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(54) Door lock with closure sensing

(57) Apparatus for controlling an electromagnetically actuatable door lock 14,16 includes infra-red transmitter/sensor on a door and a stainless steel reflector on the frame; a predetermined level of sensed radiation causing lock operation when the door is closed. In the embodiment shown a pair of LED's 56,58 (providing narrow and wider emission angles) are mounted on opposed sides of the sensor 60 to form a linear array reflecting off member 52. Alternatively the reflector is mounted at an angle to the emission axis of a single LED and the sensor axis is at an angle to the LED axis. Power to the lock coil when actuated is initially at a high DC voltage level but once the lock has closed power to the lock coil is controlled to reduce the average power consumption by some 75%.

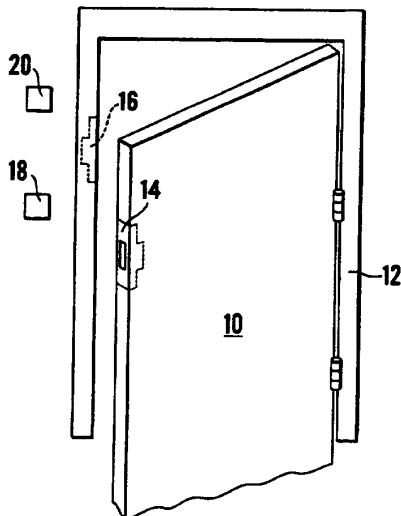


Fig. 1

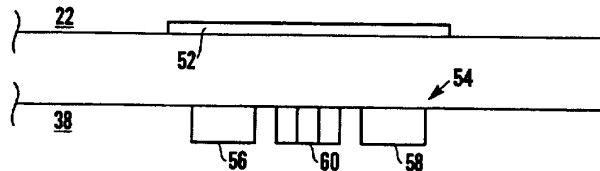


Fig. 3A

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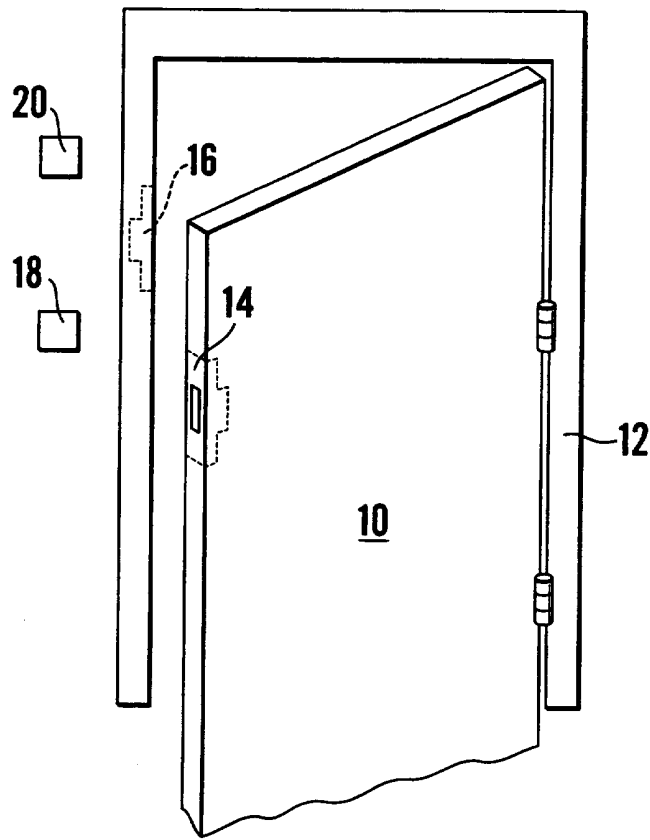


