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### Keys

The present invention relates to keys and more  
15 particularly to keys for "electronic" locks of the kind  
where a code is received by the lock from a properly  
coded key by way of inductive coupling between the two.  
Inductively-coupled key locks are relatively well known,  
at least in the patents literature, as exemplified by  
20 DE-2634303, EP-0115747, GB-2158870, GB-2174452,  
US-4549176, US-4602253 and WO-88/03594. The principle  
of operation of such devices is that the lock generates  
an alternating magnetic field in a region into which the  
key is brought, the key having circuit elements which  
25 control an inductive transmission element on the key to  
modulate or add to the field generated by the lock in  
such a way as to enable detection by the lock of a code  
programmed into the key. Preferably, although not  
essentially, the power for the circuit elements of the  
30 key is derived by rectification of the voltage induced by  
the alternating field of the lock. A particular  
advantage of this form of code transmission is that it  
avoids the need for any galvanic contact between the lock  
and key.

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It is recognised that, both in the interests of user  
acceptance and to maximise the utilisation of standard  
lock components and furniture, it is desirable that the  
overall appearance, dimensions and functionality of

"electronic" key locks should resemble as far as practicable those of their conventional mechanical counterparts. The present invention is therefore concerned with a key for an "electronic" lock which can  
5 resemble a conventional mechanical cylinder lock in that it comprises a rotatable barrel with a keyway, into which the key is inserted and turned in order to retract the associated bolt or other such locking member. A lock of this style operating on the inductive coupling principle,  
10 more particularly for vehicle doors, is disclosed in GB-2174452. In this prior art arrangement, the induction elements of both lock and key comprise a respective coil with a soft iron core. The lock coil is mounted longitudinally in a bushing at the end of the  
15 barrel, to one side of the keyway, while the key coil is mounted longitudinally in its tip, so that when the key is fully inserted in the barrel the two coils lie side-by-side, with their cores in parallel. It is evident that in an arrangement such as that, however, only a  
20 partial inductive coupling between the two coils can be achieved, in the sense that much of the magnetic flux generated by either coil will follow a path which does not pass through the other. In consequence, the total magnetic flux and energising power requirements of the  
25 lock are higher than they need be if a more efficient coupling of the inductive elements were achieved.

It is particularly desirable in the operation of a lock of this character that its power consumption be  
30 minimised, for example so that a usefully long service life can be expected when battery-operated, and because more costly components are required when high power levels must be handled. In addition, current EMC (electromagnetic compatibility) standards effectively  
35 restrict the permissible radiated electromagnetic power of devices such as electronic locks. Because this radiated power is directly related to the power levels handled in the lock, it is advantageous to keep these levels to a minimum. We believe that these criteria can

best be met in an inductively-coupled lock by ensuring that the respective inductive elements are arranged to maximise the linkage of magnetic flux between them when reading the code from the key. Accordingly, it is an  
5 aim of the invention to provide a key for an inductively-coupled lock of "cylinder" style in which this linkage can be maximised.

The invention therefore resides in a key for use with a  
10 lock having a rotatable barrel defining a keyway adapted to receive the key, and reading means adapted to receive a code from the key, when inserted in the keyway, by way of inductive coupling with a code transmission element of the key, in use the reading means generating an  
15 alternating magnetic field which passes across a region of the keyway; the key comprising a bow portion and a bit portion; the bit portion being of non-circular cross-section for transmitting rotation to a said barrel when inserted into the keyway thereof; the bit portion  
20 bearing an inductive code transmission element in the form of a coil wound about an axis transverse to the longitudinal axis of the bit portion and parallel to the direction of magnetic flux passage across a said keyway in use of a said reading means; said coil being mounted  
25 in a recess formed in the bit portion of the key and an element or elements of magnetically-permeable material being mounted in said recess to one or both sides of said coil to define part(s) of the magnetic circuit which in use links said coil to a said reading means.

