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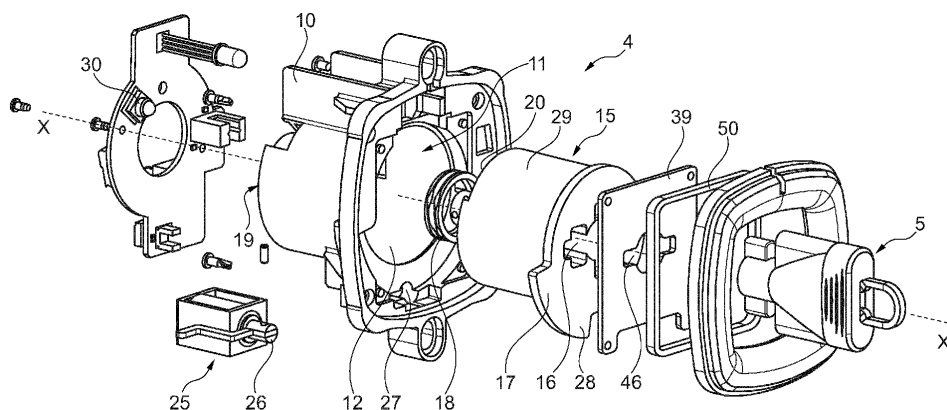
**(54) IMPROVEMENTS RELATING TO TRAPPED KEY INTERLOCK SYSTEMS**

(57) A key module (4) for a trapped key interlock panel (3), comprising:

a) a module housing (10) mountable in the trapped key interlock panel;  
b) a cylinder (15) comprising a key slot (16) for receiving a key (5), the key slot extending from a front face (17) of the cylinder rearwardly along a longitudinal axis of the cylinder, the cylinder being rotatably-mounted in the module housing to permit rotation of the cylinder relative to the module housing about the longitudinal axis between a key insertion position, in which a key is free to be inserted into or removed from the key slot, and a trapped key position, in which a key is retained in the key slot, the cylinder also being reciprocally-mounted in the module housing to permit reciprocating axial movement of the

cylinder relative to the module housing along the longitudinal axis, and the cylinder being biased forwardly within the module housing;

c) a cylinder retaining element (39) for retaining the cylinder in the module housing;  
d) a lock (25) for selectively preventing rotation of the cylinder about its longitudinal axis;  
e) a switch (30) for generating a signal when the cylinder is displaced rearwardly within the module housing against the bias of the cylinder by engagement of a key in the key slot; and  
f) an antenna (50) for receiving wireless signals from a wireless tag (6) of a key.

**Fig. 3**

## Description

### Field of the disclosure

**[0001]** The present disclosure relates to the field of trapped key interlock systems. In particular, it relates to key modules and keys for trapped key interlock systems and to improvements in trapped key interlock systems.

### Background

**[0002]** Trapped key interlock systems may be used to ensure that a sequence of events occurs in a safe and predetermined order. For example, a trapped key interlock system may comprise a mechanism that requires that a mechanical key be locked or trapped in a device until some other action occurs, for example the switching off of a piece of machinery, after which the trapped key is allowed to be released and removed for subsequent use. Trapped key interlock systems may require a plurality of keys and operations to be ordered. The use of multiple keys may be managed using a system comprising a trapped key interlock panel that can receive multiple keys and a central controller that controls access to the keys.

**[0003]** Typically, such trapped key interlock systems are each intended for use with a specific design of key that can limit their usefulness and flexibility. The use of multiple keys within a system can also increase complexity and confusion for users.

### Summary of the disclosure

**[0004]** Against this background, in a first aspect there is provided a key module for a trapped key interlock panel, comprising:

- a) a module housing mountable in the trapped key interlock panel;
- b) a cylinder comprising a key slot for receiving a key, the key slot extending from a front face of the cylinder rearwardly along a longitudinal axis of the cylinder,

the cylinder being rotatably-mounted in the module housing to permit rotation of the cylinder relative to the module housing about the longitudinal axis between a key insertion position, in which a key is free to be inserted into or removed from the key slot, and a trapped key position, in which a key is retained in the key slot, the cylinder also being reciprocally-mounted in the module housing to permit reciprocating axial movement of the cylinder relative to the module housing along the longitudinal axis, and the cylinder being biased forwardly within the module housing;

- c) a cylinder retaining element for retaining the cylinder in the module housing;

d) a lock for selectively preventing rotation of the cylinder about its longitudinal axis;

e) a switch for generating a signal when the cylinder is displaced rearwardly within the module housing against the bias of the cylinder by engagement of a key in the key slot; and

f) an antenna for receiving wireless signals from a wireless tag of a key.

**[0005]** Advantageously, the design of the key module improves the usefulness and flexibility of a trapped key interlock system by enabling a modular approach to be used wherein the trapped key interlock system can more easily be used with a wide variety of sizes and designs of keys. For example, only a very limited number of components of the key module need to be changed in order to adapt the key module to a different key. In some examples it may only require the cylinder to be changed to one adapted to a new key. In some examples it may only require the cylinder and the cylinder retaining element to be changed, for example in cases where the key is trapped directly behind the cylinder retaining element.

**[0006]** In some examples the antenna comprises an antenna coil positioned in front of the front face of the cylinder that circumscribes the key slot such that a key being inserted into the key slot passes through the antenna coil. Advantageously, locating the antenna coil in this way may provide for more reliable and accurate detection of the wireless tag of the key. In particular, it may be used to configure the system for use with keys where the wireless tag is integrated in or attached rigidly to a head or shaft of the key (as opposed to dangling from a connected fob) and to only detect the wireless tag once the key has started to be inserted into the key slot.

**[0007]** In some examples, the wireless tag of the key comprises an RFID tag, preferably a passive RFID tag.

**[0008]** The key module may comprise a key trapping element for retaining a key in the key slot when the cylinder is in the trapped key position. In some examples, the key trapping element comprises an element that at least partially occludes the key slot of the cylinder in the trapped key position to prevent withdrawal of a key from the key slot.

**[0009]** In some examples the key trapping element is the cylinder retaining element. Such a configuration may be beneficially used where the shape of the key comprises a narrowed section (of the shaft or head or other part) that has a sufficient axial length and location to permit a shoulder of the key neighbouring the narrowed section to be pushed rearwardly past the cylinder retaining element when the key is inserted into the key slot and the cylinder is displaced rearwardly so as to activate the switch. Thereby, on subsequent rotation of the key and cylinder into the trapped key position, the shoulder is clear to rotate behind a portion of the cylinder retaining element so that the cylinder retaining element at least partially occludes the key slot, thus trapping the key in the key slot.

**[0010]** In some examples the cylinder retaining element comprises a plate or ring fixedly mounted to the module housing. The plate or ring may comprise or demarcate a key entry hole that is shaped and sized to allow passage of a portion of the key in at least one orientation but to prevent withdrawal of the key once rotated into at least one other orientation.

**[0011]** In some other examples the key trapping element comprises a floating element that is reciprocally-axially movable relative to the module housing along the longitudinal axis of the cylinder.

**[0012]** The floating element may have a range of axial movement, for example, of up to 3mm. The floating element may comprise a plate. In some examples the floating element may be sandwiched between the cylinder and the cylinder retaining element and retained in the module housing by the cylinder retaining element.

**[0013]** A thickness of the floating element is preferably less than an axial length of a narrowed portion provided on a shaft or head of the key such that in use rotation of the key into the trapped key position causes the floating element to be engaged within the narrowed portion of the key with a shoulder of the key neighbouring the narrowed portion being retained rearwardly of the floating element.

**[0014]** The floating element may be beneficially used where the shape of the key either does not have a narrowed section with a suitable neighbouring shoulder or comprises a narrowed section (of the shaft or head or other part) that has an insufficient axial length and location to permit a shoulder of the key neighbouring the narrowed section to be pushed rearwardly past the cylinder retaining element when the key is inserted into the key slot and the cylinder is displaced rearwardly so as to activate the switch. For example, if the axial stroke length of the cylinder is 2.0mm and the narrowed section of the key only has an axial length of 1.8mm, then the shoulder of the key will not clear a rear face of the cylinder retaining element before the key needs to be rotated. Beneficially, the floating element may solve this problem by virtue of its ability to move axially relating to the module housing and the cylinder retaining element. Thus, taking the example above as an illustration, the floating element may be configured to have a thickness of up to 1.5mm. When the key is inserted a head of the key engages the floating element (at which point the floating element is aligned with the 1.5mm long narrowed section of the key. The key and floating plate together are pushed (further) rearwardly so as to displace the cylinder through its required 2mm stroke while at the same time maintaining the floating element aligned with the narrowed section of the key. Thereby, on subsequent rotation of the key and cylinder into the trapped key position, the shoulder of the key is clear to rotate behind a portion of the floating element so that the floating element at least partially occludes the key slot, thus trapping the key in the key slot.

**[0015]** The lock may be configured for selectively preventing rotation of the cylinder about its longitudinal axis in either rotational sense. For example, the lock may be

used to selectively enable or prevent rotation of the cylinder away from the key insertion position, into the key insertion position, away from the trapped key position, and/or into the trapped key position.

**[0016]** In some examples the lock may comprise a mechanical element that selectively physically obstructs rotation of the cylinder. In some examples the lock may be solenoid-actuated.

**[0017]** In some examples the cylinder is configured to require it to be displaced rearwardly within the module housing before it can be rotated about its longitudinal axis.

**[0018]** In a second aspect there is provided a trapped key interlock system comprising:

- i) a controller;
- ii) a trapped key interlock panel comprising one or more key modules as described above in the first aspect; and
- iii) one or more keys each comprising a wireless tag.

**[0019]** In some examples, the controller may be configured to determine that a key is inserted into a key slot of a key module when the switch of that key module is actuated by rearward displacement of its cylinder.

