United States Patent [19]

Clarke

[11] **3,829,836**

[45] **Aug. 13, 1974**

[54] **LOCKING SYSTEM RESPONSIVE TO AN ELECTRONIC KEY**

[76] Inventor: **Walter Wilson Hugh Clarke,** Marsh Ln., Eversley, Hampshire, England

[22] Filed: **Oct. 13, 1972**

[21] Appl. No.: **297,303**

[52] **U.S. Cl.** ..... **340/171 R,** 340/171 PF
[51] **Int. Cl.** **H04q 9/10,** H04q 9/12
[58] **Field of Search** ..... 340/171 R, 171 PF

[56] **References Cited**

UNITED STATES PATENTS

3,470,536	9/1969	Levine	340/171 R
3,488,632	1/1970	Clark	340/171 R
3,539,819	11/1970	Parisoe	340/171 X
3,564,501	2/1971	Flook	340/171 PF

Primary Examiner—Harold I. Pitts
Attorney, Agent, or Firm—Lerner, David, Littenberg & Samuel

[57] **ABSTRACT**

A locking system comprises locking means locking, for example, a drawer, an inductive pick-up and means for responding to an output from the pick-up to release the locking means, and a key device having an inductive field generator which can produce an output in the pick-up by induction at close range. The sensing system can be tuned to respond only to a key device generating one or more particular frequencies and a lockout arrangement can be provided to prevent release if any other frequency is present.

9 Claims, 5 Drawing Figures

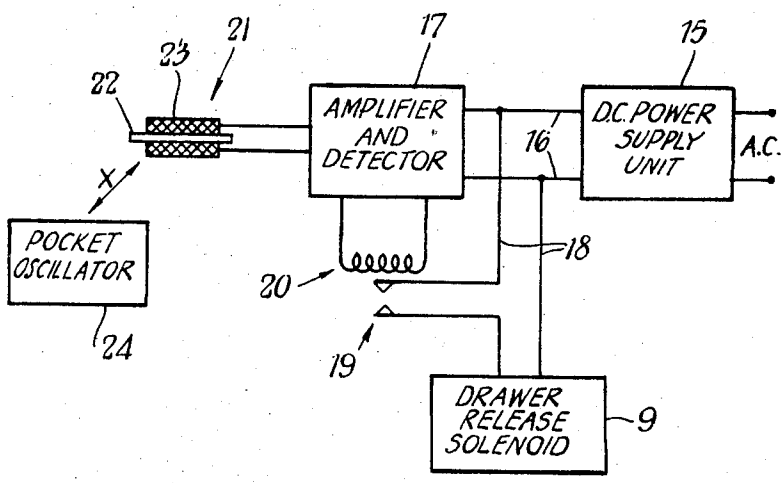
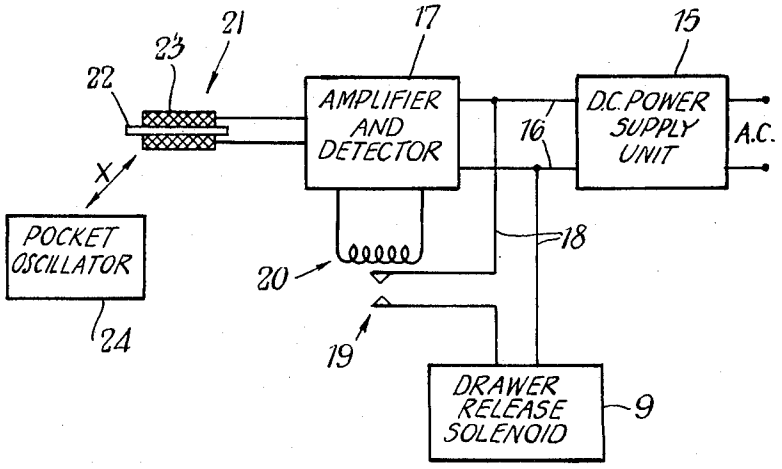


FIG. 1


21
17
15
23
22
AMPLIFIER AND DETECTOR
D.C. POWER SUPPLY UNIT
A.C.
16
X
POCKET OSCILLATOR
24
20
18
19
DRAWER RELEASE SOLENOID
9