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The invention will now be more particularly described, by way of example, with reference to the accompanying drawings in which:-

35 Figure 1 shown one example of a lock with which a key according to the present invention may be used;

Figure 2 is an interior view of the lock of Figure 1;

Figure 3 is a view of a key in accordance with the invention for use with the lock of Figures 1 and 2;

Figure 4 is a view partially broken away showing the key in the course of insertion into a cylinder unit of the lock; and

Figure 5 is a transverse cross-section through the key and cylinder unit in the position of Figure 4.

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With reference to Figures 1 and 2 the illustrated lock is of mortice style having a casing 1 and a forend 2 through which extend a dead bolt 3 and a latch bolt 4.

Extension and retraction of the dead bolt 3 is in response to rotation in an appropriate sense of an internal thrower 5 having a radial lug 6 which drives the bolt through the agency of a runner 7 moving along an arcuate track, the geometry of the runner/bolt relationship being such as to deadlock the bolt against end pressure when thrown. Retraction of the latch bolt 4 is in response to the turning of a cam 8 by means of external handles (not shown) and is likewise accomplished, via a linkage 9, by rotation of the thrower 5 to withdraw the dead bolt. As thus far described, the mechanism is of conventional design much practised by the present applicants.

Mounted externally to respective sides of the lock case 1 are pair of cylinder units 10. Each such unit has a rotatable barrel 11 with a keyway 12 and, at its inner end, a drive socket 13 whereby to turn the thrower 5. Associated with the keyway in each cylinder unit 10 is a reading head for transducing a code signal from a properly coded key when inserted therein by way of an inductively-coupled transponder method, e.g. as described in WO-88/03594 and the preferred structure of which is more fully described below. In any event, when a properly coded key is inserted into either keyway 12 its code signal is detected by the respective reading head

and transmitted via a plug connector 14 in the rear of the respective cylinder unit and a respective socket 15 in the lock case to a PCB 16 inside the lock which mounts the processing electronics which serve to determine if the key code is valid, and if so the coil of an electromagnet 17 is energised. This electromagnet is the operative part of an electromechanical release mechanism full details of the construction and operation of which are to be found in our European patent application no. 0392596. Suffice to say for the purposes of the present application, while the electromagnet 17 remains de-energised the thrower 5 is blocked by a lever 18 from turning far enough to shift the bolt(s), but when the electromagnet is energised such turning of the thrower is enabled as the lever 18 is cammed away together with another lever 19 upon which the electromagnet is mounted.

Electrical energy for the processor, reading heads and release mechanism is supplied via a lead 20 from a battery pack (not shown) housed in another mortice in the door.

Additional physical protection for the bolt runner 7, release mechanism 17/18/19 and at least that part 16A of the PCB 16 which mounts an interface circuit between the processor and the electromagnet 17 is provided by hardened steel anti-drill plates 21 located to each side of the lock case 1. The interface circuit on PCB part 16A is directly connected with the electromagnet 17 by a cable 10 (not shown) situated between these anti-drill plates.

A key 22 according to the invention and of the proper form for use with this lock is shown in Figure 3. It comprises a preferably metal blank of e.g. nickel-silver, brass or aluminium, defining bow 23 and bit 24 portions, with a transverse aperture 25 through the bow near to its tip and a narrow transverse gap 26 extending from that

aperture to the tip. Mounted within the aperture 25 is an integrated circuit chip 27 (see Fig. 5) which defines the whole of the key electronics and which is sandwiched between two pads of ferrite 28. The assembly of chip 27 and ferrite pads 28 is secured by an epoxy resin or other inert filler 29 which fills also the gap 26. The material 29 preferably surrounds all four edges of the chip/ferrite assembly 27/28 between the metal blank to cushion that assembly from the effect of mechanical shocks e.g. if the key is dropped onto a hard floor. The chip 27 includes inter alia a memory programmed with an identification or authorisation code which when transferred to the processor of the lock enables release of the thrower 5 for turning by the respective barrel 11 as indicated above. The key may also include one or more drillings 39 for cooperation with conventional pin tumblers (not shown) acting between the barrels 11 and housings 30 for indexing the key insertion and withdrawing position, preventing the barrel from being turned unless the key is fully inserted (and preventing the key from being removed until the barrel has been fully turned), and possibly providing mechanical differs between different locks and their keys. However, the principal and essential code-bearing element of the key is the IC chip 27.

