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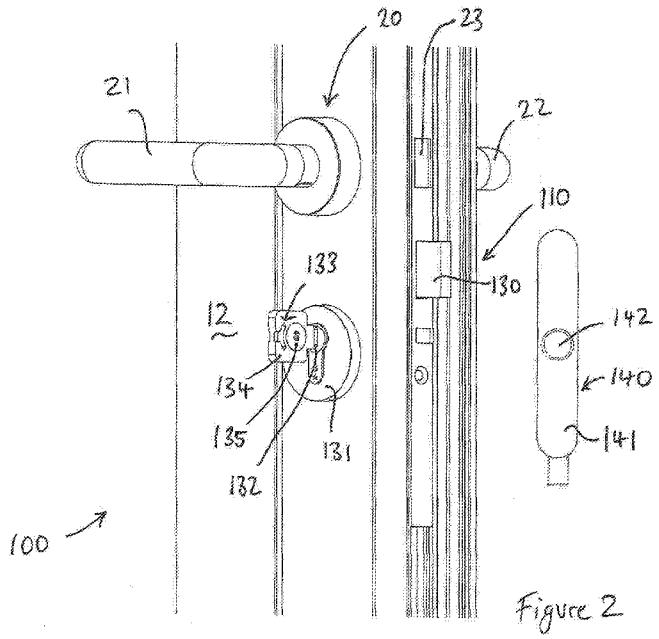

Figure 2

(57) Abstract: A locking system comprising at least one sensed element integral with or attached in use to a target object associated with a lock, said at least one sensed element preferably comprising a magnetic field generator for generating a magnetic field, the locking system further comprising sensing means configured for sensing the sensed element and processor means configured to receive output signals from the sensing means and to determine one or more lock statuses based on the output signals of the sensing means. The system may be used to determine one or more types of lock status, such statuses indicating if a key has been left in the lock, if the lock is locked / unlocked and/or which key of a set of keys has been in the lock.

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A LOCKING SYSTEM

Field of the Invention

The present invention relates to a locking system having at least one locking device for driving a lock. The present invention also relates to individual parts of the locking system. In particular, the invention relates to locking systems for windows and doors.

Background

With the wide-spread use of computers and mobile devices has come an increased presence of home automation. As well as automating the home, it would be useful to be able to monitor devices, including security devices such as locks, and in particular to monitor a range of different possible lock statuses.

Summary of Invention

According to a first aspect of the invention there is provided a locking system comprising at least one sensed element integral with or attached in use to a target object associated with a lock, the locking system further comprising sensing means, the sensed element being sensed by the sensing means in use and processor means configured to receive output signals from the sensing means and to determine one or more lock statuses based on the output signals of the sensing means.

The locking system is preferably for a window or a door, the locking assembly being for locking and unlocking the window or door. The system is configured to generate an output indicating one or more lock statuses based on the signal sensed from the sensed element, such as magnetic field if the sensed element a magnetic field generator. The system is configured to sense the presence, proximity, position and/or orientation of the sensed element in order to determine the status of the lock. The sensing means senses changes in signal from the sensed element, such as changes in magnetic field if the sensed element is a magnetic field generator. The system may have more than one target object, each having at least one sensed element attached to or integral with it.

Preferably said at least one sensed element comprises a magnetic field generator for generating a magnetic field, the sensing means being configured for sensing a magnetic field, the processor means being configured to receive output signals associated with measured magnetic field from the sensing means to determine one or more lock statuses based on the sensed magnetic field.

Preferably the lock is driven by a key, the lock being configured to receive the key for driving the lock, the system being configured to generate an output in response to the sensing means sensing the key engaged in the lock. Suitably the processor is configured to receive output signals from the sensing means and to indicate if a key is in the lock. This will indicate to the user if a key has been left in the lock. The key has an engaged configuration wherein it is inserted in the lock (whether the key is in a locked or unlocked position) and the system can be used to detect whether the key is in the engaged configuration. If the system detects the key in the engaged configuration, the system enters an alert mode so that an alert can be generated for the use. The key is configured to be turned to lock/unlock the lock assembly when in its inserted position.

Preferably the system is configured to generate an output in response to the sensing means sensing the key engaged in the lock for longer than a predetermined period of time. The output generated may cause the locking system to enter an alert mode. When in the alert mode, the system may cause one of the following output devices to be activated:

(i) an audio alert means

(ii) a remote user display means such as or a user interface

Preferably the lock is for a window or door leaf, the leaf being moveable relative to a frame between a closed position and an open position, the locking system further comprising means for determining whether the leaf is in its closed position, the locking system further being configured to generate an output in response to sensing the key engaged in the lock and sensing the leaf in the closed position. The system may be configured to cause the locking system to enter an alert mode in which an output is generated to the user in response to sensing the key present in the lock and sensing the leaf in the closed position for longer than a predetermined time. The system may be able to determine whether the leaf is in its closed position by means of a sensed element, such as a magnetic field generator located on the leaf, wherein the magnetic field sensed by the magnetometer will change depending whether the leaf is closed or other than closed (i.e. open). Alternatively

other detection means can be used to determine whether the leaf is in its closed position and to provide output signals to the processor means of the locking system.

Preferably the system comprises a key for driving the lock, the at least one sensed element being located on the key. The target object is a key in this embodiment. Preferably the key has a key bow, said at least one sensed element being located on the key bow.

Preferably the system comprises a key fob, the key fob being attached to the key in use, said at least one sensed element being integral with or mounted on the key fob such that the sensing means is able to sense the presence of the key fob when the key is engaged in the lock. The target object is a key fob in this embodiment. The key fob (also known as a key chain or key ring) may be any device that may be removably attachable to the key, for example a key chain body with a magnet mounted thereon, the key chain body being attachable to the key by any suitable means such as a split ring device. The key fob has an engaged configuration wherein the key to which the key fob is attached is inserted in the lock (whether the key is in a locked or unlocked position) and the system can be used to detect whether the key fob is in the engaged configuration. If the system detects the key fob in the engaged configuration, the system enters an alert mode so that an alert can be generated for the user.

Preferably the system further comprises a lock mechanism that is operable by a key, said at least one sensed element being located in the lock mechanism in use and wherein said at least one sensed element is moveable between a first position and a second position, the sensed element being at the first position when there is no key in an engaged configuration in the lock and the sensed element being caused to move to the second position when a key is inserted in the lock. The sensed element is integral with the target object in this embodiment.

Preferably the key further comprises a lock interacting portion for insertion in the lock, the lock mechanism having a keyway for receiving the lock interacting portion of the key, the lock interacting portion of the key having an insertion end for insertion into the keyway, said at least one sensed element being located in the keyway such that the insertion end of the key pushes the sensed element to its second position when the key is engaged in the lock. The at least one sensed element is preferably biased towards the first position. The at least one sensed element is preferably moveable via translation along a longitudinal

axis parallel with the keyway between its first and second positions. Said at least one sensed element may be moved by a key engaged in the lock mechanism on either side of the leaf, allowing the system to determine if a key has been left in the lock and on which side of the leaf it has been left.

Preferably the locking system comprises a rotatable member on which the at least one sensed element, comprising a magnetic field generator, is located in use that is rotatable between a locked configuration corresponding to a locked state of the lock and an unlocked configuration corresponding to an unlocked state of the lock, the sensing means being mounted in use to a reference structure that the rotatable member is rotatable relative to between its locked and unlocked configurations such that the system can sense whether the lock is in a locked or unlocked state based on the measured magnetic field generated by the magnetic field generator. The target object is the rotatable member in this embodiment. The system may have more than one magnetic field generator attached to the target object.

Preferably the magnetic field generator comprises a first side having a first polarity and a second side having a second polarity. Suitably the first polarity opposes the second polarity. For example the first side may have a north polarity and the second side a south polarity or vice versa. Suitably the magnetic pole orientations of the first and second sides are both parallel with the rotational axis of the rotatable member.

Preferably the first side of the magnetic field generator opposes the second side.

Preferably the system is configured to generate a first output in response to the sensing means sensing the lock in its locked state and to generate a second output in response to sensing means sensing the lock in its unlocked state. For example, the locking system may be configured such that the first side of the magnetic field generator faces towards the sensing means when the lock mechanism is in the locked state and the second side of the magnetic field generator faces towards the sensing means when the lock mechanism is in the locked state.

Preferably the system is configured to generate a first output in response to the sensing means sensing that the rotatable member has been rotated from the unlocked configuration to the locked configuration and a second output in response to the sensing

means sensing that the rotatable member has been rotated from the locked configuration to the unlocked configuration. The locking system is preferably configured to detect when a turn of the rotatable member has been made. If the lock is a double throw lock, the locking system can be configured to detect when a single turn of the rotatable member has been made and to provide a corresponding output and to detect when a second turn of the rotatable member has been made and to provide a corresponding output. The system may be configured to detect what direction the rotatable member has turned (i.e. in a locking direction or an unlocking direction).

Preferably the rotatable member comprises a key, the lock being configured to receive at least part of the key for driving the lock, and said magnetic field generator being located on the key. The target object is a key in this embodiment. Preferably the key further comprises a key bow and the rotatable member is preferably located on the key bow.

Preferably the lock has a lock mechanism and said rotatable member on which the magnetic field generator is located is located in the lock mechanism. The target object is in the lock mechanism in this embodiment.

Preferably the lock mechanism comprises a cylinder lock having a locking cam adapted to operate a locking bolt on rotation of the cam, the magnetic field generator being integral with or mounted on the locking cam.

Preferably said at least one rotatable member comprises a thumbturn for driving the lock, said magnetic field generator being located on the thumbturn.

Preferably the system comprises a set of keys comprising at least two keys for driving the lock, each key having a sensed element located thereon, each sensed element having at least one property that may be sensed by the sensing means that differs from that of other sensed elements on the other keys of the set. The system can be used to determine which key of the set of keys has been used in the lock and to provide an output as a lock status indicating which key has been used. Preferably said sensed elements are magnetic field generators, each magnetic field generator having at least one magnetic field property that differs from that of other magnetic field generators on the other keys of the set.

Preferably the system is configured to generate a different corresponding output in response to the sensing means sensing each of the sensed elements of the set. Each key may be allocated to a different user and the system can therefore identify which user's key has been inserted in the lock.

Preferably the magnetic field generators of the keys in the set differ from one another in at least one of shape, size, position on the key and magnetic field strength. Variations in shape, size position and magnetic field strength of the magnetic field generators all vary the magnetic field properties of the magnetic field generators. Where it is the position of the magnetic field generator that is varied between different keys in the set, it may be the position of the magnetic field generator relative to the lock interacting portion of the key that is varied between different keys in the set.

Preferably the sensing means is mounted in use to a reference structure. In preferred embodiments the locking system further comprises a sensor unit having a sensor housing for housing the sensing means in use, the sensor unit being configured for mounting to a reference structure in use. The reference structure may be any suitable reference structure such as the door/window leaf, door/window frame or a nearby wall, where it is sufficiently close to sense the sensed element. Preferably the sensor unit is configured for mounting outside of the lock in use. In other words, the sensor unit is configured for mounting at a location that is distanced away from the lock. The sensor unit is configured for mounting at a location other than inside the lock. In such embodiments, the sensor unit is therefore a standalone unit.

Preferably the lock is driveable by a rotatable lock driving member for rotatably driving the lock. The rotatable lock driving member may be a key or a thumbturn.

Preferably said at least one magnetic field generator is a magnet. Preferably said at least one magnetic field generator is a permanent magnet.

Preferably the sensing means is a magnetometer.

In some embodiments the sensed element is a tag which can produce a signal when activated or powered. The tag may be a bluetooth tag, RFID tag, near field communication

(NFC) tag, or any other type of tag which can be configured to provide an identifier over radio frequency.

Preferably the system is configured to operate in a calibration mode and a normal mode, wherein in the calibration mode the system is configured to register at least an output value from the sensing means when the locking system has a first predetermined lock status as a first reference input and wherein in the normal mode the system is configured to use the at least a first reference input to determine the lock status.

According to a further aspect of the invention there is provided a method of calibrating a system as described above, the method comprising, when the system is in calibration mode, registering the output from the sensing means when the locking system has a first predetermined lock status.

Preferably the method comprises the processor means receiving output signals from the sensing means associated with measured magnetic field from the sensing means and on receiving said output signals, determining one or more lock statuses based on the sensed magnetic field.