Fig. 1

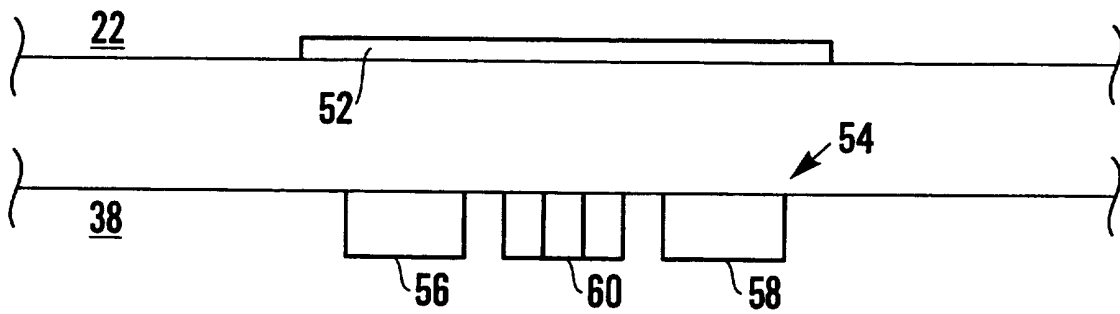


Fig. 3A

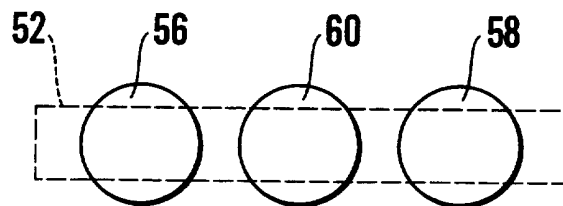


Fig. 3B

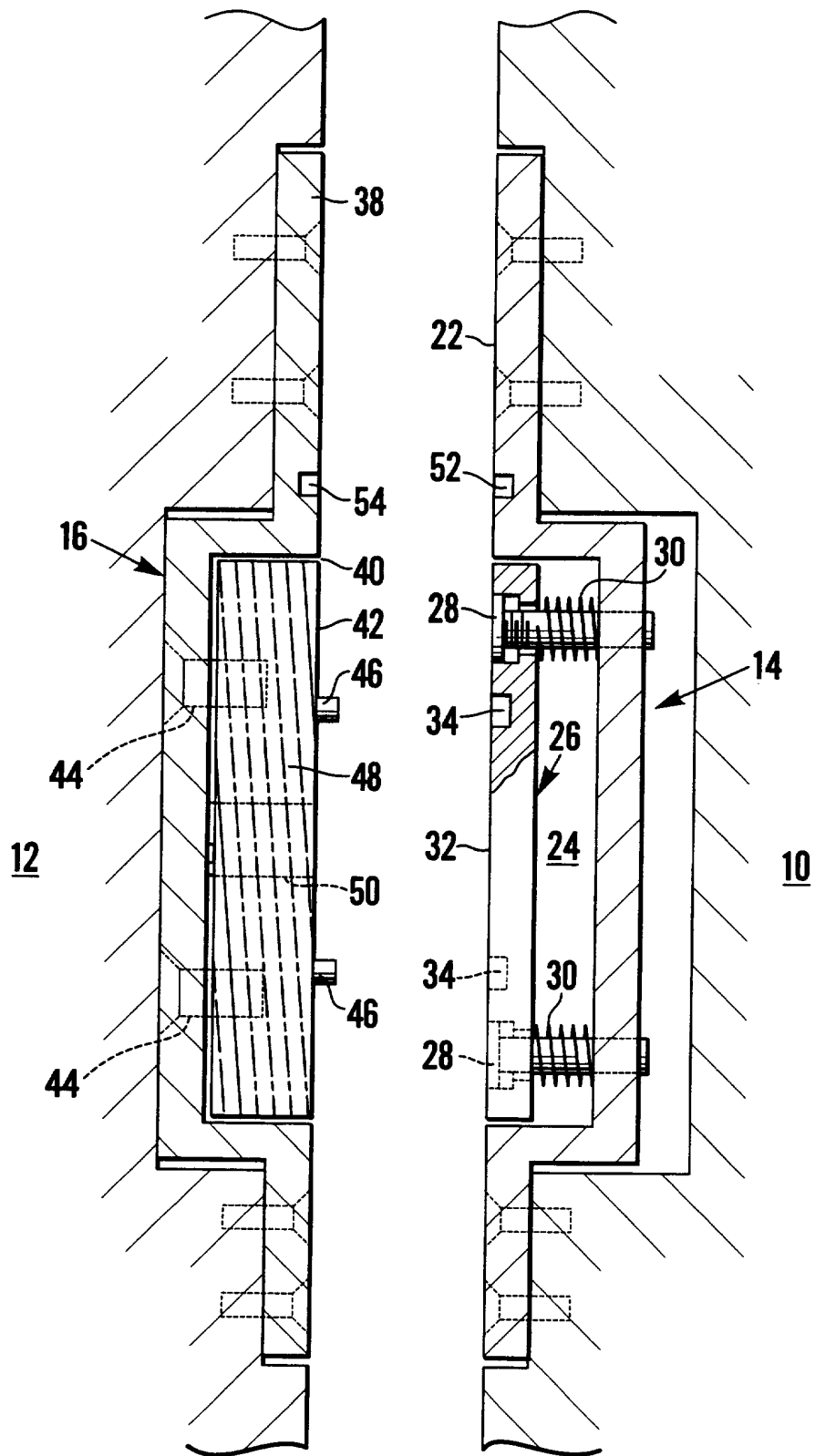


Fig. 2

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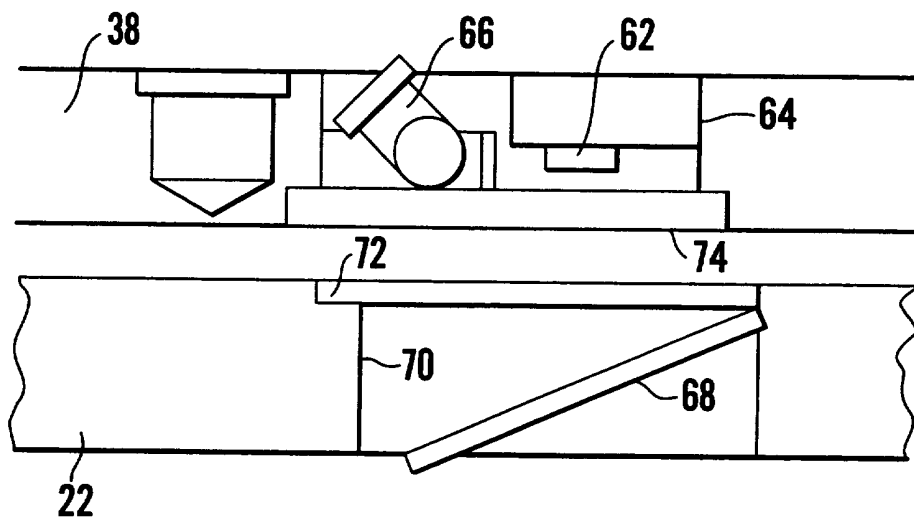


