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CONTACT PROTECTION ARRANGEMENT

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FIG. 1

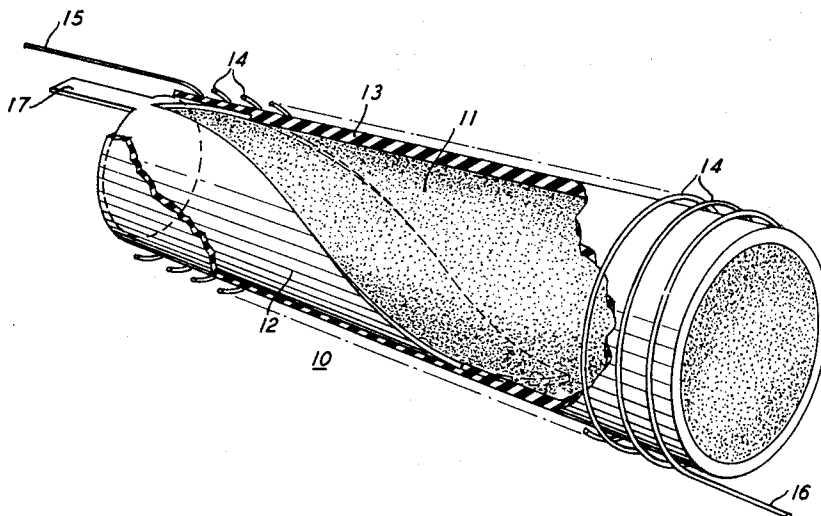
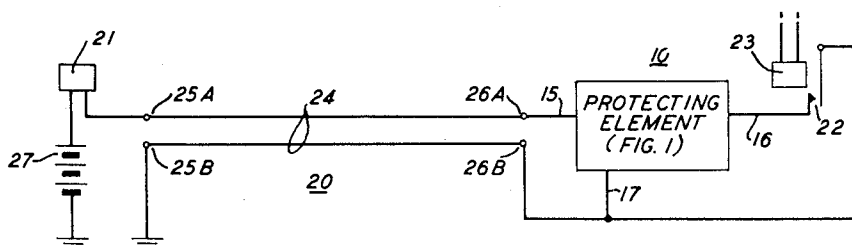


FIG. 2



1

2,958,809

CONTACT PROTECTION ARRANGEMENT

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4 Claims. (Cl. 317—11)

This invention relates to arrangements for protecting electrical contacts from deleterious erosion caused by electrical arcing and/or energy dissipation during contact operations.

Contacts of the type which make and break energized electrical circuits develop a number of faults in service. For example, the repeated making and breaking of a circuit with current flowing therethrough often results in irregular arcing attended with transfer of contact metal from one cooperating contact to the other, with consequent pitting of one contact surface and building up of projections on the other. Also, the continued transfer of material from one contact to another often brings about a localization of the contact area with a resultant increase in current density at such restricted area of contact. This localization condition renders more pronounced the deteriorating action of the contact arcing. The transfer of material under these circumstances sometimes becomes so great that a sufficient amount thereof is built up on one of the make-and-break contacts to prevent the breaking of the circuit by separation of the contacts.

In addition, the heat from arcing often forms thin films of oxides or other compounds on contact faces thereby increasing the contact resistance which in turn tends to aggravate the arc creating conditions until finally the contacts burn away or will otherwise no longer pass current.

In order to alleviate the effects of arcing there exist in the prior art several circuit arrangements for minimizing contact erosion. Various resistor-capacitor networks have been used; however, in addition to being space consuming and difficult to install in existing plant, such arrangements have usually proved to be ineffective on both the make-and-break contact operations. One such arrangement, which has been widely used, wherein a series resistor-capacitor subcombination shunted a contact to be protected has been very effective on the break contact operation but has tended to be harmful on the make contact operation. For complete contact protection such a circuit arrangement has needed to be employed with additional components which minimize contact arcing on the make contact operation.

