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(54) **System and method for automatically locating and recording a beacon**

(57) System and method for automatically locating and recording a beacon.

The present invention concerns a system and a method for automatically detecting, locating and recording at least one beacon (3) installed at a point along a track (2) designed for a guided vehicle, the system (1) comprising:

- a body (11);
- moving means for autonomously moving said body (11) along said track (2);
- at least one camera (12) installed on said body (11) and configured for taking images of the track (2);
- a processing unit (14) for driving the moving means (14), analyzing the images and detecting in said images beacon (3) installed at points along the track (2);
- recording means (15) for recording information related to each detected beacon (3).

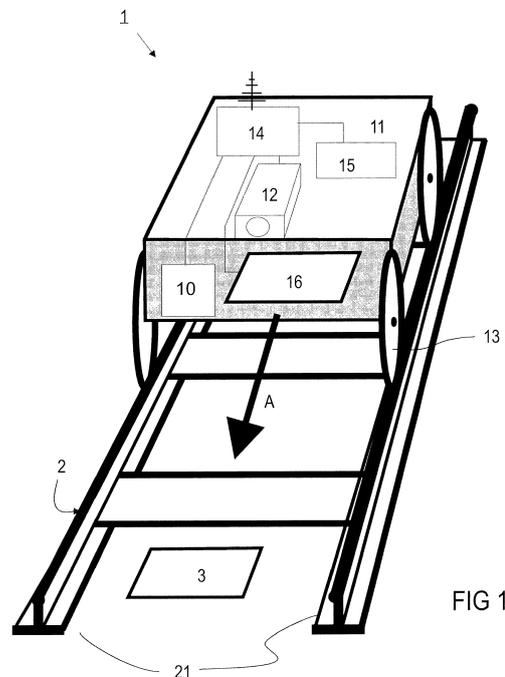


FIG 1

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## Description

**[0001]** The present invention concerns a system and a method for automatically locating and recording beacons installed at points along a route followed by a guided vehicle.

**[0002]** The present invention is directed to the detection, localization and recording of beacons or balises installed on the route or way followed by the guided vehicle and which are configured for exchanging data with the guided vehicle by means of an electromagnetic signal each time the guided vehicle passes near, for example above/over, said balise or beacon. In particular, said balise is an Eurobalise, i.e. a balise which complies with the European Train Control System, and is installed between rails of a railway followed by the guided vehicle. "Guided vehicle" according to the present invention refers to public transport means such as buses, trolleybuses, streetcars, subways, trains or train units, etc., as well as load transporting means such as, for example, overhead traveling cranes, freight trains, for which safety is a very important factor and which are guided along a route or railway by guiding means, for example at least one rail, in particular by two rails between which beacons/balises are placed.

**[0003]** Nowadays, balises are recorded using a manual procedure, wherein at least one operator has to be physically present on the track or route followed by the guided vehicle in order to record each balise by means of a portable device that has to be carried to the railway track, placed on top of the balise and then, via induction, used to upload the balise data into the portable device. This task is time consuming and might be risky for the operator.

**[0004]** An objective of the present invention is to propose a method and system for automatically locating and recording balises or beacons installed at points along a route followed by a guided vehicle.

**[0005]** The present invention proposes to make use of an autonomous system, e.g. a robot, for automatically carrying out the detection, the localization and the recording of each beacon/balise installed at points along a route followed by a guided vehicle.

**[0006]** More precisely, the invention concerns an autonomous system for automatically detecting, locating and recording at least one beacon or balise installed at a point along a route designed for a guided vehicle, e.g. a train or metro, said system comprising:

- a body;
- moving means for autonomously/independently moving said body along said route;
- at least one camera installed on said body and configured for taking images of the route;
- a processing unit for driving the moving means, in particular in a manner free of any operator input, and analyzing the images and detecting from the analysis of said images the location of each beacon;

- storing/recording means for storing/recording information related to each detected beacon, like its position and/or reference number and/or type.

