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(54) **CONTROL CIRCUIT FOR ELECTRIC UNLOCKING DEVICES USING ACTUATING SOLENOIDS**

(71) Applicant: **Hanchett Entry Systems, Inc.**, Phoenix, AZ (US)

(72) Inventors: **Edward Schoepke**, Reno, NV (US); **Leland J. Hanchett, Jr.**, Falmouth, ME (US)

(73) Assignee: **Hanchett Entry Systems, Inc.**, Phoenix, AZ (US)

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Appl. No.: **13/023,605**
Filed: **Feb. 9, 2011**

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H01H 89/00 (2006.01)
E05B 47/00 (2006.01)

(52) **U.S. Cl.**
CPC ***E05B 47/00*** (2013.01); ***E05B 47/0046*** (2013.01); *Y10T 70/7062* (2015.04)

(58) **Field of Classification Search**
CPC ... E05B 47/00; E05B 47/0046; Y01T 70/7062
USPC 361/172, 187, 206, 139, 160; 70/277
See application file for complete search history.

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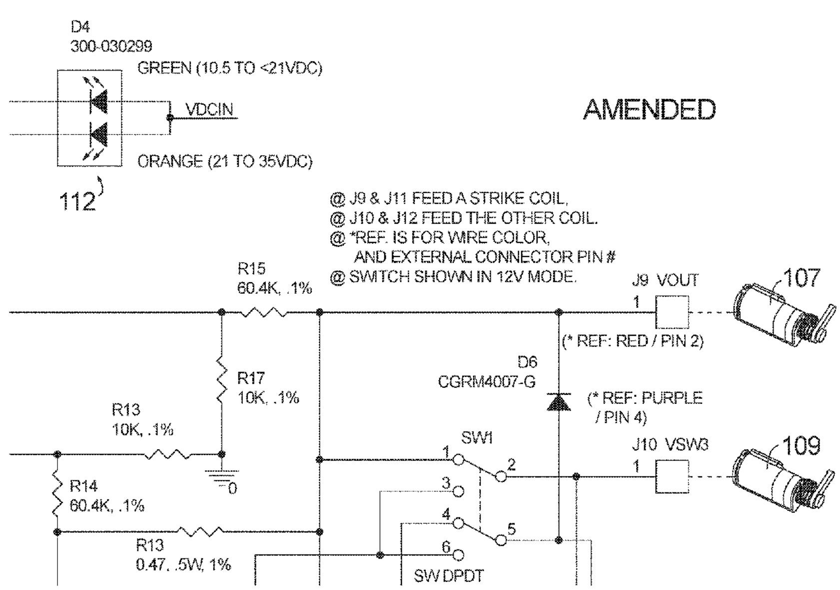
Primary Examiner — Kenneth J Whittington
(74) *Attorney, Agent, or Firm* — Woods Oviatt Gilman LLP; Ronald J. Kisicki, Esq.

(57) **ABSTRACT**

A system and method is provided for an enhanced and user friendly control circuit for an electric unlocking device, such as for example, an electric door strike or other unlocking devices utilizing actuating solenoids. The control circuit minimizes the potential for human error while also providing a small footprint, minimal DC in-rush current, over current protection, and minimized heat dissipation. Additionally, the present invention is directed to providing visual notification/diagnostics and improved field compatibility with existing electric unlocking devices.

22 Claims, 7 Drawing Sheets



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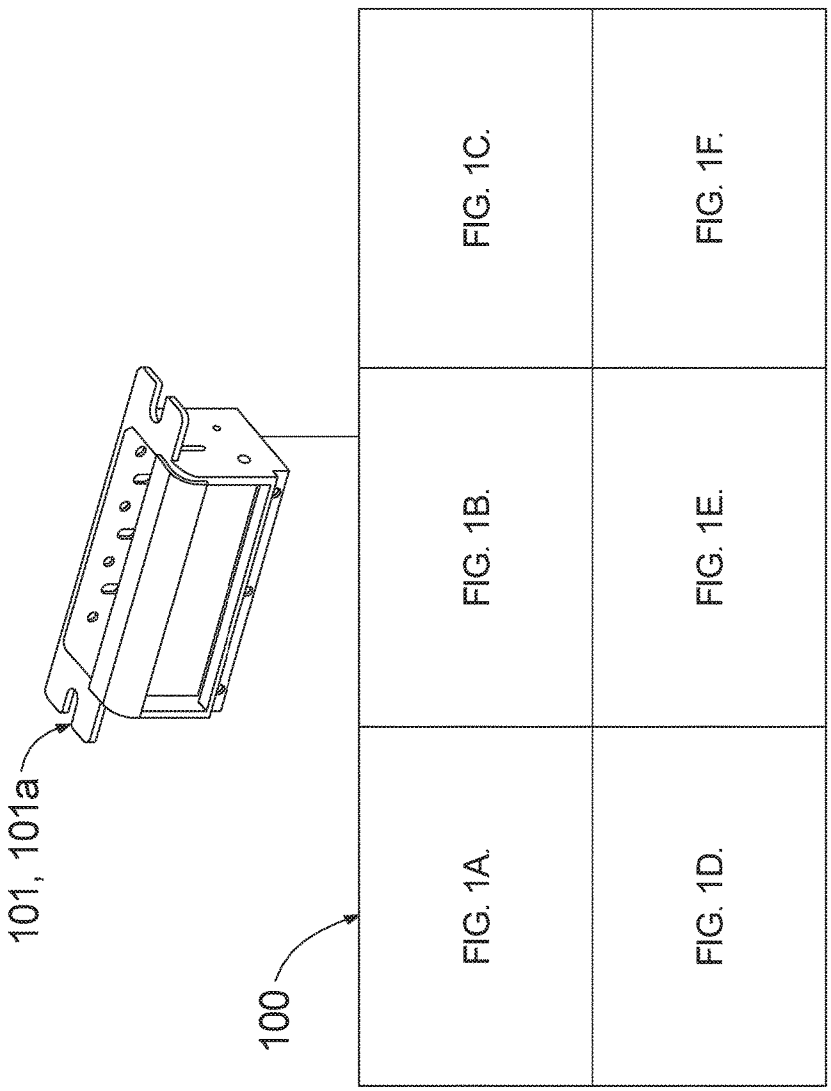

