

Dec. 7, 1971

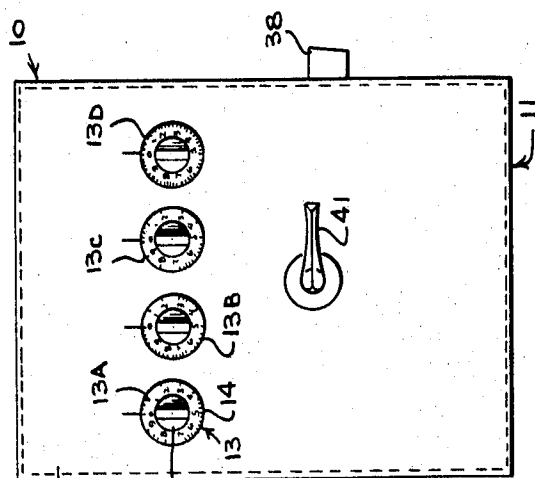
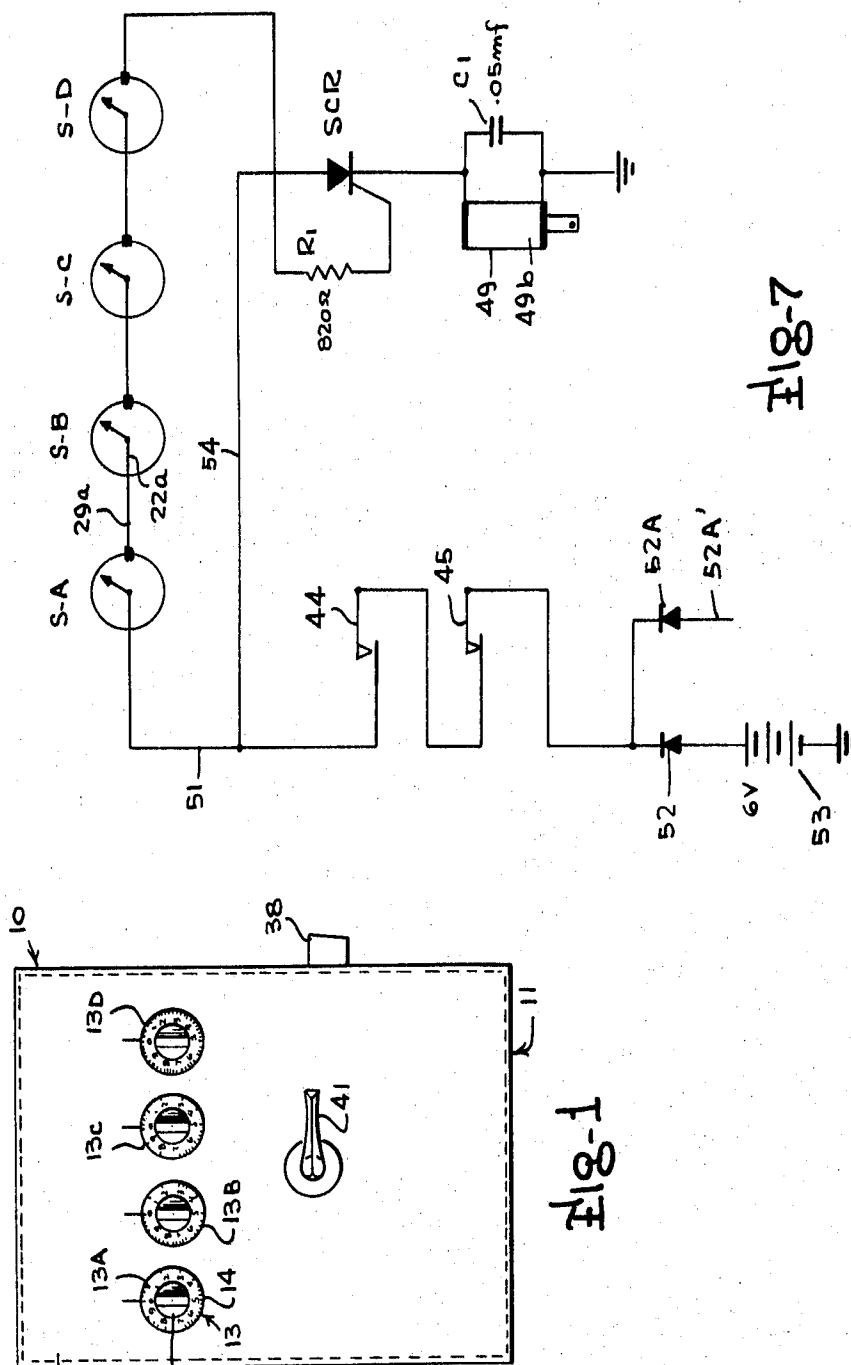
C. SUBIETA

