United States Patent

Isserstedt

[15] **3,654,522**

[45] **Apr. 4, 1972**

[54] SECURITY CONTROL DEVICE

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[22] Filed: **July 9, 1970**

[21] Appl. No.: **53,643**

Related U.S. Application Data

[63] Continuation of Ser. No. 693,039, Nov. 28, 1967, abandoned, which is a continuation-in-part of Ser. No. 533,682, Mar. 11, 1966, abandoned.

[52] **U.S. Cl.** .....**317/134,** 340/149 A, 70/277

[51] **Int. Cl.** .....**H04q** , H01h 47/00

[58] **Field of Search** .....317/134; 340/149 R, 149 A; 70/277, 278

[56] **References Cited**

UNITED STATES PATENTS

3,450,953	6/1969	Gardner	317/134
3,154,761	10/1964	O'Gorman	340/149
3,299,298	1/1967	Schinner	307/113
3,340,409	9/1967	Probert et al.	307/115
3,401,830	9/1968	Mathews	221/2
3,403,380	9/1968	Welch	340/149

FOREIGN PATENTS OR APPLICATIONS

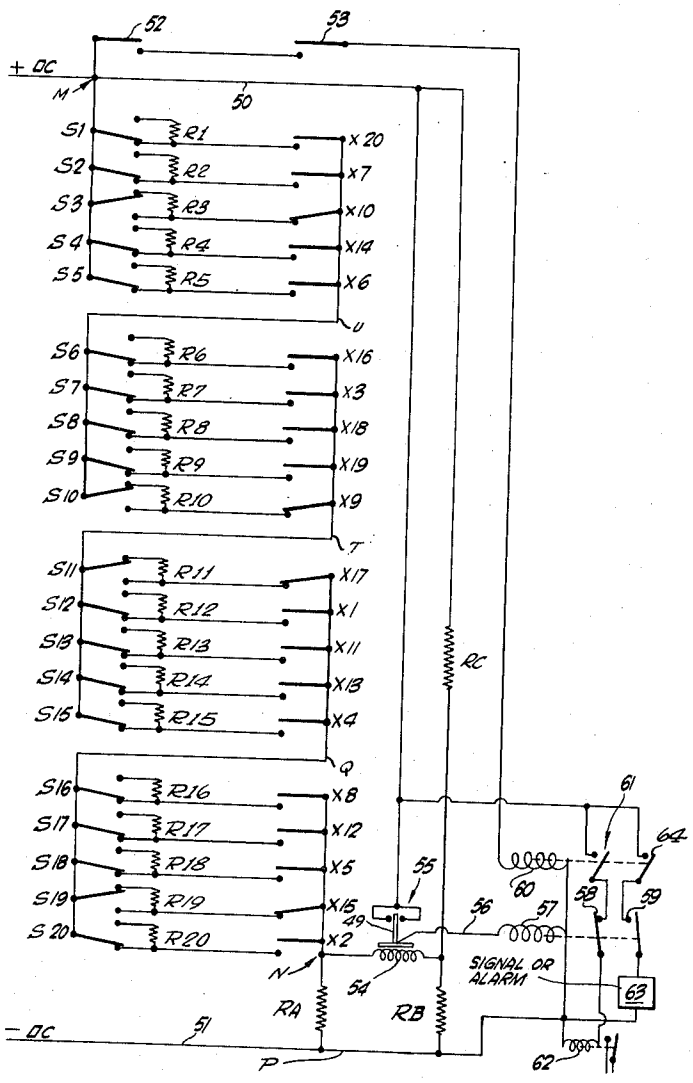
687,569	5/1964	Canada	194/CP

Primary Examiner—L. T. Hix
Attorney—Smart & Biggar

[57] **ABSTRACT**

A circuit switched from a first state to a second state only when a correct combination of switches in the circuit are actuated, and a series of unique mating arrangements of switch selectors for actuating a correct combination of switches, the circuit being switched to its second state only when a mating arrangement of switch selectors on a pair of security devices such as punched or embossed credit cards, keys, dial combinations or the like is sensed, and preferably giving a warning signal when a non-mating arrangement is sensed. A multiplicity of different combinations of mating pairs of security devices is possible, enabling identification of each individual user of the circuit.

23 Claims, 21 Drawing Figures



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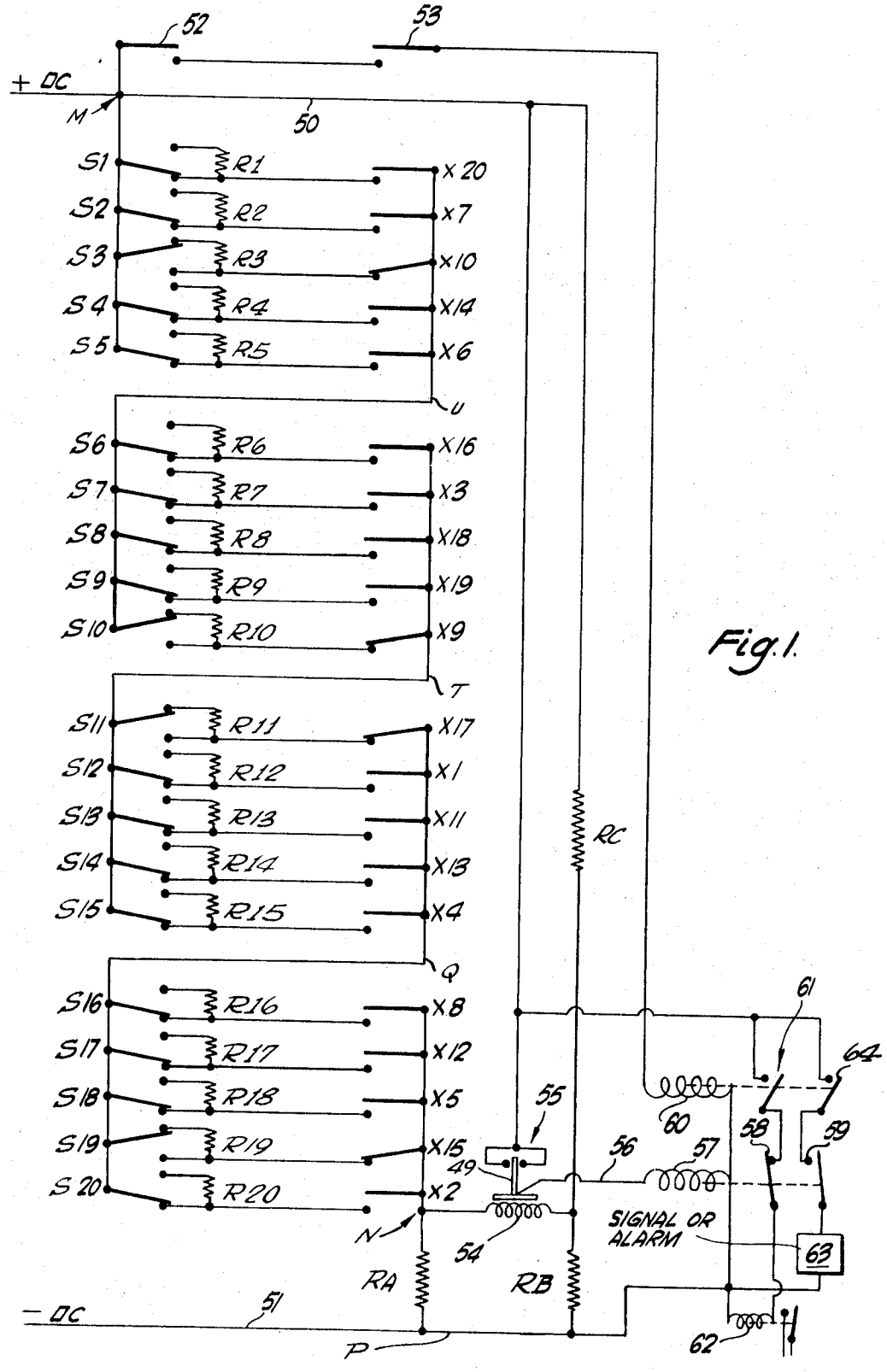


Fig. 1.

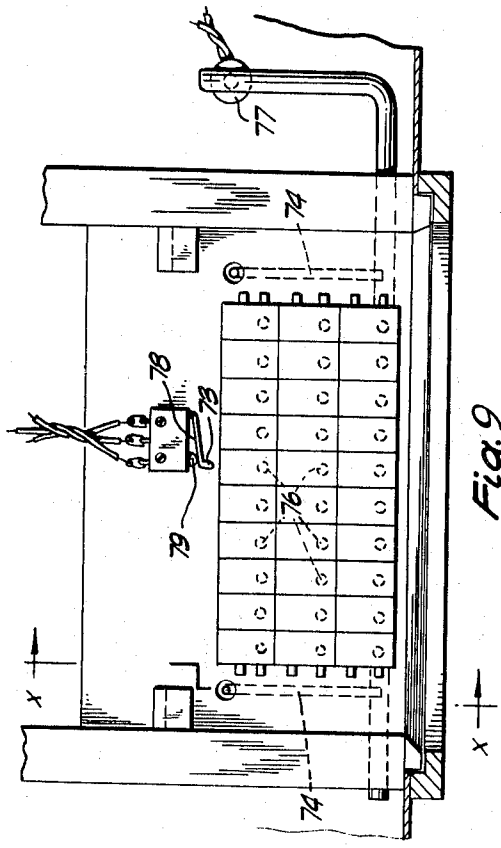


Fig. 9

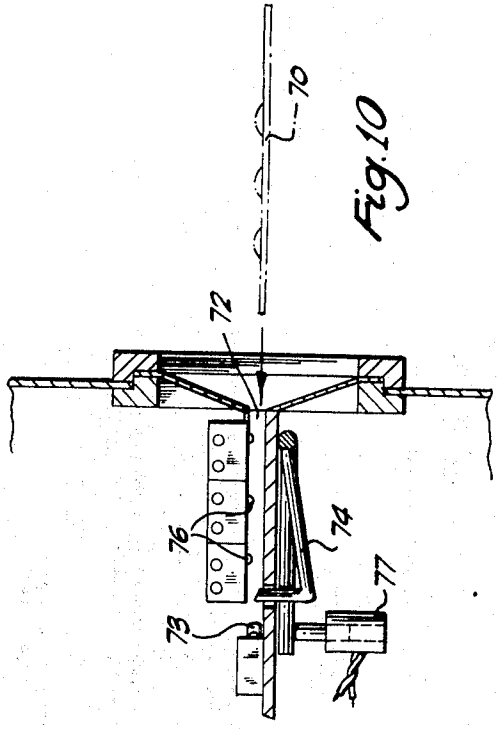


Fig. 10

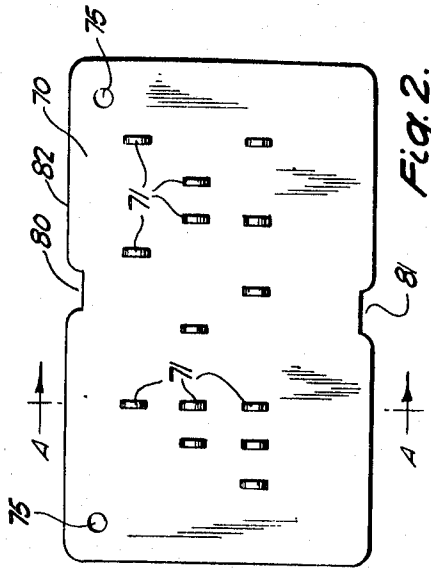


Fig. 2.

