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(54) Lock cylinder for driving a lock latch, and key thereof

(57) The lock cylinder (1) according to the invention comprises a cylinder housing (3) and a driving pin (5A, 5B) housed in the cylinder housing (3). A reading sensor (170A, 170B) detects, through exchange of electrical and/or magnetic and/or optical signals, the predetermined unlocking combination of the key (9). If the correct key is inserted in the cylinder (1), a logic unit (11) allows the driving pin (5A, 5B) to actuate the bolt (102) rotating on itself. The reading sensor (170A, 170B) and the logic unit (11) are arranged to read the predetermined unlocking combination reproduced on the key (9) while the latter is moving and is inserted in the lock cylinder 1, greatly reducing the electrical consumption of the cylinder and increasing its autonomy and safety.

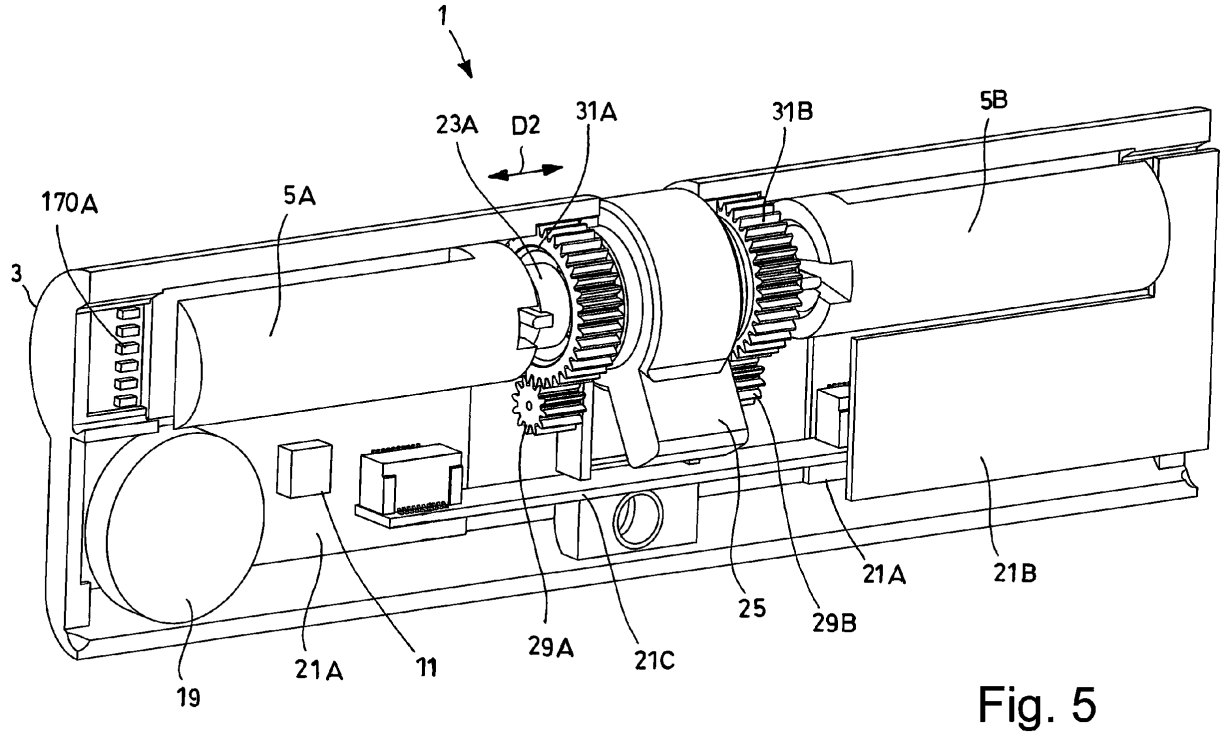

Fig. 5

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Description

Field of the invention

[0001] The present invention concerns an electronic lock cylinder suitable for replacing mechanical cylinders of known Yale type locks, and an electronic key for actuating such a cylinder.

State of the art

[0002] Current mechanical cylinder locks, i.e. so-called Yale type locks, although they are able to reproduce a large number of combinations - indicatively at least equal to a few thousand - over the years have proven to be highly vulnerable to break-in, performed with various kinds of techniques like for example key bumping, duplication through remote photography, opening through mechanical passe-partout key. Therefore, electronic locks have later been developed that are increasingly reliable, with better performance from various points of view, for example with increasingly difficult-to-discover combinations, greater flexibility of programming and reprogramming, greater freedom in managing the opening of the same lock with different keys and opening combinations. However, in order for known electronic locks to obtain the above performance they are much more expensive than standard mechanical locks, and are often not interchangeable with the latter ones. Therefore, known electronic locks are currently used in specific niche markets such as hotels or workplaces, in which the doors are specially made to mount them.
Therefore, it would be desirable to be able to make more secure the locks already installed on the outer doors of apartments, single houses, condominiums, gardens and any place in general in which it is necessary to limit and flexibly control access, by simply replacing the very common cylinders for mechanical keys of the Yale type with cylinders for electronic keys.
[0003] Such replacement is, however, hindered by various problems, including the fact that most of the cylinder locks currently installed are mounted on doors without electrical power supply; housing an electromechanical system that does not need external power supply in the small overall bulks of a current lock cylinder is currently very difficult or it involves extensive and expensive modifications to the door. In particular, it is extremely difficult to make an electromechanical system with a high degree of safety and reliability with energy consumption that is low enough to not require too frequent replacement of the batteries or of other standard storage cells normally on the market, indicatively no more than once per year, having such small sizes to be contained also in a complete standard mechanical construction -that is provided with a double-cylinder- and having also low cost.
As an example, the state of the art includes a solution (EP 1 707 712 A1, "Cylinder lock assembly with mechanical and electronic mechanism") that combines the classic mechanical code with an electronic code. The unlocking code is stored in an electronic circuit on the key that is powered by the cylinder through mobile and sliding electrical contacts, which are not very reliable because they suffer from wear and from the influence of environmental factors. The manufacturing cost of such key is higher than a simple passive key. This solution also allows the key to be inserted just at one end of the cylinder due to the presence of the battery, the motor and the decoding circuit at the other end.
In another example of the state of the art (WO 00/28179A1, "Improvements in or relating to key operated switches") an activation switch comprises a sensor for exclusively detecting the absence or the presence of the key and controlling the power supply of the locking/unlocking circuit in on/off mode. This means that the higher is the absorption of electrical energy, the longer is the time the key stays inserted in the cylinder. This solution is therefore unsuitable for replacing a classic mechanical cylinder when a battery-power is used; on the other hand, this solution is more suitable for the use with electrified and motorised locks, also by virtue of the circular section of the key and its housing that do not allow manual actuation of the bolt.
A last example of the state of the art (DE 28 07 080 A1, "Electromagnetisch betätigbares Sicherheitsschloß mit Schlüssel") describes a key that reproduces the unlocking combination through a plurality of windows all read at the same moment, when the key is completely inserted. This solution involves a high cost of the reading sensor and a high peak power absorption during the reading phase, unsuitable for being powered for a long time with a low-capacity battery, i.e. a small battery, capable of supplying only low peak currents. Moreover, with this solution it is extremely complex to manually actuate the bolt by rotating the key, since it would involve the rotation of the entire reading sensor.
[0004] A purpose of the present invention is to avoid the aforementioned drawbacks of the state of the art, and in particular to provide a cylinder for electronic key locks that can easily replace the lock cylinders for mechanical keys, for example so-called Yale locks, of locks that have already been installed.

Summary of the invention

[0005] In a first aspect of the invention such a purpose is achieved with a lock cylinder having the features according to claim 1.
None of the documents EP 1 707 712 A1, WO 00/28179A1 and DE 28 07 080 A1 teach how to make a lock provided for example with one or more reading sensors arranged to progressively detect, through exchange of electrical and/or magnetic and/or optical signals, the predetermined unlocking combination reproduced on a proper key when the latter is moving and is being inserted into the cylinder of the lock.
In a second aspect of the invention, such a purpose is

accomplished with a key used for actuating a lock cylinder having the features according to claim 14. Further characteristics of the device are the object of the dependent claims.

The advantages that can be obtained with the present invention will become clearer, to the man skilled in the art, from the following detailed description of some particular non-limiting embodiments, illustrated with reference to the following schematic figures.

List of Figures

[0006]

Figure 1 shows a perspective view of the inside of a lock and corresponding electronic key according to a first embodiment of the invention;

Figure 2 shows a perspective view of the outside of the lock cylinder of the lock represented in Figure 1;

Figure 3 shows an exploded view of the lock cylinder of Figure 2;

Figure 4 shows a diagram of the electrical circuit of the lock cylinder of Figure 2;

Figure 5 shows a perspective view of the lock cylinder of Figure 2, in partial cross-section along a longitudinal plane;

Figure 6 shows a perspective view of a first embodiment of an electronic key suitable for actuating the lock of Figure 1;

Figure 7 shows the front view of the outer housing of the lock cylinder of Figure 2;

Figure 8 shows an electrical diagram of a second embodiment of an electronic key suitable for actuating the lock of Figure 1.

Detailed description

[0007] Figures 1-7 relate to a lock and related electronic key according to a first embodiment of the invention. In the present description, by cylinder lock, unless specified otherwise, a lock is meant of the type commonly indicated in the jargon as "Yale lock" or rotary drum lock. This kind of lock generally comprises an outer housing, a rotary drum inside the drum and one or more mechanical locking/unlocking elements that, when the correct key is inserted in the drum, move transversally to the axis of the latter, allowing it to rotate.