FIG. 1.
AMENDED

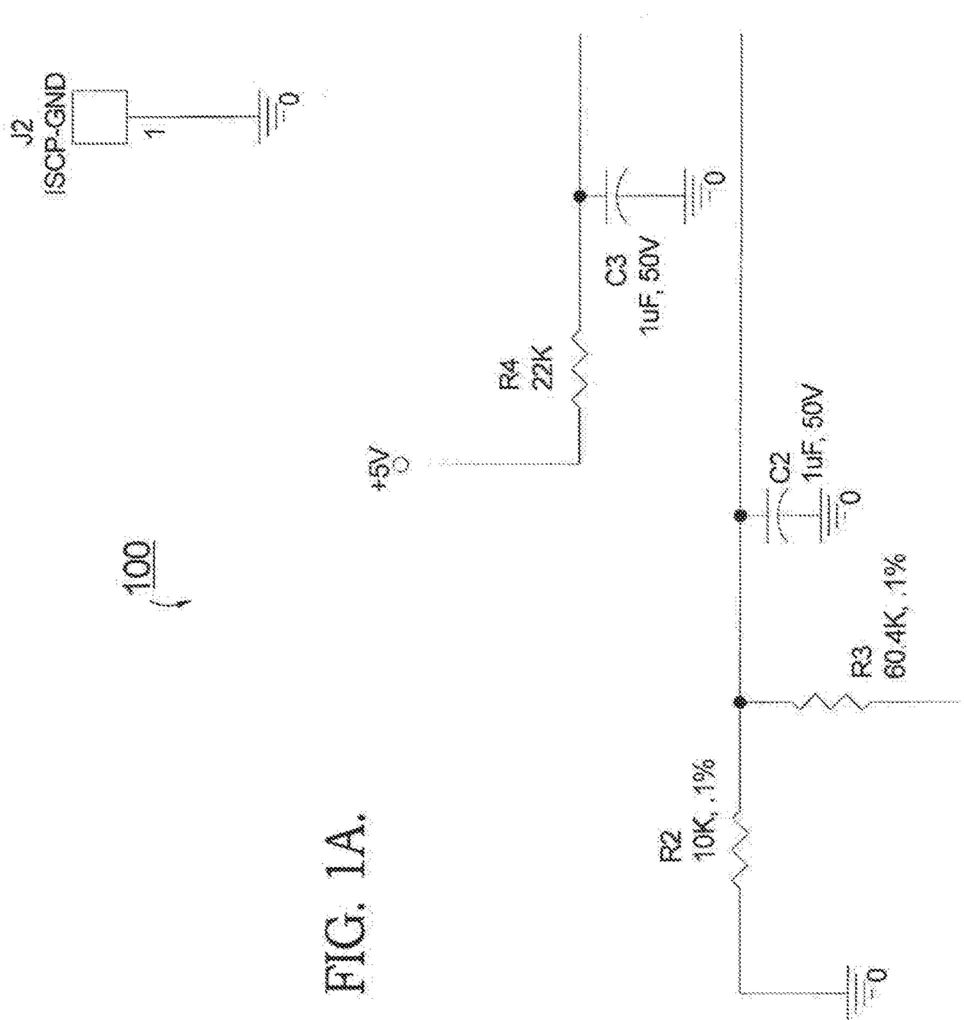
J2
ISCP-GND
1
0
C3
1uF, 50V
0
R4
22K
+5V
C2
1uF, 50V
0
R3
60.4K, .1%
R2
10K, .1%
0
100

FIG. 1A.

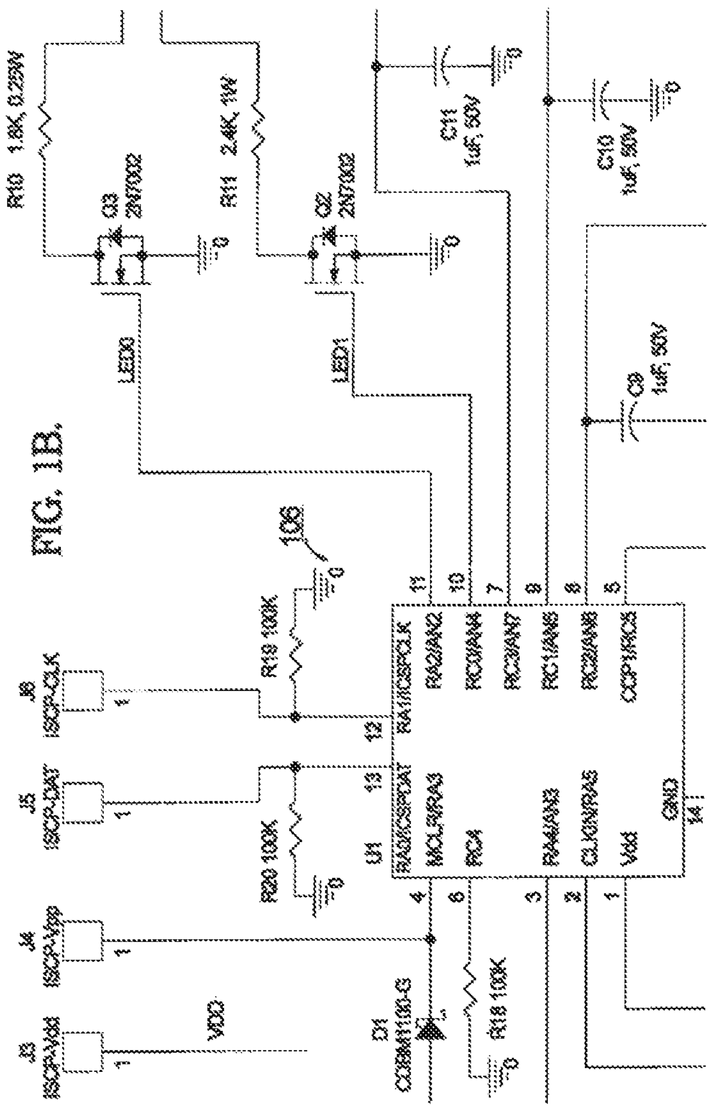
R10 1.8K, 0.25W
Q3 2N7002
R11 2.4K, 1W
Q2 2N7002
C11 1uF, 50V
C10 1uF, 50V
C9 1uF, 50V
LED0
LED1
106
R19 100K
R20 100K
R18 100K
J3 ISCP-Vdd
J4 ISCP-Vpp
J5 ISCP-DAT
J6 ISCP-CLK
VDD
D1
U1
GND
Vdd

FIG. 1B.