Fig.4

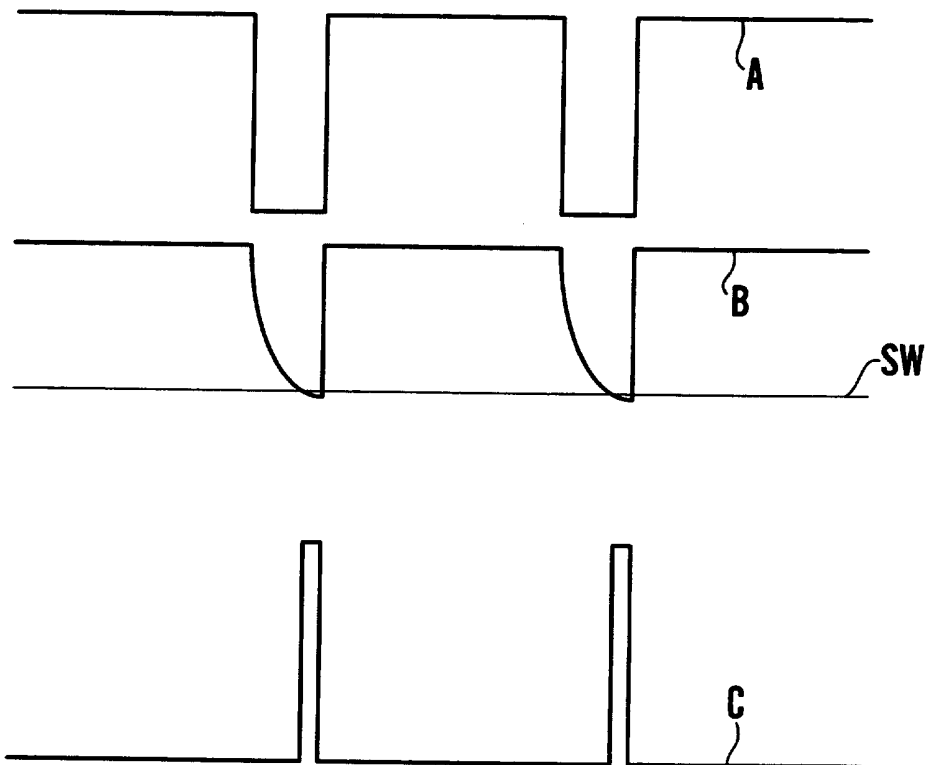


Fig.6

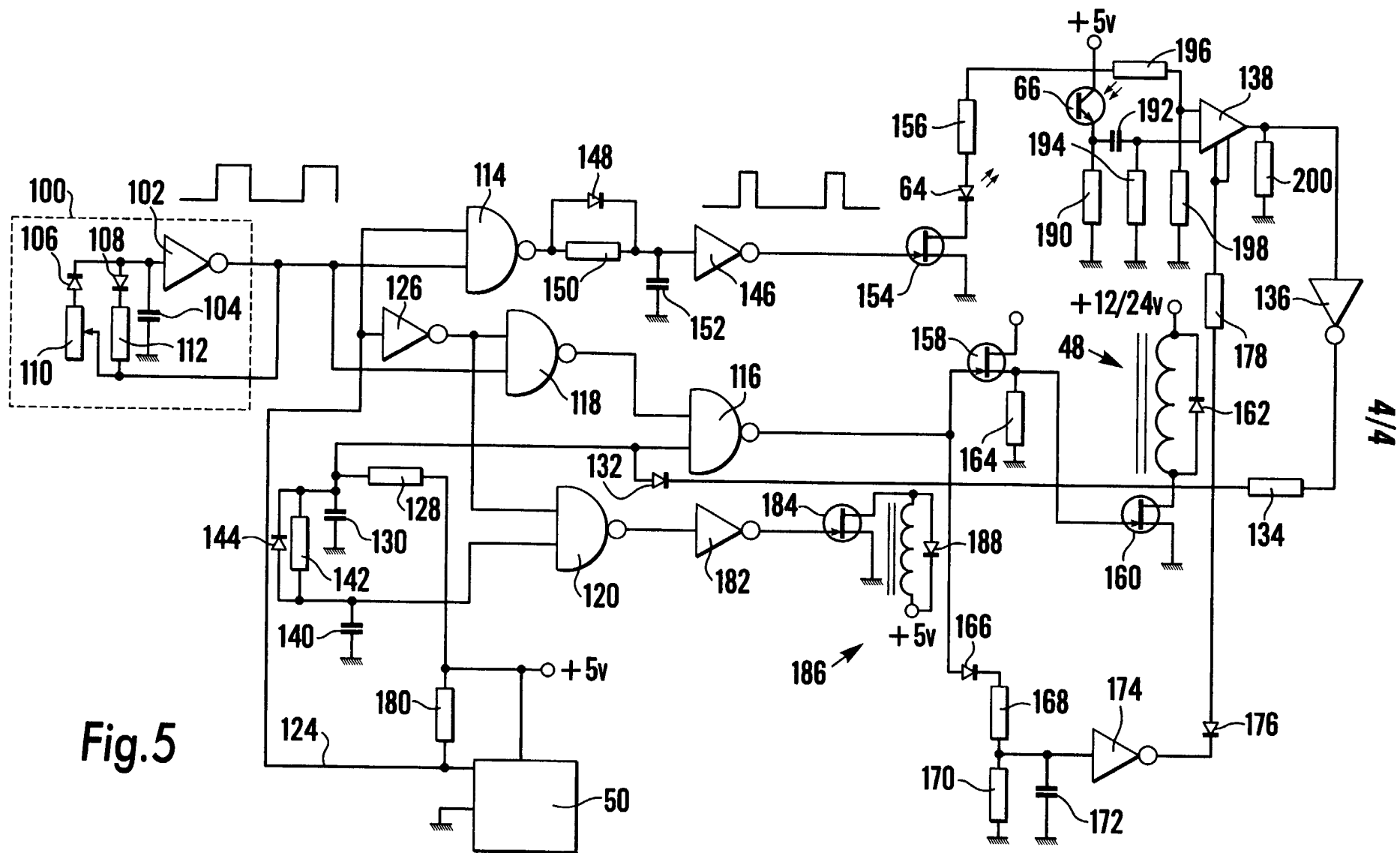


Fig.5

5 DOOR LOCKS AND APPARATUS FOR CONTROLLING SAME

10 DESCRIPTION

15 The invention relates to door locks and apparatus for controlling same, more particularly to door locks which are electromechanically driven and which are intended to give a high level of security to a particular area or facility.

20 Within this specification, and in the claims appended hereto, the term door is to be taken to encompass any door, gate, window, lid or other means for closing a portal or preventing access to an area or to a facility.

25 Traditionally locking arrangements for doors have included mechanical arrangements in which a lock bolt is thrown into position behind, or within an aperture in, a striker plate either directly by throwing the bolt or by

turning a key in a lock body, the action of the key being in turn to throw the bolt into its operative, locking, position. Once the lock bolt is engaged (either behind the striker plate or within an aperture formed in the striker plate) it may be left in that position and any key, if
5 desired, removed.

More recently there has been proposals made for electromagnetic door locks and these effectively fall into two classes.

10 The first is a contact type of lock in which there is no mechanical locking or inter-engagement of the lock parts. The two parts of the lock, the lock body and the armature, are held together by a strong electromagnetic field.

15 Such an arrangement has the drawback of requiring high power levels to hold the two parts of the lock together, which is difficult to obtain and, if obtained, usually causes rapid deterioration of the lock armature, or the drive circuit therefor.

20 This has led to a second class of electromagnetic lock in which the two parts of the lock (the armature and the body) are brought together by a strong electromagnetic field and one part of the lock physically engages with the other.

25 A first of this second class of electromagnetic lock may provide that either of the lock body or armature are provided with locking pins receivable in apertures

formed in the armature or lock body when the two parts of the lock are driven together. A second of this second class of electromagnetic lock may comprise a lock bolt which is normally contained within the body of the lock and
5 which under an electromagnetic force is driven to a position behind a striker plate or within an aperture in a striker plate.

An advantage of this second class of electromagnetic lock is that the power used to hold the
10 locking pins or bolt in position (which are usually spring biased out of engagement with the other part of the lock i.e. to an unlocked state) may be very substantially reduced when the two parts have been brought into inter-engagement.

15 For the second class of electromagnetic lock it is clearly essential that when the lock is electromagnetically actuated, so that the armature is driven towards the lock body (or bolt towards the striker plate), those two parts of the lock are correctly aligned.
20 If they are not then the mechanical interlock will fail.

Normally the door side of the lock cannot contain electrical parts and the solutions to this problem, of ensuring the correct alignment to the two lock parts, are limited.