Yale or cylinder locks can be divided into different varieties, including the pin tumbler lock, wafer tumbler lock, disc tumbler lock. By cylinder of a Yale or cylinder lock type in the common technical jargon an assembly is meant comprising the mechanism that recognises whether a correct key is inserted in it and authorises the rotation of the inner drum with respect to the outer housing of the cylinder; in the embodiment of Figure 1 the cylinder is indicated with the overall reference numeral 1 (Figure 2). The lock cylinder 1 comprises a cylinder housing 3 and a driving pin 5A, 5B housed in the cylinder housing 3. The cylinder housing 3 and the driving pins 5A, 5B are called, in the technical jargon, "fixed cylinder"/"*cilindro fisso*" and "sprocket"/"*rocchetto*", respectively. In the driving pin 5A, 5B a key seat 7 is provided that is suitable for receiving a key 9, on which the reproduction of a predetermined unlocking combination is formed (Figure 3). On the cylinder housing 3 a key opening 2 is formed so to act as a keyhole of the lock, and through which the key 9 can be introduced into the key seat 7 (Figure 2).

[0008] According to an aspect of the invention the lock cylinder 1 is provided with a logic circuit which in turn comprises:

- a reading sensor suitable for detecting, through exchange of electrical and/or magnetic and/or optical signals, the predetermined unlocking combination reproduced on the key 9 when the latter moves and is inserted into the lock cylinder 1, thus starting to detect it when the key has not yet completed its insertion stroke;
- a logic unit 11 programmed or anyway suitable for receiving the output signals of the reading sensor, checking, based on these signals, whether the predetermined unlocking combination corresponds to a predetermined opening combination stored in the logic unit and, in the affirmative case, allowing the driving pin 5A or 5B to actuate the lock bolt 13, in which the cylinder 1 is mounted, by rotating on itself (Figures 1-3); in order to do this, preferably the driving pin 5A, 5B rotates on itself around its longitudinal axis. The insertion stroke is the one the key must carry out in order to unlock the lock, for example to allow the logic unit or more generally the lock to completely read the predetermined unlocking combination.

  The reading sensor can be arranged to detect the predetermined unlocking combination reproduced on the key 9 when the latter is at least partially inserted in the key seat 7.

[0009] The logic unit 11 can consist of, or in any case comprise, a suitable programmable microprocessor.

The reading sensor preferably comprises:

- one or more emitters 170A arranged for emitting suitable detection radiations;
- one or more receivers 170B arranged for receiving the detection radiations filtered by the key 9 at least partially inserted in the key seat 7 or anyway in the keyhole 2, where the key 9 is arranged to filter the detection radiations so as to reproduce the predetermined unlocking combination.

Preferably, the emitters 170A and the receivers 170B are respectively arranged to emit and receive an electromagnetic radiation in the band of wavelengths comprised between infrared and ultraviolet inclusive, i.e. indicatively

between 1mm and 0.1μm. More preferably, the emitters 170A and the receivers 170B are respectively arranged to emit and receive infrared radiation, i.e. with wavelength indicatively comprised between 0.7 μm-1 mm, and even more preferably comprised between 0.7μm - 1.6μm, moreover making the emitters 170A and the receivers 170B less sensitive to environmental disturbances. Further advantages of this choice will be outlined hereafter.

[0010] Each emitter 170A can be or comprise for example an LED, whereas each receiver 170B can be or comprise for example a photo cell, a photo diode, a phototransistor or CCD or CMOS photodetectors.

Advantageously, one or more of the following elements is housed in the cylinder housing and is integral with it, and is also arranged outside of the driving pin, not mounted on it but integral with the outer housing 3: the logic unit 11, the reading sensor 170A, 170B, the one or more emitters 170A, the one or more receivers 170B. By doing so, all of the logic circuit of the lock cylinder 1 can be fixed and integral with respect to the outer housing 3, so to significantly simplify the power supply and signal wiring that connect the various electronic components of the logic circuit thus allowing a circuit arrangement much more compact, simpler and less bulky; the driving pin 5, which rotates with respect to the housing 3, can completely avoid the use of electrical or electronic circuits and components, it is extremely simple to be manufactured and does not pose any problem for power supply and electrical connection.

Advantageously, the reading sensor comprises a plurality of emitters 170A and a plurality of receivers 170B, and both the emitters 170A and the receivers 170B are arranged on at least one row that extends transversally, and more preferably perpendicular, to the insertion direction D1 of the key 9 in the key seat 7 or in any case in the keyhole 2 (Figures 2, 3), allowing the emitters 170A and the receivers 170B to be made less bulky.

[0011] Advantageously, as we will explain better hereafter, the emitters 170A are arranged in front of the receivers 170B so as to be able to irradiate them directly with a rectilinear trajectory, allowing the circuitry of the reading sensor to be sensibly simplified, increasing its reliability and also allowing the construction of the key 9 to be simplified.

Advantageously, the one or more emitters 170A, the one or more receivers 170B - or more generally the reading sensor - and the logic unit 11 are arranged to read the combination of the key 9 when the latter is in movement

- at least with respect to the one or more emitters 170A, to the one or more receivers 170B, or more generally, to the reading sensor - and it is inserted in the key seat 7 or in any case in the keyhole 2; this allows a smaller number of emitters 170A and receivers 170B to be used with respect to the number of encoding windows present on the key, since with a few sensors it is possible to read many windows in sequence; by doing so, the peak absorption is reduced and the space available inside the housing of the cylinder 3 and the autonomy of the cylinder is increased. Indeed, the emitters 170A and the receivers 170B can be arranged on just two rows (arrays), one for the emitters and one for the receivers, limiting the needed number of emitters and receivers for example with respect to a matrix of emitters/receivers the rows and columns of which extend over the entire side of the key 9 to read it only when it is completely inserted. Moreover, starting to read - for example progressively - the combination of the key when the latter is still moving while it is inserted makes it possible to execute in advance the validation procedure of the combination, reducing the waiting time before being able to rotate the key.

[0012] For this purpose, the emitters 170A and the receivers 170B are preferably arranged close to the opening 2 that forms the keyhole of the lock, so as to be able to start reading as early as possible the combination of the key 9 as soon as it begins to be inserted in the keyhole 2. Moreover, even the arrangement of the emitters 170A and the receivers 170B close to the opening 2 allows the layout of the logic circuit to be optimised and made less bulky.

[0013] In order to improve the reliability of reading the combination of the key when the latter is in movement, advantageously the one or more emitters 170A, the one or more receivers 170B and the logic unit 11 are arranged to read the combination of the key 9 with a so-called majority vote algorithm, i.e. the emitters 170A emit impulses of detection radiations with sufficiently high frequency so to allow the receivers 170B to carry out many readings, preferably at least three, and even more preferably at least ten, of each window 96 of the key 9 that passes in front of them when the key is being inserted in the keyhole 2. The reading with majority vote algorithm reduces the probability of incorrect readings of the combination reproduced by the key, it can be implemented with few instructions of a software program residing inside the cylinder and it can involve very low energy consumption.

[0014] In order not to need an external power supply, in the cylinder housing 3 an electrical power supply 19 is housed, arranged for powering one or more of the logic unit 11, the one or more emitters 170A and the one or more receivers 170B; advantageously, the electrical power supply 19, which can for example be a battery or another storage cell of electrochemical energy, is fixed to the housing 3 or in any case it is integral with it, contributing to make the electronic circuit that implements the logic circuit of the cylinder 1 more compact, less bulky and simple.

The logic circuit is provided with an activation switch 15 arranged to activate the logic unit 11 when the key 9 is close to the lock cylinder or partially inserted in the key seat 7 or in the key opening 2, making the logic unit 11 pass from a first stand-by operating mode, i.e. with zero

or reduced energy consumption, to one or more higher energy consumption operating modes. There can for example be two higher energy consumption operating modes: a so-called wake-up operating mode and a fully operating mode. In the fully operating mode the logic unit 11 performs all the functions needed to control the motor while engaging or disengaging - or in general actuating - the driving pin 5A and/or 5B, the power consumption of the logic unit 11 can be very high but preferably for a very short time interval, for example not longer than 3 seconds. In the wake-up operating mode the logic unit 11 performs the functions needed to switch from the stand-by operating mode to the fully operating mode and the power consumption of the logic unit 11 is preferably kept at a medium level, lower than power consumption at fully operational mode and for very short time periods, for example not longer than 3 seconds. In the stand-by operating mode, wherein the possible one or more clutch motors 27A, 27B are inactive and not supplied with power, the activity of the logic unit 11 is reduced to the bare minimum for detecting the insertion of the key 9 in the lock cylinder 1; preferably in stand-by the clock frequency of the logic unit 11 is also reduced. In stand-by, the state in which generally and advantageously most of the operating life of the lock cylinder 1 is spent, the power consumption of the logic unit 11 is preferably reduced to the minimum, for example to not more than 1% of the power consumption during wake-up or fully operational mode. The power consumption of the logic unit 11 in stand-by can for example be equal to or less than 50 μW, or in any case not more than a few tens of μW.

[0015] Advantageously, the activation switch 15 is a normally-open type. For this purpose the switch 15 can comprise or consist of one or more reed contacts capable of opening or closing in the presence of a magnetic field or in any case of a variation of the magnetic field in which the contacts are immersed. Preferably, when the key 9 is not inserted in the lock cylinder 1, the reed contacts are open, so as not carrying current and reduce power consumption of the logic unit 11 in stand-by.