**[0020]** In some examples, the controller may be configured to identify a key by interrogating its wireless tag as the key is inserted into a key slot of a key module using the antenna of the key module.

**[0021]** In some examples, the controller may be provided in whole or in part within a control panel unit that may be located locally to or remote from the trapped key interlock panel.

**[0022]** The controller may reside in one location and comprise essentially one unit, for example in the form of a discrete control unit. Alternatively, the controller may comprise a plurality of control components that work together to carry out the functions of the controller. The control components may be distributed spatially. Each control component may carry out one or more functions of the controller. The control components may be arranged locally, for example as part of a LAN. Alternatively, the control components may be arranged widely, for example as part of a WLAN. The control components may comprise remote computing resources. The control components may comprise cloud computing resources that are interconnected via a public network such as the Internet.

**[0023]** In some examples, in the trapped key position a mechanically-coded portion of the key may be fully retained within the key slot.

**[0024]** In some examples, the lock of each key module may be operatively controlled by the controller to control release of its cylinder from its trapped key position.

**[0025]** In some examples, the controller may be configured to only permit rotation of a cylinder from its key insertion position to its trapped key position if the key inserted into its key slot has been identified, via its wireless tag, to be an authorised key for that specific key

module.

**[0026]** In some examples, the wireless tag of each key may be integrated in, or fixedly mounted to or about, a head or shaft of the key.

**[0027]** In a third aspect there is provided a key for a trapped key interlock system comprising:

a head, a shaft having a mechanically-coded section, and a narrowed portion provided on the head, the shaft or therebetween;  
the key further comprising a clamp comprising a first part and a second part, the first part being lockable to the second part around the head and/or shaft of the key; wherein the clamp securely houses a wireless tag.

### Brief description of the drawings

**[0028]** Embodiments of the present disclosure will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic view of a trapped key interlock system according to the present disclosure;  
Figure 2 is a perspective view of a first embodiment of a key module and key for use as part of the trapped key interlock system of Figure 1;  
Figure 3 is an exploded view of the key module of Figure 2;  
Figure 4 is a perspective view of the key of Figure 2;  
Figure 5 is a perspective view of a portion of the key module of Figure 2;  
Figure 6 is another perspective view of the portion of the key module shown in Figure 5;  
Figure 7 is a perspective view of a second embodiment of key module from the front;  
Figure 8 is a perspective view of the key module of Figure 7 from the rear;  
Figure 9 is an exploded view of the key module of Figure 7;  
Figures 10 to 12 are views illustrating engagement of a key with a floating element of the key module of Figure 7; and  
Figures 13 to 16 are perspective views (assembled and exploded) of examples configurations of key.

### Detailed description

**[0029]** Figure 1 shows a schematic view of a trapped key interlock system 1 of the present disclosure. The trapped key interlock system 1 comprises a controller 2, a trapped key interlock panel 3 that itself comprises a plurality of individual key modules 4, and a plurality of keys, each key 5 comprising a wireless tag 6, for example a RFID tag.

**[0030]** The controller 2 may be provided in a control panel unit 7 that may be located locally to or remote from the trapped key interlock panel 3. Both the control panel

unit 7 and the trapped key interlock panel 3 may be integrated into a single housing if desired.

**[0031]** In the illustrated example, the trapped key interlock panel 3 comprises 16 key modules 4. The number of key modules 4 within the trapped key interlock panel 3 may be altered as desired to be greater than or less than 16.

**[0032]** Figures 2 to 6 show a first embodiment of a key module 4 that may be used in the trapped key interlock panel 3 together with a key 5 inserted into the key module 4.

**[0033]** The key module 4 comprises a module housing 10 that is mountable in the trapped key interlock panel 3. The module housing 10 may define a cavity 11 having a front-facing opening 12 for receiving a cylinder 15.

**[0034]** The cylinder 15 comprises a key slot 16 for receiving a key 5. The key slot 16 extends from a front face 17 of the cylinder 15 rearwardly along a longitudinal axis X-X of the cylinder 15.

**[0035]** The cylinder 15 is rotatably-mounted in the module housing 10 to permit rotation of the cylinder 15 relative to the module housing 10 about the longitudinal axis X-X between a key insertion position, in which a key 5 is free to be inserted into or removed from the key slot 16, and a trapped key position, in which a key 5 is retained in the key slot 16. Figure 2 illustrates the key 5 in the trapped key position.

**[0036]** The cylinder 15 is also reciprocally-mounted in the module housing 10 to permit reciprocating axial movement of the cylinder 15 relative to the module housing 10 along the longitudinal axis X-X. The cylinder 15 is biased forwardly within the module housing 10. In the illustrated example as shown in Figure 3 a spring 18 extending between a rear face 19 of the module housing 10 and a rear face 20 of the cylinder 15 is used to provide the bias.

**[0037]** A lock 25 is provided for selectively preventing rotation of the cylinder 15 about its longitudinal axis X-X. The lock 25 may be solenoid-actuated, for example. The lock 25 may comprise a locking bolt 26 that can be moved in and out of a position in which it prevents or limits rotation of the cylinder 15 about its longitudinal axis X-X. As shown in Figures 3 and 5, the lock 25 may be located so that the locking bolt 26 can be moved through an aperture 27 in the module housing 10 into and out of engagement with the cylinder 15.

**[0038]** The cylinder 15 may comprise a detent 28 for restraining rotational movement of the cylinder 15. The detent 28 may comprise a portion of the cylinder wall 29 or front face 17 that projects radially outwards from a remainder of the cylinder body and that can be engaged by the lock 25. As shown in Figures 3 and 5, the detent 28 may comprise a radial enlargement of the cylinder 15 at or near the front face 17 of the cylinder 15 aligned with the location of the locking bolt 26.

**[0039]** A switch 30 is provided for generating a signal when the cylinder 15 is displaced rearwardly within the module housing 10 against the bias of the cylinder 15 by

engagement of a key 5 in the key slot 16. The switch 30 may be a push-button switch.

**[0040]** The cylinder 15 may comprise a raceway 35 in which the switch 30 may be engaged and run as the cylinder 15 is rotated. As shown in the example of Figure 6, the raceway 35 may be provided on a rear face 20 of the cylinder 15 and extend through an angle sufficient to permit rotation of the cylinder 15 between its key free position and trapped key position.

**[0041]** The cylinder 15 may be configured to require it to be displaced rearwardly within the module housing 10, so as to actuate the switch 30, before it can be rotated about its longitudinal axis X-X. The configuration may be achieved by physical means. For example, as shown in Figure 6 (and Figure 8 discussed below with respect to the second embodiment) the cylinder 15 may be provided with a rotary catch 36 that must be disengaged before the cylinder 15 can be rotated. The rotary catch 36 may comprise one or more radial projections 37 that project from a portion of the cylinder 15, for example an axially-extending boss 38 at the rear of the cylinder 15. The module housing 10 may be provided with an annular seat 40 for the boss 38 that has an aperture in which the boss 38 may slide axially and one or more radial grooves, openings or cut-outs 41 that are sized and shaped to receive the one or more projections 37 of the boss 38. In the examples illustrated in Figures 6 and 8 the boss 38 comprises two diametrically-opposed projections 37 and the annular seat 40 comprises four radial openings 41 at 90 degree spacing. When the cylinder 15 is biased into its forwardmost position the two projections 37 of the boss 38 are received in two of the radial openings 41, e.g. the horizontal two radial openings 41. In this position engagement of the projections 37 against the annular seat 40 prevents cylinder 15 rotation. To rotate, the cylinder 15 must first be displaced rearwards to move the projections 37 out of alignment with the radial openings 41 (as shown in Figure 8) at which point the switch 30 is push-actuated and the cylinder 15 can be rotated. Once the cylinder 15 has been rotated to align the projections 37 with the vertical radial openings 41 the cylinder 15 is enabled to move forwardly and deactuate the switch 30.

**[0042]** As shown in Figure 3, the key module 4 further comprises a cylinder retaining element 39 for retaining the cylinder 15 in the module housing 10. The cylinder retaining element 39 may comprise a plate or ring fixedly mounted to the module housing 10. The cylinder retaining element 39 may be formed from sheet material, for example, sheet steel or other metal. The cylinder retaining element 39 may be mounted to the module housing 10 by suitable means. Preferably, the cylinder retaining element 39 is mounted in fixed relationship to the module housing 10 so that this is no or minimal relative movement between the parts.

**[0043]** The cylinder retaining element 39 may comprise a key opening 46 that is sized and shaped to a specific key design.

**[0044]** The key module 4 may comprise a key trapping

element for retaining the key 5 in the key slot 16 when the cylinder 15 is in the trapped key position. Typically, the key trapping element comprises an element that at least partially occludes the key slot 16 of the cylinder 15 in the trapped key position to prevent withdrawal of a key 5 from the key slot 16.

**[0045]** In the embodiment of Figures 2 to 6, the key trapping element is the cylinder retaining element 39 itself and the cylinder retaining element 39 performs both the function of retaining the cylinder 15 in the module housing 10 and trapping the key 5 in the trapped key position.

**[0046]** An antenna is provided for receiving wireless signals from a wireless tag 6 of the key 5. The antenna may comprise an antenna coil 50 positioned in front of the front face 17 of the cylinder 15 that circumscribes the key slot 16 such that a key 5 being inserted into the key slot 16 passes through the antenna coil 50.

**[0047]** The key 5 for the first embodiment of key module 4 is shown in Figure 4 and comprises a head 60 and a shaft 61. The head 60 is provided with the wireless tag 6. In this example, the wireless tag 6, e.g. RFID, may be integrated into the housing of the key head 60.

**[0048]** The shaft 61 comprises a mechanically-coded portion which in this example comprises two radial lugs 62 that project from opposite sides of the shaft 61. The key 5 further comprises a narrowed section 63 between the lugs 62 and the head 60. The narrowed section 63 has an axial length L. For example for this type of key 5 the axial length L may be 2.5 to 4.00mm or more. The forwardmost face of the lugs 62 define a pair of front-facing shoulders 64 of the key 5 that neighbour the narrowed section 63.

