

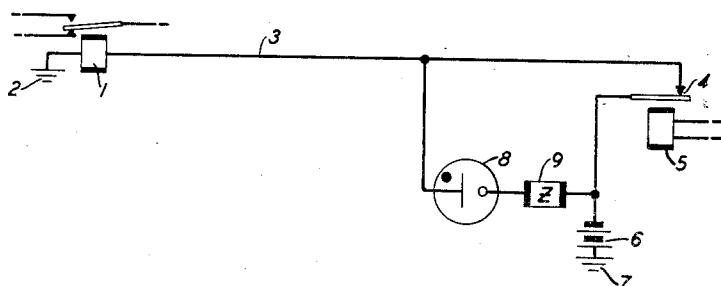
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ELECTRIC SWITCH CONTACT PROTECTION

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ELECTRIC SWITCH CONTACT PROTECTION

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This invention relates to the protection of switch contacts in electrical circuits, particularly to the protection of relay switch contacts in communication switching circuits.

An object of this invention is the improvement of contact protection arrangements for switches in electrical circuits.

A more particular object of the invention is the improvement of contact protection devices in which a gas tube shunting the contacts is employed as a protecting element.

In the typical communication switching circuit, the energization and deenergization of a relay winding is controlled usually by the opening and closing of relay contacts which are subject to erosion in the process. The employment of a gas tube shunting a pair of relay contacts as a contact protection element in such circuits has long been under study in the art. It is well understood that a gas tube, shunting contacts which control an electric load, reduces the erosion of the contacts. Gas tube protectors have a number of advantages among which are that they are relatively inexpensive and that the gas tube protector does not generate arcs on reclosure of the contacts as in the case when a condenser forms one of the protecting elements.

It is well understood in the art also that the cold cathode gas tube as a protector of contacts is subject to at least two limitations which up to the present have restricted its widespread application. The first limitation is that the gas tube does not break down instantly on application of its control voltage when the contacts are opened. During the interval prior to breakdown the transient voltage applied across the separating contacts which the tube is intended to protect rises to such value that arcing and plastic deformation reclosures occur.

As to this first limitation it is also well understood in the art that the adverse effect of delay in the breakdown of the tube may be minimized by speeding up the discharge in the tube. To this end radio active materials have been introduced into the tube and other measures have been taken in the design of the tube to minimize the delay in discharge and the attending buildup of excessive potentials before the contacts have separated sufficiently to prevent serious arcing between them.

The erosion of opening contacts is minimized if the voltage of the transient at the first instant of opening has not risen to a value at which arcing or plastic deformation reclosures can occur and if the voltage of the transient does not attain such a value before the contacts have definitely separated, and if the rate of increase of the transient voltage is such that it does not attain a value during contact separation adequate to cause a spark-over through the corresponding interven-

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ing space at any instant. In other words to prevent arcing the transient voltage at each instant must be maintained below the spark-over value for the corresponding contact separation at each instant. This, however, is not presently attainable through the use of gas tube protection in the 50-volt communication switching plant and it is probable that it is not possible of ultimate attainment using this means of protection.

Quantitative study indicates that if a gas discharge tube had no time lag in establishing conductivity, it might, in the 50-volt telephone plant, be expected to limit the voltage between opening contacts to about 65 volts. But this would not prevent a certain amount of arcing which occurs at as low as 10 to 15 volts, if the magnitude of the current is large enough, nor would it completely eliminate reclosures which, on occasion, occur below 50 volts especially with silver contacts. No gas tubes presently known, including those which have therein substances to increase the speed of discharge, break down instantly on application of their critical voltage. Time lags of from 10 to 50 microseconds have been measured when these tubes are used as protection on contacts operating common telephone switching relay loads. During the longer of these intervals, the voltage may rise to 300 or more volts, several reclosures and spark-overs may then occur and cause erosion. Many gas tubes once having established conductivity do not maintain it constantly until the voltage between their electrodes has fallen below the sustaining value. The glow discharge may break and be reestablished several times, each break causing sparking and erosion of the contacts.

It is anticipated that improvements in design of the gas tube will effect greater uniformity of characteristics and will tend to shorten the interval of delay before conduction through the tube is established. Fairly uniform delays of 10 to 15 microseconds before conduction is established and corresponding voltages approximating 65 volts on the opening of contacts in the typical 50-volt communication plant switching circuit may be possible of attainment in the future and would probably afford generally satisfactory contact performance, since the adverse effect of the arcing resulting therefrom would probably not be excessive.

The second of the two limitations to which the cold cathode gas tube is subject as a contact protector and which greatly restricts its application is that it delays the release of the load relay by an amount which is often prohibitive. This difficulty is very materially reduced by the present invention. This is achieved by connecting a gas tube, preferably a cold cathode gas tube, and a thyrite varistor, or an element having similar properties, arranged in series with the gas tube,

in a circuit branch shunting the contacts to be protected. The effect of this on the relay release delay will be described hereinafter.