[0016] Advantageously, the logic circuit comprises two boards or plates for electronic circuits 21A, 21B arranged facing one another; the one or more emitters 170A are fixed on one of the two boards or plates, for example 21a, whereas the one or more receivers 170B are fixed on the other of the two boards or plates, for example 21B (Figure 5): such an arrangement sensibly simplifies the practical embodiment of the logic circuit, for example making it much easier to face the emitters 170A and the receivers 170B opposite one another. In general, the contraposition of the plates 21A, 21B makes it possible to greatly simplify the paths and the connections of the tracks that supply the various components of the logic circuit or transmit the related signals, and in order to allow the interconnection of electrical power supply or signals between the two plates it may be sufficient to use dedicated pins or a suitable connector.

[0017] Advantageously, each pair of boards or plates for electrical circuit 21A, 21B is separated, in the direction perpendicular to the insertion and extraction direction of the key, by an empty space in which the electrical power supply 19 is housed (Figure 5): this arrangement also greatly contributes to simplify the logic circuit, and in particular its power supply or signal tracks, as well as reducing the overall size of the circuit itself, allowing larger and higher capacity batteries 19 to be housed in the cylinder housing 3. Advantageously, the electrical contacts that touch the power supply 19 supplying its energy to the rest of the logic circuit of the cylinder 1 are arranged one on a power supply plate 21A or 21B, the other contact on the other facing power supply plate, 21B or 21A respectively, further simplifying the circuit.

[0018] Advantageously, an opening 35 is formed on the cylinder housing 3 arranged on the front or rear face of the lock cylinder 1, so as to face onto the empty space between the two boards or plates for electrical circuits 21A, 21B, allowing access and allowing the storage cell 19 to be easily replaced, with a very basic and compact electro-mechanical construction.

In order to be able to open and close a door with a key from both sides, it may be useful to have a lock cylinder like that of Figure 5, provided with two driving pins 5A, 5B able to be actuated one by inserting a key for example from outside a home, and the other from inside.

[0019] Advantageously, the lock cylinder 1 comprises an actuating clutch arranged for:

- mechanically engaging with at least one of the driving pins 5A, 5B allowing the latter to actuate, e.g. by rotating on itself, the bolt 102 of the lock 100 in which the lock cylinder 1 is mounted, when the logic unit 11 detects that key 9 that reproduces an unlocking combination equal to one of the predetermined opening combinations stored in the logic unit 11 is at least partially inserted in the key seat 7 or in any case in the keyhole 2; and
- mechanically disengaging from at least one of the driving pins 5A, 5B preventing it from actuating, e.g. by rotating on itself, the bolt 102 when the logic unit 11 does not detect that a key 9 that reproduces an unlocking combination equal to the opening combination stored in the logic unit 11 is at least partially inserted in the key seat 7 or in any case in the keyhole 2.

[0020] As shown in Figure 5, the actuating clutch can comprise one or more sliding shafts 23A, 23B, each of which is arranged to engage and disengage reversibly with a corresponding driving pin 5A, 5B translating along its axis (arrow D2). Each sliding shaft 23A, 23B can be permanently engaged with the bolt actuation tooth 25, so as to be able to actuate it.

The lock cylinder 1 is advantageously provided with one or more clutch motors 27A, 27B each of which is arranged to move a corresponding sliding shaft 23 under the control of the logic unit 11.

As shown in Figures 4, 5, each clutch motor 27 can actuate the corresponding sliding shaft 23A, 23B through a speed reducer comprising the gear wheels 29A, 29B; 31A, 31B and the screw/nut screw mechanism 33A, 33B.

[0021] Figure 6 shows an embodiment of a key 9 that is particularly advantageous and suitable for being used to actuate a lock cylinder 1 according to the invention. The key 9 comprises a control head 90, a shank 92 narrower than the control head 90 and preferably a gripping end 94, wider than the shank and arranged to be gripped. The control head 90 is preferably shaped substantially like a plate or parallelepiped, and more preferably like a more or less squashed parallelepiped. On the control head 90 a plurality of windows 96 is preferably formed, some of which can be crossed by detection radiations - i.e. they are transparent to radiation -, whereas the material that surrounds them is more opaque to such radiations. The transparent windows 96 are arranged so that the detection radiations emitted by one of the emitters 170A after having crossed a corresponding window 96 strike one of the receivers 170B. Preferably, the windows 96 are aligned according to a plurality of rows 90R and columns 90C.

[0022] Preferably, the number of rows 90R and/or columns 90C is equal to or greater than three. For example, the number of rows 90R can be comprised between 4 and 5, and the number of columns 90C between 4 and 10. Such numbers of rows and columns allow a key to compose a sufficiently large number of opening combinations; indeed, with three rows and three columns it is possible to compose more than 500 possible nominal opening combinations, with four rows and four columns it is possible to compose more than 65000 and with five rows and six columns it is possible to compose more than one billion, i.e. much more than the number of combinations (100,000) above which the standard EN 1303 classifies a lock at the maximum degree of safety.

[0023] Preferably, the unlocking combination reproduced by the key 9 is obtained by ensuring that part of the windows 96 are also opaque to the detection radiations. The number and position of the transparent windows 96 and of the opaque windows is preferably different in the various columns 90C, so as to greatly increase the number of possible combinations potentially able to be reproduced by the key 9.

[0024] Advantageously, the transparent windows 96 are made from a material substantially opaque to visible light but transparent to non visible detection radiation, i.e. ultraviolet or infrared, emitted by the emitters 170A. Advantageously, each window 96 fills the corresponding cavity formed in the remaining part of the head 90 flush with the surface of the head itself. These last two solutions make windows 96 practically invisible to the naked eye, greatly reducing the possibility of copying the opening combination for example by taking a picture or casts of the key, or probing with tools inside the keyhole 2.

[0025] Advantageously, on the free end of the control head there is an activation element 98 arranged to activate the activation switch 15 when the control head 90 starts to enter into the keyhole of the lock 2 or into the key seat 7. The activation element 98 can be or can comprise for example a permanent magnet, an electromagnet or another generator of magnetic field or even just a piece of electrically and/or magnetically conductive material, depending on the type of activation switch 15 used. The choice of a permanent magnet has the advantage of not requiring a key 9 with batteries or other sources of internal energy and allows a switch to be used that does not have mechanical contacts with the key (contactless), providing advantages in terms of reliability of activation and much longer lifetime, thanks to the lower exposure to wear and to foreign agents; in this case preferably the activation switch 15 comprises or consists of reed contacts that are open in the absence of magnetic fields.

[0026] As an alternative the activation switch 15, besides reed contacts can comprise a permanent magnet that, when the key 9 is not inserted in the lock cylinder 1, keeps the reed contacts open - which in this case would be normally-closed type - whereas the activation element 98 preferably comprises a material capable of deviating the flux lines of the field of the permanent magnet enough to open the reed contacts when the key 9 is inserted into the cylinder 1. Mounting the permanent magnet on board of the lock instead of the key allows the costs of the system to be reduced, whilst still allowing a switch without mechanical contacts with the key (contactless) to be made.

[0027] Advantageously, the two smaller sides of the cross sections of the control head 90 are substantially shaped like an arrowhead or peaked (Figure 6), just as the smaller sides of the keyhole 2 of the cylinder correspondingly have such a shape (Figures 2, 7), so as to ensure the correct orientation of the key in the lock without occupying the useful surfaces of the key reserved for the encoding windows. In other embodiments that have not been shown however, the cross sections of the control head 90 of the key advantageously have a shape without axial, rotary, star-like or circular symmetries, so as to ensure that the key is inserted in the keyhole with a single and very precise orientation with respect to the insertion direction.

Preferably, the key 9 is purely passive and not powered by any internal electrical or chemical energy source.

[0028] In order to be able to open and close a door with a key from both sides, as shown in Figure 5 a lock cylinder according to the invention can also be provided with two keyholes 2 and with some or all of the following items: two or more emitters 170A, two or more receivers 170B, two clutch motors 27A, 27B, two groups of gear wheels and of screws 29A, 31A, 33A; 29B, 31B, 33B. Advantageously, in order to reduce the energy consumption of the cylinder 1, both the emitters 170A, the receivers 170B and the clutch motors 27A, 27B are controlled by a single logic unit 11 and are powered by a single storage cell 19. For this purpose the logic circuit advantageously comprises a fifth board or plate for electronic circuits or flexible

plate or flat cable 21C that mechanically fixes and electrically connects the two boards 21A and/or the two boards 21B together, according to the insertion and extraction direction of the key (Figure 5). Advantageously one or more electric conductors that electrically connect together the electrical and electronic components arranged on the two boards or plates 21A or 21B are arranged on the fifth board or plate, for example connecting the single storage cell 19 and/or the single logic unit 11 to both of the emitters 170A, both of the receivers 170B and/or both of the clutch motors 27A, 27B. Preferably, the fifth board 21C is already fixed to and integral with the two boards 21A and/or the two boards 21B before being inserted in the rest of the lock cylinder 1: this solution allows the assembly of the cylinder itself to be simplified.

[0029] A possible example of use and of operation of the lock cylinder 1 and of a lock on which it is mounted will now be described.

When the key 9 is not inserted in the keyhole 2 or in the key seat 7 of the lock, the contacts of the activation switch 15 are for example open, the logic circuit of the cylinder 1 is in the first stand-by operating mode with minimum energy consumption and the sliding shaft 23A is disengaged from the corresponding driving pin 5A.

