

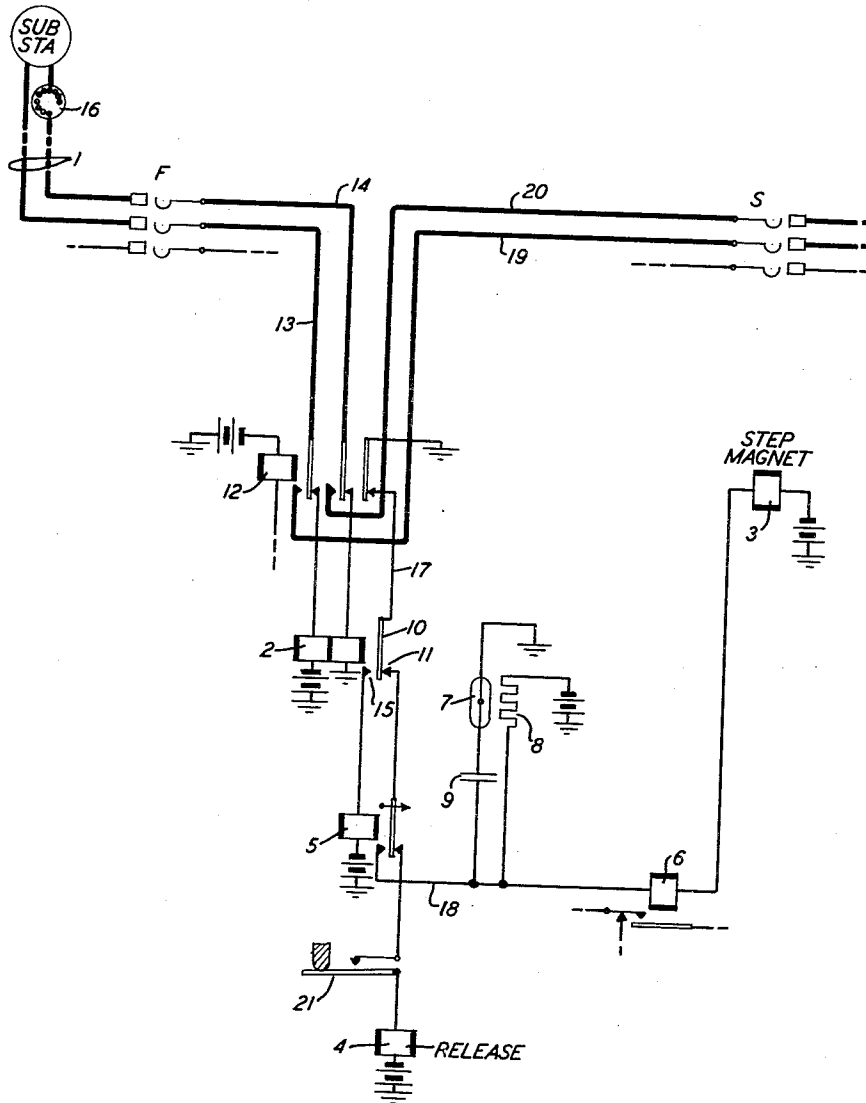
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D. T. MAY

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PROTECTIVE DEVICE

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INVENTOR
D.T. MAY

BY *M.V.T. McKerney*
ATTORNEY

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PROTECTIVE DEVICE

David T. May, Port Washington, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

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This invention relates to electrical systems in which current-carrying circuits are opened and closed by switching devices, such as relay contacts.

5 The objects of the invention are to protect the contacts utilized for opening and closing these circuits; to prevent excessive sparking; to eliminate surges from the circuits; and otherwise to effect improvements in these systems.

10 In the process of producing successive electrical impulses for the purpose of operating automatic switches in telephone systems, it is necessary to repeatedly open and close circuits having inductive elements therein, such as the windings of stepping magnets and relays. As it is the
15 usual practice to open and close these circuits by means of relays, the contacts of these relays deteriorate, because of current arcs formed at the moment of opening and closing, unless some circuit provision is made to prevent it. One of the common safeguards is to connect a condenser in parallel with the circuit controlling contacts of the relay. The condenser, when chosen with the proper capacitance, is a very efficient means
20 for absorbing the surge that results from the opening of the contacts. However, when the contacts reclose, the entire condenser charge is dissipated across the closing contacts, resulting in injury and, in many cases, in the actual welding together of the contact members. To care
25 for this condition, it is necessary to provide a series resistance to assist in dissipating the condenser discharge. The insertion of this resistance on the other hand lowers the efficiency of the condenser in absorbing the inductive energy of the surge produced when the contacts are opened. Thus, the design of contact protection circuits has in the past been a compromise between these two conditions.