Preferably the lock of any system as described above is for a window or a door leaf, the leaf being moveable between an open position and a closed position, the lock comprising a lock mechanism and said at least one sensed element being located in the lock mechanism in use, the sensing means being mounted in use to a reference structure that the leaf moves relative to when moving between its open and closed positions, the system being configured to receive output signals associated with measured magnetic field from the sensing means to determine the position of the leaf.

Preferably the system further comprises a user interface. The user interface may be a switch means or a mobile computing devices (such as a mobile telephone or tablet computer). Where the user interface is a mobile computing device, it may include an application on the mobile computing device allowing it to interact with the locking system. The application may be configured to be used during calibration of the system and/or indication of the lock status to the user.

Preferably system further comprises a memory.

Preferably the sensor means and/or processor means is battery powered.

Preferably the system further comprises wireless transmission means to transmit output signals from the system to a user interface.

According to a further aspect of the invention there is provided a key for use in any system as described above. Preferably the key comprises a recess for receiving said at least one sensed element therein. Suitably the sensed element is fixed to the key by suitable fixing means such as glue or a friction fit. The recess in the key device for receiving said at least one sensed element is shaped and sized to receive the at least one sensed element.

According to a further aspect of the invention there is provided a set of keys configured for use in any system as described above.

According to a further aspect of the invention there is provided a lock for use in any system as described above.

According to a further aspect of the invention there is provided a magnetic field generator for use in any system as described above. The magnetic field generator may be sized and shaped for attachment to a key, key fob, thumbturn or part of a lock or mounting in a lock of any system as described above.

The different systems described herein are modular in that more than one system as described herein can be applied in an overall system. For example, a system may include means for monitoring more than one of the following: whether a key has been left in a door, whether a lock is locked or unlocked and which key of a set of keys has been used.

The lock status can be used as part of a wider monitoring system and/or displayed on user display means such as a smartphone, remote control or other device which can receive data, preferably also having a user interface.

References herein to mounting of any first element to any second element encompass direct or indirect mounting (e.g. the mounting of the first element to a third element which is mounted to the second element). References to mounting a first item to any second

item herein include location on any part of the second item, for example location on an internal part of the second item (i.e. location in the second item).

Brief Description of the Drawings

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram showing some of the elements of a basic locking system according to the invention;

Figure 2 shows an embodiment of a locking system for use with a lock for indicating when a key has been left in a door, the lock shown mounted to a door, the system involving a key with a magnet mounted thereon;

Figure 3 shows a basic flow diagram illustrating a method for calibrating the system of Figure 2;

Figure 4 shows a basic flow diagram illustrating an alternative method for calibrating the system of Figure 2;

Figure 5 shows an embodiment of a locking system for use with a lock for indicating when a key has been left in a door, the system involving a key fob with a magnet mounted thereon;

Figure 6A shows a perspective view of a locking system for indicating when a key has been left in a door, the lock including a moveable magnet in the lock cylinder;

Figure 6B shows a cross-sectional view through a lock of Figure 6A, the lock being shown with a key which is being inserted but has not been fully inserted in the lock;

Figure 6C shows a cross-sectional view through the assembly of Figure 6A, but with the key fully inserted in the lock;

Figure 7A shows a perspective view of a locking system for indicating whether a lock is locked or unlocked by means of a magnet on the key, the key being in a locked position;

Figure 7B shows the assembly of Figure 7A, the key being in an unlocked position;

Figure 8A shows a perspective view of the lock of a locking system for indicating whether a lock is locked or unlocked by means of a magnet in the lock, the lock being in a locked state;

Figure 8B shows the assembly of Figure 8A, the lock being partway between a locked and unlocked state;

Figure 9 shows an alternative lock of a locking system for indicating whether a lock is locked or unlocked by means of a magnet in the lock, with the housing for the lock cylinder not shown;

Figure 10 shows a basic flow diagram illustrating a method for calibrating a system like that of Figures 7, 8 or 9;

Figure 11 shows a perspective view of a door with lock and three different keys in a set of keys that can be matched to specific users;

Figure 12 shows a basic flow diagram illustrating a method for calibrating a system of Figure 11.

Description of the Preferred Embodiments

The present embodiments represent currently the best ways known to the applicant of putting the invention into practice. But they are not the only ways in which this can be achieved. They are illustrated, and they will now be described, by way of example only.

Any common features between the assemblies/systems in the different figures are referenced by common reference numerals.

A basic locking system of the invention will now be described with reference to Figure 1, which shows a block diagram showing the main elements of a basic locking system. The locking system 10 has at least one sensed element 12 integral with or attached in use to a target object associated with a lock assembly 11, as will be described further below in relation to various embodiments of the invention. In some embodiments, the sensed element comprises a magnetic field generator for generating a magnetic field. The system also comprises a sensing means 13 for sensing a magnetic field and processor means 14 configured to receive output signals associated with measured magnetic field from the sensing means and to determine one or more lock statuses based on the sensed magnetic field. The system may have a memory 17 for storing magnetic field properties or values associated with magnetic field properties as sensed by the sensor 13 and/or for storing ID information associated with individual keys used in the system as will be described. Alternatively or in addition, the system may include a server or means for communicating with a server, the server being for storing magnetic field properties as sensed by the sensor and/or for storing ID information associated with individual keys used in the system. The processor 14 receives output signals associated with sensed magnetic field from the

sensor 13 and outputs one or more lock statuses based on the sensed magnetic field, depending on the position and/or orientation of the target object.

The system optionally has a status indicator 15 (which may be a user interface) for indicating the lock status to a user. In the embodiments described herein, the locking system is for a window or door leaf, the lock being for securing the window or door leaf relative to a frame. However, it will be understood that the locking system could be used for any type of lock, not just a lock for a window/door leaf.

EMBODIMENTS RELATING TO KEY LEFT IN LOCK STATUS

One of the lock statuses that the system may be configured to detect is whether a key has been left in the lock of the lock assembly. Occasionally a user of a lock that is operated by a key may unintentionally leave a key in the lock. This may occur, for example if the user is carrying things when they unlock the door and they forget to take the key out of the lock for example. A key left in the lock may remain there for a long time. For example, a key may remain in the lock until the next time that a user wants to lock or unlock the door. A key left on the outside of an external door may be stolen, which puts the building at risk from thieves. It would be useful to have a system that provides a warning device for indicating to a user that a key has been left in a lock. A first embodiment of a system for determining whether a key has been left in a lock will be described in relation to Figure 2.

Referring to Figure 2, a locking system 100 is shown for use with a lock 110, which is shown mounted in a door 12. The door also has a handle assembly 20 mounted thereto, which has first and second handle grips 21, 22 on each side of the door 12 which drive a sprung latch 23. The lock 110 has a locking mechanism which drives a locking bolt 130. The locking bolt 130 is moveable between a locked position (i.e. a secured position) in which it extends from the edge of the door leaf 12 as shown in Figure 2 and an unlocked position (i.e. an unsecured position) in which it is retained within a recess in the door leaf. The lock 110 has a faceplate 131 mounted to a face of door, the faceplate 131 having a key access hole 132 therein which leads to a keyway for receiving a portion of the key therein. A key 133 is shown inserted in the lock. Rotation of the key 133 between a locked configuration and an unlocked configuration operates the lock to move the locking bolt 130 between its secured position and unsecured position. The key 133 is shown in Figure 2 in its locked position.

The key 133 has a key bow 134 (i.e. the part left protruding from the keyway when the key is engaged in the lock and which can be used by the user to apply torque to the key, also known as the key grip). Mounted on the key bow 134 is a sensed element 135 comprising a magnetic field generator (which in this embodiment is a permanent magnet). The sensed element 135 may of course be mounted elsewhere on the key, other than the bow. The system further comprises a sensor for sensing magnetic field, which in this embodiment is a magnetometer, which is housed in a sensor unit 140. The sensor unit 140 may be employed in the other embodiments described herein. The sensor unit 140 may be a standalone unit for mounting to the door frame (not shown) or other suitable reference structure such as the door leaf or wall, where it is sufficiently close to sense the magnetic field generated by the magnet 135 when the key is inserted in the lock. The sensor unit 140 may for example be built in the door frame (i.e. hidden in the door frame) or mounted on the door frame. The sensor unit 140 may alternatively be mounted in a door handle backplate or locking cylinder guard. The sensor unit 140 may also contain other electronic components such as a battery or means for connection to a power source, and communications means such as a bluetooth RF module. Other communication means may be employed, the communication means preferably being nearfield wireless technology. The communications means may be configured to transmit signals associated with measured magnetic field from the sensor to a processor and/or to transmit signals associated with the lock status to a status indicator such as a display means or interactive user interface. The sensor unit 140 may contain a processor that generates a lock status output based on the measured magnetic field or a processor may be located elsewhere in communication with the sensor. In this embodiment the sensor unit 140 has a housing 141 in which the relevant components such as the magnetometer are housed.

The key bow 134 has a recess shaped and sized to receive the magnet 135. In other embodiments the magnet 135 may be fully housed within (i.e. hidden) in part of the key 133, such as in the key bow 134. The magnetometer in the sensor unit 140 senses the magnetic field generated by the magnet 135 attached to the key 133. The magnetic field properties sensed by the magnetometer will differ depending on whether the key 133 is inserted in the lock 110 or is remote from the lock 110. The sensor unit 140 may have an audio alert means (not shown), the system being configured to sound the audio alert means if the system detects that a key 133 has been left in the keyway. For example, the audio alert may be a buzzer, which may be in sensor unit 140 or on a wireless audio unit,

or an app running on a mobile phone or tablet computer may be configured to provide an audible alert in response to a key left in lock status. Alternatively, for systems which are configured for use with a user interface, the user can be alerted via the user interface (visually or audibly) that a key 133 has been left in the keyway.

In operation, the magnetometer in sensor unit 140 monitors the magnetic field. If the key 133 with magnet 135 mounted thereon is inserted in the keyway in the lock 110, the magnetometer will detect the magnetic field change arising from the proximity of the magnet 135 to the magnetometer. The system may be configured to alert the user via audio alert means or a user interface to a status of key left in lock, if the system detects that the key 133 is in the lock. For example, the system may be configured to alert the user if the key 133 has been detected as left in the lock for more than a predetermined length of time. Alternatively, the system may be configured to alert the user to a status indicating that the key 133 has been left in the lock only if the key 133 is detected in the lock with the door leaf closed (if the key is left in the lock, but the door leaf is open, this may be intentional as the user may be intending to remove the key once the door is closed; however if the key is left in the lock and the door leaf is closed, this is probably unintentional). The system may determine that the leaf is closed by means of determining the proximity of the key 133 to the sensor unit 140. For example, if the sensor unit 140 is mounted on the door frame, close to the lock, the system will only provide a key left in lock status if the key 133 is determined to be in close proximity to the sensor unit 140 (whereas if the key 133 is not close to the sensor unit 140, the door 12 may be open and therefore the key 133 may have been intentionally left in the lock). The locking system may optionally include additional means for determining whether the leaf is in a closed position. One option is the inclusion of an additional magnetic field generator such as a permanent magnet somewhere on the leaf, with the magnetic field generated by the magnet on the leaf being sensed by the magnetometer in the sensor unit 140. The sensor unit 140 should be mounted on a reference structure, such as the door frame, that the leaf moves relative to when it moves between its closed and open positions. The magnetic field sensed by the magnetometer will change depending whether the leaf is closed or other than closed (i.e. open) and the sensed magnetic field can be used by the system to determine whether the leaf is open or closed. Alternatively a magnetic field generator may be mounted on the door frame or other static reference structure and the sensor unit 140 may be mounted on the leaf to sense the magnetic field generated by the magnetic field generator mounted on the door frame and on the key 133. Detection means other than magnetic detection

means can of course be used to determine whether the leaf is in its closed position and to provide output signals to the processor of the locking system.