As the amplitude of the transients occurring at contacts opening and closing circuits are influenced to a great extent by both the inductance and the distributed capacitance to ground of the conductors connected to the contacts, and as a large part of the energy in these transients is at high frequencies, typically of the order of 500,000 cycles per second or more, it is obvious that modification of the high frequency or surge impedance of the conductors connecting a contact to its associated circuit will affect the arcing created and the energy dissipated at the contacts during make-and-break operations. Accordingly, it has been recognized to be advantageous to insert in series with and close to the contacts a network which will make it possible for the contacts to see a high radio frequency impedance but a low direct-current resistance.

2

To this end it has long been known that arcing occurring during contact operations can be minimized or eliminated by connecting an inductor which has a high impedance at contact arc transient frequencies in series with the contact energizing circuit at a point close to said contact. Various arrangements have been suggested which involve the use of an inductor in this way. Typical of such arrangements is one described in my United States Patent No. 2,594,890, which issued April 29, 1952 which involves the insertion of one or more ferrite beads surrounding the conductor leading to the contacts. This arrangement performs the function of imparting to the surrounded portion of conductor a high impedance at high frequencies so as to slow down and dissipate the charging of the distributed conductor capacitance on a make contact operation, and during a break contact operation the bead is used to insert a dissipative resistance component to the contact connecting a conductor so that a large part of the energy which is stored in the distributed capacitance of the conductor and which causes arcing, is dissipated in the loading bead instead of the contact.

The present invention relates to an improved arrangement for protecting the relay contacts. In particular, there is provided in an integral unit protection in both the make-contact and the break-contact operations.

The basic feature of the invention is a transmission line element which includes both an inductive member which is inserted serially with the contacts to be protected and a capacitive member which is inserted in parallel across the contacts. The element is further characterized in that either or both of these reactive members provides an impedance per unit length which varies progressively along the element in a manner to result in a characteristic surge impedance for the element which varies along its length. The variation in surge impedance is used to introduce an impedance mismatch to the transients intermediate between the voltage supply and the contacts whereby reflections tend to minimize the extent to which the transients affect the contacts.

In an illustrative embodiment of the invention, the element comprises a core which is magnetic at the transient frequencies and surrounding the core a conductive winding. This winding provides the series inductance of the element. Additionally, a conductive sheath is positioned adjacent the winding but insulated therefrom to form a distributed capacitance with the winding. In the preferred embodiment of the invention, the sheath is introduced intermediate between the core and the winding in the form of a metallic layer deposited over a portion of the surface of the core and the desired variation in surge impedance of the element is achieved primarily by varying the effective width of the sheath with distance along the core.

The invention will be better understood from the following more detailed description taken in conjunction with the accompanying drawing in which:

Fig. 1 shows in perspective with a portion cut away a contact protecting element in accordance with the invention; and

Fig. 2 shows a circuit which includes an element of the kind shown in Fig. 1 being used to protect a pair of relay contacts.

With reference now to the drawing, Fig. 1 depicts one form of contact protecting element 10 in accordance with the invention. The element 10 includes a core 11, here shown as a solid frustum of a cone with the left hand end of smaller transverse dimension, of a magnetic material which retains a high permeability at the radio frequencies characteristic of the transients that are encountered in opening and breaking the contacts to be protected. Especially useful for this purpose are the class of magnetic

materials known as the ferrites which retain magnetic properties at high frequencies and are relatively good insulators. Over a portion of the surface of the core there is deposited a sheath of conducting material 12, typically copper. When the core is of insulating material such as ferrite, the sheath may be in intimate contact with the core; otherwise, it is necessary to provide insulation between the sheath and core. As shown, the distance which the sheath extends around the core decreases with distance along the core from left to right. At the left hand end, the core is completely surrounded by the sheath, and at the right hand the core is completely free of the sheath. It will be convenient to describe this as a decrease with distance from left to right of the effective width of the sheath. An insulated conductive single layer winding 14, typically copper wire, is coiled around the core and the conducting sheath. Because the core is a frustum of a cone, the diameter of the winding will increase with distance toward the larger right end. Where high voltage transients are anticipated, it is advantageous to provide an insulating sheath 13 over the conducting sheath, as shown, to provide additional insulation between the conducting sheath and the coil. Ends 15 and 16 of the coil and an electrical connection 17 to the conducting sheath serve as the terminal connections of the element.

