



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.12.2019 Bulletin 2019/50

(51) Int Cl.:
B66B 1/34 (2006.01) B66B 5/00 (2006.01)

(21) Application number: **18175872.3**

(22) Date of filing: **05.06.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

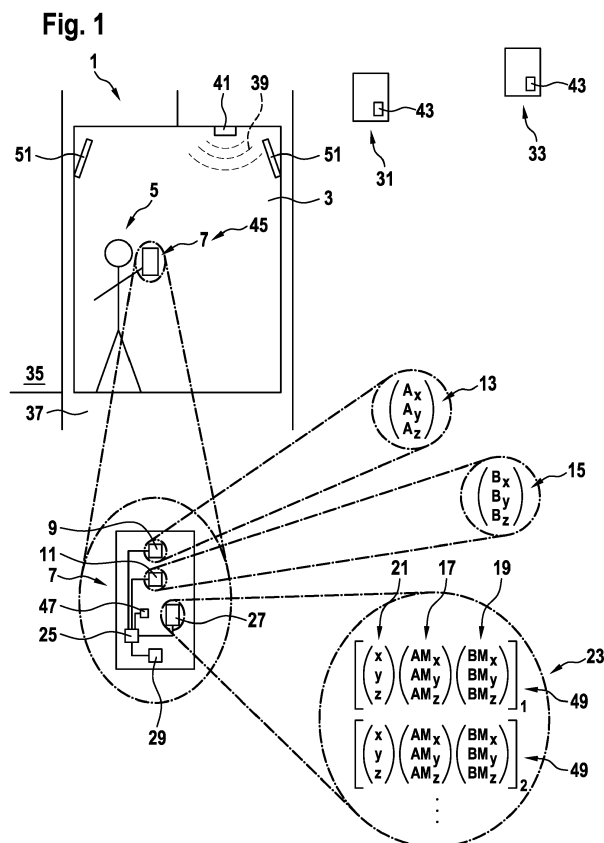
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(54) **METHOD AND MONITORING DEVICE FOR MONITORING LOCATIONS OF A PASSENGER WITHIN AN ELEVATOR CABIN**

(57) A method and device (45) for monitoring locations of a passenger (5) within an elevator cabin (3) using a passenger's smart mobile device (7) are proposed. The method comprises a learning phase and an application phase. During the learning phase, a map (23) is generated, wherein the map (23) comprises local 3D-magnetometer-data (17) for each of multiple locations through-

out the elevator cabin (3). During the application phase, the location of the passenger (5) is determined based on a comparison of actual 3D-magnetometer-signals (13) measured by a 3D-magnetometer-sensor (9) comprised in the passenger's smart mobile device (7) with the 3D-magnetometer-data (17) comprised in the map (23).



Description

[0001] The present invention relates to a method and a monitoring device for monitoring locations of a passenger within an elevator cabin. Furthermore, the present invention relates to a computer program product for performing or controlling the proposed method and to a computer readable medium comprising such computer program product stored thereon.

[0002] Elevators typically comprise a cabin, which may be displaced along a vertical displacement path such as an elevator shaft and may be stopped at different stopping positions at various levels in a building. Passengers may enter and exit the cabin and may be located within the cabin during travelling for example from one floor level to another.

[0003] As described in further detail below, it has been found that information about a location at which a passenger is located within the elevator cabin may be valuable for various reasons.

[0004] WO 2004/084556 A1 describes monitoring a lift area by means of a 3D sensor. Therein, the 3D sensor may provide three-dimensional image information and such image information may be processed using specified processing hardware in order to allow for example detecting conditions in the elevator or malfunctions of the elevator. For example, by using the 3D sensor for supervising an interior space of the elevator cabin, a number of passengers in the cabin, a number of passengers entering or exiting the cabin, an overload situation, a presence of obstacles within a door area, etc. may be detected.

[0005] However, in such conventional approach, substantive additional hardware is generally required for monitoring passenger locations within the elevator cabin. Furthermore, monitoring passengers with a 3D sensor taking images within the elevator cabin may provoke a passenger's privacy concerns.

[0006] There may be a need for an alternative method and device for monitoring locations of passengers within an elevator cabin. Particularly, such method and device may preferably be adapted for simply and reliably determining the location of one or more passengers in the elevator cabin with reduced hardware requirements to be supplied in the elevator. Furthermore, such method and device may be adapted for minimising privacy concerns of the passengers. Additionally, there may be a need for an elevator comprising such monitoring device, for a computer program product which, when executed in a programmable monitoring device, instructs the monitoring device for performing or controlling the proposed method and for a computer readable medium comprising such computer program product stored thereon.

[0007] Such needs may be met with the subject-matter of the independent claims. Advantageous embodiments are defined in the dependent claims and in the following specification.

[0008] According to a first aspect of the present inven-

tion, a method for monitoring locations of a passenger within an elevator cabin using a passenger's smart mobile device is proposed. The method comprises a learning phase and an application phase. During the learning phase, a map is generated. The map comprises local 3D-magnetometer-data for each of multiple locations throughout the elevator cabin. During the application phase, the location of the passenger is determined based on a comparison of actual 3D-magnetometer-signals with the 3D-magnetometer-data comprised in the map. The actual 3D-magnetometer-signals are measured by a 3D-magnetometer-sensor comprised in the passenger's smart mobile device.

[0009] According to a second aspect of the present invention, a method for monitoring locations of a passenger within an elevator cabin using a passenger's smart mobile device is proposed. The method comprises determining the location of the passenger based on a comparison of actual 3D-magnetometer-signals measured by a 3D-magnetometer-sensor comprised in the passenger's smart mobile device with 3D-magnetometer-data comprised in a map. Therein, the map was generated during a preceding learning phase such as to comprise the 3D-magnetometer-data locally for each of multiple locations throughout the elevator cabin.

[0010] According to a third aspect of the invention, a monitoring device being configured for monitoring locations of a passenger within an elevator cabin by being configured for performing and/or controlling the method according to an embodiment of the second aspect of the invention is proposed.

