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(54) **DETERMINING WHEN TO INITIATE AN ACCESS CONTROL PROCEDURE**

(57) It is provided a method for determining when to initiate an access control procedure of a portable key device for unlocking a lock controlling access to a physical space. The method being performed in an access control device connected to the lock. The method comprised the steps of: repeatedly determining a position of the portable key device in relation to the lock; repeatedly calculating a direction of movement based on determined positions; determining when there is intent to open the lock based on the direction of movement; and initiating an access control procedure when intent to open the lock is determined

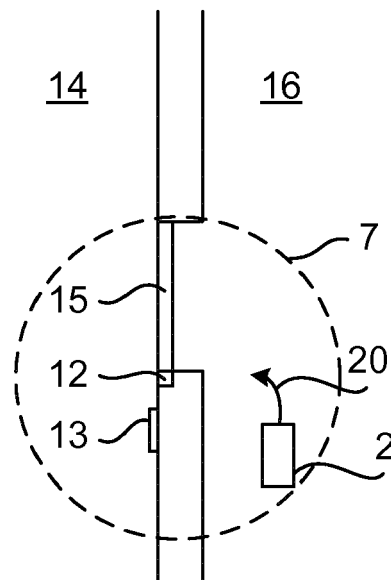


Fig. 2B

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Description

TECHNICAL FIELD

[0001] The invention relates to a method, access control device, computer program and computer program product for determining when to initiate an access control procedure of a portable key device for unlocking a lock, wherein the lock controls access to a physical space.

BACKGROUND

[0002] Locks and keys are evolving from the traditional pure mechanical locks. These days, there are wireless interfaces for electronic locks, e.g. by interacting with a portable key device. For instance, Radio Frequency Identification (RFID) has been used as the wireless interface.

[0003] When RFID is used, the user needs to present the portable key device in close proximity to a reader connected to the lock. In order to provide a more user friendly solution, wireless interfaces with greater range are starting to be used. This allows the interaction between the portable key device and the lock to occur without user interaction, e.g. with a portable key device being located in a pocket or handbag. However, in such a situation, there is a risk that a user unintentionally unlocks the lock, for instance by simply walking by the reader.

SUMMARY

[0004] It is an object to determine when there is intent of a user to open a lock to thereby prevent unintentional opening of locks, without the need for a user to explicitly handle the key.

[0005] According to a first aspect it is provided a method for determining when to initiate an access control procedure of a portable key device for unlocking a lock controlling access to a physical space. The method being performed in an access control device connected to the lock. The method comprised the steps of: repeatedly determining a position of the portable key device in relation to the lock; repeatedly calculating a direction of movement based on determined positions; determining when there is intent to open the lock based on the direction of movement; and initiating an access control procedure when intent to open the lock is determined.

[0006] The method may further comprise the step of: starting the method only when the portable key device is located in a predetermined area in relation to the lock.

[0007] The method may further comprise the step of: repeatedly calculating a speed of movement based on determined positions: In such a case, the step of determining comprises determining when there is intent also based on the speed of movement.

[0008] The step of determining when there is intent may comprise determining that there is intent when the direction of movement is towards the lock and the speed of movement slows down as the position of the portable

key device becomes closer to the lock.

[0009] The step of determining may comprise determining when there is intent also based on the position.

[0010] The access control device may be connected to a plurality of locks controlling access to respective physical spaces. In such a case, the step of determining when there is intent comprises determining whether there is intent to open for any of the plurality of locks.

[0011] According to a second aspect it is provided an access control device arranged to determine when to initiate an access control procedure of a portable key device for unlocking a lock controlling access to a physical space. The access control device comprises: a processor; and a memory storing instructions that, when executed by the processor, cause the access control device to: repeatedly determine a position of the portable key device in relation to the lock; repeatedly calculate a direction of movement based on determined positions; determine when there is intent to open the lock based on the direction of movement; and initiate an access control procedure when intent to open the lock is determined.

[0012] The access control device may further comprise instructions that, when executed by the processor, cause the access control device to: start the mentioned instructions only when the portable key device is located in a predetermined area in relation to the lock.

[0013] The access control device may further comprise instructions that, when executed by the processor, cause the access control device to repeatedly calculate a speed of movement based on determined positions. In such a case, the instructions to determine comprise instructions that, when executed by the processor, cause the access control device to determine when there is intent also based on the speed of movement.

