Oct. 13, 1942.

A. M. CURTIS

2,298,468

CONTACT PROTECTION

Filed Oct. 4, 1938

FIG. 1

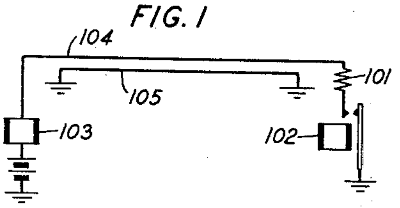


FIG. 2

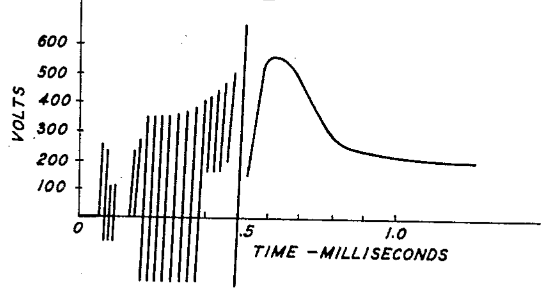


FIG. 1A.

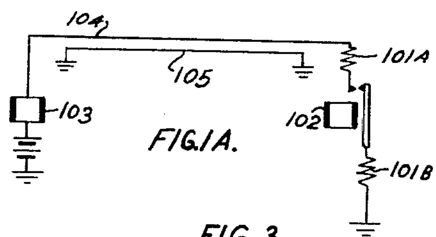


FIG. 3

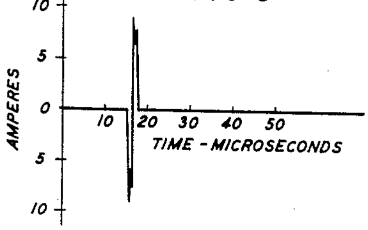


FIG. 4

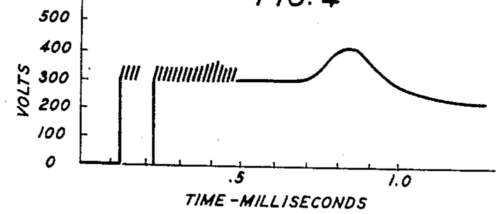


FIG. 5

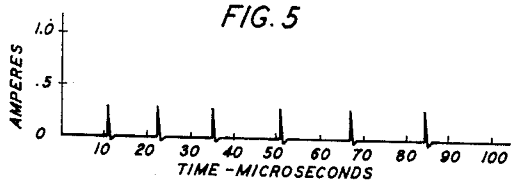
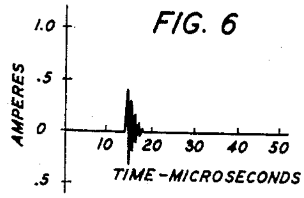


FIG. 6



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UNITED STATES PATENT OFFICE

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CONTACT PROTECTION

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Application October 4, 1938, Serial No. 233,242

4 Claims. (Cl. 175—294)

This invention relates to the protection of elements in electrical circuits which make and break electrical contact, such as relay contacts, switch blades, key contacts, etc., against deterioration, caused by sparking, pitting, depositing residue, etc. As is generally known the sparking associated with making and breaking electrical contacts is attended by deterioration of the contacting members.