A feature of this invention is a contact protector comprising a cold cathode gas tube and a thyrite varistor or an element having similar properties in series shunting the contacts to be protected.

The thyrite varistor may be associated with the gas tube in any of three ways: (1) it may be mounted in any convenient manner within the impervious envelope of the tubes which envelope may be of glass, metal or other suitable material; (2) the thyrite varistor may be mounted in the base of the tube; (3) it may be mounted external to the tube.

Preferably the protection device is arranged in either of the first two of the manners enumerated and preferably also the protection unit is incorporated into the structure of the relay of which the contacts to be protected form a part for convenience in handling and to minimize the length of the conductors by means of which the protection device is connected to the contacts to be protected, so as to minimize the reactance introduced into the circuit by the connections between the protector and the protected contacts.

A thyrite varistor suitable for employment with a gas tube as a contact protector in a typical switching circuit in the 50-volt communication plant may be for instance cylindrical in shape having a diameter of approximately $\frac{1}{8}$ " to $\frac{1}{4}$ " and a length of about 1".

Refer now to the drawing which shows a typical communication switching circuit including the contact protector of the present invention. In the drawing a load consisting of the winding of relay 1 is connected in a circuit extending from ground 2, through the winding, conductor 3, closed contact 4 of relay 5 and battery 6 to ground 7. As the winding of relay 5 is energized and deenergized by means of a circuit not shown, contact 4 is opened and closed breaking and establishing the circuit through the winding of relay 1. In this process the contacts 4, as is well known, are eroded in part as a result of the sudden discharge of the energy stored in the circuit as the contacts are opened.

A protection circuit is connected in shunt with contacts 4. The circuit consists of cold cathode gas-filled tube 8, which may be any cold cathode gas-filled tube, but preferably one which becomes conductive in the shortest possible time and at a suitably low voltage. The tube 8 will ordinarily have two electrodes and a single gap therebetween connected in series with thyrite varistor 9. However, the tube 8 may have more electrodes and may have more than one gap. Good results have been obtained by employing the 313A cold cathode gas tube manufactured by the Western Electric Company, Incorporated. This gas tube is described in the Bell Laboratories Record for December 1936 on pages 114 to 116, inclusive. It is particularly pointed out, however, that the 313A tube has three electrodes, namely a cathode, a control electrode and an anode and two gaps, one between the control electrode and the cathode and one between the anode and cathode. When this tube is employed connections indicated in the drawing are established between the cathode and control electrode and the anode and anode gap are not employed. This arrangement is followed to take advantage of the fast operation and low breakdown voltage of the gap be-

tween the control electrode and cathode of this particular tube.

It is desirable that the connections for the contact protection circuit be short to minimize the reactance introduced thereby.

The resistance of the thyrite varistor to a current equal to that of the load should be in the order of a thousand ohms but may be somewhat less. This resistance should rise with decreasing current to a value about equal to the E/I of the gas tube at the release current of the relay load.

A comparison was made of the load relay release times for four different arrangements, using a typical relay employed in the communication switching plant. The relay employed was a Western Electric Company, Incorporated, "U" type relay well known in the art having a 700-ohm winding and the 313A tube above described. The results are presented in the following tabulation.

Contact Protection Employed	Relay Release Time
	Milliseconds
Cold cathode gas tube alone.....	35
Cold cathode gas tube+ordinary 1000-ohm resistance....	24
Cold cathode gas tube+thyrite (as above).....	13
No protection.....	11

Comparable shortening of the relay release time has been obtained with both cold cathode gas-filled tubes and relays of other types.

From the foregoing it is apparent that the use of the cold cathode gas tube plus the thyrite varistor as a protector added but 2 milliseconds to the release time of the relay as compared to the release time when no protection of any kind was employed. When an ordinary 1000-ohm resistance was employed together with the cold cathode gas tube the release time was considerably greater, 13 milliseconds longer, than the release time when no protection was used. When a cold cathode gas tube alone was used the release time was more than three times as long as when no protection was employed, that is, 35 milliseconds as compared with 11 milliseconds.

The initial voltage of the transients occurring when the gas tube plus the thyrite varistor are used are approximately the same as those when using the gas tube alone, although the initial voltage was somewhat higher in the former case. The transient voltages occurring when the ordinary 1000 ohms resistance is employed in series with the tube were definitely higher than with the tube alone.

The term varistor as used herein means a resistance having non-linear voltage current characteristics, more specifically having high resistance at low voltage and low resistance at high voltage. Thyrite is the commercial name applied to such a varistor composed of silicon carbide crystals and an insulating binder of kaolin. Varistors are described in Patent 1,822,742 issued September 8, 1931, to K. B. McEachron.