**[0049]** In use, the key 5 is inserted into the key slot 16 of the cylinder 15 by inserting the shaft 61 and lugs 62 of the key 5 through the key opening 46 of the cylinder retaining element 39. Inserting the key 5 fully brings the wireless tag 6 of the key 5 close to the antenna coil 50 and preferably close to the plane of the antenna coil 50. Pushing on the key 5 also causes the cylinder 15 to be displaced rearwards thereby actuating the switch 30 by contact between the switch 30 and the rear face 20 of the cylinder 15 within the raceway 35. The rearward displacement also causes the front-facing shoulders 64 of the key 5 to be moved past a rear face 47 of the cylinder retaining element 39.

**[0050]** Actuation of the switch 30 causes an input to be sent to the controller 2 which causes the lock 25 to allow rotation of the cylinder 15. In examples where the lock 25 is solenoid actuated, a solenoid may cause the locking bolt 26 to move out of the position in which it prevents or limits rotation of the cylinder 15 by withdrawing the locking bolt 26 out of alignment with the detent 28 of the cylinder 15. In some examples, the key module 4 may further comprise a solenoid position sensor, such a fork sensor to monitor movement of the solenoid and the locking bolt 26 and/or detect errors in the solenoid movement.

**[0051]** Additionally, the controller 2 may receive a signal from the antenna coil 50 which may be used by the controller 2 to interrogate the wireless tag 6 of the key 5 to identify the key 5 and determine whether the key 5 is a correct key for the key module 4 in which it has been inserted. In some examples, the locking bolt 26 may only be moved out of the position in which it prevents or limits rotation of the cylinder 15 once it has been determined by the controller 2 that the key 5 is the correct key for the key module 4.

**[0052]** Next the key 5 is manually rotated to rotate the cylinder 15 into the trapped key position during which movement of the front-facing shoulders 64 of the key 5 are rotated behind the sheet material of the cylinder retaining element 39 preventing the key 5 being withdrawn. Once the cylinder 15 is rotated into the trapped key position releasing the key 5 permits the cylinder 15 to move forwards under its bias engaging the rotary catch 36 of the cylinder 15, e.g. the projections 37 of the cylinder boss 38 are engaged in the radial openings 41 of the annular seat 40. At the same time the switch 30 is disengaged from the rear face 20 of the cylinder 15 and deactuated allowing the controller 2 to determine that the trapped key position has been achieved. In some examples, the key module 4 may further comprise a cylinder position sensor, such as a fork sensor, to determine whether the cylinder 15 is in the trap position. If required the controller 2 may make a further interrogation of the wireless tag 6 using the antenna coil 50 to confirm that the wireless tag 6 (and therefore the key 5) is still present in the key slot 16.

**[0053]** In some examples, when the cylinder 15 is in the key trapped position, the controller 2 may continuously interrogate the wireless tag 6 using the antenna coil 50 to confirm the wireless tag 6 (and therefore the key 5) continues to be present in the key slot 16. As such removal of the key 5 as a result of tampering with the key 5 would be detected.

**[0054]** To unlock the key 5, actuation of the switch 30 causes the input to be sent to the controller 2 which causes the lock 25 to allow rotation of the cylinder 15. The key 5 is manually rotated to rotate the cylinder 15 from the trapped key position to the key free position, such that the key 5 can be withdrawn from the key slot 16.

**[0055]** In some examples the control panel unit 7 may be used to allow or disallow locking or unlocking of the key 5 from the key module 4. For example, the control panel unit 7 may be provided with a security authorisation input such as a PIN pad or a security card reader. Based on the security authorisation input, the control panel unit 7 may determine which if any of a plurality of key modules 4 to activate. The activated key modules 4 may be activated by activating the switch 30. For example, in an activated state, the switch 30 may be activated such that when pressed the solenoid is caused to move. In a deactivated state, the switch 30 may have no effect on the solenoid. As such, it is only possible for the switch 30 to cause lock 25 to allow rotation of the cylinder 15 when the key

module 4 is activated following an appropriate security authorisation input. In this way, it is possible to prevent withdrawal or insertion of keys by an unauthorised user.

**[0056]** Figures 7 to 12 show a second embodiment of a key module 4 that may be used in the trapped key interlock panel 3 together with a key 5 inserted into the key module 4. In the following only the differences between the second and first embodiments will be described. In other respects it should be understood that the key module 4 of the second embodiment is the same as that of the first embodiment. Aspects and features of the embodiments may be mixed in any desired combination unless the contrary is explicitly indicated.

**[0057]** In this second embodiment the key trapping element comprises a floating element 70 that is reciprocally-axially movable relative to the module housing 10 along the longitudinal axis X-X of the cylinder 15 rather than the cylinder retaining element 39.

**[0058]** The floating element 70 may have a range of axial movement of up to 3mm. The floating element 70 may comprise a plate. As shown in Figure 9, the floating element 70 may be sandwiched between the cylinder 15 and the cylinder retaining element 39 and retained in the module housing 10 by the cylinder retaining element 39. The floating element 70 may comprise a key opening 71 that is sized and shaped to a specific key design or other opening or feature that enables trapping of the key 5 as discussed below. The floating element 70 may comprise one or more extensions or shoulders 72 that can be engaged against the module housing 10 to prevent rotation of the floating element 70 relative to the module housing 10 about the longitudinal axis X-X.

**[0059]** The design of key 5 of the second embodiment is shown in Figures 7 and 13 and comprises a head 60 and a shaft 61 having a mechanically-coded section. A narrowed section 63 is present between the head 60 and the mechanically-coded section 61 but this has a small axial length L of only about 1.8mm. A clamp 80 comprising a first part 81 and a second part 82 is provided that engages around the head 60 and/or shaft 61 of the key 5. The first part 81 is lockable to the second part 82 by suitable means such as a security bolt 83 (in which the driving head 84 can be snapped off after fixing to hinder unbolting of the parts). The clamp 80 securely houses a wireless tag 6, e.g. an RFID tag.

**[0060]** As shown in Figures 11 and 12, a thickness of the floating element 70 is beneficially less than an axial length of a narrowed portion 63 provided on a shaft 61 or head 60 of the key 5 configured for use with the specific key module 4 such that in use rotation of the key 5 into the trapped key position causes the floating element 70 to be engaged within the narrowed portion 63 of the key 5 with a shoulder 64 of the key 5 neighbouring the narrowed portion 63 being retained rearwardly of the floating element 70. In the illustrated example the thickness of the floating element 70 may be up to 1.5mm.

**[0061]** In use, the key 5 is inserted into the key slot 16 of the cylinder 15 by inserting the mechanically-coded sec-

tion of the shaft 61 of the key 5 through the key opening 46 of the cylinder retaining element 39 and through the key opening 71 of the floating element 70. Inserting the key 5 fully brings the wireless tag 6 in the clamp 80 of the key 5 close to the antenna coil 50 and preferably close to the plane of the antenna coil 50 as shown in Figure 7. At the same time the key 5 engages the floating element 70 (at which point the floating element 70 is aligned with the 1.8mm long narrowed section 63 of the key 5. The key 5 and floating plate 70 together are pushed (further) rearwardly so as to displace the cylinder 15 through its required 2mm stroke while at the same time maintaining the floating element 70 aligned with the narrowed section 63 of the key 5. Thereby, on subsequent rotation of the key 5 and cylinder 15 into the trapped key position, the shoulder 64 of the key 5 is clear to rotate behind a portion of the floating element 70 so that the floating element 70 at least partially occludes the key slot 16, thus trapping the key 5 in the key slot 16.

**[0062]** Figures 14 and 15 illustrate additional examples of key design. Beneficially a wide range of key designs can be made to work with the system of the present disclosure. In particular, the shape and size of the clamp 80 may be adjusted to the external shape and configuration of the key 5.

**[0063]** Figure 16 illustrates an additional example of key design. Different to the key designs shown in Figure 13 to 15, in Figure 16 the wireless tag 6 is attached to the key 5 by including the wireless tag 6 in a cap 91 having a slot for housing the wireless tag 6. The cap 91 is securable to the key 5 by the security bolt 83 which is screwed into a nut 85. When the key 5 is in use, for example when the key is inserted into the key module 4, the slot for housing the wireless tag 6 may not be accessible because the slot would be against the key module 4. In this way, the wireless tag 6 may be prevented from being removed while the key 5 is in use.

**[0064]** In some examples (not shown in the Figures), the clamp 80 and/or the cap 91 may comprise shoulders. In the first embodiment of the key module 4, when the clamp 80 and/or the cap 91 is secured to the key 5, the key 5 may be rotated into the trapped key position such that the shoulders of the clamp 80 and/or the cap 91 are rotated behind the sheet material of the cylinder retaining element 39, preventing the key 5 from being withdrawn. Similarly, in the second embodiment of the key module 4, the shoulders of the clamp 80 and/or the cap 91 may be rotated behind the floating element 70. For example, in some examples, the key 5 may continuously narrow and as such may provide no or insufficient shoulders for engaging the sheet material of the cylinder retaining element 39 and/or, where present, the floating element 70.

**[0065]** In any of the above embodiments, the module housing 10, the cylinder 15, the cylinder retaining element 39 and/or the floating element 70 may be made from a strong plastic such as plastic ABS and/or a strong metal such as stainless steel, for example Inox 304 sheet metal.