**[0007]** The present invention also concerns a method for automatically detecting, locating and recording at least one beacon or balise installed at a point along a route designed for a guided vehicle like a train or metro, said method comprising:

- moving an autonomous system, like a robot, along said route, wherein the autonomous system is capable of autonomously/independently moving along said route, notably by means of moving means controlled by a processing unit;
- taking images of said route by means of at least one camera on-board the system;
- detecting and locating each beacon/balise installed at a point along said route by analyzing the images of said route taken by the camera when the system is moving along said route;
- recording/storing information related to each detected beacon, like its position and/or reference number and/or type, in storing/recording means of the system.

**[0008]** The present invention refers thus to an autonomous system, i.e. a system that does not require to be driven by an operator. The processing unit according to the invention is configured for driving the autonomous system along the track by controlling the moving means, for detecting, locating and recording balises identified by means of the camera, free of any operator input. Of course, it might be possible for an operator to remotely take the lead and drive the system according to the invention if needed. Optionally, the autonomous system may comprise at least two cameras, a first camera pointing forward for taking images of the track in front of the autonomous system and identifying approaching balises, and a second camera pointing perpendicularly to the track, i.e. to the ground, used for a precise location of the balise.

**[0009]** Further aspects of the present invention will be better understood through the following drawing:

Figure 1 schematic representation of an autonomous system according to the invention.

**[0010]** Figure 1 shows a preferred embodiment of an autonomous system 1 according to the invention, wherein the autonomous system 1 is in particular a robot. Said autonomous system 1 comprises a frame or body 11 in, or on, which is installed at least one camera 12 configured for taking images of a route or track 2, said track 2 comprising guiding means for guiding a guided vehicle along a path defined by said track 2, said guiding means being for example one or several rails configured for guiding the guided vehicle, and in particular the autonomous sys-

tem 1 according to the invention. Preferentially, the autonomous system 1 according to the invention is thus configured for using the same guiding means provided by the track 2 as those used by the guided vehicle, e.g. said rails 21, in order to move on the same path as the guided vehicle along the track 2. One or several balises 3 are installed at points along the track 2 and are configured for exchanging data with the guided vehicle when the latter passes at proximity, e.g. above, said balise 3.

**[0011]** The autonomous system 1 comprises moving means for autonomously moving its body 11 along the track 2. Said moving means may comprise a connection to a power source and/or a power source, a motor 10 for converting the power of the power source into mechanical energy capable of moving the body 11, and therefore the autonomous system 1. Preferentially, the motor converts the power of the power source, e.g. electric power, into a mechanical energy that makes a shaft rotating, and wherein the rotation of said shaft drives at least one wheel 13 into rotation. Preferentially, the moving means of the autonomous system 1 according to the invention are configured for making use of an identical type of interaction with the track 2 as the guided vehicle has with said track 2 for moving the body 11, and therefore the autonomous system 1. For example, if the guided vehicle is a train comprising wheels that are supported by rails 21, then preferentially, the autonomous system 1 comprises wheel 13, that are configured for being supported by the same rails 21. Additionally, the moving means according to the invention are in particular configured for cooperating with the guiding means of the track 2 that are configured for guiding the guided vehicle along the path defined by said track 2. For example, the wheels 13 of the moving means are configured for being supported and guided by the rails 21 of the track 2. Of course, the present invention is not restricted to autonomous systems 1 using the guiding means of the track 2 for being guided along said track 2, but is also open to autonomous systems 1 like a drone capable of identifying the track 2 by means of the camera 12, and to follow the path described by said track 2.

**[0012]** The moving means according to the invention are in particular controlled by a processing unit 14 of the autonomous system 1 according to the invention. In particular said processing unit 14 is connected to the camera 12 for processing each image taken by the camera 12 during the displacement of the autonomous system 1 along the track 2. The processing unit 14 preferentially comprises communication means for communicating with a remote communication device installed for instance in a remote command center. The camera 12 is notably configured for taking images of track sections in front of the body 11 (hereafter also called downstream section) compared to its direction of displacement (indicated by the arrow A in the particular case of Fig. 1). Preferentially, the processing unit 14 is connected to storing means 15 which may comprise a database for storing data and/or uploading data and/or modifying data already

recorded in said storing means 15 and/or database.