3,625,033

ELECTROMECHANICAL COMBINATION LOCK CONSTRUCTION

Filed Sept. 18, 1970

4 Sheets-Sheet 1



INVENTOR

CARLOS SUBIETA

BY
Mason, Fenwick & Lawrence
ATTORNEYS

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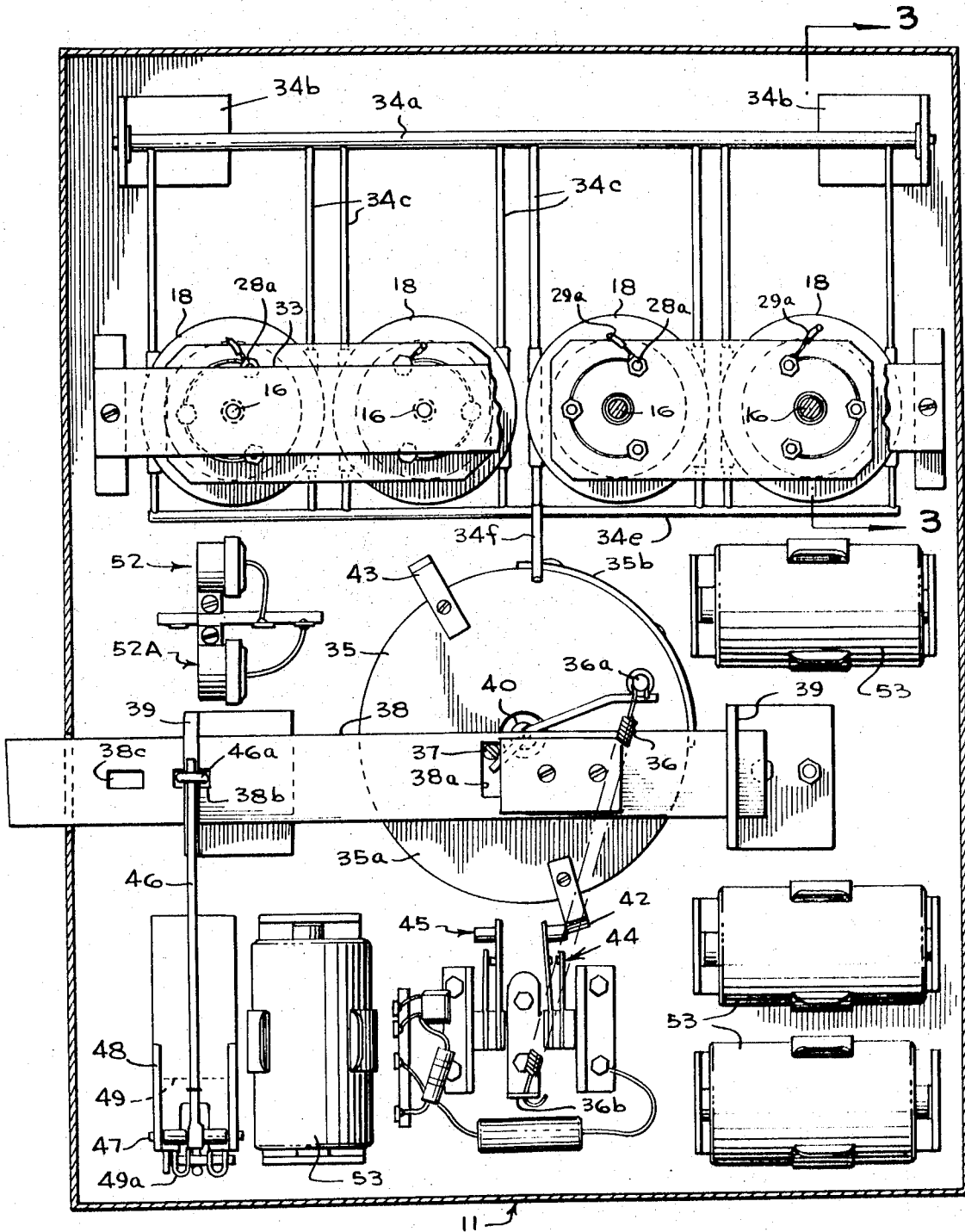
C. SUBIETA