Two general types of transients have been identified as a result of cathode ray oscilloscope studies of the discharge as contacts make and break in the range of currents and inductive loads usually met in telephone switching practice. One of these, which we shall call the "A" type, is a gas glow discharge and is less destructive than a second type which consists of a succession of sparks which we shall call the "B" type. The characteristics of these two different discharges will be discussed in detail hereunder. A means is disclosed herein for controlling the type of discharge which occurs in an electrical circuit as contacts are made and broken, so that, under circuit conditions conducive to the establishment generally of the destructive B type transient, the relatively harmless A type transient is made to predominate, greatly extending the useful life of the contacting members. This is performed by connecting a non-reactive resistance such as a carbon rod in series with the contacting member and the load and immediately adjacent to the contacts to be protected, or the non-reactive resistance may be divided into two units both connected in series with the load and one adjacent to each contacting member. Connection of the non-reactive resistance immediately adjacent to the contacts is important, as it has been found that connecting the same resistance elsewhere in the series connection, say adjacent to the load rather than to the contacts, does not result in the predominance of the desirable A type transient which extends the useful contact life. It has been found further that the B type transient is more objectionable in causing interference in neighboring radio receivers and that in suppressing it the benefits are two-fold, namely, first, contacts are protected, and second, radio receiver interference is suppressed.

It is an object of this invention to protect members making and breaking contact in an electrical circuit against deterioration.

It is a further object of this invention to suppress radiations of waves which cause interference in radio receivers by means of a device effective also to protect contacts.

It is a further object of this invention to control the type of transient discharge occurring when contacts in an electrical circuit make and break, so that a type identified as destructive to said contacts and which also causes interference in radio receivers is suppressed.

It is a further object of this invention to protect the contacting members in an electrical circuit by the use of an inexpensive non-reactive resistance connected in series with and adjacent to the contacting members.

A feature of this invention is the use of a pure resistance to protect contacts.

A further feature of this invention is the connection of non-reactive resistance in series with electrical contacts to protect said contacts.

A further feature of this invention is the connection of non-reactive resistance in series with and adjacent to electrical contacts to protect said contacts and suppress radiation.

The invention may be understood from the following description when read with reference to the associated drawing in which:

Fig. 1 represents a typical electrical circuit in which the contacts of relay 102, which make and break, are protected by non-reactive resistance 101, which is located in the circuit immediately adjacent to the front contact of the relay.

Fig. 1A is a modification of the arrangement of Fig. 1 in which the non-reactive resistance is arranged in two units, 101A and 101B, each located immediately adjacent one of the making and breaking contacts.

Fig. 2 is a drawing, reproducing an actual oscillogram, of the destructive type of transient discharge accompanying a circuit break, in a circuit generally comparable electrically with Fig. 1, except that the method of contact protection of this invention is not employed. Instead of being arranged as in Fig. 1, when the oscillogram per Fig. 2 was taken, the non-reactive protective resistance 101 was located adjacent relay 103. The ordinates in Figs. 2 to 6, inclusive, represent voltage or current as specified and the abscissae represent time.

Fig. 3 is a drawing, reproducing an actual oscillogram, of a single current surge accompanying one spark-over of the voltage indicated in Fig. 2. The horizontal scale of this figure is approximately fourteen times larger than that of Fig. 2. The peak of the current surge reaches 9 amperes although the steady state current in the circuit before the contact opened was only .022 ampere.

Fig. 4 is a drawing, reproducing an actual voltage time oscillogram, of the more desirable type of transient which is found to predominate, on the breaking of the circuit arranged per this invention as in Fig. 1.

Fig. 5 is a drawing, reproducing an actual oscillogram of some of the current surges accompanying the voltage transient of Fig. 4.

Fig. 6 is a drawing, reproducing an actual oscillogram, of a current surge on closing the circuit arranged as in Fig. 1, except that the protective resistance is not located according to this invention, but is located adjacent the winding of relay 103. The ordinate represents current which reaches .4 ampere.

It was not possible to obtain an oscillogram showing a current surge on closure of the circuit per Fig. 1 arranged in accordance with this invention, as the surges on closure are reduced to about one-tenth their original value and were not within the range of the oscillograph sensitivity.