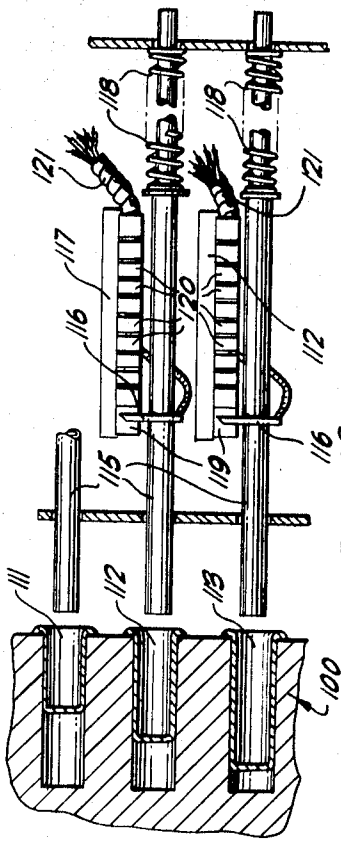


Fig. 13



Fig. 2A

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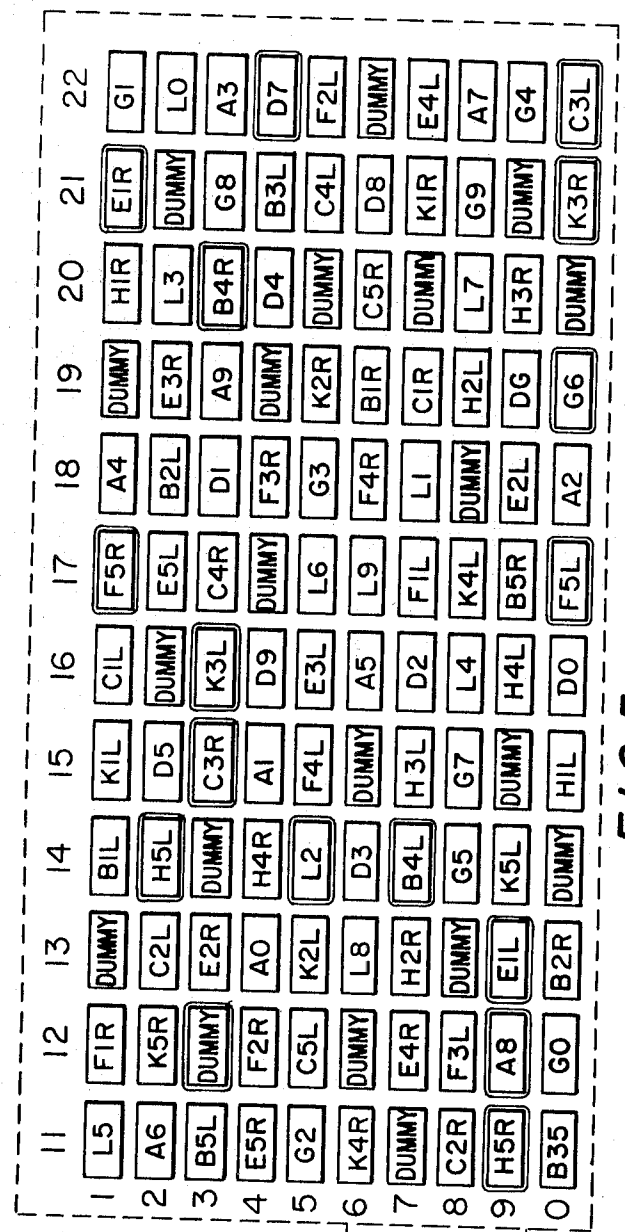


FIG. 5

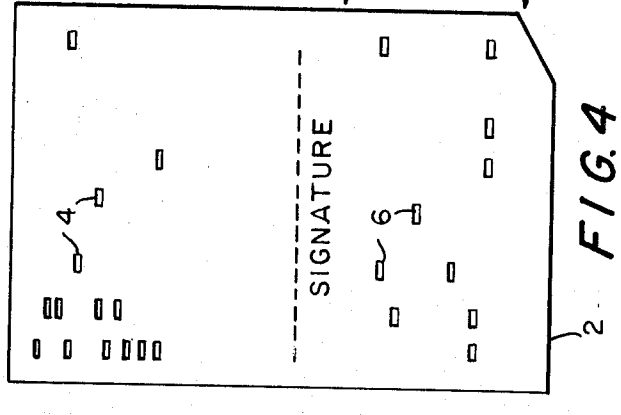


FIG. 4

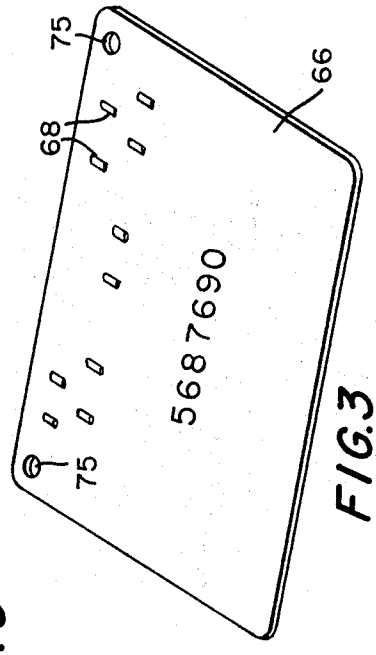


FIG. 3

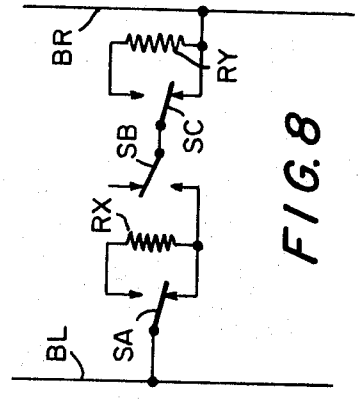


FIG. 8

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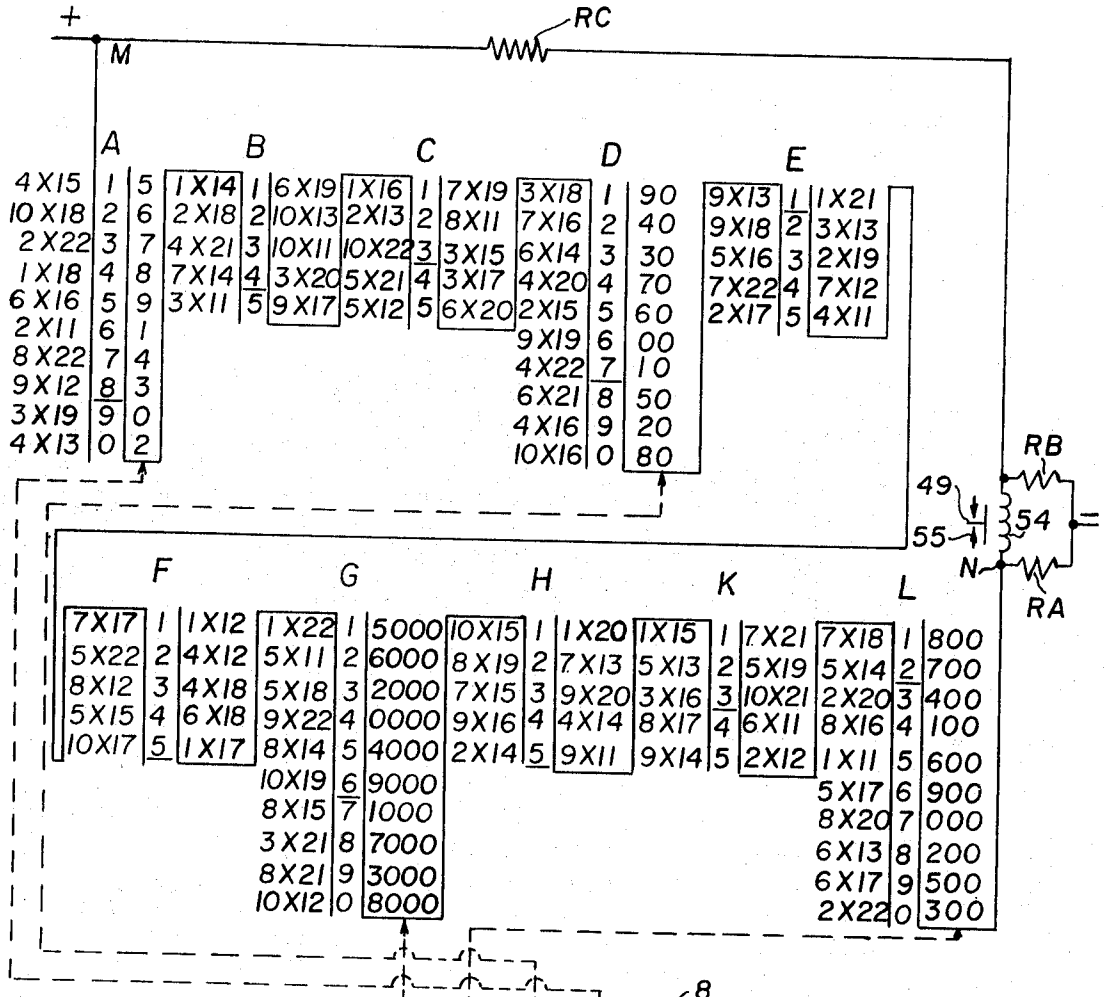


FIG. 6

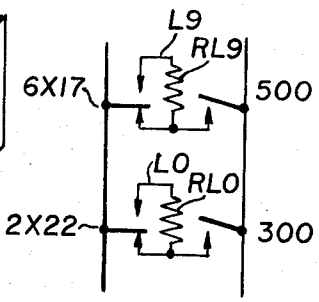


FIG. 6A

1	G7	L4	D7	A6 1
2	G3	L8	D9	A0 2
3	G9	L0	D3	A8 3
4	G5	L3	D2	A7 4
5	G1	L9	D8	A1 5
6	G2	L5	D5	A3 6
7	G8	L2	D4	A2 7
8	G0	L1	D0	A4 8
9	G6	L6	D1	A5 9
0	G4	L7	D6	A9 0