[0011] According to a fourth aspect of the invention, an elevator being configured for monitoring locations of a passenger within an elevator cabin by being configured for performing and/or controlling the method according to an embodiment of the second aspect of the invention is proposed.

[0012] According to a fifth aspect of the invention, a computer program product is proposed, the computer program product comprising computer readable instructions which, when performed by a processor of a monitoring device, instruct the monitoring device to performing and/or controlling the method according to an embodiment of the second aspect of the invention.

[0013] According to a sixth aspect of the invention, a computer readable medium comprising a computer program product according to an embodiment of the fifth aspect of the invention is proposed.

[0014] Ideas underlying embodiments of the present invention may be interpreted as being based, inter alia and without restricting a scope of the invention, on the following observations and recognitions.

[0015] In order to determine locations of a passenger within an elevator cabin without requiring substantive additional hardware in the elevator and/or without compromising the passenger's privacy concerns, it is suggested to use sensor capabilities of a smart mobile device carried by the passenger in order to derive information about the

location of the passenger. Therein, it is used that modern smart mobile devices comprise various sensors which allow measuring various physical parameters. Particularly, it is taken advantage of the fact that a magnetic field varies in strength and/or orientation depending on the location within the elevator cabin where the magnetic field is measured. Based on this fact, a map may be generated, wherein the map represents characteristics of the magnetic field at each of various locations throughout the elevator cabin. Such characteristics of the magnetic field are referred to herein as 3D-magnetometer-data. Particularly, such 3D-magnetometer-data may comprise information about a strength and orientation of the magnetic field within a three-dimensional space. In other words, the 3D-magnetometer-data may characterise a vector of the magnetic field defined by its magnitude and orientation. Having such map generated during a preceding learning phase, a monitoring device may use this map during the subsequent application phase. In such application phase, actual 3D-magnetometer-signals measured by a 3D-magnetometer-sensor may be compared with the 3D-magnetometer-data of the map. The 3D-magnetometer-sensor may be comprised in the passenger's smart mobile device. Based on the comparison, information about the location of the smart mobile device and, consequently, of the passenger carrying this device may be derived.

[0016] In other words, the approach described herein beneficially uses the fact that, today, many passengers carry mobile devices which themselves already comprise a multiplicity of sensors. Such sensors may enable measuring various physical parameters. At least some of these parameters may vary depending on a location within the elevator cabin and may therefore be characteristic for each location within the elevator cabin. Particularly, it has been found that a 3D-magnetometer-sensor being comprised in many modern passenger's mobile devices may be used for sensing the local magnetic field with a sufficiently high precision such as to detect slight differences in such local magnetic field depending on the measurement location within the elevator cabin. Accordingly, upon actually measuring the local magnetic field characteristics and comparing it with 3D-magnetometer-data included in the map generated during the learning phase, required information about the passenger's location may be derived.

[0017] For example, a passenger's mobile device may be a mobile phone, a smart phone, a tablet computer, a smartwatch, a so-called smart wearable for example in the form of an electronic smart textile or any other portable terminal device. Such mobile device may comprise various sensors such as a microphone, an acceleration sensor, a rotation rate sensor, a magnetic field sensor forming a magnetometer-sensor, a camera, a pressure sensor, a light sensor, a humidity sensor, a gas sensor, etc. Particularly, acceleration sensors and magnetic field sensors may be embodied as three-dimensional or 3D sensors which may provide measurement values in three

directions orthogonal to each other. Furthermore, the mobile device may comprise a processor for processing data received from the sensors. Additionally, the mobile device may comprise a data transmission unit for transmitting data to external devices via wireless data communication and/or wired data communication. Due to its capability of measuring and, optionally, processing physical parameters, such mobile devices are also referred as "smart" mobile devices.

[0018] It has been found that variations in the magnetic field present at various locations throughout the elevator cabin may be particularly beneficially used for deriving information about the passenger's location. Therein, magnetic fields in the elevator may result, for example, from the terrestrial magnetic field. Furthermore, magnetic fields may be generated by elevator components such as magnets comprised e.g. in an electric motor of an elevator drive engine. Furthermore, magnetic field sources such as permanent magnets may be provided throughout an elevator shaft for example for establishing position markers or flags. Local variations in magnetic fields may be provoked, for example, due to different components and/or materials comprised in the elevator and its environment, such components and materials differently promoting or blocking magnetic fields depending, inter-alia, on their magnetic properties and/or their geometry. For example, the magnetic field variations may be measured with high precision with the 3D-magnetometer-sensor comprised in many smart mobile devices. Therein, the magnetic field variations may be measured independent of an identity of the passenger and/or his smart mobile device such that the location of the passenger may be determined based on information about such magnetic field variations without compromising the passenger's privacy concerns. Optionally, the information about the magnetic field variations may be processed only after further measures are executed to make them anonymous.

[0019] Upon generating the map during the learning phase, the location at which a set of 3D-magnetometer-data is measured should be precisely known. For example, coordinates of such location may be obtained from an indoor navigation system, a GPS system, a system observing and analysing an environment within the elevator cabin or similar means. The information about the measurement location may be stored together with the set of 3D-magnetometer-data. Accordingly, the map may comprise data couples in which for each measurement location measured 3D-magnetometer-data are stored.

[0020] According to embodiments of the first and second aspects of the invention, during the learning phase, the map is generated such as to comprise for each of the 3D-magnetometer-data additional 3D-orientation-data indicating an orientation of the 3D-magnetometer-data. Then, during the application phase, the location of the passenger is determined additionally taking into account a comparison of an orientation of the passenger's smart mobile device indicated by a 3D-accelerometer-signal

measured by a 3D-accelerometer-sensor comprised in the passenger's smart mobile device with the 3D-orientation-data comprised in the map.