[0030] If a key 9 is inserted in the keyhole 2 or in the key seat 7, the permanent magnet of the activation element 98 closes the contacts of the reed that acts as activation switch 15; the closure of the contacts is detected by the logic unit 11, which passes from the stand-by state to the wake-up state, and from this to the fully operational state. The logic unit 11 then activates the emitters 170A and the receivers 170B, starting to supply them with power, which start to progressively read the unlocking combination reproduced by the windows 96. More specifically, the emitters 170A and the receivers 170B detect the sequence of ones and zeros reproduced by the various columns 90C of the key as the columns slide in front of the emitters 170A and the receivers 170B, i.e. while the key 9 is moving to enter into the keyhole of the lock. If the logic unit 11 detects that the unlocking combination read by the receivers 170B is equal to one of the opening combinations stored in the unit 11 itself, it commands the unlocking of the cylinder 1 by actuating the clutch motor 27, which through the gear wheels 29A, 31A and the screw mechanism 23A makes the sliding shaft 23A translate, engaging it with the driving pin 5A and keeping it simultaneously engaged with the bolt actuation tooth 25. Therefore, by rotating the driving pin 5A by turning the key 9 inserted in the key seat 7 it is now possible to rotate - or in any case actuate - the tooth 25 and open or close the bolt of the lock 102. If the key 9 is extracted from the lock, or in any case from the keyhole 2 or from the key seat 7, preferably the logic unit 11 is programmed or in any case arranged to disengage again the driving pin 5A from the sliding shaft 23A, once again preventing the actuation of the tooth 25 rotating the driving pin 5A.

[0031] If a key 9 that reproduces an unlocking combination different from the opening combination, or from one of the opening combinations, stored in the logic unit 11 is inserted into the keyhole 2 or into the key seat 7, or a tool is inserted that does not reproduce any combination that can be read by the receivers 170B, even if the activation switch 15 closes

- or in any case activates - the logic unit 11 is arranged, or in any case programmed, to keep the driving pin 5A disengaged from the sliding shaft 23A, making it rotate idly and preventing actuation of the tooth 25 acting on the driving pin 5A. Similarly, the driving pin 5A stays disengaged from the sliding shaft 23A even when a key, or other tool, not able to close, or in any case activate, the activation switch 15 is inserted into the keyhole 2 or into the key seat 7. Advantageously, the logic circuit is arranged to go back to the first zero or reduced consumption mode (stand-by) for example in one or more of the following situations:
- after it has correctly detected the unlocking combination of the key, and the driving pin 5A and/or 5B is enabled to actuate the bolt;
- after a predetermined time period has passed since the key 9 was completely inserted into the lock cylinder 1 without the logic unit having read the correct unlocking combination on the key (time out procedure);
- after a predetermined time period has passed since the cylinder 1 left the null or reduced consumption condition.

These last solutions also contribute to substantially reduce the energy consumption of a lock according to the invention, for example avoiding running down the batteries 19 by simply leaving the key 9 inserted in the cylinder 1, even in unlocked condition, for an indefinite time. This behaviour allows the use of the key 9 and the behaviour of the cylinder 1 to be made very similar to that of a classical mechanical key and cylinder.

[0032] It is clear how the previous teachings allow to make an electronic lock cylinder with an external Yale profile without external power supply, having very low power consumption, great energy autonomy even without external power supply - indicatively, such as to require replacement of the batteries even only once every 1-2 years - and great safety and resistance to unauthorised attempts to break in or to duplicate the key.

[0033] Indeed, the choice to activate the lock cylinder 1 by making it pass to the higher consumption mode only when the key 9 is inserted greatly reduces the energy consumption of the cylinder, since the latter stays in the first minimum energy consumption operating mode, i.e. stand-by, on average for at least 90% or in any case for the majority of its operating life. The particular choice of reed contacts to make the activation switch 15 allows the energy consumption of the lock cylinder 1 to be kept quite low in the stand-by state, as well as allowing a simple, cost-effective switch to be made without mechanical con-

tact with the key 9. The different solutions that allow the electrical/electronic circuit housed in the lock cylinder 1 to be made more compact and simplified also contribute to reduce its energy consumption in general. Since the driving pin 5 is turned manually by the end user through the key 9, the movement of the bolt 102 and the opening of the lock do not involve absorption of energy from the storage cell 19 and make using the new lock totally equivalent - i.e. manual - to that of old mechanical locks; this does not prevent making cylinders for motorised locks of the latest generation according to the invention. Since they are only used to move the sliding shafts 23A, 23B, the clutch motors 27A, 27B absorb very little energy and can have for example approximately maximum powers of about 40 mW or even less.

[0034] The shape substantially like a plate, like a parallelepiped - or in any case different from that of a rotation solid - of the control head 90, in particular like a squashed parallelepiped, is particularly effective and handy for manually rotating the driving pin 5, as well as reducing the wear of the head 90 itself and of the inside of the lock. The narrower shank 92 of the control head 90 advantageously allows a narrower keyhole 2 to be adopted that better protects the components inside the cylinder 1. If advantageously, when the key 9 is completely inserted into the seat 7 of the cylinder, the reading sensor 170A, 170B is at the shank 92, all of the circuits and the electrical components of the lock can be placed outside of the driving pin 5A, 5B and stay fixed with respect to the cylinder housing 3 while the pin 5A or 5B rotates; this allows the electromechanical implementation and circuitry of the cylinder 1 to be made substantially simpler, avoiding for example sliding electrical contacts or transmission of electromagnetic signals.

[0035] Thanks to the previous solutions it is possible to make a cylinder for an electronic key lock that has the shape and the size of current standardised cylinders, and in particular lock cylinders with a so-called European, English, Scandinavian or Australian profile, all in the oval or semi-oval versions, and yet other unified profiles like for example so-called loose inside/outside cylinder, rim cylinder, mortise cylinder or cylinder for deadbolt. Figure 7 provides an indicative example of the external dimensions of the cross sections of a common European profile cylinder, in which the electrical-electronic circuits and the mechanisms according to the invention can be housed: the height H1 can be about 33 mm, the width L1 about 17 mm and the width L2 about 10 mm.

[0036] Based on the previous description it is clear how, unlike for example known mechanical cylinder locks, it is not possible to discover the opening combination of the lock according to the invention by probing with mechanical tools inside the keyhole 2. The fact that, like in the embodiment of Figures 1-7, the sliding shafts 23A, 23B, the clutch motors 27A, 27B and their gears are arranged in the most inner part of the lock cylinder 1, protected by big and strong driving pins 5A, 5B, as well as the absence of exposed rotating parts, greatly increases the safety and resistance to break-in of the lock.

[0037] Since they do not need external power supply, the lock cylinders according to the invention can replace, very easily and at low cost, the mechanical cylinders - for example with pistons - currently mounted on the overwhelming majority of external doors of homes, gardens, enclosures, wine cellars, garages, offices, workplaces and places with limited access in general. Since the combination or combinations for opening it can be simply stored in the logic unit 11, it is clear how a cylinder for locks 1 according to the invention is particularly suitable for being used with different keys that can open and close it with different opening combinations, and allows the modification of the opening combination - or combinations - to be managed with great flexibility and ease through a simple reprogramming of the logic unit 11, the replacement of keys and the management of various situations like for example losing a key, changing tenants, enabling opening with one new key and only one, opening a lock with different keys and opening some locks, but not others, with a single key.

[0038] The example embodiments described above can undergo various modifications and variations without departing from the scope of protection of the present invention. As an alternative to the reed contacts the activation switch 15 can for example comprise:

- a purely mechanical switch, normally open and that is temporarily closed following the pushing, or other mechanical action, imparted by the key 9 when the latter is at least partially inserted in the keyhole 2; or
- two electrical contacts 160A, 160B that are short-circuited by a conducting portion 162 of the key 9, where the conducting portion 162 acts as an activation element (Figure 8);
- a switch capable of making the logic circuit pass from the first null or reduced energetic consumption operating mode to the second higher energetic consumption operating mode when the key 9 is close to the lock cylinder - for example a few millimetres or centimetres, for example 0-30 mm and more preferably between 0-10 mm-, without having to necessarily be inserted in it.

[0039] Instead of an emitter 170A and a receiver 170B of infrared light, visible light or ultraviolet radiation, the reading sensor can comprise a microcircuit reader, said microcircuits being able to be housed on the key 9. A lock cylinder according to the invention can also be powered from the outside, for example if mounted on security doors with external power supply also - but not only - in order to motorise opening, still ensuring the operation of the door when there is no current. A lock cylinder according to the invention can also be arranged to be opened with a key on just one side of a door, and in this case a single emitter 170A, a single receiver 170B, a single driving pin 5A, a single sliding shaft 23A and a single clutch motor 27A can be provided. A key 9 can also be provided

with several activation elements 98, arranged so to be read in sequence while the key is inserted or extracted from the keyhole 2 and allow the logic unit to recognise whether the key is inserted or extracted from the lock cylinder; for this purpose, an activation element 98 can be placed on the free end of the key and a second activation element 98 closer to the end to be gripped. The control head 90 can more generally have a different shape from that of a solid of revolution, and for example have a radiated symmetry or completely asymmetrical shape with respect to the rotation axis of the key 9.

[0040] In general, all of the details can be replaced by technically equivalent elements. For example, the materials used, as well as the sizes, can be whatever according to the technical requirements. It should be understood that an expression of the type "A *comprises* B, C, D" also comprises and describes the particular case in which "A *consists of* B, C, D". The examples and lists of possible variants of the present application should be considered to be non-exhaustive lists.