25 To date proposals have been made for the use of mechanical location sensors, actuating switches, fixed magnets which activate magnetic reed switches, and fixed

magnets which activate electronic Hall effect devices.

We believe these solutions all have their inherent problems.

5 It is generally undesirable to use a mechanical sensor in an electromagnetic or electronic lock. Reed switches have proved, in practice, to be unreliable.

Due to the initial distance between the two locking parts of the lock (the armature and the body) Hall sensors and reed switches using permanent magnets have an
10 accuracy which is undesirable - we would estimate +/- 10mm.

An object of the invention is to provide a system for correctly aligning the positions of the parts of an electromechanically actuated lock with much greater accuracy than has heretofore been the case.

15 In a first aspect the invention provides apparatus for controlling an electromagnetically actuable door lock, the apparatus including electromagnetic radiation transmitter and sensor means for mounting on or in one of the door and frame in which the door closes and
20 a reflector on or in the other of the door and frame in which the door closes, means monitoring the output of the sensor means and providing an output in response to a predetermined level of sensed radiation to drive the lock parts electromagnetically together.

25 The frequency of the radiation transmitted and sensed is preferably in a particular frequency range, desirably in the infra-red range.

With especial advantage the wave length of the infra-red radiation is in the range of 900-1000nm.

The radiation transmitter means preferably incorporates one or more LED's.

5 The radiation transmitter and sensor means may be for mounting on or in the door frame and the reflector on or in the door.

The reflector means may comprise a stainless steel member.

10 The radiation transmitter means may include a pair of LED's one adapted to provide a narrow angle of emission and the other to provide a wider angle of emission, the pair of LED's being mounted on diametrically opposed sides of the sensor means to form a linear array.

15 In this arrangement the reflector means preferably comprises a strip of stainless steel the length of which is substantially the same or slightly longer than the length of the linear array of the LED's and sensor means.

20 The radiation transmitter means may include a single LED and the reflective element be mounted at an angle to the axis of light emitted by the LED when the door is in a position for the lock to be actuated.

25 Advantageously the receiving axis of the radiation sensor is at angle to the transmitting axis of the LED.

As noted above a particular advantage of

electromagnetically actuated locks which provide for the mechanical inter-engagement of parts of them is that the power required to keep those parts in mechanical inter-engagement once the lock is in a locking position, can be
5 reduced.

Various suggestions have been proposed for this in the past. One, in particular, providing that the power initially required to drive the lock armature into engagement with the lock body is provided at a level which
10 is boosted or increased from the normally supplied level of power to the lock. This can be achieved in a variety of ways one, for example, being that capacitive means is provided which is initially charged and which, when the drive mechanism for the lock is energised, initially,
15 provides a boost, or increase, to the normal power level supplied to drive and hold the lock parts together.

Such an arrangement can have disadvantages and does little to decrease the "normal" power level required to hold the lock parts in inter-engagement. We have found
20 that by using an electromagnetically actuated lock incorporating a system as defined above for determining the correct alignment of lock parts, it is possible to provide an arrangement for holding the lock parts in mechanical inter-engagement at a desirably reduced average holding
25 power; reduced to a level below what has until now been readily achieved.

In a second aspect the invention provides an

electromagnetically actuated door lock including control apparatus for controlling power supply to the lock as defined above, the arrangement further comprising an oscillator, first logical means which when enabled passes
5 a signal dependent upon the output of the oscillator to a driver for the radiation transmitter means, second logical means which when enabled is operable to supply power to a lock coil included in the lock at a continuous DC level or to a level switched at a rate determined by the output of
10 the oscillator, third logical means operable to switch the output of the second logical means between its two enabled states, means monitoring the output of the radiation sensor means and operable to enable the second logical means causing power to be supplied to the lock coil at the
15 continuous DC level, and means monitoring the operation of the lock to provide an output when the lock coil is energised which will disable the first logical means and cause the first logical means to switch the output of the second logical means to cause power to be supplied to the
20 lock at a rate determined by the oscillator.

The lock may further include means monitoring the output of the second logical means and resetting the apparatus if the lock coil monitoring means provides no output indicative that the coil is energised.

25 The coil monitoring means may comprise a Hall sensor responsive to the level of magnetic flux in the lock coil and operable to provide a logical HIGH output voltage

when there is no power supplied to the coil and a logical LOW output voltage when power is supplied to the coil.

The lock may further include means monitoring the condition of the lock and providing an indication that the lock is properly secure.

The oscillator desirably has a Mark:Space ratio of 2:3 and runs at a frequency of 22Khz.

The first logical means may comprise a NAND gate coupled to receive the oscillator output and, when the output of the Hall sensor is at a logical HIGH voltage level to pass a signal which is the inverse of the oscillator output to the driver electromagnetic radiation transmitter means.

The second logical means may comprise a second NAND gate one input of which is held initially at a logical HIGH voltage level whilst the other input is initially held at a logical HIGH voltage level and wherein the means monitoring the output of the radiation sensor means enables the second NAND gate to pass power to the lock coil driver.

The third logical means may comprise a third NAND gate to one input is passed the output of the oscillator and to the other input of which is passed the inverted output of the Hall sensor, the third NAND gate output providing an input to the second gate which input comprises the oscillator output when the Hall sensor is at a low voltage level.

The means providing an output indication of the

condition of the lock desirably comprises a fourth NAND gate one input to which is the inverted output of the Hall sensor and the other input to which is taken from means providing a logical HIGH voltage level for a pre-determined
5 period longer than that normally required for the Hall sensor to switch its output upon the lock being actuated.

The means monitoring the power fed to the lock coil may comprise capacitor means chargeable whilst the lock coil is being powered and operable to cause the means
10 monitoring the output of the electromagnetic radiation receiver to be re-set after a pre-determined time period.

The above and other aspects, features and advantages of the invention will become apparent from the following description of embodiments thereof now made with
15 reference to the accompanying drawings in which:-

Figure 1 schematically illustrates a door fitted with an electromagnetically actuatable lock embodying the invention,

Figure 2 illustrates in more detail, though still
20 schematically, mechanical parts of the lock illustrated in Figure 1,

Figure 3 shows at A and B respectively side and plan views of a first arrangement of radiation transmitters and sensor mounted in the door frame of Figure 1 and a
25 reflector mounted on the door edge in the arrangement of Figure 1,

Figure 4 illustrates another arrangement of a

radiation transmitter and sensor mounted in the door frame of Figure 1 and a reflector in the door of Figure 1,

Figure 5 is a schematic circuit diagram of the elements of an electromagnetically actuatable lock shown in Figure 2 using the radiation transmitter, sensor and reflector arrangement of Figure 4, and

Figure 6 illustrates operation of part of the circuit of Figure 5.