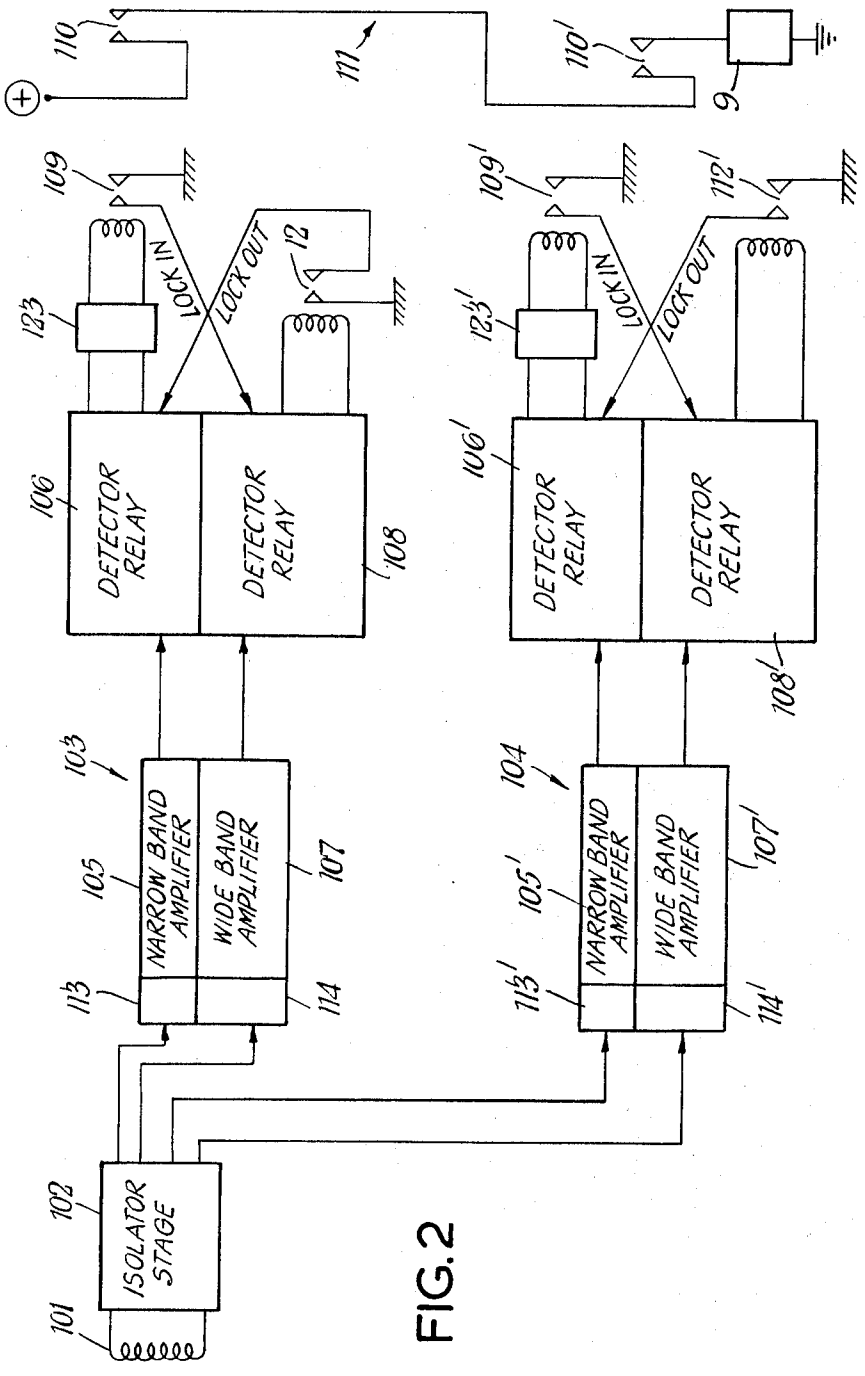

110
111
110'
9
109
109'
112'
LOCK IN
LOCK OUT
12
123
123'
106
106'
DETECTOR RELAY
DETECTOR RELAY
108
108'
103
104
105
105'
NARROW BAND AMPLIFIER
WIDE BAND AMPLIFIER
107
107'
113
113'
114
114'
102
ISOLATOR STAGE
101

