably be embedded at least one ferromagnetic reference marker of a certain geometry, as a starting point for every memorized track.

The navigation system is primarily intended for mobile robots and particularly for robot systems in the building industry. One example of this is so called power floats, which treat a certain area of the floor surface to be. As soon as the reinforcement pattern has been memorized this can act as a basis for all future track generation over the same surface. A cleaning robot then may use the same information when the building of the house has been finished.

Also other types of vehicles, e.g. unmanned industrial trucks can use the same navigation system and the savings then will become big as compared to installation of fixed loop systems.

Therefore the invention is not limited only to robot systems but can be used for all navigation or positioning on surfaces or structures of reinforced concrete.

CLAIMS

1. A method for navigation of unmanned vehicles (4), preferably mobile robots within a predetermined area over a surface of reinforced concrete (2), whereby the vehicle is equipped with driving means for propelling and with steering means for steering the vehicle, characterized in, using a geometric structure present within the area as reference for the navigation, which geometric structure is constituted by the reinforcement (3;3x,3y) of the reinforced concrete surface (2).
2. A method according to claim 1, characterized in, providing on the vehicle at least one detector (7,8,9,10), and feeding this with impulses derived from the pattern, which is formed by the reinforcement (3;3x,3y) of the concrete (2).
3. A method according to anyone of the preceeding claims, characterized in, storing measurement values obtained during manual travel over desired surface and using such values for generating and comparing track at unmanned travel.
4. A method according to anyone of the preceeding claims, characterized in, gathering measurement values for generating and comparison of track for unmanned travel from constructional drawing material in form of computer-readable transfer.
5. A method according to anyone of claims 1 to 3, characterized in, gathering measurement values for generating and comparison of track for unmanned travel from a computer positioned on the vehicle, which first follows the outer limiting areas of

the surface by aid of density measurement and thereupon covers the surface by means of incremental translatory movement or another predetermined motion pattern.

5 6. A method according to anyone of claims 3, 4 or 5,
c h a r a c t e r i z e d i n,
that the means for treatment of the measurement signals
incorporates a correction and reconstruction function based
on a pattern information stored in a computer.

10 7. A system for navigation of unmanned vehicles (4), prefe-
rably mobile robots within a predetermined area over a sur-
face of reinforced concrete (2), whereby the vehicle is
equipped with driving means for propelling and with steering
15 means for steering the vehicle, in accordance with the
method according to claim 1,
c h a r a c t e r i z e d t h e r e i n,
that the system incorporates at least one detector (7,8,9,
10) provided on the vehicle (4) and adapted to receive
20 measurement values from a geometric structure present within
the area, and constituted by the reinforcement (3;3x,3y) in
a concrete surface, and that the vehicle (4) is equipped
with means for treatment of said measurement values, said
means being connected to said steering means for feeding
25 said treated measurement values to said steering means for
the steering of the vehicle.

8. A system according to claim 7,
c h a r a c t e r i z e d t h e r e i n
30 that its detectors are four Hall elements (7,8,9,10) for
magnetic field measurement or another detector for contact-
free detection of metal.

9. A system according to claim 7 or 8,
35 c h a r a c t e r i z e d t h e r e i n,
that the detectors are four magnetic field detectors (7,8,9,
10), which in pairs (7,8;9,10) are positioned opposed to

each other and where the distance (7-8) between the detectors of one of the pairs is distinctly bigger than the distance (9-10) between the two detectors of the second pair.