**[0013]** Preferentially, said camera 12 is configured for capturing in real time at least one image of a downstream section of said track 2, said downstream section being a track portion extending from a first point of said track 2 located downstream of said body 11 to a second point of said track 2 located downstream of said body 11, the distance separating the camera 12 from the second point being greater than the distance separating the camera 12 from said first point. The processing unit 14 is able to automatically analyze each image taken by each camera 12, to identify and locate said downstream section therein and to determine in real time if a balise 3 is located in said downstream section, notably between said first point and second point.

**[0014]** Preferentially, the processing unit 14 is able to digitize each image captured by the camera 12 for transforming said captured image into a format that can be used for localizing the balise 3. The processing unit 14 is configured for detecting if a balise 3 is comprised in the image acquired by the camera and optionally for detecting and identifying the track 2. For this purpose, the processing unit 14 uses in particular an object recognition algorithm. Advantageously, the identification of the track 2 in each image may help detecting balises 3, since the position of a balise 3 compared to the track position might be used as a parameter for searching balises in the images acquired by the camera, said parameter being for example used by the object recognition algorithm.

**[0015]** Alternatively, said camera 12 might be configured and installed for taking images of portions of track that are located under the body 11 of the autonomous system 1. In other words, said camera 12 may point perpendicularly to the track or ground (optical axis of the camera perpendicular to the track). This configuration of the camera 12 may help in determining the position of the balise 3 compared to the position of the body 11. Indeed, it is then easier to determine the center of the balise 3 by making at least one part of the balise coinciding with the optical axis of the camera 12. In another preferred embodiment, the autonomous system 1 may comprise two cameras, a first camera pointing forward as previously described, and a second camera having its optical axis pointing perpendicularly to the track 2 as described above, so that the first camera might do a first approximation of the location and position of the balise and is used for controlling the approach of the autonomous system 1 toward the balise 3, and the second camera is used for the precise determination of the location/position of the balise under the body 11 of the autonomous system 1. The images of both cameras might be processed by means of object recognition algorithm in order to determine balise characteristics and position. In the following text, "first camera" will refer to a camera pointing forwards and "second camera" will refer to a camera pointing perpendicularly to the track as previously described. The autonomous system 1 might comprise both first and second cameras, or alternatively only one

of them.

**[0016]** Preferably, the processing unit 14 uses said object recognition algorithm for identifying a presence or absence of balise 3 in each image captured by the camera 12, for example by the first and/or second camera. In particular, the recognition algorithm uses geometric recognition techniques applied to each image or to a part of each image (for example only to the part comprising the track, or only to the part comprised between two rails 21 of a track 2) for identifying for example the balise 3, and in particular the downstream section of the track 2. For example, the object recognition algorithm is in particular capable of first searching for a track 2 (e.g. a track downstream section) in the image acquired by the camera, preferentially by the first camera, and second, once a track 2 or track downstream section has been identified in said image, searching for a balise 3 only on an area of the image wherein the track 2 or track downstream section has been identified. The object recognition algorithm preferentially uses automatic learning techniques such as boosting for identifying objects, like the track 2 or the balise 3, in the images taken by the camera 12. Techniques such as boosting for identifying objects in images are well known by the skilled man and do not need further explanations.

**[0017]** Preferably, and in order to identify a balise 3 in an image, an in particular in order to recognize said track 2 in the image acquired by the camera, e.g. by the first camera and/or the second camera, the recognition algorithm is able to make a correlation or matching between a set of pixels of the image captured by said camera and a set of features of the balise 3, and preferentially also of the track 2, wherein said features might be previously saved in the database of the autonomous system 1 according to the invention. Preferentially, said features define for example specific geometric shapes of the balise 3, and preferentially also of the track 2, said features facilitating the track/balise identification by means of the object recognition algorithm by comparing features of the images with the features recorded for the balise/track in said database.