FIG. 2

FIG. 3

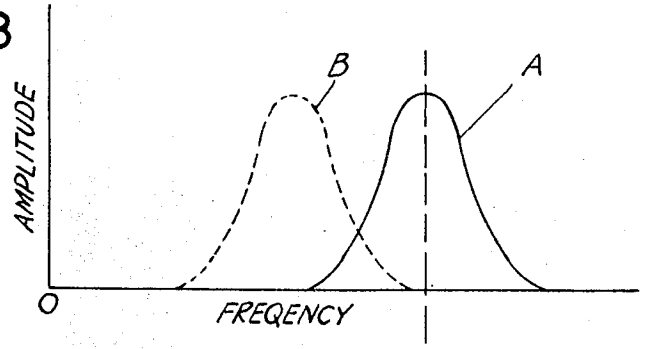


FIG. 4

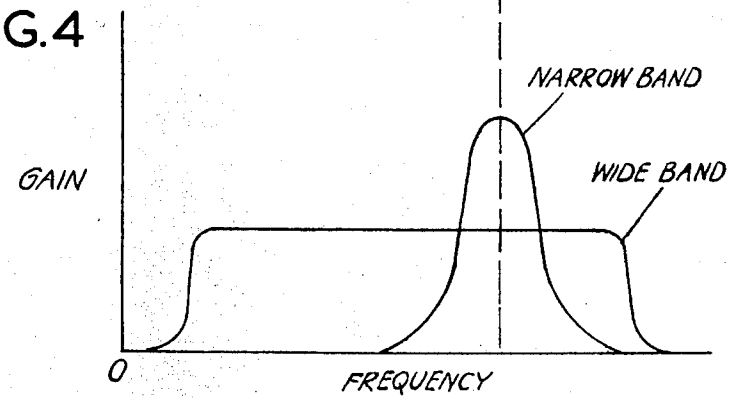
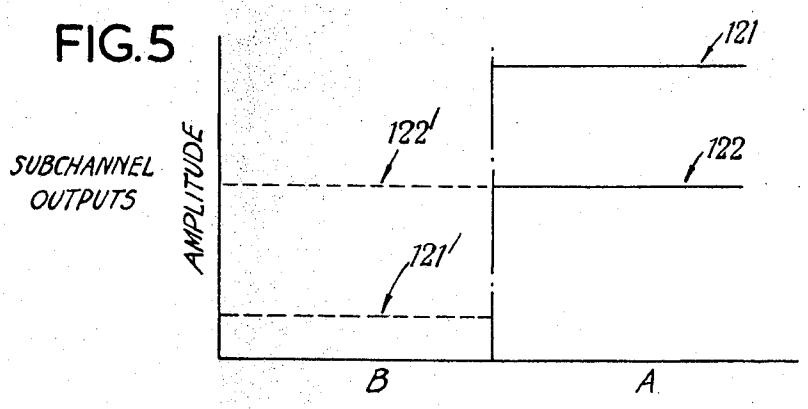


FIG. 5



LOCKING SYSTEM RESPONSIVE TO AN ELECTRONIC KEY

FIELD OF THE INVENTION

This invention relates to a locking system which may be used for drawers, tills, doors, windows or other members which it may be desired to lock in position, or for disabling cash tills or power supplies, and many other applications where there is a requirement for only an authorised person or persons to be able to effect some kind of operation. The term "locking" should be interpreted accordingly.

BACKGROUND OF THE INVENTION

U.S. Pat. No. 3,564,501 discloses a system for unlocking a door, in which an appropriate radio transmitter is carried by the authorised person. When the door knob is slightly turned receiver circuitry is suddenly actuated to check whether the frequency of the transmitter is the correct one. If not, a lockout channel ensures that further turning of the door knob, and hence opening of the door, is prevented. At the time when the circuitry is actuated the transmitter may be very close, since it is on the person. The system must therefore be arranged so that at very short range the receiver amplifiers will not become saturated because this could allow the trip or release channel to operate before the lockout channel if a high-powered broad band transmission were applied to the system by an unauthorised person. On the other hand, the signal strength can easily then be insufficient to operate the trip or release channel if the transmitter carried by an authorised person is a little further away. Thus for satisfactory operation the transmitter would always have to be positioned rather precisely or relatively expensive automatic volume control circuitry would have to be built into the receiver.