The system 100 can optionally be configured to include a calibration mode as well as a normal mode for normal operation. For systems that include a calibration mode, the system is operated in calibration mode initially when setting up the system. It is not necessary to calibrate the system of Figure 2, however it helps the system to operate more reliably and helps to eliminate the effects of stray magnetic fields. Figure 3 is a basic diagram illustrating the initial steps for calibrating the system. At 50, in order to calibrate the system the user places the system into calibration mode by providing a signal to a processor. In this embodiment the signal is provided to the system by pressing a push button 142 (a 'sync' button) on the sensor unit 140. Alternatively, the user can enter the system into calibration mode via a user interface or the calibration mode may be entered automatically when the sensor unit 140 is powered up for the first time. The user interface may be a mobile phone or tablet computer with an app running on it. Once the system is in calibration mode, at 51 the user is prompted by the system to insert the key 133 in the lock. After the user has placed the key 133 in the lock, at 52, the user provides an indication to the processor that the key 133 has been placed in the lock. The user may be prompted to count to a certain number (e.g. 5) before providing an indication to the system that the key is in the lock. In the embodiment of Figure 2, this is done by pressing the sync button 142 again. At 53, the processor then records one or more properties of the magnetic field produced by the magnet 135 as sensed by the magnetometer and stores at least one of the properties or values derived therefrom in a memory. The processor uses the output signals recorded by the magnetometer at 53 to establish calibration parameters that can then be used when the system is operating in normal mode following calibration to correlate the magnetic field output from the magnetometer when the system is in normal mode to determine whether the key 133 is in the lock.

The system is preferably calibrated when the door is closed. The system will record the influence on the magnetic field of the key 133 with magnet 135 thereon when the key is engaged in the lock and when the door is closed. If, when operating in normal mode, the magnetometer senses magnetic field properties that correspond to those in which the key 133 is engaged in the lock with the door closed, the system will provide an indication of this lock status to the user.

For systems which include an additional magnet mounted on or in the door 12 for determining whether the leaf is closed using the sensor unit 140, in order to employ signals relating to the leaf position during determination by the processor of a possible key left in lock status, the system can be calibrated to register the leaf in the closed position. The steps for calibrating this part of the system will be similar to the steps shown in Figure 3 except that at 51 the user will be prompted to close the leaf, at 52 the user will be prompted to provide an indication to the system that the leaf is closed (e.g. by pressing sync button 142) and at 53 the magnetic field properties with the leaf in the closed position will be recorded. The system may optionally be configured to include further calibration steps for registering the leaf in an open position in addition to a closed position.

If the lock 110 is a 'double-keyed' or 'double cylinder' lock that requires a key to operate it from the internal and external sides of the door, the system can optionally be calibrated to determine if a key left in the lock is on the internal or external side of the door. This can be done by the steps shown in Figure 4. As for the calibration steps of Figure 3, at 60, firstly the user places the system in calibration mode (e.g. by pushing the sync button 142). At 61, the user is prompted to place the key in a first predetermined position, i.e. in the lock on a first side of the door leaf (e.g. on the external side of the door). Prompts to the user in this and other embodiments may be provided by a remote user interface. At 62, the user provides an indication to the system that the key is in the first predetermined position (e.g. by pushing the sync button 142). At 63, the system then records the magnetic field properties sensed by the sensor with the key in the first predetermined position. At 64, the user is prompted to place the key in the lock on the other side of the door (the second predetermined position). At 65, the user provides an indication to the system that the key is in the second predetermined position (e.g. by pushing the sync button 142). At 66, the system records the magnetic field properties sensed by the sensor with the key in the second predetermined position. When the system is operating in normal mode, if a key is left in the lock, the system can use the values recorded during calibration to determine whether the key has been left on the internal or external side of the door and to provide a status to the user accordingly.

After calibration (in this embodiment and other embodiments), the user may cause the system to enter a normal mode via the user interface or this may occur automatically after the calibration steps have been completed. In the normal mode the processor periodically determines one or more magnetic field properties sensed by the magnetometer and

compares it or them to the values / calibration parameters stored in the memory, e.g. to determine if the key 133 has been left in the lock. The processor is configured to provide an output indicating the lock status. This output can be provided to the user via a status indicator (which may be the user interface for example). The output indicating the status of the lock may be transmitted to the user interface via the wireless transmission means.

Referring to Figure 5, an alternative locking system 200 that alerts a user if a key is left in the lock is shown. The system 200 is similar to the system of Figure 2, the only difference being that instead of a magnet being mounted on the key bow, there is a key fob 236 for attachment to the key, the key fob 236 including a magnet 235. The key fob 236 is shown exploded from the key 233, however in normal use the key fob 236 will be attached to the key 233 using suitable attachment means (not shown) such as a split ring or chain. Otherwise, the system 200 is generally arranged and set up as for system 100.

The key fob 236 has an engaged configuration wherein the key 233 to which the key fob 236 is attached is inserted in the lock (whether the key is in a locked or unlocked position) and the system can be used to detect whether the key fob 236 is in the engaged configuration. If the system detects the key fob in the engaged configuration, the system enters an alert mode so that an alert can be generated to the user of a key left in lock status via the status indicator.

In operation, if the key 233 with key fob 236 attached thereto is inserted in the keyway in the lock 110, so that the key fob 236 is in its engaged configuration, the magnetometer in the sensor unit 140 will detect the magnetic field change arising from the proximity of the magnet 235 to the magnetometer. As with the system 100 of Figure 2, the system 200 may be configured to alert the user if the system detects that the key fob 236 is in its engaged configuration and therefore that the key 233 must have been left in the lock. The same alert means may be used as for the system of Figure 2. As with system 100, preferably the system may be configured to only alert the user to a key left in lock status if the key fob 236 is detected in the engaged configuration and the leaf is closed. The system may also be optionally configured to only alert the user to a key left in lock status if the key fob 236 is detected to be for more than a predetermined length of time.

The system 200 may optionally be calibrated in the same way as for the system of Figure 2. For example, the user can calibrate the system 200 using the same steps as shown in

Figure 3, namely inserting the key 233 with key fob 236 attached thereon in the lock (so that the key fob 236 is in an engaged configuration wherein it is in close proximity with the sensor unit 140) and prompting the system to record the magnetic field properties when the key 233 and key fob 236 are in the engaged configuration. For a double-keyed lock that requires a key to operate it from both sides of the door, the system 200 can optionally be calibrated in the same way as shown in Figure 4.

In this embodiment the key fob 236 has a key fob body 236a made of non-magnetic material having a recess 236b therein for receiving the magnet 235. However it will be understood that the key fob 236 may comprise a body made wholly from a material that is a magnetic field generator. In this embodiment, the recess 236b is shaped and sized to receive the magnet 235. The magnet 236b is fixed to the key fob 236 by suitable fixing means such as glue or a friction fit. The key fob body 236a has a small hole 236c for receiving a ring or chain or other suitable attachment means for attaching the key fob 236 to the key 233.

A set of keys 133 for use with the system 100 or set of key fobs 236 for use with the system 200 can be provided, so that each user of a building has a key or key fob for use with the relevant system (or the user has spare keys or key fobs).

Referring to Figures 6A to 6C, an alternative locking system 300 that alerts a user if a key is left in the lock 310 is shown. In this system there is a magnetic field generator such as a permanent magnet built into the lock mechanism, which moves from first position to a second position when a key is inserted in the lock and wherein the sensor (i.e. a magnetometer) detects a magnetic field change arising from the magnet in the lock cylinder having moved to the second position to detect a key left in lock status.

Referring to Figure 6A, the lock 310 is a cylinder lock having a lock cylinder 337 as the lock mechanism. In this embodiment the lock cylinder 337 is a Euro Profile lock cylinder, although it will be appreciated that the present invention is not limited to a Euro Profile lock cylinder. Referring to Figure 6B, the lock cylinder 337 comprises a housing 338 and a pin tumbler locking mechanism defining a keyway 332a in which a key 233 can be received to operate the lock. The key 233 has a blade portion 233a having a plurality of cuts formed therein, each of which is alignable with a tumbler pin in the locking mechanism. The blade portion 233a of the key 233 is shown diagrammatically in Figures 6B and 6C, therefore the

cuts in the blade portion are not visible in the figures. Other lock mechanisms may be employed in the lock, other than a pin tumbler locking mechanism of course. Rotation of a key 233 in the lock causes a lock driving member (such as a cam lever) to rotate, the lock driving member in turn driving a locking bolt 330 between a locked position in which it extends from the edge of the door leaf 12 as shown in Figure 6A and an unlocked position (i.e. an unsecured position) in which it is retained within a recess in the door leaf.

The keyway 332a has a first end through which the key 233 is inserted, forming a key access hole 332 in the face plate 331 of the lock 310, and a second end opposite the first end, the keyway having an end wall 332b at its second end. The lock cylinder 337 has a magnet 335 positioned at the second end of the keyway 332a. A spring 339 is arranged between the magnet 335 and the end wall 332b, the spring 339 being configured to bias the magnet 335 away from the end wall 322b. In this embodiment the spring 339 is a helical compression spring, however it will be understood that other biasing means may be used to bias the magnet 335 away from the end wall 332b. The magnet 335 is configured to be slidable back and forth in the keyway 332a between a first position shown in Figure 6B and a second position shown in Figure 6C, wherein the spring 339 is compressed and the magnet 335 is closer to the end wall 332b than in the first position.

The key 233 has an engaged configuration wherein it is fully inserted in the keyway 332a. The first position of the magnet 335 is its at rest position, when there is no key 233 in the engaged configuration in the lock. As a key 233 approaches its engaged configuration, the tip of the key pushes the magnet 335, so that once the key 233 reaches the engaged configuration, the magnet 335 has been moved into its second position, as shown in Figure 6C.

The system 300 includes a sensor unit 140 of the type used in the systems 100, 200 previously described, the sensor unit 140 comprising a magnetometer for sensing magnetic field changes. The sensor unit 140 may be mounted on the door frame or on the leaf, or another reference structure that the magnet 335 moves relative to when moving between its first and second positions.

In operation if the key 233 is inserted in the keyway 332a, the magnetometer in the sensor unit 140 will detect the magnetic field change arising from the magnet 335 moving from its first position to its second position. As with systems 100, 200, the system 300 may be

configured to alert the user if the system detects that the magnet 335 is at the second position, and therefore that the key 233 must have been left in the lock. The same alert means may be used as for systems 100, 200. The system 300 may be configured to alert the user if the system detects that the magnet 335 has been at its second position for more than a predetermined length of time. Alternatively, in the same way as for systems 100, 200, this system 300 may be configured to alert the user to a status indicating that the key 233 has been left in the lock only if the magnet 335 is detected at the second position and it is determined that the door leaf is in the closed position. For example, if the sensor unit 140 is on the door frame, the system will only alert the user to a key left in lock status if the magnet 335 in the lock cylinder is detected to be in a position that corresponds with the closed position of the door. Alternatively, the system may include additional detection means for providing signals to the system which indicate if the door leaf is closed.

The system 300 may optionally be calibrated in the same way as for system 100, 200. For example, the user can calibrate the system 300 using the same steps as shown in Figure 3, namely inserting the key 233 in the lock (so that the magnet 335 moves to the second position) and prompting the system to record the magnetic field properties when the key 233 is in the engaged configuration.

For a double-keyed lock that requires a key to operate it from both sides of the door, the system 300 may have two keyways, one for each side of the lock, each keyway having an end wall and a magnet located near the end wall and biased away from the end wall by a compression spring. The magnet in each keyway will operate in a similar way to the magnet 335 of lock 310 if a key is inserted in the keyway that the magnet is located in. Alternatively, a double-keyed lock may have a single magnet located in a mid-portion of the lock between the two keyways, the magnet being biased in its rest position (which it is in when there is no key in the lock) and which can be pushed into another position when a key is engaged on the internal side of the door or into a further position when a key is engaged on the external side of the door, and the movement of the magnet between the positions can be detected by the sensor in the sensor unit 140. For a double-keyed lock that requires a key to operate it from both sides of the door, the system can optionally be calibrated in the same way as shown in Figure 4.

The magnet 335 located in the lock cylinder can be used as means for determining whether the door leaf 12 is in a closed position, as well as for determining whether a key has been

left in the lock. In order for the magnet 335 to be employed in this way, the sensor unit 140 must be mounted on a reference structure, such as the door frame, that the leaf moves relative to when it moves between its closed and open positions. The magnetic field sensed by the magnetometer will change depending whether the leaf is closed or other than closed (i.e. open). The steps for calibrating this part of the system will be similar to the steps shown in Figure 3 except that at 51 the user will be prompted to close the leaf, at 52 the user will be prompted to provide an indication to the system that the leaf is closed (e.g. by pressing sync button 142) and at 53 the magnetic field properties with the leaf in the closed position will be recorded. The system may optionally be configured to include further calibration steps for registering the leaf in an open position in addition to a closed position.

