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[54] **DEVICE FOR RECONDITIONING SWITCH CONTACTS**

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[51] **Int. Cl.** **H01h 1/60**

[58] **Field of Search** ..... 307/137; 317/9 AC, 9 R

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[57] **ABSTRACT**

The so-called "coherer effect" is utilized for reconditioning the touching faces of a movable contact and a fixed break contact of each of several selector switches in a cascade connection. Connected in series in a closed circuit formed by the movable contacts and the fixed break contacts of the selector switches is power supply means such that each time the movable contact of any of the selector switches is returned to the break contact thereof from the corresponding make contact, the insulating oxide films or the like which may have been formed on the touching faces of the contacts are electrically ruptured by a sufficiently high voltage delivered from the power supply means.

5 Claims, 3 Drawing Figures

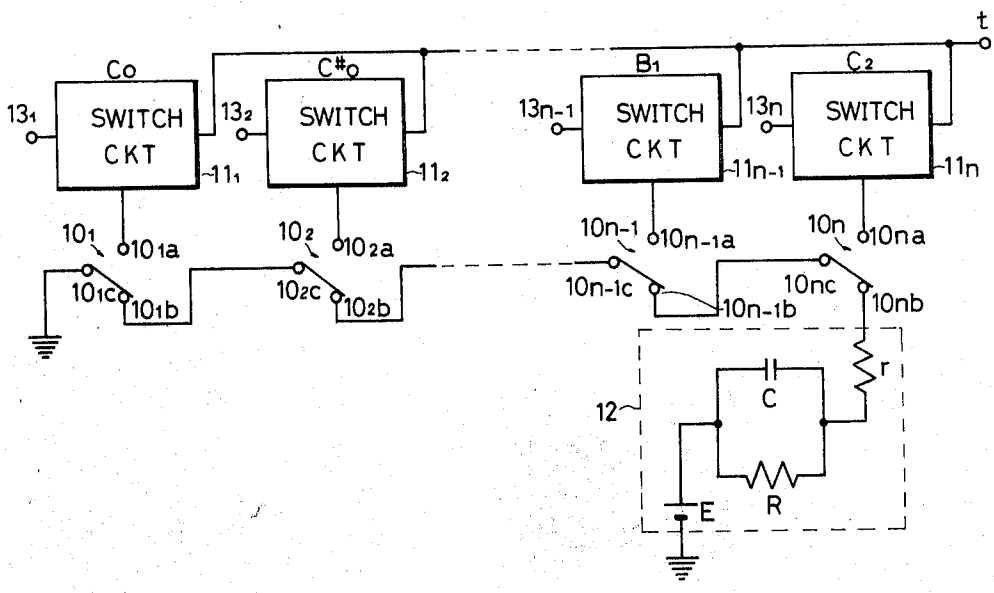


FIG.1

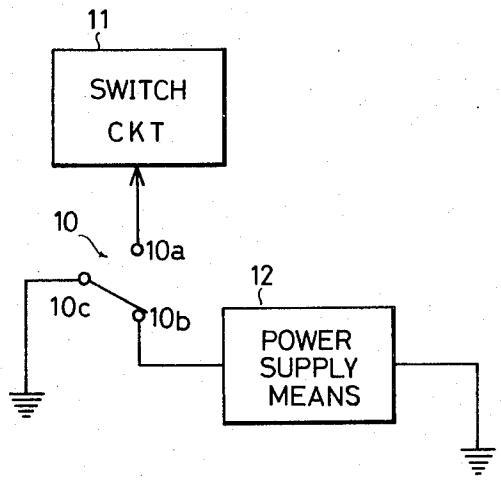


FIG.2

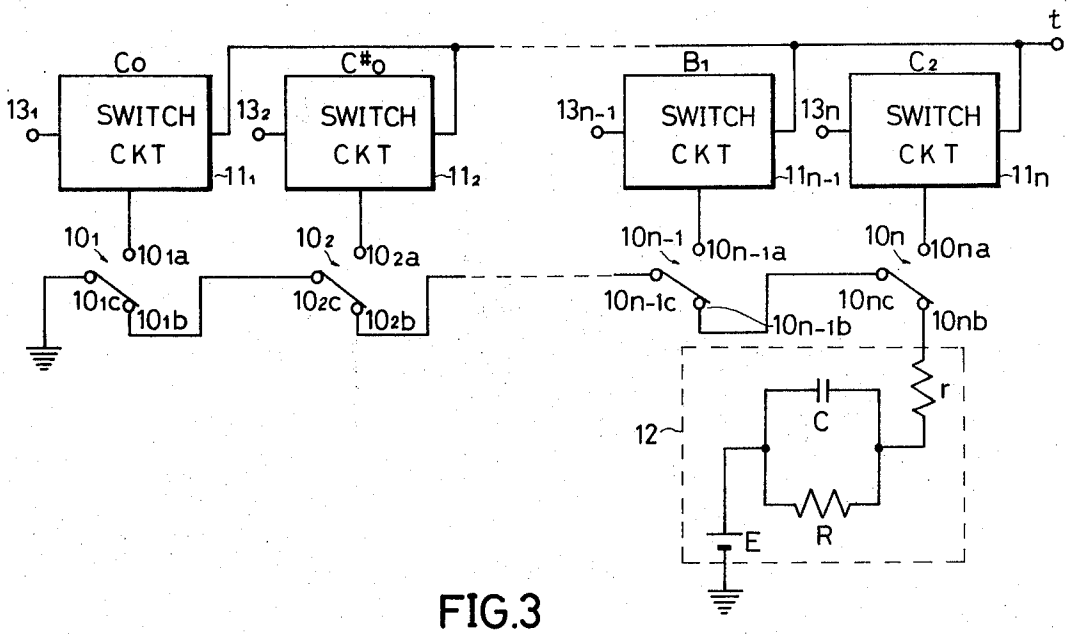
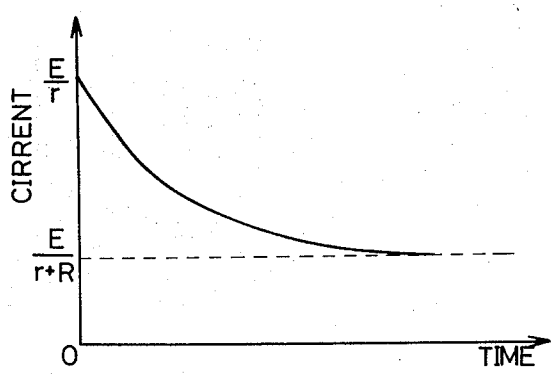


FIG.3



DEVICE FOR RECONDITIONING SWITCH CONTACTS

BACKGROUND OF THE INVENTION

This invention relates to a novel device for automatically reconditioning the touching faces of switch contacts through electrical breakdown of the insulating oxide films or the like which may be formed thereon due to arcing or for other reasons. The device of this invention is applicable, for instance, to a number of interconnected selector switches which are operable from the keyboards of an electronic organ or like musical instruments to cause conduction through the corresponding switching circuits connected between the tone generator circuit and the tone coloring circuit of the electronic musical instrument.

In an electronic organ or other keyboard instruments, the aforesaid switching circuits are provided for the respective keys of the instrument. Their inputs are connected to the respective tone generators and their outputs to the common tone coloring circuit. Hence, when any of the switching circuits is rendered conductive by the depression of the corresponding key, an output signal from the corresponding tone generator is permitted to pass therethrough to the tone coloring circuit. In this manner the switching circuits function substantially as gate circuits.

Each of the switching circuits has a control input connected to the fixed make contact of each of the selector switches in a cascade connection, such that the movable contact of each selector switch is connected to the fixed break contact of the next switch. The movable contacts of all the selector switches are normally held in touch with their respective break contacts, and only the movable contact of the selector switch at one extremity of the cascade connection is grounded. Therefore, if two different keys of the electronic musical instrument are depressed at the same time, with the result that the movable contacts of the two corresponding ones of the selector switches are moved into touch with their make contacts, then conduction is caused only through the switching circuit corresponding to that one of the two closed selector switches which is positioned closer to the aforesaid selector switch whose movable contact is grounded.