Furthermore, the power of small radio transmitters in relation to their cost is relatively low, and at low powers considerable signal amplification in the receiver will be needed to operate a locking device, so that to obtain the necessary output power it is necessary to have either a relatively high-powered transmitter of several stages of amplification in the receiver, either of which involves consequent expense.

SUMMARY OF THE INVENTION

An object of this invention is to provide a locking system which at least partly overcomes the disadvantages of such a prior system.

This invention provides a system in which a key device comprises an inductive field generator and the sensing system becomes inductively coupled to the generator by the generated field, at sufficiently short ranges.

The inductive field is not radiated or transmitted, but simply expands and contracts, and is quite localised thus minimising interference with any electronic equipment that may be nearby. It can be generated very simply, e.g. by a battery operated Hartley or Colpitts oscillator driving a coil which is preferably ferrite cored. Such a generator can produce a signal of several millivolts in a similar cored coil at a distance of tens of centimetres, thus requiring little amplification and dominating stray radiation which may be in the vicinity.

Thus the generating and sensing circuitry can be very simple and inexpensive.

The sensing system is actuated as soon as the coupling reaches a threshold level as the key device approaches a pick-up device. The circuitry thus takes its own decision when the signals in it are at a suitable level, and is not suddenly loaded with input signals by the operation of a door-knob, so that the complication and expense of automatic voltage control is not required while at the same time precise positioning of the key device is unnecessary.

The key device may remain small enough to be worn in the manner of a wristwatch.

In order that the invention may be more clearly understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a locking system in accordance with the invention,

FIG. **2** shows two-channel sensing circuitry for use in the invention, in block diagram form,

FIG. **3** shows qualitatively the frequency characteristics of "right" and "wrong" inductive field generators,

FIG. **4** shows qualitatively the frequency response of the narrow and wide band subchannels of the sensing circuitry of FIG. **2**, and

FIG. **5** shows qualitatively the outputs from the two subchannels when radiation from a wrong and a right generator is applied to the sensing circuitry of FIG. **2**.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** illustrates a locking system, by means of which energisation of a solenoid, when desired, is effected. The solenoid may be so arranged that when energised it withdraws a latching member which locks, for example, a desk drawer in a closed position, this being known in itself.

A DC power supply unit **15** has its input connected to the AC mains and has its output lines **16** connected on the one hand to the power supply input of amplifier and detector circuitry **17** and on the other hand, via lines **18**, to input terminals of the solenoid **9**. The contacts **19** of a relay whose coil **20** is fed from the output of the amplifier and detector circuitry **17** are connected in one of the lines **18** so that when the coil **20** is energised the contacts **19** will be closed and the solenoid **9** will become energised from the supply unit **15**.

The actual circuitry of the DC power supply unit **15** and the amplifier and detector circuitry **17** may be of any suitable kind, various suitable circuitry being known. The output from the DC power supply unit **15** may be, for example, about 12 volts.

Connected to the input of the amplifier and detector circuitry **17** is a pick-up **21** consisting of an inductive coupling element in the form of a ferrite core **22** carrying a coil **23**.

The key device for the system is a self-contained inductive field generator **24** which, as already mentioned, may consist of a battery driven transistor oscillator, which may be allowed to run permanently, driving an inductive coupling element in the form of a coil on a ferrite core.

The pick-up **21** will be positioned, somewhere in the desk, or elsewhere, so that the key device **24** can be brought into its vicinity. When the key device approaches the pick-up and the distance X between the device **24** and pick-up **21** becomes sufficiently small that the signal induced in the pick-up **21** is great enough to produce an output from the amplifier and detector circuitry **17** which is effective to close the contacts **19,** the solenoid **9** will be energised, thereby releasing the locking device in the manner already referred to.