40 According to the present invention the necessity of impairing the efficiency of the condenser in order to restrict its rate of discharge to a safe value is obviated by connecting it across the contacts to be protected in series with a
45 variable-resistance element which responds to temperature changes and automatically assumes resistance values that are best suited to both the open circuit condition and closed circuit condition of the contacts. The normal resistance of
50 the variable-resistance unit is of such high magnitude that discharge currents from the series condenser are not permitted to flow in sufficient intensity to injure the relay contacts. However, by effecting an increase in its temperature, the
55 resistance unit responds with an immediate drop

in its resistance to a value such that current surges are permitted to flow readily through the unit for the purpose of charging the condenser. The protective arrangement is therefore equipped with a heating coil for the variable-resistance
5 unit, and these elements—the condenser, the resistance unit, and the heating coil—are connected in the circuits in such a way that the resistance unit is heated to place it in its low-resistance state when the current surges are to
10 be absorbed by the condenser and is cooled and correspondingly restored to its high-resistance condition when it is desirable to prevent the sudden discharge of the condenser through the relay contacts.

15 The foregoing and other features of the invention will be described in detail in the following specification, which should be considered in conjunction with the accompanying drawing.

In the drawing the invention is illustrated as
20 applied to a selector switch in an automatic telephone system. The switch illustrated is of the step-by-step type, such as those used in step-by-step central office systems. For simplicity those parts of the selector not essential to an understanding of the present invention have been
25 omitted in the drawing. For a full understanding of the details of these switches reference is made to Automatic Telephony, second edition, by Smith and Campbell, pages 53 to 67. It will, of course, be understood that the invention is not
30 limited in its application to switches of this type; it may be applied to other types of switches and in fact to other types of systems, including relay and key-controlled circuits, where protection
35 is needed for circuit contacts.

Referring particularly to the drawing, a telephone subscriber's line 1 is shown appearing in the terminals of a line-finder switch F in the central office. The line finder F (which may be
40 of any type known in the art) is associated individually with a selector switch S. The selector S is equipped with an impulse relay 2, with setting and releasing magnets 3 and 4, respectively, with controlling relays 5, 6 and 12, and with
45 other operating and controlling circuit mechanism not disclosed in the drawing. In addition to these devices the selector switch S is also provided with a variable-resistance element 7 and its associated heating coil 8 for the purpose of
50 protecting the contacts of the impulse relay 2.

The variable-resistance element 7 may be made of any material, such as boron, silver sulphide or uranium oxide, having a high negative temperature coefficient of resistance. If the element is
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to be used for the protection of contacts that open and close at a relatively high rate, it is necessary to design the element and its heating coil so that a correspondingly rapid change in the temperature of the element can be secured. By applying sufficient energy to its heating coil, the resistance element can be heated almost instantaneously. And, by properly proportioning the surfaces and volume of the element, it can be made to lower its temperature at a rapid rate following the removal of the heating current.

While the resistance element disclosed herein may be of any suitable construction and of any desired materials, a general understanding of elements of this type may be had from British Patent 472,144, accepted September 17, 1937.

The resistance element 7 is included in series with a condenser 9 in a circuit which is, in effect, connected across the armature contact 10 and its back contact 11. The purpose of the element 7 in this circuit is to introduce a high resistance to the flow of discharge current from the condenser 9; at times when this discharge current would damage the contacts of relay 2, without offering any appreciable resistance to the flow of charging current in said circuit at times when it is desirable to allow current surges to flow into the condenser instead of flowing through the contacts of the relay. To this end the resistance element 7 is equipped with a heating coil 8, which is placed in close proximity to said element. And, by causing current to flow in the coil 8 at the proper times, the resistance of the element 7 may be made to alternate between its high and low values.