CODE FOR CUSTOMERS NUMBERS

FIG. 7

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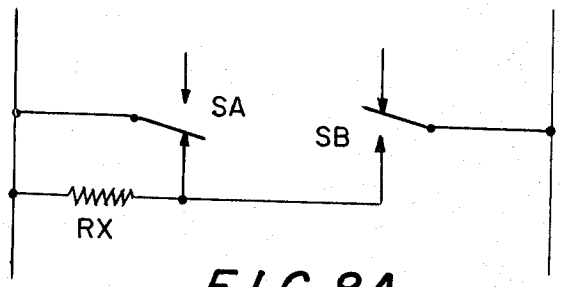


FIG. 8A

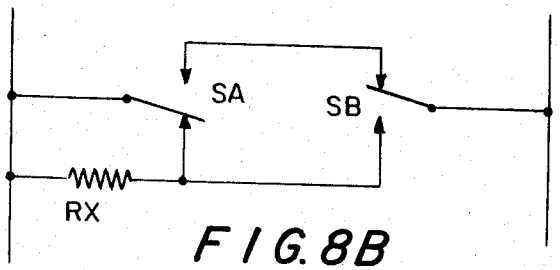


FIG. 8B

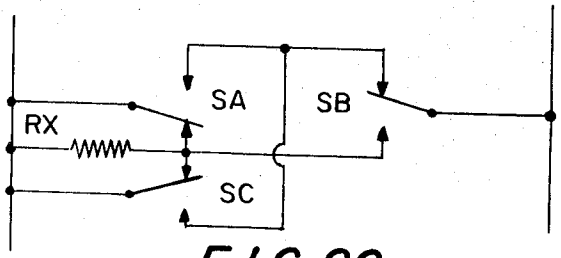


FIG. 8C

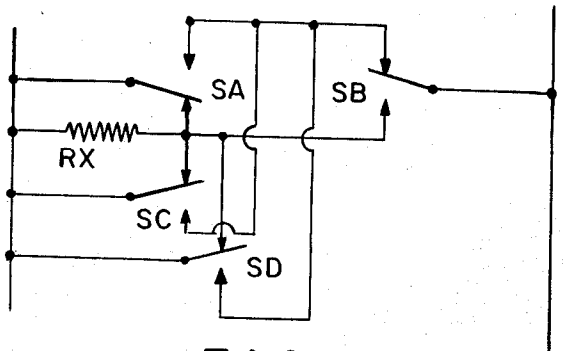


FIG. 8D

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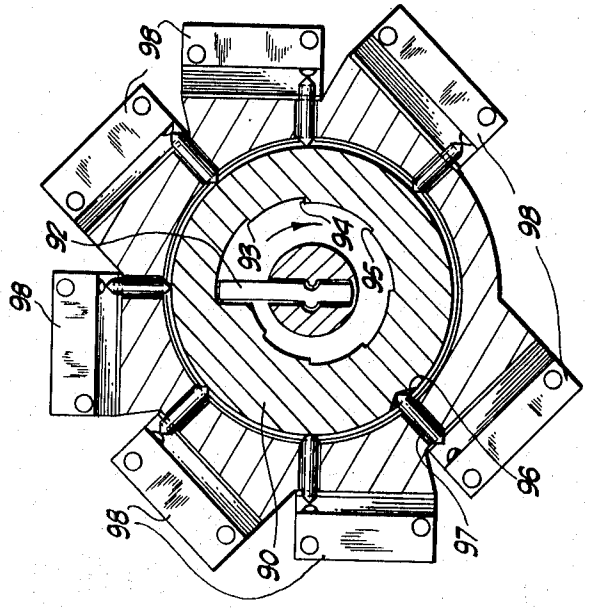


Fig. 12

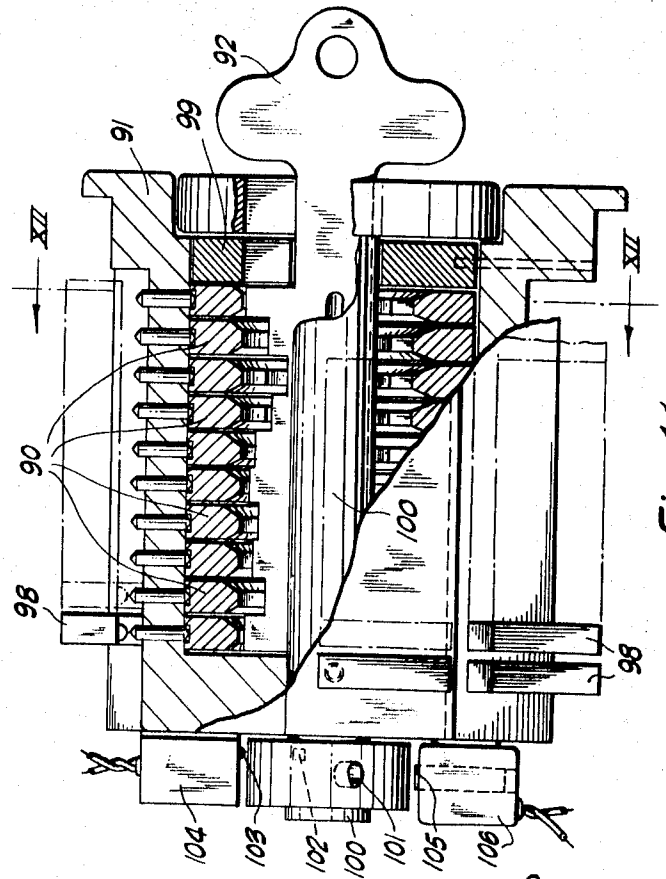


Fig. 11

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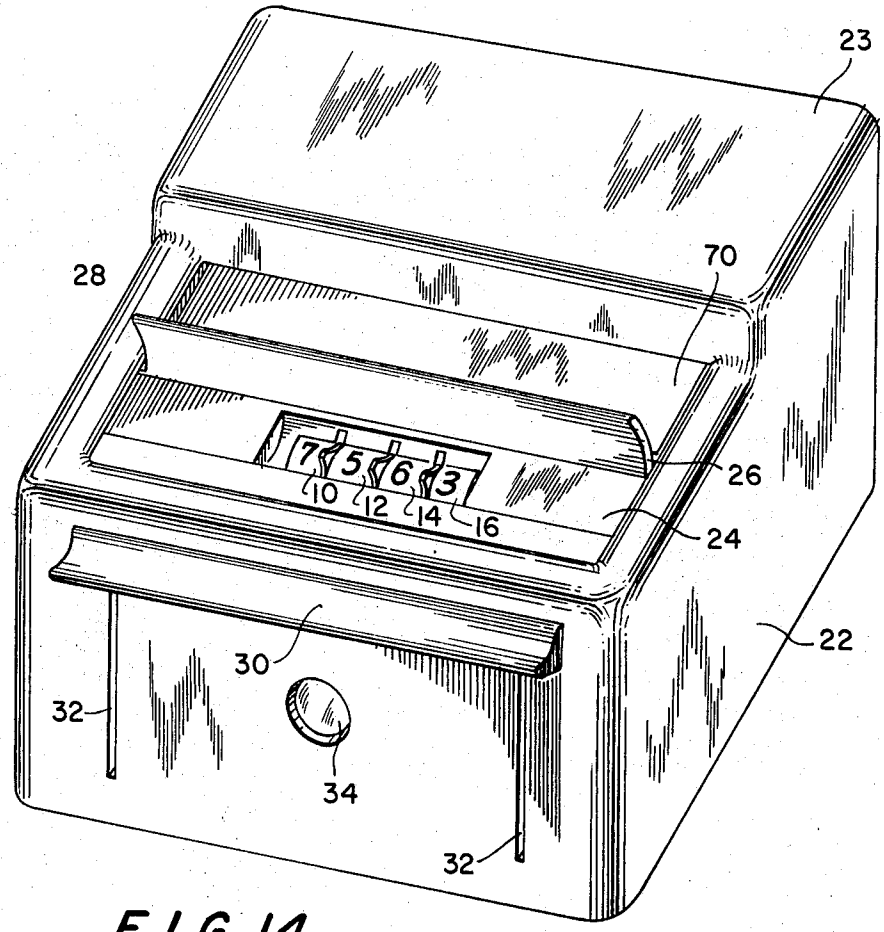


FIG. 14

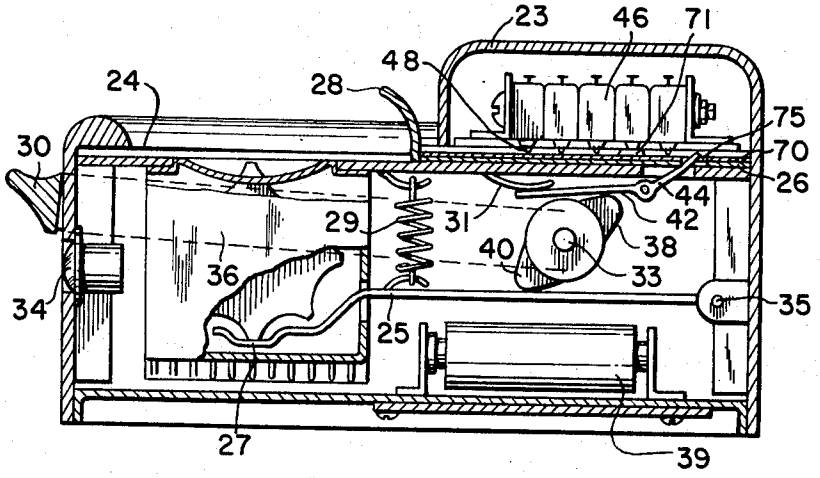


FIG. 15

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SECURITY CONTROL DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a security control system. The present application is a continuation of application Ser. No. 693,039 filed Nov. 28, 1967, now abandoned, which was a continuation-in-part of application Ser. No. 533,682 filed Mar. 11, 1966, now abandoned.

The system according to the invention is particularly adapted for the control of actuation mechanisms such as those for vending machines, security door locks, security deposit boxes and other mechanisms which it is intended should be capable of actuation only by a selected group of ascertained people. It may, for example, be used in conjunction with the vending apparatus described in applicant's U.S. Pat. No. 3,491,870 issued Jan. 27, 1970.

An object of the present invention is to provide a security control system that requires at least two separate mating security devices to be sensed in order to provide security clearance. This feature is intended to avoid security clearance of an unauthorized person who has obtained one of the security devices.

One of the objects of the present invention is to provide a security control device of the above character in which the degree of security obtained is independent of the number of individuals within the selected group of ascertained people.

A further object of the invention is to provide a security control system which can be operated by a multitude of individuals each having mating security devices which are different for each individual (thus enabling the identification of any individual who has obtained security clearance).