With reference to Figures 4 and 5, these show the structure of the inductive reading head in each cylinder unit 10. These units comprise a housing 30 of die-cast alloy, e.g. Mazak (registered trade mark), or possibly of plastics, in which is journaled the respective barrel 11 of e.g. brass or again possibly plastics. Mounted within the housing at a selected axial distance from its front face is a U-shaped ferrite element 31. This is embedded in the housing 30 in epoxy resin or other inert filler 32 and has its two ends juxtaposed to the barrel 11. Wound around one of the limbs of this U, close to the barrel, is a field-generating and detection coil 33, connected by wires 34 to an associated oscillator and

detection circuit (not shown). The barrel 11 also incorporates two ferrite elements 35 at the same axial position as the housing element 31. The elements 35 extend from either side of the keyway 12 to the periphery of the barrel so as to be juxtaposed to respective ends of the element 31 when the barrel is in the key-insertion position shown in the Figures. In the case of a metal barrel 11, the ferrite elements 35 are electrically isolated therefrom by respective plastics inserts 36 (and which prevent the gap 26 in the key tip from being short-circuited by the metal barrel when the gap 26 just passes the ferrites 35 during insertion of the key).

In use, as the tip of a key 22 is passed into the entrance of the keyway 12 in either cylinder unit 10 a microswitch (not shown) in the respective housing 30 is depressed which actuates the aforesaid oscillator to supply a high frequency (typically 10MHz) energising current to the coil 33, which induces a corresponding alternating magnetic field in the ferrite element 31. It will be appreciated especially from Figure 5 that in the key-insertion position of the barrel 11 the juxtaposed ferrite elements 35 will act as extensions to the U-shaped element 31 and define collectively with that element a toroidal core structure with an air gap spanning a localised region of the keyway 12 at a selected axial distance from its entrance. The magnetic flux generated by the coil 33 is concentrated in this core structure and passes across that region of the keyway with little loss. In this respect the relative magnetic permeability of the material in elements 31 and 35 is preferably at least 100 times that of free space, for a ferrite with low loss at the chosen frequency.

The axial distance of the ferrite core structure 31/35 along the keyway 12 is less than the axial distance along the key bit 24 of the chip 27 from the stop shoulder 37 which defines the limit of insertion of the key. Accordingly, the chip 27 and its flanking ferrite pads 28

pass through the alternating magnetic field between the ferrite elements 35 of the barrel before the key is fully inserted, and in the course of this passage the key code is read. More particularly, the key chip 27 bears an integrated coil as its inductive transmission element, wound in a plane at right angles to the magnetic flux passing across the keyway and positioned for maximum coupling with the field generated by the housing coil 33. The coil on chip 27 is located symmetrically in the key, so the latter is reversible in the sense of its orientation for insertion in the keyway. The presence of the gap 26 in the key tip prevents the metal of the key blank surrounding the chip 27 from acting as a shorted turn around the key coil, which would otherwise introduce a high loss; (in the alternative a high-strength plastics blank could be used). The voltage induced in the key coil by the alternating magnetic field passing across the keyway is rectified to power the active components of the integrated circuit and its frequency, suitably divided, acts as a clock for logic circuitry which drives a shift register containing the identification code data from the aforesaid memory. This data is applied to the key coil so as to modulate or add to the field generated in the keyway by the housing coil 33 and the key code is derived in the lock by a detector circuit on the PCB 16 which is connected to the coil 33. Further details of the operation of the electronics to transfer the code from the key to the lock can be found in WO-88/03594. The key code is read in this way before the key is fully inserted in order to give the lock electronics time to determine the validity of the code and to give the electromagnet 17 of the release mechanism time to build up its attraction force to a maximum before the user of the key will begin turning of the barrel 11.

