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3,134,254

SECURE LOCKING SYSTEM

Filed Jan. 24, 1961

2 Sheets-Sheet 1

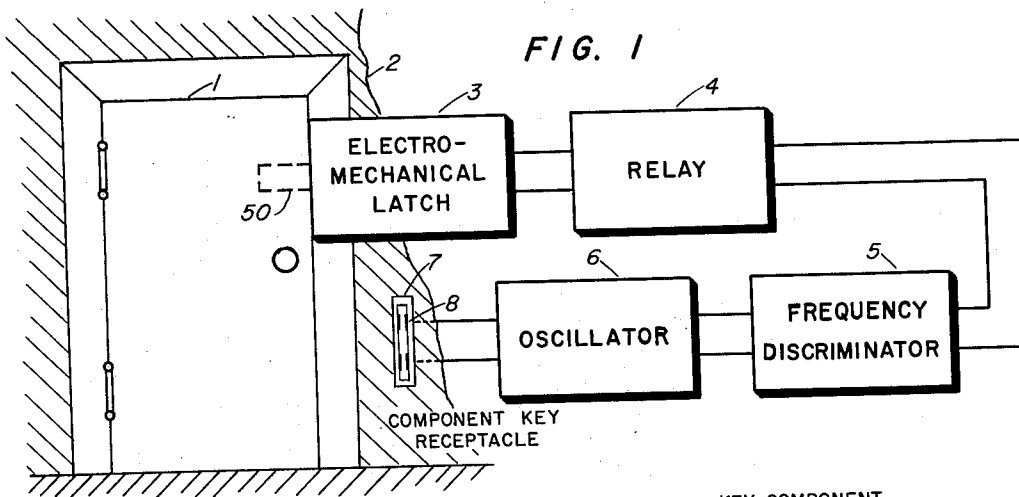


FIG. 2

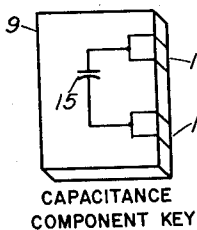


FIG. 3

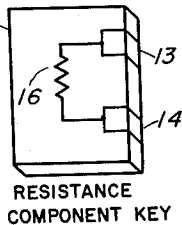
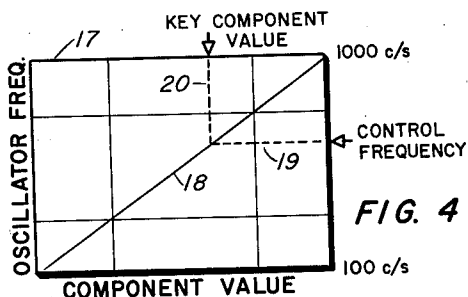
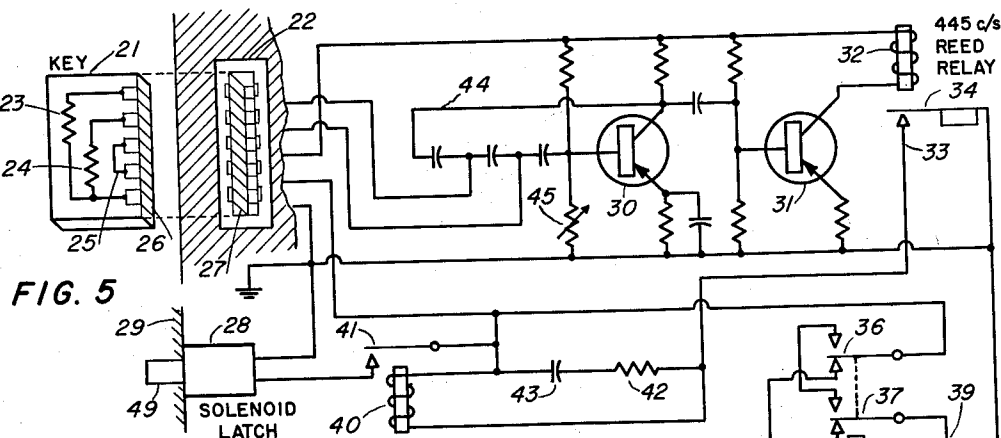
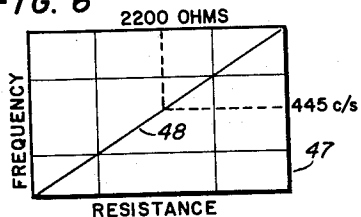