A detailed description of the circuits will now be given. For this purpose, assume that the subscriber of line 1 wishes to make a telephone call. When he initiates the call, the line finder F operates in the well-known manner to seize his line. Upon seizure of the calling line a circuit is closed from battery through the left winding of impulse relay 2, inner back contact of relay 12, conductor 13, through the finder switch F, over the loop of the calling line 1, through the finder switch F and conductor 14, middle back contact of relay 12, through the right winding of relay 2 to ground. Relay 2 attracts its armature 10, and a circuit is closed from ground through the outer back contact of relay 12, conductor 17, armature contact 10 and its front contact 15, winding of slow-release relay 5 to battery. Relay 5 attracts its armature and holds it in the attracted position during momentary interruptions of its circuit by the impulse relay 2. The subscriber now manipulates his dial 16 to open and close the circuit of relay 2 any number of times in succession.

On the first opening of the line 1 relay 2 releases its armature 10, which engages the back contact 11 and closes the following circuit: Grounded conductor 17, armature 10, back contact 11, front contact of relay 5, conductor 18, winding of relay 6, through the winding of the vertical stepping magnet 3 to battery. Magnet 3 operates in this circuit and advances the brushes of the selector S one step. The control relay 6 also operates. At the same time a further circuit is closed from the grounded conductor 17 through armature 10 and contact 11, front contact of relay 5, conductor 18 through the heating coil 8 to battery. The coil 8 heats the resistance element 7, causing it to assume its low-resistance condition. Nothing further occurs until the subscriber's line 1 is reclosed at the end of the first impulse.

When the subscriber's line does close at the end of the first impulse, the impulse relay 2 is reenergized and attracts its armature 10. As the armature 10 separates from its back contact 11, the circuit of the magnet 3 and relay 6 is broken, and the inductance of these devices produces a high electromotive force which tends to continue the flow of current in the circuit. It is the surge produced by this relatively high induced electromotive force that causes arcing across the contacts 10 and 11 unless protection is provided. Since, however, the resistance element 7 is in its low-resistance state at the instant the surge occurs, the surge flows over the following circuit and charges the condenser 9 instead of producing an arc across the separating contacts 10 and 11: Battery through the winding of magnet 3, winding of relay 6, condenser 9, resistor 7 in its low-resistance state to ground. Thus the condenser 9 receives the inductive surge, and the contacts 10 and 11 are permitted to separate without detrimental sparking. Upon the opening of contacts 10 and 11 the energizing circuit of coil 8 is opened, and resistance element 7 begins to cool and to assume its high-resistance condition. The time required for the element 7 to cool following the deenergization of coil 8 is such that the resistance of the charging circuit of condenser 9 is not increased appreciably until the contacts 10 and 11 have separated enough to obviate any possibility of arcing. On the other hand, the element 7 cools with sufficient rapidity, following the deenergization of coil 8, to reach its full high value before the circuit of relay 2 is opened for the next impulse.

When, after a moment, the line 1 opens again for the next impulse, relay 2 again releases its armature 10. As the armature 10 approaches its back contact 11, the condenser 9, being fully charged, would, unless otherwise prevented, apply its full voltage across the gap of contacts 10 and 11. At this instant, however, the resistor 7 is in its high-resistance condition, limiting the flow of discharge current from condenser 9 to a low value. No arcing occurs therefore as contacts 10 and 11 approach each other, and, when these contacts have finally closed the condenser 9 discharges over the following circuit: Ground through the resistance element 7, condenser 9, front contact of relay 5, contacts 11 and 10 to the grounded conductor 17. Since element 7 is at its high-resistance value at this instant, the intensity of the discharge current is limited to a value which does not injure contacts 10 and 11. As the contacts 10 and 11 close, the heating coil 8 is again energized, and the element 7 begins to lower its resistance value. By the time element 7 has reached its low-resistance value condenser 9 has partly discharged, and the remainder of the discharging action takes place without injury to contacts 10 and 11, particularly since these contacts are now fully closed and since the voltage across the terminals of the condenser has been substantially lowered.