Figure 1 shows a door 10 hingeably mounted in a door frame 12 and incorporating an electromagnetically actuatable lock embodying the invention.

The first part 14 of the lock is carried in the edge of the door 10 whilst the second part 16 of the lock is mounted in door frame 12 adjacent the position of the part 14 when the door 10 is fully closed.

The arrangement embodying the invention further incorporates a switch 18 and an indicator lamp 20 shown schematically adjacent the door frame 12. Switch 18 enables operation of the lock and lamp 20 indicates whether the lock is secure.

It will be readily appreciated that the positions of the first and second parts 14 and 16 of the lock (in the door 10 and door frame 12) may be varied. They may be placed anywhere desired along the edge of the door or in the top or bottom of the door. Furthermore, it will be appreciated that locking arrangements embodying the invention may include more than one pair of parts 14 and 16

- a plurality of associated pairs of parts 14 and 16 may be provided along the peripheral edges, top and bottom of the door and frame if desired.

5 Furthermore it will be appreciated that the arrangement shown in Figure 1 is not limited to use with a door as shown but may be used with any door, gate, window, lid or other means for closing a portal or aperture or preventing access to an area or to a facility.

10 Figure 2 shows the first part 14 of the lock to comprise an assembly in the form of an armature frame 22 mounted flush with the edge of the door. A generally centrally located recess 24 in frame 22 houses an armature 26 of suitable magnetisable, material (for example mild steel).

15 Armature 26 is held in the central recess 24 of the frame 22 by bolts 28. Weak springs 30 coupled between the armature 26 and the base of the frame hold the armature with its face 32 generally flush with the edge of the door.

20 The face 32 of armature 26 is pierced by two apertures 34 spaced apart as shown and extending for a short distance (generally less than 5mm) into the body of the armature 26.

25 The second part 16 of the lock comprises a frame 38 let into the edge of the door frame 12 such that its outer face is generally flush with the surface of the door frame.

Frame 38 includes a generally centrally located

aperture 40 in which is mounted a lock body assembly 42 held rigidly in position by screws 44.

The outermost face of assembly 42 is generally flush with the edge of the door frame.

5 Two shear pins 46 are provided in assembly 42 and extend from the outermost face thereof by approximately 3mm. The shear pins 46, when the door is fully closed, are in register with the apertures 34 on the face 32 of the armature 36.

10 The lock body assembly 42 includes an electromagnetic coil 48 and a Hall effect sensor 50.

In addition to the above described parts the door frame supports one or more infra-red transmitters and sensors and the door a reflector which, when the door is
15 fully closed, is in register with those infra-red transmitters and sensors.

Figure 3 shows one arrangement of the infra-red transmitters and sensor and the reflector enabling the invention in more detail.

20 From Figure 3 it will be seen that the electromagnetic radiation transmitters comprise a pair of LED devices 56, 58 mounted centrally on diametrically opposed sides of an infra-red sensor 60. As can be seen, particularly from Figure 3B, the reflector carried in the
25 door comprises a stainless steel strip 52 somewhat narrower than the height of the array 54 of the transmitters and sensor and somewhat longer than its overall extent.

One of the infra-red transmitting LED's preferably emits light through a narrow angle of, say, not more than $\pm 10^\circ$ whilst the other, emits light through a much broader angle of, say, $\pm 30^\circ$. The sensor preferably
5 has an acceptance angle of $\pm 20^\circ$.

The intensity of the light emitted by the LED's 56, 58 may be adjusted as may their manner of illumination. The sensitivity of the sensor 60 may likewise be adjusted.

The frequency at which the LED devices 56 and 58
10 emits infra-red light when energised is preferably within the range 900-1000nm.

Figure 4 shows another arrangement of the light emitter and sensor and reflector elements embodying the invention. In particular Figure 4 shows a single LED 62
15 carried in the frame 38 mounted in the door frame 12 in a container 64. Also in the container 64 is an infra-red sensitive opto-transistor 66 (preferably that sold by the Sharp Corporation under the designation "Sharp PT380F"). Whilst the axis of the LED 62 is generally normal to the
20 surface of frame 38 the axis of the opto-transistor 66 is canted at an angle (preferably 30°) as shown. The reflector 68 in this arrangement is carried within a recess 70 of the frame 22 carried by door 10 and is also held at an angle within the recess (approximately 10°) directing light from
25 the LED 62 towards the transistor 66. The recess 70 and container 64 may be covered with plastics plates transparent to infra-red radiation 72 and 74 as shown.

As with other, known, electromagnetically actuated locks operation of the device is as follows. With the door open switch 18 is closed to provide power to a drive circuit operation of which will be described below.

5 The door 10 is then closed in the frame 12. When the two parts of the lock 14 and 16 are correctly aligned (that is to say the recesses 34 in the face 32 of armature 26 are in register with the locking pins 46) power is applied to the coil 48 in the lock body 42 pulling the
10 armature 26 towards it (against the action of springs 30) such that the pins 46 pass into the recesses 34.

 The correct alignment of the pins 46 with the recesses 34 is determined in the described lock by the relative positions of the reflector and infra-red
15 transmitter(s) and sensor carried on the parts 14 and 16 of the lock.

 With the arrangement of Figure 3, as the door moves to a more fully closed position light from the LED's 56 and 58 will be reflected by the stainless steel strip 52
20 back to the sensor 60. When the level of light falling upon the sensor 60 reaches a level indicating the pins 46 are in register with the recesses 32 the drive circuit for the coil 48 in the lock body is actuated pulling the armature towards the lock body 42. Once this has been effected the
25 pins 46 lie within the recesses 34 providing mechanical inter-engagement of the two parts 14 and 16 of the lock.

 Similarly, with the arrangement of Figure 4, the

intensity of light received by opto-transistor 66 from reflector 68 will increase until it reaches a level indicating that the pins 46 are in register with the recesses 34. The drive circuit for the coil 48 is then
5 actuated to cause mechanical interengagement of the parts 14 and 16 of the lock.

Operation of a drive circuit for the lock shown in Figures 1, 2 utilizing the transmitter/sensor arrangement shown in Figure 4 will now be described with
10 reference to the schematic circuit diagram of Figure 5.