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ELECTROMECHANICAL COMBINATION LOCK CONSTRUCTION

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4 Sheets-Sheet 2



INVENTOR

Fig-2

CARLOS SUBIETA

BY
Mason, Fenwick & Lawrence
ATTORNEYS

Dec. 7, 1971

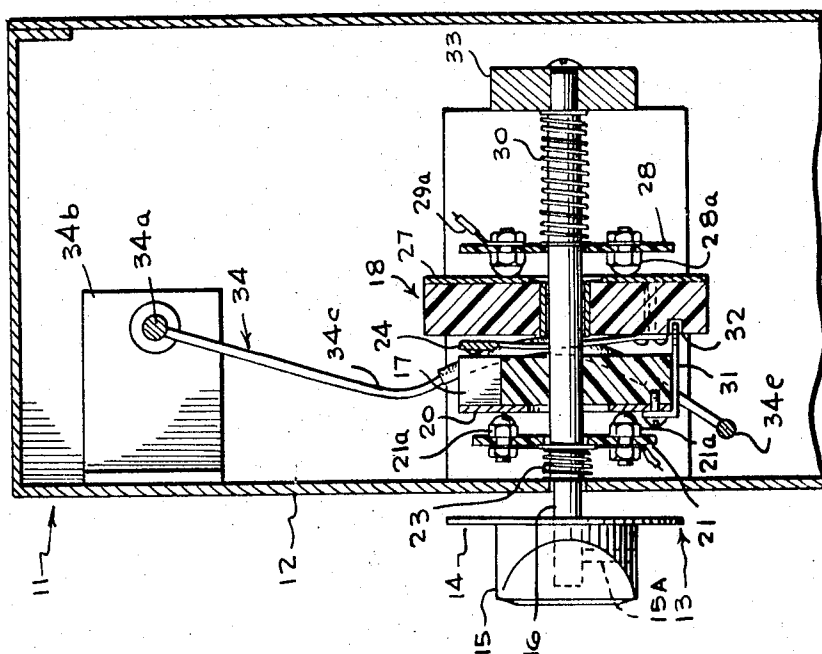
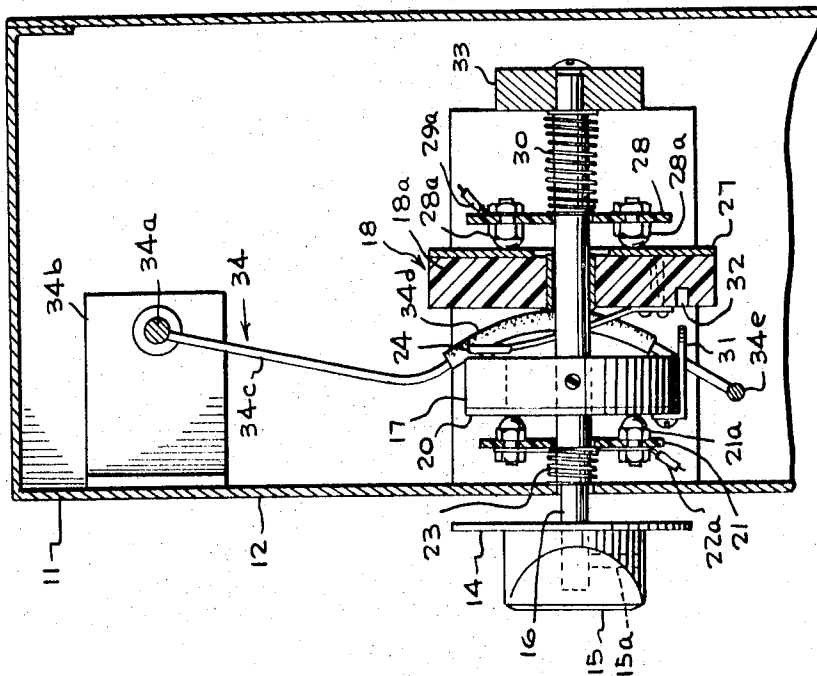
C. SUBIETA