Another object of the invention is to provide such a security control system for use with a recording device which is adapted to provide and store a record of each person who actuates the controlled machinery so that, for example in the case of the device being used in connection with a security lock controlling night-time access to a building, the record would show the times of entry and departure and identity of each person having access to the building during the night.

A further object of the invention is to provide such a security control system which may readily be associated with printing means whereby the details of other information related to the actuation of the control mechanism may be recorded and stored. For example, when the device of the invention is associated with a vending machine, such additional information could take the form of invoice information related to the purchase made by the user of the vending machine.

SUMMARY OF THE INVENTION

According to the invention, there are provided at least two security devices, at least one of which is preferably a small portable device, for each person within the ascertained group. These portable devices may be in the form of keys, punched or embossed cards, for example. One of the security devices may be accessible to all of the ascertained group and may be for example, a thumbwheel switch capable of different switch positioning patterns (one for each person) as will be hereinafter described. Each of the security devices (of any one type) is provided with a unique arrangement of switch selectors, each of which is adapted upon sensing of the security device, for example by insertion of the security device in a receptacle associated with the controlled machinery, to actuate a corresponding switch so that each security device when so sensed will operate a pre-selected pattern of such switches. There may be associated with one or more of such security devices means for pre-setting information to be sensed by sensing means associated with the controlled machine.

According to a preferred embodiment of the invention, the switches actuated by the switch selectors of the security devices are associated with fixed resistors selectable connectable into the variable arm of a Wheatstone bridge. When the bridge is balanced, security clearance results. The switch selector-switch correspondence is such that balancing of the bridge occurs only when mating switch selector arrangements are sensed. Thus an authorized vending machine customer (say) may insert his own personal credit card (say) into an appropriate card senser, which actuates those switches corresponding to the unique pattern of switch selectors (embossments, for example) on the credit card. The other security device may be, for example, a thumbwheel switch at the vending machine, which is set by the customer to the customer's unique, remembered code number, thereby actuating other of the switches. Since the customer's remembered code number is preselected to mate with his credit card switch selector pattern, the switch selectors of the thumbwheel switch combine with the switch selectors of the credit card to actuate a correct combination of switches introducing that resistance into the variable arm of the bridge required to balance the bridge, permitting the vending machine to operate. If the thumbwheel switch setting does not mate with the credit card, the bridge is unbalanced, the vending machine does not operate, and means may be provided to produce a warning signal in this situation.

While in the foregoing a Wheatstone bridge has been specifically mentioned and mention has been made of connecting a number of fixed resistances in the variable arm of such bridge, it will be appreciated that any electrical network which functions in a manner similar to a Wheatstone bridge may be similarly adapted to carry out the present invention. Furthermore, it is not necessary that the fixed resistances or the equivalent which are connected by the sensing of the switch selectors be inserted only in one arm of the bridge (referred to for convenience as the "variable arm") since it is obvious that the purposes of the invention can be accomplished equally well by inserting fixed resistances in several or all of the arms. The essential feature of the invention is that mating arrangements of switch selectors of mating security devices be such that when the switches which correspond to them are actuated, the responsive circuit including such switches will be in a predetermined stable state that cannot be achieved by the sensing of only one security device or of non-mating arrangements of switch selectors. For simplicity of explanation, however, the invention is herein described in relation to a Wheatstone bridge circuit with a variable arm in which the fixed resistances controlled by the switch selectors are connected or disconnected.

The security of the system according to a preferred embodiment of the invention depends upon the ratio of the number of fixed resistors to the number which must be connected in order to cause the actuation of the controlled machine, and the manner in which the fixed resistors are grouped.

The switches which are actuated by the switch selectors are associated with fixed resistors which are arranged in parallel in a plurality of series-connected groups in the variable arm of a Wheatstone bridge. The fixed resistors within each group are so connected that one of the switches, when actuated by a switch selector on one of said security devices, effects connection between one group bus and one end of a fixed resistor, while a mating switch selector on the same or the other security device controls a switch which in its actuated state connects the other bus of the group to the other end of said fixed resistor thus connecting it between the buses, and while in its rest state connects the bus to the same end of said fixed resistor (thus shorting the two buses if it is at rest while its mating switch is actuated).

As mentioned previously, it is not necessary that the fixed resistors be connected or disconnected only in the one arm of the bridge and consequently the groups of fixed resistors mentioned in the preceding paragraph may be situated either all in the one arm of the bridge or in several or all of the arms.

The Wheatstone bridge is so arranged that it is balanced or has a predetermined output voltage across its central leg when only one fixed resistor in each group of fixed resistors is connected between the buses of each group, and all other fixed resistors are disconnected. If, for example, there are three groups, and if the value of one fixed resistor is R ohms, the

necessary total value of the variable arm to balance the bridge will be 3 R ohms. Within the groups, the fixed resistors are arranged for parallel connection between the buses, so that if two fixed resistors are connected between the buses of one group, the value of the group will be one-half R ohms. If any two switches associated with a particular resistor short the buses of that group, the effective resistance of that group becomes zero ohms. Thus, it will be seen that unless the condition is met that only one fixed resistor in each group is connected between the buses of that group, and all other resistors are disconnected the closest that the total value of the variable arm can come to 3 R ohms is 2.5 R ohms where two groups meets the condition and one group has two fixed resistors connected between its buses.

Taking a simple case where there are three groups of three fixed resistors, it can easily be calculated that there are 27 different combinations of switch selectors on two security devices that would connect one resistor between the buses of each group, and thus a group of 27 individuals could each have a different mating pair of switch selector arrangements which would actuate the controlled machine.

The degree of security obtained, however, is much higher, and can be appreciated by assuming that a lock picker had found a security device which connects one end of one resistor in each group to one of its associated buses, and now tries to operate the right switchs to connect these three resistors to the other associated buses, without connecting any other resistors between the buses and without shorting the buses of any group.

Firstly, he would have to know that the resistors were divided into three groups since obviously if less or more than three switches are made the circuit will not operate. There are 84 possible combinations of three groups of three switches each. Of these, it would be necessary for him to select the only one that would not open circuit or short two buses so as to (say) set off the alarm. In other words, even with one of a mating pair of security devices in his hands, and knowledge that there were three groups of three resistances, the lock-picker would have only one chance in 84 of operating the controlled machine, and 83 chances out of 84 of being apprehended.

Mathematically the maximum size of the ascertained group who can be given different pairs of control members which will operate the controlled machine can be expressed as N^r where N is the total number of fixed resistors in each group and r is the total number of groups. Thus, where there are ten groups of seven resistances each, the maximum size of the group becomes 7^{10} or 282,475,249.

The total number of possible combinations of r groups of N resistances each is given by the formula

$$\frac{N!}{r!(N-r)!}$$

which for seven groups of 10 resistances =

$$70\,!/10\,!\,60\,! = 396{,}704{,}524{,}216$$

The security can be increased still further by having a number of "dummy" switch selectors on the security devices.

The security is increased by the fact that the sensing device may be designed to lock onto at least one of the security devices when it is sensed and to release the security device only after actuation of the controlled machine, for example. Thus, if a non-mating pair of security devices are sensed and the alarm system sounds, at least one of the security devices remains locked in receptacles of the sensing device until released by the security personnel in charge of the machine. With this embodiment, then, there is no possibility of an unauthorized actuation of the machine being accomplished by trail and error means as can be done with an ordinary mechanical lock.

Instead of having two security devices, the approved personnel may carry only one security device for insertion into a receptacle and may be given a number to remember. In place of a second portable security device, there may be a second security device in the form of a push-button keyboard or thumbwheel switch by means of which the personnel actuate one set of switches simply by setting the remembered number on the second security device before inserting their portable security device in its receptacle on the sensing device.

SUMMARY OF THE DRAWINGS

The security control device of the invention will be further understood from the following detailed description of a number of embodiments thereof taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a simplified schematic drawing of a Wheatstone bridge circuit illustrating the principle upon which the fixed resistances are switched in and out of the variable arm thereof;

FIG. 2 is a plan view of a security device in the form of an embossed plastic card;

FIG. 2A is a cross-section taken along the plane A—A of FIG. 2;

FIG. 3 is a plan view of a security device in the form of a perforated plastic card;

FIG. 4 is a plan view of a security device in the form of a standard size punch card bearing pre-punched information;

FIG. 5 is a chart showing the interrelationship of the pre-punched hole pattern on the card of FIG. 4 and the switch arrangement of FIG. 6;

FIG. 6 is a simplified schematic circuit diagram illustrating switching circuits of a type appropriate for use with the pre-punched card of FIG. 4 and a remembered code number to which a thumbwheel switch can be set;

FIG. 6A is a detail circuit diagram showing in greater detail an exemplary pair of switching units from the circuit of FIG. 6;

FIG. 7 is a chart showing the interrelationship of the thumbwheel switch settings to the switch arrangement of FIG. 6;

FIGS. 8, 8A, 8B, 8C and 8D are circuit diagrams of alternative switching unit designs;

FIG. 9 is a cut-away plan view view of a receptacle for the plastic card shown in FIG. 2;

FIG. 10 is a vertical cross-section of the receptacle shown in FIG. 9 taken along the plane X—X;

FIG. 11 is a side view partly in section illustrating the use of a key as a security device showing the key in position in a suitable receptacle;

FIG. 12 is a cross-section taken along the plane XII—XII of FIG. 11;

FIG. 13 is a fragmentary view of an alternative form of control member wherein the control elements are eyelets of predetermined depth;

FIG. 14 is a perspective view of a device for sensing an identification card and correlating it with a code number, constructed according to the invention;

FIG. 15 is a side elevation view partially in section, of the device of FIG. 14.

DESCRIPTION OF PREFERRED EMBODIMENTS WITH REFERENCE TO THE DRAWINGS

FIG. 1 illustrates in a schematic form the electric circuity relating to one specific embodiment of security control apparatus according to the invention.

In FIG. 1, a Wheatstone bridge can be seen whose arms are formed by resistors RA, RB, RC and the switches and resistors located electrically between the points M and N. The DC voltage to the bridge is applied across points M and P, and the central leg of the bridge comprises the coil **54** of a polarized relay **55**. The armature **49** of the relay **55** is normally in mid position between its two associated contacts when no current is flowing in the coil **54**. If current flows in the coil **54**, the armature **49** moves into contact with one of its associated contacts and a circuit is made through the relay **55** via armature **49**, lead **56** and relay coil **57** from positive bus **50** to negative bus **51**.

Let it be assumed, as an example, that the security control device of FIG. 1 is being used in a vending machine. To this end, a relay 62 is provided to initiate the vending operation. If current flows through the coil of the relay 62, its associated contacts will be closed to actuate the vending operation, which need not be further described for the purposes of the present description. All that is desired is that no current should flow through the coil of relay 62 unless the security control apparatus responds to a correct combination of security devices.