## Claims

1. A key module for a trapped key interlock panel, comprising:

- a) a module housing mountable in the trapped key interlock panel;
- b) a cylinder comprising a key slot for receiving a key, the key slot extending from a front face of the cylinder rearwardly along a longitudinal axis of the cylinder,

the cylinder being rotatably-mounted in the module housing to permit rotation of the cylinder relative to the module housing about the longitudinal axis between a key insertion position, in which a key is free to be inserted into or removed from the key slot, and a trapped key position, in which a key is retained in the key slot, the cylinder also being reciprocally-mounted in the module housing to permit reciprocating axial movement of the cylinder relative to the module housing along the longitudinal axis, and the cylinder being biased forwardly within the module housing;

- c) a cylinder retaining element for retaining the cylinder in the module housing;
- d) a lock for selectively preventing rotation of the cylinder about its longitudinal axis;
- e) a switch for generating a signal when the cylinder is displaced rearwardly within the module housing against the bias of the cylinder by engagement of a key in the key slot; and
- f) an antenna for receiving wireless signals from a wireless tag of a key.

2. A key module as claimed in claim 1, wherein the antenna comprises an antenna coil positioned in front of the front face of the cylinder that circumscribes the key slot such that a key being inserted into the key slot passes through the antenna coil.

3. A key module as claimed in claim 1 or claim 2, wherein the key module comprises a key trapping element for retaining a key in the key slot when the cylinder is in the trapped key position.

4. A key module as claimed in claim 3, wherein the key trapping element comprises an element that at least partially occludes the key slot of the cylinder in the trapped key position to prevent withdrawal of a key from the key slot.

5. A key module as claimed in claim 3 or claim 4, wherein the key trapping element is the cylinder

retaining element.

6. A key module as claimed in any preceding claim, wherein the cylinder retaining element comprises a plate or ring fixedly mounted to the module housing. 5
7. A key module as claimed in claim 3 or claim 4, wherein the key trapping element comprises a floating element that is reciprocally-axially movable relative to the module housing along the longitudinal axis of the cylinder. 10
8. A key module as claimed in claim 7, wherein:  
  
the floating element has a range of axial movement of up to 3mm; and/or 15  
the floating element comprises a plate; and/or  
the floating element is sandwiched between the cylinder and the cylinder retaining element and retained in the module housing by the cylinder retaining element; and/or 20  
a thickness of the floating element is less than an axial length of a narrowed portion provided on a shaft or head of the key such that in use rotation of the key into the trapped key position causes the floating element to be engaged within the narrowed portion of the key with a shoulder of the key neighbouring the narrowed portion being retained rearwardly of the floating element. 25 30
9. A key module as claimed in any preceding claim, wherein the lock is solenoid-actuated.
10. A key module as claimed in any preceding claim, wherein the cylinder is configured to require it to be displaced rearwardly within the module housing before it can be rotated about its longitudinal axis. 35
11. A trapped key interlock system comprising: 40  
  
i) a controller;  
ii) a trapped key interlock panel comprising one or more key modules as claimed in any preceding claim; and 45  
iii) one or more keys each comprising a wireless tag.
12. A trapped key interlock system as claimed in claim 11, wherein the controller is configured to: 50  
  
determine that a key is inserted into a key slot of a key module when the switch of that key module is actuated by rearward displacement of its cylinder; and/or 55  
identify a key by interrogating its wireless tag as the key is inserted into a key slot of a key module using the antenna of the key module.

13. A trapped key interlock system as claimed in claim 11 or 12, wherein:

in the trapped key position a mechanically-coded portion of the key is fully retained within the key slot; and/or  
the lock of each key module is operatively controlled by the controller to control release of its cylinder from its trapped key position; and/or  
the controller is configured to only permit rotation of a cylinder from its key insertion position to its trapped key position if the key inserted into its key slot has been identified, via its wireless tag, to be an authorised key for that specific key module.

14. A trapped key interlock system as claimed in any one of claims 11 to 13, wherein the wireless tag of each key is integrated in, or fixedly mounted to or about, a head or shaft of the key.

15. A key for a trapped key interlock system comprising:

a head, a shaft having a mechanically-coded section, and a narrowed portion provided on the head, the shaft or therebetween;  
the key further comprising a clamp comprising a first part and a second part, the first part being lockable to the second part around the head and/or shaft of the key;  
wherein the clamp securely houses a wireless tag.



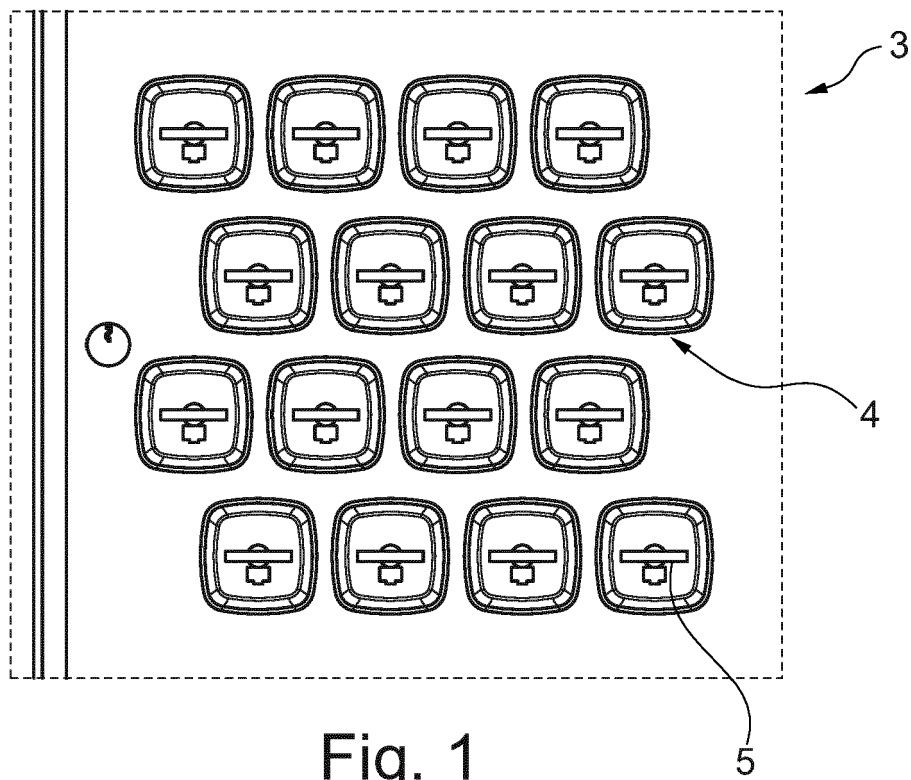
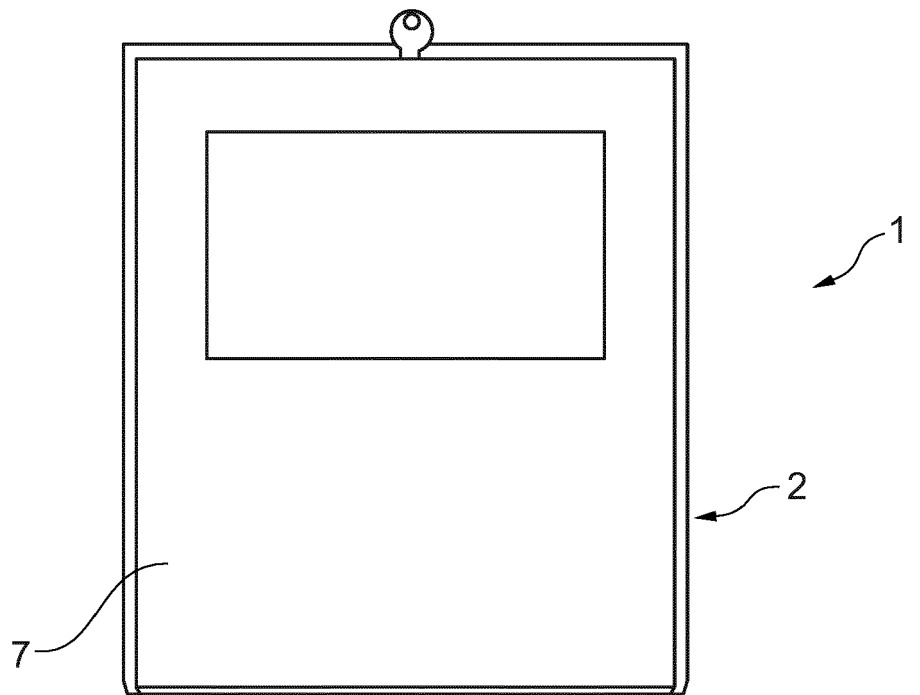