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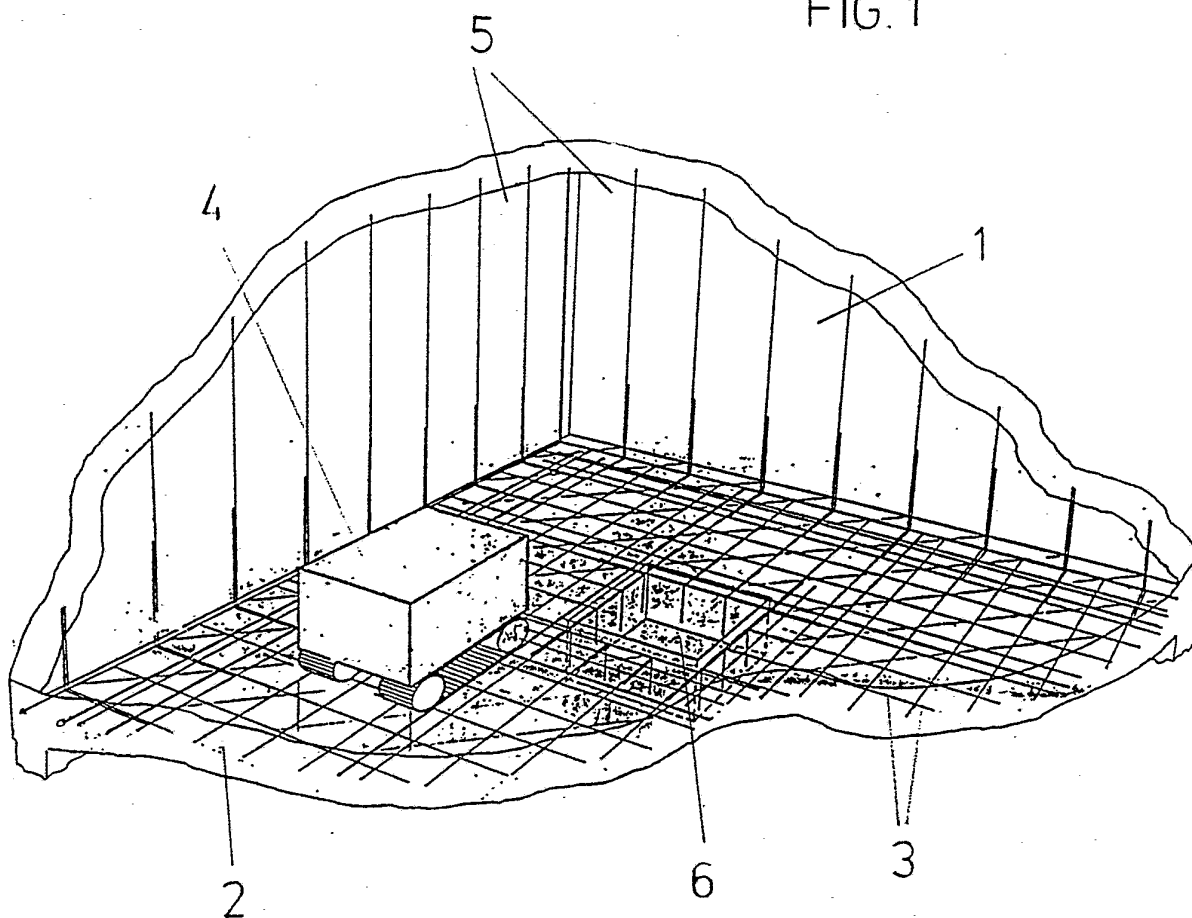
10. A system according to anyone of claims 7 - 9,
c h a r a c t e r i z e d t h e r e i n
that the outer detector elements (7,8,9,10) are positioned at the outer border angles of the vehicle (4) and are positioned at an angle (α) outwards from the sides of the vehicle for giving a detection area (11) extending outside the area (4a) delimited by the vehicle sides.

11. A system according to anyone of claims 7 to 10,
15 c h a r a c t e r i z e d t h e r e i n
that at least one ferromagnetic reference marker of a certain geometry is embedded in the concrete (2), as a starting point for every memorized track.