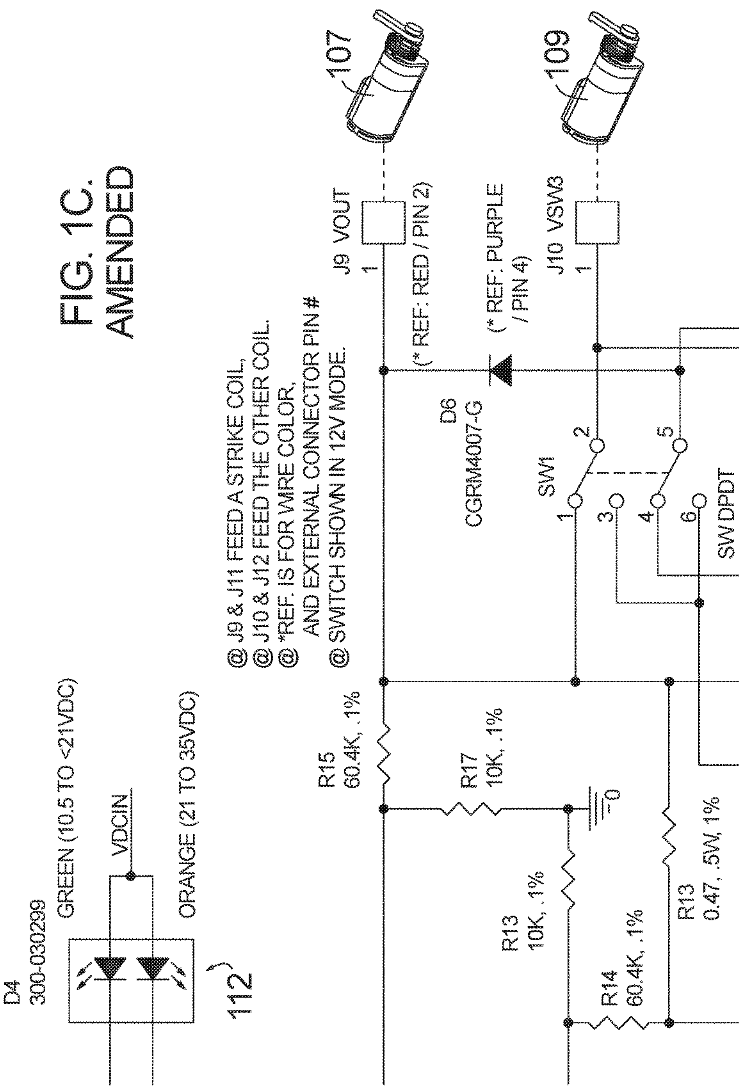

FIG. 1C.
AMENDED

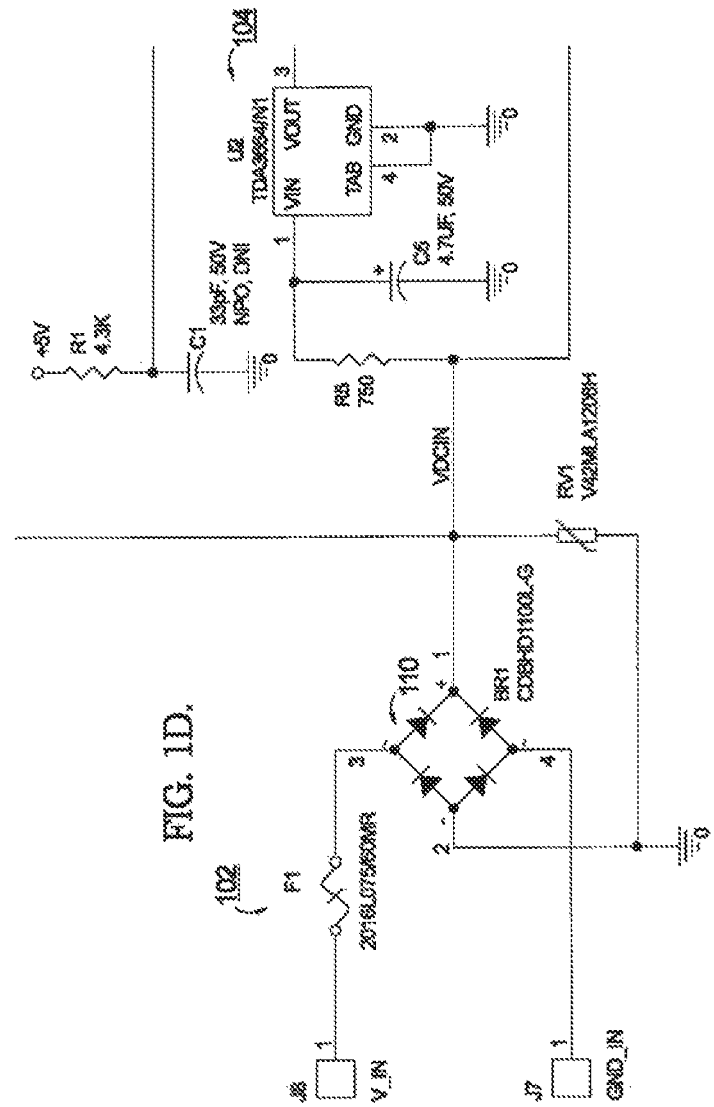
102
104
110
+5V
R1
4.3K
C1
R5
750
C5
4.7UF, 50V
U2
VIN
VOUT
TAB
GND
VDCIN
RV1
BR1
F1
J6
V_IN
J7
GND_IN

FIG. 1D.

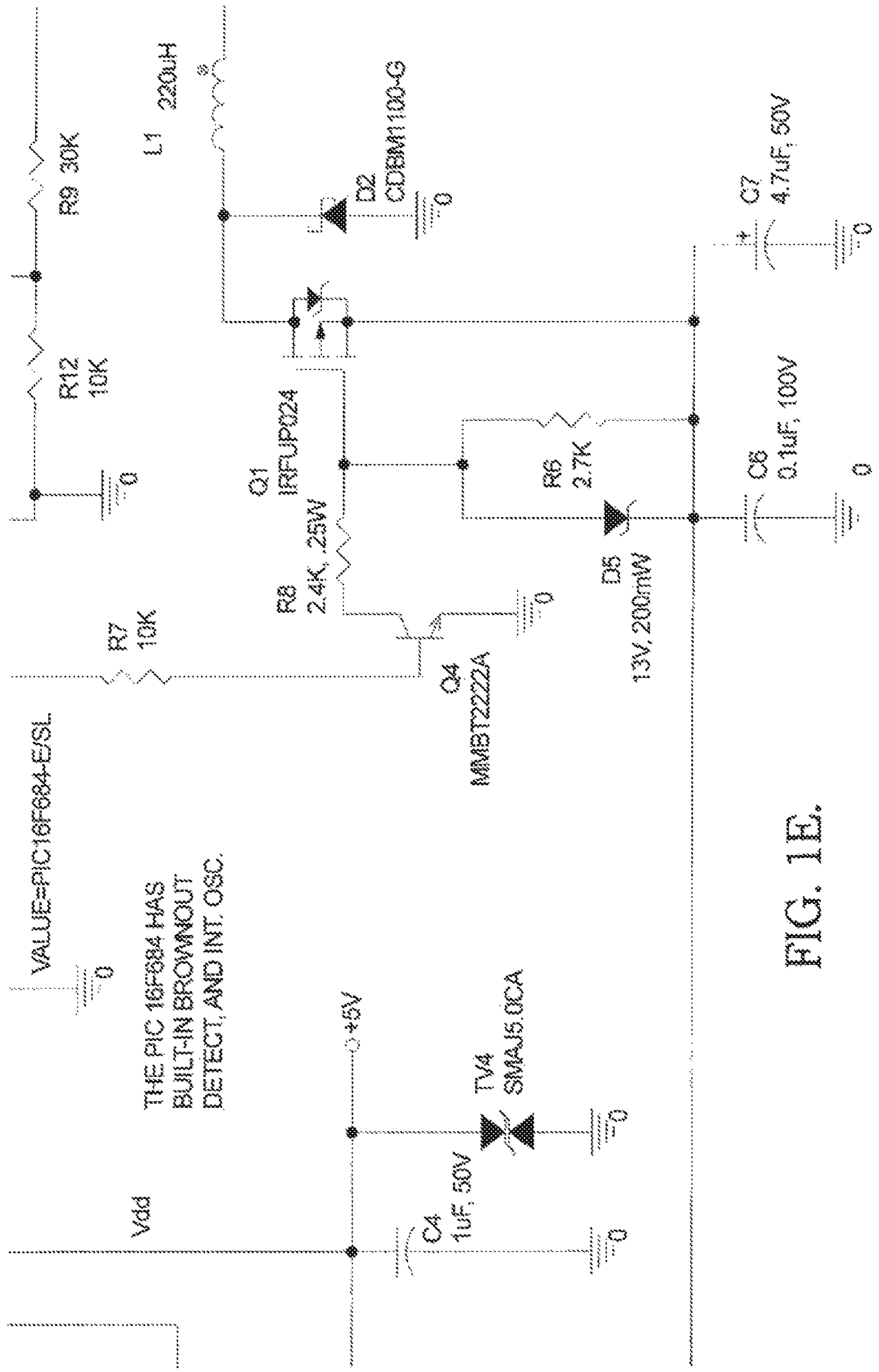
R9 30K
R12 10K
L1 220uH
D2 CDBM1100-G
C7 4.7uF, 50V
Q1 IRFUP024
R6 2.7K
C6 0.1uF, 100V
R8 2.4K, .25W
D5 13V, 200mW
R7 10K
Q4 MMBT2222A
VALUE=PIC16F684-E/SL
THE PIC 16F684 HAS BUILT-IN BROWNOUT DETECT, AND INT. OSC.
+5V
TV4 SMAJ5.0CA
Vdd
C4 1uF, 50V
0