FIG. 6



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FIG. 7

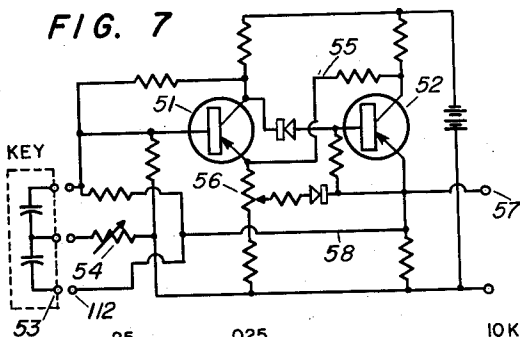
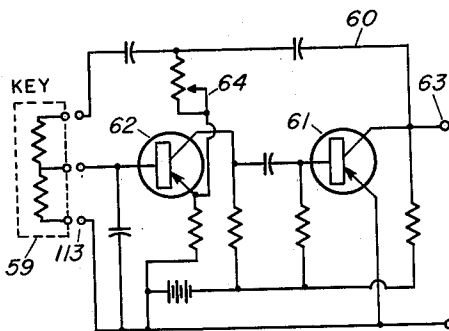


FIG. 8

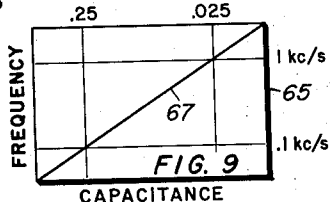
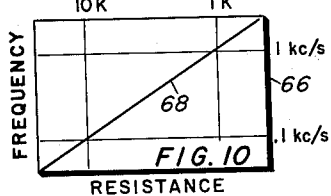
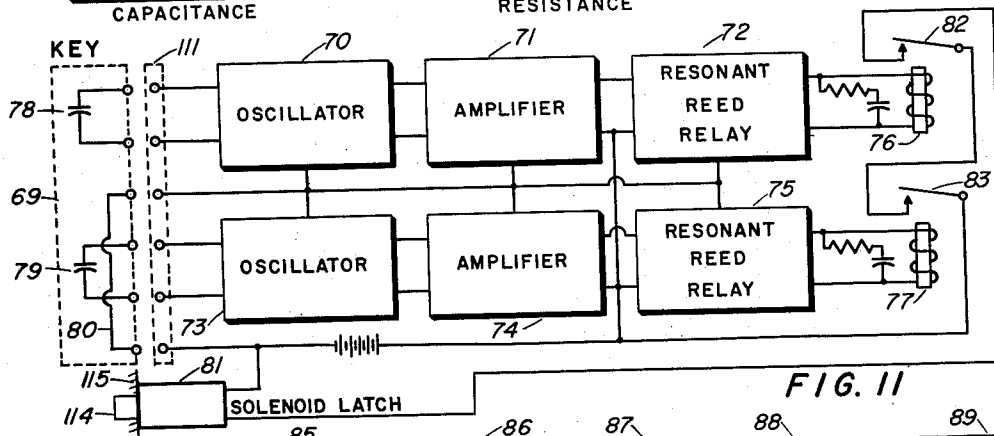
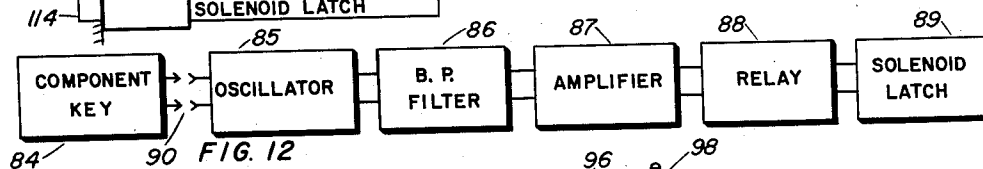
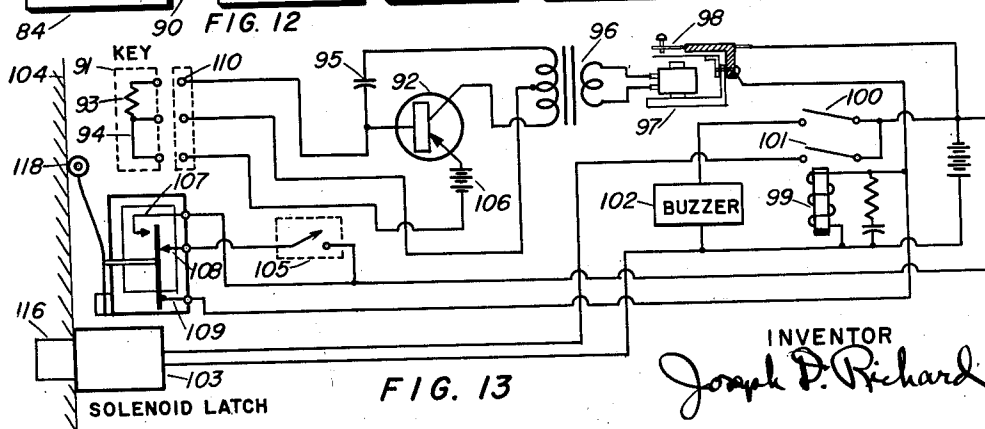