It may be further desired that a signal or alarm device 63 be actuated if an incorrect combination of security devices is used by a customer or an unauthorized person. Accordingly, it is desired that current flow through the signal or alarm device 63 only if an incorrect combination of security devices is utilized, or if the switches and resistances in the variable arm of the Wheatstone bridge are in some manner tampered with.

Sensing of the appropriate security devices by corresponding sensing apparatus (not shown in FIG. 1) results in the closing of switches 52 and 53, each corresponding to the insertion of one of the security devices into a corresponding receptacle of the sensing apparatus, thereby completing a circuit to relay coil 60. (Of course, in some applications one or both switches 52, 53 may preferably be replaced by a closed circuit). The coil 60 cooperates with delayed-action contacts 61 and 64 to close the contacts after an appropriate delay interval which permits the transients that may occur during initial switching of the switches of FIG. 1 to become dissipated so that a false alarm which might be caused by such transients will not occur. When the contacts 61 and 64 close, a circuit can be made from positive bus 50 to negative bus 51 either through alarm device 63 or through vending operation control coil 62 depending upon which of the two sets of contacts 58 and 59 is closed. If no current is flowing through coil 54, this implies that a correct combination of security devices has been sensed and accordingly the switch 58 will be closed, permitting current to flow through coil 62 thereby initiating the vending operation. If, on the other hand, the bridge is unbalanced because of an incorrect combination of security devices having been sensed, or for any other reason, the bridge will permit current to flow through coil 54, thus biasing armature 49 into contact with one of the two contacts from which it can draw current from positive bus 50, thereby actuating relay coil 57 and pulling contacts 58 and 59 to the left, in which position contacts 58 are open and contacts 59 are closed. Thus, in this circumstance, once contacts 61 and 64 close in response to current flow through coil 60, the alarm device 63 is actuated.

Returning to a consideration of the Wheatstone bridge, the resistors RA, RB and RC are conveniently of equal resistance, and the relay 55 is designed to permit the vending operation to occur only when no current flow through relay coil 54, i.e. when the bridge is balanced. This means that between the points M and N, there must be switched in a resistance that is equal to that of resistor RC.

It will be observed that the resistors and switches between the points M and N are arranged by way of example, in four groups of five. Switches S1 to S5, resistors R1 to R5, and (arbitrarily) switches X6, X7, X10, X14 and X20 are in the first (uppermost) group of switches and resistors, between the points M and U. The switches S6 to S10 and resistors R6 to R10 are included in the second group between points U and T, and additionally (again arbitrarily) switches X3, X9, X16, X18 and X19 are in this group. In the third group, between points T and Q, switches S11 to S15, resistors R11 to R15, and (again arbitrarily) switches X1, X4, X11, X13 and X17 are present. In the last group between the points Q and N, switches S16 to S20 and resistors R16 to R20 are present, in addition to switches X2, X5, X8, X12 and X15.

The irregular numbering of the right hand series of switches is intended to illustrate that the physical arrangement of the switch selectors for the left hand group of switches and the right hand group of switches need not correspond. Indeed, in a practical device, it is desired that they should not correspond, so that a counterfeiter who is in possession of a customer's security device will not be able to devise a counterfeit of the mating security device which would enable him to actuate the vending machine.

Conveniently, each of the resistors R1 to R20 is of equal value and is equal to one-fourth of the resistance of resistor RC. While the arm MN could include a fixed resistance it need not have any significant fixed resistance and in the example being considered it is assumed to have zero fixed resistance. Accordingly, in order to have the Wheatstone bridge balanced, it is necessary to switch in to arm MN of the bridge one resistor from each of the four groups of resistors. It will be understood of course that the arrangement of four groups of five resistors is exemplary only and any desired plurality of groups including any desired plurality of resistors per group could be used instead, provided the sum of the resistances is equal to the resistance of resistor RC when a correct combination of security devices is sensed.

In the Example of FIG. 1, the correct combination of security devices is illustrated as being one that actuates switches S3, S10, S11 and S19 connected to the left hand group buses of the Figure, and X9, X10, X15 and X17 connected to the right hand group buses. Thus, in the first group of resistors, between points M and U, resistor R3 is switched in. In the second group, between points U and T, resistor R10 is switched in. In the third group, between points T and Q, resistor R11 is switched in. In the fourth group, between points Q and N, resistor R19 is switched in. The total resistance of the four switched-in resistors is of course equal to the resistance of resistor RC, and therefore the bridge is balanced.

The switches S1 to S20, X1 to X20 and the resistors R1 to R20 may be regarded as forming 20 switching units, shown in a vertical array in FIG. 1, each comprising one of the switches S1 to S20, a corresponding one of the switches X1 to X20, and the corresponding resistor interposed between the two. Thus, for example, the upper most switching unit comprises switch S1, resistor R1, and switch X20. Each switching unit has a rest state, in which the left hand switch is connected to the lower terminal of its associated resistor, and the right hand switch is disconnected from the resistor. Each switching unit has an actuated state, in which the left hand switch is connected to the upper terminal of its associated resistor, and the right hand switch is connected to the resistor, thereby to connect the resistor between the left and right buses of its group. The switches are normally in their rest state, and only those that correspond to sensed switch selectors are actuated.

In FIG. 1, the switches S1 to S20 and X1 to X20 between points M and N are shown in the positions they would occupy when two security devices having mating arrangements of switch selectors are sensed. However, the other switches of FIG. 1 are shown in the positions they would occupy in the absence of any external actuation.

In balanced condition, the relay coil 54 draws no current in either direction, so that armature 49 of polarized relay 55 remains centered between its two contacts and no current is able to pass through lead 56 from armature 49. Accordingly, switches 58 and 59 remain biased to the right as illustrated in FIG. 1, in which position switch 58 is closed and switch 59 is open.

It will be noted that if only one switch element in the group of switches S1 to S20 or the group of switches X1 to X20 is incorrectly actuated, instead of a "correct" switch, it is impossible to balance the bridge. Suppose, for example, that instead of the switch S3, the switch S2 were actuated with the other switches remaining in the same positions as they are shown to have in FIG. 1. In such a case, switch S3 would remain in its lowermost position providing a short-circuit between points M and U via switch X10, so that the actuation of switch S2 would have no effect. Accordingly, the sum total of the resistances between M and N would be only three-fourth of the required resistance to balance the resistor RC, which would mean that current would flow through coil 54 and the alarm would be sounded.

Similarly, if any one of the switches in the X series were incorrectly actuated, again the bridge arm MN would become unbalanced. For example, suppose that switch X11 were actuated instead of switch X10. Then, in the first group of switches, there would be an open circuit between points M and U with the result that the bridge would be unbalanced. Even if a switch in the same group, say switch X14, were actuated instead of the switch X10, the result would be a resistance value only three-fourth of the desired value between points M and N, so that the bridge continues to be unbalanced.

It is apparent that circuit elements can be associated with each of the switches S1 to S20 inclusive, and X1 to X20 inclusive, to make possible a readout for accounting purposes, etc., of the actuated switches into a recording device for recording the identity of the actuator of the switches. Thus, in the vending machine example which has been the subject of this exemplary discussion, the switch combination S3, S10, S11, S19 could be associated with the name and address of a predetermined customer and any products dispensed as a result of the vending operation could be filled to the customer allocated this particular switch combination.

It will be appreciated that all the resistors R1 to R20 inclusive need not be of identical values — all that is required is that the total resistance switched in as a result of actuation of the appropriate switches be equal to the resistance of resistor RC. However, it will generally be more convenient to have all the resistors R1 to R20 inclusive of the same resistance value.

Further, it will be appreciated that the bridge circuit could operate so that the vending operation (say) would begin if the sum total of the resistances in the arm MN of the bridge were greater to or less than the resistance of resistor RC by a predetermined amount. In this case, the central leg of the bridge would respond to a current of a preset magnitude and polarity to permit the relay coil 62 to operate — the polarized relay 55 discussed in the example herein would be inappropriate for such modification. In the modified version, a current flow of incorrect polarity or magnitude would cause the actuation of the signal or alarm and would fail to actuate the relay coil 62. It will be apparent to persons skilled in the art that one of several known circuit designs could be employed to achieve this result. Generally speaking, it would seem simplest to have the bridge balanced rather than to have a fixed current of a given polarity flowing, as the condition for initiating the vending operation (say).

Finally, it is apparent that while in the example discussed, all of the adjustable switches and resistors are shown in a single arm of the Wheatstone bridge, it is possible to put some of the switches and resistors in one or more of the other arms of the bridge so that the net result of the proper selection of switches is to balance the bridge (or unbalance it in a predetermined fashion). However, again it would seem simplest to have all of the variable switches and resistors actuated by the sensing of the security devices, in a single arm of the bridge rather than in more than one arm.

Any desired mechanical configuration can be used for the security devices actuating the S series of switches on the one hand and the X series of switches on the other. FIGS. 2, 3, 4, 11 and 13 illustrate exemplary embodiments of such members.

There is illustrated in FIG. 2 an embossed car 70 with a number of bumps 71 embossed thereon as may be appreciated from the section illustrated in FIG. 2A. The embossed card 70 is adapted to fit in the receptacle illustrated in FIGS. 9 and 10 by insertion through the slot 72 until contact is made with the push contact 73 which operates a relay raising the arms 74 through the holes 75 in the embossed card 70 retaining the latter securely within the receptacle. Positioned above the slot 72 is an array of push contacts 76 which are adapted to be engaged by the bumps 71 so that when the embossed card 70 is retained in slot 72, a pattern of push contacts 76 will be made which corresponds to the pattern of the bumps 71 on the card. Each of the push switches 76 is connected to actuate a relay controlling the position of one of the switches S1 to S20 or X1 to X20 (see FIG. 1). As illustrated in FIG. 9, there is provision for 30 push switches 76 so that 10 of the switch positions shown can be dummies. It will be appreciated, however, that the number of switches 76 may be made to correspond exactly to the number of controlled switches.

The controlled machine may have associated with it a contact-making device, for instance a push switch, which is depressed by the actuating movement of the machine and which is so connected as to energize relay 77 when the controlled machine has actuated. The energizing of the relay 77 releases the arms 74 releasing the embossed card 70. The arm 78 of the pressure contact 73 may be spring loaded for instance by means of a spring loaded plunger 79 so that upon lowering of the arms 74 the embossed card 70 will be partially pushed out of the slot 72 for easy recovery.

From the foregoing description it will be inferred that failure to actuate the controlled machine by balancing the bridge (or as the case may be) implies that the card 70 remains locked into the receptacle by the arms 74 in engagement with the holes 75 of the card 70. Thus an unauthorized person attempting to operate the controlled machine should be unable to make more than one attempt — the alarm device 63 (see Figure 1) will operate, the card 70 will be retained by the machine, and the unauthorized person will thus have to flee or be apprehended by the operator of the machine; in either event only the operator will be able to take action to release the card. (The specific means of doing this will of necessity depend upon the particular installation, and need not be discussed in detail here. By way of example, the operator could throw a switch accessible only to him to energize the relay 77).