FIG. 1E.

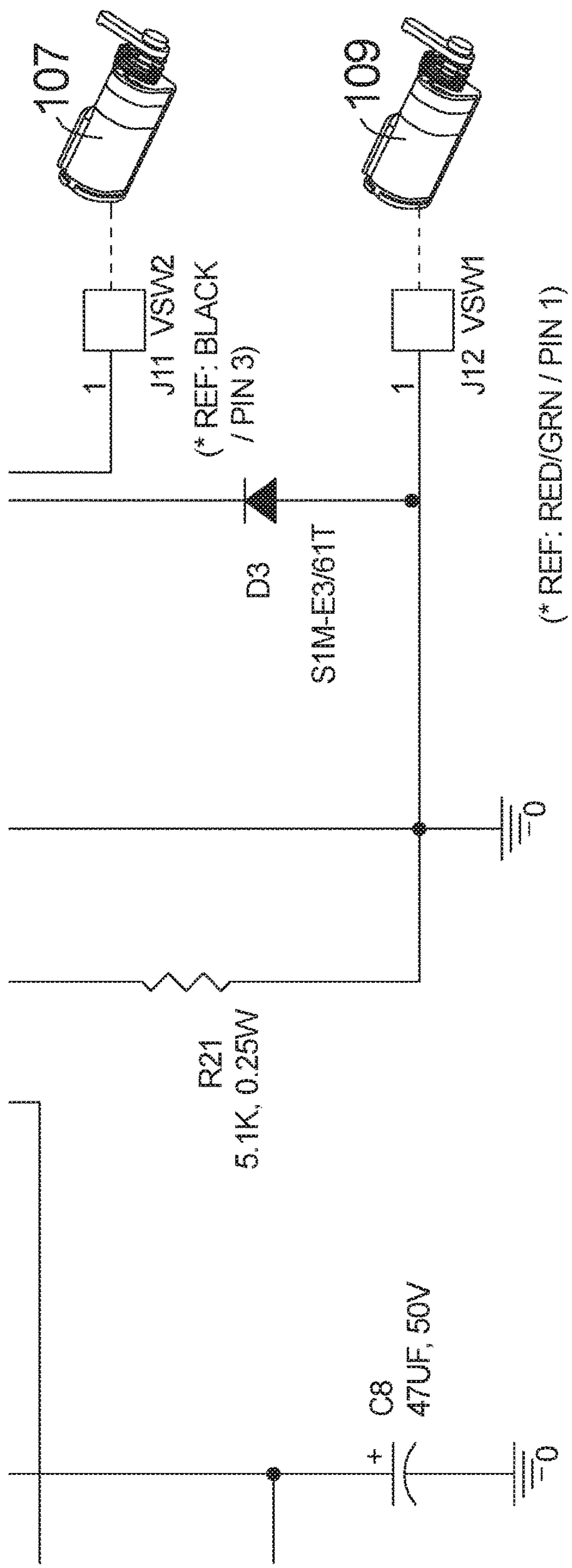

FIG. 1F.
AMENDED

CONTROL CIRCUIT FOR ELECTRIC UNLOCKING DEVICES USING ACTUATING SOLENOIDS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Patent Application No. 61/303,125, filed Feb. 10, 2010. U.S. Patent Application No. 61/303,125 is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present invention generally relates to a system and method for providing an enhanced and user friendly control circuit for electric unlocking devices using actuating solenoids. The inventive control circuit minimizes the potential for human error while also providing a small footprint, minimal DC in-rush current, over current protection and minimized heat dissipation. Additionally, the present invention is directed to providing visual notification/diagnostics and improved field compatibility with existing electric unlocking devices. Examples of electric unlocking devices benefiting from this invention include electrified locks and electric door strikes.

BACKGROUND OF THE INVENTION

There has been wide spread use of keypads and other input devices to provide secure access to buildings or other objects, e.g., safes, automobiles, jail cells, etc. In conjunction with this trend, electric unlocking devices such as, for example, electrified door locks and electric door strikes are routinely used to control entry or access by means of a remote switch or other trigger. For example, it is frequently desirable in a security application to energize an actuator, such as for example a solenoid, used in engaging/disengaging an electric door strike. There may be varying modes of operation for an electric door strike, commonly referred to as "Fail Secure" and "Fail Safe".

In the fail secure mode, a loss of power leaves the door strike in the locked condition. The solenoid that drives the strike to unlock the door may be powered only briefly to unlock the door, and because of the low duty cycle, the average power demand is low. In certain applications (i.e., employer entrance doors) the fail secure strike may be powered for eight or more hours while the door strike is held in an unlocked mode.

In the fail safe mode, the door strike is unlocked by a loss of power. Fail safe strikes are powered continuously except while the door is unlocked. This requires a high duty cycle with relatively high average power demands and heat dissipation. Reducing the heat dissipation in the circuit for such a unit is very desirous for longevity, user safety, etc.