Since these selector switches are operated each time the corresponding keys of the electronic organ or the like are depressed, the touching faces of their contacts become easily covered with insulating films due to the oxidation of the contact metals as a result of arcing. Such insulating oxide films can prevent proper electrical connection between the control inputs of the switching circuits and the ground. The accumulation of dust on the touching faces of the selector switch contacts can also prevent proper electrical contact therebetween. Although these undesirable outcomes can be avoided to some extent by plating the touching faces with some precious metal and by always keeping them clean, these measures are not quite practical in view of the large number of the selector switches which must be provided correspondingly to the respective keys of the electronic organ or the like.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide a novel device for automatically reconditioning the touching faces of switch contacts by electrically rupturing the insulating oxide films or the like which may be formed thereon.

Another object of the invention is to provide a device wherein the so-called coherer effect produced between metals upon application of sufficiently high voltage is utilized to cause the breakdown of the insulating films which may be formed on the touching faces of switch contacts.

A further object of the invention is to provide a device such that the touching faces of the contacts of a number of interconnected switches can always be held in proper operative condition without use of any precious metals designed to prevent their oxidation, so that the switches can be manufactured inexpensively, and their service life greatly extended, by use of the device of this invention.

A still further object of the invention is to provide a device such that the voltage required to cause the coherer effect is impressed to the touching contacts of the interconnected switches only when any one of these switches is operated, while only a negligible amount of current is permitted to flow through the contacts as long as all the switches are held inoperative.

With these objects in view and the other objects hereinafter made apparent, this invention provides, in a switch of the type comprising a movable contact, a fixed break contact, and at least one fixed make contact to be connected to a desired circuit, a device for reconditioning the touching faces of the movable contact and the fixed break contact which comprises power supply means connected in series in a closed circuit formed by the movalbe contact and the fixed break contact. The power supply means is adapted to rupture, by virtue of the coherer effect, the insulating films on the touching faces of the movable contact and the fixed break contact each time the movable contact is moved into touch with the fixed break contact.

The coherer effect itself has long been known to electricians. The touching faces of a pair of contacts tend to become covered with insulating films, due for the most part to the oxidation of the metal of which the contacts are made. As long as these films are each from about 1 or 2 nanometers in thickness, the free electrons within the metals are capable of passing therethrough so that the films offer but little resistance to the passage of current. However, as the thickness of the films grows closer to 10 nanometers, hardly any current is permitted to pass therethrough so that the switch is no longer capable of functioning properly.

By virtue of the coherer effect, even such thick insulating films can be electrically ruptured, if sufficiently high voltage is impressed to the touching faces of the contacts. The electric field strength necessary to cause this electrical breakdown of the insulating oxide films is known to be about 10^8 volts per meter in the case of nickel oxide, and about 10^5 volts per meter in the case of silver oxide. Accordingly, in order to rupture an insulating nickel oxide film having a thickness of about 10 nanometers by the coherer effect, there is required a voltage of only about one volt. This phenomenon is utilized by the present invention for automatically reconditioning the touching faces of switch contacts.

The features which are believed to be novel and characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and mode of operation,

together with the additonal objects and advantages thereof, will be best understood from the following description of preferred embodiments taken in conjunction with the accompanying drawings throughout which like reference characters designate like circuit elements.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a schematic electrical diagram explanatory of the operating principles of the device according to the invention;

FIG. 2 is a schematic electrical diagram of a preferred embodiment of the invention in which the device is adapted for use with a number of interconnected selector switches operable from the keyboards of an electronic organ or the like to cause conduction through the corresponding switching circuits; and

FIG. 3 is a graph explanatory of the change with time of the magnitude of current flowing through the interconnected selector switches in the embodiment of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The operating principles of the device according to this invention will first be briefly explained with reference to FIG. 1, in which the reference numeral 10 generally designates a switch comprising two fixed contacts numeral a and 10*b* and a movable contact 10*c*. One of the fixed contacts, 10*a*, is a make contact connected to any desired circuit or device 11 such for example as one of the switching circuits of an electronic organ or like keyboard instruments which operates each time the corresponding key on the keyboards of the electronic musical instrument is depressed, as hereinafter set forth in further detail in relation with the embodiment of FIG. 2.

The other fixed contact 10*b* is a break contact which is grounded via power supply means 12 adapted to rupture, by virtue of the above explained coherer effect, the insulating oxide films or the like which may be formed on the touching faces of the contacts 10*b* and 10*c*. The movable contact 10*c* of the switch is also grounded, so that a closed circuit is formed which involves the contacts 10*b* and 10*c* and the power supply means 12.