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4 Sheets-Sheet 3



INVENTOR

CARLOS SUBIETA

BY
Mason, Fenwick & Lawrence
ATTORNEYS

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C. SUBIETA

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4 Sheets-Sheet 4

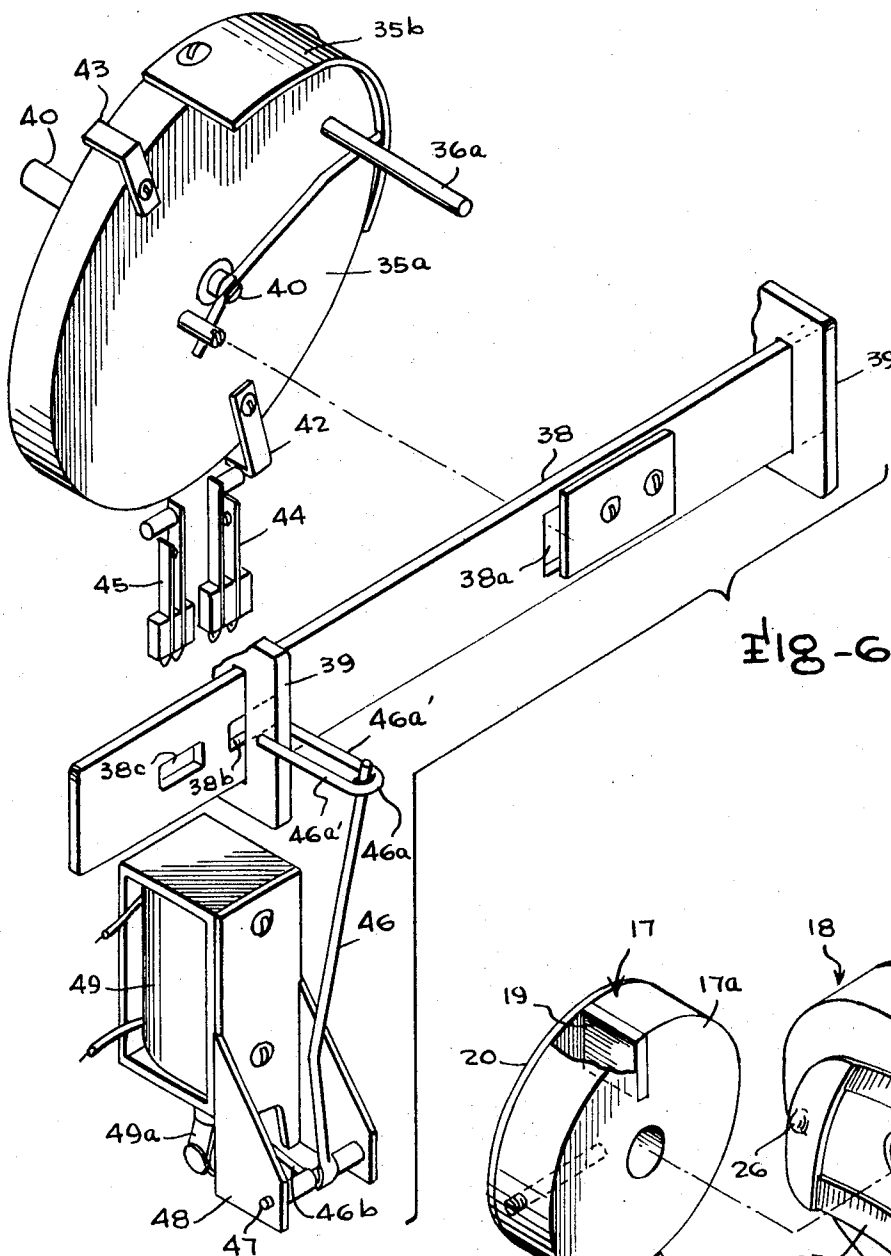


Fig-6

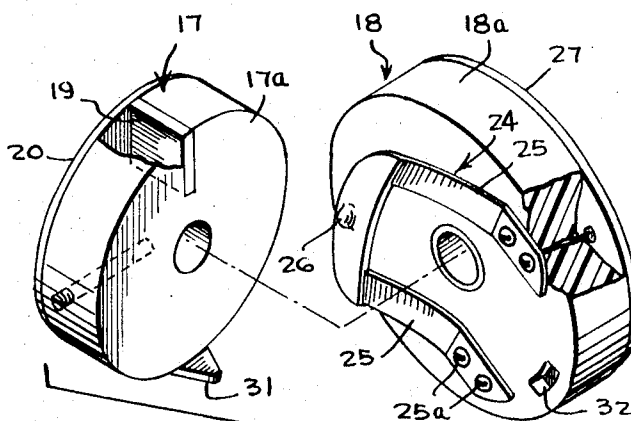


Fig-4

INVENTOR

CARLOS SUBIETA

BY
Mason, Fenwick & Lawrence
ATTORNEYS

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3,625,033

ELECTROMECHANICAL COMBINATION LOCK CONSTRUCTION

Carlos Subieta, Kensington, Md., assignor to Representation Unlimited, Washington, D.C.

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11 Claims

ABSTRACT OF THE DISCLOSURE

An electromechanical combination lock construction, formed of a plurality of dial assemblies having an exterior, manually rotatable dial and a shaft fixed thereto carrying a first wheel of insulating material which has a radial electrical contact formation at a particular angular position thereon, and another wheel member of insulating material which is movable between forward and rearward positions axially of the shaft and carries a spring contact member to engage the confronting face of the first mentioned wheel and close an electrical circuit with the contact formation on the first mentioned wheel at a particular angular position of the dial. An exposed lever, and a cam operated thereby, control certain limit switches and activate a device to mechanically couple the rear wheels with the front wheels for coordinate rotation when the lock is in unlocked condition and to shift the rear wheels to a decoupled relation to the front wheels when the lock is moved to locked condition. The lever and cam also control retracting and projecting movement of a bolt when the latter is released by establishing an electrical circuit upon dialing of the proper combination.

BACKGROUND AND OBJECTS OF THE INVENTION

The present invention relates in general to combination locking devices, and more particularly to an electromechanical combination lock construction wherein the combination of the lock is whatever combination the dials were standing on at the time the lock was last shifted to locked condition.

Heretofore, many combination lock structures have been made available, such as dial operated mechanical combination locks, dial operated or push button operated electrical combination locks, or various types of electromechanical combination locks. Many of these have had provision for changing the combination of the lock whenever the security closure on which the lock is mounted is in opened condition, usually by insertion of a combination change key in the lock housing after a particular change combination of numbers has been dialed, after which the dial or dials can be rotated to the new combination and the change key removed to set the new combination. It is desirable in many uses of combination locks for high security purposes, to be able to frequently change the lock combination, such as on a daily basis or even more often. The conventional lock constructions and combination change mechanisms heretofore available involved combination change procedures which are sufficiently complex to render them inconvenient for such frequent changing of the lock combination.

An object of the present invention is the provision of a novel electromechanical combination lock construction having a particularly simple means of changing the combination such that the combination may be readily changed any time the lock is in open or unlocked condition by rotating the dials to the new combination desired, and the new combination is automatically set when the lock is returned to locked condition.

Another object of the present invention is the provision of a novel combination lock construction as described in the preceding paragraph, wherein a plurality of independent rotatable dials, for example four dials, are provided to form the total combination, so that a plurality of dials must be independently and separately attacked to gain unauthorized entry.

Another object of the present invention is the provision of a combination lock construction as described in either of the two preceding paragraphs, which resist unauthorized detection of the combination through the use of listening devices, and which has relatively few components, facilitating reduced cost for mass production.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a front elevation view of an electromechanical combination lock construction embodying the present invention;

FIG. 2 is a rear elevation view, with the cover removed;

FIG. 3 is a vertical transverse section view taken along the line 3—3 of FIG. 2, showing the contact carrying wheels associated with one of the dials with the lock unit in unlocked condition;

FIG. 4 is an exploded perspective view of an associated pair of the contact carrying wheels;

FIG. 5 is a vertical transverse section view similar to FIG. 3, but showing the contact carrying wheels in the position assumed when the lock unit is in locked condition;

FIG. 6 is a perspective view of the opening cam showing the open and close limit switches and the wheel shifting bar assembly activated thereby; and

FIG. 7 is a schematic diagram of the electrical circuit of the lock.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings, wherein like reference characters designate corresponding parts throughout the several figures, the electromechanical lock of the present invention is indicated generally by the reference character 10 and includes a housing 11 of any desired construction, which preferably would have at least the front wall 12 thereof formed of hard plate material which is resistant to drilling. The housing 11 may, for example, have a removable rear cover plate 11a assembled to the remainder of the housing by any conventional means.