EMBODIMENTS RELATING TO LOCKED / UNLOCKED STATUS

A locking system 400 will now be described in relation to Figures 7A and 7B in which the system can be used to determine whether a lock is locked or unlocked (i.e. a locked / unlocked status of the lock) by means of a magnet built into the key grip. The system 400 is similar to the system 100, having a key 433 with a magnet 435 mounted on the key bow 434, the key being receivable in a lock 110. Like key 133, key the bow 434 of key 433 has a recess shaped and sized to receive the magnet 435. Like system 100, system 400 also has a sensor unit 140 containing a magnetometer for sensing magnetic field changes. The magnet 435 has a first side having a first magnetic polarity and a second side having a second magnetic polarity. In Figure 7A, the first side of the magnet 435 is visible, which in this embodiment is a south magnetic pole, indicated by the inclusion of the symbol 'S' on the magnet 435. In Figure 7B, the key 433 has been turned 180° compared to the position in Figure 7A and the second side of the magnet 435 is visible, which in this embodiment is a north magnetic pole, indicated by the inclusion of the symbol 'N' on the magnet 435. In this embodiment the first side of the magnet 435 opposes the second side, although they need not be opposite sides, but may be arranged at other angles to one another. When the key 433 is engaged in the lock it is rotatable to operate the lock. The key 433 is rotatable in the lock between a locked configuration as shown in Figure 7A, in which the locking bolt 130 extends from the edge of the door leaf 12 and an unlocked configuration as shown in Figure 7B, in which the locking bolt 130 is retained within a recess in the door leaf. The sensor unit 140 is mounted to a reference structure that the key 433 rotates relative to (such as the door frame, not shown) such that the magnetometer

in the sensor unit 140 detects magnetic field changes arising from the rotation of magnet 435 in order to allow the system to determine whether the lock is locked or unlocked.

Referring to Figure 7A, in this embodiment when the key 433 is in the locked configuration, the south pole of the magnet 435 faces towards the leaf latch edge 12a and the north pole faces towards the leaf hinge edge (not shown). In order to unlock the lock, the key 433 is rotated 180°, wherein the north pole of the magnet 435 faces towards the leaf latch edge 12a and the south pole faces towards the leaf hinge edge (not shown), as shown in Figure 7B. Via measurement of the magnetic field sensed by the magnetometer in sensor unit 140, the system 400 can determine whether the key 433 is in the locked or unlocked configuration as the magnetic field sensed will be different when the key is in the locked and unlocked positions due to the different positions of the south and north poles of the magnet 435. The system is configured to provide a lock status (locked or unlocked) to the user via a status indication means based on the magnetic field measurements sensed by the magnetometer in sensor unit 140.

For some locks, the key will be in the same position when the lock is locked and unlocked. Some such locks require a 360° turn of the key (single turn) or even a 720° turn (double turn) in order to move the lock between an unlocked state and a locked state. For locks that involve a double turn, the lock may have a "double throw" locking bolt in which a first 360° turn of the key causes the locking bolt to project by a first distance and a second 360° turn of the key causes the locking bolt to project by a further distance. The system can be configured to detect which direction the key 433 is turning in (i.e. in a locking direction or in an unlocking direction) by means of detecting the direction that the north and south magnetic poles of the magnet 435 are rotating in. In this way, the locking system 400 can detect if the lock is in a locked or unlocked state, even if the key is in the same position when the lock is locked and unlocked. The system can also be configured to detect how many turns of the key have been made. The changes in magnetic field measured by the magnetometer will follow a particular pattern as the key is turned by 360°, which will repeat as the key is turned a further 360°. The system can be configured to determine how many turns of the key have been made by monitoring the changes in magnetic field monitored by the magnetometer. For a double throw lock for example, the locking system can be configured to provide an output indicating a single throw status of the locking bolt if the key is rotated by a single turn and to provide an output indicating a double throw status of the locking bolt if the key is rotated by a double turn.

In other types of cylinder lock, the lock mechanism includes a spring return mechanism that returns the lock to a locked configuration (i.e. with the locking latch extended) unless force is applied to the key to keep it in an unlocked position. For use with such locks the system can be configured such that changes in magnetic field measured by the magnetometer as the key is turned to unlock the lock mechanism can be detected so that the system can identify if the lock is being unlocked.

The system 400 can be modified so that the locking bolt 130 is driven by a "thumbturn" (not shown in the figures) instead of a key, as is well known in the art. In this case, the magnet 435 will be located on the thumbturn device. As with the magnet of the key embodiment in system 400 of Figures 7A and 7B, the magnet of the thumbturn has a first side having a first magnetic polarity and a second side having a second magnetic polarity. The position / number of turns made by the thumbturn device can be monitored by the magnetometer in the same way as for a key as described above.

The system 400 with key 433 or thumbturn can optionally be calibrated as will be described later.

Referring to Figures 8A and 8B, a lock 510 for an alternative locking system 500 that can be used to indicate whether a lock is locked or unlocked is shown. In this embodiment the magnet is built into the cam lever of the lock. The lock 510 is a cylinder lock. The particular lock shown in the figures is a Euro Profile cylinder, although it will be appreciated that the present invention is not limited to a Euro Profile cylinder lock. The cylinder lock 510 comprises a housing 570. Within the housing 570 is a lock drum (not visible in Figures 8A and 8B) comprising a pin tumbler locking mechanism defining a keyway which can receive a key 533 therein. The key 533 can be rotated to rotate the lock drum. The cylinder lock 510 has a cam 571 which is co-axial with and connected to the lock drum for rotation therewith. The cam 571 has a generally cylindrical body 571a and has a radially projecting protrusion as a cam lever 571b. Rotation of the key 533 when engaged in the keyway rotates the lock drum, causing the cam 571 to rotate, thereby actuating a locking bolt (not shown) or other locking mechanism for locking the leaf.

The lock 510 includes a magnet 535 located on the cam lever 571b. As the cam lever rotates 571b, the magnet 535 also rotates. The magnet 535 has a first side having a first

magnetic polarity and a second side having a second magnetic polarity, opposite the first side. In this embodiment the first and second sides of the magnet 535 both extend substantially parallel with one another and substantially parallel to a radius of the circular cross-section of the cylindrical cam body 571a, so that the first and second sides of the magnet 535 are substantially parallel with the two largest sides of the cam lever 571b. The magnetic poles of the magnet may of course be arranged differently in relation to the cam 571. Instead of a single magnet on a part of the lock cylinder that rotates during operation of the lock, more than one magnet may be included thereon.

The system includes a sensor unit 140 comprising a magnetometer for sensing changes in magnetic field as influenced by movement of the magnet 535, like in previous embodiments. The sensor unit 140 is mounted in use to a reference structure that the cam 571 rotates relative to as the lock is being operated, such as the leaf or preferably the frame.

For locks in which the cam lever 571b is moveable between a locked position when the lock is in locked state and a different, unlocked position when the locks is in an unlocked state, the system 500 can be configured to determine whether the lock is in the locked or unlocked state by means of the magnetometer in sensor unit 140 sensing the position of the cam lever 571b by means of the different magnetic field properties that will be sensed by the magnetometer when the cam lever 571b is in the locked and unlocked positions. The lock can be calibrated in the locked and unlocked states as will be described later.

Alternatively, the system can be configured to detect movement of the cam 571b and the direction that the cam 571b with magnet 535 thereon is turning in (i.e. in a locking direction or an unlocking direction) by means of detecting the direction that the north and south magnetic poles of the magnet 535 are rotating relative to the magnetometer so that the system can indicate if the lock has been locked or unlocked. Such a system may be used for example with locks with require a full turn or a double turn of the lock cylinder to lock and unlock the lock. The system can also be configured to detect how many turns of the key have been made if the lock is configured to operate by more turns than just a single turn. For a double throw lock for example, the locking system can be configured to provide an output indicating a single throw status of the locking bolt if the key is rotated by a single turn and to provide an output indicating a double throw status of the locking bolt if the key is rotated by a double turn.

Instead of a key 533, the lock 510 may of course be operated by a thumbturn.

Referring to Figure 9, a lock 610 for an alternative locking system 600 that can be used to indicate whether a lock is locked or unlocked is shown. In this embodiment the magnet is built into the cylinder lock drive. The lock 610 is a cylinder lock having a lock drum 637a, the cylinder lock being similar to that in Figures 8A and 8B except that instead of having a magnet located on the cam lever 571b, in lock 610 there is a magnet 635 located in a part of the lock drum which rotates as the key 633 is rotated to lock and unlock the lock mechanism. The keyway 632a has a first end through which the key 633 is inserted, forming a key access hole 632 in the face plate 631 of the lock 610, and a second end opposite the first end. In this embodiment the magnet 635 is located at or towards the second end of the keyway 632a and the magnet 635 rotates as the lock drum rotates. The magnet 635 has a first side having a first magnetic polarity and a second side having a second magnetic polarity, opposite the first side. In Figure 9, the first side of the magnet 635 is visible, which in this embodiment is a south magnetic pole, indicated by the inclusion of the symbol 'S' on the magnet 635. In this embodiment the first and second sides of the magnet 635 extend substantially parallel with the longitudinal axis of the keyway 632a. As the lock drum rotates during locking and unlocking of the lock 610, the magnet 635, with opposing polarities on its opposite sides will rotate. The system 600 is configured to determine the locked/unlocked status of the lock based on the rotation of the south and north polarity faces of magnet 635, in the same way as for system 500.

The systems 400, 500 and 600 can optionally be calibrated in a similar way as shown in Figure 4. For example, for systems 400 in which the key 433 or systems 500 in which the cam 571 is moveable between a locked position when the lock is in locked state and a different, unlocked position when the locks is in an unlocked state, during calibration the system can be registered when the lock is in a locked configuration (a first predetermined position) and then again when the lock is in an unlocked configuration (a second predetermined position).

An example of the calibration steps for a lock for a system 400, 500, 600 which requires a 360° turn of the key/thumbturn (single turn) to lock is shown in Figure 10. At 80, the system is entered into calibration mode, with the lock in the unlocked state. At 81 the user is prompted to lock and unlock the lock, during which the system records the change in

magnetic field values for locking and unlocking. Alternatively the steps could be carried out but starting with the lock in a locked state, and at 81 the user would be prompted to unlock and lock the lock.

Conventional locks will only receive a key in a fixed position. For example, in the lock 110 of Figures 7A and 7B the key is inserted in a first position as shown in Figure 7A when the lock is in a locked configuration and in a second position as shown in Figure 7B when the lock is in an unlocked configuration. For some locks the key is received in a single position, whether the lock is locked or unlocked when the key is inserted. The engagement of the key in a set position creates a fixed position for the north and south poles of the magnet 435 when the key is engaged in a lock, allowing the magnetic field properties to be reliably recorded during calibration. Locks 510 and 610 are configured such that the lock cylinder is always at a predetermined orientation about its longitudinal axis when the lock is in a locked and unlocked state and therefore the magnet built into the lock will be also (whether the lock cylinder is at a single predetermined orientation when locked and unlocked or at different orientations when locked and unlocked). Therefore, this provides a fixed start position when the key is inserted to lock/unlock, allowing the magnetic field properties to be reliably recorded during calibration.

The change in magnetic field caused by rotation of the poles of magnet 435, 535, 635 in each embodiment is detected by the magnetometer to determine whether the lock is locked or unlocked. The option to calibrate systems 400, 500, 600 helps eliminate noise that may affect the determined status, providing a more accurate determination of the locked / unlocked status. The change in magnetic field caused by rotation of the north and south poles of the magnet when turning in a locking direction or when turning in an unlocking direction can be registered during calibration mode so that if the same pattern of change in magnetic field is detected when the system is operating in normal mode, the system can detect if the lock is being locked or unlocked.

EMBODIMENTS RELATING TO KEY MATCHING

Any of the systems above that involve a key with a sensed element thereon may be provided as a system comprising a set of keys, the set comprising at least two keys for driving the lock, each key having a sensed element thereon, each sensed element having at least one property that may be sensed by the sensing means that differs from the other

sensed element(s) of the other key(s) of the set. When a key from the set of keys is used in the lock, the system can determine which user of a set of users has used their key, as will be explained below. For example, each key may have a magnetic field generator thereon, each magnetic field generator having at least one magnetic field property that differs from the other magnetic field generator(s) of the other key(s) of the set.