Fig. 1

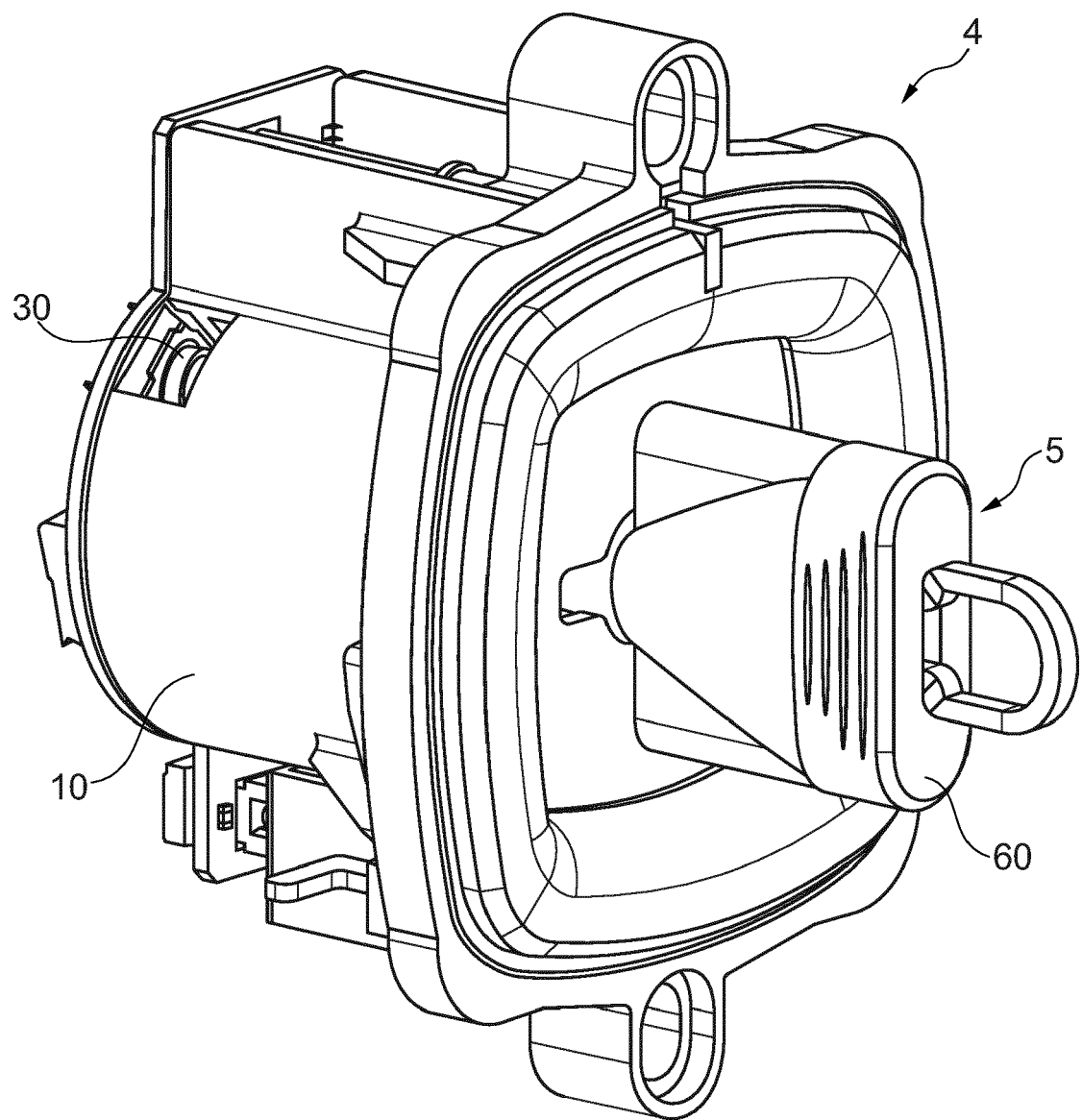


Fig. 2

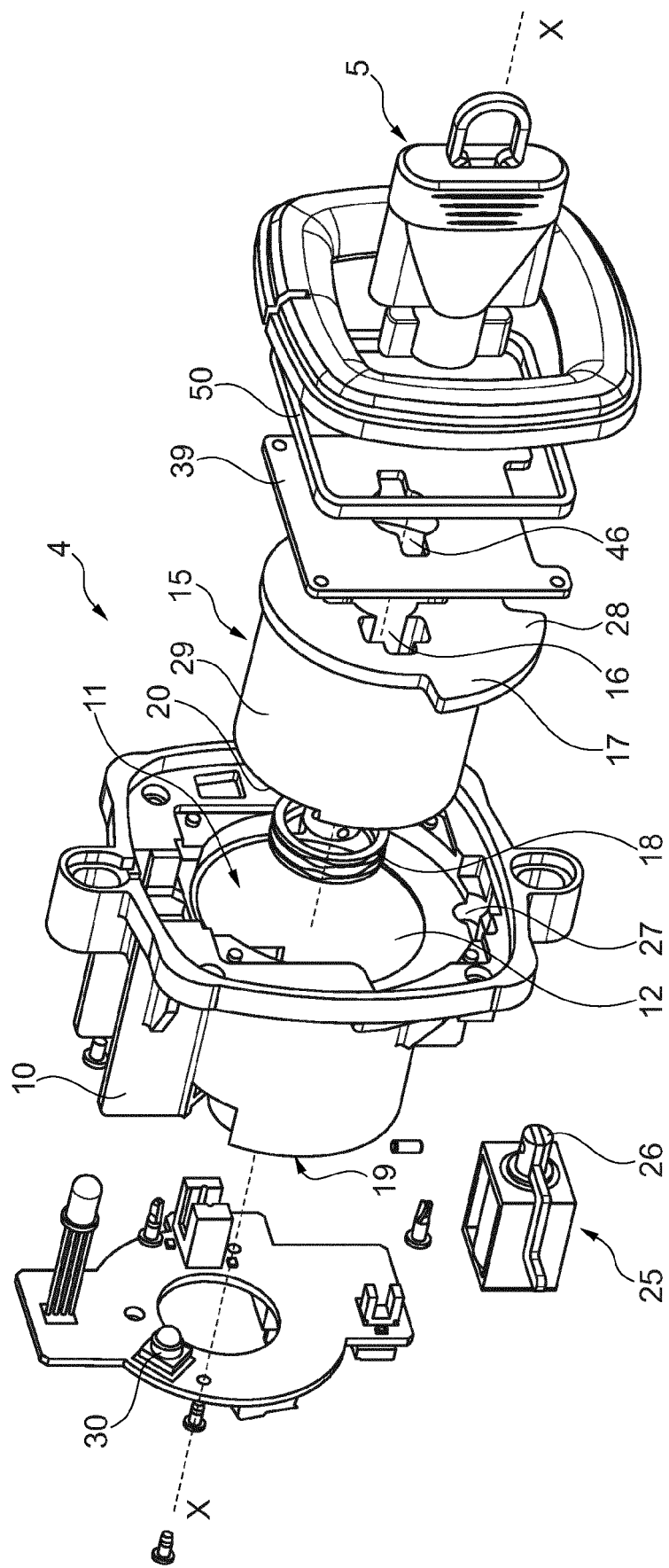
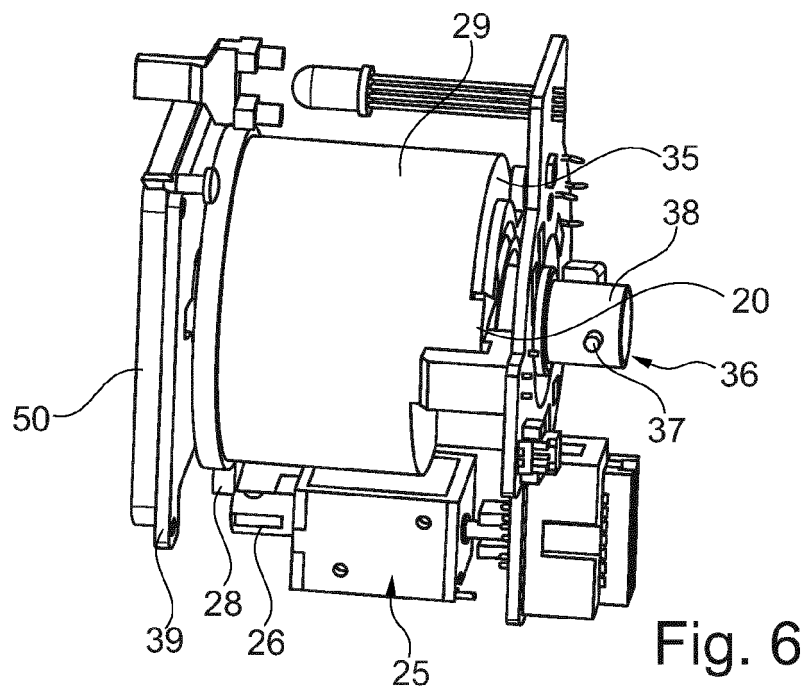
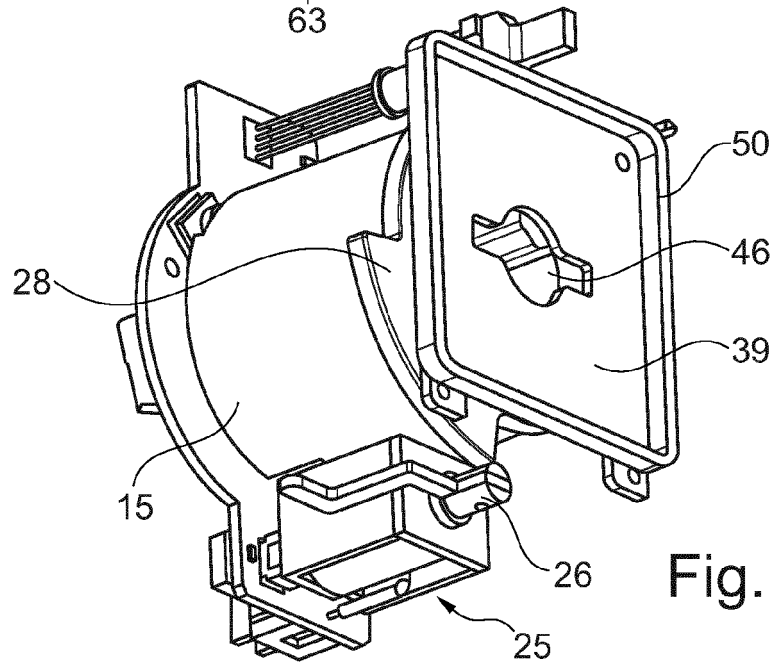
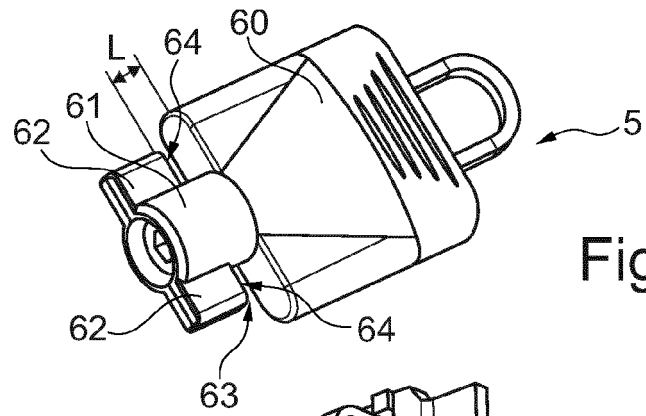