Referring now to Fig. 1, a simple electrical circuit is shown. A path may be traced from ground, through battery, the winding of relay 103, conductor 104, non-reactive resistance 101, to the front contact of relay 102. The circuit is open at the armature. If current is supplied to the winding of relay 102, its core is energized, attracting the armature and closing the circuit heretofore traced to ground. When the relay winding is deenergized, the armature separates from its contact under the influence of spring tension in the armature spring. The conductor 104 represents a length of sixty feet of 22 gauge wire which was used when the oscillograms were made. It is one of a pair of wires, the mate to which, conductor 105, is grounded at each end at the positions of relays 102 and 103 as indicated. Its length was chosen as representing a common conductor length in a telephone switchboard.

As is generally well known, as the circuit is made and broken, transient voltages are established in the circuit, depending upon the electrical characteristics of the circuit. These transient voltages and the current surges accompanying them may be very much greater than the normal operating voltage and current in the circuit. In Fig. 1, for instance, which if resistance 101 is omitted is a typical circuit frequently encountered in telephone and telegraph switching the voltage of the battery is 45 volts. The resistance of the relay is 1050 ohms and the resistance of non-reactive resistance 101 is 1000 ohms. The steady state current is 22 milliamperes.

When the non-reactive resistance 101 is located adjacent relay 103, it is found on opening the contacts as indicated in Fig. 2, that the energy in the circuit is dissipated in a succession of sparks, often several hundred, at increasing voltages. The value of these voltages is indicated by the scale of Fig. 2. It may be observed that they reach approximately 650 volts. This is more than fourteen times the full voltage of the power source in Fig. 1.

The ordinate in Fig. 3 indicates that 9 amperes flow through the contacts during a single voltage spark-over per Fig. 2. This is approximately 400 times the steady state current. Fig. 3 does not represent the maximum current surge that has been observed for this condition. Current surges as great as 15 amperes have been observed.

When non-reactive resistance 101 consisting of a carbon rod is located as in Fig. 1 adjacent the contact of relay 102, in accordance with this invention, it has been found that the character of the transient voltages at the contacts when opened is generally in accordance with Fig. 4. For the first few ten-thousandths of a second there are a series of spark-overs from approximately 300 volts, followed by the establishment of a gas arc which maintains a flow of current at about 280 volts, until the discharge of the energy in the circuit permits the final rupture of the circuit from .6 to 1.5 milliseconds after the initial separation of the contacts.

The current flowing in the contacts during this transient is comparatively small as indicated by the ordinates in Fig. 5 which represent the current accompanying a series of voltage surges per Fig. 4 near the beginning. The current surges for a contact in a circuit per Fig. 1 protected per this invention would equal approximately .3 of an ampere which is about fourteen times the steady state current, as opposed to 400 to 680 times the steady state current with the same non-reactive resistance in circuit in a different location.

The above description provides a comparison of the transient voltages and currents developed when a circuit per Fig. 1 is broken under two different conditions, namely, (1) when a non-inductive resistance is located adjacent the relay contact and (2) when the same non-inductive resistance is located adjacent the relay winding. We will now compare the transient currents developed when the circuit is closed for the two conditions.

Fig. 6 shows a current surge when the circuit per Fig. 1 is closed with the non-reactive resistance 101 located adjacent the winding of relay 103. It reaches .4 ampere or approximately twenty times the steady state current condition. This was compared with the current condition on closure of a circuit per Fig. 1 with the non-inductive resistance located immediately adjacent the contact. It was found that for this condition the surge was too small to be measured with the apparatus available indicating that the non-reactive resistance affords protection also for the circuit closure condition in that it substantially eliminates surges due to the discharge of the line wire.