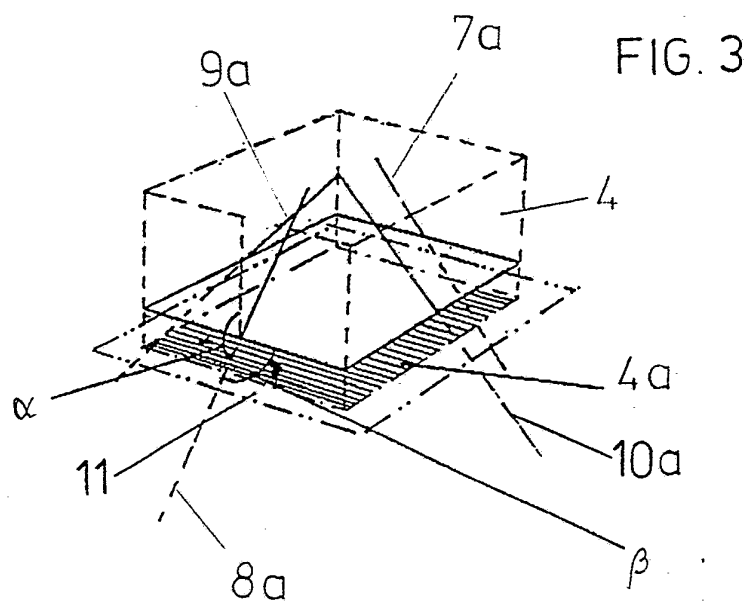
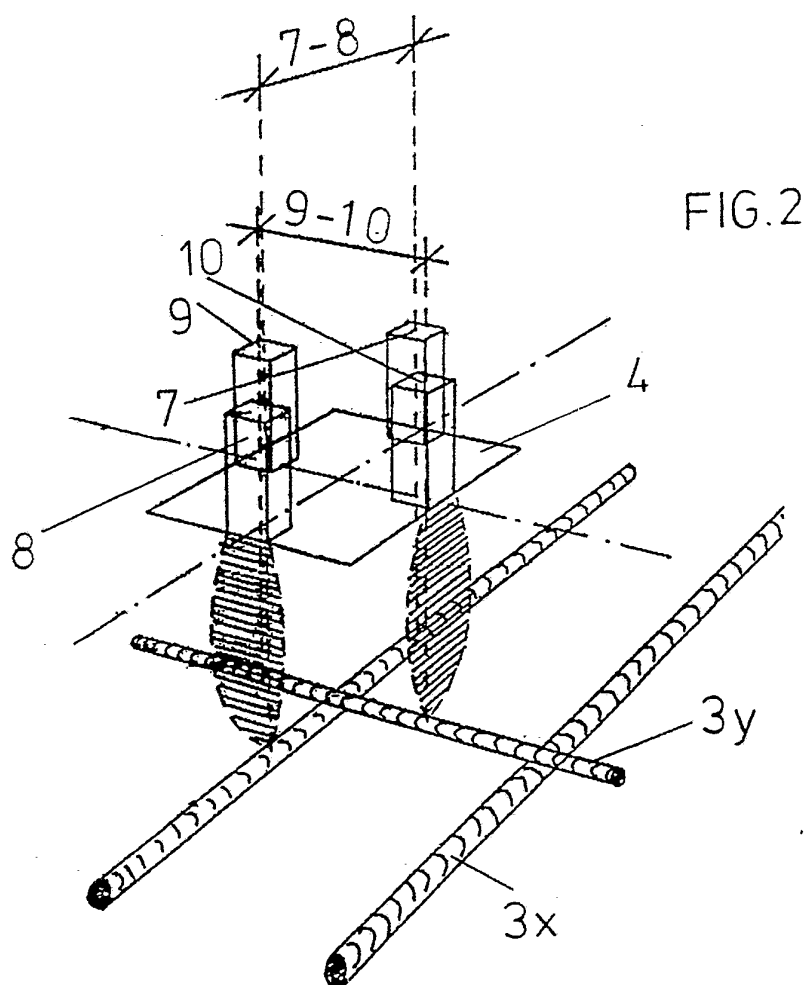
1/2

1:2

FIG. 1



SUBSTITUTE



SUBSTITUTE

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 90/00819

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)⁶

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 05 D 1/03

II. FIELDS SEARCHED

Minimum Documentation Searched⁷

Classification System

Classification Symbols

IPC5

G 05 D, B 25 J

Documentation Searched other than Minimum Documentation
to the extent that such Documents are included in Fields Searched⁸

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹

Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	EP, A1, 142594 (AUTOMAX KABUSHIKA KAISHA) 29 May 1985, see claim 1 ---	1-11
A	Patent Abstracts of Japan, Vol 9, No 239, P391, abstract of JP 60- 93523, publ 1985-05-25 HITACHI SEISAKUSHO K.K. -- -----	1-11

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

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IV. CERTIFICATION

Date of the Actual Completion of the International Search

24th April 1991

Date of Mailing of this International Search Report

1991-04-29

International Searching Authority

SWEDISH PATENT OFFICE

Signature of Authorized Officer

ANDERS AXBERGER

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 90/00819**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on **91-03-23**
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 142594	85-05-29	NONE	