As will be appreciated from Figure 5, the ferrite pads 28 on the key act as further extensions of the toroidal magnetic core structure 31/35 during insertion of the

key, to further concentrate the alternating field in the region of the key coil. This material is hard and wear-resistant and also provides good physical protection to the IC chip 27. The provision of two ferrite pads on  
5 the key is not an essential feature of the invention, however, and in other embodiments one or other of them may be omitted, depending on the permissible width of the air gap in the overall toroidal core structure. Neither is the use of an on-chip key coil essential, and in other  
10 embodiments a discrete wire coil may be employed in the key in an equivalent location to the chip 27 illustrated in the Figures.

Our copending United Kingdom patent application no.  
15 9126864.9 (publication no. 2252356) claims a lock comprising: a housing; a barrel defining a keyway borne rotatably in the housing and adapted to receive and be turned by a properly coded key; reading means adapted to receive the code from a said key when inserted in said  
20 keyway, by way of inductive coupling with a code transmission element of the key; and means for controlling the operation of the lock whereby to enable the retraction of a bolt or other such locking member by turning of the barrel when a proper key code is received  
25 via said reading means; wherein the reading means includes a coil for generating an alternating magnetic field in a region of said keyway and a coil for detecting a modulation or addition to said field by the transmission element of a properly coded key when located  
30 in said region of the keyway; said coil(s) surrounding part of a toroidal magnetically-permeable core structure which defines a gap spanning the aforesaid region of said keyway; and wherein said core structure is collectively defined at least by a first frusto-toroidal part mounted  
35 in said housing, around which said coil(s) wind, and which presents two ends in proximity to said barrel, and by two further parts mounted in the barrel, one to either side of the aforesaid region of said keyway, and which are juxtaposed to respective ends of said first part when

the barrel is in the key-reading position relative to the housing.



## CLAIMS

1. A key for use with a lock having a rotatable barrel defining a keyway adapted to receive the key, and reading means adapted to receive a code from the key, when inserted in the keyway, by way of inductive coupling with a code transmission element of the key, in use the reading means generating an alternating magnetic field which passes across a region of the keyway; the key comprising a bow portion and a bit portion; the bit portion being of non-circular cross-section for transmitting rotation to a said barrel when inserted into the keyway thereof; the bit portion bearing an inductive code transmission element in the form of a coil wound about an axis transverse to the longitudinal axis of the bit portion and parallel to the direction of magnetic flux passage across a said keyway in use of a said reading means; said coil being mounted in a recess formed in the bit portion of the key and an element or elements of magnetically-permeable material being mounted in said recess to one or both sides of said coil to define part(s) of the magnetic circuit which in use links said coil to a said reading means.
2. A key according to claim 1 wherein said bit portion is of elongate cross-section and said coil is mounted therein in a plane parallel to the longer dimension thereof.
3. A key according to claim 1 or claim 2 wherein said bit portion is made of metal and said coil and element(s) of magnetically-permeable material are insulated from the metal of said bit portion.
4. A key according to claim 3 wherein the metal of the bit portion surrounding said recess is interrupted at least at one location to prevent the same acting as a shorted turn.



5. A key according to claim 1 or claim 2 wherein said bit portion is made of plastics.

6. A key according to any preceding claim wherein said  
5 coil is formed as an integral element of an integrated circuit which provides also circuit elements for the storage and retrieval of said code.

7. A key according to any preceding claim wherein said  
10 coil is formed on a flat chip which is sandwiched within said recess between two flat said elements of magnetically-permeable material.

8. A key according to any preceding claim wherein the  
15 or each said element of magnetically-permeable material is made of ferrite.

9. A key substantially as hereinbefore described with reference to Figures 3 to 5 of the accompanying drawings.