Installers of electric unlocking devices such as electric door strikes are constantly confronted by the lack of standardization in the industry relative to supply voltage for strike operation. Some strikes are designed to operate at 12 or 24, or up to 40 volts DC; others are designed for 12, 16 or 24 VAC. As such, supply voltages ranging from 12 to 40 Volts DC or 12 to 28 Volts AC may be present at a particular location and the installer would need to match the device to the available voltage. As a result, the installer needs to stock a supply of various versions of door strikes and sometimes make complicated adjustments at a consumer site. This creates the opportunity for errors in strike installation or configuration.

It is desirable to provide a system that simplifies installation while accommodating the variations in actuating coil requirements. It is also desirable to determine if an error has been made in the connection of an electric unlocking device, or to receive an indication of other problems with the control circuit. This status information must be readily observable without the need for other equipment or diagnostic tools.

What is needed is a robust and efficient solution that can be universally implemented without the drawbacks described above. A solution that provides simplified and universal connectivity to existing unlocking devices, or new installations of such devices, feedback to the installer, and troubleshooting or diagnostic status while avoiding the short comings of current systems, would be advantageous.

The present invention fulfills these as well as other needs.

SUMMARY OF THE INVENTION

In order to overcome the above stated problems, the present invention provides features and advantages in the control circuit for an electric unlocking device such as for example an electric door strike, wherein a microcontroller is utilized to provide pulse width modulation for voltage control, over current protection, automatic strike voltage level selection and control, and circuit status indication.

In one aspect, the present invention is directed to a control circuit for a solenoid driven electric unlocking device operable in a first or second voltage level range, including: 1) a power stage including an input rectifier and a polyfuse; 2) a microcontroller; 3) a low current voltage regulator to power the micro controller; 4) means for connecting the control circuit to an external power source; 5) switching means for selecting an actuating coil configuration for a connected one of a first or second voltage rated actuating coil, wherein said polyfuse is connected to said external power source and in series with said rectifier to provide over current protection for the control circuit. The input rectifier is operably connected to the external power source to provide a rectified DC voltage at a first or second voltage level range, wherein said voltage regulator has an input connected to the DC output of said input rectifier and an output that is connected to provide power to the microcontroller. The microcontroller operates to provide, in cooperation with other components of the control circuit, the first or second output DC voltage level to power the connected one of said first or second voltage rated actuating coils.

In another aspect, the present invention is directed to utilizing a microcontroller to provide pulse width modulation for the circuit voltage output and also to provide the punch time duration for energizing the electric unlocking device close to full input voltage.

In a further aspect, the present invention is directed to feeding back the state of the actuating coil configuration selection switch to the microcontroller.

In an even further aspect, the present invention is directed to indicating the correctness of the actuating coil configuration selection switch position (high voltage range or low voltage range) with one or more light emitting diodes. The correct voltage available for the installation of the electric unlocking device may also be indicated by said light emitting diodes.

In another aspect, the present invention is directed to providing diagnostic information via light emitting diodes, such as when the selected voltage for operation, as determined by the feedback of said selection switch, is inconsistent with the voltage range for the connected electric unlocking device.

In yet another aspect, the present invention is directed to enabling the microcontroller to remain active in the event of an over current or short circuit situation that blows the polyfuse.

In another aspect, the present invention is directed to providing only a small DC input filtering capacitor connected to the DC output of the rectifier, whereby DC in-rush energy is minimized and external relay contacts feeding the control circuit are protected from the risk of welding.

Additional benefits of the above described system and method for providing controlled power are set forth in the following discussion.

BRIEF DESCRIPTION OF THE DRAWINGS

The above mentioned and other features and advantages of this invention, and the manner of attaining them, will become apparent and be better understood by reference to the following description of the invention in conjunction with the accompanying drawing, wherein:

FIGS. **1**A-**1**F are connecting segments of a schematic drawing of an exemplary electrical control circuit in accordance with the invention. FIG. **1** shows the orientation of each segment (**1**A-**1**F) to form the entire electrical control circuit diagram.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Generally, the systems, components and methods described herein for providing power and control according to the present invention may be implemented in a variety of hardware, software or combinations thereof.

A representative circuitry for enabling the present invention is presented including components, devices and their interconnections.

The present invention generally relates to a system and method for providing power to optimally control an electric unlocking device such as an electric door strike. The present invention provides circuitry to minimize human error, eliminate some field configuration wiring, minimize DC in-rush current, reduce heat dissipation, and provide visual feedback of circuit and field conditions, as well as circuit protection and improved field compatibility with existing electric unlocking devices.

The present invention is applicable to doors, gates or other similar access mediums that may be locked/unlocked remotely or locally by the use of a supplied power source and an electric unlocking device. The invention is described herein with reference to the schematic diagram of FIGS. **1**A-**1**F which illustrates an exemplary control circuit **100** (FIG. **1**) *for an solenoid driven electric unlocking device 101, such as an electric door strike 101a*. The control circuit **100** has two ranges of operation, namely a low voltage range and a high voltage range. The low DC voltage range is characterized by an input voltage in the range of approximately 10.5 to just less than 21 VDC. The high DC voltage range is characterized by voltages ranging between 21 and 33 VDC. The low AC voltage range is characterized by an input voltage in the range of approximately 10.5 to just less than 15.5 VACrms. The high AC voltage range is characterized by voltages ranging between 15.5 and 30 VACrms. The various components of the circuit **100** enable and provide the features of the invention that were previously highlighted. More specifically, the circuit comprises a power stage **102**, a microcontroller **106**, a low current voltage regulator **104** to power the microcontroller, a pair of light emitting diodes (LEDs) **112**, a double pole double throw switch SW**1**, feeds J**9**, J**11** to *a voltage rated actuating coil 107, such as* a first actuating coil **[**(not shown)**]**, feeds J**10**, J**12** to *a voltage rated actuating coil 109, such as* a second actuating coil **[**(not shown)**]**, and a number of transistors, diodes, capacitors and resistors. The control circuit **100** enables the receipt, control and passage of power to an actuating coil. The circuit **100** also provides feedback via the LEDs **112** to thereby simplify coil installation and limit the potential for error.

The power stage **102** (FIG. **1**D) comprises a bridge rectifier **110** having input terminals **3**, **4** and output DC terminals **1**, **2**. The input terminals **3** and **4** of the bridge rectifier **110** may be connected to an AC or DC power source V_in/GND_in via input connections J7 and J**8** independent of the mode of operation, that is, whether in the AC mode or DC mode. When a particular voltage level is applied at the input of bridge rectifier **110**, that input voltage results in a comparable level of rectified DC voltage VDC_{in}, which represents the input voltage to the subsequent components of the control circuit **100**. The negative DC terminal **2** of bridge rectifier **110** is connected to circuit ground 0. The positive DC terminal **1** of bridge rectifier **110** is connected to a filter capacitor C**2** (FIG. **1**A) to pin **3** of the microcontroller **106** (FIG. **1**B). The positive DC terminal of bridge rectifier **110** (FIG. **1**D) is also connected to a filter capacitor C**5** (FIG. **1**D), to the low current voltage regulator **104** (FIG. **1**D) and across filter capacitor C**6** (FIG. **1**E) to the collector of a transistor Q**4** (FIG. **1**E) and the base of a pass-through MOSFET transistor Q**1** (FIG. **1**E). A MOSFET transistor is used in circuit **100**, in accordance with the invention, because of its lower on-resistance characteristic compared to a BJT transistor. The lower on-resistance translates into lower power dissipation. Recalling that $P=I^2R$, where P is the electric power, R is the resistive load and I the electric current, since the MOSFET transistor offers lower on-resistance, it translates into lower power or heat dissipation.