Referring to Figure 11, a system 700 including set of three keys 733x, 733y, 733z is shown. Each key has a magnet mounted thereon that differ from the magnets on the other keys in the set in shape and/or size. For example, key 733x has a rectangular magnet 735x on its bow, key 733y has a small circular magnet 735y on its bow and key 733z has a large circular magnet 635z on its bow. Each magnet 735x, 735y, 735z will generate different magnetic field properties due to its different shape/size, which will be sensed by the magnetometer in sensor unit 140 when the key is engaged in the lock 710. Instead of magnets of different shapes/sizes, the magnets on different keys may have the same shape and size as each other, but simply have different magnetic field strengths. In this embodiment, the key bow of each key 733x, 733y, 733z has a recess shaped and sized to receive the corresponding magnet 735x, 735y, 735z. As in previous embodiments, the magnet of each key is fixed to the key by suitable fixing means such as glue.

The system 700 may be set up to match each key in a set to a corresponding user so that, when the lock 710 has been operated the system can generate a status output indicating which user has operated the lock 710. The method for setting up the system so that each key is matched with a user is effectively a calibration method. Referring to Figure 11, an example calibration method is shown. With the sensor unit 140 mounted at its reference position, e.g. on the frame near the locking cylinder, when the system is in calibration mode, the user will be prompted at 91 to engage a first key in the lock and leave it in the lock for a predetermined time (for example for a count of 5 seconds). At 91 the systems records the magnetic field properties with the first key in the lock. At 92 the user then provides an indication to the system that the previous steps have been carried out, for example by pressing sync button 142 on the sensor unit 140. At 93 the user is prompted to enter an ID (for example a name) for the first key into a user interface, this ID then being associated with the first key in the system. At 95, steps 91-94 are then repeated for at least a second key in the set. Once the system has been set up to associate an ID with each key in the set, if a key is used in the lock 710, the system can then provide an output status indicating the ID associated with that key, to identify which user has used the lock.

A set of such keys and a sensor unit 140 could be provided, even if the position or movement of the key is not being monitored (i.e. to determine if a key has been left in the lock or to determine if the lock is locked/unlocked) so that the system can monitor who is locking and unlocking the door.

The magnets 135, 235, 335, 435, 535, 635, 735 in the system described may be magnetic field generators other than permanent magnets. For example, they may be electromagnets. The magnets may be fixed to their target objects in each embodiment by any suitable fixing means.

Instead of using a magnet as the sensed element(s) in each of the embodiments, the or each sensed element may be a tag which can produce a signal when activated or powered. Suitable tags may be bluetooth tags, RFID tags, near field communication (NFC) tags or any other type of tag which can be configured to provide a signal over radio frequency. The sensing means in such embodiments is any suitable sensing for sensing the signal from the tag when the tag is activated or powered. The tags may be passive or powered. The tag(s) and corresponding sensor means may be incorporated into the above embodiments in place of the magnet(s) and magnetometer to provide equivalent functionality of the above embodiments but with a different type of sensed element(s) and sensor.

References herein to doors can equally refer to windows and vice versa.

Claims

1. A locking system comprising at least one sensed element integral with or attached in use to a target object associated with a lock, the locking system further comprising sensing means, the sensed element being sensed by the sensing means in use and processor means configured to receive output signals from the sensing means and to determine one or more lock statuses based on the output signals of the sensing means.

2. A locking system according to claim 1, wherein said at least one sensed element comprises a magnetic field generator for generating a magnetic field, the sensing means being configured for sensing a magnetic field, the processor means being configured to receive output signals associated with measured magnetic field from the sensing means to determine one or more lock statuses based on the sensed magnetic field.

3. A locking system according to claim 1 or 2, wherein the lock is driven by a key, the lock being configured to receive the key for driving the lock, the system being configured to generate an output in response to the sensing means sensing the key engaged in the lock.

4. A locking system according to claim 3, wherein the system is configured to generate an output in response to the sensing means sensing the key engaged in the lock for longer than a predetermined period of time.

5. A locking system according to claim 3 or 4, wherein the lock is for a window or door leaf, the leaf being moveable relative to a frame between a closed position and an open position, the locking system further comprising means for determining whether the leaf is in its closed position, the locking system further being configured to generate an output in response to sensing the key engaged in the lock and sensing the leaf in the closed position.

6. A locking system according to any of claims 3 to 5, wherein the system comprises a key for driving the lock, the at least one sensed element being located on the key.

7. A locking system according to any of claims 3 to 6, wherein the system comprises a key fob, the key fob being attached to the key in use, said at least one sensed element

being integral with or mounted on the key fob such that the sensing means is able to sense the presence of the key fob when the key is engaged in the lock.

8. A locking system according to any of claims 3 to 6, wherein the system further comprises a lock mechanism that is operable by a key, said at least one sensed element being located in the lock mechanism in use and wherein said at least one sensed element is moveable between a first position and a second position, the sensed element being at the first position when there is no key in an engaged configuration in the lock and the sensed element being caused to move to the second position when a key is inserted in the lock.

9. A locking system according to claim 8, wherein the key further comprises a lock interacting portion for insertion in the lock, the lock mechanism having a keyway for receiving the lock interacting portion of the key, the lock interacting portion of the key having an insertion end for insertion into the keyway, said at least one sensed element being located in the keyway such that the insertion end of the key pushes the sensed element to its second position when the key is engaged in the lock.

10. A locking system according to any preceding claim, wherein the locking system comprises a rotatable member on which the at least one sensed element comprising a magnetic field generator is located in use that is rotatable between a locked configuration corresponding to a locked state of the lock and an unlocked configuration corresponding to an unlocked state of the lock, the sensing means being mounted in use to a reference structure that the rotatable member is rotatable relative to between its locked and unlocked configurations such that the system can sense whether the lock is in a locked or unlocked state based on the measured magnetic field generated by the magnetic field generator.

11. A locking system according to claim 10, wherein the magnetic field generator comprises a first side having a first polarity and a second side having a second polarity.

12. A locking system according to claim 11, wherein the first side of the magnetic field generator opposes the second side.

13. A locking system according to any of claims 10 to 13, wherein the system is configured to generate a first output in response to the sensing means sensing the lock in

its locked state and to generate a second output in response to sensing means sensing the lock in its unlocked state.

14. A locking system according to any of claims 10 to 13, wherein the system is configured to generate a first output in response to the sensing means sensing that the rotatable member has been rotated from the unlocked configuration to the locked configuration and a second output in response to the sensing means sensing that the rotatable member has been rotated from the locked configuration to the unlocked configuration.

15. A locking system according to any of claims 10 to 14, wherein the rotatable member comprises a key, the lock being configured to receive at least part of the key for driving the lock, and said magnetic field generator being located on the key.

16. A locking system according to any of claims 10 to 15, wherein the lock has a lock mechanism and said rotatable member on which the magnetic field generator is located is located in the lock mechanism.

17. A locking system according to claim 16, wherein the lock mechanism comprises a cylinder lock having a locking cam adapted to operate a locking bolt on rotation of the cam, the magnetic field generator being integral with or mounted on the locking cam.

18. A locking system according to any of claims 10 to 13, wherein said at least one rotatable member comprises a thumbturn for driving the lock, said magnetic field generator being located on the thumbturn.

19. A locking system according to any preceding claim, wherein the system comprises a set of keys comprising at least two keys for driving the lock, each key having a sensed element located thereon, each sensed element having at least one property that differs from that of other sensed elements on the other keys of the set.

20. A locking system according to claim 19, wherein said sensed elements are magnetic field generators, each magnetic field generator having at least one magnetic field property that differs from that of other magnetic field generators on the other keys of the set.

21. A locking system according to claim 19, wherein the system is configured to generate a different corresponding output in response to the sensing means sensing each of the sensed elements of the set.

22. A locking system according to claim 20 or 21, wherein the magnetic field generators of the keys in the set differ from one another in at least one of shape, size, position on the key and magnetic field strength.

23. A locking system according to any preceding claim, wherein the sensing means is mounted in use to a reference structure.

24. A locking system according to any preceding claim, wherein the locking system further comprises a sensor unit having a sensor housing for housing the sensing means in use, the sensor unit being configured for mounting to a reference structure in use.

25. A locking system according to any preceding claim, wherein the lock is driveable by a rotatable lock driving member for rotatably driving the lock.

26. A system according to any preceding claim, wherein said at least one magnetic field generator is a magnet.

27. A system according to any preceding claim, wherein the sensing means is a magnetometer.

28. A system according to any preceding claim, wherein the sensed element is a tag which can produce a signal when activated or powered.

29. A system according to claim 24, wherein the tag is a bluetooth tag, RFID tag, near field communication (NFC) tag, or any other type of tag which can be configured to provide an identifier over radio frequency.

30. A system according to any preceding claim, wherein the system is configured to operate in a calibration mode and a normal mode, wherein in the calibration mode the system is configured to register at least an output value from the sensing means when the

locking system has a first predetermined lock status as a first reference input and wherein in the normal mode the system is configured to use the at least a first reference input to determine the lock status.

31. A method of calibrating a system according to claim 30, the method comprising, when the system is in calibration mode, registering the output from the sensing means when the locking system has a first predetermined lock status.

32. A method of determining one or more lock statuses of a lock using a locking system according to any of claims 1 to 31, the method comprising the processor means receiving output signals from the sensing means associated with measured magnetic field from the sensing means and on receiving said output signals, determining one or more lock statuses based on the sensed magnetic field.

33. A system according to any preceding claim, wherein the lock is for a window or a door leaf, the leaf being moveable between an open position and a closed position, the lock comprising a lock mechanism and said at least one sensed element being located in the lock mechanism in use, the sensing means being mounted in use to a reference structure that the leaf moves relative to when moving between its open and closed positions, the system being configured to receive output signals associated with measured magnetic field from the sensing means to determine the position of the leaf.

34. A system according to any preceding claim, the system further comprising a user interface.

35. A system according to any preceding claim, the system further comprising a memory.

36. A system according to any preceding claim, wherein the sensor means and/or processor means is battery powered.

37. A system according to any preceding claim, wherein the system further comprises wireless transmission means to transmit output signals from the system to a user interface.

38. A key configured for use in the system of any preceding claim.

39. A key according to claim 38, wherein the key comprises a recess for receiving said at least one sensed element therein.

40. A set of keys configured for use in the system of any preceding claim.

41. A lock configured for use in the system of any preceding claim.

42. A magnetic field generator configured for use in the system of any preceding claim.

43. A system substantially as hereinbefore described with reference to any suitable combination of the drawings.

44. A key substantially as hereinbefore described with reference to any suitable combination of the drawings.

45. A set of keys substantially as hereinbefore described with reference to any suitable combination of the drawings.

46. A lock substantially as hereinbefore described with reference to any suitable combination of the drawings.

47. A magnetic field generator substantially as hereinbefore described with reference to any suitable combination of the drawings.