It will be appreciated that the amplifier and detector circuitry **17** produces a DC output voltage from the oscillatory input voltage which it receives from the pick-up **21.**

By virtue of the nature of electromagnetic relays they release at a lower current than is required to operate them. Thus an extended range between the key and the pick-up may occur without re-locking, once they have been close enough together to operate the relay. For example, closure can occur at 40 centimetres and re-opening at 60 centimetres range. This effect can also be enhanced by adding a biassing signal to the rectified DC signal from the detector.

An automatic closing means may also be incorporated. For example, it is possible to connect a small motor to the back of the drawer by a cord wrapped on a small diameter pulley driven by the motor and have changeover contacts on the relay to ensure that the motor is energised when the locking device is not. The motor will then wind up the cord and re-close the drawer if it has been left open, once the key device is out of the vicinity of the pick-up. To protect the motor from continuous stall load a microswitch within the drawer can be set to interrupt the supply to the motor once the drawer is closed. An alternative closing arrangement may comprise a pin for holding the drawer open against a bias spring, the pin being withdrawn by a solenoid operated by the changeover contacts, thus allowing the drawer to be closed by the spring.

From the security point of view, the person responsible for a desk, cabinet or till, for example, merely has to close the drawer to ensure locking, and since unlocking will occur automatically once he returns (provided the key device is on his person and the range properly adjusted) there is little, if any, incentive for him to not close and thus lock the drawer to avoid the normal trouble of unlocking it later. Of course, the system is even more secure if the automatic closing arrangement described above is also incorporated. The operating range of the system will normally be adjusted such that the desk or cabinet is unlocked only when the person responsible is close enough to supervise it and once he is further away it becomes locked.

Turning now to FIG. **2,** in that more refined system an inductive pick-up **101,** which may for example consist of a coil wound on a ferrite core, becomes inductively coupled with a generator which is not shown, but which may be of the same kind as described above. The output signal from the pick-up **101** is passed by an isolator stage **102** to the input of a first channel generally indicated at **103** and a second channel generally indicated at **104.**

The channel **103** comprises two subchannels, firstly a narrow frequency band subchannel which includes a narrow band amplifier **105** receiving the output from the isolator stage **102** and applying its output signal to a lock-in relay **106,** and secondly, a wide band amplifier **107** also receiving an output signal from the isolator stage **102** and passing its wide band amplified signal to a lock-out relay **108.** A sufficient input signal to relay **106** will cause operation of the relay to close contacts **109** and **110.** Closure of contacts **109** renders relay **108** inoperative, as will become clearer from the description which follows, and operation of contacts **110** partly closes a circuit generally indicated at **111** which is the power supply circuit to, for example, the solenoid of a locking system such as that described above.

The application of a sufficient input signal to relay **108** operates contacts **112** which are effective, as will be more fully described, to inhibit operation of the relay **106,** thereby preventing any signals passing through the narrow band subchannel from resulting in operation of the supply circuit contacts **110.**

The second channel **104** is the same as the first channel **103** with the exception that the frequency band of its narrow band amplifier **105'** is centred at a different frequency from that of the narrow band amplifier **105** in channel **103.** The components of channel **104** are shown by the same reference numerals as those of channel **103,** but primed.

The amplifiers **105, 107, 105'** and **107'** can be identical in most respects, though tuned LC circuits **113, 113'** can be included in the input stages of the narrow band amplifiers **105, 105'** so as to provide the narrow band characteristic of these amplifiers, as compared with capacitive couplings **114, 114'** at the corresponding positions in the wide band amplifiers **107, 107'.** The effect of the capacitors is to cut off the low end of the frequency response curve of the wide band amplifiers so as to exclude the possible effect of stray mains frequency. Each of the amplifiers **105, 107, 105'** and **107'** preferably incorporates an adjustable potentiometer (not shown) by which the gains of these amplifiers can respectively be adjusted.

To simplify explanation of the operation of the sensing circuitry it will be assumed that it has only one channel, namely the channel **103,** and that only the pair of contacts **110** lies in the power supply circuit **111** of the solenoid. The effect of the inclusion of a second and further channels will then be explained.

Assume that an inductive field generator having a relatively well defined frequency corresponding to that of the narrow band amplifier **105** is brought within range of the inductive pick-up **101.** The output signal of such a generator, or key device, is indicated by the curve "A" in FIG. **3.** Such a generator would be the right key for a locking system tuned to that frequency.