FIG. 11



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SECURE LOCKING SYSTEM

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6 Claims. (Cl. 70-277)

The present invention relates generally to lock and key systems. More specifically the present invention is directed to a method and apparatus wherein a door or the like may be securely fastened by means of a mechanical bolt or latch which may be drawn by a removable key. A locking system is provided in which an electromechanical bolt or latch is controlled by an electronic circuit which is actuated by a key comprising at least one electronic circuit element of a specific value.

A lock is a mechanical electrical, hydraulic, or electronic device which temporarily links two objects until the position of its internal structure is altered to effect the release of the objects. Locks in general use, as on doors, consist of a bolt guarded by an obstacle and controlled by a key. The bolt usually slides horizontally or vertically but may also be pivoted or rotary. A key is a removable instrument by which the bolt of a lock is shot or drawn. The key usually rotates but may also act by sliding or pushing. Most door locks are used to keep the door in a shut position besides securing it and are usually provided with a bevelled spring bolt which is pushed into the lock case when closing the door.

Locks are among the oldest known inventions of man and they have been in use for several thousand years. Locks and keys have been made in almost an infinite variety of forms. The detailed operation and construction of those types which are in general use today are well known by those skilled in the art and need not be described herein. In most locks, a door is held in a closed position by means of a bolt secured by a pickable mechanism which is supposed to be releasable only by inserting and turning an easily reproducible key. Certain burglarious persons have availed themselves of these conditions to the detriment of the burglarizable among us. Fear, anxiety, and high insurance rates have resulted from this inherent weakness in our locked doors.

An outstanding objection to the locking systems used in the past has been the vulnerability of the bolt controlling mechanism to picking or tampering by burglars and the like.

Another outstanding objection to the locking systems used in the past has been the ease with which keys could be duplicated for nefarious and dishonest purposes.

Another objection to the locking systems used in the past is the limited strength provided by a single bolt which must be light enough to be actuated by a manually turned key.

The present invention provides a locking system which is devoid of the abovementioned disadvantages and which at the same time is economical and otherwise practical.

An object of my invention is to provide a locking system in which the bolt controlling mechanism is not susceptible to picking or tampering by virtue of its physical construction.

Another object of the present invention is to provide a locking system in which the bolt controlling mechanism is not accessible to aspiring burglars and the like because of its physical location.

A further object of the present invention is to provide a lock and key system in which the key may not be duplicated without destroying the original key. Any desired number of identical keys may be made originally but none may be later duplicated without exact knowledge of their construction.

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Still another object of the present invention is to provide a locking system in which any number of bolts or latches of as large a size as desired may be actuated by a single key without the expenditure of mechanical effort.

Other objects and advantages will become more apparent from a study of the following specifications and drawings in which:

FIGURE 1 is a schematic drawing and block diagram showing the method and apparatus of my invention. The relative organization between the key receptacle, latch control circuit, electromechanical latch, and the locked door is shown.

FIGURE 2 shows one kind of key according to my invention in which the electronic component is a capacitor having some preselected specific value.

FIGURE 3 shows another kind of key according to my invention in which the electronic component is a resistor having some preselected specific value.