The basic operating elements of the lock assembly comprise a plurality of manually operable dial units, generally indicated by the reference character 13, four of which are provided in the illustrated embodiment and are designated by reference characters 13A to 13D. These dial units 13 include a disc-like dial 14 having graduations and numbers adjacent the circular periphery thereof and a knob 15 fixed thereto which may be of any desired form and is designed to facilitate manual rotation of the dial. It will be understood that any number of dial graduations may be employed on each dial, such as ten graduations, fifty graduations, or preferably 100 graduations. In the case of 100 dial graduations, if four dials are employed, 100 million possible combinations will be available for the lock. The dial assembly formed by the dial 14 and knob 15 of each dial unit is fixed to its respective shaft 16, which in the illustrated example is accomplished by a set screw 15a. The shaft 16 of each respective dial unit extends through the front wall of the lock housing, and through any safe or file cabinet

door or the like which may be interposed between the lock housing and the dials, and has a pair of wheel members 17 and 18 on each shaft 16 within the housing.

The forwardmost or front wheel members 17, which are of smaller diameter than the rear wheel members 18, are fastened or fixed to their respective shafts 16 in any desired manner, either by being keyed to the shaft, or secured by set screws, or press fitted on the shaft, or by any other known fastening means. These front wheels 17 are formed of a cylindrical wheel body portion 17a of electrically non-conductive or dielectric material which has a center opening for its shaft 16 and a radial cut extending from its periphery close to but spaced slightly from the center opening of the wheel. The radial cut is occupied by a thin conductive sheet or strip 19 forming an electrical contact strip shaped to provide a completely smooth even surface at the cylindrical periphery of the wheel and at the rear face of the wheel. The front face of the wheel member 17 is covered by a circular metallic sheet 20 which is fixed on the face of the nonconductive wheel portion by any suitable adhesive or bonding agent, and which is conductively joined to the radial thin conductive sheet 19. Forwardly, of the wheel member 17 between the wheel member and the front wall 12 is a fiber panel 21 having an opening through which the shaft 16 passes, forming a support for a pair of contacts 21a which are electrically connected together and to a wire conductor 22a and are in rubbing contact with the circular metallic sheet on the front face of the front wheel 17. In the embodiment illustrated, one fiber panel 21 is of sufficient length to span forwardly across two of the wheel members 17 associated with the first two dial units 13A and 13B, and another fiber panel 21 spans the front wheel members 17 associated with the dial units 13C and 13D and these panels are resiliently urged rearwardly toward their associated wheel members 17 by coil springs 23 surrounding the associated shafts 16 and compressed between the fiber panel 21 and the front wall 12 of the housing 11.

The rear wheel 18 is freely movable axially of its associated shaft 16 and also comprises a cylindrical non-conductive wheel body portion 18a, and has a substantially U-shaped contact support 24 formed of a spring sheet member fastened at the ends of its legs 25 to the wheel body portion 18a by screws 25a and having a contact such as a button or contact projection 26 supported on the bight or cross portion of the U-shaped spring contact support 24. The spring contact support 24 may be made of phosphorous bronze or similar spring sheet material and the legs curved outwardly somewhat as illustrated in FIGS. 3 and 5 to urge the contact member 26 into rubbing engagement with the rear face of the wheel body portion 17a of front wheels 17 so as to engage the radial conductor strip or sheet 19 when the wheel member 17 is at a particular angular position relative to the wheel member 18. The U-shaped spring contact support 24 is electrically connected by a wire extending through the wheel body portion 18a, for example from one of the mounting screws 25a, to an annular metallic sheet 27 fixed on the rear face of the wheel body portion 18a in a manner similar to the means for fixing the metallic sheet 20 on the wheel member 17. A rear fiber panel 28, similar to the front fiber panel 21, is provided for example, one panel of which spans across the wheel members 18 associated with the dial units 13A and 13B, and another panel 28 which spans the wheel members 18 associated with the dial units 13C and 13D. These fiber panels 28 carry a pair of forwardly projecting contacts 28a arranged diametrically of the associated shaft 16 to bear against and establish electric contact with the annular metallic sheet 27 of the associated wheel member 18, the two contacts 28a being electrically connected together and to a wire conductor 29a. The fiber panels 28 are apertured to receive the shafts 16 of each of the dial units therethrough, and

coil springs 30 surround each of the shafts and are compressed between the fiber panels 28 and a rear frame member 33 apertured to support the rear ends of the shafts 16 to continuously urge the fiber panels 28 forwardly.