**[0018]** Preferably, said method according to the invention may in particular include a learning phase intended to create said database. The learning phase may comprise an acquisition of images by the camera of the autonomous system 1 when the latter is moving on a track 2 comprising beacons/balises installed at known points along the track 2. Said images acquired during the learning phase might be used as "learning" images (i.e. typical images representing a track comprising balises) for the detection by the object recognition algorithm of the balise and/or the track during the learning phase. During said learning phase, track/balise features, like specific geometric shapes of the balise 3 and/or of the track 2, might be automatically stored in the database by the processing unit 14. In particular, once said learning phase is completed, then said database is used by the object recognition algorithm for the identification in real time of

balise/track features in images captured by the camera. Advantageously, said database might be upgradable and adaptive in that, once said learning phase is completed, it can be updated in real time using new images acquired by said camera during subsequent runs of the autonomous system 1 along the track 2 in order to complete the database and to improve the identification process of balises 3 by means of the object recognition algorithm.

**[0019]** Preferentially, each time a balise 3 is identified by the object recognition algorithm in an image taken by the camera 12, in particular by the first camera and/or the second camera, then the processing unit 14 may carry out at least one of the following steps:

- 15 - decreasing the moving speed of the body 1, i.e. of the autonomous system 1, by controlling the moving means, e.g. the motor, so that the speed of the autonomous system 1 according to the invention when passing above/close to a balise 3 is smaller than its speed when no balise is detected in order to improve the determination of the location of the balise 3. For example, the images taken by the first camera are used by the processing unit for controlling the approach of the autonomous system 1 towards the balise 3, and once the autonomous system 1 passes above the balise 3, the second camera and/or a device 16 (see below) might be used for determining the exact location of the balise, wherein the processing unit is able to determine for example the time T corresponding to an alignment of the optical axis of the second camera with a part of the balise (e.g. an edge) and/or the alignment of a receiving loop of the device 16 with a transmitting loop of the balise 3, and to deduct from the position of the autonomous system 1 at said time T the position of the balise, wherein said balise position might then be recorded in the database and/or transmitted to a remote control center;
- 40 - controlling a device 16 for communicating with the balise 3, said device 16 comprising for example an emitter and a receiver and being installed on the body 11 so that in particular at least its emitter and receiver face the balise 3 when the body passes over/above the balise 3. Preferentially, the emitter is configured for remotely powering the balise 3, in particular by means of radiant energy. Said emitter comprises for example an antenna comprising an emitting loop for radiating energy, in particular radio frequency energy, the balise being then powered by said radiated energy and able to transmit, in return, an electromagnetic signal. The receiver comprises an antenna incorporating at least one receiving loop for picking up the electromagnetic signal produced by the balise 3, more precisely the electromagnetic signal produced by a transmitting loop of the balise 3, the receiver comprising thus a receiving loop configured for picking up the electromagnetic signal sent by the balise 3 in response to its powering by the emitter

and for delivering a signal SR to the processing unit 14, said signal SR being current induced by the electromagnetic signal in said receiving loop, wherein said current provides a measure of the amplitude of the electromagnetic signal in function of the position of the receiving loop (e.g. in function of the position of the center of the receiving loop) compared to the position of the balise 3, more precisely compared to the position of the center of the transmitting loop of the balise 3. In the context of the present invention, the center of the balise 3 refers to the center of its transmitting loop, and centers of receiving or transmitting loops are notably geometric centers. The processing unit 14 is capable of processing the signal SR delivered by the receiving loop in order to collect information sent by the balise 3 in response to its powering and is able to send information to the balise 3, wherein said information may comprise the position of the balise 3 and/or a reference number. The processing unit is capable to determine the time T at which the center of the receiving loop coincides with the center of the transmitting loop from the signal SR. Such technique of balise center determination is known by the persons skilled in the art and does not need further explanations;

- controlling a geolocation system for determining the position of each balise 3. Said geolocation system being preferentially installed in or on the body 11. Said geolocation system may make use of the camera installed on or in the body 11 and preferentially configured for having its optical axis pointing perpendicularly to the track 2, i.e. of said second camera, or of the device 16, for determining the position of the balise 3. For example, the position of the optical axis of the second camera might be used for determining the position of the balise on the track 2. Indeed, the processing unit 14 is able to identify said balise 3 in images taken by the second camera by means of said object recognition algorithm and to determine when the second camera optical axis points to or coincides with a part of the balise 3 from analyzing said images. For example, the database may comprise pre-recorded images of the balise, wherein data regarding the distance between the balise center and said part is recorded and used by the processing system for determining the position of the center of the balise 3 at the time T from the position of said part at said time T compared to the position of the autonomous system at said time T, wherein the position of the autonomous system at said time T is determined by means of the geolocation system. By position of the autonomous system, it has to be understood the position of a reference point (for example its geographic coordinates and/or the distance separating said reference point from a fixed reference as described below) of the autonomous system, and therefore, the determination of the position of the balise center compared to the po-