FIGURE 4 shows the relationship between the specific value of the electronic component in the key and the control frequency of the locking system shown in FIGURE 1.

FIGURE 5 shows a more practical locking system according to my invention including a component key, key receptacle, control circuits, and solenoid door latch. A standby power supply is also shown.

FIGURE 6 shows the relationship between the value of the resistors in the key and the oscillator frequency for the locking system of FIGURE 5.

FIGURE 7 shows a type of oscillator usable in the locking system in which capacitors are the frequency controlling components in the key.

FIGURE 8 shows a type of oscillator usable in the locking system in which resistors are the frequency controlling components in the key.

FIGURE 9 shows the relationship between oscillator frequency and key component capacitance for the circuit shown in FIGURE 7.

FIGURE 10 shows the relationship between oscillator frequency and key component resistance for the circuit shown in FIGURE 8.

FIGURE 11 shows a locking system according to my invention in which two control circuits are used to operate the latch or bolt.

FIGURE 12 shows an alternate apparatus for locking systems in which a filter is used as frequency discriminator instead of a resonant reed relay.

FIGURE 13 shows a locking system according to my invention in which a resistor is used as the frequency determining component in the key. A remote unlock switch, door interlock switch, and open door buzzer are also included along with the locking system.

Referring again to FIGURE 1, a door 1 is shown conventionally mounted in the wall 2. An electromechanical latch 3 restrains the door in a closed position by means of the bolt 50. The electromechanical latch 3 is similar to a conventional solenoid and the bolt 50 may be either an extension of the movable solenoid core or else connected to it by means of a mechanical linkage. When the electromechanical latch 3 is energized by means of the relay 4, the bolt 50 is withdrawn so that the door 1 may be opened. Mounted on the wall 2 adjacent to the door 1 is an electrical receptacle 7 having electrical contacts 8 which are electrically connected to the oscillator 6. The output of the oscillator 6 goes to the frequency discriminator 5. When the oscillator 6 operates at the discriminator frequency the relay 4 is actuated thereby allowing the door to be opened. The electrical receptacle 7 serves as the key receptacle according to my invention. A key such as shown in FIGURE 2 comprises at least one electronic component or circuit element which is integral with an electrical connector which

matches the key receptacle 7. Similar connectors are commonly used with printed circuits and are well known in the art. A capacitor 15 is shown molded into a plastic rectangular block 9 with its terminals attached to the exposed contacts 11 and 12. The object in FIGURE 2 may be described as a component key because it contains an electrical component of a specific or "key" value. The particular component shown in FIGURE 2 is a capacitor but other components or circuit elements could be used instead or in combination. The component key 9 fits into the key receptacle 7 so that the contacts 11 and 12 of the component key 9 match with corresponding contacts in the key receptacle 7. When the key 9 is inserted in the receptacle 7, the capacitor 15 is connected into the circuit of the oscillator 6 in such a way that the frequency of the oscillator 6 is determined by the capacitance of the capacitor 15. It can be seen that only keys containing capacitors of one specific value can be used to open the door 1 of FIGURE 1. The foregoing description is only illustrative of one mode of operation and assumes that the oscillator 6 is a type the frequency of which may be determinable by a single capacitor. Actually many types of oscillator circuits may be used equally well. Oscillators in common use may be controlled by one or more resistors, capacitors, or inductors, or by various combinations of these components.

FIGURE 3 shows a component key 10 containing a resistor 16 suitably connected to the exposed contacts 13 and 14. The component key 10 would be suitable for use with an oscillator whose frequency is controllable with a single resistor of a specific value such as the one shown in FIGURE 13.

FIGURE 4 shows the relationship between component value and oscillator frequency for the apparatus such as shown in FIGURES 1 and 2. The plotted data 18 of the graph 17 shows that for a specific control frequency 19, such as would be determined by the pass frequency of the discriminator 5, a specific key component value 20 is required. Components of the same type but of different values result in frequencies other than the control frequency and the door 1 remains locked.