It will be observed from FIG. 2 that the embossed card 70 is provided with the marginal notches 80 and 81 which are slightly off-set from each other. The position of the notches 80 and 81 is such that when the card is inserted in slot 72 in the proper manner, the margin 82 will engage the pressure contact 73, but if the card is inserted upside down or backwards, either the notch 80 or the notch 81 will coincide with the position of the contact 73 so that the contact will not be made.

FIG. 3 illustrates a credit card similar to that of FIG. 2 except that instead of embossments 71, holes 68 are used to provide the coded information corresponding to the customer's security number.

FIGS. 4, 5, 6 and 7 illustrate a practical application of circuitry of the type described with reference to FIG. 1 in conjunction with the security devices in the form of a pre-punched card taken from a book of such cards issued to the customer, and a thumbwheel switch on which the customer can enter a remembered code number, known only to him, at the time of utilizing one of his pre-punched cards. For example, suppose that it is desired to operate an automatic vending device. The customer is supplied with a book of prepunched cards, of the standard punched card form used by data processing devices, by the operator of the vending machine. When the customer wishes to purchase something from the automatic vending device, he extracts one of the pre-punched cards from his book of cards, inserts it into a card sensing and recording device, and concurrently sets the thumbwheel switch to his personal code number. The code number should be a relatively small number so that the customer can remember it without difficulty. The number of course should not be printed on nor be in any way deducible from the pre-punched cards so that any one who obtains the customer's book of cards will be unable to utilize them, because the customer's personal code number, remembered only by the customer, is unknown to the person coming into possession of the customer's book of cards.

It will be appreciated that a large vending system, for example, a nation-wide vending system, will require greater security than is afforded by having only a small (say four digit) code number on the thumbwheel switch and a four digit code number punched onto the customer's card. The security of the

system can, however, be increased simply by increasing the number of bits of information on the card itself, without increasing the number of digits in the remembered code number. This will be apparent from the description which follows of FIGS. 4, 5, 6 and 7.

Turning now to FIG. 4, a pre-punched card 2 of conventional size and shape is shown bearing at the top portion punched information comprising punched holes 4 representing customer data such as the customer's name and address, and at the bottom of the card, security control data in the form of punched holes 6 representing predetermined switch selectors. The middle position of the card is left blank for the punching of information on the card at the time that a sale is made. For example, when the vending machine (say) is actuated, information relating to the identity of the location of the particular vending device used, the particular items purchased by the customer, and the total amount that the customer is to be billed, can be punched onto the card as well as printed on a receipt for the customer's benefit. The details of the vending operation are not a part of the present invention and need not be further discussed.

FIG. 5 is a chart showing the correspondence of the punched holes 6 to switch positions in the switch array of FIG. 6. FIG. 6 is a simplified circuit diagram showing ten groups A, B, C, D, E, F, G, H, K, and L of switching units. Four of the groups A, D, G and L each have 10 switching units, whereas the other six groups each have only five switching units. This is of course by way of illustration, and many other groupings of switching units are possible.

A switching unit in the circuit of FIG. 6 includes two separate switch elements, as illustrated in greater detail in FIG. 6A. Figure 6A illustrates the switching arrangement for the lower two switching units L9 and L0 in group L. Switching unit L9 is normally in a rest state but is actuated, switching in the resistor RL9, when the left hand switch, normally in its lowermost position, is brought into contact with the uppermost terminal of the resistor RL9, and when the right hand switch, normally open, is brought into contact with the lowermost terminal of the resistor RL9. This is exactly the switching arrangement previously described with reference to FIG. 1, and is that of all the other switching units of FIG. 6.

Some of the groups of switching units of FIG. 6 are actuated, switching in their associated resistors, by the sensing of two preselected holes in the punched card 2 for each switching unit so actuated. For example, the switching unit B1 is rendered operative if a hole in the punch card 2 exists at position 1X14 and another hole exists at position 6X19. These of course are arbitrary relationships. The hole designation 1X14 refers to a possible hole in the top row of the security control part of the card 2 and in the fourth column from the left. The rows have been given in FIG. 5 the arbitrary row numbers 1 to 10, while the column numbers have been arbitrarily designated as 11 through 22 inclusive. A reference to 1X14 thus signifies the top row, and the fourth column from the left, of the array of possible holes on the card 2. Referring to this particular possible hole position, it will be noted that the chart of FIG. 5 cross-references, at the possible hole position 1X14, the switch position B1L. This refers to the B group, switching unit B1, and the "L" for the left hand switch element of the switching unit B1. Similarly, the possible hole position 1X12 is cross-referenced to switch unit group F, switch unit F1, and the right hand switch element of the switch unit F1. An immediate reference to FIG. 6 shows that the right hand switch element of switching unit F1 is cross-referenced to possible hole position 1X12.

In the switching unit arrangement of FIG. 6, there are seventy switching units, requiring a total of 140 switch selectors, because in the example under consideration, actuation of two switch elements are required to render operative any given switching unit. In a four-digit thumbwheel switch 40 of the 140 switch selectors required are provided by the thumbwheel switch, leaving 100 to be provided by the punch card 2. But there are 120 hole positions available on the punch card 2. This means that 20 of the possible hole positions on the punch card 2 may be dummy positions, some of which may be punched to cause confusion to counterfeiters. For example, the punched card 2 shown in FIG. 4 has a hole punched at the dummy hole position 3X12. This hole produces no effect whatever in the circuit of FIG. 6.

For groups B, C, F, H, and K of FIG. 6, a switching unit is rendered operative by the sensing of mating holes on the punch card 2 which correspond to the switch selectors for a given switching unit in these groups. For example, the switch unit C1 would be rendered operative by the sensing of holes at punch card position 1X16 and 7X19. In contrast, switching unit groups, A, D, G, and L comprise switch units each of which is rendered operative by the sensing of a predetermined switch selector comprising a hole on the punch card 2 and a mating corresponding switch selector being one of the ten possible switch positions on one of the four dials of a four-digit thumbwheel switch 8. Each dial of the thumbwheel switch may be connected to a ten-position switch of conventional design. The details of the thumbwheel switch design are within the ordinary skill of the art and are not a part of the present invention. In the example of FIG. 6, the dial 10 provides 10 switch selector positions corresponding to the right-hand 10 switch elements of switching unit group G, as illustrated FIG. FIG. 7. The dial 12 corresponds to the right-hand array of switch elements for the switching unit group L of FIG. 6, the dial 14 corresponds to the right-hand switch elements in switching unit group D, and finally the dial 16 provides 10 switch selector positions for the right-hand switches of the 10 switching units in group A of FIG. 6. It will be observed that the number appearing to the customer on any of the dials 10, 12, 14 and 16 does not have to be the same as the switch element position of the matching group. Thus, the numeral 9 appearing on dial 10 corresponds to the 6th switch unit in group G of FIG. 6, not the 9th switching unit. Also, obviously, the left hand dial 10 need not correspond to the left hand switching unit group. In the example shown, it does not — it corresponds to the group G of FIG. 6. Further, it is obviously not necessary that all of the switch selector positions for any given dial fall within the same switching unit group, although for convenience of wiring this may be preferable. In the example illustrated, the switch selector positions for each dial do in fact match with switching units in only one switching unit group.

In the chart in FIG. 5, hole positions corresponding to holes actually punched on the punch card 2 are encircled. Similarly, switch elements G6, L2, D7 and A8 on the chart of FIG. 7 which correspond to the dial setting 9713 on the dials 10, 12, 14 and 16 respectively of the thumbwheel switch 8 are encircled. In FIG. 6, the switching units rendered operative are shown as completing a circuit between the left-hand and right-hand group buses, but it must be understood that a switching unit resistance is thereby switched in.

Turning to the operation of the circuit of FIG. 6, it is necessary that a resistance equal to that of resistor RC be switched in between points M and N, so that no current flows through coil 54 and thus the armature 49 remains centered. The circuitry associated with the switch contacts 55 and the armature 49 is not shown in FIG. 6, for the purpose of clarity and description, but may be the same as or analogous to the corresponding circuitry of FIG. 1.

Assuming that the resistances RA, RB and RC are each 100 ohms, then a resistance of 10 ohms must appear across each switching unit group A, B, C, D, E, F, G, H, K and L. Thus each switching unit resistance will be 10 ohms, and one and only one switch unit must be connected in each of the 10 groups, as has already been explained with reference to a different example in FIG. 1. To recapitulate the principle briefly, if there is any one of the 10 groups whose ten switching units are all inoperative, that group will not have a resistance of 10 ohms, but will represent an open circuit or a short circuit. Further, if more than one switching unit in any group is actuated, the resistance reflected by the group will be less than 10

ohms. For example, if two switching units in a group are rendered operative, the group containing these two units will present a resistance of 5 ohms instead of the required 10 ohms.

Accordingly, the operator of the security control device must ensure that each customer is given a book of punched cards and a thumbwheel switch number to remember, which, when the thumbwheel switch number is entered by the customer and his card sensed by the card sensing machine, renders operative one and only one switching unit in each of the 10 groups. The particular customer given a book of punched cards identical to those of FIG. 4, and given the thumbwheel switch code number **9713** to remember, will succeed in balancing the circuit of FIG. 6 when he turns the thumbwheel switch **8** to the code number **9713** and inserts his punch card **2** in the card sensing machine (not shown). In group A, the switching unit **A8** is rendered operative because the two corresponding switch selectors, namely a hole in punch card **2** at position **9X12**, and the numeral **3** position of thumbwheel switch dial **16**, actuate the two switch elements of switching unit **A8**. In group B, switching unit **B4** is actuated, switching in its associated fixed resistor (not shown), by mating holes on the punch card **2**, namely hole **7X14** and hole **3X20**. By comparing the hole positions in which holes are punched and the dial settings of the thumbwheel switch **8** with the switching unit array of FIG. **6**, it can be readily seen that switching units **C3**, **D7**, **E1**, **F5**, **G6**, **H5**, **K3** and **L2** are also rendered operative by the sensing of the punch card **2** and the setting of the thumbwheel switch **8** to the code number **9713**. Thus the criterion for bridge balancing is satisfied, and the customer is able to complete his purchase.