On the next closure of the line 1, terminating the second impulse, relay 2 attracts its armature 10. As the armature 10 recedes from contact 11 another surge occurs in the coils of magnet 3 and relay 6, and this surge again flows into the condenser 9 where it is stored instead of passing through the separating contacts 10 and 11.

This action continues on each succeeding impulse, the surges being stored in the condenser 9 and the condenser 9 being discharged gradually

with each successive operation of the impulse relay.

After the selector switch S has been fully operated, the relay 12 operates and extends the conductors 13 and 14 over conductors 19 and 20 through the brushes of selector S to the next switch beyond.

When it is desired to release the connection, relay 12 is deenergized, and a circuit is completed from ground through the outermost contact of said relay, conductor 17, armature 10 and contact 11, back contact of relay 5, off-normal contacts 21 through the winding of the release magnet 4 to battery. The magnet 4 energizes and restores the selector switch S to its normal position. The finder switch F is also restored in the usual manner, and all other equipment utilized in the connection is similarly returned to its normal condition.

20 What is claimed is:

1. In combination, a circuit having a source of current and an inductive element therein, relay contacts for closing said circuit to permit current to flow from said source through said inductive element, a resistor having a pronounced temperature coefficient of resistance connected in parallel to said relay contacts, a heating coil for said resistor, and a circuit for said coil closed through said relay contacts.

30 2. In combination, a circuit having a source of current and an inductive element therein, relay contacts for closing and opening said circuit successively to cause impulses of current to flow through said inductive element, a resistor the resistance of which is variable between relatively high and low resistance values, a circuit for connecting said resistor across said relay contacts, and circuit means made effective by the opening of said contacts for causing said resistor to assume its high-resistance value and made effective by the closure of said contacts for causing said resistor to assume its low-resistance value.

40 3. In combination, a circuit having a source of current and an inductive element therein, relay contacts for closing and opening said circuit successively to cause impulses of current to flow through said inductive element, a resistor the resistance of which is variable between relatively high and low resistance values, a circuit for connecting said resistor across said relay contacts, and means controlled by said relay contacts for causing said resistor to assume its high-resistance value prior to each closure of said contacts and to assume its low-resistance value prior to each opening of said contacts.

50 4. In combination, a circuit having a source of current and an inductive element therein, relay contacts for closing and opening said circuit successively to cause impulses of current to flow

through said inductive element, a resistor the resistance of which varies with its temperature between relatively high and low values, a circuit for connecting said resistor in parallel with said relay contacts, and heating means controlled by said relay contacts for causing said resistor to present a high resistance to the flow of current at the closure of said contacts and to present a low resistance to the flow of current at the opening of said contacts.

5. In combination, an impulse circuit having an inductive element and a source of current therein, contacts in said circuit, means for opening and closing said contacts to produce impulses of current in said circuit, a condenser for storing the currents induced by said inductive element upon the opening of said impulse circuit, a charging circuit and a discharge circuit for said condenser, a resistor the resistance of which is variable between upper and lower values, said resistor being included in both said charging and discharge circuits, and means for causing said resistor to present a relatively low resistance to the flow of current in said charging circuit and a relatively high resistance to the flow of current in said discharge circuit.

6. In combination, an impulse circuit having an inductive element and a source of current therein, contacts in said circuit, means for opening and closing said contacts to produce impulses of current in said circuit, a condenser for storing the currents induced by said inductive element upon each opening of said contacts and for discharging said currents on each closure of said contacts, a charging circuit for said condenser excluding said contacts, a discharge circuit for said condenser including said contacts, a resistor the resistance of which is variable between high and low values, said resistor connected in series with said condenser in both the charging and discharge circuits, and means controlled by said contacts for causing said resistor to present a low resistance to the flow of current in said charging circuit when said contacts open and to present a high resistance to the flow of current in said discharge circuit when said contacts close.

7. In combination, a circuit having a source of current and an impedance element therein, relay contacts for closing and opening said circuit successively to cause impulses of current to flow through said impedance element, a resistor having a negative temperature coefficient of resistance, a circuit for connecting said resistor across said relay contacts, and means for causing said resistor to assume its high-resistance value preparatory to the closure of said contacts and its low-resistance value preparatory to the opening of said contacts.

DAVID T. MAY.