[0014] The instructions to determine when there is intent may comprise instructions that, when executed by the processor, cause the access control device to determine that there is intent when the direction of movement is towards the lock and the speed of movement slows down as the position of the portable key device becomes closer to the lock.

[0015] The instructions to determine may comprise instructions that, when executed by the processor, cause the access control device to determine when there is intent also based on the position.

[0016] The access control device may be connectable to a plurality of locks controlling access to respective physical spaces. In such a case, the instructions to determine when there is intent comprise instructions that, when executed by the processor, cause the access control device to determine whether there is intent to open for any of the plurality of locks.

[0017] According to a third aspect it is provided a computer program for determining when to initiate an access control procedure of a portable key device for unlocking a lock controlling access to a physical space. The computer program comprises computer program code which, when run on an access control device, causes the access

control device to: repeatedly determine a position of the portable key device in relation to the lock; repeatedly calculate a direction of movement based on determined positions; determine when there is intent to open the lock based on the direction of movement; and initiate an access control procedure when intent to open the lock is determined.

[0018] According to a fourth aspect it is provided a computer program product comprising a computer program according to the third aspect and a computer readable means on which the computer program is stored.

[0019] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig 1 is a schematic diagram showing an environment in which embodiments presented herein can be applied;

Figs 2A-B are schematic top view diagrams illustrating when an access control procedure should be initiated or not, in the environment shown in Fig 1;

Fig 3 is a schematic top view diagram illustrating when an access control procedure should be initiated in a situation where a plurality of locks are connected to an access control device;

Fig 4 is a flow chart illustrating an embodiment of a method performed in the access control device of Fig 1 for determining when to initiate an access control procedure of a portable key device for unlocking a lock;

Fig 5 is a schematic diagram illustrating an embodiment of the access control device of Figs 1-3; and

Fig 6 shows one example of a computer program product comprising computer readable means.

DETAILED DESCRIPTION

[0021] The invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are

shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout the description.

[0022] Fig 1 is a schematic diagram showing an environment in which embodiments presented herein can be applied. Access to a physical space 16 is restricted by a physical barrier 15 which is selectively unlockable. The physical barrier 15 stands between the restricted physical space 16 and an accessible physical space 14. Note that the accessible physical space 14 can be a restricted physical space in itself, but in relation to this physical barrier 15, the accessible physical space 14 is accessible. The barrier 15 can be a door, gate, hatch, cabinet door, drawer, window, etc. In order to unlock the barrier 15, an access control device 13 is provided. The access control device 13 is connected to a physical lock 12, which is controllable by the access control device 13 to be set in an unlocked state or locked state.

[0023] The access control device 13 communicates with a portable key device 2 over a wireless interface using a plurality of antennas 5a-b. The portable key device 2 is any suitable device portable by a user and which can be used for authentication over the wireless interface. The portable key device 2 is typically carried or worn by the user and may be implemented as a mobile phone, a smartphone, a key fob, wearable device, smart phone case, RFID (Radio Frequency Identification) card, etc. In Fig 1, two antennas 5a-b can be seen. However, there may be more antennas provided in connection with the access control device 13. Using wireless communication, the authenticity and authority of the portable key device can be checked in an access control procedure, e.g. using a challenge and response scheme, after which the access control device 13 grants or denies access. Alternatively or additionally, the portable key device 2 can be used in the same way to, when granted, trigger the barrier to be opened e.g. using a door opener. The antennas may also be used in determining a position of the portable key device 2, e.g. using angle of arrival.

[0024] Providing multiple antennas provides additional benefits. For instance, the antennas can be used for beam forming, multiple input/multiple output (MIMO) transmissions, redundancy between antennas, differential antennas, etc.