FIGURE 5 shows a more practical locking system according to my invention. A higher degree of security is achieved by the use of two resistors 23 and 24 in the component key 21. The component key 21 fits into and matches the contacts of the component key receptacle 22. The contacts of the component key receptacle are connected into the circuit of a conventional transistor phase-shift oscillator. When the component key 21 is inserted in the receptacle 22, the resistors 23 and 24 form part of the feedback circuit 44 which determines the frequency of the oscillator circuit made up of the transistor 30 and associated components. The oscillator signal is amplified by the transistor 31 which drives the coil 32 of the resonant reed relay. When the oscillator frequency is the same as the resonant frequency of the reed 34, intermittent contact is made between the reed and the contact 33 thereby actuating the control relay coil 40 which closes the contacts 41 which energizes the solenoid 28 which pulls the bolt 49 which, in turn, releases the door 29. Obviously two resistors each with a precisely specific value must be integral with any key capable of unlocking the door 29. Two of the contacts of the key 21 bridged by the wire 25 are used to turn the transistor circuits on only when the key 21 is inserted in the receptacle 22. Since the resonant relay contacts comprising the reed 34 and the fixed contact 33 are only closed intermittently as the reed vibrates, the resistor 42 and the capacitor 43 are necessary to keep the contacts 41 of the control relay closed without chattering. The locking apparatus shown in FIGURE 5 is normally operated from the A.C. line at the primary of the transformer 46. A D.C. voltage is provided by the power supply 38 suitable for operating the transistor circuits. A standby battery 39 operates the circuits if the line power fails. The bat-

tery 39 voltage is not sufficient to keep the relay contacts 36 and 37 closed so that when the line power fails the battery operated system is isolated from the power supply. Since the circuits are turned on only when the key 21 is inserted, the locking system can be operated for long periods on the battery supply alone in the event of power line failure. The battery 39 is continuously charged when the line power is on.

FIGURE 6 shows the relationship between the value of the resistors 23 and 24 in the key 21 and the oscillator frequency for the circuit of FIGURE 5. It can be seen that a resistance of 2200 ohms causes an oscillator frequency of 445 cycles per second which is the same as the resonant frequency of the reed 34 of the resonant frequency relay. The key 21 can be used for unlocking the door 29 only when the value of the resistors 23 and 24 is 2200 ohms.

FIGURE 7 shows another type of resistance-capacitance controlled oscillator suitable for use with my invention. The bridged-T network coupled from the emitter of the transistor 52 to the base of the transistor 51 provides negative feedback which reduces gain except at the notch frequency. Other feedback paths improve amplitude and frequency stability. The two capacitors in the key 53 are part of the bridged-T and the frequency of the oscillator varies according to value of these capacitors. The relationship is shown in FIGURE 9.

FIGURE 8 shows a transistorized version of a standard Wien Bridge oscillator using a grounded emitter configuration. The frequency of operation is determined by the resistance-capacitance combinations in the feedback loop including the two resistors in the key 59. The relationship between the resistance of these two resistors and the oscillator frequency is shown by the graph 66 in FIGURE 10.

FIGURE 11 shows another arrangement according to my invention in which separate components in the key 69 control the frequency of two separate oscillators 70 and 73. When the key 69 is inserted in the receptacle 111 the capacitor 78 determines the frequency of the oscillator 70. The output signal of the oscillator 70 in amplifier 71 and drives the resonant reed relay 72. When the oscillator 70 frequency is the same as the resonant frequency of the reed relay 72, the contacts close intermittently thereby actuating the control relay 76 which closes the contacts 82. In a similar manner the capacitor 79 in the key 69 determines the frequency of the oscillator 73. It can be seen that when both of the capacitors 78 and 79 in the key 69 are exactly the right value, the solenoid latch 81 is energized thereby pulling the bolt 114 and unlocking the door 115. A wire 80 between two of the contacts in the key 69 serves to connect power to the various circuits only when the key 69 is inserted into the receptacle 111. The dual oscillator arrangement in FIGURE 11 presumably offers a higher degree of security than does the single oscillator types. However, the single oscillator circuit with two components in the key is adequate for almost all purposes where high security must be maintained.

FIGURE 12 shows in block diagram an alternate arrangement for a locking system according to my invention. The key component 84 controls the frequency of the oscillator 85. When the oscillator signal is of the proper frequency it passes through the filter 86 and is amplified by the amplifier 87. The amplified signal actuates the relay 88 which then energizes the solenoid latch 89. Although other types of frequency discriminating devices may be used in the locking system, such as the band-pass filter of FIGURE 12, the resonant reed relay has proven to be most satisfactory.