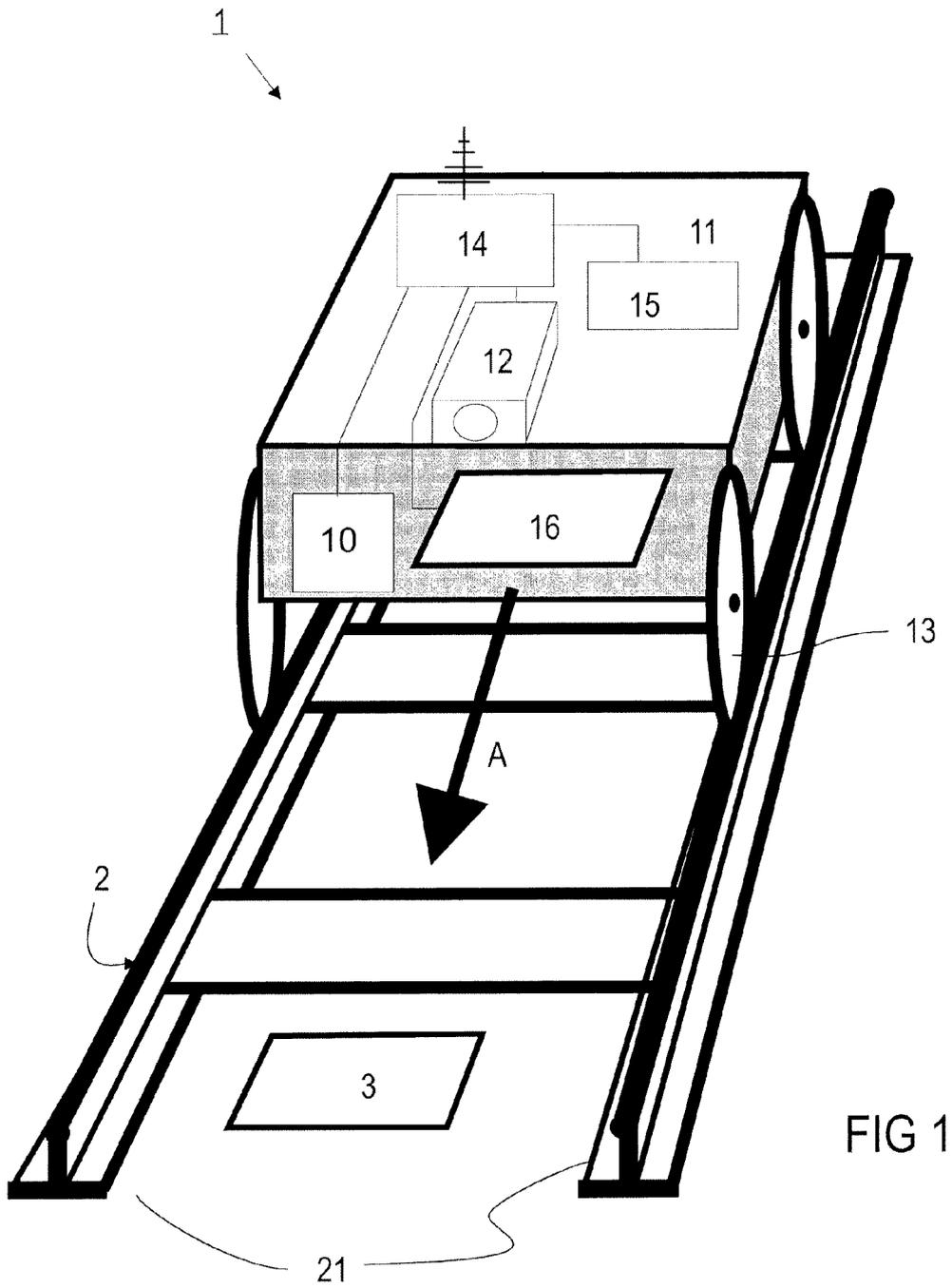
sition of the autonomous system means the determination of the position of the balise center compared to the position of the reference point. For example, said reference point might be the projection of the optical axis of the second camera on a horizontal plane. Said geolocation system is in particular configured for determining the position of the reference point of the autonomous system, e.g. the position of the optical axis of said second camera, compared to the fixed reference, the fixed reference being in particular a fixed position on a guided vehicle network, for instance a starting point on the track 2, by using techniques such as odometry and/or Global Positioning System techniques. The same applies mutatis mutandis for the determination of the position of the center of the receiving loop compared to said fixed reference, wherein the center of the receiving loop might be chosen as reference point. Once the position of the balise 3 is determined, then the processing unit 14 may write information related to the balise 3 position on a memory of the balise by means of the device 16 for communicating and/or may write said information in said database, and/or may compare an information related to the balise position provided by the balise 3 to the determined position, and/or may automatically communicate said position to a remote control center.