[0021] Expressed differently, the map generated during the learning phase may not only comprise the 3D-magnetometer-data for each of multiple locations but may additionally comprise information indicating at which orientation such 3D-magnetometer-data is measured or captured. For example, the orientation of the 3D-magnetometer-data may be identical for all 3D-magnetometer-data acquired at the multiple locations. However, it may also be possible that the orientation of the 3D-magnetometer-data may vary depending on where this 3D-magnetometer-data is required. For example, during the learning phase, the 3D-magnetometer-data may be measured with a 3D-magnetometer-sensor being moved throughout the various locations but being always held at a constant orientation. Alternatively, the 3D-magnetometer-sensor may be reoriented into various orientations at the different measurement locations and the information about the orientation with which the 3D-magnetometer-data have been acquired is stored in the 3D-orientation-data.

[0022] Later, in the application phase, this 3D-orientation-data may be taken into account upon comparing the actual 3D-magnetometer-signal acquired by the 3D-magnetometer-sensor with the previously acquired 3D-magnetometer-data stored in the map. Particularly, the 3D-orientation-data stored in the previously generated map may be compared with a 3D-accelerometer-signal provided by a 3D-accelerometer-sensor included in the passenger's smart mobile device. Such 3D-accelerometer-sensor may measure accelerations acting onto the smart mobile device. Particularly, the 3D-accelerometer-sensor may detect accelerations resulting from gravity, such that information about a current orientation of the smart mobile device may be derived. Accordingly, based on such information, the 3D-magnetometer-signal acquired with the 3D-magnetometer-sensor in the current orientation of the smart mobile device may be processed such as to be directly comparable to the 3D-magnetometer-data stored in the map.

[0023] According to an embodiment, during the learning phase, the map is generated such as to comprise local 3D-magnetometer-data for each of multiple locations throughout the elevator cabin upon the elevator cabin being located at each of multiple levels throughout an elevator shaft.

[0024] In other words, the 3D-magnetometer-data may not only be acquired while the elevator cabin is stationary at one single level, i.e. for example at a stopping position adjacent to a floor. Instead, 3D-magnetometer-data may be acquired at various levels of the elevator cabin throughout the elevator shaft.

[0025] Expressed differently, 3D-magnetometer-data may for example acquired during the learning phase in a first step when the elevator cabin is at a first level, wherein, in this first step, 3D-magnetometer-data are ac-

quired at multiple locations throughout the elevator cabin. Subsequently, in a second and/or further steps, additional 3D-magnetometer-data may be acquired after the elevator cabin has been displaced to a second and/or further levels, wherein, in these additional steps, 3D-magnetometer-data may again be acquired at multiple locations throughout the elevator cabin.

[0026] Accordingly, the entire map generated during the learning phase may not only be a two-dimensional map in a plane parallel to a single level of the elevator cabin but may comprise further data relating to other planes at other levels of the elevator cabin and may therefore be a three-dimensional map. Accordingly, the map may include 3D-magnetometer-data for various locations within a three-dimensional volume included in the elevator shaft. Such three-dimensional volume may comprise locations at a level of floors at which the elevator cabin stops and, additionally, may also comprise locations vertically in between such elevator cabin stop levels.

[0027] Accordingly, using such three-dimensional map, in the application phase, a current location of the passenger may be determined even when the elevator cabin is currently moving between various floors levels. Accordingly, the current location of the passenger may be tracked even when the passenger moves around in the elevator cabin during the cabin is travelling throughout the elevator shaft.

[0028] According to an embodiment of the invention which may be seen as a simplified implementation of the preceding embodiment, during the learning phase, the map is generated such as to comprises local 3D-magnetometer-data for each of multiple locations throughout the elevator cabin upon the elevator cabin being stopped at each of multiple floors.

[0029] In other words, the 3D-magnetometer-data may not have to be acquired continuously or at short vertical distances at various levels throughout the elevator shaft, as may be the case for the preceding embodiment. Instead, it may be sufficient to generate the map only with 3D-magnetometer-data acquired when the elevator cabin is located at a cabin stop level adjacent to one of the floors in the building. Accordingly, 3D-magnetometer-data acquisition may be simplified and/or a data volume of the 3D-magnetometer-data comprised in the map may be reduced.

[0030] Nevertheless, a location of the passenger may be determined based on such limited map with 3D-magnetometer-data acquired only at floor levels at least for cases where the passenger just entered the elevator cabin while the cabin is stopped at one of the floor levels. Assuming that the passenger does not walk around in the elevator cabin after having entered it and having found a standing position, i.e. assuming that the initial location of the passenger after having entered the elevator car is constant during the elevator ride, determining the passenger's location based on such reduced map may be sufficient in many cases.

[0031] During the application phase, a current floor lev-

el at which the passenger is currently located may be determined based on data obtained by the smart mobile device. Based on such information, the limited map acquired for this floor level during the learning phase may be used for determining the passenger's current location within the elevator cabin. For example, the current floor level may be determined based on a beacon signal individually transmitted by each of a multiplicity of beacon signal transmitters located at each of the floors in a building, each beacon signal transmitter emitting a beacon signal indicating the identity and/or level of the associated floor. Alternatively, the current floor level could be determined based on an altitude signal obtained in the smart mobile device. Such altitude signal may indicate a current altitude of the smart mobile device for example based on data of a barometric sensor and/or of a GPS sensor, the current altitude being directly correlated to the current floor level.

[0032] According to a specific implementation, during the application phase, the passenger's position may not only be determined upon entering the cabin based on the associated limited map for the current floor level. Instead, additionally, the passenger's position may also be tracked during an elevator ride taking into account further limited maps for other floor levels upon actually reaching these floor levels. For example, when a passenger enters the cabin at a ground floor, his initial position may be determined based on the limited map as previously learned at the ground floor level. Subsequently, when travelling for example to a first floor, the passenger's position may be tracked by determining his position based on the limited map as learned for this first floor level. The passenger's current floor level may be determined based on data obtained in the smart mobile device such as a received floor-individual beacon signal, a barometric signal, a GPS signal, an integration of 3D-accelerometer-signals provided by a 3D-accelerometer-sensor of the smart mobile device, etc.