In FIGURE 13 the value of the resistor 93 in the component key 91 determines the frequency of the modified grounded-emitter Hartley type transistor oscillator. The wire 94 allows the oscillator to be powered by the battery 106 when the key 91 is inserted into the recep-

tacle 110. The oscillator signal is coupled to the resonant reed relay 97 by the transformer 96 which also serves as the oscillator coil. When the resistor 93 is of the correct or "key" value, the oscillator frequency is the same as the resonant frequency of the reed and the contacts 98 are intermittently closed thereby actuating the relay coil 99 and closing the contacts 100 and 101. When the contacts 100 are closed the buzzer 102 sounds. When the contacts 101 are closed the solenoid latch 103 is actuated thereby pulling the bolt 116 which unlocks the door 104. The resistor 93 serves as the base return resistor of the oscillator circuit. The frequency of operation depends on the value of the capacitor 95 and on the value of the resistor 93. For a given value of capacitor 95 the frequency of the oscillator can vary from about 20 cycles per second to about 10 kilocycles per second depending on the value of the resistor 93. When the door 104 is closed, the lever arm 118 of a micro-switch is depressed so that the contacts 108 are closed and the contacts 107 are open. A normally open switch 105 is in series with the closed contacts 108. The switch 105 allows a receptionist or the like to open the door 104 from some remote location without the use of a key. Once the door is open, the contacts 107 are closed and the relay 99 is actuated as long as the door remains open. The bolt 116 is thus kept retracted as long as the door is open. The buzzer 102 also sounds as long as the door is kept open.

In a preferred embodiment of my invention a resonant reed relay is used to discriminate between signals of different frequencies. Resonant reed relays are well known in the art and are commercially available over a frequency range of 20 cycles per second to 1600 cycles per second or greater. Power levels of a few milliwatts are sufficient to actuate them. Typical bandwidth ranges between 0.2% and 2.0%. Resonant reed relays have extremely high selectivity; they are reliable, inexpensive, and require a minimum of associated electronic circuitry. The length of the vibrating reed may be set so that it responds to a specific narrow band of frequencies corresponding to the mechanical resonance of the reed. When energy is applied electromagnetically from the relay coil at the resonant frequency, the reed vibrates with sufficient amplitude so as to make intermittent contact with a closely spaced second contact member. The reed relay contacts make only intermittently and can pass a limited electrical current and for these reasons the reed relays are usually used to actuate an auxiliary relay which controls the power circuits. The details of a typical resonant reed relay are shown in FIGURE 13.

Any electronic circuit element can be used as a key component according to my invention so long as they are capable of controlling or otherwise modifying the flow of electrons in the associated control circuit. A single capacitor has been found to be a very satisfactory key component. A physically small capacitor of relatively low capacitance can be used in the key so that it is connected in parallel with a larger capacitor which is permanently connected in the control circuitry when the key is inserted. In this case the key component causes the oscillator frequency to shift to the resonant reed frequency when the key is inserted.

The key receptacle may be situated either on the door itself or preferably on the wall adjacent to the door. Any number of solenoid latches can be controlled by the control relay. Where a high degree of security is maintained, it might be desirable to have several electromechanically controlled bolts on a single door all of which can be actuated and drawn by the insertion of the key.

Another important advantage of the present invention should be recognized. Referring to FIGURE 5 we see a typical locking system according to my invention. All of the keys for this particular lock are identical. The

key 21 represents one such key capable of opening the lock. When the system is first placed in operation, a typical key 21 is inserted in the receptacle 22 and the oscillator frequency is adjusted to the precise center frequency of the resonant reed 34 by means of the adjustable resistor 45. The system is then operable by any of the identical keys. In lock and key systems where various persons are in possession of the keys, it is commonly necessary to change the lock and reissue new keys for security reasons. In such an event the lock apparatus of FIGURE 5 need not be replaced and the reed relay need not be adjusted to a new frequency. A new set of identical keys would be issued having slightly different component values from the original keys. One of the new keys is inserted in the key receptacle 22 and the adjustable resistor 45 is once more adjusted to bring the oscillator frequency back to the center frequency of the resonant reed 34. The locking system will be then operable only by the new keys.