In this circuit configuration of FIG. 1 the power supply means 12 is assumed to be such that upon closure of the contacts 10*b* and 10*c*, a sufficiently high voltage is impressed to the touching faces of these contacts with the result that the insulating films, if any, on the contact faces become electrically ruptured due to the coherer effect. The contacts 10*b* and 10*c* of the switch 10 are thus reconditioned for proper operation.

In the embodiment shown in FIG. 2, the device of this invention briefly outlined above is adapted for reconditioning the contact faces of a series of selector switches used to control the operations of the aforementioned switching circuits of an electronic organ or like musical instruments. Each of these switching circuits, designated by the reference characters 11_1 to 11_n in FIG. 2, performs a switching function each time the corresponding key of the electronic musical instrument is depressed. The inputs 13_1 to 13_n of these switching circuits are connected to the respective tone generators, not shown, of the musical instrument, whereas their outputs 14_1 to 14_n are connected commonly to a terminal *t* which is to be connected to the input of a tone coloring circuit or the like also not shown in the drawing.

It may be noted that the switching circuits 11_1 to 11_n correspond to the respective keys of the musical instrument. The switching circuit 11_1, for instance, is rendered conductive when the key C_0 is depressed. Likewise, the other switching circuits 11_2,...11_{n+1} and 11_n are made conductive when the keys C # $_0$,...B_1 and C_2 are depressed, respectively. While these switching circuits may incorporate mechanical contacts, gate circuits making use of usual transistors or field-effect transistors are now employed in preference to such mechanical devices.

A series of selector switches 10_1 to 10_n in cascade connection are also provided correspondingly to the respective keys of the electronic musical instrument. All these selector switches are of identical construction, each comprising two fixed contacts and a single movable contact. The movable contact 10_{1c} of the selector switch 10_1 only is grounded, and the fixed break contacts 10_{1b} to 10_{nb} of all the selector switches are connected to the movable contacts 10_{2c} to 10_{nc} of the adjoining selector switches. The fixed make contacts 10_{1a} to 10_{na} of the selector switches are connected to the control inputs of the respective switching circuits 11_1 to 11_n.

The fixed break contact 10_{nb} of the selector switch 10_n is grounded via the power supply means 12 adapted as aforesaid to electrically rupture the insulating oxide films or the like which may be formed on the touching faces of the movable contacts 10_{1c} to 10_{nc} and the fixed break contacts 10_{1b} to 10_{nb} of all the selector switches 10_1 to 10_n. It may be noted that since the movable contact 10_{1c} and the fixed break contact 10_{nb} of the selector switches 10_1 and 10_n at both extremities of the cascade connection are grounded, either directly or indirectly, a closed circuit is formed by the movable contacts 10_{1c} to 10_{nc} and the fixed break contacts 10_{1b} to 10_{nb} of all the selector switches. The power supply means 12 connected in series in this closed circuit is composed of a series connection of a resistor *r* having relatively low resistance, a parallel circuit of a capacitor C and a resistor R having relatively high resistance, and a DC power supply E capable of producing a constant DC voltage. The resistor *r* may have a resistance of about 100 ohms, and the resistor R a resistance of about 100 kilo-ohms.

Proceeding to the description of a mode of operation of this preferred embodiment of the invention, let it now be supposed that the key C # $_0$ of the electronic musical instrument is depressed to cause conduction through the switching circuit 11_2. Thereupon the movable contact 10_{2c} of the selector switch 10_2 is caused to move from the break contact 10_{2b} to the make contact 10_{2a}, with the result that the control input of the switching circuit 11_2 becomes grounded via the contacts 10_{2a} and 10_{2c} of the selector switch 10_2 and the contacts 10_{1b} and 10_{1c} of the selector switch 10_1. The switching circuit 11_2 is now rendered conductive to permit an output signal from the tone generator corresponding to the key C # $_0$ to pass therethrough to the terminal *t* and thence to the tone coloring circuit or the like.