[0025] When the access control procedure results in granted access, the access control device 13 sends an unlock signal to the lock 12, whereby the lock 12 is set in an unlocked state. In this embodiment, this can e.g. imply a signal over a wire-based communication, e.g. using a serial interface (e.g. RS485, RS232), Universal SerialBus (USB), Ethernet, or even a simple electric connection (e.g. to the lock 12), or alternatively using a wireless interface. When the lock 12 is in an unlocked state,

the barrier 15 can be opened and when the lock 12 is in a locked state, the barrier 15 cannot be opened. In this way, access to a closed space 16 is controlled by the access control device 13. It is to be noted that the access control device 13 and/or the lock 12 can be mounted in a fixed structure (e.g. wall, frame, etc.) by the physical barrier 15 (as shown) or in the physical barrier 15 (not shown).

[0026] Figs 2A-B are schematic top view diagrams illustrating when an access control procedure should be initiated or not, in the environment shown in Fig 1. As is explained in more detail below, the position of the portable key device 2 is repeatedly determined. Based on consecutive positions, this allows the speed and direction of travel of the portable key device 2 to be repeatedly determined.

[0027] Looking first to Fig 2A, the portable key device 2 here moves in a direction 20 straight past the lock 12. The speed is essentially constant. Such a movement indicates that a user carrying the portable key device 2 has no intent of passing through the barrier 15. Hence, no access control procedure is initiated, whereby the lock 12 is prevented from opening simply by the passing of the portable key device 2. It is to be noted that in this scenario, the portable key device 2 is located within the access controlled physical space 16; however, the same procedure can be applied when the portable key device 2 is located within the accessible physical space 14.

[0028] Optionally, the portable key device 2 needs to be within a predetermined area 7 in relation to the lock 12 to even be under consideration for the access control procedure.

[0029] Looking now to Fig 2B, the portable key device 2 here moves in a direction 20 towards the barrier 15 and/or the lock device 12. Also, the speed of movement of the portable key device 2 decreases as the portable key device 2 approaches the barrier 15. Together, this is an indication of intent to open the lock 12. The access control device 13 detects the direction (towards the lock) and speed of movement (slowing down), thereby determining the intent to open and initiates the access control procedure which, if successful, opens the lock 12.

[0030] Fig 3 is a schematic top view diagram illustrating when an access control procedure should be initiated in a situation where a plurality of locks are connected to an access control device.

[0031] In this embodiment, a single access control device 13 is used to control access for four different locks 12a-d controlling four respective barriers 15a-d for access to respective restricted physical spaces 16a-d.

[0032] Also here, the position, direction of movement and speed of movement of the portable key device 2 is repeatedly determined. In analogy with what is explained above, the direction and speed can be used to determine intent of a user carrying the portable key device 2 to open a lock. However, here, the access control device also determines which one of a plurality of locks that the user indicates intent to open. In this example, the access con-

trol device 13 determines that there is an intent to open the third lock 12c.

[0033] Using this system, the locks 12a-d can be simple devices which do not need individual capability of access control, since intent to open a particular lock can be determined by the access control device 13, even when used for a plurality of locks. By using a single access control device 13 for a plurality of locks, a very cost effective solution is provided compared to if each lock needs its own access control device.

[0034] Fig 4 is a flow chart illustrating an embodiment of a method performed in the access control device of Fig 1 for determining when to initiate an access control procedure of a portable key device for unlocking a lock. As explained above, the lock controls access to a physical space.

[0035] In an optional conditional *close to lock* step 40, it is determined whether the portable key device is located in a predetermined area in relation to the lock, here also denoted close to the lock. The area can be defined as a certain distance from the lock, a certain distance from the barrier associated with the lock, or any other suitable shape. Optionally, the portable key device needs to be within the predetermined area longer than a threshold duration for the portable key device to be considered to be in the predetermined area. This prevents people quickly passing by a lock from being considered to be close to the lock to trigger the intent determination. It is to be noted that there may exist a second longer duration which, if exceeded when the portable key device is within the predetermined area determines intent, regardless of direction etc. as determined below. If the portable key device is determined to be close to the lock, the method proceeds to a *determine position* step 42. Otherwise, this step is repeated, optionally via a delay (not shown).

[0036] In the *determine position* step 42, a position of the portable key device is determined. The position can be determined in relation to the lock. The position can be determined using any suitable procedure. For instance, the position of the portable key device can be determined based on angle of arrival measurements. Angle of arrival measurements can be done when there are at least two antennas. When a wireless signal is received from the portable key device 2, a time difference in receiving the wireless signal can be detected. This can e.g. be detected using a phase difference between the received signals. Using the time difference, an angle of arrival (AoA) is calculated. The AoA is an angle in relation to a line between the antennas. The measurement can be performed for two pairs of antennas (optionally one antenna is mutual in the two pairs), to obtain two lines of direction to the portable key device 2. The position of the portable key device can then be determined as the position where the two lines cross. More pairs of antennas can be used to gain better precision and/or position determination in three dimensions.

[0037] Alternative or additional procedures for determining position of the portable key device can be applied

such as time or arrival, inertia sensors in the portable key device, etc.

[0038] In a *calculate direction* step 44, direction of movement of the portable key device 2 is calculated based on at least two consecutive positions determined in the *determine position* step 42.

[0039] In an optional *calculate speed* step 45, speed of movement of the portable key device 2 is calculated based on at least two consecutive positions determined in the *determine position* step 42. Timestamps for the positions are also used to determine speed.

[0040] In a conditional *intent to open* step 46, the access control device determines when there is intent to open the lock based on the direction of movement. Optionally, the intent is also determined based on the speed of movement of the portable key device. Optionally, the intent is also determined based on the position of the portable key device 2. In one example, intent can be determined when the direction of movement is towards the lock and the position is within a certain distance from the lock. In one example, intent can be determined when the direction of movement is towards the lock and the speed of movement slows down as the position of the portable key device becomes closer to the lock.

[0041] When there is intent, the method proceeds to the *initiate access control* step 48. When there is no intent, the method returns to step 40, or step 42 when step 40 is not executed.

[0042] In the *initiate access control* step 48, an access control procedure is initiated when intent to open the lock is determined. The access control procedure is then performed as known in the art per se, e.g. using a challenge-response protocol between the access control device and the portable key device. It is to be noted that the access control procedure can be performed in the access control device performing this method. Alternatively, the device performing the access control procedure is a separate device in the same location or in a different location as the access control device performing this method.

[0043] Optionally, as shown in Fig 3 and explained above, the access control device is connected to a plurality of locks controlling access to respective physical spaces. In such a case, conditional *intent to open* step 46 comprises determining whether there is intent to open for any of the plurality of locks. In such a case, the intent to open can be determined for one lock at a time until an intent for a lock is found or until intent for all of the plurality of locks has been checked.

[0044] Using this method, the active range for the lock can be reduced, which reduces the risk of a man in the middle attack.

[0045] Fig 5 is a schematic diagram illustrating an embodiment of the access control device 13 of Fig 1.

[0046] A processor 60 controls the general operation of access control device 13. The processor 60 can be any combination of one or more of a suitable central processing unit (CPU), multiprocessor, microcontroller unit (MCU), digital signal processor (DSP), application

specific integrated circuit (ASIC) etc., capable of executing software instructions or otherwise configured to behave according to predetermined logic. Hence, the processor 60 can be capable of executing software instructions 66 stored in a memory 64, which can thus be a computer program product. The processor 60 can be configured to execute the method described with reference to Fig 4 above.

[0047] The memory 64 can be any combination of random access memory (RAM) and read only memory (ROM). The memory 64 also comprises persistent storage, which, for example, can be any single one or combination of magnetic memory, optical memory, solid state memory or even remotely mounted memory.

[0048] A data memory 65 is also provided for reading and/or storing data during execution of software instructions in the processor 60, for instance positions, directions and speeds for one or more portable key devices. The data memory 65 can be any combination of random access memory (RAM) and read only memory (ROM).

[0049] The access control device 13 further comprises an I/O interface 63 for communicating with other external entities such as one or more locks 12 and a portable key device 2, e.g. to exchange digital authentication data. The I/O interface 63 communicates with the portable key device 2 over a wireless interface using a plurality of antennas 5. The antennas 5, as explained above, can be used to determine the position of the portable key device. The I/O interface 63 supports wireless communication over any suitable wireless interface, e.g. using Bluetooth, Bluetooth Low Energy (BLE), any of the IEEE 802.15 standards, Radio Frequency Identification (RFID), Near Field Communication (NFC), any of the IEEE 802.11 standards, wireless USB, etc. For communication with the lock 12, the I/O interface 63 may also support any of the wireless interfaces or wire based communication, e.g. using Universal Serial Bus (USB), Ethernet, serial connection (e.g. RS-485).

[0050] Optionally, the access control device 13 also includes a user interface 9, e.g. comprising any one or more of a light emitting diodes (LED) or other lights, a display, keys or keypad, etc.

[0051] Optionally, the access control device 13 is combined with the lock 12 in a single device. In such a case, one or more of the components of the access control device 13 can be shared with the lock 12.

[0052] Fig 6 shows one example of a computer program product comprising computer readable means. On this computer readable means a computer program 91 can be stored, which computer program can cause a processor to execute a method according to embodiments described herein. In this example, the computer program product is an optical disc, such as a CD (compact disc) or a DVD (digital versatile disc) or a Blu-Ray disc. As explained above, the computer program product could also be embodied in a memory of a device, such as the computer program product 64 of Fig 5. While the computer program 91 is here schematically shown as a

track on the depicted optical disk, the computer program can be stored in any way which is suitable for the computer program product, such as a removable solid state memory, e.g. a Universal Serial Bus (USB) drive.

[0053] The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

Claims

1. A method for determining when to initiate an access control procedure of a portable key device (2) for unlocking a lock (12, 12a-d) controlling access to a physical space (16), the method being performed in an access control device (13) connected to the lock, the method comprising the steps of:

repeatedly determining (42) a position of the portable key device (2) in relation to the lock (12, 12a-d);
repeatedly calculating (44) a direction of movement based on determined positions;
determining (46) when there is intent to open the lock based on the direction of movement;
and
initiating (48) an access control procedure when intent to open the lock is determined.

2. The method according to claim 1, further comprising the step of:

starting (40) the method only when the portable key device (2) is located in a predetermined area (7) in relation to the lock (12, 12a-d).

3. The method according to claim 1 or 2, further comprising the step of:

repeatedly calculating (45) a speed of movement based on determined positions; and
wherein the step of determining (46) comprises determining when there is intent also based on the speed of movement.

4. The method according to claim 3, wherein the step of determining (46) when there is intent comprises determining that there is intent when the direction of movement is towards the lock and the speed of movement slows down as the position of the portable key device becomes closer to the lock.

5. The method according to any one of the preceding claim wherein the step of determining (46) comprises determining when there is intent also based on the

position.

6. The method according to any one of the preceding claims, wherein the access control device (13) is connected to a plurality of locks (12a-d) controlling access to respective physical spaces, and wherein the step of determining when there is intent comprises determining whether there is intent to open for any of the plurality of locks (12a-d).

7. An access control device (13) arranged to determine when to initiate an access control procedure of a portable key device (2) for unlocking a lock (12, 12a-d) controlling access to a physical space (16), the access control device comprising:

a processor (60); and
a memory (64) storing instructions (66) that, when executed by the processor, cause the access control device (3) to:

repeatedly determine a position of the portable key device (2) in relation to the lock (12, 12a-d);
repeatedly calculate a direction of movement based on determined positions;
determine when there is intent to open the lock based on the direction of movement;
and
initiate an access control procedure when intent to open the lock is determined.

8. The access control device according to claim 7, further comprising instructions (66) that, when executed by the processor, cause the access control device (3) to:

start the mentioned instructions only when the portable key device (2) is located in a predetermined area in relation to the lock (12, 12a-d).

9. The access control device according to claim 7 or 8, further comprising instructions (66) that, when executed by the processor, cause the access control device (3) to repeatedly calculate a speed of movement based on determined positions; and wherein the instructions to determine comprise instructions (66) that, when executed by the processor, cause the access control device (3) to determine when there is intent also based on the speed of movement.

10. The access control device according to claim 9, wherein the instructions to determine when there is intent comprise instructions (66) that, when executed by the processor, cause the access control device (3) to determine that there is intent when the direction of movement is towards the lock and the speed of movement slows down as the position of the portable

key device becomes closer to the lock.

11. The access control device according to any one of claims 7 to 10, wherein the instructions to determine comprise instructions (66) that, when executed by the processor, cause the access control device (3) to determine when there is intent also based on the position. 5
12. The access control device according to any one of claims 7 to 11, wherein the access control device (13) is connectable to a plurality of locks (12a-d) controlling access to respective physical spaces, and wherein the instructions to determine when there is intent comprise instructions (66) that, when executed by the processor, cause the access control device (3) to determine whether there is intent to open for any of the plurality of locks (12a-d). 10 15
13. A computer program (91) for determining when to initiate an access control procedure of a portable key device (2) for unlocking a lock (12, 12a-d) controlling access to a physical space (16), the computer program comprising computer program code which, when run on an access control device (13), causes the access control device (13) to: 20 25

repeatedly determine a position of the portable key device (2) in relation to the lock (12, 12a-d);
repeatedly calculate a direction of movement based on determined positions; 30
determine when there is intent to open the lock based on the direction of movement; and
initiate an access control procedure when intent to open the lock is determined. 35
14. A computer program product (90) comprising a computer program according to claim 13 and a computer readable means on which the computer program is stored. 40

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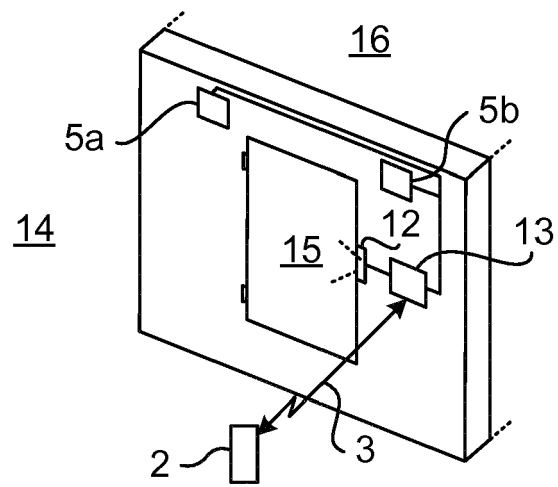


Fig. 1

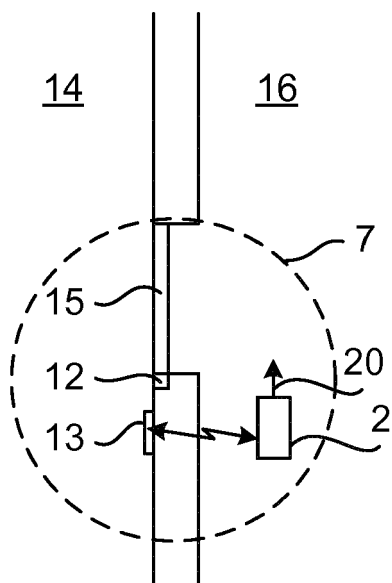


Fig. 2A

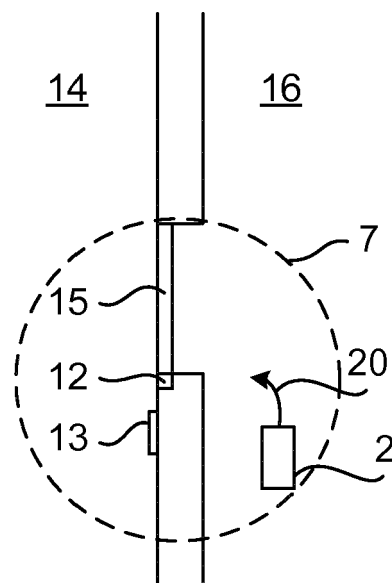


Fig. 2B

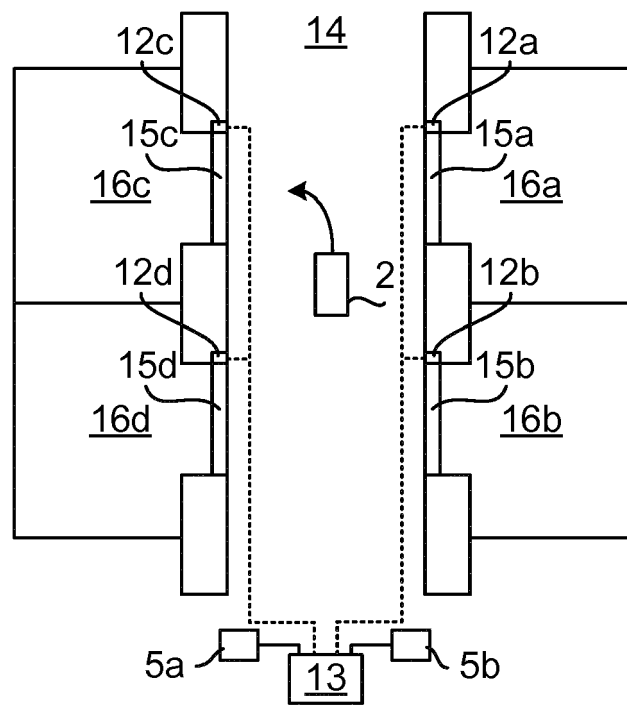


Fig. 3

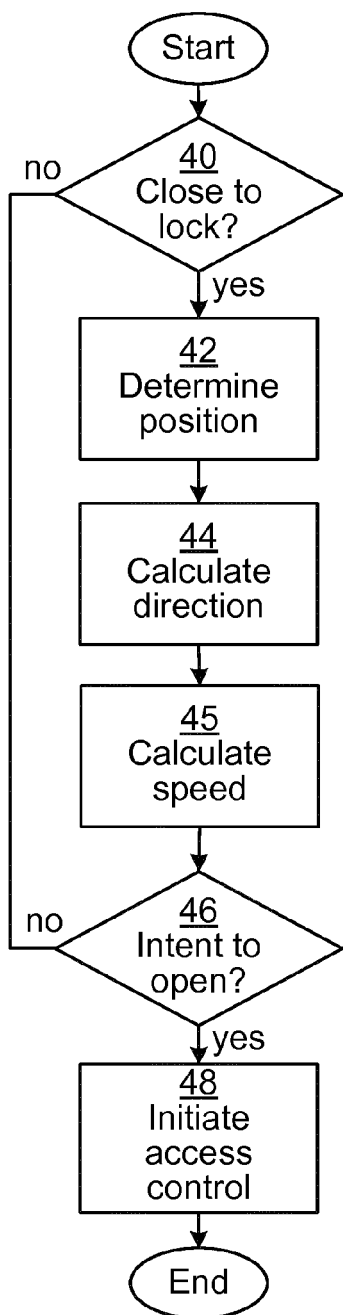


Fig. 4

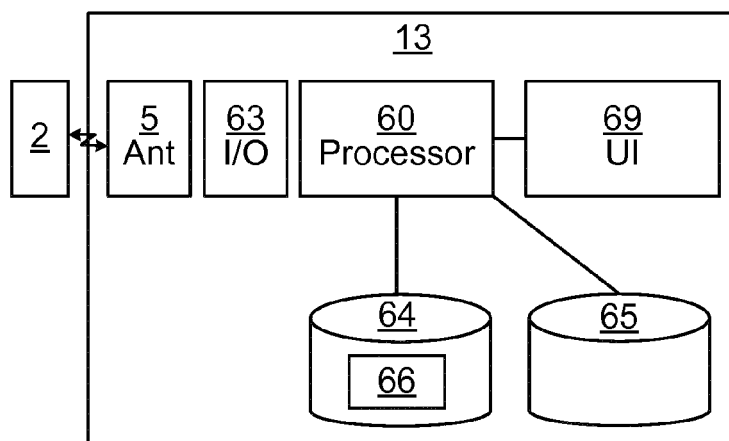


Fig. 5

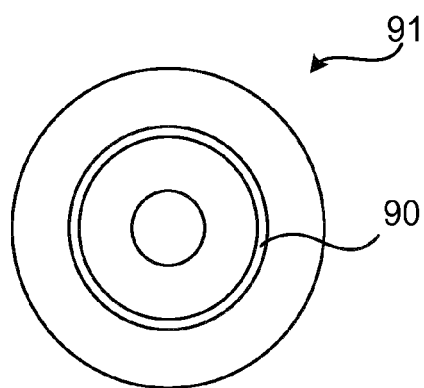


Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 15 18 6838

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X	US 8 935 052 B2 (HERMANN STEFAN [DE]) 13 January 2015 (2015-01-13) * column 2, line 1 - column 3, line 39 * * column 4, line 15 - column 5, line 64 * * column 8, line 45 - column 13, line 14 * * abstract; figures *	1-14	INV. G07C9/00
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 23 March 2016	Examiner Miltgen, Eric
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			

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

EP 15 18 6838

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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