Fig. 3



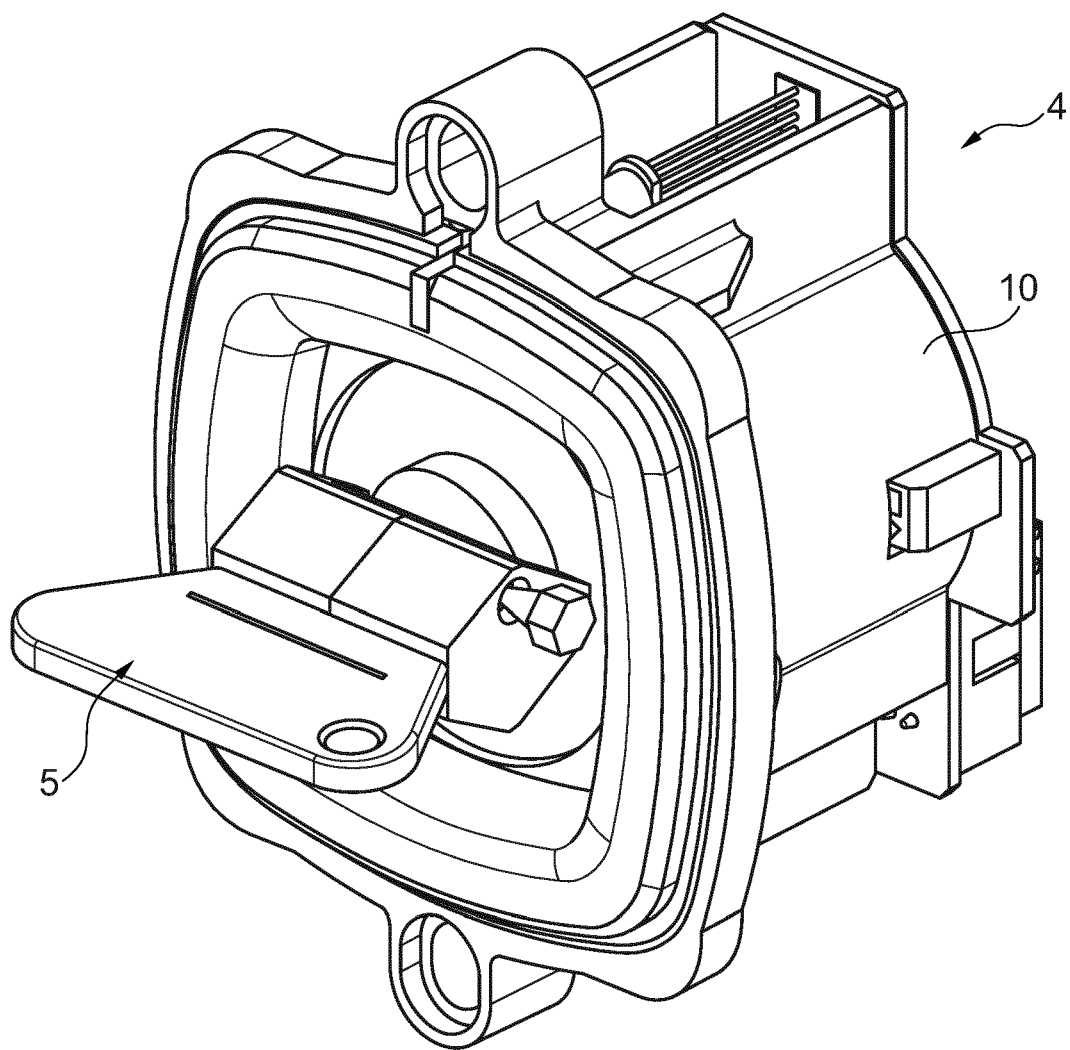


Fig. 7

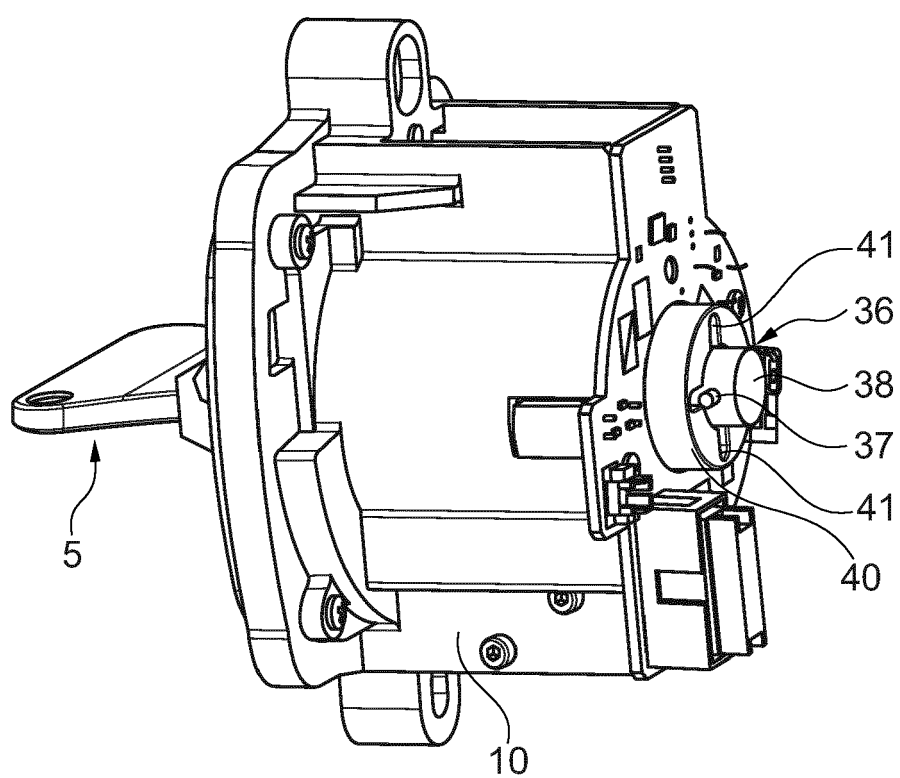


Fig. 8

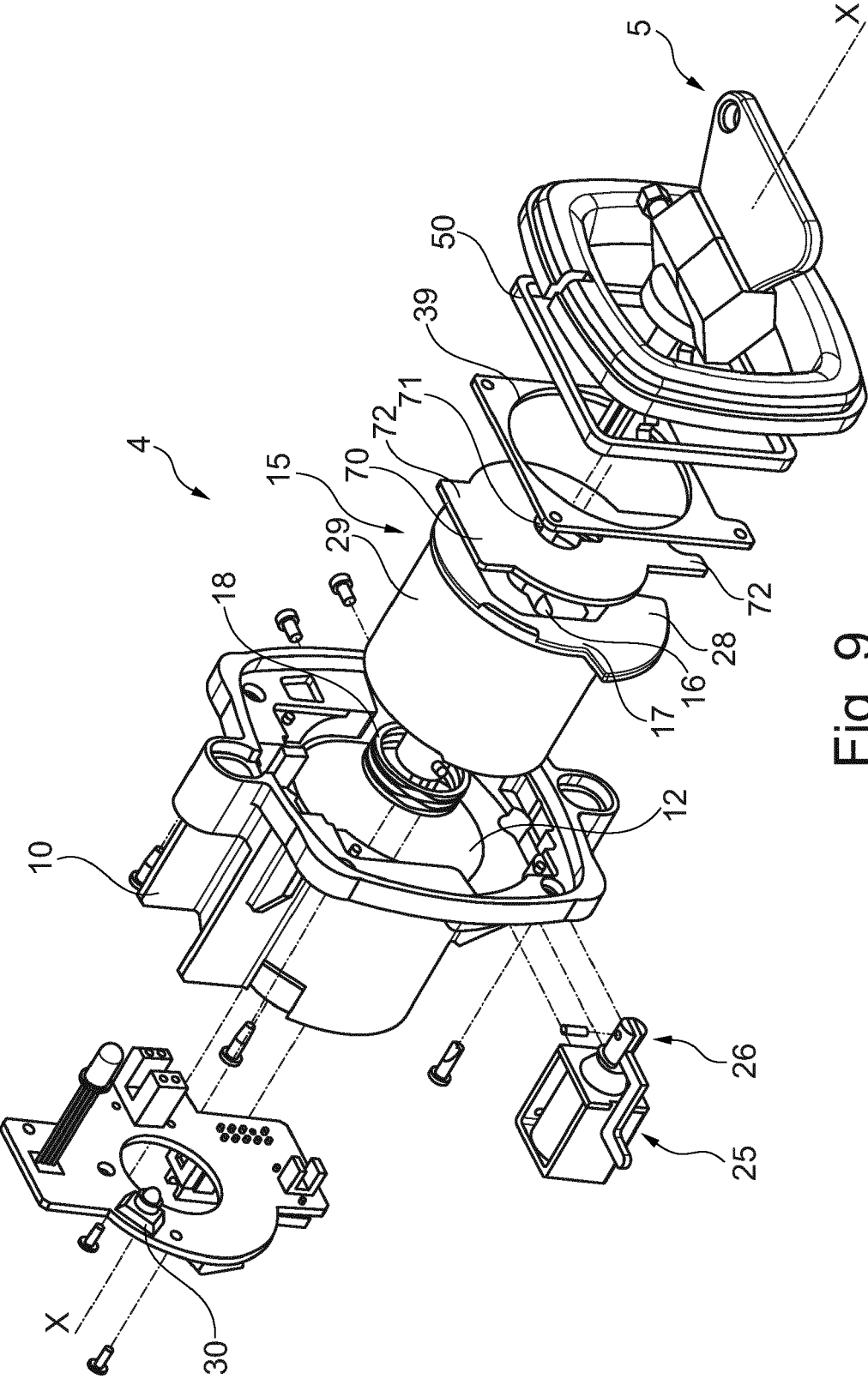


Fig. 9

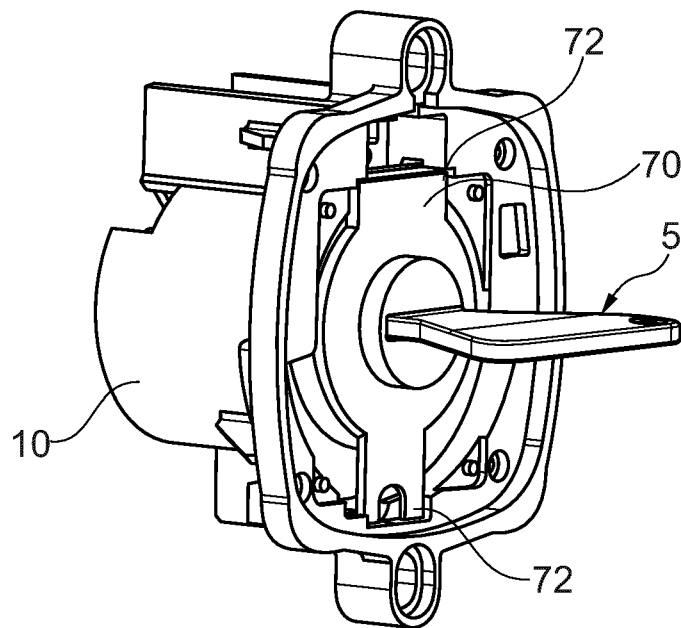


Fig. 10

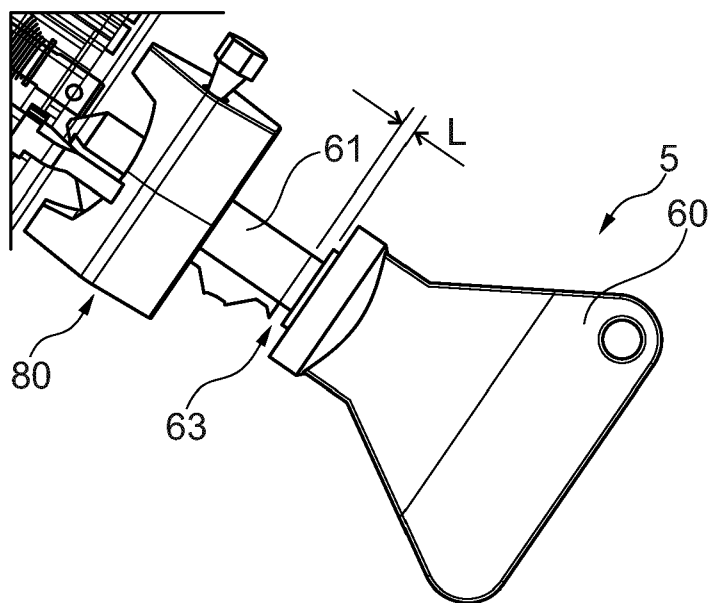


Fig. 11

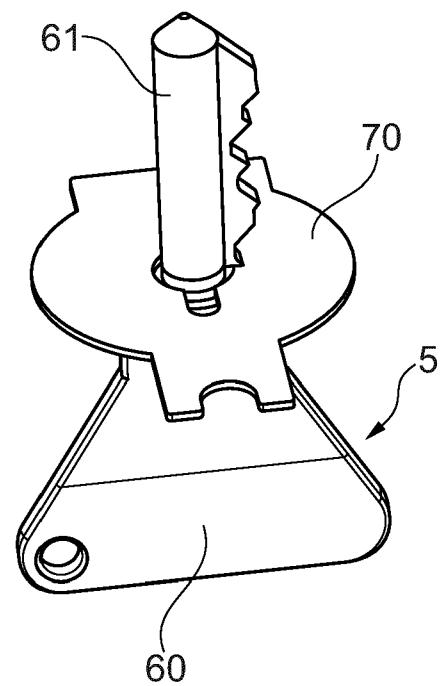


Fig. 12



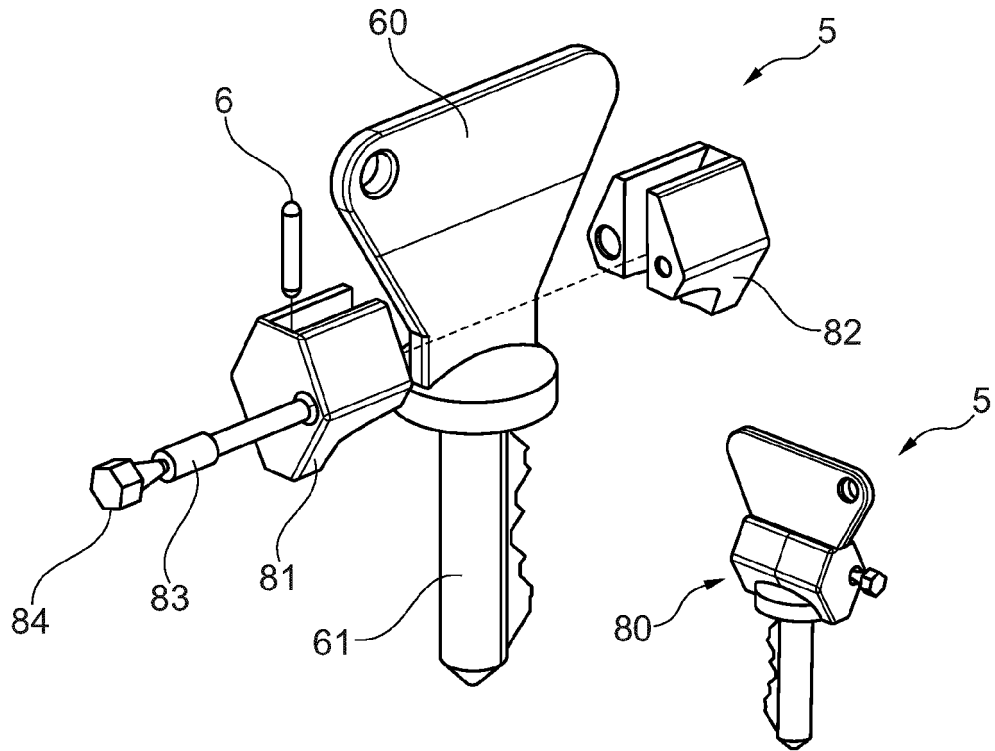


Fig. 13

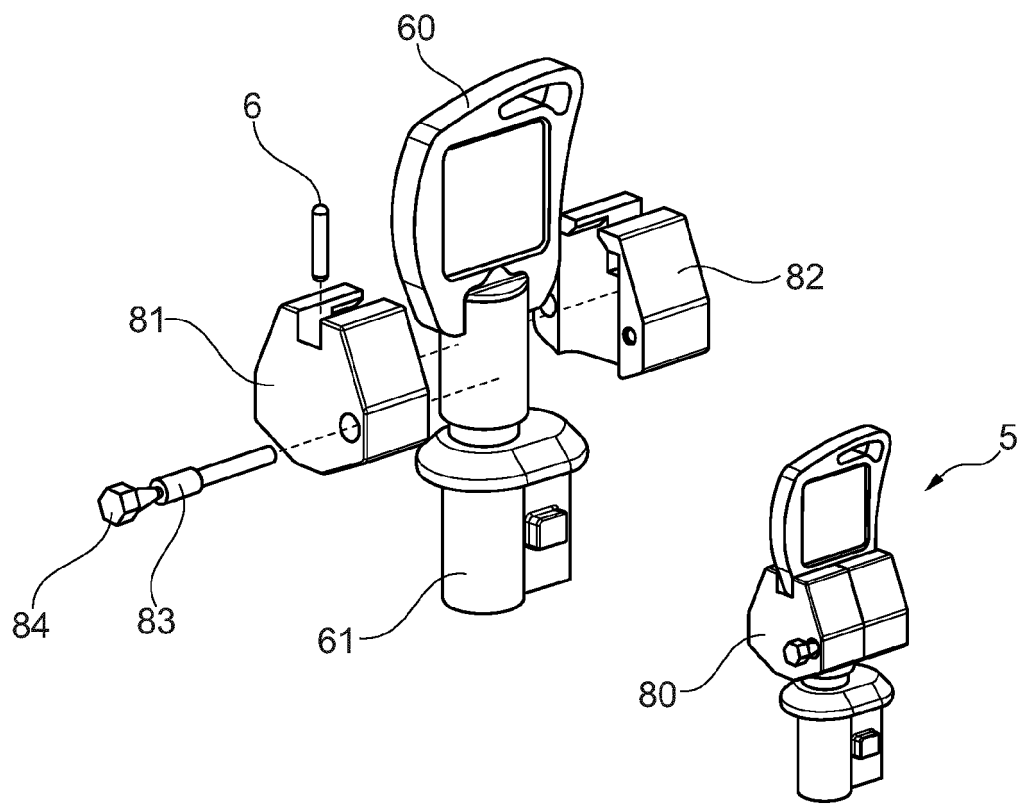


Fig. 14

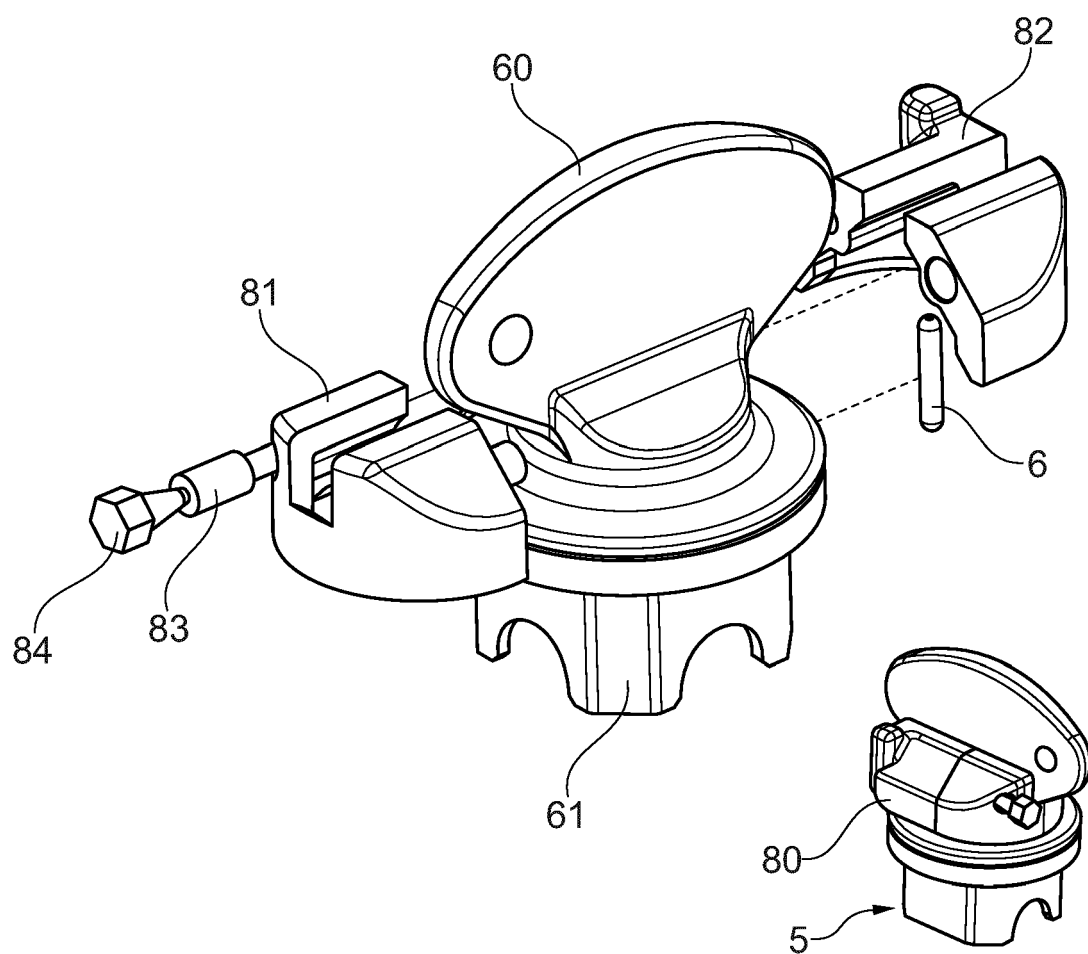


Fig. 15

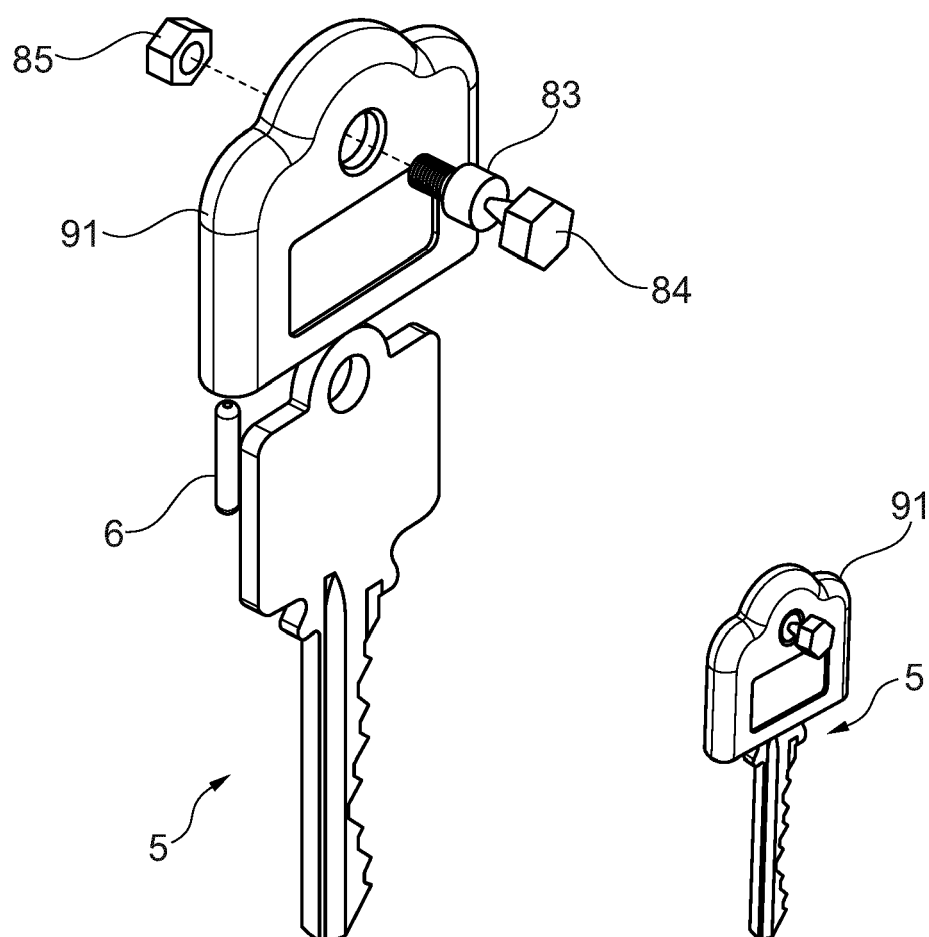


Fig. 16



## EUROPEAN SEARCH REPORT

Application Number

EP 23 30 6276

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2008/202178 A1 (LANZ CHRISTOPHER P [US] ET AL) 28 August 2008 (2008-08-28)	1-7, 9-14	INV. E05B1/00 H01H27/06
A	* paragraph [0036] - paragraph [0061]; figures 1-18 *	8	
Y	CN 101 113 647 A (TOKAI RIKI CO LTD [JP]) 30 January 2008 (2008-01-30)	1-7, 9-14	
A	* page 10 - page 28; claim 7; figures 1-10 *	8	
A	US 6 828 902 B2 (SOUNDCRAFT INC [US]) 7 December 2004 (2004-12-07) * column 2, line 55 - column 7, line 36; figures 1-4 *	1-14	TECHNICAL FIELDS SEARCHED (IPC)  E05B H01H E05C
A	US 8 123 119 B1 (GROMLEY NEIL [US] ET AL) 28 February 2012 (2012-02-28) * column 7, line 23 - column 33, line 33; figures 1-28 *	1-14	
<del>The present search report has been drawn up for all claims</del>			
Place of search <b>The Hague</b>		Date of completion of the search <b>8 January 2024</b>	Examiner <b>Drabko, Jacek</b>
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document			

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Application Number

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**CLAIMS INCURRING FEES**