Claims

1. Lock cylinder (1) suitable for actuating a lock bolt (102) and comprising:

- a cylinder housing (3);
- a driving pin (5A, 5B) housed in the cylinder housing (3) and wherein a key seat (7) is obtained, which is suitable for receiving a key (9), whereon a predetermined unlocking combination is reproduced;

and wherein:

a) the lock cylinder (1) is provided with a logic circuit which in turn comprises:

- a reading sensor (170A, 170B) suitable for detecting progressively, through exchange of electrical and/or magnetic and/or optical signals, the predetermined unlocking combination reproduced on the key (9) when the latter is being inserted in the lock cylinder (1);
- a logic unit (11) programmed or anyway arranged for stimulating and receiving the signals from the reading sensor (170A, 170B), for verifying, on their basis, whether the predetermined unlocking combination corresponds to a predetermined opening combination stored in the logic unit (11) and, in the affirmative case, for allowing the driving pin (5A, 5B) to actuate the bolt (102) by rotating on itself;

b) the logic circuit is provided with an activation switch (15) arranged for:

- activating the logic unit (11) when the key (9) is in the proximity of the lock cylinder and/or partially inserted in the lock cylinder (1) by making the logic unit (11) pass from a first null or reduced energetic consumption operating mode to a second higher energetic consumption operating mode.

2. Lock cylinder (1) according to claim 1 wherein the activation switch (15) is open, at least when the key (9) reproducing the predetermined opening combination is not inserted in the cylinder (1) or in one or more of the following conditions:

i) after the unlocking combination of the key has been correctly detected, and the driving pin (5A, 5B) is in a condition to actuate the bolt;
ii) after a predetermined time period has passed since the key (9) has been completely inserted into the lock cylinder (1) without the logic unit having read the correct unlocking combination on the key (time out procedure);
iii) after a predetermined time period has passed since the cylinder (1) has come out from the null or reduced consumption condition.

3. Lock cylinder (1) according to claim 1 wherein the activation switch (15) comprises or consists of one or more reed contacts.

4. Lock cylinder (1) according to claim 1, wherein the reading sensor comprises:

- one or more emitters (170A) arranged for emitting detection radiations;
- one or more receivers (170B) arranged for receiving the detection radiations filtered or anyway processed by the key (9) when it moves and is at least partially inserted in the lock cylinder (1), where the key (9) is suitable for filtering or anyway acting on the detection radiations so as to reproduce the predetermined unlocking combination.

5. Lock cylinder (1) according to one of the previous claims, wherein one or more of the following elements is housed in the cylinder housing (3) and is integral with the latter: the logic unit (11), the reading sensor (170A, 170B), the one or more emitters (170A), the one or more receivers (170B).

6. Lock cylinder according to claim 1, comprising a plurality of emitters (170A) and a plurality of receivers (170B), wherein both the emitters and the receivers are arranged on at least one row which extends

transversally to the insertion direction of the key in the lock cylinder (1).

7. Lock cylinder according to one or more of the previous claims, wherein the cylinder housing (3) is conformed so as to reproduce one of the following standardized profiles: oval or semi-oval European profile, oval or semi-oval English profile, oval or semi-oval Scandinavian profile, oval or semi-oval Australian profile, rim cylinder, loose inside/outside cylinder, mortise cylinder, deadbolt cylinder.

8. Lock cylinder according to claim 1, comprising an electrical power supply (19) arranged for powering one or more of the logic unit (11), the one or more emitters (170A) and the one or more receivers (170B), and the electrical power supply (19) is housed in the cylinder housing (3) and is integral with it.

9. Lock cylinder according to claim 1, wherein the logic circuit comprises two boards or plates for electronic circuits (21A, 21B) facing towards each other, wherein:

- the one or more emitters (170A) are fixed on one of the two boards or plates for electronic circuits (21A);
- the one or more receivers (170B) are fixed on the other of the two boards or plates for electronic circuits (21B) .

10. Lock cylinder according to claim 1, wherein electrical power supply (19) is housed between the two boards or plates for electronic circuits (21A, 21B).

11. Lock cylinder according to claim 1, comprising:

- two driving pins (5A, 5B), each of which is located close to an end of the cylinder housing (3) opposite to the end close to which the other driving pin is located, so as to allow opening a door or other shutter, whereon the lock cylinder is mounted, by inserting the key (9) from both sides of the door or other shutter and at least partially rotating it; and
- two reading sensors (170A, 170B), each of which is arranged for detecting the predetermined unlocking combination reproduced on the key (9) when the latter is at least partially inserted in an end of the cylinder housing (3);
- a logic unit (11) programmed or anyway arranged for receiving the output signals of both reading sensors (170A, 170B) and for allowing at least one of the driving pins (5A, 5B) to activate the bolt (102) if the unlocking combination detected by at least one of the two reading sensors corresponds to the predetermined opening combination.

12. Lock cylinder according to claim 1, wherein the logic circuit comprises:

a) two first boards or plates for electronic circuits (21A), each of which is located close to one end of the cylinder housing (3) opposite to the end close to which the other first board or plate (21A) is located;
b) two second boards or plates for electronic circuits (21B), each of which is located close to one end of the cylinder housing (3) opposite to the end close to which the other second board or plate (21B) is located;
c) a fifth board or plate for electronic circuits or flexible plate or flat cable (21C) fixed or anyway integral with the two first (21A) and/or second boards or plates for electronic circuits (21B) and interposed between them;
d) a logic unit (11) and/or a storage cell (19), each of which is fixed on just one of the first (21A) or second boards or plates for electronic circuits (21B); and wherein:

- on each of the first boards or plates for electronic circuits (21A) one or more emitters (170A) are fixed;
- on each of the second boards or plates for electronic circuits (21B) one or more receivers (170B) are fixed;
- on the fifth board or plate for electronic circuits (21C) one or more electric conductors are present, arranged for allowing the logic unit (11) to exchange signals and/or power supply with the one or more emitters (170A) and/or the one or more receivers (170B) fixed on both the first (21A) or the second boards or plates for electronic circuits (21B) and/or the possible clutch motors (27A, 27B) located close to both ends of the cylinder housing (3).

13. Lock cylinder according to claim 1, comprising an actuating clutch arranged for:

- mechanically engaging with at least one of the driving pins (5A, 5B) allowing the latter to actuate the lock bolt (102) wherein the lock cylinder (1) is mounted, when the logic unit (11) detects that a key (9) is at least partially inserted in the lock cylinder (1), key which reproduces an unlocking combination equal to the predetermined opening combination; and
- mechanically disengaging from at least one of the driving pins (5A, 5B) preventing the latter from actuating the lock bolt (102) wherein the lock cylinder (1) is mounted, when the logic unit

(11) does not detect that a key (9) is at least partially inserted in the lock cylinder (1), key which reproduces an unlocking combination equal to the predetermined opening combination.

14. Key (9) for actuating a lock cylinder (1) having the features according to one or more of the previous claims, wherein:

- the key (9) reproduces the predetermined unlocking combination through a plurality of windows (96) arranged so as to form a plurality of rows (90R) and columns (90C);
- at least some of the windows (96) are transparent to an electromagnetic radiation of a predetermined frequency band;
- the number of rows or columns is equal to or greater than three;

the key (9) also being provided with an activating element switch (98) arranged for triggering the closure or opening of the activation switch (15) when the key (9) is close to the lock cylinder (1) and/or at least partially inserted in the lock cylinder (1), and the activating element switch (98) can possibly comprise one or more elements chosen from the following group: a permanent or non permanent magnet, an electromagnet, an electric conductor arranged for short-circuiting the contacts of the activation switch (15).

15. Key (9) according to claim 14, wherein each of the windows can alternatively be:

- transparent to part or all of the spectrum of visible light;
- opaque to part or all of the spectrum of visible light but transparent to part of non visible electromagnetic radiation, like for example infrared or ultraviolet radiation.