The effect illustrated herein, due to the connection of a resistance adjacent to a contact and separating the contact from the line wire leading to an inductive load may be explained briefly as follows: Assume first that the line is directly connected to a contact and the two contacts commence to separate. The circuit is ruptured, leaving energy stored in the inductive load which flows into the line wire (considered now as a capacity) and charges it to a voltage at which a spark takes place between the separating contacts. The energy in the line is discharged through a minute area of the contacts, violently fusing it and reopening the circuit. The voltage between the contacts at the instant of rupture may be of either sign, depending on the phase of the oscillation of the line wire at which the rupture occurs, but it is below the sparking voltage, and the circuit remains open and the line wire is recharged by the energy still remaining stored in the inductive load until sparking voltage is reached a second time. This process is repeated many times until the distance between the constantly separating contacts is too great to permit the decreasing stored energy in the inductive load to charge the line wire to a sparking voltage. The repeated sparks and explosive reopenings volatilize the contact metal and produce repeated powerful high frequency oscillations in the line wire which are radiated and cause noise in adjacent circuits. This phenomena has been called for convenience the type B transient.

When, however, the capacity of the line wire shunting the contacts and the inductive load is very small, the rate of flow of energy from the inductance as the contacts separate is so rapid that the voltage is not permitted to pass through zero after the first few spark-overs occur, but is maintained in the neighborhood of 300 volts and a gas glow discharge is established. This spreads out over the contact surface (reducing the current density) while the stored energy flows through the glow discharge at a steady moderate rate until it is nearly all dissipated, the reduced concentration of current resulting in less erosion of the contacting areas. It is usually not practical to reduce the length of the line wire as much as is required to produce the glow discharge (A type) transient, but the effect of the line wire can be very much reduced by the method of this invention. By interposing a substantial non-inductive resistance between contact and line wire, the rate of discharge of the line is reduced sufficiently so that the contact voltage is maintained at or above the ionization voltage of air and the stored energy is then dissipated continuously at a relatively low rate through the diffused gas glow discharge.

As stated above, the non-reactive resistance may be divided into two units, and one of each of said units connected to each of the making and breaking contacts as indicated by resistances **101A** and **101B** of Fig. 1A. The magnitude of the resistance and reactance of the two combined resistances **101A** and **101B** should not aggregate more than that of the single resistance **101** of Fig. 1. They should be located each immediately adjacent its respective contact. The relative amounts of the resistance connected to each contact does not appear to be important. The values and form of the voltage and current curves described for Fig. 1 apply equally to Fig. 1A.

What is claimed is:

1. In a telephone or telegraph switching system, an electrical circuit comprising a ground, a battery, a relay winding, a first electrical conductor, a carbon resistance, a pair of cooperating relay contacts adapted to open and close, a second electrical conductor, an electrical conducting path extending sequentially in series from said ground, through said battery, through said winding, through said first conductor, through said resistance, said resistance being connected immediately adjacent one of said contacts, through said contacts, through said second conductor and thence to said ground, the magnitude of the reactance of said resistance being of the order to promote the establishment dominantly of a gas glow transient discharge as said contacts make and break to protect said contacts against deterioration.

2. In a telephone or telegraph switching system, an electric circuit, an electromagnetic switching relay therein, a pair of cooperating metallic electrical contacts on said relay adapted to open and close to interrupt an electrical current through said contacts and a lumped resistance, of the order of reactance of carbon rod, connected immediately adjacent one of said contacts, to protect said contacts against deterioration as said contacts make and break to successively close and open the path of the current.

3. In a telephone or telegraph switching system, a circuit extending sequentially in series from ground, through a battery, through a lumped inductance, through a conducting line, through a first non-reactive type resistance located immediately adjacent one of a pair of current making and breaking contacts, through said contacts through a second non-reactive type resistance located immediately adjacent the other of said pair of contacts and thence to ground, the magnitudes of the resistances and reactances of said non-reactive type resistances being of the order to protect said contacts against deterioration.

4. In a telephone or telegraph switching circuit, a circuit including a source of electromotive force, a lumped inductance, a conducting line, a pair of non-reactive type resistances, one of said pair located immediately adjacent a first metallic contact and the other of said pair located immediately adjacent a second metallic contact, means for making and breaking said contacts to open and close said circuit, the electrical characteristics of said resistances being chosen to protect said contacts from deterioration.

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