Each of the front wheel members 17 carry a coupling pin or drive pin 31 at an eccentric position thereon which projects rearwardly toward the companion rear wheel member 18 and is normally seated in a socket 32 in the front face of the rear wheel member 18 when the rear wheel members 18 are in the forwardly disposed unlocking position illustrated in FIG. 3. Thus whenever the associated dial and the forward wheel member 17 and associated shaft 16 fixed relative to each other are rotated while the rear wheel member 18 is in the forward position illustrated in FIG. 3, the companion wheel members 17 and 18 of each dial unit will be intercoupled together by the coupling pin 31 and socket 32 and will be rotated in a coordinate manner. However, when the lock is shifted to a locked position, as illustrated in FIG. 5, the wheel members 18 are shifted rearwardly to decouple the pins 31 from the sockets 32 and render the wheels 17 and their associated shafts and dials rotatable independently of the associated rear wheel member 18. This is accomplished by means of a bar assembly 34 comprising, in the illustrated example, a horizontal pivot bar 34a supported in pivot brackets 34b fixed to the lock housing and having bar members 34c depending therefrom, if desired fastened together at their lower ends by another horizontal cross bar 34e, wherein the bar members 34c have portions which lie forwardly of the front faces of the rear wheel members 18 outwardly of the peripheries of the wheel members 17. These portions of the bar members 34c adjacent the front faces of the wheel members 18 may have frictional pad formations 34d, such as rubber pads, to engage diametrically opposite front face portions of the wheel members 18 when the bar assembly 34 is displaced rearwardly from its normal rearmost position. The lower or free end portion of the bar assembly 34, which is formed by the lower cross bar 34e in the illustrated embodiment, has a cam follower finger or tongue 34f projecting therefrom rearwardly lapping the peripheral portion of a rotatable control cam 35 journaled in the front wall of the lock housing below the bank of dial assemblies.

The control cam 35 in the illustrated embodiment is formed of a cylindrical body 35a which is resiliently biased to a first or counterclockwise limit position illustrated in FIG. 2 by a spring 36 extending between an anchor pin 36a on the cam body 35a and a stationary anchor 36b, and having a drive pin 37 extending rearwardly through a slot 38a in a bolt 38 guided for reciprocative movement between projected and retracted positions by guide brackets 39. A shaft 40 is fixed in relatively non-rotatable relation to the cylindrical body 35a of the control cam and projects to an exposed forward position where a control lever 41 is fixed to the forward end of the shaft. A cam strip 35b is fixed to the periphery of the cylindrical body 35a of the cam 35 along a portion of its circumferential extent and is positioned and shaped to engage the cam follower finger 34f of the bar assembly 34 and pivot the latter rearwardly during clockwise movement of the cam 35 to the locking position illustrated in FIG. 2, during which the pad formations 34d are brought into contact with the front faces of the rear wheel members 18 and shift them rearwardly along their associated shafts 16 while retaining them against rotation to decouple the sockets 32 from the coupling pins 31. During the opposite or counterclockwise rotation of the control cam 35 from the locking position of FIG. 2 to the unlocking position, the cam follower finger 34f rides off of the cam strip 35b permitting the bar assembly 34 to pivot forwardly to the position illustrated in FIG. 3, swinging the bar members 34c forwardly and allowing the rear wheel members 18 to be urged forwardly by the springs 30 to

again couple the sockets 32 and coupling pins 31. The control cam 35 also has a pair of abutments or projections 42 and 43 thereon to respectively activate first and second limit switches 44 and 45 as will be later described.

The bolt 38 has first and second pairs of locking slots 38b and 38c respectively positioned to lie immediately to opposite sides of the guide brackets 39a when the bolt is in locking and unlocking positions, to receive the ends of legs 46a' of a U-shaped staple member 46a fixed on the end of a pivoted lever 46. The lever 46 is fixed on the pivot pin 47 journaled in a supporting bracket 48 and has an angular extension 46b coupled to the plunger 49a of a solenoid unit 49.

The electrical circuit of the lock is illustrated schematically in FIG. 7, wherein the rotary switch is effectively formed by the companion pairs of wheel members 17 and 18 of the dial units 13A to 13D are indicated by reference characters S-A to S-D respectively. These rotary switches S-A to S-D are connected in series circuit relation, for example by connecting the wire 29a associated with the contacts 28a of the first dial unit 13A to the wire conductor 22a connected to the contacts 21a associated with the second dial assembly 13B, and similarly interconnecting the remaining dial units 13C and 13D to form the series rotary switch array. The wire conductor 22a associated with the first dial unit 13A is connected by a conductor 51 through the first and second limit switches 44 and 45 and diode 52, for example an IN3492 diode, to one terminal of a DC power source indicated schematically as battery 53. This may take the form of a plurality of series connected dry cell batteries of appropriate voltage rating, or mercury cells, or any other commercially available DC power source. The conductor 51 connected to the left hand end of the array of rotary switches S-A to S-D, as viewed in FIG. 7, is also connected by conductor 54 through a silicon controlled rectifier (SCR), to one end of the coil 49b of the solenoid 49 whose other end is connected to ground, a capacitor C1 being connected across the solenoid coil 49b. The gate of the silicon controlled rectifier is connected through a resistor R1 to the conductor 29a connected to the contacts 28a associated with the last dial assembly 13D.