**[0020]** To summarize, the present invention proposes a system and a method for automatically detecting beacons at points along a route of a guided vehicle, wherein a processing unit is used for detecting beacons in images taken by a camera on-board said system.

### Claims

1. System (1) for automatically detecting, locating and recording at least one beacon (3) installed at a point along a track (2) designed for a guided vehicle, the system comprising:
  - a body (11);
  - moving means for autonomously moving said body (11) along said track (2);
  - at least one camera (12) installed on said body (11) and configured for taking images of the track (2) ;
  - a processing unit (14) for driving the moving means (14), analyzing the images, detecting in said images beacon (3) installed at points along the track (2), and determining the position of each beacon (3) ;
  - recording means (15) for recording information related to each detected beacon (3).
2. System (1) according to claim 1, configured for cooperating with guiding means of the track (2) de-

- signed for guiding the guided vehicle in order to be guided along said track (2).
3. System according to claim 1 or 2, wherein the processing unit (14) comprises communication means. 5
  4. System according to one of the claims 1-3, wherein the recording means (15) includes a database. 10
  5. System according to one of the claims 1-4, wherein the processing unit (14) is configured for identifying at least one portion of track (2) in each image.
  6. System according to one of the claims 1-5, wherein the processing unit (14) comprises an object recognition algorithm. 15
  7. System according to one of the claims 4 to 6, wherein the database comprises information related to features of the balise (3) and/or the track (2). 20
  8. System according to one of the claims 1 to 7, comprising a device (16) for communicating and exchanging information with the balise (3). 25
  9. System according to one of the claims 1 to 8, comprising a geolocation system for determining the position of the balise (3). 30
  10. Method for automatically detecting, locating and recording at least one beacon (3) installed at a point along a track (2) designed for guiding a guided vehicle, the method comprising: 35
    - moving an system (1) along said track (2), wherein the system (1) is capable of autonomously moving along said track (2);
    - taking images of said track (2) by means of at least one camera (12) on-board the system (1); 40
    - detecting and locating beacons (3) installed at a point along said track (2) by analyzing, by means of a processing unit (14) of the system (1), the images of said track (2) taken by the camera (12) when the system (1) is moving along said track (2); 45
    - recording information related to each detected beacon (3) in recording means (15) of the system (1). 50
  11. Method according to claim 10, comprising controlling a device (16) for communicating with the beacon (3) by means of the processing unit (14).
  12. Method according to claim 10 or 11, comprising controlling a geolocation system for determining the position of each beacon (3). 55
  13. Method according to one of the claims 10-12, comprising using an object recognition algorithm for detecting at least one part of the track (2) and/or the beacon (3) in the images taken by the camera (12).
  14. Method according to one of the claims 10-13, comprising a learning phase for automatically collecting information related to the track (2) and/or beacon and storing said information in a database.
  15. Method according to claim 14, wherein the object recognition algorithm uses said information stored in the database for identifying the track (2) and/or beacon (3) in the images acquired by the camera (12).





EUROPEAN SEARCH REPORT

Application Number  
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>23 February 2015</b>	Examiner <b>Janhsen, Axel</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82