In these specifications and drawings of my invention I have selected an oscillator as the control circuit. The frequency of the oscillator is determined by the value of one or more circuit elements in the removable key assembly. A resonant reed relay is shown as the preferred frequency discriminator because of its selectivity and stability and because it can perform simultaneous switching and discriminating functions. The electromechanical bolt may consist of a conventional bevelled spring latch mechanically coupled to a solenoid which may be actuated either directly by the reed relay contacts or preferably by an intermediate relay.

The component key of my invention can be made in a variety of physical shapes and sizes. A simple rectangular block two inches high, one inch wide, and three-eighths inch thick has proven to be a convenient size. At least one electronic component must be included in the key and this has been cast into a block of opaque epoxy resin with the leads attached to the contacts of a male printed circuit connector which protrude from one edge of the plastic block. The electronic component is protected from moisture and other damage by being cast into a block of plastic. The opaque plastic also serves to conceal the nature of the key components from those who would attempt to duplicate the key. The component key receptacle, which is mounted on or near the door, can consist of a female printed circuit connector which matches the key connector. In a preferred form of my invention two of the contacts of the key are shorted as described and shown in the specifications and drawings so that the electronic control circuits are powered only when the component key is inserted in the key receptacle.

A variation of the locking system described herein could consist of a component key containing a complete transistor oscillator which is powered only when inserted into the key receptacle. The oscillator signal could be fed to the control circuitry through one of the contacts of the connectors. Within the present state of the art the above described "oscillator key" could be easily constructed with the same dimensions as the component key described above. Sufficient advantage would not be gained by building the oscillator into the key to offset the several obvious disadvantages.

As can be seen from the foregoing specifications and drawings I have provided a method and apparatus for locking doors or the like in which the bolt controlling mechanism is not susceptible to picking or tampering by virtue of its physical construction and its location relative to the key receptacle. The locking system employs a removable key which is difficult to duplicate without destroying the original key. By increasing the complexity of the key somewhat, it becomes almost impossible to duplicate without exact knowledge of its construction details. Of course any number of keys may be made originally and additional ones may be made later as long

as the exact values of the electronic components are known. The locking system of the present invention allows any reasonable number of electromechanically controlled bolts or latches to be used on a door and they can be all actuated simultaneously by the insertion of the component key into the key receptacle without the expenditure of mechanical effort. A standby battery power supply may be included if desired so that the system will remain functional in the event of local power failure.

While I have described particular embodiments of my invention for purposes of illustration, it will be understood that various modifications and adaptations thereof may be suggested to those skilled in the art without departing from the spirit and scope of the invention as defined in the following claims.

Having thus fully described my invention I claim:

1. In a locking circuit including locking apparatus and a removable key assembly embodying at least one complete electronic circuit component of a specific value, locking apparatus which comprises: an open electronic oscillator circuit, the resulting frequency of which may be determined by the aforementioned specific valued circuit component of the key assembly when connected therein to close said oscillator circuit; contact means removably engageable by the key assembly for electroconductively connecting the said electronic component of the key assembly into said oscillator circuit, a specific oscillator frequency thereby resulting; frequency discriminating means responsive only to signals of said specific resulting frequency from said oscillator; switching means responsive to the output of said frequency discriminator, said switching means being thereby actuated whenever signals of the specific frequency are produced by said oscillator; and electromechanical latching means responsive to the closure of said switching means, said latching means being suitable for locking a door or the like in a closed position until being actuated by said switching means.

2. In a locking circuit including locking apparatus and a removable key assembly embodying at least one complete electronic circuit element of a specific value and at least a pair of electrical contacts to which the terminals of the circuit element are connected locking apparatus which comprises: a key receptacle comprising an electrical contact assembly into which the aforementioned pair of electrical contacts of the key assembly may be inserted, the key receptacle being mounted conveniently near a latchable door; an electronic oscillator circuit the frequency of which may be determined by the value of the aforementioned key electronic circuit element, the circuit element being connected into the said oscillator circuit upon the insertion of the key assembly into said key receptacle, a specific oscillator frequency thereby resulting; frequency discriminating means responsive only to signals of the specific frequency; electric switching means responsive to the output of said frequency discriminator, said switching means being thereby closed in response to oscillator signals of the specific frequency; and electromechanical latching means responsive to said switching means said latching means being so arranged to securely hold the aforementioned door in a closed position until the removable key assembly is inserted into said key receptacle.