[0033] Additionally, in case, an initial position of a passenger within the elevator cabin is determined based on the 3D-magnetometer-signals, it may also be possible to subsequently track the passenger's position not based on the 3D-magnetometer-signals but based on the 3D-accelerometer-signals as provided by the smart mobile device's 3D-accelerometer-sensor. For example, a motion of the passenger within the elevator cabin may be tracked by integrating the 3D-accelerometer-signals, thereby obtaining information of the passenger's new positions.

[0034] According to an embodiment, during the learning phase, the map is generated using a robot carrying a 3D-magnetometer and moving around within the elevator cabin.

[0035] In other words, the learning phase may be performed without necessarily needing efforts of human services staff. For example, specific robots may be provided which are configured to autonomously move within the elevator cabin. Such robots may carry a 3D-magne-

tometer. The 3D-magnetometer may be a separate device or may be an integral part of the robot. Accordingly, upon moving around throughout the elevator cabin, the robot may bring the 3D-magnetometer to various measurement locations at which the magnetometer may then measure the required 3D-magnetometer-data.

[0036] Coordinates of the measurement locations may be provided by the robot. For example, the robot may know a specific starting point from which its motion throughout the elevator cabin is started and, furthermore, the robot may provide precise information about its movement path such that, taking into account both information, measurement locations may be precisely localised. Alternatively, the robot may comprise an indoor navigation system, a GPS system or other means for determining precise position information. In a specific implementation, the robot may be configured to vertically move the 3D-magnetometer to different heights such that the 3D-magnetometer may measure 3D-magnetometer-data not only in a single plane parallel to a bottom of the elevator cabin but in multiple planes at different heights. Accordingly, position information defining the location of a measurement of the 3D-magnetometer-data may comprise x-y-coordinates for example along a plane parallel to the bottom of the elevator cabin and, optionally, may further comprise z-coordinates in a height direction vertical to this plane. The robot may then supply such position information together with the 3D-magnetometer-data in order to generate the map. Alternatively, position information may be obtained by a localisation means directly integrated into the 3D-magnetometer.

[0037] According to an embodiment of the second aspect of the invention, upon determining the location of the passenger, the comparison between the actual 3D-magnetometer-signals and the 3D-magnetometer-data comprised in the map is performed in the smart mobile device.

[0038] In other words, the data processing for comparing the 3D-magnetometer-signals measured by the 3D-magnetometer-sensor in the smart mobile device with the 3D-magnetometer-data in the map is performed within the smart mobile device. Generally, such smart mobile device has significant data processing capacity. For example, the smart mobile device may comprise a data processor and/or data storing memory and/or a data transmission interface. Accordingly, the smart mobile device may include all electronic hardware necessary for suitably processing the 3D-magnetometer-signals and 3D-magnetometer-data in order to derive information about the location of the passenger. Optionally, data of the map may be stored within the data storing memory of the smart mobile device. Alternatively, such data may be stored externally, for example in an external server or a data cloud and may be retrieved therefrom.

[0039] Performing the comparison between the actual 3D-magnetometer-signals and the 3D-magnetometer-data within the smart mobile device may be advantageous particularly in cases where the elevator itself has

no or no sufficient data processing capacity. For example, less modern elevators may not comprise an elevator controller including a sufficiently powerful computing unit such that in such elevators no data processing may be performed. By performing data processing mainly within the smart mobile device, hardware requirements for the elevator may be reduced and/or it may be possible to modernise or retrofit older elevators such as to enable implementation of the method proposed herein.

[0040] According to a specific embodiment, the smart mobile device has access to a variety of maps generated for different elevators. In such case, identity information may be transmitted and received by the smart mobile device, the identity information indicating an identity of the elevator in which the smart mobile device is actually located. Furthermore, upon the determining of the location of the passenger, the smart mobile device may select a specific map out of the variety of maps based on the identity information and may perform the comparison of the actual 3D-magnetometer-signals with the 3D-magnetometer-data comprised in the selected specific map.

[0041] In other words, the smart mobile device may not only be configured to use a single map generated for a specific elevator and therefore be able to determine locations of passengers only within this single elevator but may be configured to access a variety of maps generated for different elevators. For example, such different maps may be stored within the smart mobile device's memory. Alternatively, the smart mobile device may retrieve such different maps from a server or a data cloud.

[0042] In such implementation, when the comparison between the actual 3D-magnetometer-signals and the 3D-magnetometer-data is to be performed within the smart mobile device, the smart mobile device has to know in which elevator cabin it is actually used. For this purpose, identity information indicating the identity of the elevator is provided. Such identity information may be transmitted to the smart mobile device such that, upon receiving this identity information, the smart mobile device may select which of the multiple accessible maps shall be used to determine the passenger's location within the current elevator cabin.

[0043] The identity information may be provided and/or transmitted in various ways.

[0044] For example, a light signal may be generated within the elevator cabin and may be received by a light sensor of the smart mobile device. Specifically, a high-frequency pulsating light, preferably having a wavelength invisible for the human eye, may be generated for example at a ceiling of the elevator car and may deliver an encoded message to the light sensor. This message may encode a unique identifier to indicate which elevator cabin the passenger is in.

[0045] Alternatively, the identity information may be provided via a beacon signal transmitted to the smart mobile device, this beacon signal comprising a unique identifier.

[0046] As a further alternative, wireless communica-

tion between the smart mobile device and an elevator controller is conceivable such that the smart mobile device may obtain information about the identity of the elevator from the elevator controller.

[0047] According to an embodiment alternative to performing data processing mainly in the smart mobile device, the comparison between the actual 3D-magnetometer-signals and the 3D-magnetometer-data comprised in the map may be performed in a data processing device being external to the smart mobile device. In such case, the actual 3D-magnetometer-signals may be transmitted by the smart mobile device and may be received by the data processing device.