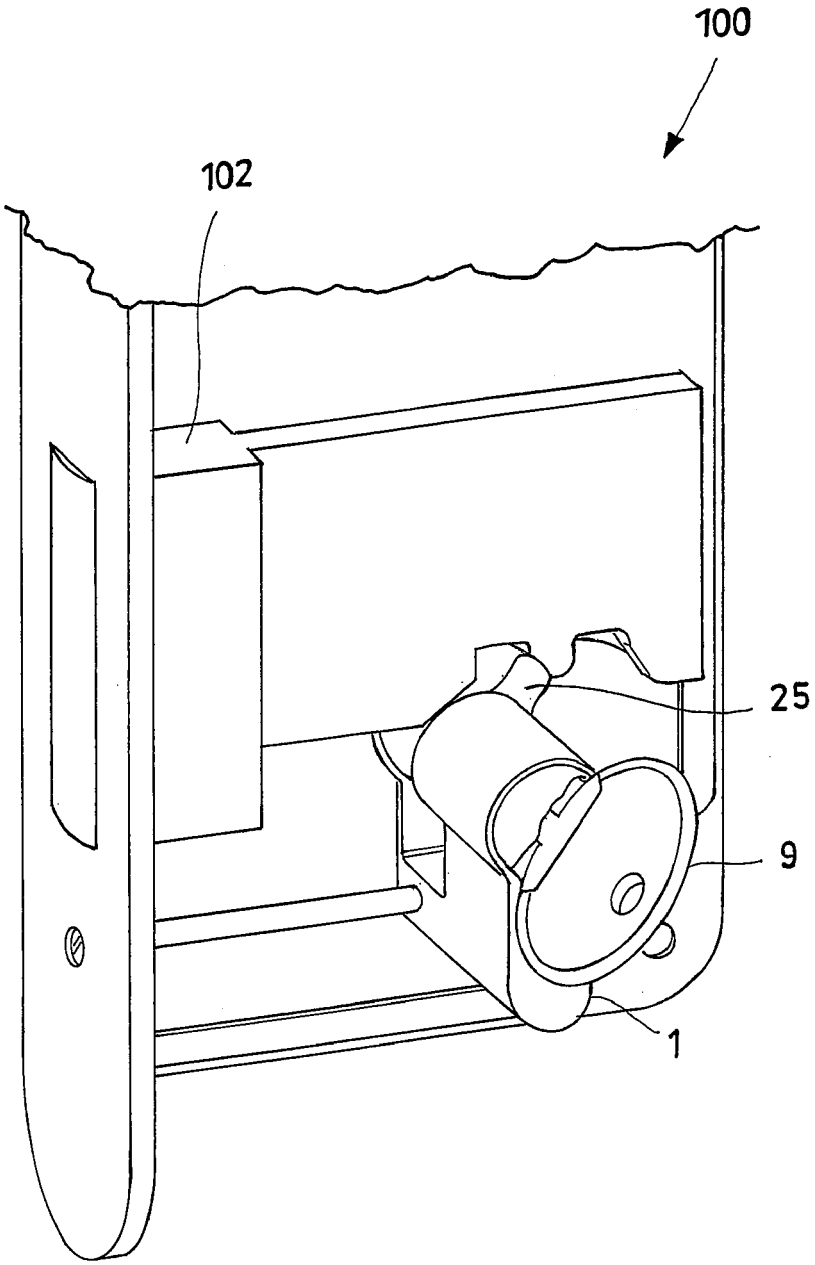


Fig.1

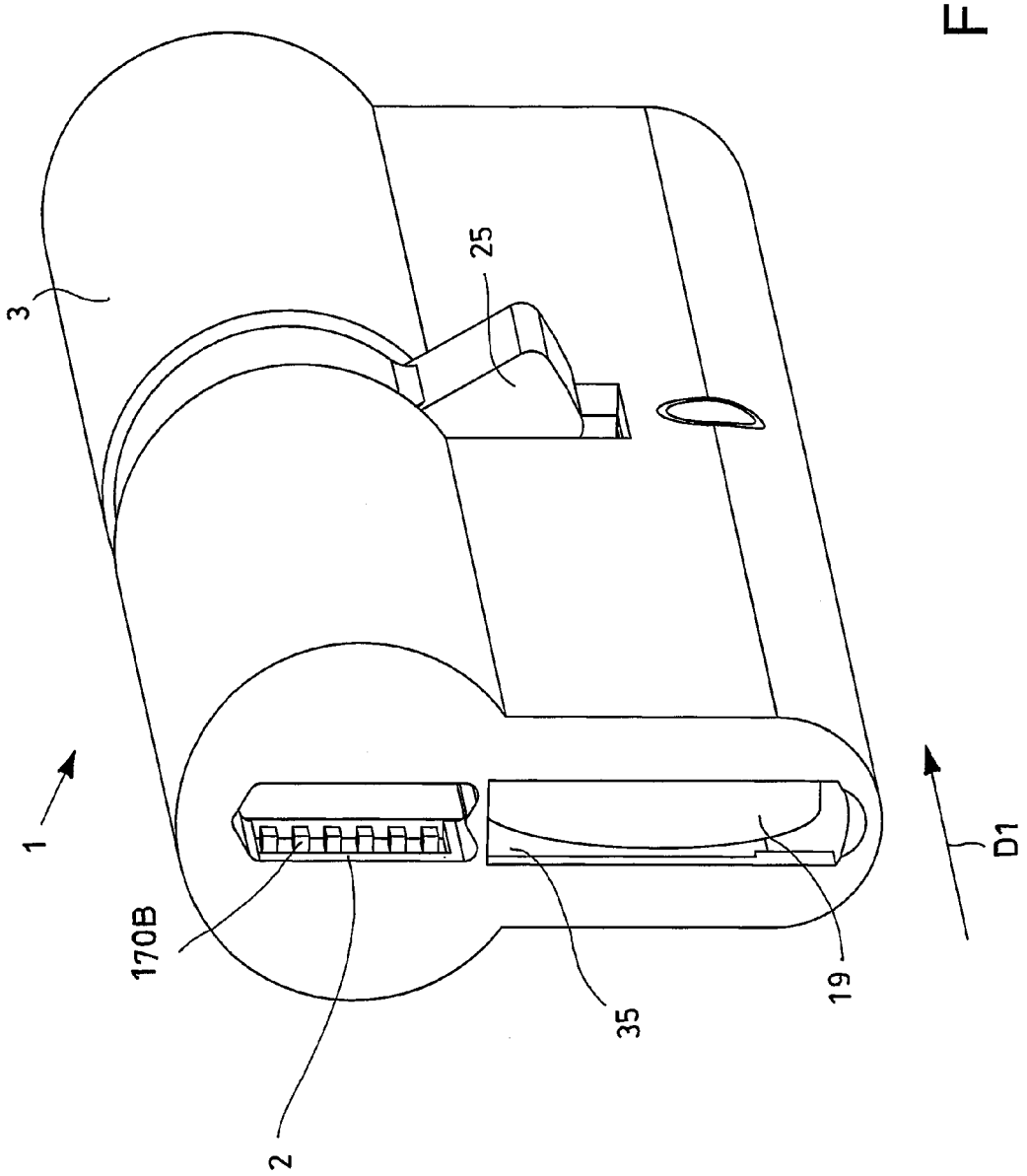


Fig. 2

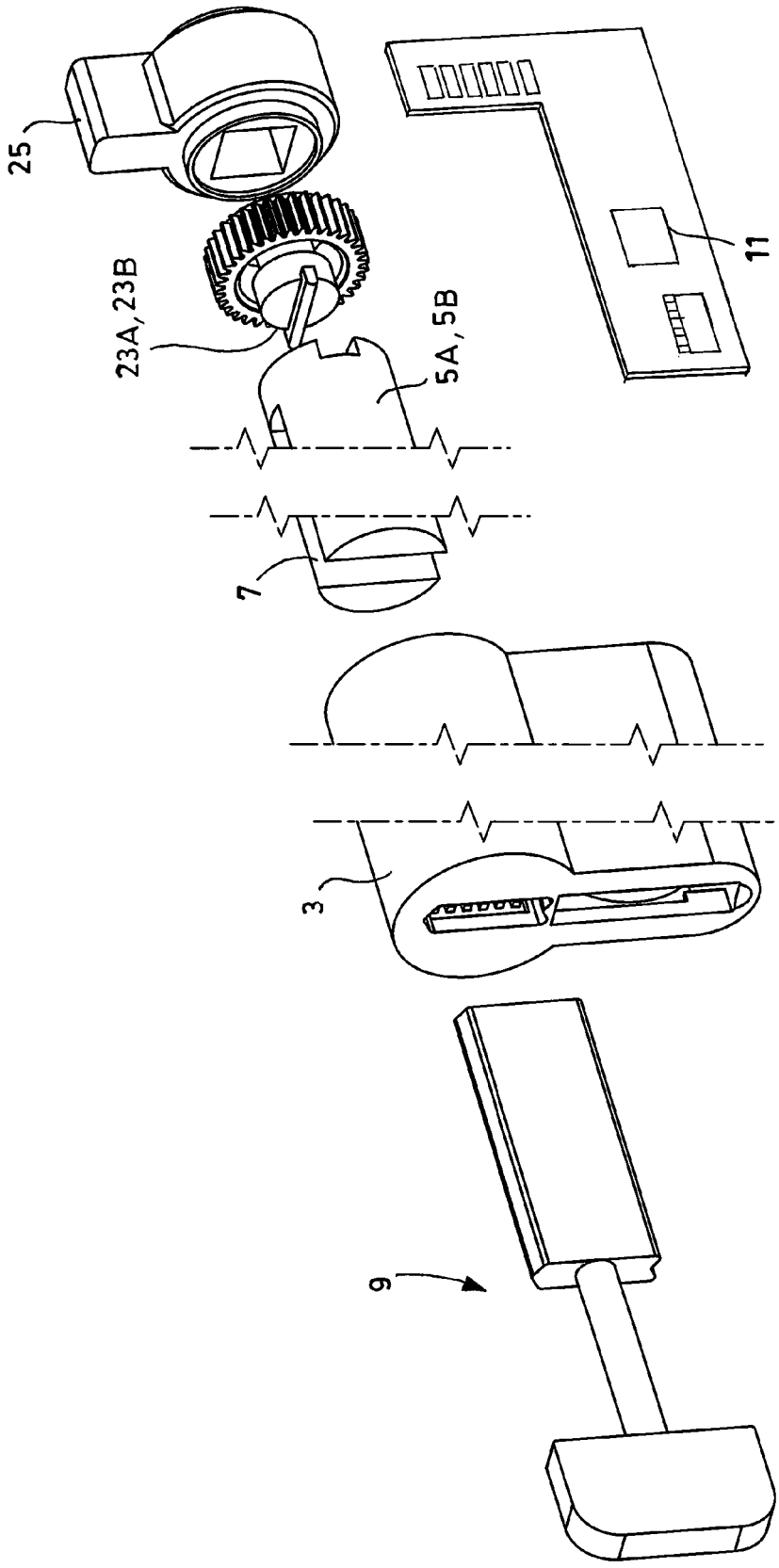


Fig. 3

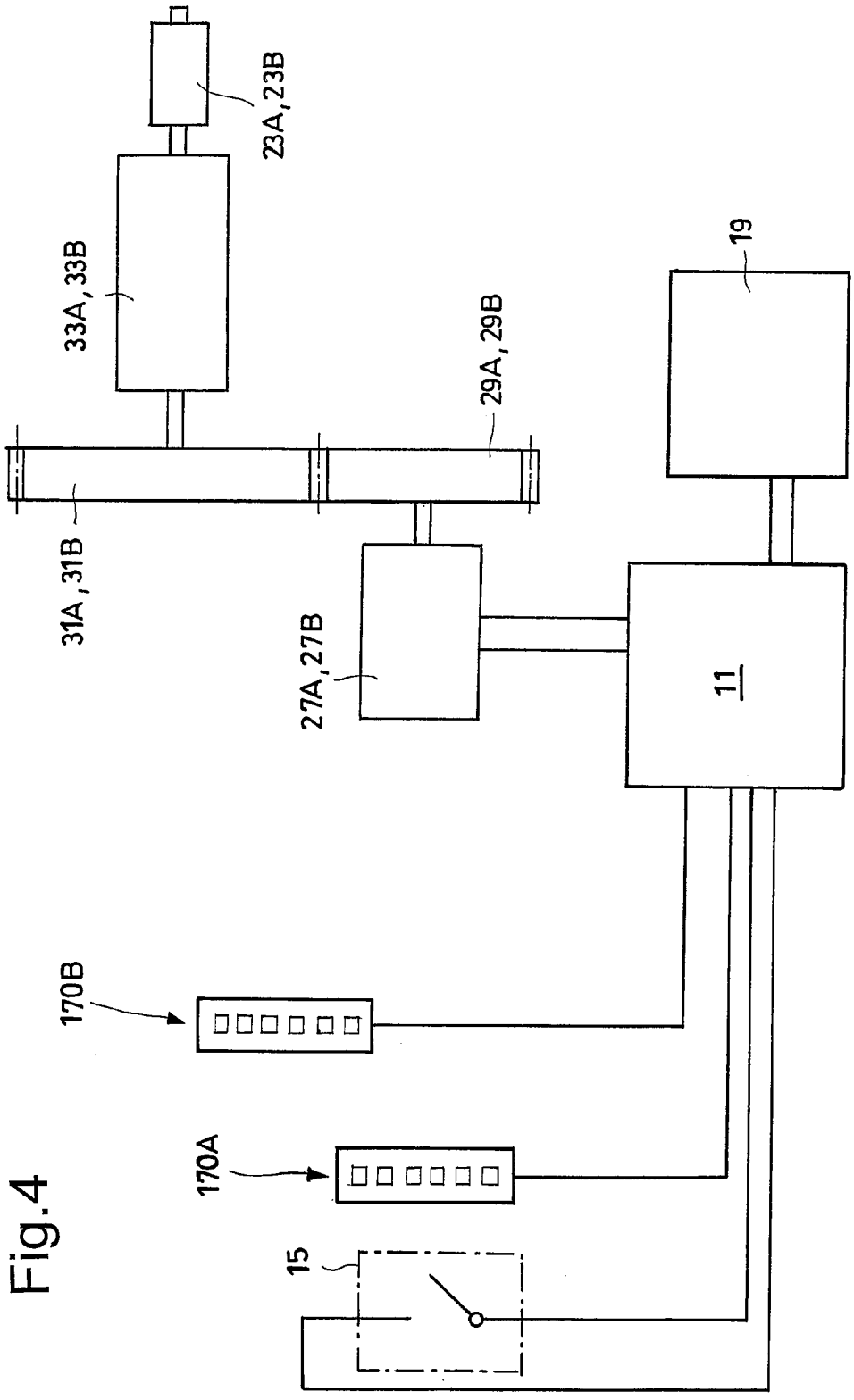