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

**LACK OF UNITY OF INVENTION**

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

**see sheet B**

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

**1-14**

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



# LACK OF UNITY OF INVENTION SHEET B

Application Number

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

## 1. claims: 1-14

A key module for a trapped key interlock panel, comprising:  
a) a module housing mountable in the trapped key interlock panel;

b) a cylinder comprising a key slot for receiving a key, the key slot extending from a front face of the cylinder rearwardly along a longitudinal axis of the cylinder, the cylinder being rotatably-mounted in the module housing to permit rotation of the cylinder relative to the module housing about the longitudinal axis between a key insertion position, in which a key is free to be inserted into or removed from the key slot, and a trapped key position, in which a key is retained in the key slot, the cylinder also being reciprocally-mounted in the module housing to permit reciprocating axial movement of the cylinder relative to the module housing along the longitudinal axis, and the cylinder being biased forwardly within the module housing;

c) a cylinder retaining element for retaining the cylinder in the module housing;

d) a lock for selectively preventing rotation of the cylinder about its longitudinal axis;

e) a switch for generating a signal when the cylinder is displaced rearwardly

within the module housing against the bias of the cylinder by engagement of a key in the key slot; and

f) an antenna for receiving wireless signals from a wireless tag of a key

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## 2. claim: 15

A key for a trapped key interlock system comprising:  
a head, a shaft having a mechanically-coded section, and a narrowed portion provided on the head, the shaft or there between;

the key further comprising a clamp comprising a first part and a second part, the first part being lockable to the second part around the head and/or shaft of the key;

wherein the clamp securely houses a wireless tag

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

EP 23 30 6276

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-01-2024

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
<b>US 2008202178 A1</b>	<b>28-08-2008</b>	<b>CA 2613618 A1</b>	<b>06-06-2008</b>
		<b>US 2008202178 A1</b>	<b>28-08-2008</b>
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<b>CN 101113647 A</b>	<b>30-01-2008</b>	<b>CN 101113647 A</b>	<b>30-01-2008</b>
		<b>EP 1903508 A2</b>	<b>26-03-2008</b>
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		<b>JP 2008030627 A</b>	<b>14-02-2008</b>
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<b>US 6828902 B2</b>	<b>07-12-2004</b>	<b>AT E524928 T1</b>	<b>15-09-2011</b>
		<b>AU 2002330971 B2</b>	<b>11-09-2008</b>
		<b>CA 2457796 A1</b>	<b>13-03-2003</b>
		<b>EP 1430729 A1</b>	<b>23-06-2004</b>
		<b>ES 2395075 T3</b>	<b>08-02-2013</b>
		<b>US 2002047777 A1</b>	<b>25-04-2002</b>
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<b>US 8123119 B1</b>	<b>28-02-2012</b>	<b>US 7607573 B1</b>	<b>27-10-2009</b>
		<b>US 8016188 B1</b>	<b>13-09-2011</b>
		<b>US 8123119 B1</b>	<b>28-02-2012</b>
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82