The drive circuit shown in Figure 5 includes an oscillator 100 comprising an inverter 102, capacitor 104, diodes 106 and 108 and resistors 110 and 112. Capacitor 104 charges at a rate dependent upon the value of the resistor
15 110 and discharges at a rate dependent upon the value of resistor 112. It will be appreciated that by adjusting resistor 110 the ON period of oscillator 100 may be altered. Resistor 112 determines the OFF period of the oscillator. The combination of ON and OFF periods
20 determines the output frequency of the oscillator 100. Resistor 110 is preferably adjusted so that the Mark:Space ratio of oscillator 100 is about 2:3 ($20\mu\text{s}$ and $30\mu\text{s}$ respectively), with the result that the output frequency is approximately 20KHz.

25 The circuit further includes four NAND gates 114, 116, 118 and 120. The output of oscillator 100 is fed directly to an input of each of gates 114 and 118.

The Hall sensor 50 in the arrangement is arranged to provide a logical HIGH voltage level output when it detects no magnetic flux (that is to say when coil 48 is unenergised) and a logical LOW voltage level output when it
5 detects magnetic flux in that coil. The output 124 of the Hall sensor 50 forms a second input to the NAND gate 114 and is fed, via an inverter 126, to form an input to NAND gates 118 and 120.

As can be seen the output of NAND gate 118 is fed
10 as an input to NAND gate 116 the other input of which is coupled via a resistor 128 to a low positive voltage supply. A capacitor 130 is provided coupling the second input of NAND gate 116 to ground. The resistor 128 and capacitor 130 effectively act to produce a short time delay
15 (some 400 μ s long) in the operation of this part of the circuit as will be described below.

The second input to gate 116 is also coupled by a diode 132 and resistor 134 to the output of an inverter 136. The input of inverter 136 is the output of a
20 comparator 138 forming part of the infra-red receiver in the apparatus and including the infra-red sensitive opto-transistor 66.

The second input to gate 120 is coupled to a delay circuit including a capacitor 140, resistor 142 and
25 diode 144 as shown.

The output of gate 114 is fed to an inverter 146 via wave shaping components - diode 148, resistor 150 and

capacitor 152. When the output of gate 114 is at a logical HIGH voltage level capacitor 136 is charged rapidly via diode 148 and when the output of gate 114 is at a logical LOW voltage level the capacitor 136 discharges relatively slowly via resistor 134.

The output of gate 114, it will be appreciated, follows the inverse of the output of oscillator 100 producing a series of negative going pulses which have the approximate wave form shown at A in Figure 6. Figure 6 also shows at B the shaped wave applied to inverter 142 and the level, SW, at which the inverter responds to the shaped pulses it receives from gate 114 to produce a series of positive going pulses shown at C some 8-10 μ s long. The output of inverter 146 controls operation of an FET 154 driving the LED 64. LED 64 is coupled to the low positive voltage supply by, possibly, a current limiting resistor 156.

The output of NAND gate 116 controls operation of an FET 158 the source of which is coupled to the gate of another FET 160 in series with the lock coil 48 (shunted by a blocking diode 162). A resistor 164 is coupled between the source of FET 158 and ground to enhance switching of FET 160.

The output of NAND gate 116 is also coupled via a diode 166 via a pair of resistors 168 and 170 to ground. Resistors 168 and 170 form a voltage divider with resistor 170 being shunted by a capacitor 172. The junction of

resistors 168 and 170 forms an input to an inverter 174 the output of which is coupled by a diode 176 and resistor 178 to a strobe control of comparator 138.

To ensure the output 124 of Hall sensor 50 is maintained at a logical HIGH voltage level at all times no flux is being sensed a resistor 180 is provided between the output 124 of the sensor 50 and the low positive voltage supply.

The output of NAND gate 120 is fed via an inverter 182 to control operation of an FET 184 in turn controlling energisation of a relay 186 (the coil of which is shunted by a blocking diode 188) in the monitoring circuit including lamp 20 (not shown in Figure 5). Relay 186, when operated, closes the circuit of lamp 20 causing the lamp to be illuminated.

The infra-red sensitive opto-transistor 66 is coupled between the low positive voltage supply and a resistor 190 which is grounded. The emitter of transistor 66 is coupled by a capacitor 192 to one input of comparator 138. A resistor 194 runs from this input of comparator 138 to ground. The second input to comparator 138 is taken from a tap in a voltage divider formed by resistors 196 and 198 coupled between the low positive voltage supply and ground. A resistor 200 couples the output of comparator 138 to ground.

By appropriate adjustment of the various elements the output of comparator will not change until sufficient

irradiation of opto-transistor 66 by LED 64 is received from the reflector element 68.

Assuming the door is open and a user wishes to close and lock it he powers up the circuit shown in Figure 5 (closing switch 18); at this time the output 124 of Hall sensor 50 is at a logical HIGH voltage level and forms one input to gate 114. In this condition, as noted, the output of gate 114 follows the inverse of the output of oscillator 100. This signal is fed, via inverter 146 to the LED 64 driver formed by the FET 154.

As the door is open opto-transistor 66 does not receive any incident radiation and provides no output to comparator 138. The output of comparator 138 which forms the input to inverter 136 is at a logical LOW voltage level in this condition. The output of inverter 136 is therefore at a logical HIGH voltage level and diode 132 blocked.

The output of the Hall sensor 50 is inverted at 126 and provides a logical LOW voltage level to inputs of gates 118 and 120. Thus the outputs of these two gates are at a logical HIGH voltage level.

The logical HIGH voltage output of gate 118 is fed as an input of gate 116. The other input to gate 116 is also at a logical HIGH voltage level (resistor 128 being coupled to the low positive supply) and its output is therefore at a logical LOW voltage level and FET 158 is held OFF which in turn holds FET 160 OFF and no electrical power is applied to lock coil 48.

Again at this time the first input to NAND gate 120 (equal to the input of gate 118) is held at a logical LOW voltage level whilst its second input is driven to a logical HIGH voltage level (via capacitor 140 and resistor 142).

The output of gate 120 is therefore at a logical HIGH voltage level such that the output of inverter 182 is at a logical LOW voltage level and holding FET 184 biased OFF. Thus FET 184 does not provide power to the monitor relay 186.

When the door reaches a locking position the output of opto-transistor 66 rises and after a time (determined by resistors 190, 194 and capacitor 192), the second input to comparator 138 rises to a level at which its output (fed as an input to inverter 136) is driven to a logical HIGH voltage level. The output of inverter 136 falls to a logical LOW voltage level. Diode 132 is then forward biased and conducts and after a short delay (approximately $400\mu\text{s}$) determined by capacitor 140 the second input to gate 116 will go to a logical LOW voltage level. The change in this input to gate 116 sends its output to a logical HIGH voltage level, biasing FET 158 ON which in turn biases FET 160 ON. At this time power is provided to coil 48 at a continuous high positive DC level.