Fig.4

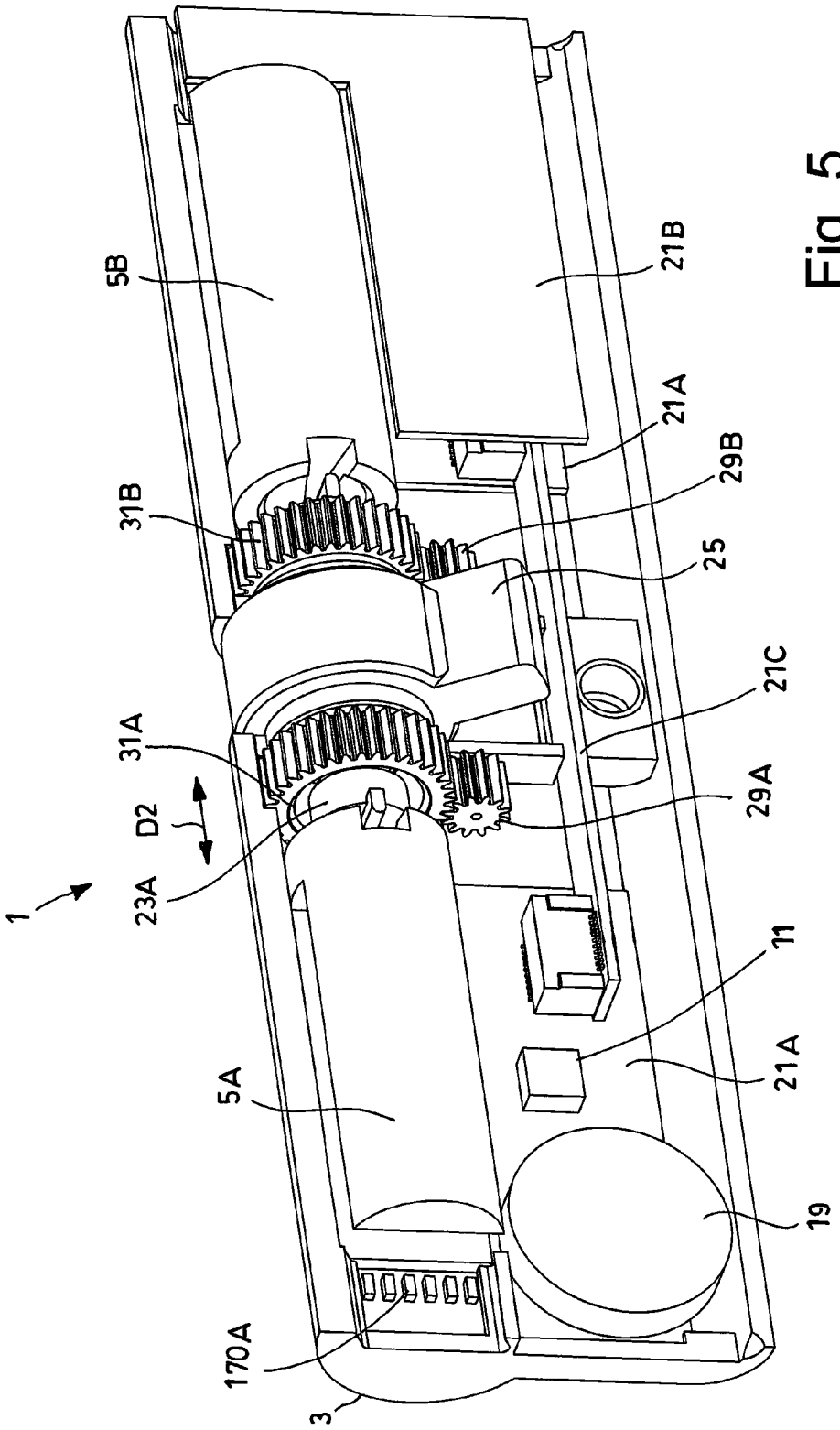


Fig. 5

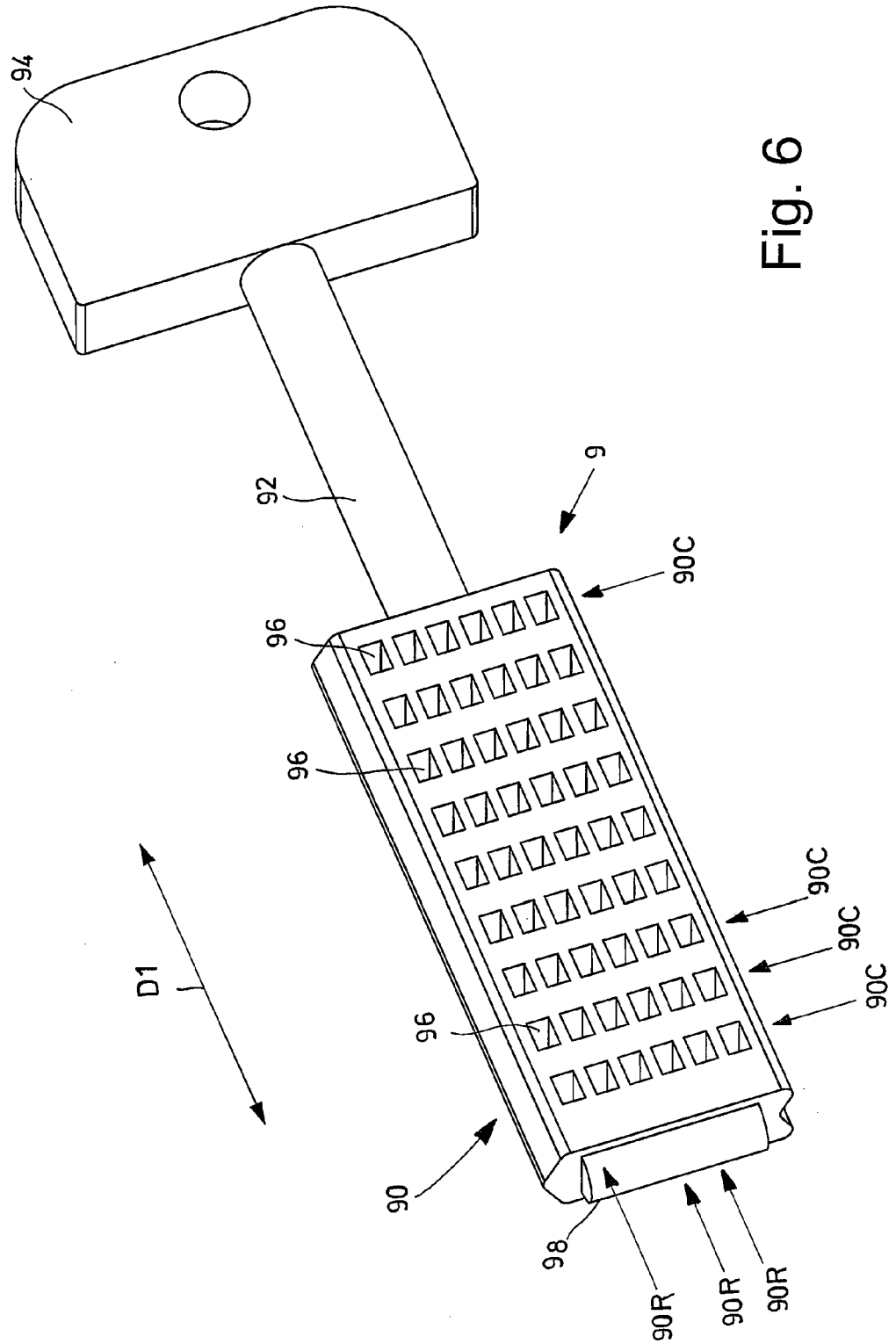


Fig. 6

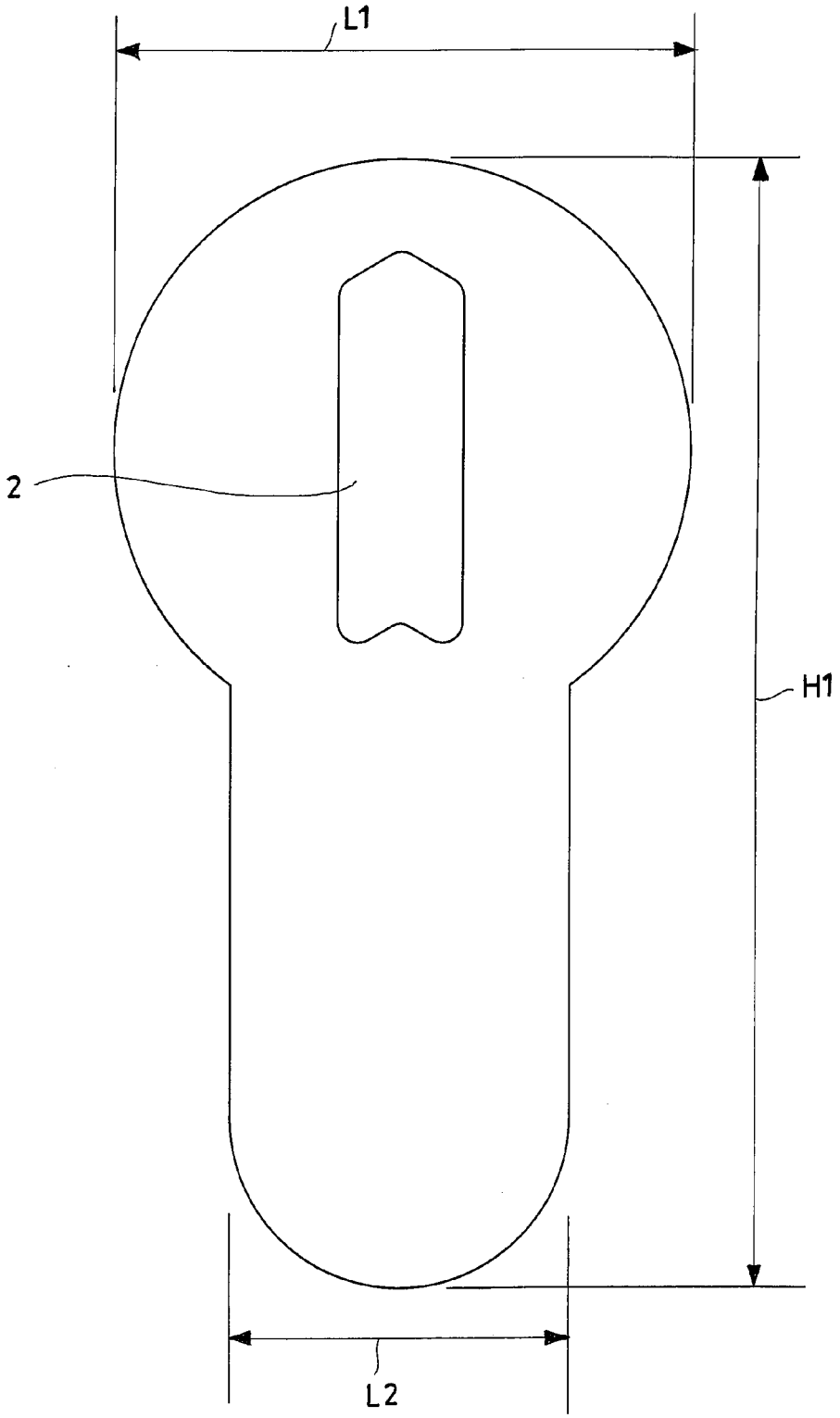
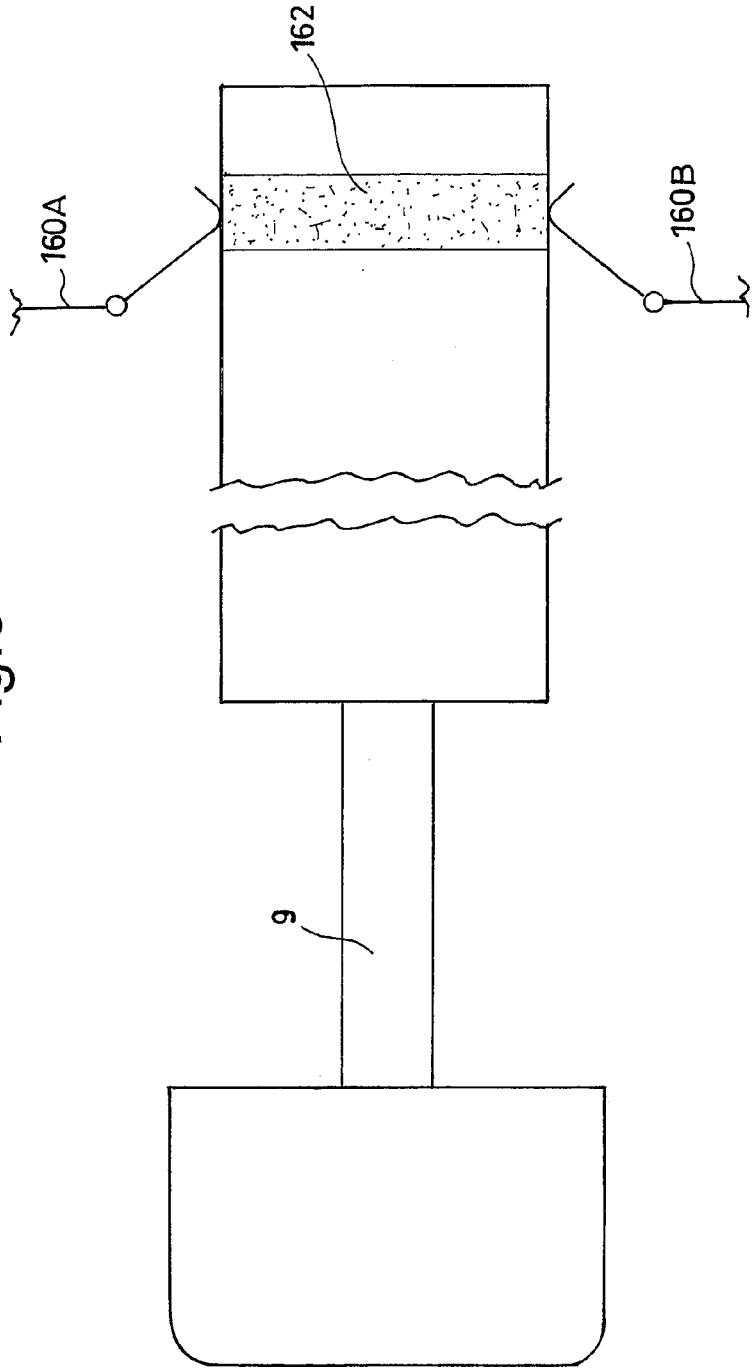


Fig. 7

Fig.8



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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 7719

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