When the proper combination has been dialed on the dials of all four dial units 13A to 13D, the contact 26 on the contact support spring member 24 carried by the wheel members 18 of each dial assembly will be in contact with the radial metallic strip or sheet 19 in each of the wheel members 17, completing the electrical circuit therebetween and effectively closing all four of the rotary switches S-A to S-D. The control cam 35 must then be rotated a few degrees from the closed position by operation of the control lever 41, rotating the cam counterclockwise as viewed in FIG. 2, to permit the limit switch 44 to close, whereupon, since the other limit switch 45 is already closed, battery voltage is applied through the closed rotary switches to the gate of the silicon controlled rectifier and is impressed upon closure of the limit switch 44 across the silicon controlled rectifier, turning the SCR on the allowing current to pass to the coil 49b of the opening solenoid 49. The solenoid is thus energized, retracting its plunger 49a, which swings the lever 46 rearwardly to withdraw the ends of the legs of staple member 46a from locking slots 38b in the bolt 38, whereupon the movement of the drive pin 37 on the control cam 35 in the slot 38a will retract the bolt 38 to unlocking position. Also, during the counterclockwise rotation of the control cam 35 to the unlocking limit position, the cam strip 35b was moved in such a way that progressively shallower portions engaged the cam follower finger 34f of the bar assembly 34, allowing the bar assembly 34 to pivot forwardly to the release position and consequently permitting the coil springs 30 to shift the fiber panels 28 and rear wheel members 18 forwardly to the positions shown in FIG. 3 to seat the coupling pins 31 in the sockets 32 so that the wheel members 17 and 18 are then inter-

coupled for coordinate rotation. Thus, when the lock is in this unlocked condition, the dials 14 can be rotated to new combination positions. Then, upon manipulating the control lever 41 to rotate the control cam 35 back to the locking position, in a clockwise direction as viewed in FIG. 2, the action of the cam strip 35b on the cam follower finger 34f will shift the bar assembly 34 rearwardly bringing the pad formations 34d into engagement with the front faces of the rear wheel members 18 and shifting them rearwardly along their shafts 16 a sufficient distance to decouple the pins 31 from the sockets 32 and leave the forward wheel members 17 free for independent rotary movement relative to the rear wheel members 18. The rear wheel members 18 are restrained against angular movement from the positions to which they were adjusted when the dials were rotated while the lock was open, because of the frictional engagement of the pad formations 34d against the faces of the wheel members 18.

It will be appreciated that the abutment 43 engaging the limit switch 45 at the end of the opening stroke of the control cam 35 opened the limit switch 45, deenergizing the solenoid coil 49b and releasing the lever 46 for spring return to latching relation with the bolt 38 wherein the ends of the staple 46a are inserted in the locking slots 38c. Also upon return movement of the control cam 35 in a clockwise direction to reclose the lock, the solenoid coil 49b is again energized to withdraw the latching staple 45a from the bolt locking slots as soon as the abutment 43 leaves the limit switch 45, and engagement of the abutment 42 with the limit switch 44 at the closed limit position of the control cam 35 again breaks the supply circuit to the solenoid coil 49b so that the spring 46a returns the lever 46 to the latching position.

To provide a means for opening the lock in the event of power failure of the batteries 53, another diode 52a is connected in parallel with the diode 52 to a lead 52a' which may terminate in a jack or contact on and insulated from the front wall, to the connected to an exterior DC source when needed to prevent a lockout.

What is claimed is:

1. An electromechanical combination lock comprising a plurality of rotatable dial assemblies forming rotary switch units to be angularly adjusted to various positions for dialing the combination of the lock; each dial assembly having a manually rotatable dial and a shaft rotated thereby, a first wheel member fixed on the shaft having a first electrically conductive contact at an eccentric location thereon, a second wheel member rotatably and axially movable relative to the shaft having a second electrically conductive contact carried at an eccentric location thereon to engage the first contact of the companion first wheel member at one angular position thereof during relative rotation of the wheel members; operating means including a manually operable member for shifting the lock between locked and unlocked conditions, means blocking said shifting except when said contacts of each of the respective dial assemblies are in engagement, coupling means for releasably coupling each second wheel member to its companion wheel member for coordinate rotation when the lock is in unlocked condition, and means for decoupling said wheel members from each other responsive to shifting of the lock to locked condition whereby the second wheel members remain at the angular positions which they last occupied when the lock is shifted from unlocked to locked condition.

2. An electromechanical combination lock as defined in claim 1, including a reciprocative bolt, said operating means including a rotatable cam having an eccentric pin for moving said bolt between locking and unlocking positions, and pivoted positioning means moved by said cam for moving said second wheel members axially away from the first wheel members during shifting of the lock to locked condition to decouple them and for releasing the second wheel members to coupled positions relative to the

7

first wheel members during shifting of the lock to unlocked condition.

3. An electromechanical combination lock as defined in claim 1, wherein said first wheel members are each formed of a cylindrical wheel body of electrically non-conductive material having a narrow radial cut there-
through spaced from said shaft and occupied by electrically conductive material terminating flush with the rear face of the wheel body and forming said first contact, an annular layer of electrically conductive material on the front face of the wheel body electrically connected with the material in said cut, and said lock including stationary contactors in continuous wiping engagement with the layer of conductive material during rotation of the first wheel members to continuously establish circuit connections from stationary conductors to the conductive material in said cuts.