Energisation of coil 48 causes the armature 26 to be pulled onto the lock body and the pins 46 to enter the recesses 34.

The output of Hall sensor 50 will switch to a logical LOW voltage level.

The first input to gate 114 falls to this logical LOW voltage level and the output of gate 114 switches to a continuous logical HIGH voltage level. The output of inverter 146 falls to a logical LOW voltage level cutting the drive to the LED 64. As a result the output of comparator 138 will go to a logical LOW voltage level causing inverter 136 to again block diode 132.

The output of inverter 126 now provides as an input to gate 118 a logical HIGH voltage level and thus the output of gate 118 begins to follow the inverse output of oscillator 100. As a result one input to gate 116 begins to follow the inverse output of oscillator 100 and as the other input to gate 116 is at a logical HIGH voltage level, the output of gate 116 will follow that of oscillator 100. FET 158 begins to switch ON and OFF at the oscillator frequency in turn switching FET 160 at that frequency so that the current passed to the lock coil 48 is chopped in accordance with the Mark:Space ratio of the output of oscillator 100 and at the frequency of that signal.

As lock coil 48 is being powered for only part of the time (it being driven by the oscillator 100) there is a consequential reduction in power usage from the continuous DC power level. This may be adjusted by trimming the components such that lock coil 48 takes approximately 25% of the full power level. Thus there is a

very significant reduction in the overall power supplied to lock coil 48 with the result that the cost of running the system is reduced and deleterious effects of prolonged application of DC power to the coil are obviated.

5 After a time delay determined by capacitor 140 the second input to gate 120 will go to a logical HIGH voltage level. The other input to gate 120 is already at a logical HIGH voltage level. The output of gate 120 will therefore switch to a logical LOW voltage level causing the
10 output of inverter 182 to go to a logical HIGH voltage level biasing FET 184 ON. This causes current to pass the coil of monitor relay 186 in turn causing illumination of lamp 20.

 The setting of monitor relay 186 is dependent
15 upon the output of the Hall sensor 50 being at a logical LOW voltage level (current supplied to the lock coil 48) and the second input to gate 120 going to a logical HIGH voltage level after the time delay caused by capacitor 140. The values of the elements 140, 142 and 144 are chosen such
20 that the delay before the second input to gate 120 switches is sufficient for the lock coil 48 to have been driven at the oscillator frequency for long enough time to allow the charge on capacitor 172 to have been reduced via resistor 170. The Hall sensor 50 is adjusted to indicate that the
25 magnetic field is good, that is to say the Hall sensor 50 output stays at a logical LOW voltage whilst the coil is powered at the oscillator frequency.

If there is an obstruction which prevents the armature 26 fully engaging the lock body the output of gate 116 will continue to cause FET's 158 and 160 to apply continuous DC power to the lock coil 48. This continued application will cause the voltage on capacitor 172 to rise until it reaches a level sufficient to provide a logical HIGH voltage level to the input of inverter 174. Thus the output of inverter 174 will switch to a logical LOW voltage level forward biasing diode 176 and strobing the comparator 138 such that its output changes the input to inverter 136 to a logical LOW voltage level. The output of inverter 136 will then go to a logical HIGH voltage level blocking diode 132 and after a period determined by the capacitor 130 the second input to gate 116 is switched to a logical HIGH voltage level. Thus the output of gate 116 will change switching OFF FETs 158 and 160 and so cutting the power supply to lock coil 48.

It is possible that the Hall sensor may be sensitive enough to provide a "magnetic flux sensed" output (a logical ZERO voltage level) before armature 26 contacts the lock body and so cause coil 48 to be driven at the oscillator frequency. To meet this circumstance the values of components 168, 170 and 172 are selected such that the input to inverter 174 will rise to a logical HIGH voltage level again initiating a re-set sequence for the circuitry.

It will be appreciated that the indication given by lamp 20 that the lock is secure only obtains when relay

186 is energised. This condition is achieved only when the inputs to gate 120 indicate both the Hall sensor 50 has provided an output indicative of current in lock coil 48 for a sufficiently long period (without capacitor 172 charging to a level causing the output of inverter 174 to switch to a logical ZERO voltage level) to indicate the lock is secure.

Variations may be made to the described arrangement without departing from the scope of the invention. For example it is envisaged that the input to inverter 136 may be fed directly from the opto-transistor 66. However, this would not enable ready adjustment of the incident infra-red level at which the output of the opto-transistor 66 will cause the output of inverter 136 to change.

It will be appreciated that many other variations may be made to the above described arrangements without departing from the scope of the invention.

In particular it should be kept in mind that the parameters noted above for various components within the arrangement may be varied without departing from the scope of the invention.

The beam angles of the infra-red transmitters and the acceptance angle of the sensor as disclosed have been found to provide for acceptable operation of the drive circuitry with a variation in spacing between them. Other configurations may, however, be used.

The number of sensors may be increased if desired and the number of LED's also increased.

Whilst the arrangement particularly described is of a locking arrangement in which an armature is pulled
5 onto a lock body such that pins engage in recesses it will be appreciated that the arrangements disclosed may be applied to a lock in which a bolt is held in position behind (or within an aperture in) a striker plate.

The particular advantages of the arrangement
10 disclosed is that it gives a very high accuracy in sensing alignment of the lock parts - enabling the lock to be actuated immediately the door is closed and thus providing a greater level of security than has heretofore been possible.

15 The particular arrangements described enable their ready adjustment in various installations. Operating distances for the frames may vary between installations which means that the opto-transistor has to operate between about 2mm to 20mm. This is achievable as the maximum
20 output changes the distance and the unit has to be set to operate at the lowest level, 2.5v at 2mm distance. This in turn means that as the elements of the lock are moved apart more light is reflected back to the sensor and it will reach this 2.5v switching point earlier during the locks
25 movement as it closes. The result of this is that there is a sensitivity of about +/-1mm at best to about +/-2mm at worst. This is compensated for in practice by adjusting

the armature to travel further. Although the lock is triggered slightly earlier in this case the armature takes longer to reach the body as the door is moving.

It is believed that the particular arrangement
5 proposed for driving the LED's has advantage. In the circuit proposed the radiation transmitter consumes an average of 50mA equivalent to .25A peak and the maximum safe current for the LED's used is 1A so they are worked well within their operational limits.

10 Again the opto-transistor proposed is pulsed so that high ambient DC light levels have no effect. The very narrow ($8\mu s$) pulses used to drive the LED's reduces power consumption by the opto-transistor.