From the foregoing description, it can be seen that the described embodiment of a security system according to the invention comprises:

a. a plurality of first security devices (for example, embossed credit cards) each having a unique predetermined arrangement of *m* first switch selector means (for example, embossments on the card), *m* being an integer;

b. a plurality of second switch selector means (for example, thumbwheel switch dials or a pattern of embossments on a key) arranged in *n* groups (*n* being an integer) so that for each unique arrangement of *m* first switch selector means there is a unique mating arrangement of *n* second switch selector means;

c. sensing means for simultaneously sensing the arrangements of switch selector means (for example, a receptacle for embossed cards as described below with reference to FIG. **9**, and the mechanical and electrical elements necessary to transform the mechanical information embossed on the card and set on the thumbwheel switch to electrical information in the bridge circuit); and

d. a responsive circuit (e.g. a Wheatstone bridge circuit) having at least two stable states (e.g. balanced and unbalanced) and comprising p groups (*p* being an integer) of at least two switching units (a switching unit being the combination of a "S" switch and mating "X" switch in FIG. **1**, for example) per group responsive to the sensing means (the switch positions of the groups of resistor switches in the bridge conform to the mechanical information on the embossed card and thumbwheel switch, for example), each switching unit having a rest state (the combination of the lower position for the "S" switch of FIG. **1**, the upper position for the mating "X" switch of FIG. **1**, for example) and an actuated state (e.g. the combination of the upper position for the "S" switch and lower position for the mating "X" switch of FIG. **1**) and being actuated by the sensing of a unique predetermined mutually exclusive combination of *x* switch selector means, *x* being an integer (*x*=2 in FIG. **1**), the responsive circuit FIG. switched to a predetermined one (e.g. the balanced condition) of its stable states only when any one but only one switching unit in each of the groups of switching units is in actuated state (e.g. the bridge of FIG. **1** is balanced only when one and only one switching unit taken from each of the four groups of switching units is in actuated state); and wherein any one of the mating arrangements of a first and a second switch selector means actuates one but only one switching unit in each of the groups of switching units when said last-mentioned first and second switch selector means are sensed by the sensing means.

FIGS. **1** and **6** exemplified switching units having only two switch elements per switching unit. However, it is possible to have more than two switch elements per switching unit, as can be seen from FIG. **8**. FIG. **8** illustrates a switching unit having three switch elements. It is assumed to be one of a group of such switching units connected in parallel in its group and the groups of switching units are of course connected in series as has been previously described. The switching unit of FIG. **8** comprises the resistors RX and RY and the three switch elements SA, SB and SC, whose arms are normally in the positions illustrated in FIG. **8**. The resistors RX and RY do not have to have the same resistance, but may conveniently have a resistance R, in which case the switching unit, when rendered operative, has a resistance **2R**. If there are N groups of switching units in the bridge, then the bridge is balanced when a resistance of **2NR** is switched into the switch groups connected in series. It will be obvious that this can happen only if all three switches in any one switching unit of any given group are changed from their normal rest position to their actuated position. As before, if more than one switching unit is rendered operative, the resistance for the group, instead of being **2R**, will be only R, and thus there is no way in which the bridge can become balanced.

Alternative arrangements of resistors and switches within switching units, to accommodate two or more switch elements per unit, will be obvious to those skilled in the art. As examples, FIGS. **8A**, **8B**, **8C** and **8D** are circuit diagrams of a few such alternatives.

FIG. **8A** shows a two-switch switching unit having switches SA, SB and one associated resistor RX. The switches SA and SB are shown in their rest positions; it is obvious that they must both be actuated in order to actuate the unit (i.e. in order to have the resistance between the left and right buses be that of resistor RX). This circuit has the advantage that switches SA and SB each require only one active contact — the upper contact in each case is not connected to any external circuitry, and may be dispensed with altogether.

FIG. **8B** shows a further two-switch switching unit, with the arms of the two-switches SA, SB shown in their rest positions. Again both switches must be actuated to render operative the switching unit, i.e. to switch in the resistor RX between the buses. The unit of FIG. **8B** has the advantage that if any left-hand switch or any right-hand switch in any group of switching units is incorrectly actuated by an unauthorized customer, the buses of that group are shorted and there will be no way to balance the bridge.

FIGS. **8C** and **8D** are three- and four-switch modifications of the switching unit of FIG. **8B**. They illustrate that any number of switches may be added simply by connecting each additional switch to short out the resistor RX in rest position and to connect the left bus to the upper contact of the switch SB in actuated position. In this way, all three switches in FIG. **8C** and all four switches in FIG. **8D**, etc. must be actuated in order to render the switching unit operative, and again the incorrect actuation of any one switch shorts the left and right buses, making it impossible to balance the bridge.

It will further be obvious to those skilled in the art that it is not necessary to use resistors in order to utilize the present invention. The principle requirement is a switching arrangement that requires a correct combination of switches to be actuated in order for the circuit to achieve some predetermined state, and means for actuating correct combinations of switches in response only to mating arrangements of switch selectors. As perhaps the most obvious suitable circuit excluding resistors, a bridge circuit using capacitors or inductors instead will readily occur to those skilled in the art.

In general, it will be simpler and more convenient to have only two switch elements in a switching unit. It is also obvious

that more than two security devices can be used in mating combinations, but a combination of two such devices, particularly when one is a manually-operable device which must be set to correspond to a code number in the memory of the customer, should, for most applications, provide adequate security.

FIGS. 11 and 12 illustrate a switch positioning means adapted to be operated by the turning of a key. This device consists essentially of 10 teflon discs 90 contained within the plastic housing 91, each one of which is adapted to cooperate with one of 10 slots in the key 92. The interior of each disc 90 is stepped at regular angular intervals as at 93, 94 and 95 so that the amount that any given disc 90 will turn when the key 92 is turned through one revolution will depend upon the depth of the slot in the key 92 corresponding to that particular disc. In the device as illustrated there are seven steps and, therefore, seven different depths to which each slot in the key 92 may be cut. (Obviously, the key is for use in a 10×7 switch configuration rather than the 4×5 configuration of FIG. 1). On the periphery of each disc is a detent 96 which cooperates with a plunger 97 to operate a switch contained in a switch housing 98, each such switch controlling the position of one of the switch means associated with the Wheatstone bridge circuit as illustrated in FIG. 1. It will readily be seen that upon inserting the key and turning it through one full revolution, 10 of the switch means contained in housing 98 will be made, thus operating the switch means in the Wheatstone bridge circuit in accordance with a pattern predetermined by the depth of the slots in the key 92. The key 92 fits in cylinder 100 upon which is mounted the cam 101 which has the radially projecting rise 102 which is adapted to cooperate with the plunger 103 to close a switch within the switch housing 104 controlling the position of switch 52 or 53 (or both of them) in the circuit illustrated in FIG. 1 when the key has been turned through one full revolution. Spaced from the rise 102 on the cam 101 is a radial recess adapted to accommodate the end of the plunger 105 of solenoid 106 which may be connected in the signal or alarm circuit of the alarm 63 (see FIG. 1) whereby when the switch within housing 104 is operated, if the bridge circuit is not balanced, the plunger 105 is projected into the said recess preventing rotation of the key and thus preventing its removal by virtue of guard 99. Alternatively, the plunger 105 may be spring-loaded, and retractable by the energization of a solenoid actuated by an operating movement of the controlled machine.

FIG. 13 illustrates a special form of security device which is adapted to be combined with selector card for an automatic vending machine. The selector card 110, which does not itself form a part of this invention and the construction of which will therefore not be described in detail, but which is described in applicant's copending application Ser. No. 664,811, filed Aug. 31, 1967 is adapted for insertion in a suitable receptacle on the operating panel of an automatic vending machine (not shown) and has on its leading edge a plurality of eyelets 111, 112 and 113, each one of which is of a predetermined depth. Each eyelet registers with a spring loaded plunger 115 which carries contact 116 of a selector switch 117 and is biased outwardly by compression springs 118. In the fully extended position as shown, contact 116 rests against an insulated element 119 which is aligned with the 10 separate contact elements 120. Upon the selector card 110 being pushed home within the receptacle, each contact 116 will make contact with a particular one of the contact elements 120 of its associated selector switch 117 determined by the depth of the eyelet. The 11 wire cables 121 connect with the switch means associated with the Wheatstone bridge circuit making in each case the switch which corresponds to the element 120 which is made by the contact 116. In the arrangement illustrated in FIG. 13 there are 10 switch elements 120 in each of seven selector switches, although for simplicity all of these are not shown, this arrangement being adapted for use in a Wheatstone bridge circuit where there are 7 groups of 10 resistors each associated with the variable arm of the Wheatstone bridge. As is the case with the circuit illustrated in FIG. 1, the positioning of the control switches in the Wheatstone bridge circuit may suitably be accomplished by relays energized by the selector switch circuits.

In some circumstances, it may be sufficient for the purposes of the security control required, to use the security devices simply to identify the customer to some other person. For example, suppose that a customer is provided with a credit card of the type shown in FIG. 2 having embossed thereon certain security control information in the form of an array of embossments 71, and that the customer is also given a security code number to remember, which may be set upon a thumbwheel switch or the like. For an automatic vending machine, the customer himself may insert his credit card into a suitable receptacle for sensing and enter his remembered code number on an appropriate series of dials, thereby to be able to obtain the selected merchandise on credit. However, it may be desired also to permit the customer to use his credit card to obtain cash advances from a bank, for example. In such a case, the security control would involve a presentation of the customer's credit card to the bank official, and the customer would have to divulge his rembered code number to the official so that a correlation could be made. FIGS. 14 and 15 illustrate a simple device which will make possible such a correlation by the bank official.

The security control apparatus in FIGS. 14 and 15 is shown generally as 22, and includes a housing 23 having a slot 24 conveniently placed for the reception of a credit card 70 in a slide 26 provided with a gripping member 28. As can be seen in FIG. 15, within the housing 23 is an array of microswitches 46 having projecting switch actuators 48 adapted to contact corresponding embossments 71 on the credit card 70. When the credit card 70 has been placed in the slide 26, the gripping handle 28 can be used to push the slide 26 into the housing so that the credit card 70 comes into contact with the array of microswitches 46 located conveniently above the slide 26 when it has been inserted into the housing 23. By way of example, the particular row of microswitches 46 that can be seen in FIG. 15 in contact with the credit card 70, which has been pushed home by the slide 26, indicates that only one embossment 71 has come into contact with a corresponding one (the second from the right) of the five exemplary microswitches illustrated, and that the other four microswitches 46 have not been actuated as there is no corresponding embossment on the card 70. When the slide 26 is pushed home, finger 44 of cam follower 42 is forced by the spring 31 to project into the hole 75 (see FIG. 2) of the credit card 70. This ensures that the credit card 70 is properly in position and does not become displaced while a reading of the card is obtained.

Following insertion of the slide 26 underneath the array of microswitches 46, the bank official, having been divulged the customer's code number, enters the number on thumbwheel switch 8. By way of example, a four-digit thumbwheel switch is shown in FIG. 14, having individually adjustable dials 10, 12, 14 and 16 each bearing ten digits.

The comparison circuit within the housing 23, not shown, may be a bridge circuit and associated circuitry completely analogous to that of FIGS. 1 and 6. The number and arrangement of switch units may of course vary depending upon the number of embossments positions possible on the credit card 70. The comparison circuitry is designed to provide an "all clear" signal in the form of the illumination of a signal lamp 34 if the customer's code number matches the information embossed on his credit card 70, thereby permitting the bridge to balance. A battery 39 may power the bridge and the lamp 34.