Because of the coincidence of frequencies the narrow band amplifier **105** will produce a relatively high amplitude output signal as indicated at **121** in FIG. **5** while, by virtue of suitable setting or adjustment of the relative gains of amplifiers **105** and **107,** the wide band amplifier **107** will produce a lower output signal as indicated at **122** in FIG. **5.** Thus, as the generator approaches the pick-up the inductive coupling will become great enough for the relay **106** to be operated, whose input signal is the greater, and hence the wide band subchannel will be immediately rendered ineffective by closure of contacts **109** and the power supply circuit will be energised by closure of contacts **110** so that the solenoid **9** will operate to release the locking system.

Assume now that a wrong frequency generator, i.e. one whose frequency is not within the band of the narrow band amplifier **105** in the sensing circuitry, is brought towards pick-up **101**, the generator field being indicated by the broken line B in FIG. **3**. Because the frequency is well within the range of the wide band amplifier **107** this amplifier will produce the same amplitude of output signal as before, as indicated at **122'** in FIG. **5**. However, only very small output signals will be obtained from amplifier **105** as indicated at **121'** in FIG. **5**, the small amplitude of this signal depending on the degree of overlap between the frequency spread of the generator and the pass band of the narrow band amplifier **105**. In these circumstances, it will be evident that relay **108** in the wide band subchannel will be operated first to close contacts **112** thus locking out or inhibiting the action of relay **106** in the narrow band subchannel and preventing the contacts **110** from being closed to release the locking system.

If an attempt were made to deceive the system by bringing a wide frequency band generator close to the pick-up **101**, then, assuming that its total power is only about the same as that of the narrow band generator previously considered, the output from the wide band subchannel would still be at about the level **122** or **122'** whereas, since only a small proportion of its output would be within the pass band of the narrow band amplifier **105**, the output signal of the narrow band subchannel would be lower than that of the wide band subchannel, for example at a level similar to that indicated at **121'** in FIG. **5**. Thus, the lock out condition would occur and the solenoid would not be operated to release the locking device.

If a wide frequency band generator were used which had a much greater power output so that sufficient energy lay within the frequency band of the narrow band amplifier **105** to make the output signal of the narrow band channel greater than that of the wide band channel, then it would be possible to deceive the system. To avoid this problem a delay circuit **123**, which may consist of a capacitor, is provided in the narrow band channel, providing sufficient delay to ensure that in the event of sudden saturation of both amplifiers **105** and **107** it will always be the relay **108** which operates first, thus locking out the system.

If a swept frequency generator is brought within range of the pick-up **101** then the lock-out conditions illustrated by the left hand side of FIG. **5** would be present. The locking system is prevented from releasing during the short periods of time when the generator frequency passes through the pass band of the narrow band amplifier **105** because the lock out subchannel will already have locked out the output of the narrow band subchannel.

The security of the system is then further improved by the addition of more channels, two channels being illustrated in FIG. **2** but more than two channels being quite simple to arrange. The situation then is that concurrent closure of the series of contacts **110, 110'**, etc. in the power supply circuit **111** can only be achieved if in every one of the channels the output of the narrow band subchannel reaches a predetermined level before the output of the wide band subchannel in the same channel does.

The lock out contacts **112** or **112'** can be arranged to operate some form of alarm or warning device so as to provide an alarm or warning when any attempt is made to release the locking system using an inductive field generator which is not the right one for that system.

The invention can also be used to control the power supply to any kind of equipment, operation of which is to be restricted. For example, cash registers are available which depend on electric power for most, if not all, of their functions, including opening of the cash drawer. By utilising a locking system in accordance with this invention, in conjunction with a matching key device, the contacts **110** for example being arranged in the cash register power supply circuit, it will be appreciated that only a person having the right key device will be able to operate the cash register. The attempted use of a wrong key device, or the absence of a key device, will cause the power supply to stay cut off. The same principle is applicable, in accordance with the invention, to other equipment having a power supply of any kind, e.g. lathes, hydraulic lifts, motor cars (ignition circuit or fuel supply) and may have safety as well as security aspects.