[0048] In other words, instead of comparing the actual 3D-magnetometer-signals and the 3D-magnetometer-data comprised in the map within the smart mobile device, such comparison may be performed within another data processing device. Such data processing device may be for example part of an elevator controller located in the elevator arrangement. Alternatively, such data processing device may be part of a remote-control device being located remote to the elevator arrangement.

[0049] The map or maps including the 3D-magnetometer-data may be stored in data storage memory of such data processing device. Alternatively, these data may be stored at another location and may be retrieved therefrom upon request.

[0050] The actual 3D-magnetometer-signals measured by the 3D-magnetometer-sensor of the smart mobile device may be transmitted to the external data processing device for example via wireless data transmission.

[0051] Accordingly, based on the comparison between the actual 3D-magnetometer-signals and the 3D-magnetometer-data of the maps, the external data processing device may determine the current location of the passenger carrying the smart mobile device.

[0052] Contrary to the embodiments mentioned further above, in such embodiment it is not necessary to transmit any identity information regarding the identity of the elevator to the smart mobile device as the smart mobile device does not need to know in which elevator it is currently used. Instead, it may be sufficient that the smart mobile device transmits its actual 3D-magnetometer-signals to the external data processing device which may already have the information about the identity of the elevator.

[0053] According to an embodiment of the present invention, the information about the determined location of the passenger may be applied for at least one of:

- providing personalized information to the passenger at the location of the passenger;
- using the information about the determined location of the passenger for optimizing elevator operation;
- using the information about the determined location of the passenger upon monitoring elevator operation.

[0054] In other words, there may be various possibilities of applying or using the information about the location of the passenger as determined by embodiments of the method described herein.

[0055] For example, personalised information may be provided to the passenger at its current location. For such purpose, for example a multiplicity of screens may be provided within the elevator cabin. Via such in-cabin screens, targeted advertising or targeted displaying of information may be provided to the passenger.

[0056] Alternatively or additionally, the information about the current location of a passenger may be used for optimising an operation of the elevator. For example, passenger herding may be implemented in order to arrange passengers for efficient ingress into or egress from the elevator cabin, which may be particularly beneficial in elevators for high-rise buildings.

[0057] Furthermore, alternatively or additionally, the information about the current location of a passenger may be used for optimising monitoring capabilities for monitoring an elevator operation. For example, when it is known that a passenger is located in the elevator cabin at a location close to a cabin door, his mobile phone and its sensors may be used for monitoring an operation of the cabin door for example upon opening or closing the cabin door, such approach being described in the earlier, not yet published European patent application with the application number 18169453.0 of the present applicant.

[0058] Embodiments of the method proposed herein may be performed or controlled by a monitoring device for monitoring locations of a passenger within an elevator cabin in accordance with the above-mentioned second aspect of the invention. Particularly, such monitoring device may be implemented by specifically configuring a smart mobile device using for example specific hardware and/or software adaptations. Alternatively, the monitoring device may be implemented as a part of an elevator controller. As a further alternative, the monitoring device may be implemented as a part of a remote-control for the elevator. Specifically, the monitoring device may obtain 3D-magnetometer-signals and, optionally, 3D-accelerometer-signals from sensors of the smart mobile device via a suitable signal transmission interface. The monitoring device may then have a data processing capacity comparing these actual signals with corresponding data stored in maps generated during a preceding learning phase. Accordingly, the monitoring device may comprise a central processing unit CPU and/or an electronic memory unit with which obtained information received from the sensors of the smart mobile device may be processed and/or stored. Signal communication with the smart mobile device and/or its sensors may be via hardwiring or wireless.

[0059] Furthermore, embodiments of the method proposed herein may be performed or controlled by executing a computer program product in accordance with the above-mentioned fifth aspect of the invention. Such computer program product may be executed for example in

a programmable monitoring device according to the third aspect of the invention. The computer program product may be programmed in any computer readable language.

[0060] Finally, embodiments of the computer readable medium in accordance with the above-mentioned sixth aspect of the invention may be any computer readable medium being able to store the described computer program product. For example, the computer readable medium may be a CD, a DVD, a flash ROM, a PROM or EPROM, etc. Furthermore, the computer readable medium may be a computer or server from which the computer program product may be downloaded.

[0061] It shall be noted that possible features and advantages of embodiments of the invention are described herein partly with respect to a monitoring method and partly with respect to a monitoring device. One skilled in the art will recognize that the features may be suitably transferred from one embodiment to another and features may be modified, adapted, combined and/or replaced, etc. in order to come to further embodiments of the invention.

[0062] In the following, advantageous embodiments of the invention will be described with reference to the enclosed drawing. However, neither the drawing nor the description shall be interpreted as limiting the invention.

[0063] Fig. 1 shows an elevator in which a location of a passenger is to be monitored with a method in accordance with an embodiment of the present invention.

[0064] The figure is only schematic and not to scale.

[0065] Fig. 1 shows an elevator 1 comprising an elevator cabin 3. The elevator cabin 3 may be displaced vertically throughout an elevator shaft 37 and may be stopped for example at various levels adjacent to different floors 35. A passenger 5 may enter the elevator cabin 3 and may move or stay within the elevator cabin 3 at different locations.

[0066] In order to enable monitoring current locations of the passenger 5, a passenger's smart mobile device 7 may be used as forming part of a monitoring device 45. The passenger 5 may carry his smart mobile device 7 for example in one of his hands, in a pocket or elsewhere close to his body such that the location of the smart mobile device 7 essentially corresponds to the location of the passenger 5.

[0067] As indicated in the enlarged partial view in Fig. 1, the smart mobile device 7 may comprise various sensors such as a 3D-magnetometer-sensor 9, a 3D-accelerometer-sensor 11, a light sensor 47 and possibly further sensors (not shown). Furthermore, the smart mobile device 7 may comprise a data processor 25 for processing data and/or signals and a memory 27 for storing data. Additionally, the smart mobile device 7 may comprise a data interface 29 for exchanging data or signals with external devices such as a data processing device 43 comprised in an elevator controller 31 or comprised in a remote monitoring centre 33.

[0068] For determining the current locations of the pas-

senger 5, sensor signals acquired with sensors of the smart mobile device 7 may be compared with sensor data stored in a map 23 which has been generated during a preceding learning phase. The map 23 may comprise location data associated to each of the sensor data, such that, upon the comparison of the actual sensor signals with the sensor data in the map 23, a current location of the passenger 5 may be determined.

[0069] Particularly, the map 23 may comprise multiple sets 49 of measurement values acquired during the learning phase, each set 49 including 3D-location-data 21 representing coordinates (X, Y, Z) of a measurement location at which measurements of physical parameters have been executed during the learning phase. Furthermore, the map 23 may comprise in each of its sets 49 of measurement values various sensors data acquired at the measurement location during the learning phase. Particularly, the sets 49 of measurement values may comprise 3D-magnetometer-data 17 and 3D-orientation data 19.

[0070] Specifically, 3D-magnetometer-signals 13 may be acquired using the 3D-magnetometer-sensor 9 of the smart mobile device 7. These 3D-magnetometer-signals 13 represent a magnitude and orientation of a magnetic field in three dimensions at the location of the 3D-magnetometer-sensor 9. Furthermore, 3D-accelerometer-signals 15 may be acquired using the 3D-accelerometer-sensor 11 of the smart mobile device 7. Such 3D-accelerometer-signal 15 represents a current orientation of the smart mobile device 7 in three dimensions.

[0071] The 3D-magnetometer-signal 13 is then compared with 3D-magnetometer-data 17 stored in the map 23. Particularly, the 3D-magnetometer-signal 13 may be a set composed of three components (Ax, Ay, Az) representing a magnetic field strength in each of three orthogonal directions (x, y, z). The 3D-magnetometer-data 17 comprised in the map 23 may include a multiplicity of sets 49 of measurement values, each set 49 including three components (AMx, AMy, AMz) representing a magnetic field strength in each of the three orthogonal directions (x, y, z). Accordingly, by comparing the components (Ax, Ay, Az) included in the 3D-magnetometer-signal 13 with the components (AMx, AMy, AMz) comprised in each of the sets in the 3D-magnetometer-data 17, a set 49 matching in a best way with the 3D-magnetometer-signal 13 may be identified.

[0072] In order to enable a direct comparison of the actually measured 3D-magnetometer-signal 13 and the 3D-magnetometer-data 17 stored in the map 23, the actual orientation of the smart mobile device 7 as represented by the 3D-accelerometer-signal 15 may be compared with 3D-orientation-data 19 stored in the map 23. Based on such comparison of the actual orientation of the smart mobile device 7 as represented by three components (Bx, By, Bz) in the 3D-accelerometer-signal 15 with the 3D-orientation-data 19 as represented by three components (BMx, BMy, BMz) representing an orientation at which the 3D-magnetometer-data where acquired,

the comparison of the actually measured 3D-magnetometer-signal 13 and the 3D-magnetometer-data 17 may be calibrated.

[0073] Accordingly, upon comparing the actually measured 3D-magnetometer-signal 13 with the 3D-magnetometer-data 17 comprised in the sets 49 of measurement values included in the map 23 and identifying a best match, a location (X, Y, Z) identified in the associated 3D-location-data 21 comprised in this best matching set 49 may be found. Accordingly, the current location of the passenger 5 may be determined.

[0074] A processing of the data and signals may be performed within the smart mobile device 7 itself. For such purpose, one or a multiplicity of maps 23 may be stored in the memory 27 of the smart mobile device 7 or may be made accessible e.g. from a server or a data cloud.

[0075] The data processor 25 of the smart mobile device 7 may then be used for comparing the 3D-magnetometer-signals 13 with the 3D-magnetometer-data 17, possibly taking into account the 3D-accelerometer-signals 15 and 3D-orientation-data 19.

[0076] Finally, the determined information about the location (X, Y, Z) of the passenger 5 may for example be transmitted via the data interface 29 to external devices such as the elevator controller 31 or the remote monitoring centre 33 for further use. For example, the information about the passenger's location may be used for displaying targeted advertising or information to the passenger 5 via one of a multiplicity of screens 51 arranged in a closest neighbourhood to the passenger's location.

[0077] In a simplified approach, maps 23 may be acquired during the learning phase only at each of multiple floor levels, i.e. when the elevator cabin 3 stopped at such floor levels, but no maps 23 are necessarily learned for altitudes in between such floor levels. In the application phase, when a passenger enters the elevator cabin 3, an identity or level of its current floor may be determined, for example based on a received beacon signal, a barometric signal, etc. and a limited map 23 acquired for this floor level may then be used for determining the passenger's 5 position. Optionally, other limited maps 23 may be used for position determination upon reaching other floor levels, this being determined for example based on received beacon signals, barometric signals, GPS signals, integrated accelerometer signals, etc.

[0078] In case, an initial position of a passenger 5 within the elevator cabin 3 is determined based on the 3D-magnetometer-signals 13 as proposed herein, it may also be possible to subsequently track the passenger's position not based on the 3D-magnetometer-signals 13 but based on the 3D-accelerometer-signals 15 as provided by the smart mobile device's 7 3D-accelerometer-sensor 11. For example, a motion of the passenger 5 within the elevator cabin 3 may be tracked by integrating the 3D-accelerometer-signals 15, thereby obtaining information of the passenger's new positions.

[0079] In case there are multiple maps 23 accessible,

each map 23 being previously generated for one of a multiplicity of elevators 1, the smart mobile device 7 should be enabled to determine in which of the multiplicity of elevators 1 it is currently located such that a correct one of the maps 23 may be used in subsequent data processing.

[0080] For such purpose, a signal including an identity information 39 identifying the elevator 1 may be transmitted to the smart mobile device 7. For example, a light source 41 may emit high-frequency pulsating light in order to thereby deliver an encoded message to the light sensor 47 in the smart mobile device 7. This message may encode a unique identifier to indicate which elevator cabin 3 the passenger 5 is currently in. Alternatively, a beacon signal or a signal transmitted upon communication with the elevator controller 31 may be received by the smart mobile device 7 such as to identify the elevator 1.

[0081] Alternatively, the smart mobile device 7 may transmit its 3D-magnetometer-signal 13 and 3D-accelerometer-signal 15 to the external data processing device 43 and the comparison with the 3D-magnetometer-data 17 may be performed in this data processing device 43.

[0082] Finally, it should be noted that the term "comprising" does not exclude other elements or steps and the "a" or "an" does not exclude a plurality. Furthermore, elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

Claims

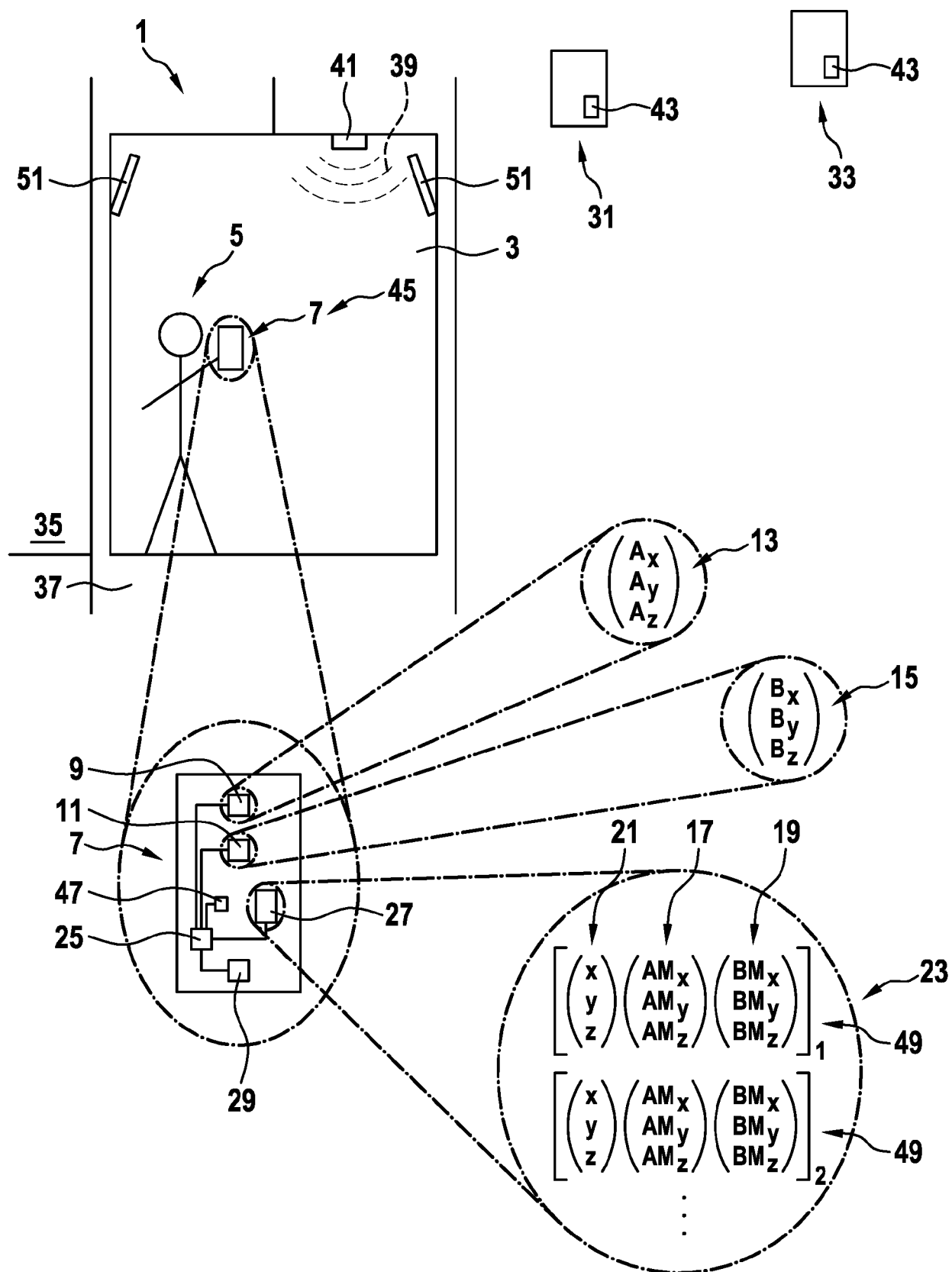
1. Method for monitoring locations of a passenger (5) within an elevator cabin (3) using a passenger's smart mobile device (7), the method comprising a learning phase and an application phase; wherein, during the learning phase, a map (23) is generated, wherein the map (23) comprises local 3D-magnetometer-data (17) for each of multiple locations throughout the elevator cabin (3); and wherein, during the application phase, the location of the passenger (5) is determined based on a comparison of actual 3D-magnetometer-signals (13) measured by a 3D-magnetometer-sensor (9) comprised in the passenger's smart mobile device (7) with the 3D-magnetometer-data (17) comprised in the map (23).
2. Method of claim 1, wherein, during the learning phase, the map (23) is generated such as to comprise for each of the 3D-magnetometer-data (17) additional 3D-orientation-data (19) indicating an orientation of the 3D-magnetometer-data (17), and

wherein, during the application phase, the location of the passenger (5) is determined additionally taking into account a comparison of an orientation of the passenger's smart mobile (7) device indicated by a 3D-accelerometer-signal (15) measured by a 3D-accelerometer-sensor (11) comprised in the passenger's smart mobile device (7) with the 3D-orientation-data (19) comprised in the map (23).

3. Method of one of the preceding claims, wherein, during the learning phase, the map (23) is generated such as to comprise local 3D-magnetometer-data (17) for each of multiple locations throughout the elevator cabin (3) upon the elevator cabin (3) being located at each of multiple levels throughout an elevator shaft (37).
4. Method of one of the preceding claims, wherein, during the learning phase, the map (23) is generated such as to comprises local 3D-magnetometer-data (17) for each of multiple locations throughout the elevator cabin (3) upon the elevator cabin (3) being stopped at each of multiple floors (35).
5. Method of one of the preceding claims, wherein, during the learning phase, the map (23) is generated using a robot carrying a 3D-magnetometer and moving around within the elevator cabin (3).
6. Method for monitoring locations of a passenger (5) within an elevator cabin (3) using a passenger's smart mobile device (7), the method comprising: determining the location of the passenger (5) based on a comparison of actual 3D-magnetometer-signals (13) measured by a 3D-magnetometer-sensor (9) comprised in the passenger's smart mobile device (7) with 3D-magnetometer-data (17) comprised in a map (23), wherein the map (23) was generated during a preceding learning phase such as to comprise the 3D-magnetometer-data (17) locally for each of multiple locations throughout the elevator cabin (3).
7. Method of claim 6, wherein the map (23) was generated such as to comprise for each of the 3D-magnetometer-data (17) additional 3D-orientation-data (19) indicating an orientation of the 3D-magnetometer-data (17), and wherein the location of the passenger (5) is determined additionally taking into account a comparison of an orientation of the passenger's smart mobile device (7) indicated by a 3D-accelerometer-signal (15) measured by a 3D-accelerometer-sensor (11) comprised in the passenger's smart mobile device (7) with the 3D-orientation-data (19) comprised in the map (23).

8. Method of one of claims 6 and 7,
wherein the comparison between the actual 3D-magnetometer-signals (13) and the 3D-magnetometer-data (17) comprised in the map (23) is performed in the smart mobile device (7). 5
9. Method of claim 8,
wherein the smart mobile device (7) has access to a variety of maps (23) generated for different elevators (1),
wherein identity information (39) is transmitted and received by the smart mobile device (7), the identity information (39) indicating an identity of the elevator (1) in which the smart mobile device (7) is actually located, and 10
wherein, upon the determining of the location of the passenger (5), the smart mobile device (7) selects a specific map (23) out of the variety of maps (23) based on the identity information (39) and performs the comparison of the actual 3D-magnetometer-signals (13) with the 3D-magnetometer-data (17) comprised in the selected specific map (23). 15 20
10. Method of one of claims 6 and 7,
wherein the comparison between the actual 3D-magnetometer-signals (13) and the 3D-magnetometer-data (17) comprised in the map (23) is performed in a data processing device (43) being external to the smart mobile device (7); and 25
wherein the actual 3D-magnetometer-signals (13) are transmitted by the smart mobile device (7) and are received by the data processing device (43). 30
11. Method of one of claims 6 to 10,
wherein information about the determined location of the passenger (5) is applied for at least one of: 35
- providing personalized information to the passenger (5) at the location of the passenger (5);
- using the information about the determined location of the passenger (5) for optimizing elevator operation; 40
- using the information about the determined location of the passenger (5) upon monitoring elevator operation. 45
12. Monitoring device (45) being configured for monitoring locations of a passenger (5) within an elevator cabin (3) by being configured for at least one of performing and controlling the method according to one of claim 6 to 11. 50
13. Elevator (1) being configured for monitoring locations of a passenger (5) within an elevator cabin (3) by being configured for at least one of performing and controlling the method according to one of claim 6 to 11. 55
14. Computer program product comprising computer readable instructions which, when performed by a processor (25) of a monitoring device (45), instruct the monitoring device (45) to at least one of performing and controlling the method according to one of claims 6 to 11.
15. Computer readable medium comprising a computer program product according to claim 14 stored thereon.

Fig. 1



**PARTIAL EUROPEAN SEARCH REPORT**

Application Number

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of
subsequent proceedings, as the European search report

EP 18 17 5872

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2014/320121 A1 (PERTTUNEN MIKKO [FI] ET AL) 30 October 2014 (2014-10-30) * abstract * * paragraphs [0025] - [0049] * * figures 1-7 *	6-15	INV. B66B1/34 B66B5/00
X	EP 3 184 963 A1 (THOMSON LICENSING [FR]) 28 June 2017 (2017-06-28) * abstract * * paragraphs [0013] - [0045] * * figures 1-17 *	6-15	
X	WO 2013/065042 A1 (RONEN SHAI [IL]) 10 May 2013 (2013-05-10) * abstract * * paragraphs [0070] - [0326] * * figures 1-29 *	6-15	
A,D	WO 2004/084556 A1 (INVENTIO AG [CH]; DEPLAZES ROMEO [CH]; CORTONA ELENA [CH]) 30 September 2004 (2004-09-30) * the whole document *	6-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B66B

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

3

Place of search	Date of completion of the search	Examiner
The Hague	3 December 2018	Oosterom, Marcel
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 03/82 (P04E07)

**INCOMPLETE SEARCH
SHEET C**Application Number
EP 18 17 5872

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Claim(s) completely searchable:
6-15

Claim(s) not searched:
1-5

Reason for the limitation of the search:

1. The present application contains two independent claims of the same category, namely independent method claim 1 (with dependent claims 2 to 5) and independent method claim 6 (with dependent claims 7 to 11), which do not fall under one of the exceptions under Rule 43(2) EPC.

In response to the invitation under Rule 62a EPC, the applicant indicated that the search is to be carried out on the basis of claims 6 to 15.

Consequently, claims 1 to 5 have not been searched.

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

EP 18 17 5872

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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03-12-2018

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REFERENCES CITED IN THE DESCRIPTION

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- WO 2004084556 A1 [0004]
- EP 18169453 A [0057]