4. An electromechanical combination lock as defined in claim 2, wherein said first wheel members are each formed of a cylindrical wheel body of electrically non-conductive material having a narrow radial cut there-
through spaced from said shaft and occupied by electrically conductive material terminating flush with the rear face of the wheel body and forming said first contact, an annular layer of electrically conductive material on the front face of the wheel body electrically connected with the material in said cut, and said lock including stationary contactors in continuous wiping engagement with the layer of conductive material during rotation of the first wheel members to continuously establish circuit connections from stationary conductors to the conductive material in said cuts.

5. An electromechanical combination lock as defined in claim 1, wherein said second wheel members are each formed of a cylindrical wheel body of electrically non-conductive material, a U-shaped electrically conductive spring member fastened at the free end portions of its legs to the wheel body and having a contact button carried on the bight portion of the spring member, said second wheel members being movable axially on their respective shafts from first positions closely adjacent and coupled to the companion first wheel members to second positions spaced and decoupled from the companion first wheel members, said spring members being shaped to continuously urge the buttons thereof into rubbing contact with the confronting rear face of the companion first wheel members at both said first and second positions of the second wheel members.

6. An electromechanical combination lock as defined in claim 2, wherein said second wheel members are each formed of a cylindrical wheel body of electrically non-conductive material, a U-shaped electrically conductive spring member fastened at the free end portions of its legs to the wheel body and having a contact button carried on the bight portion of the spring member, said second wheel members being movable axially on their respective shafts from first positions closely adjacent and coupled to the companion first wheel members to second positions spaced and decoupled from the companion first wheel members, said spring members being shaped to continuously urge the buttons thereof into rubbing contact with the confronting rear face of the companion first wheel members at both said first and second positions of the second wheel members.

7. An electromechanical combination lock as defined in claim 3, wherein said second wheel members are each formed of a cylindrical wheel body of electrically non-conductive material, a U-shaped electrically conductive spring member fastened at the free end portions of its legs to the wheel body and having a contact button carried on the bight portion of the spring member, said second wheel members being movable axially on their respective shafts from first positions closely adjacent and coupled to the companion first wheel members to second positions spaced and decoupled from the companion first

8

wheel members, said spring members being shaped to continuously urge the buttons thereof into rubbing contact with the confronting rear face of the companion first wheel members at both said first and second positions of the second wheel members, an annular layer of electrically conductive material on the rear face of the wheel body of each of said second wheel members electrically connected to said spring member, and rear stationary contactors in continuous wiping engagement with the layer of conductive material on said rear face to establish circuit connections from stationary conductors to said contact buttons.

8. An electromechanical combination lock as defined in claim 4, wherein said second wheel members are each formed of a cylindrical wheel body of electrically non-conductive material, a U-shaped electrically conductive spring member fastened at the free end portions of its legs to the wheel body and having a contact button carried on the bight portion of the spring member, said second wheel members being movably axially on their respective shafts from first positions closely adjacent and coupled to the companion first wheel members to second positions spaced and decoupled from the companion first wheel members, said spring members being shaped to continuously urge the buttons thereof into rubbing contact with the confronting rear face of the companion first wheel members at both said first and second positions of the second wheel members, an annular layer of electrically conductive material on the rear face of the wheel body of each of said second wheel members electrically connected to said spring member, and rear stationary contactors in continuous wiping engagement with the layer of conductive material on said rear face to establish circuit connections from stationary conductors to said contact buttons.

9. An electromechanical combination lock as defined in claim 2, wherein said second wheel members are of larger diameter than said first wheel members, said pivoted positioning means comprising a frame having a plurality of arms which forwardly lap peripheral portions of the front faces of said second wheel members projecting radially beyond the first wheel members, said arms being movable between forward positions spaced out of engagement with the second wheel members and rearward positions engaging and shifting the second wheel members to positions decoupling them from their companion first wheel members.

10. An electromechanical combination lock as defined in claim 8, wherein said second wheel members are of larger diameter than said first wheel members, said pivoted positioning means comprising a frame having a plurality of arms which forwardly lap peripheral portions of the front faces of said second wheel members projecting radially beyond the first wheel members, said arms being movable between forward positions spaced out of engagement with the second wheel members and rearward positions engaging and shifting the second wheel members to positions decoupling them from their companion first wheel members.

11. A combination lock comprising a plurality of rotatable dial assemblies forming rotary dial units to be angularly adjusted to various positions for dialing the combination of the lock; each dial assembly having a manually rotatable dial and a shaft rotated thereby, a first wheel member fixed on the shaft having a first lock releasing formation at an eccentric location thereon, a second wheel member rotatably and axially movable relative to the shaft having a second lock releasing formation carried at an eccentric location thereon to assume a selected position relative to the first releasing formation of the companion first wheel member for establishing a release condition of the wheel members of the dial assembly at one angular position thereof during relative rotation of the wheel members; operating means including

9

a manually operable member for shifting the lock between locked and unlocked conditions when said first and second lock releasing formations of each of the respective dial assemblies assume said release condition, means for preventing actuation of said operating means to shift the lock to unlocked condition when the wheel members of any of said dial assemblies do not occupy said release condition, coupling means active only when the lock is in unlocked condition for releasibly coupling each said second wheel member to its companion wheel member for coordinated rotation, and means for decoupling said wheel members from each other responsive to shutting of the lock to locked condition whereby the second wheel members remain at the angular positions

10

which they last occupied when the lock is shifted from unlocked to locked condition thereby establishing the combination which must be dialed to reopen the lock.

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U.S. Cl. X.R.

70—315; 200—43