Following the actuation of the comparison circuitry (not shown), the credit card 70 may be released by depressing the gripping handle 30, which is attached to a pair of crank members 36 rotatable on shaft 33 and adapted for vertical movement relative to the housing 23 by means of slots 32. Fixed to the crank members 36 are cams 38 and 40. Upon depressing the gripping member 30, the cam 38 forces the cam follower 42 to pivot clockwise, withdrawing the finger 44 from the hole 75 in the credit card 70, thus permitting the credit card to be

released by withdrawing the slide **26**. At the same time, the cam **40** depresses arm **25** mounted for pivotal movement about a pin **35** fixed to the housing **23** and held against the cam **40** by means of spring **29**. The arm **25** is provided with a reset element **27** which cooperates with resetting members (not shown) of the thumbwheel switch **8** to reset all dials to zero. This is a safety precaution to prevent a second customer from obtaining the code number of the previous customer by looking at the dial setting.

While a few exemplary security devices have been illustrated in detail, it is to be understood that the present invention contemplates the positioning of the switches associated with the bridge circuit by any appropriate known means, either simultaneously as would be the case with the embossed card **70** and other forms of physical pattern adapted to cooperate with a suitable receptacle or sequentially such as is the case with the key operated device illustrated in FIGS. **11** and **12**, keyboard push buttons or stepped relay systems such as are associated, for instance with the familiar telephone dial.

It is also to be understood that the switch positioning means instead of being mounted on physically separate articles may all be mounted on a combined security device so that the switching units are actuated by the operation of a single device which carries all of the switch selectors necessary to actuate mating switch selectors. For example, a portable key or card might include a fixed pattern of switch selectors as well as a manually-adjustable variable pattern, the variable pattern being set by the user to correspond to his memorized security code number just before the device is sensed.

I claim:

1. A security system for operation by any one of a plurality of persons each having an individual security device having a unique pre-determined arrangement of m first switch selector means, comprising: a plurality of second switch selector means arranged in n groups such that for each said pre-determined arrangement of first switch selector means there exists a mating unique pre-determined arrangement of n second switch selector means, with each of the *n* second switch selector means in a different group; means accessible to said persons for controlling the selection of said second switch selector means; sensing means for simultaneously sensing the arrangement of first switch selector means of any one of the first security devices and for sensing any of said pre-determined arrangements of second switch selector means; a responsive circuit having at least two stable states and comprising *p* groups of at least two switching units per group responsive to the sensing means, each switching unit having a rest state and an actuated state and being actuated by the sensing of a unique pre-determined mutually exclusive combination of *x* switch selector means, the responsive circuit being switched to a predetermined one of its stable states only when any one but only one switching unit in each of the groups of switching units is in actuated state; wherein *m*, *n*, *p* and *x* are integers, *x* is greater than 1,

$$p=\frac{m+n}{x};$$

; wherein: any one of the mating arrangements of first and second switch selector means actuates one but one switching unit in each of the groups of switching units when said last-mentioned first and second switch selector means are sensed by the sensing means, the groups of switching units are connected in series, the switching units in each group are connected in parallel, each switching unit in a rest state is either a short circuit or an open circuit, each switching unit in its actuated state has a resistance R, and the responsive circuit is in its said pre-determined stable state only when the series resistance of the groups of switching units is (p.R + R_o), and where R_o is a pre-determined fixed resistance of zero or greater.

2. A system as defined in claim **1**, wherein the groups of switching units are connected in series as one arm of a bridge circuit that is balanced only when the series resistance of the groups of switching units is p.R.

3. A system as defined in claim **1**, additionally comprising a warning device responsive to the condition of the responsive circuit and producing a warning signal when, upon sensing an arrangement of first switch selector means and an arrangement of second switch selector means, the series resistance of the groups of switch units is not p.R.

4. Security control apparatus comprising: a bridge circuit having a variable resistance arm and being in a predetermined condition only when the said arm has a predetermined resistance; *p* groups of at least two fixed resistors per group each having a predetermined resistance, the fixed resistors in each group being selectably connected in parallel into the associated group and the groups of fixed resistors being connected in series; *x* switches for each fixed resistor, each switch having a rest state and a selectably actuated state, and any fixed resistor being connected into its group only when all of its associated *x* switches are in their actuated state; a plurality of first security devices each having a unique predetermined arrangement of m first switch selector means, a plurality of second switch selector means arranged in n groups such that for each said predetermined arrangement of first switch selector means, there is a mating unique predetermined arrangement of n second switch selector means with each of the n second switch selector means being in a different group of second switch selector means; means for conforming the switches to any one of said arrangements of first switch selector means and any one of said arrangements of second switch selector means so that predetermined ones of said switches are actuated by predetermined ones of said switch selector means in a one-to-one correspondence; whereby only for any mating arrangement of first and second switch selector means the total series resistance of the groups of fixed resistors equals said predetermined resistance of the arm; and wherein *m*, *n*, *p* and *x* are integers, *x* is greater than 1, and

$$p=\frac{m+n}{x}.$$

5. Apparatus as defined in claim **4**, wherein the bridge circuit is a Wheatstone bridge circuit and the predetermined condition is a balanced condition.

6. Apparatus as defined in claim **4**, wherein the fixed resistors have identical resistance R and the predetermined resistance of the arm is pR.

7. Apparatus as defined in claim **4**, wherein $x=2$.

8. Apparatus as defined in claim **4**, wherein, only for any mating arrangement of first and second switch selector means, one and only one fixed resistor in each group of fixed resistors is connected into its associated group of fixed resistors.

9. Apparatus as defined in claim **4**, wherein the fixed resistors have identical resistance R and the predetermined resistance of the arm is (pR + Ro), where Ro is the fixed resistance of the variable arm when the bridge is balanced.

10. Security control apparatus comprising: a Wheatstone bridge circuit with a variable arm, said Wheatstone bridge circuit being so connected as to be balanced only when the resistance of said variable arm has a predetermined value; a plurality of groups of fixed resistors of predetermined resistance associated with said variable arm, the resistors in each said group being adapted for selectable parallel connection between group buses associated with such group, said groups being connected in series in said arm, whereby the resistance of any group is the resistance of those fixed resistors of the group which are connected between the group buses plus any predetermined fixed resistance, and the total resistance of said variable arm will equal the total resistance of all of said groups plus any predetermined fixed resistance; first and second switches associated with each of said fixed resistors, said first switch being adapted to connect a group bus to either end of its associated resistor and being in its rest state connected to that end of its associated resistor electrically nearest the second switch, said second switch being normally open and selectably closable to connect one end of its associated resistor to the other bus of the group whereby, only when said

second switch is actuated to be closed, and said first switch is actuated to be connected to the end of its associated resistor electrically remote from said second switch will such resistor be connected between said buses; means for actuating predetermined ones of said first and second switches to correspond to the pattern of switch selector means on any one of a series of first security devices each having a unique one of such patterns, means for actuating predetermined ones of said second switches to correspond to a selected pattern of switch selector means on a second security device; the patterns of first and second switch selector means being arrangeable in mating pairs which correspond to actuated first and second switch positions which connect fixed resistors between the buses of said groups to give said variable arm a total resistance equal to said predetermined value, and wherein non-mating pattern pairs correspond to actuated first and second switch position which give the variable arm a resistance other than said predetermined value.

11. Security control apparatus as defined in claim **10** in which there are from two to 10 groups each containing from two to seven fixed resistors.

12. Security control apparatus as defined in claim **10**, wherein each group contains at least **2** fixed resistors.

13. Security control apparatus as defined in claim **12**, wherein the fixed resistors have the same resistance.

14. Security control apparatus as defined in claim **10**, in which each first security device is in the form of a stiff card which has a unique pattern of embossments as switch selector means and wherein the means for actuating the switches to correspond to said pattern comprises a receptacle for said card; and means within said receptacle operable by said embossments for actuating those switches corresponding to the pattern of embossments on said card.

15. Security control apparatus as defined in claim **10**, in which each first security device is in the form of a stiff card which has a unique pattern of holes as switch selector means and wherein the means for actuating the switches to correspond to said pattern comprises a receptacle for said card; and means within said receptacle operable by said holes for actuating those switches corresponding to the pattern of holes on said card.

16. Security control apparatus as defined in claim **15** comprising latch means for retaining said card in said receptacle, latch actuating means within said receptacle operable by said card as the same is pushed home in said receptacle to retain said card therein; and latch release means for releasing said card for withdrawal from said receptacle.

17. Security control apparatus as defined in claim **16**, wherein said latch release means is actuated only in response to the balancing of the Wheatstone bridge.

18. A security control device as defined in claim **13**, wherein each first security device is a key having a unique pattern of slots as switch selector means and wherein said means for actuating said switches comprises a lock mechanism in which there is a rotatable disc for each slot of said key, each such disc being rotatable through a predetermined angle corresponding to the depth of the slot to which it corresponds, and a detent on the periphery thereof adapted to cooperate with a plurality of third switches angularly positioned within said casing in angular positions corresponding to the predetermined angles through which said disc may be rotated, whereby upon rotation of said key through one full revolution said detent will cooperate with one of said third switches to actuate the same, each of said third switches associated with each of said discs being connected to control the position of a corresponding one of the first and second switches whereby upon a key being turned through one complete revolution the first and second switches corresponding to the slots of the key are actuated.

19. A security control device as defined in claim **13** in which each first security device has a unique pattern of switch selector means in the form of eyelets of varying predetermined depth adapted on insertion in a receptacle associated with the bridge circuit to cooperate with plunger elements of plunger-type selector switches, the contacts of said plunger-type selector switches being adapted to actuate corresponding ones of the first and second switches.

20. Apparatus as defined in claim **13**, additionally including means responsive to the balancing of the bridge circuit to initiate the operation of a controlled machine.

21. Apparatus as defined in claim **20**, additionally including a warning device responsive to the bridge circuit and providing a warning signal when non-mating pairs of patterns of first and second switch selector means actuate the switches thereby to cause an imbalance of the bridge circuit.

22. Apparatus as defined in claim **13**, wherein the second switch selector means are physically associated with a series of second security devices each of which has a unique predetermined pattern of second switch selector means mating with a unique predetermined pattern of first switch selector means on a predetermined one of said first security devices.

23. Apparatus as defined in claim **13**, wherein the second switch selector means are arranged in groups and are physically associated with a manually operable device having individually-adjustable means for each said last-mentioned group for selecting in each group any one of the second switch selector means in such group whereby the selected second switch selector means actuate corresponding ones of said first and second switches, and wherein each pattern of first switch selector means mates uniquely with a unique selection of second switch selector means taken one from each group of second switch selector means.

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