Connected between power supply J**8** and input terminal **3** of the bridge rectifier **110** is a polyfuse F**1** (FIG. **1**D) for providing a first level of over current protection for the control circuit **100**. Notably, the polyfuse F**1** is of a type having very low resistance, so as to provide lower heat dissipation as well.

The bridge rectifier **110** utilizing schottky diodes in accordance with the invention exhibits approximately a 0.6 VDC drop for each pair of diodes in the bridge. This is particularly important when working with low voltage electric unlocking devices operating at the low end of the input range. Further, as compared to typical bridge diodes, schottky diodes provide a lower voltage drop across the diode. The lower voltage drop translates to lower power consumption and therefore reduces heat dissipation in the circuit as well.

The low current voltage regulator **104** (FIG. **1**D) is utilized to provide power to pin **1** of the microcontroller **106** (FIG. **1**B). Low current voltage regulator **104** (FIG. **1**D) may be an integrated circuit of the type described as a TDA3864/N1 from Philips Semiconductors which meets the necessary specifications to support the configuration of this embodiment of the present invention. The integrated circuit of the regulator **104** is described in a product specification data sheet dated Dec. 14, 2000, as a fixed 5 V regulator with very low dropout voltage/quiescent current, which operates over a wide supply voltage range. In the present invention, the regulator **104** is utilized to provide a backup function, whereby power is provided to the microcontroller **106** (FIG. **1**B) for a short period of time when the supply voltage (i.e., voltage applied at pin **1** of regulator **104** or the control circuit **100** supply power V_{in} is zero) spikes to 0 V or even −1 V, such as when the polyfuse F**1** (FIG. **1**D) blows. Through this configuration, the microcontroller **106** can remain active when polyfuse F**1** is blown.

In the preferred embodiment of the present invention, the microcontroller **106** (FIG. **1**B) is an integrated circuit of the type described as PIC16F684 from Microchip Technology Inc. in the publication, PIC12F683 Data Sheet 8-Pin Flash-Based, 8-Bit CMOS Microcontrollers with nano Watt Technology (2004, Microchip Technology Inc.). PIC16F684 meets the necessary specifications to support the configuration of this embodiment of the present invention. The microcontroller **106** comprises input/output ports, timers, comparator module, analog to digital (A/D) conversion, and a pulse width modulation module. In this embodiment of the present invention, the microcontroller **106** is utilized to provide pulse width modulation for output voltage regulation, LED diagnostic indications, circuit control and switch position detection.

The pulse width modulation provides the primary building block required for the control of a switching power supply. In the ordinary use of a pulse width modulator as a control circuit, the pulse width modulator pulses a pass transistor ON and OFF at a fixed frequency and continuously adjusts the duty cycle as needed to regulate the output voltage to a fixed level.

In the present invention, Q**1** (FIG. **1**E) is the pass transistor. Transistor Q**1** is a MOSFET n-channel enhancement-mode device. The microcontroller **106** (FIG. **1**B) is configured to operate in an enhanced pulse width modulation mode, with a single pulsed output CCP**1**/RC**5** at pin **5** of the microcontroller **106**. The pass transistor Q**1** (FIG. **1**E) is connected to pin **5** of the microcontroller **106** (FIG. **1**B) via transistor Q**4** (FIG. **1**E). By controlling the pass transistor Q**1**, the microcontroller can enable or disable power to the connected actuating coil at both of the coil feed pairs via J**9**, J**11** (FIG. **1**C) or J**10**, J**12** (FIG. **1**F). The pulsed DC voltage delivered by Q**1** (FIG. **1**E) is filtered by L**1** (FIG. **1**E) and C**8** (FIG. **1**F). As Q**1** is turned OFF, the energy stored in L**1** tends to sustain the current through L**1**, and recovery zener diode D**2** (FIG. **1**E) provides a path for inductor current during the OFF time of Q**1**. Pulse width modulation is achieved by utilizing a clock source to provide timing parameters.

Clock source modes for the microcontroller **106** (FIG. **1**B) may be internal to the microcontroller or, optionally, external to the microcontroller. When optionally configured in the external resistor-capacitor (RC) mode, the microcontroller **106** utilizes a clock input at pin **2**. Pin **2** of microcontroller **106** is connected between a timing resistor R**1** (FIG. **1**D) and a timing capacitor C**1** (FIG. **1**A) to provide the frequency for the pulse width modulation. Timing resistor R**1** and timing capacitor C**1** are connected in series in an RC network circuit between a 5 V supply and ground 0. By manipulating the RC network circuit signal to pin **2** of the microcontroller **106** (FIG. **1**B), the interval for the pulse of the internal timer may be adjusted. In a preferred embodiment, capacitor C**1** and resistor R**1** are selected to set the timing interval for approximately 0.1 μSec.

Time interval T=RC In(3) where R=4.3K ohm and C=33 Pico farad.

The microcontroller **106** (FIG. **1**B) is further configured in a RCIO mode meaning that pin **3** is configured as an additional general purpose input/output (I/O) pin. Pin **3** of microcontroller **106** is connected across filter capacitor C**2** (FIG. **1**A) to the DC output **1**, **2** of the bridge rectifier **110** (FIG. **1**D), thereby providing the level of rectified input DC voltage (VDC_{in}) to the microcontroller **106**. Pin **4** of microcontroller **106** is set up as a Master Clear Reset for the microcontroller **106**.

Pin **6** of microcontroller **106** is configured as a general purpose I/O and is tied to ground through resistor R**18** (FIG. **1**B).

Pin **8** of the microcontroller **106** is configured and connected to sense the position of the switch SW**1** (FIG. **1**C). The microcontroller **106** determines if there is consistency between the rectified input pulsating voltage VDC_{in} and the preset position of switch SW**1** for the voltage level of a particular type of electric unlocking device.

Pins **7** and **9** of the microcontroller **106** (FIG. **1**B) are configured and connected to obtain voltage feedback and sense voltage drop in connection with the switching operation of the pass transistor Q**1** (FIG. **1**E).

Pins **10** and **11** of the microcontroller **106** (FIG. **1**B) are configured as I/O ports that are utilized via respective MOSFET transistors Q**2** and Q**3** (FIG. **1**B) to drive the LEDs **112** (FIG. **1**C). The LEDs **112** comprise a green LED operable in the approximate range of 10.5 VDC to <21 VDC; and an orange LED operable in the approximate range of 21 VDC to 35 VDC. As earlier described, the rectified supply voltage VDC_{in} is applied to the LEDs **112**. LEDs **112** are installed in parallel, with each LED being connected through a resistor R**10**, R**11** (FIG. **1**B) to respective transistors Q**3**, Q**2** (FIG. **1**B).

Importantly, the microcontroller **106** (FIG. **1**B) is "aware" of all control circuit conditions and parameters, i.e., the control circuit input voltage VDCin, switch SW**1** (FIG. **1**C) position, and the voltage(s) provided to the electric unlocking device *101*. The microcontroller **106** is operably configured to enable or disable power supplied to the electric unlocking device *101* via pass transistor Q**1** (FIG. **1**E) and provide visual feedback/status via LEDs **112** (FIG. **1**C).

The present invention provides a low voltage drop between VDC_{in} and the output voltage at the electric unlocking device *101*, during the two-second punch time. Punch time as used herein refers to the brief time period between when a voltage is first applied to the control circuit, followed by a voltage settling time, and when the voltage drops to the reduced, continuous duty level. The low voltage drop is accomplished by utilizing schottky diodes in the bridge rectifier and MOSFET for the pass transistor Q**1**, both of which also improve efficiency. For example, when an input voltage of 12 V is first applied, the output voltage of the control circuit **100** of the present invention drops near full input voltage, as for example by approximately 1.5 volts, for approximately two seconds. In the low voltage range of operation this means a voltage as low as 10.5 VDC+/−15% during the two-second punch time for this example.

When in AC operation mode, contact J**8** (FIG. **1**D) is powered through a conventional power source and receives an input voltage of nominally 12 or 24 Volts AC. Contact J**8** is in electrical connection with bridge rectifier **110**. Bridge rectifier **110** converts the sine wave to a full wave rectified

DC signal VDCin with only minimal smoothing from the 4.7 μf capacitor C7 (FIG. 1E). Traditionally, electronic circuits of this type, that is, those that accept an AC signal to power DC components, first rectify the AC signal, and then the resulting pulsating DC signal is filtered or smoothed before it is applied to the circuit components. The filtering of the pulsating DC signal is typically accomplished by introducing a large value capacitor across the output of the rectifier. For example, a capacitance in the range of approximately 300 μf may be utilized to provide a smoothing of the pulsating DC signal. However, the presence of such a capacitance (300 μF) produces an undesirable characteristic when the circuit is operated in the DC mode.

When in the DC mode, the presence of a large capacitor results in a significant DC in-rush current. A large DC in-rush current can create a spark in the relay supplying power to the circuit each time the relay is activated. Over time, the contacts of the relay can stick or become welded together thereby rendering the circuit inoperable. Circuit **100** of the present invention overcomes this undesirable characteristic by replacing the large filter capacitor with a significantly smaller filter capacitor. Small filter capacitor C7 (FIG. 1E), such as for example a 4.7 μf capacitor, while having a reduced filtering-ability which is acceptable for the application, significantly reduces the level of DC in-rush current. The reduced levels of DC in-rush current from the smaller filter capacitor, when considered together with the resistive loads in the circuit, that is, the length/thickness of wire, the resistance of the polyfuse, etc, effectively reduces the potential for welding together the relay contacts that feed the control circuit **100**.

When in the AC mode of operation, the use of the small capacitor C7 (FIG. 1E) results is no filtering of the rectified DC signal VDCin. In other words, the circuit **100** receives a pulsating DC signal. In the preferred embodiment of the present invention, the circuit **100** and the components therein are adapted to operate with the pulsating DC signal and enable the operation of the actuating coils. This is possible because the solenoids used are fast enough to respond to ½ cycle of the incoming AC voltage.

Voltage surge suppression is provided by the connection of a transient surge suppression device RV1 (FIG. 1D) across the output DC terminals of the bridge rectifier **110**. The full wave rectified signal VDCin is applied to the voltage regulator **104** (FIG. 1D), the base of the pass transistor Q1 (FIG. 1E) and to an input pin of the microcontroller **106** (FIG. 1)B, which may then enable comparison.

The rectified signal VDCin is applied to the regulator **104** (FIG. 1D), which provides the necessary voltage Vout with a small current, to power the microcontroller **106** (FIG. 1B).

The rectified signal VDCin is applied to the source of transistor Q1 (FIG. 1E). Transistor Q1 has its conduction path (Gate to Drain to Source in the case of a HEXFET power MOSFET) provide pass through fast switching for the control circuit **100**.

Having described the components of the present invention along with the interconnections therein, attention is directed next to the operational aspects of the control circuit **100**.

When an installer is utilizing a low voltage level electric unlocking device, i.e., a device requiring an operating voltage in the range of 10.5 to <21 VDC, the installer sets the switch SW1 (FIG. 1C) accordingly. The installer then wires a supply voltage V_in, which may be AC or DC to the input of the control circuit **100**. This supply voltage V_in must therefore ideally be in the low level range.

In operation, the microcontroller **106** (FIG. 1B), causes either or both the green or orange LEDs **112** (FIG. 1C) to be turned on by applying a signal to the respective pins **10**, **11**. For example, if as described above, the rectified supply voltage is approximately 12 VDC (low voltage range) and the switch SW1 (FIG. 1C) has been appropriately set for a 12 V electric unlocking device (low voltage range), then the microcontroller **106** (FIG. 1B) having sensed VDCin on pin **3** and the switch position on, pin **8** and finding consistency therewith, would turn ON the pass transistor Q1 (FIG. 1E) to provide power to the actuating coil and also turn ON pin **11** thereby enabling the green LED **112** (FIG. 1C) to be illuminated. Conversely, if the microcontroller **106** (FIG. 1B) detects an inconsistency between the switch setting and the sensed VDCin on pin **3**, the pass transistor Q1 (FIG. 1E) would be turned OFF. LEDs **112** (FIG. 1C) would be alternately flashed in a sequence that is indicative of a problem. Similarly, if there are other problems detected, such as an over current situation, the pass transistor Q1 (FIG. 1E) would also be turned OFF and the LEDs **112** (FIG. 1C) would provide diagnostic status information. The microcontroller **106** (FIG. 1B) provides fast response to circuit or external problems. The polyfuse F1 (FIG. 1D) on the other hand detects circuit problems but with a slower response than the microcontroller **106**.

Utilizing the various signal level and inputs described earlier, the microcontroller **106** (FIG. 1B) of the present invention may communicate six states via the LEDs **112** (FIG. 1C). Specifically, the following indications are provided by the associated LED flashing sequences and durations:

Flashing Green	Input voltage is below low voltage range.
Flashing Orange	Input voltage is above high voltage range.
Solid Orange	Circuit set to operate the electric unlocking device in the High Voltage Range (between 21 and 33 VDC or between 15.5 and 30 VACrms)
Solid Green	Circuit set to operate the electric unlocking device in the Low Voltage Range (between 10.5 and <21 VDC or between 10.5 and 15.5 VACrms)
Alternatively Flashing Orange-Green	Over current or short at output of unit
Alternatively Flashing Orange-Orange-Green-Green	SW1 in wrong position.

As would be appreciated by one skilled in the art, the color, sequencing and durations for the flashing of the LEDs may be varied without departing from the scope of the present invention.

From the foregoing, it will be seen that this invention is one well adapted to attain all the ends and objects herein above set forth together with other advantages which are inherent to the method and system. It will be understood that certain features and sub combinations are of utility and may be employed without reference to other features and sub combinations. This is contemplated by and is within the scope of the claims. Since many possible embodiments of the invention may be made without departing from the scope thereof, it is also to be understood that all matters herein set forth or shown in the accompanying drawings are to be interpreted as illustrative and not limiting.

The constructions described above and illustrated in the drawings are presented by way of example only and are not intended to limit the concepts and principles of the present invention. As used herein, the terms “having” and/or “including” and other terms of inclusion are terms indicative of inclusion rather than requirement.

While the invention has been described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements or components thereof to adapt to particular situations without departing from the scope of the invention. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope and spirit of the appended claims.

What is claimed is:

1. A control circuit for an electric unlocking device, wherein the *electric unlocking* device is rated for a plurality of voltage levels, *and wherein the electric unlocking device includes one of a first voltage rated actuating coil or a second voltage rated actuating coil,* the control circuit comprising:

- a power stage including an input rectifier;
- a microcontroller;
- a voltage regulator; and
- means for connecting the control circuit to an external power source having one of said plurality of voltage levels; and
- *mechanical* switching means for selecting a specific voltage input level [for a connected] *corresponding to* one of [a plurality of] *the first* voltage rated [actuators] *actuating coil or the second voltage rated actuating coil*;
- said input rectifier connected to said external power source to provide a *rectified* DC voltage;
- said voltage regulator having an input connected to said rectified DC voltage and an output operably connected to power said microcontroller;
- said microcontroller operably connected to provide said rectified DC voltage at said specific voltage input level for [a connected] *the corresponding* one of [a plurality of] *the first* voltage rated [actuators] *actuating coil or the second voltage rated actuating coil* provided that said specific voltage input level selected by said *mechanical* switching means matches a voltage rating of [said connected] *the corresponding* one of [said plurality of] *the first* voltage rated [actuators] *actuating coil or the second voltage rated actuating coil*.

2. The control circuit of claim **1** wherein said voltage regulator is a low current voltage regulator.

3. The control circuit of claim **1** wherein said microcontroller provides pulse width modulation for voltage control and [for determining the punch time duration] for energizing the electric unlocking device near a full input voltage *during a punch time*.

4. The control circuit of claim **1** wherein said *mechanical* switching means is selectively positionable to provide said selected specific voltage input level and a selected position of said *mechanical* switch means is fed back to said microcontroller.

5. The control circuit of claim **4** wherein a correct position of said *mechanical* switching means is indicated by said microcontroller.

6. The control circuit of claim **5**, further comprising at least one light emitting diode wherein said correct position of said *mechanical* switching means is indicated by illumination of said at least one light emitting diode.

7. The control circuit of claim **1** wherein said specific voltage input level for the [connected] *corresponding* one of [said actuators] *the first voltage rated actuating coil or the second voltage rated actuating coil* is indicated by said microcontroller.

8. The control circuit of claim **7** further comprising at least one light emitting diode, wherein said specific voltage input level for the [connected] *corresponding* one of [said actuators] *the first voltage rated actuating coil or the second voltage rated actuating coil* is indicated by illumination of said at least one light emitting diode.

9. The control circuit of claim **4** further comprising at least one light emitting diode, wherein *said microcontroller is configured to illuminate said at least one light emitting diode* if the selected position of said *mechanical* switch means is inconsistent with the specific voltage input level for the [connected] *corresponding* one of [said plurality of] *the first* voltage rated [actuators, said at least one light emitting diode is illuminated to convey the inconsistency] *actuating coil or the second voltage rated actuating coil*.

10. The control circuit of claim **9** wherein said at least one light emitting diode includes first and second light emitting diodes, and [said first and second light emitting diodes] *wherein said microcontroller is configured to* convey the inconsistency by an alternating sequencing or pulsating of each of said first and second light emitting diodes.

11. The control circuit of claim **1** further including a polyfuse connected to said external power source and to said rectifier to provide secondary over current protection for the control circuit, wherein said polyfuse includes a first closed circuit state and a second blown circuit state, and wherein said [circuit is configured so that said microcontroller remains powered and active] *voltage regulator operates to provide power to said microcontroller* for a short *period of* time when said polyfuse is in said second blown circuit state.

12. The control circuit of claim **1** further comprising a DC input filtering capacitor connected to an output of said rectifier wherein said DC input filtering capacitor is configured to reduce DC in-rush energy and welding together of relay contacts feeding the control circuit.

13. The control circuit of claim **12** wherein said DC input filtering capacitor is a 4.7 μf capacitor.

14. The control circuit of claim **1** wherein said rectified DC voltage is provided via a low on-resistance transistor switch.

15. The control circuit of claim **14** wherein said low on-resistance transistor switch is a MOSFET transistor.

16. The control circuit of claim **1** further comprising at least one light emitting diode wherein at least one of an over current or shorts at an output of the control circuit is indicated by illumination of said at least one light emitting diode.

17. The control circuit of claim **1** wherein said electric unlocking device is an electric door strike.

18. The control circuit of claim **17** wherein said electric door strike is solenoid driven.

19. The circuit of claim **1** wherein said DC voltage provided by said input rectifier is a pulsating unfiltered signal.

20. The circuit of claim **19** wherein said pulsating unfiltered signal operates a solenoid driven electric unlocking device.

21. A control circuit for an electric unlocking device, wherein the electric unlocking device is rated for a plurality of voltage levels, and wherein the electric unlocking device includes one of a first voltage rated actuating coil or a second voltage rated actuating coil, the control circuit comprising:

- *an input rectifier;*

a microcontroller;

a voltage regulator; and

means for connecting the control circuit to an external power source having one of said plurality of voltage levels;

mechanical switching means for selecting a specific voltage input level corresponding to one of the first voltage rated actuating coil or the second voltage rated actuating coil;

said input rectifier connected to said external power source to provide a rectified DC voltage;

said voltage regulator having an input connected to said rectified DC voltage and an output operably connected to power said microcontroller;

said microcontroller operably connected to provide pulse width modulation for voltage control.

22. The control circuit in accordance with claim 21 wherein said pulse width modulation is used during a punch time for energizing the unlocking device near a full input voltage.

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