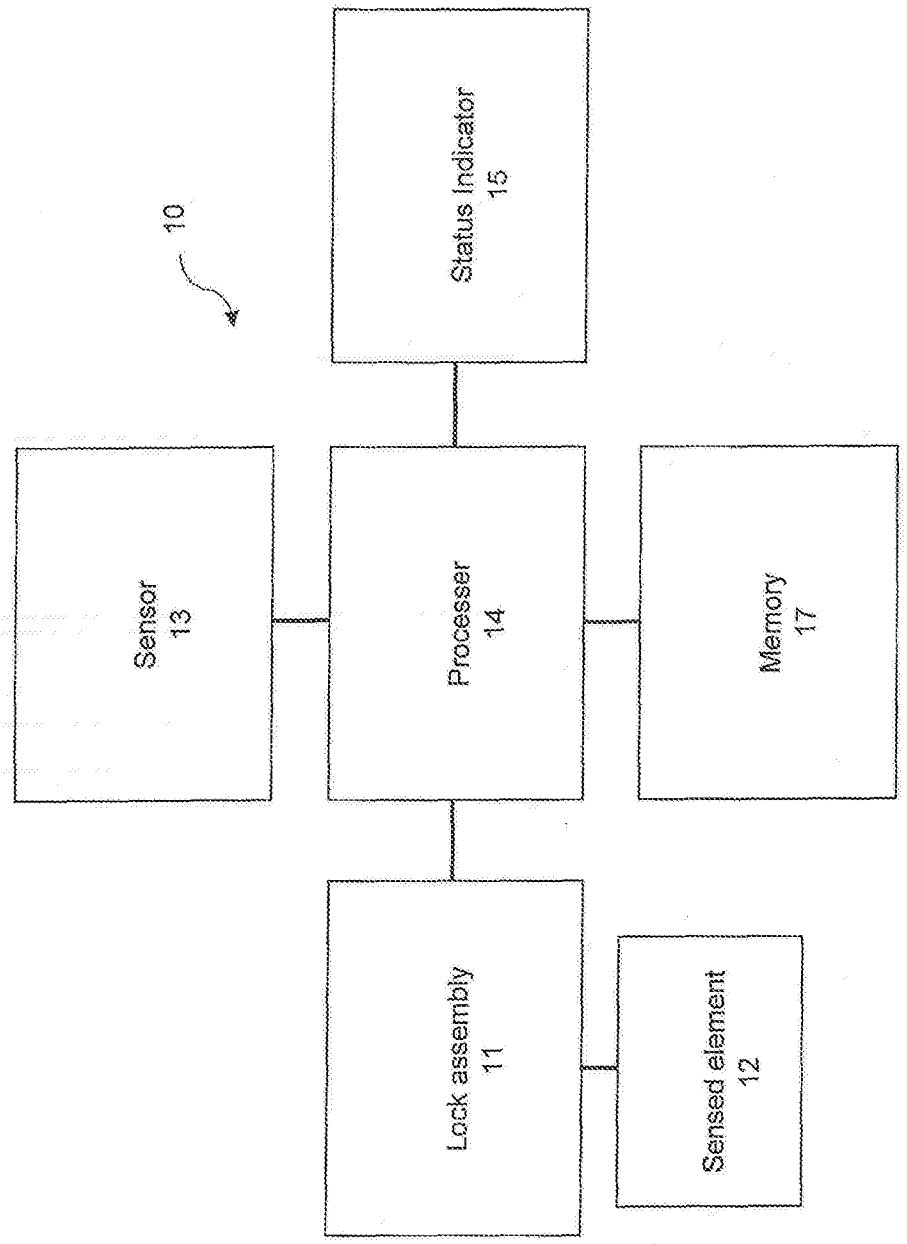

10
Status Indicator
15
Sensor
13
Processer
14
Memory
17
Lock assembly
11
Sensed element
12

FIGURE 1

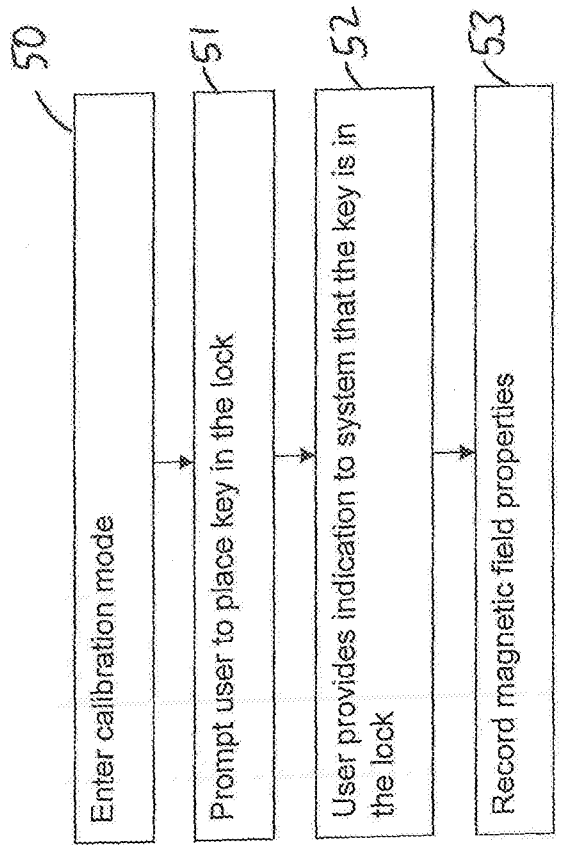


Figure 3

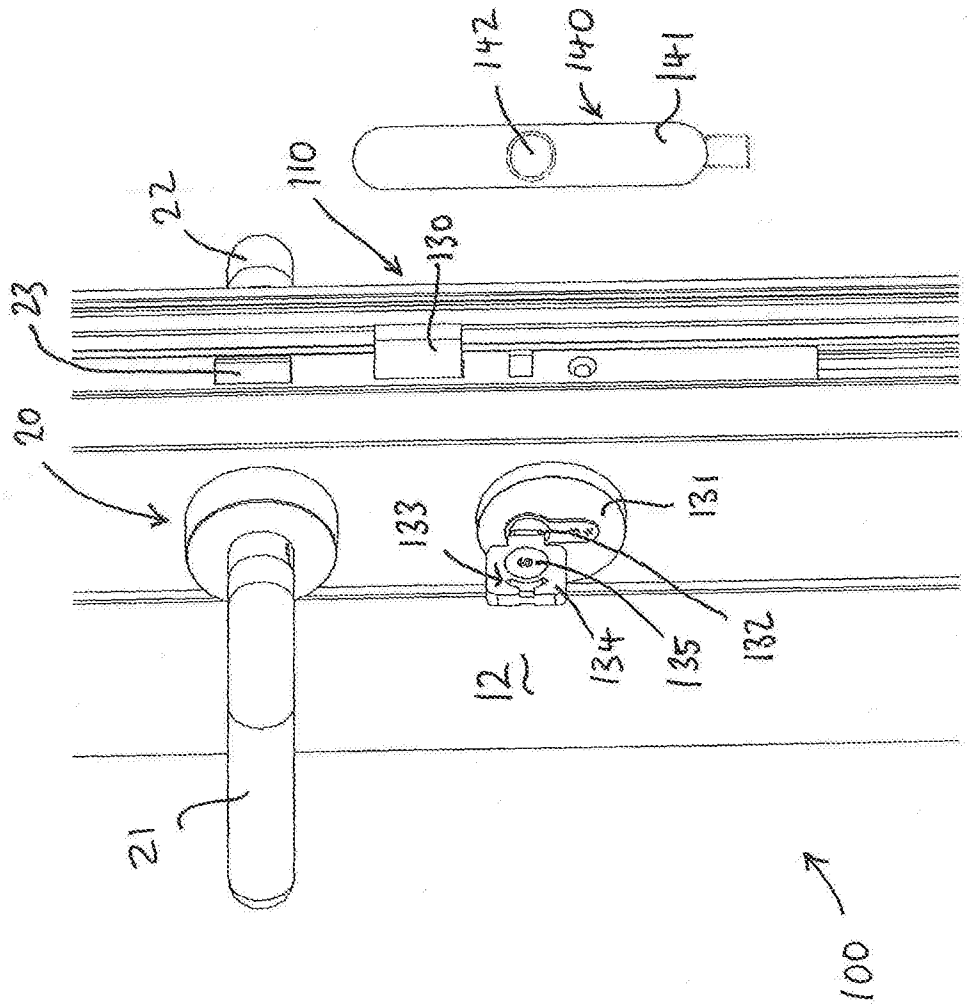


Figure 2

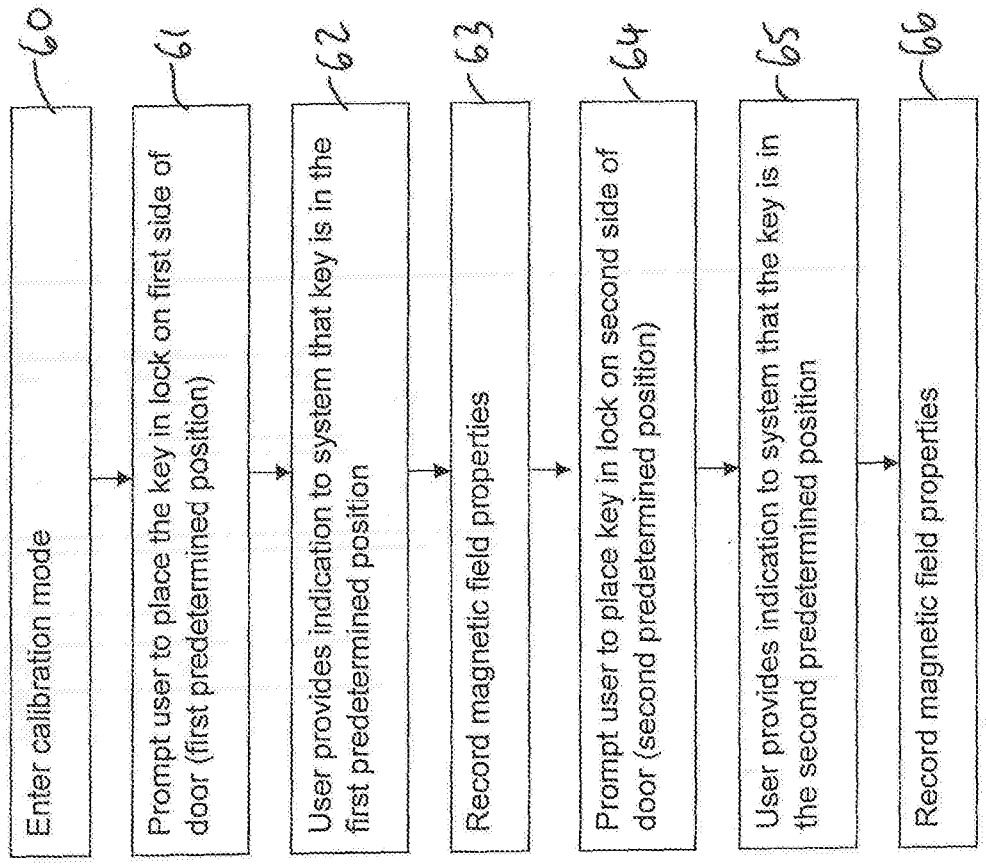

60
Enter calibration mode
61
Prompt user to place the key in lock on first side of door (first predetermined position)
62
User provides indication to system that key is in the first predetermined position
63
Record magnetic field properties
64
Prompt user to place key in lock on second side of door (second predetermined position)
65
User provides indication to system that the key is in the second predetermined position
66
Record magnetic field properties