It is possible for the release or trip subchannel to have a broad-band response curve and for the lockout channel to have a similar response curve but with a notch at the tuned frequency, whereby lockout will not occur when only tuned frequency inductive energy is received.

A preferred frequency for the generator is between 1 and 50 KHz. This has been found to increase security because at such relatively low frequency a radio transmitter would have to have very large power and a corresponding antenna to produce sufficient inductive effect at the pick-up.

The inductive coupling elements need not be ferrite cored. Other magnetisable material, e.g. iron laminations, could be used and, in the case of the pick-up an open coil or a large single loop (e.g. round a doorway) could be employed. The pick-up may be provided with a conductive shield e.g. of metal foil, to keep out radio waves without interfering significantly with the inductive coupling.

Where the key device has more than one frequency, separate oscillators each driving its own inductive coupling element and tuned to a respective frequency may be used.

The sensing circuitry can be entirely solid state instead of including relays as described.

The DC power supply unit **15** could be arranged to operate from a battery instead of from AC mains, as described.

The key device can be arranged so as to automatically switch itself on if its carrier were attacked, and the sensing circuitry can be arranged to automatically actuate an alarm of any kind in response.

The various novel features disclosed herein are believed to constitute inventions in themselves, not only in combination with each other.

I claim:

1. A locking system comprising:

a key device, said key device comprising an inductive field generator for providing an inductive field;

inductive pick-up means for receiving said inductive field from the inductive field generator;

a locking device;

a release subchannel coupled to the pick-up means and responsive to the receipt of said inductive field

by the pick-up means to release the locking device;

a further subchannel coupled to the pick-up means and responsive to the receipt of said inductive field by the pick-up means to prevent release of the locking device;

said further subchannel being ineffective to produce said preventive response when the received inductive field has a predetermined characteristic; and

means for delaying the response of the release subchannel to a received inductive field relative to the response of the further subchannel to said received inductive field.

2. A locking system as claimed in claim **1**, wherein the key device is self-contained and battery powered.

3. A locking system as claimed in claim **1**, wherein said release subchannel is adapted to release said locking means only when said pick-up means receives sufficient induced energy in a limited frequency band; and said further subchannel is adapted to prevent release of said locking means when said pick-up means receives sufficient energy outside said frequency band, said predetermined characteristic being the absence of said sufficient energy outside said frequency band.

4. A locking system as claimed in claim **3**, wherein the limited frequency band of the release subchannel is provided by a tuned LC circuit, said LC circuit being connected in the release subchannel.

5. A locking system as claimed in claim **3** comprising a plurality of channels each said channel including a said release subchannel and a said further subchannel, the release subchannels having different frequency bands and being for releasing the locking means only when the pick-up means receives sufficient induced energy within the bands of each of them, and each of the further subchannels being for rendering ineffective its associated release subchannel when said pick-up means receives sufficient energy outside the frequency band of said associated release subchannel.

6. A locking system as claimed in claim **1** comprising a plurality of channels each said channel including a said release subchannel and a said further subchannel, the release subchannels together being responsive to the receipt of said inductive field by the pick-up means to release the locking device, each of the further subchannels being for rendering ineffective its associated release subchannel when the received inductive field does not have a respective predetermined characteristic, whereby release of the locking device by the release subchannels is prevented unless the received inductive field has all the respective predetermined characteristics required to prevent all the further subchannels rendering ineffective their associated release subchannels.

7. A locking system as claimed in claim **6** wherein each of said respective predetermined characteristics is the absence of sufficient received energy outside a predetermined limited frequency band.

8. A locking system as claimed in claim **1** wherein said release subchannel and further subchannel are continuously active whereby to respond automatically when an increasing inductive field received by the pick-up means reaches a threshold level.

9. A locking system as claimed in claim **1** wherein the release and further subchannels each contain amplifying means the gain of which is independently adjustable.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,829,836 Dated August 13, 1974

Inventor(s) Walter Wilson Hugh Clarke

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the title page after "Appln. No. 297,303" insert:

-- Foreign Application Priority Data

October 14, 1971	Great Britain	47868/71
January 11, 1972	Great Britain	1311/72

Signed and Sealed this

fifth Day of *August 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks