April 21, 1970 A. E. JOEL, JR 3,508,202

ELECTRONIC COMBINATION LOCK

Filed April 17, 1967 2 Sheets-Sheet 1

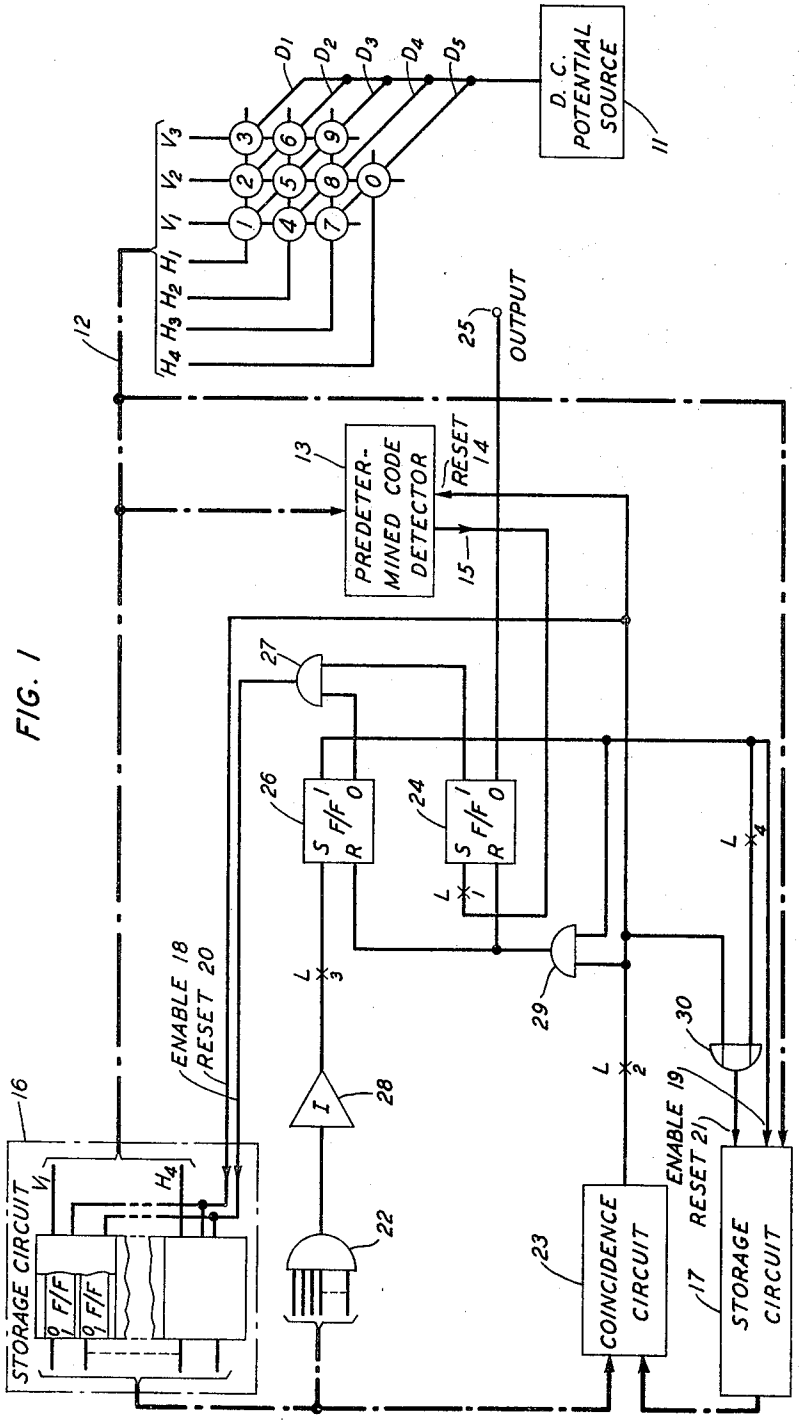

FIG. 1

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April 21, 1970 A. E. JOEL, JR 3,508,202

ELECTRONIC COMBINATION LOCK

Filed April 17, 1967 2 Sheets-Sheet 2

FIG. 3

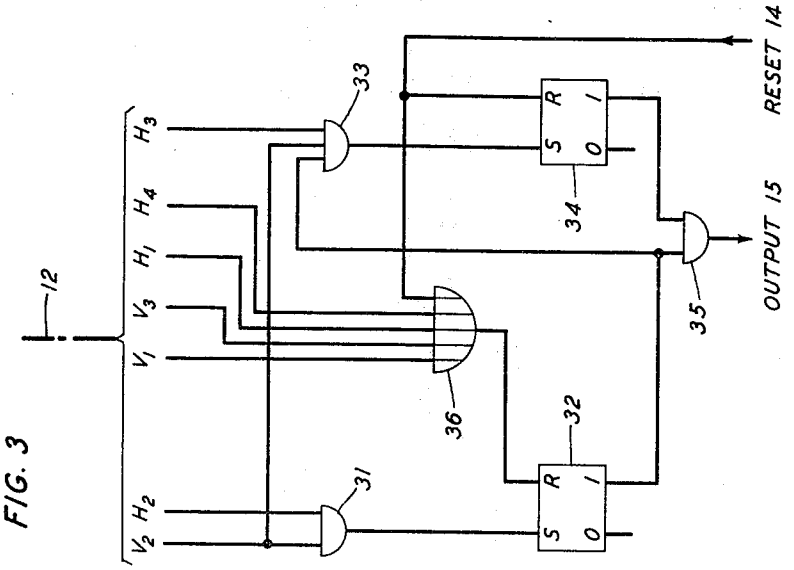
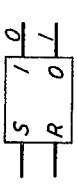


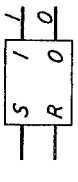
FIG. 2

KEY:

RESET STATE



SET STATE



STEP	DET. 13	F/F 24	F/F 26	GATE 27	COINC. 23	GATE 22	INV. 28	GATE 29
① INITIAL CONDITION	0	RESET	RESET	0	1	1	0	0
② PREDETERMINED CODE PUT IN	1	RESET	RESET	0	1	1	0	0
③ L OPERATED AND RELEASED	0	SET	RESET	1	1	1	0	0
④ PUSH BUTTONS OPERATED AND RELEASED	0	SET	RESET	1	0	0	1	0
⑤ L OPERATED AND RELEASED	0	SET	SET	0	0	0	1	0
⑥ PUSH BUTTONS OPERATED AND RELEASED	0	SET	SET	0	1	0	1	0
⑦ L OPERATED AND RELEASED	0	RESET	RESET	0	0	1	0	MOM. 1

United States Patent Office 3,508,202 Patented Apr. 21, 1970

3,508,202

ELECTRONIC COMBINATION LOCK

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Filed Apr. 17, 1967, Ser. No. 631,286
Int. Cl. H04q 3/02
U.S. Cl. 340—147 3 Claims

ABSTRACT OF THE DISCLOSURE

A detector circuit and flip-flop circuit arangement forming part of a combination lock is set only after a predetermined input code is applied. After this arrangement is set, a storage circuit stores a random input code. The lock is now locked and may be left. To reopen the lock, a storage circuit-coincidence circuit arrangement recognizes a reapplication of the random code and resets all of the circuitry.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to electronic combination locks.

Description of the prior art

Combination locks provide several advantages over key-operated locks. With a combination lock, for example, an authorized person need not be concerned with a key which may be forgotten or lost. Furthermore, access by an unauthorized person who has found or stolen a key is eliminated. Still further, combination locks are frequently more pick-proof than key-operated locks.

Notwithstanding the above advantages, combination locks have not received as widespread use as key-operated locks. One reason for this lack of use is that they are easily locked by unauthorized persons. Another reason is that it is often difficult or impossible to change an opening combination so as to foil persons no longer authorized to open a lock.

SUMMARY OF THE INVENTION

An object of the present invention is to restrict the locking of an electronic combination lock to authorized persons and, furthermore, to permit such persons to determine the code necesary to reopen it.

This and other objects are achieved in accordance with the invention by an electronic combination lock which is locked, or set, by a predetermined code. After setting, but before leaving the lock, a random code is applied to and stored in it. At this point, the lock cannot be reopened, or reset, until this random code is again applied. A person may therefore be authorized to reopen the lock without having to be given the ability to set it. Furthermore, his authorization to reopen the lock is readily removed merely by using a different random code at the time the lock is set.

Embodiments of the invention include a predetermined code detector whose output is effective to remove an enabling potential at an output terminal and, furthermore, to enable a first storage circuit. After a random code has been stored in this circuit, the circuit is made nonresponsive to further inputs while a second storage circuit is enabled. When the random code is stored in the second storage circuit, an output is produced by a coincidence circuit. This output is effective to place the embodiment back in its initial state.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a block diagram of an electronic combination lock embodying the invention;

FIG. 2 is a table showing the steps followed in operating the lock of FIG. 1 and the results produced by these steps; and

FIG. 3 is a block diagram at a predetermined code detector that may be used in the lock of FIG. 1.

DESCRIPTION OF THE DISCLOSED EMBODIMENT

A plurality of pushbutton switch assemblies numbered 1 through 9 and zero are shown at the right-hand side of FIG. 1. Connected to these assemblies are a plurality of horizontal leads H_1 through H_4, vertical leads V_1, V_2 and V_3 and diagonal leads D_1 through D_5. The diagonal leads are all connected to a direct current source 11 while the remaining leads form a cable 12. The operation of any one of the pushbuttons causes a direct current voltage to appear on the vertical and horizontal leads associated with that button. The operation of button 5, for example, causes a direct current voltage to appear on leads H_2 and V_2.

Cable 12 is connected to a predetermined code detector 13. This detector has a reset input 14 and an output 15. When the pushbuttons are operated in accordance with a predetermined code, a voltage is produced at output 15. A detector that operates in this manner is disclosed in FIG. 3.

Cable 12 is also connected to storage circuits 16 and 17. These two circuits are identical and include pluralities of flip-flop that register, when enabled, the operations of the pushbuttons. Circuits 16 and 17 have enable inputs 18 and 19 and reset inputs 20 and 21, respectively.

(In the following discussion a flip-flop is assumed to have ONE and ZERO side outputs. In its reset, or initial, state, the ZERO side output is a binary ONE while the ONE side output is a binary ZERO. In its set state, the binary ONE and ZERO outputs are reversed. This is shown in the key in FIG. 2.)

The ZERO sides of the flip-flops in storage circuit 16 are applied to an AND gate 22 and a coincidence circuit 23. AND gate 22 produces a binary ONE output only when storage circuit 16 is in its reset state.

The ZERO sides of the flip-flops in storage circuit 17 are similarly applied to coincidence circuit 23. Circuit 23 produces a binary ONE output when the outputs of circuits 16 and 17 match one another. Circuit 23 is conventional in nature and may take the form of a plurality of individual coincidence circuits feeding an AND gate.

The output of detector 13 is connected to the set input side of a flip-flop 24 by way of a pair of normally open contacts L_1 on a switch assembly L. When the predetermined code has been applied to detector 13 and contacts L_1 are closed, flip-flop 24 is set.

The ZERO side output of flip-flop 24 is connected to an output terminal 25. The ONE and ZERO outputs appearing on terminal 25 may be used as enabling and disabling voltages, respectively, to control any one of a number of devices. When used in a telephone handset, for example, the ZERO output would produce a disabling action so that the telephone could not be used by an unauthorized person.

As will become apparent from the following discussion, coincidence circuit 23 and AND gate 22 produce ONE outputs and flip-flop 24 and detector 13 are in

their reset states when the lock of FIG. 1 is in its initial or reset, state (i.e., when an enabling potential appears on terminal **25**). This is shown in the first step of the chart in FIG. 2. When the predetermined code is applied by pushbuttons **1** through **9** and zero (causing a ONE output from detector **13**) and contacts L_1 are closed, flip-flop **24** is set and a disabling output is produced at terminal **25**. At the same time contacts L_1 are closed, a set of contacts L_2 connected between the output of coincidence circuit **23** and reset input **14** are closed and detector **13** is reset. This is shown in the second and third steps of the chart in FIG. 2.

The ONE side of flip-flop **24** and the ZERO side of a flip-flop **26** are applied to an AND gate **27**. Flip-flop **26** is initially in a reset state. The set input of flip-flop **26** is connected by way of a pair of normally open contacts L_3 (which are part of switch assembly L) and an inverter **28** to the output of AND gate **22**. Flip-flop **26** is not set, therefore, until the ZERO sides of storage circuit **16** produce other than all ONE outputs and contacts L_3 are closed. This flip-flop is, therefore, still in its reset state when the third step of FIG. 2 has been executed. Consequently, AND gate **27** produces a ONE output at step (3) which enables storage circuit **16** so that it will register subsequent operations of pushbuttons **1** through **9** and zero.

The fourth step in the operation of the lock of FIG. 1 involves operating pushbuttons **1** through **9** and zero in a random but memorized code, or combination. The output of AND gate **22** is a ZERO so that the output of inverter **28** is a ONE. Switch assembly L is again operated which sets flip-flop **26** with the result that storage circuit **16** is disabled and storage circuit **17** is enabled. This is illustrated in step (5) of FIG. 2.

In order to reinstate an enabling input at terminal **25** (i.e., to reopen the lock), the pushbuttons must be operated in the previously stored random code. This may be done by the person originally setting the lock or by a person who has been authorized to unlock it. When the pushbuttons have been operated in accorddance with this code, the outputs of storage circuit **17** match the outputs of storage circuit **16** with the result that coincidence circuit **23** produces a ONE output as shown in step (6) of FIG. 2. The seventh and final step involves operating and releasing switch L. This step results in the performance of a number of functions. In particular, storage circuit **16** and detector **13** are directly reset, flip-flops **24** and **26** are reset in response to a ONE output from an AND gate **29** and storage circuit **17** is reset in response to a ONE output from an OR gate **30**. When flip-flop **24** is reset, an enabling output is again produced on terminal **25**.

From the above discussion, it is believed apparent that:

(1) Only a person knowing the predetermined code may set the lock,

(2) The lock may be reopened by anyone knowing the random code,

(3) A person may be authorized to reopen the lock while not being authorized to set it, and

(4) The reopening combination may be changed each time the lock is set, thereby readily preventing a previously authorized person from reopening the lock.

The lock will reopen in response to the random code only when storage circuit **17** is in its reset state upon application of the random code. It is possible, however, for this circuit to be in other than its reset state because once it has been enabled, it responds to any operation of the pushbuttons. In order to assure a reset state just prior to applying the random code, a set of normally open contacts L_4 are connected between the ONE side of flip-flop **26** and OR gate **30**. Operation of switch assembly L just prior to use of the random code assures that storage circuit **17** is in its reset state.

One or more "race" conditions may exist when the lock is constructed. Such conditions may be overcome through the use of conventional techniques. As an example, when the lock is being reopened, one of storage circuits **16** and **17** may be reset before resetting has been completed elsewhere in the lock. Such a condition would remove the ONE output from coincidence circuit **23** and the remaining circuits would not be reset. This condition is readily overcome by placing a capacitor across the output of coincidence circuit **23** so that the voltage level cannot immediately change levels.

FIG. 3 shows a predetermined code detector that may be used in the lock of FIGI. 1. This detector is wired to particular vertical and horizontal leads of cable **12** so as to produce, when enabled, a ONE output when buttons **5** and **8** are operated in that order. In particular, when the detector is enabled and button **5** is operated, an AND gate **31** produces a ONE output which sets a flip-flop **32**. When button **8** is then operated, an AND gate **33** produces a ONE output which sets a flip-flop **34**. The ONE output on the ONE sides of these two flip-flops are recognized by an AND gate **35** which, in turn, produces a ONE output on the detector output terminal **15**.

The detector of FIG. 3 is reset when a ONE is applied to its reset input **14**. In particular, such a ONE is applied directly to the reset side of flip-flop **34** and by way of an OR gate **36** to the reset side of flip-flop **32**.

This detector is also reset when an incorrect code is applied. That is, because leads V_1, V_3, H_1 and H_4 are connected to OR gate **36**, the operation of pushbutton **1**, **2**, **3**, **4**, **6**, **7**, **9** or **0** after the operation of pushbutton **5** causes flip-flop **32** to be reset.

It is believed readily apparent that the detector of FIG. 3 may be made responsive to other input codes by changing the wiring of the leads from cable **12**.

I claim:

1. A combination comprising:

first means which is set to product a particular output only after the application of a predetermined code,

second means connected to said first means to store, only after said particular output is produced, a random code applied to said combination,

third means connected to said second means to reset said first and second means upon the second application of said random code to said combination, and

output terminal means connected to said first means to make available said particular output.

2. In combination:

first means which produces an output in response to a predetermined code,

second and third means each of which when enabled produces an output representative of a random code,

fourth means producing an output in response to the simultaneous occurrence of said second and third means outputs,

means responsive to said first means output to enable said second means,

means responsive to said second means output to disable said second means and enable said third means,

means responsive to said fourth means output to disable said third means, and

means responsive to said fourth means output to reset said first, second and third means.

3. In combination:

first means which produces an output in response to a predetermined code,

second and third means each of which when enabled produces an output representative of a random code,

fourth means producing an output in response to the simultaneous occurrence of said second and third means outputs,

a first flip-flop connected to receive a set input only after said first means output is produced,

transmission means connected between said first flip-flop and said second means to enable said second means when said first flip-flop is in its set state,

a second flip-flop connected to receive a set input only after said random code has been applied to said second means,

means connected between said second flip-flop and said transmission means to disable said transmission means when said second flip-flop is in its set state,

means connected between said second flip-flop and said third means to enable said third means when said second flip-flop is in its set state.

means connected between said fourth means and said first, second and third means and said first and second flip-flops to reset each of said first, second and third

means and said first and second flip-flops after said fourth means output is produced, and

output terminal means connected to said first flip-flop.

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DONALD J. YUSKO, Primary Examiner

U.S. Cl. X.R.

340—164