Figure 4

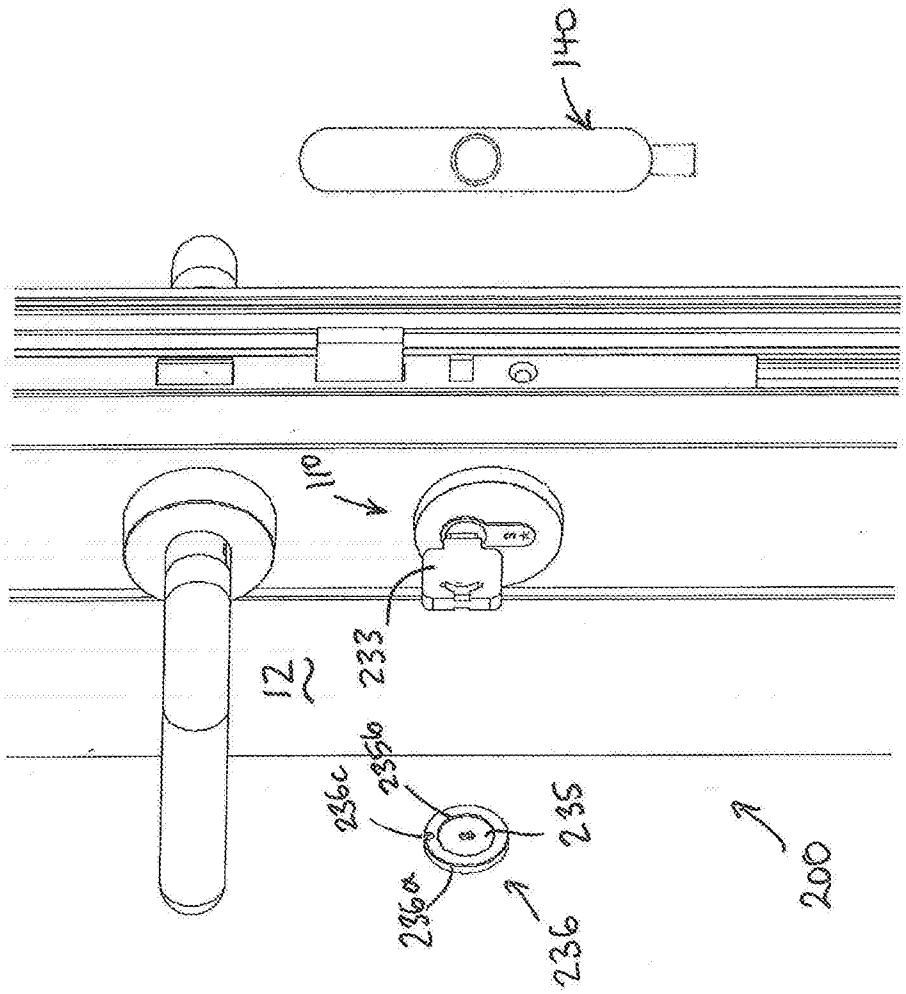


Figure 5

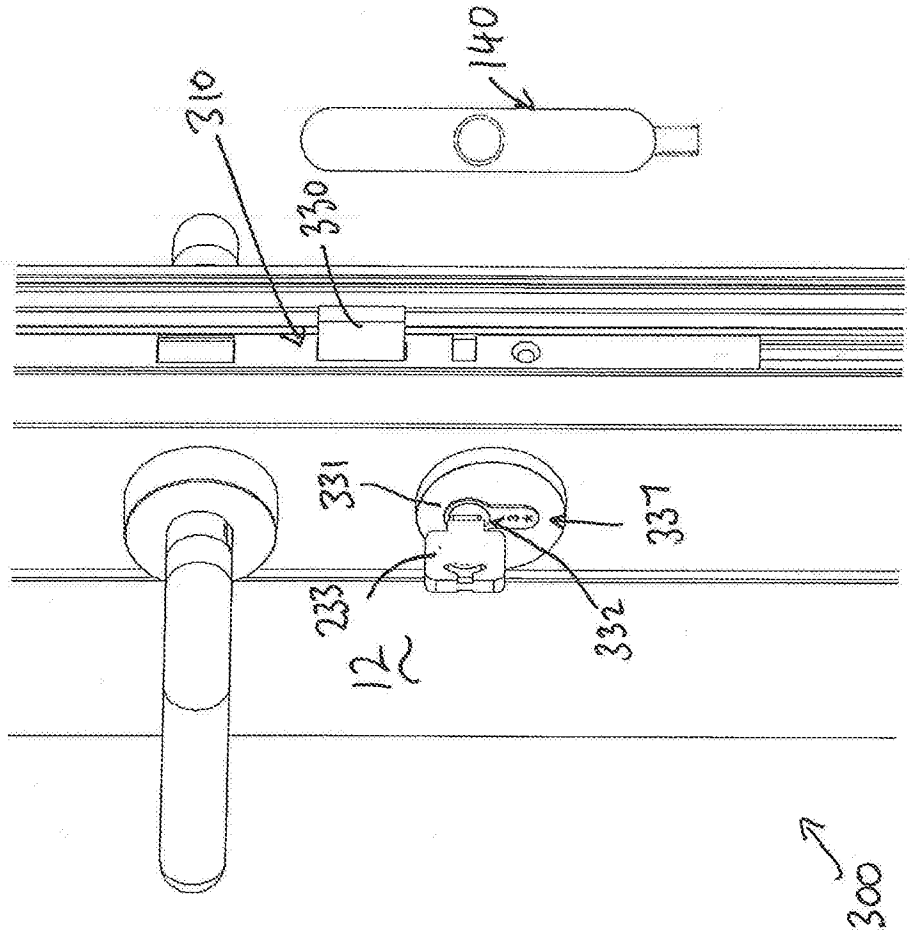


Figure 6A

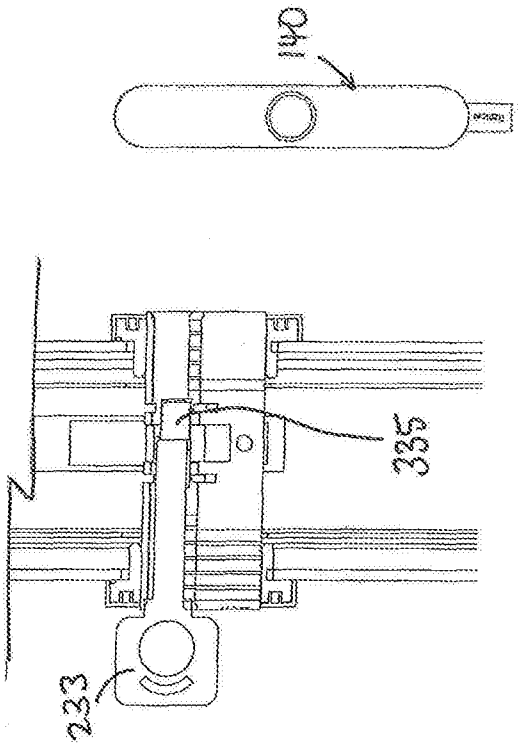


Figure 6C

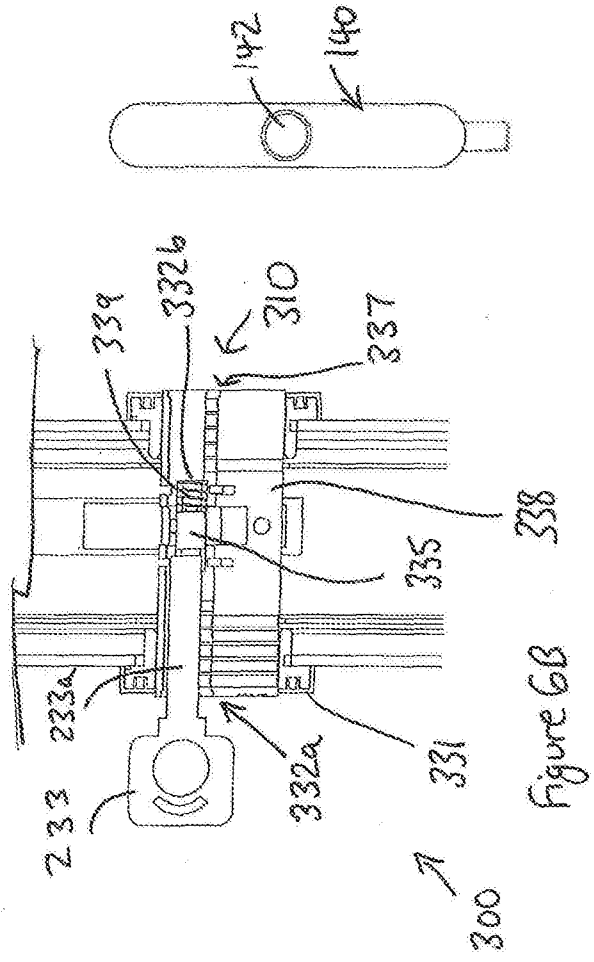


Figure 6B

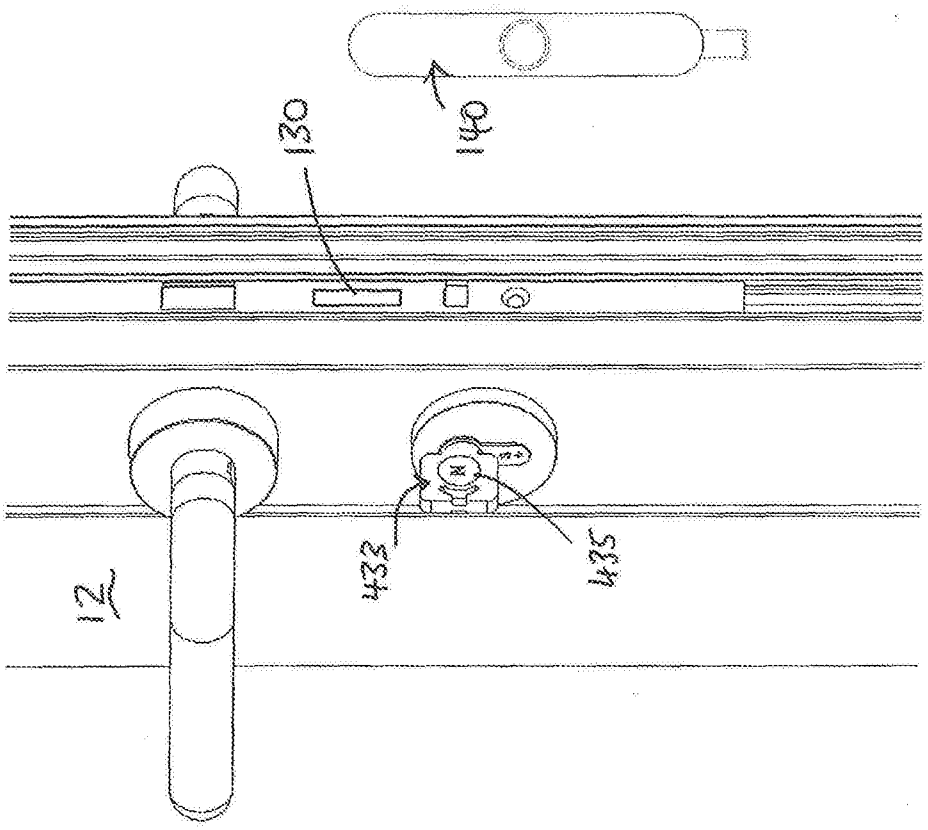


Figure 7B

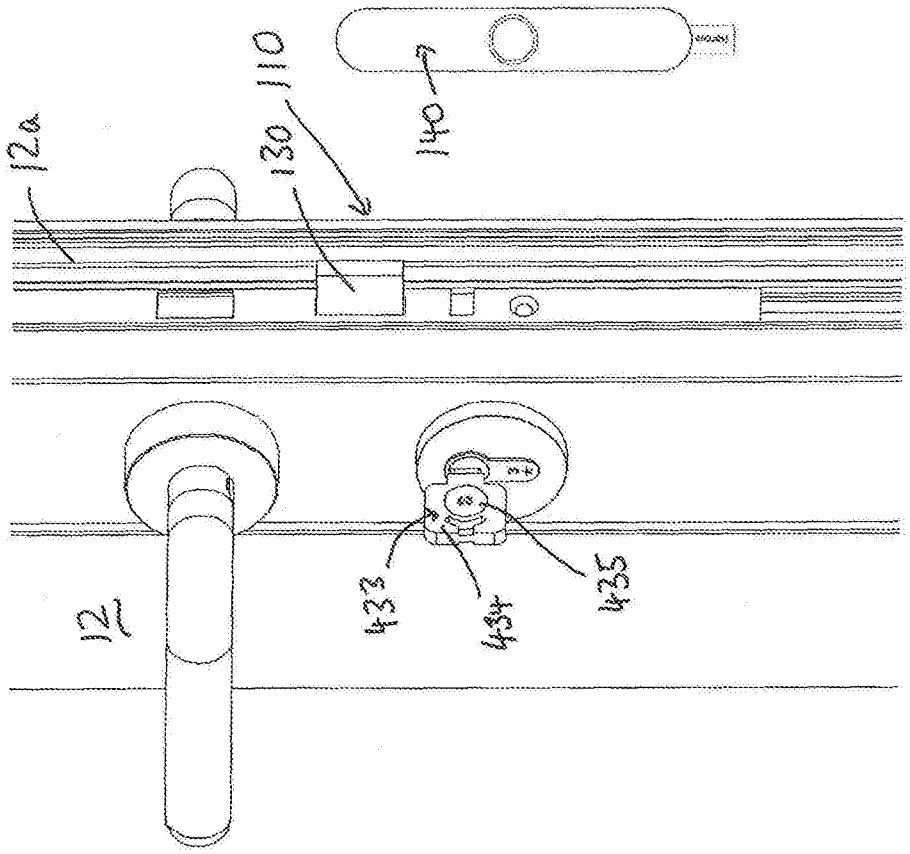
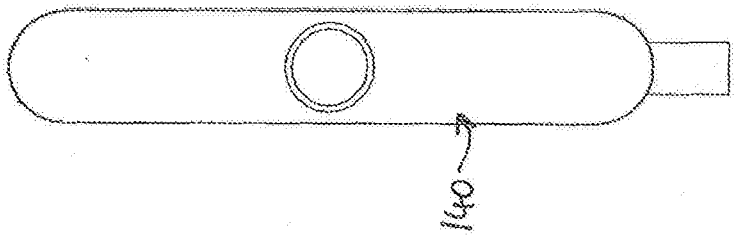


Figure 7A



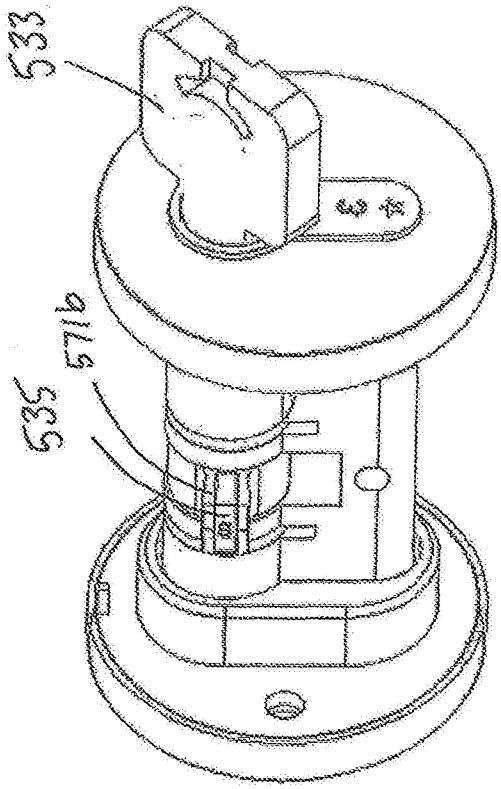


Figure 6B

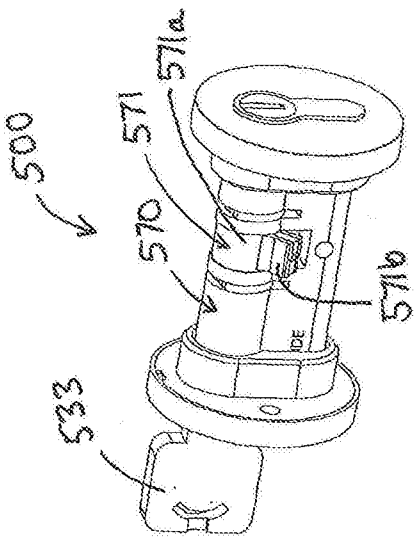


Figure 6A

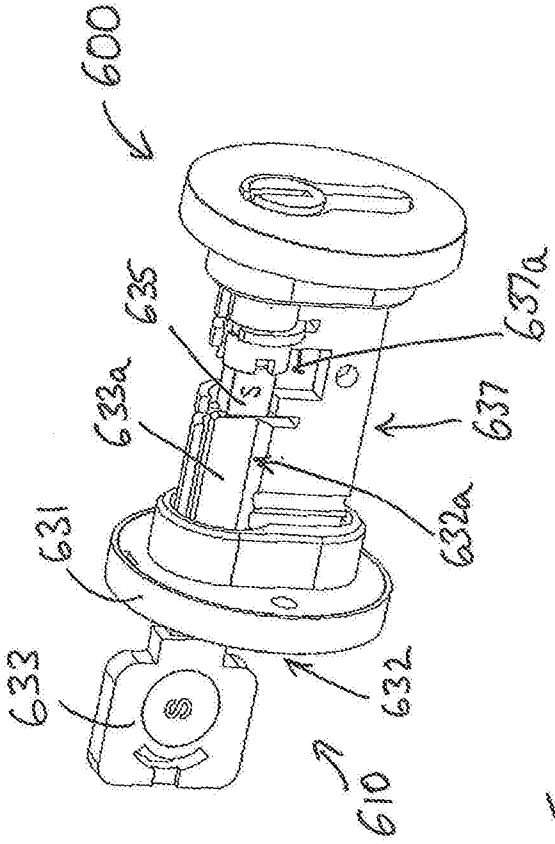


Figure 9

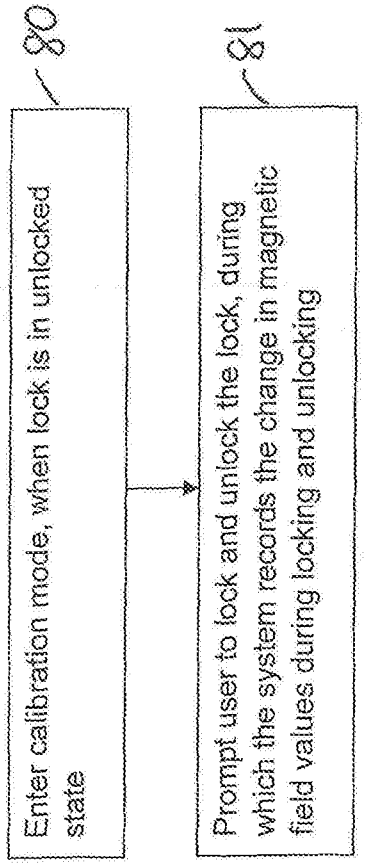

80
Enter calibration mode, when lock is in unlocked state
81
Prompt user to lock and unlock the lock, during which the system records the change in magnetic field values during locking and unlocking

Figure 10

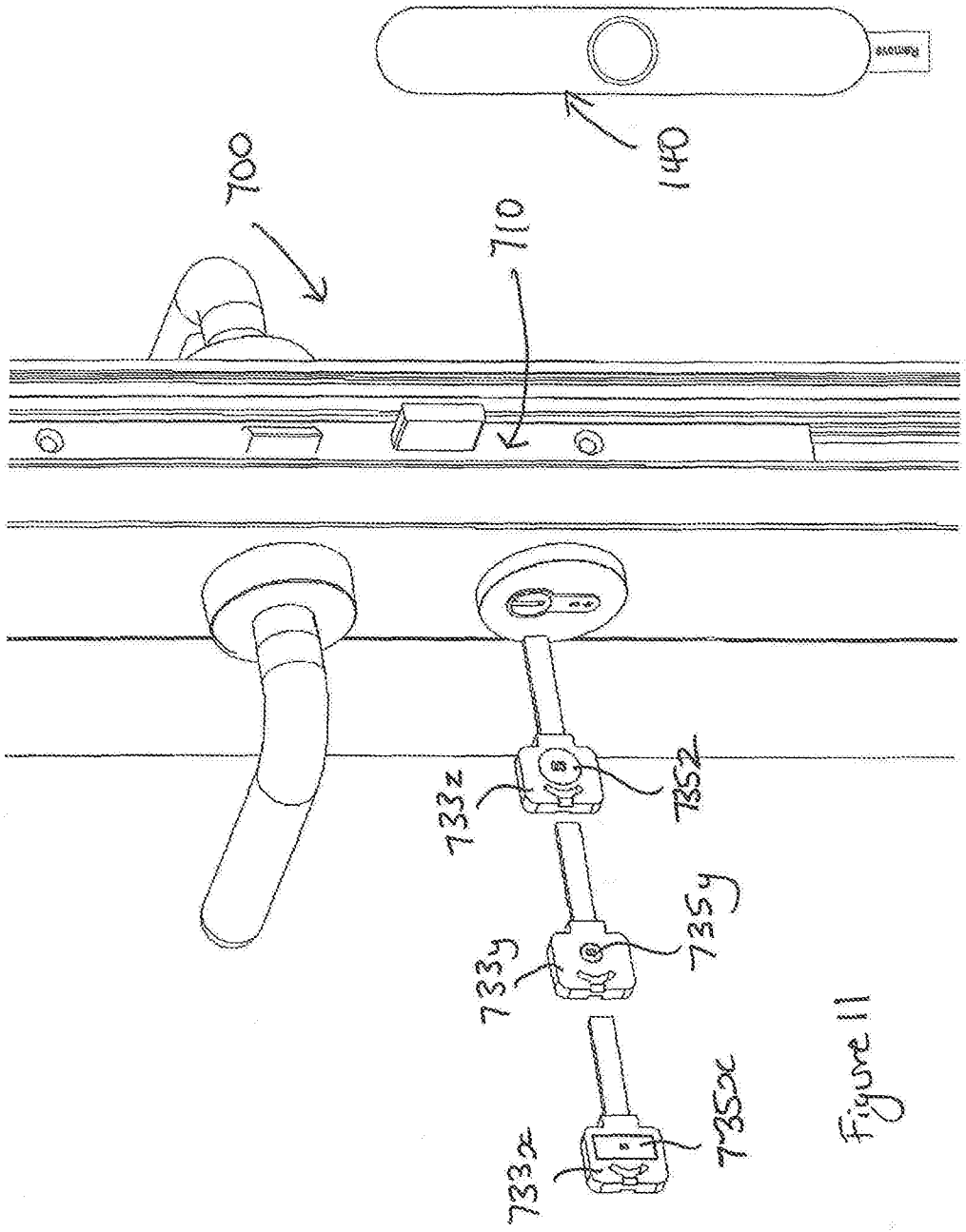


Figure 11

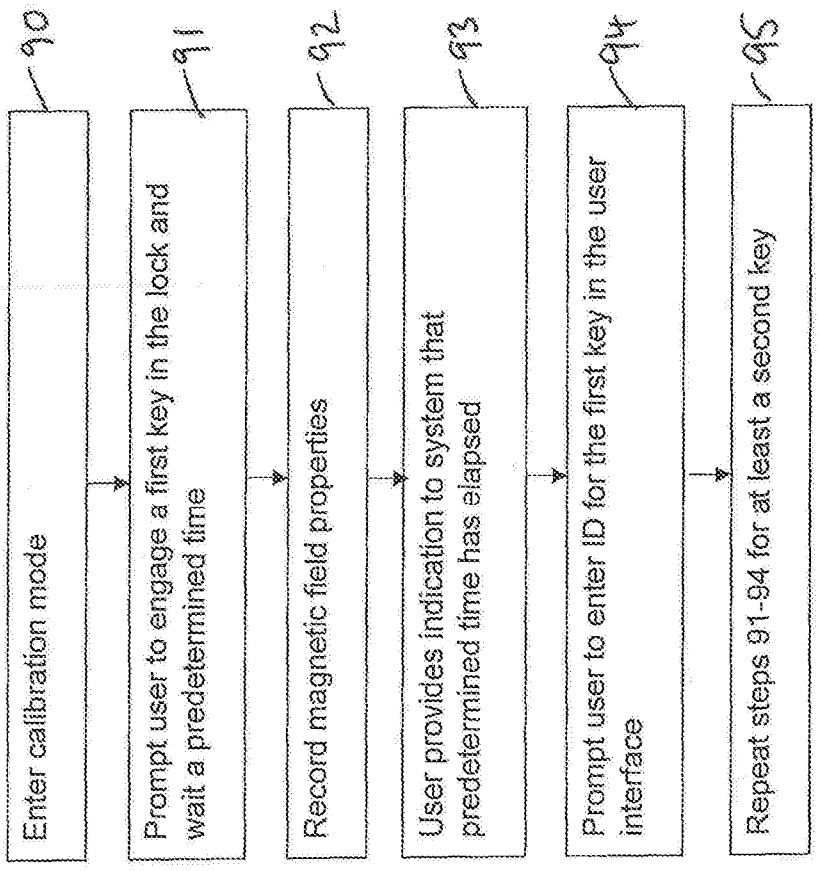

90
Enter calibration mode
91
Prompt user to engage a first key in the lock and wait a predetermined time
92
Record magnetic field properties
93
User provides indication to system that predetermined time has elapsed
94
Prompt user to enter ID for the first key in the user interface
95
Repeat steps 91-94 for at least a second key

Figure 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2018/053032

A. CLASSIFICATION OF SUBJECT MATTER
INV. E05B45/06 E05B47/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E05B

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017/111619 A1 (WIRELESS GUARD LTD [NZ]) 29 June 2017 (2017-06-29)	1,2, 10-16, 18, 23-37, 41-47
A	the whole document	3-9,17, 19-22, 38-40

X	EP 3 070 683 A1 (GIGASET COMMUNICATIONS GMBH [DE]) 21 September 2016 (2016-09-21)	1,3,4,6, 19,38,39
Y	the whole document	5,7-10, 17
A		11-16, 18, 20-37, 40-47

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 February 2019	06/03/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Cruyplant, Lieve

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2018/053032

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/084299 A1 (FISHER JOSEPH JOHN [US] ET AL) 10 April 2008 (2008-04-10)	1
Y	the whole document	5
A		2-4,6-47

Y	US 2010/328089 A1 (EICHENSTEIN JOSEPH [US] ET AL) 30 December 2010 (2010-12-30) abstract	7

Y	WO 97/15034 A1 (GUIM R [US]; GUIM ELENA [US]) 24 April 1997 (1997-04-24)	8-10
A	the whole document	1-7, 11-47

Y	DE 203 20 720 U1 (BEILSTEIN GERT [DE]; BLOCH KLAUS [DE]) 25 August 2005 (2005-08-25) the whole document	17

A	US 2011/285528 A1 (WEINSTEIN HILLEL [IL] ET AL) 24 November 2011 (2011-11-24) abstract	19-22,40

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2018/053032

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US 2011285528 A1	24-11-2011	NONE	