The thyrite varistor operates to break the glow in the tube by, in effect, appropriating a rapidly increasing proportion of the transient voltage as the current decreases with the decrease of the energy stored in the load relay. A stage is reached where the drop across the thyrite varistor remains substantially constant with decreasing total voltage and current. This is followed by the breaking of the glow discharge sometimes preceded by oscillations of 10-15 volt amplitude.

The variations in voltage and current throughout the entire process are presently not completely known. Determination of their varying values is complicated by a slight decrease in the voltage across the gas column with decreasing current. In any event the gas tube plus the thyrite varistor series combination gives a result which is better than either alone, since the thyrite varistor used without the gas tube gives a considerably slower release than any included in the above tabulation. The employment of the thyrite varistor with the cold cathode gas-filled tube, therefore, appears to practically eliminate the second of the two limitations to the widespread use of the cold cathode gas-filled tube as a contact protector. For many applications where its relative cheapness recommended its use and where the number of contact operations were not so great that the first of the two limitations precluded its employment and where it has heretofore been inapplicable because of the relay release delay which it introduced, it is, as a result of the present invention, now available.

What is claimed is:

1. In an electrical circuit, an electric load comprising a neutral electromagnetic relay having a winding and a first pair of unenclosed contacts thereon arranged to close and to release, a second pair of unenclosed contacts in said circuit controlling the connection of a source of direct-current potential in said circuit to said winding, a contact protector connected in shunt with said second pair of contacts, said protector comprising a gas-filled discharge tube and a non-reactive, non-linear resistance, said resistance having relatively high magnitude at low voltage and relatively low magnitude at high voltage, connected in series with said tube to protect said second contacts against deterioration and to reduce the delay in the release of said first pair of contacts when said second pair of contacts open.

2. An electrical circuit extending through a neutral electromagnetic relay winding and a pair of cooperating relay contacts, said contacts unenclosed, said contacts arranged to make and break to control the connection of a source of direct-current potential, in said circuit, to said winding, a contact protector connected to said contacts, said protector having a cold cathode gas-filled tube to reduce the magnitude of the transient voltages generated as said contacts break and a non-reactive, non-linear resistance, said resistance having relatively high magnitude at low voltage and relatively low magnitude at high voltage, in series with said tube, to minimize the delay in the deenergization of said winding after said contacts break.

3. A protector against erosion for unenclosed electrical contacts including means to minimize the delay in the dissipation of electrical energy stored in a direct-current neutral electromagnetic relay winding controlled by said contacts, said protector comprising a gas-filled tube and a non-reactive, non-linear resistance, said resistance having a relatively high magnitude at low voltage and a relatively low magnitude at high voltage, connected in series with said tube both connected in shunt with said contacts.

4. A pair of unenclosed contacts in an energized direct-current electrical circuit, said circuit including a lumped inductance, means for opening said contacts to deenergize said circuit and a contact protector connected to said circuit compris-

ing a cold cathode gas-filled tube and a non-reactive, non-linear resistance, said resistance having a relatively high magnitude at low voltage and a relatively low magnitude at high voltage, said resistance connected in series with said tube to minimize the adverse effect of the deenergization of said circuit and to reduce the delay in said deenergization.

5. In combination, an electrical switching telephone or telegraph circuit consisting of a source of grounded direct-current potential of approximately 50 volts, an electromagnetic relay winding of approximately 700 ohms and a pair of unenclosed contacts connected in series to ground, a contact protector shunting said contacts, said protector consisting of a cold cathode gas-filled tube and a non-linear resistance both connected in series, said resistance connected directly to said tube and in close proximity to said tube, said non-linear resistance having a relatively high magnitude at low voltage and a relatively low magnitude at high voltage, the magnitude of said resistance to the normal steady state current flowing through said winding being approximately 1,000 ohms, the magnitude of said resistance increasing with decreasing current to a value equal approximately to the resistance of said tube at the release current value of said relay, so as to minimize the delay in the release of said relay.

6. A contact protector for unenclosed contacts in a direct-current circuit, said circuit including lumped inductance, to increase the speed of deenergization of the protected circuit, said protector comprising a gas-filled tube and a resistance in series, both connected in shunt to the contacts to be protected, said resistance of a material the resistance characteristic of which is expressed by the formula $RI^a = c$, where R is the resistance of the material for any value of current I, I is the corresponding current passing through the resistance, a is a constant, approximately 0.80 ± 0.15 , depending upon the material of the resistance, and c is a constant dependent upon the shape of the material of the resistance.

LAVALETTE STEVENSON CURTIS,
Executrix of the Estate of Austen M. Curtis,
Deceased.

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