When the key C # $_0$ is succeedingly released, the movable contact 10_{2c} of the selector switch 10_2 is caused automatically to return to the break contact 10_{2b} from the make contact 10_{2a}. Thereupon the output

voltage from the DC power supply E is delivered via the capacitor C and the resistor r to the fixed break contacts 10_{nb} to 10_{1b} and the movable contacts 10_{nc} to 10_{1c} of the selector switches 10_n to 10_1 and thence to the ground. It will be noted that the capacitor C has been completely discharged during depression of the key C #0. Thus, when the movable contact 10_{2c} of the selector switch 10_2 is returned as aforesaid to the break contact 10_{2b} thereof, the voltage at the capacitor terminal opposite to the DC power supply E has a value E, so that the current flowing at this instant through the break contacts and movable contacts of the selector switches 10_n to 10_1 has an approximate maximum value E/r, as is graphically represented in FIG. 3.

The DC voltage impressed to the touching faces of the break contact 10_{2b} and movable contact 10_{2c} of the selector switch 10_2 is assumed to be sufficiently high to produce the coherer effect thereby rupturing the insulating oxide films or the like which may have been formed thereon. The contacts 10_{2b} and 10_{2c} are thus reconditioned for proper operation.

Thereafter, if all the selector switches 10_1 to 10_n are held unactuated, that is, if their movable contacts 10_{1c} to 10_{nc} are held in touch with the fixed break contacts 10_{1b} to 10_{nb} respectively, the electrostatic charge of the capacitor C gradually increases until after a predetermined length of time the current starts flowing through the resistors R and r to the selector switches. Since, however, the resistor R has sufficiently high resistance as previously mentioned, the value, $E/(R+r)$, of the current flowing through the selector switches is negligible, as will be seen from the curve of FIG. 3.

It will now be apparent that each time any of the selector switches 10_1 to 10_n is operated, the insulating films which may have been formed on the touching faces of the movable contact and the fixed break contact of that selector switch are electrically ruptured due to the DC voltage impressed thereto from the power supply means 12. Nevertheless, as long as all the selector switches are held inoperative, only a negligible amount of current is permitted to flow through the circuit formed by the DC power supply E, the resistors R and r, the fixed break contacts and the movable contacts of the selector switches 10_n to 10_1, and the ground.

Although the switch contact reconditioning device according to this invention has been shown and described hereinbefore in terms of preferred embodiments thereof, it will be easy for those skilled in the art to devise many modifications, substitutions or changes of such specific embodiments to meet various requirements which may arise in regard to their applications or manufacture. It is therefore appropriate that the invention be construed broadly and in a manner consistent with the proper scope or fair meaning of the appended claims.

I claim:

1. In a switch of the type comprising a movable contact, a fixed break contact, and at least one fixed make contact to be connected to a desired circuit, a device for reconditioning the touching faces of said movable contact and said fixed break contact comprising power supply means connected in series in a closed circuit formed by said movable contact and said fixed break contact, said power supply means being adapted to cause the electrical breakdown of insulating films on the touching faces of said movable contact and said fixed break contact each time said movable contact is returned to said fixed break contact from said fixed make contact.

2. The device as set forth in claim **1,** wherein both of said movable contact and said fixed break contact are grounded to form said closed circuit.

3. In a cascade connection of a plurality of switches, each of said switches being of the type comprising a movable contact, a fixed break contact, and at least one fixed make contact to be connected to a desired circuit, said fixed break contact of each of said switches being connected to said movable contact of the next switch, a device for reconditioning the touching faces of said movable contact and said fixed break of each of said switches, comprising power supply means connected in series in a closed circuit formed by said movable contacts and said fixed break contacts of said switches, said power supply means being adapted to cause the electrical breakdown of insulating films on the touching faces of said movable contact and said fixed break contact of each of said switches each time said movable contact is returned to said fixed break contact from the corresponding fixed make contact.

4. The device as set forth in claim **3,** wherein said movable contact of the switch at one extremity of said cascade connection and said fixed break contact of the switch at the other extremity of said cascade connection are grounded to form said closed circuit.

5. The device as set forth in claim **3,** wherein said power supply means comprises a DC power supply capable of delivering a constant DC voltage, a parallel circuit of a capacitor and a resistor having relatively high resistance, said parallel circuit being connected in series with said DC power supply, and a resistor having relatively low resistance connected in series with said parallel circuit.

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