3. In a locking circuit, the combination of a removable key assembly embodying at least one electronic component of a specific value, a first pair of electrical contacts to which the terminals of said electronic component are attached, and a shunted second pair of electrical contacts integral with said key assembly; a key receptacle comprising a fixed electrical contact assembly into which said first and second pairs of electrical contacts of said key assembly may be inserted, said key receptacle being mounted conveniently near a latchable door or the like; an electronic oscillator circuit, the frequency of which is determined by the value of said key electronic

component, said key component being connected into the said oscillator circuit through the said fixed electrical contact assembly of said key receptacle when said key assembly is inserted, a specific oscillator frequency thereby resulting; an electrical power source for said oscillator circuit connectable between two of the contacts of said key receptacle, said two contacts being connected together through said shunted second pair of electrical contacts of said key assembly when it is inserted into said key receptacle; frequency discriminating means responsive only to signals of the specific frequency; electrical switching means responsive to the output of said frequency discriminating means, said electrical switching means being thereby closed in response to oscillator signals of the specific frequency; and electromechanical latching means responsive to said electrical switching means, said latching means being suitable for securely fastening the aforementioned door or the like in a closed position until being actuated by said electrical switching means.

4. In a locking circuit including locking apparatus and a removable key assembly embodying at least one complete electronic circuit component of a specific value, locking apparatus which comprises: an electronic oscillator circuit, the frequency of which may be determined by the aforementioned specific valued circuit component; means for connecting the electronic component into said oscillator circuit, a specific oscillator frequency thereby resulting; a resonant reed relay, the contacts of which close only in response to signals of the specific frequency from said oscillator; power switching means effected through the closure of the contacts of said resonant reed relay, said power switching means being thereby actuated whenever signals of the specific frequency are produced by said oscillator; and electromechanical latching means responsive to said power switching means, said latching means being arranged to hold a door or the like in a closed position until being actuated by said power switching means.

5. In a locking circuit including locking apparatus and a removable key assembly embodying at least one complete electronic circuit element of a specific value and at least a pair of electrical contacts to which the terminals of the circuit element are connected, locking apparatus which comprises: a key receptacle comprising an electrical contact assembly into which the aforementioned pair of electrical contacts of the key assembly may be inserted, said key receptacle being mounted conveniently near a latchable door; an electronic oscillator circuit the frequency of which may be determined by the value of the aforementioned key electronic circuit element, the circuit element being connected into the oscillator circuit upon the insertion of the key assembly into said key receptacle, a specific oscillator frequency thereby resulting; a resonant reed relay, the contacts of which close only in response to signals of the specific frequency from said oscillator; power switching means effected through the closure of contacts of said resonant reed relay, the said power switching means being thereby actuated whenever signals of the specific frequency are produced by said oscillator; and electromechanical latching means responsive to said power switching means, said latching means being so arranged to securely hold the aforementioned door in a closed position until being actuated by said power switching means.

6. In a locking circuit, the combination of a removable key assembly embodying at least one electronic component of a specific value, a first pair of electrical contacts to which the terminals of said electronic component are connected, and a shunted second pair of electrical contacts integral with the aforementioned key assembly; a key receptacle comprising a fixed electrical contact assembly into which said first and second pairs of electrical contacts of said key assembly may be inserted, said key receptacle being mounted conveniently near a latch-

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able door or the like; an electronic oscillator circuit, the frequency of which is determined by the value of said key electronic component, said key component being connected into said oscillator circuit through said fixed electrical contact assembly of said key receptacle when said key assembly is inserted, a specific oscillator frequency thereby resulting; an electrical power source for said oscillator circuit connectable between two of the contacts of said key receptacle, said two contacts being connected together through said shunted second pair of electrical contacts of said key assembly when it is inserted into said key receptacle; a resonant reed relay, the contacts of which close only in response to signals of the specific frequency from said oscillator; power switching means effected through the closure of the contacts of said resonant reed relay, said power switching means being thereby actuated whenever signals of the specific frequency are

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produced by said oscillator; and electromechanical latching means responsive to said power switching means, said latching means being suitable for securely holding the aforementioned door or the like in a closed position until being actuated by said power switching means.

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