It will be noted that as soon as the lock is
15 energised (power applied to lock coil 48) the location sensor is switched out of circuit reducing the opportunity of the lock being tampered with.

The flux within the lock coil is constantly monitored and thus the lock monitor (lamp 20) shows the
20 true status of the lock at all times.

Should the lock become obstructed it would initiate a re-setting sequence after a few seconds. This, in practice, gives an audible warning of the obstruction as the lock first tries to engage and then disengages.

25 Other variations may be made to the described arrangement, as will be seen by those skilled in the art, without departing from the scope of the invention.

CLAIMS

1. Apparatus for controlling an electromagnetically
actuatable door lock, the apparatus including electromagnetic
5 radiation transmitter and sensor means for mounting on or
in one of the door and frame in which the door closes and
a reflector on or in the other of the door and frame, means
monitoring the output of the sensor means and providing an
output in response to a predetermined level of sensed
10 radiation to drive the lock parts electromagnetically
together.

2. Control apparatus as claimed in Claim 1, wherein
the frequency of the radiation transmitted and sensed is in
a predetermined frequency range.

15 3. Control apparatus as claimed in Claim 2, wherein
the radiation is in the infra-red range.

4. Control apparatus as claimed in Claim 3, wherein
the wave length of the infra-red radiation is in the range
of 900-1000nm.

20 5. Control apparatus as claimed in any one of claims
1 to 4, wherein the radiation transmitter means
incorporates one or more LED's.

6. Control apparatus as claimed in any one of claims
1 to 5, wherein the radiation transmitter and sensor means
25 are for mounting on or in the door frame and the reflector
on or in the door.

7. Control apparatus as claimed in any one of claims

1 to 6, wherein the reflector means comprises a stainless steel member.

8. Control apparatus as claimed in Claim 5 and Claim 6, or Claim 5 and Claim 7, wherein the radiation transmitter means comprises a pair of LED's one adapted to provide a narrow angle of emission and the other to provide a wider angle of emission, the pair of LED's being mounted on diametrically opposed sides of the sensor means to form a linear array.

9. Control apparatus as claimed in Claim 8, wherein the reflector means comprises a strip of stainless steel the length of which is substantially the same or slightly longer than the length of the linear array of the LED's and sensor means.

10. Control apparatus as claimed in Claim 5 and Claim 6 or Claim 5 and Claim 7, wherein the radiation transmitter means comprises a single LED and the reflective element is mounted at an angle to the axis of light emitted by the LED when the door is in a position for the lock to be actuated.

11. Control apparatus as claimed in Claim 10, wherein the receiving axis of the radiation sensor is at angle to transmitting axis of the LED.

12. An electromagnetically actuated door lock including control apparatus as claimed in any one of claims 1 to 11 for controlling power supply to the lock, the arrangement comprising an oscillator, first logical means which when enabled passes a signal dependent upon the

output of the oscillator to a driver for the radiation transmitter means, second logical means which when enabled is operable to supply power to a lock coil included in the lock at a continuous DC level or to a level switched at a rate determined by the output of the oscillator, third
5 logical means operable to switch the output of the second logical means between its two enabled states, means monitoring the output of the radiation sensor means and operable to enable the second logical means causing power
10 to be supplied to the lock coil at the continuous DC level, and means monitoring the operation of the lock to provide an output when the lock coil is energised which will disable the first logical means and cause the first logical means to switch the output of the second logical means to
15 cause power to be supplied to the lock at a rate determined by the oscillator.

13. A lock as claimed in Claim 12, further including means monitoring the output of the second logical means and resetting the apparatus if the lock coil monitoring means
20 provides no output indicative that the coil is energised.

14. A lock as claimed in Claim 14 or Claim 15, wherein the coil monitoring means comprises a Hall sensor responsive to the level of magnetic flux in the lock coil and operable to provide a logical HIGH output voltage when
25 there is no power supplied to the coil and a logical LOW output voltage when power is supplied to the coil.

15. A lock as claimed in any one of claims 12 to 14,

further including means monitoring the condition of the lock and providing an indication that the lock is properly secure.

16. A lock as claimed in any one of claims 12 to 15,
5 wherein the oscillator has a Mark:Space ratio of 2:3 and runs at a frequency of 22Khz.

17. A lock as claimed in Claim 14 and any one of claims 15 and 16, wherein the first logical means comprises a NAND gate coupled to receive the oscillator output and,
10 when the output of the Hall sensor is at a logical HIGH voltage level to pass a signal which is the inverse of the oscillator output to the driver electromagnetic radiation transmitter means.

18. A lock as claimed in any one of claims 14 to 19,
15 wherein the second logical means comprises a second NAND gate one input of which is held initially at a logical HIGH voltage level whilst the other input is initially held at a logical HIGH voltage level and wherein the means monitoring the output of the radiation sensor means enables
20 the second NAND gate to pass power to the lock coil driver.

19. A lock as claimed in Claim 14 and any one of claims 15 to 18, wherein the third logical means comprises a third NAND gate to one input is passed the output of the oscillator and to the other input is passed the inverted
25 output of the Hall sensor, the third NAND gate output providing an input to the second gate which input comprises the oscillator output when the Hall sensor is at a low

voltage level.

20. A lock as claimed in Claim 14 and any one of claims 15 to 19, wherein the means providing an output indication of the condition of the lock comprises a fourth
5 NAND gate one input to which is the inverted output of the Hall sensor and the other input to which is taken from means providing a logical HIGH voltage level for a pre-determined period longer than that normally required for the Hall sensor to switch its output upon the lock being
10 actuated.

21. A lock as claimed in any one of claims 12 to 20, wherein the means monitoring the power fed to the lock coil comprises capacitor means chargeable whilst the lock coil is being powered and operable to cause the means monitoring
15 the output of the electromagnetic radiation receiver to be re-set after a pre-determined time period.

22. Control apparatus as claimed in Claim 1 and substantially as described with reference to Figures 5 and 6 of the accompanying drawings.

20 23. A door lock as claimed in Claim 12 and substantially as described with reference to Figures 1, 2 and 3 of the accompanying drawings.

24. A door lock as claimed in Claim 12, and substantially as described with reference to Figures 1, 2
25 and 4 of the accompanying drawings.



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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): E2A (ABL)

Int Cl (Ed.6): E05B 63/20

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	FR 2 707 324 A (SURZUR) see page 4, lines 20-26 and WPI Abstract Acc. No. 95-054253/	1

X Document indicating lack of novelty or inventive step
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