It can be appreciated that the winding, aided by the magnetic core, serves as an inductor, the inductance per unit length of which increases with distance toward the right hand end because of the increasing diameter of the winding. Similarly, the winding and the conductive sheath together form a capacitor, the capacitance per unit length of which decreases with distance toward the right hand end because of the decrease of the effective width of the sheath. The net effect is that the characteristic surge impedance of the network formed increases with distance toward the right hand end.

In Fig. 2 there is shown a circuit arrangement 20 incorporating an element 10 of the kind shown in Fig. 1. This circuit arrangement is designed for energizing the winding 21 of a load relay when the contacts 22 of a control relay are closed by the application of a voltage to the relay winding 23. The circuit arrangement includes a cable 24 whose opposite ends form terminals 25A, 25B and 26A, 26B. Interconnected between terminals 25A, 25B are a voltage supply 27 and the winding 21 of the load relay which is to be energized by the voltage supply 27 when the circuit is closed. Interconnected between terminals 26A, 26B are the protecting element 10 and the relay contacts 22 to be protected. The element 10 is intended to be of the kind shown in Fig. 1 and, accordingly, the same reference numerals have been used in the two figures to designate its three terminals 15, 16 and 17. As shown, the terminals 26A and 26B of the cable 24 are connected respectively to terminals 15 and 17 of the protecting element and the contacts 22 to be protected are connected between terminals 16 and 17 of the protecting element. In effect, this results in the introduction of the inductance associated with the element in series with the contacts and of the capacitance associated with the element in shunt across the contacts.

When the winding 23 is energized and the contacts 22 closed, the high frequency high amplitude transients traveling along the cable 24 from the direction of the voltage supply 27 are diverted from the contacts 22 by two effects. First, the high impedance of the inductance associated with the winding of the coil of the protecting element reduces the amplitude of the radio frequency current which can flow through the contacts. Additionally, the impedance discontinuity presented by the protecting element to these transients introduces reflections before they reach the contacts, which reflection mitigates their effects. In particular, since as previously discussed the element provides a progressively higher surge impedance in going from terminal 15 to terminal 16, at terminals 26A, 26B of the cable 24 the transients see a much

higher surge impedance when looking out in the direction toward contacts 22 than when looking back in the direction of the voltage supply 27. This impedance discontinuity introduces at this point a partial reflection back to their source of the transients emanating from the direction of voltage supply 27, thereby minimizing their effect on contacts 22.

When winding 23 is deenergized resulting in the breaking apart of contacts 22, the RC network provided by the series resistance of the coil of the element and the shunt impedance of the conducting sheath of the element acts in the usual fashion to mitigate the effect of the resulting transients.

From the foregoing discussion, it is evident that it is desirable to achieve a large change in surge impedance between the two ends of the protecting element. The general principles for achieving such changes are well known to workers in the art. For example, in the embodiment depicted both the distributed inductance and capacitance are varied in opposite senses to achieve a larger variation than would be provided by a variation of either parameter alone. However, in some instances it may prove preferable to vary only one. If the core were made cylindrical and the diameter of the winding kept uniform, the distributed inductance, too, would remain uniform. Alternatively, if the effective width of the sheath were kept uniform, the distributed capacitance would remain uniform.

Moreover, various configurations are possible for the core and sheath to achieve the desired variation in impedance. Typically, a wedge-shaped core may be preferable in some instances for achieving the desired variation of inductance. Also it may be desirable to have the core protrude from the winding on end 16 so as to compensate for end demagnetizing effect.

Various other modifications are feasible for achieving the desired variation in either the inductance or capacitance. Such techniques would include appropriate changes in the spacing of the turns of the coil for affecting the inductance and alternatively changes in the thickness of the dielectric separating the conducting sheath from the coil for affecting the capacitance.

Accordingly, it is to be understood that various other arrangements will be possible without departing from the spirit and scope of the invention.

What is claimed is:

1. In combination, circuit means including a pair of electrical contacts which are adapted to be opened and closed in operation, and a circuit element for protecting said contacts during operation comprising a magnetic core, a conductive winding surrounding said core for connection in series with the pair of electrical contacts, and a conductive sheath adjacent the conductive winding and insulated therefrom for forming therewith a capacitive means for insertion in parallel across the pair of electrical contacts, the circuit element being further characterized by a surge impedance which progressively increases with distance along the winding toward the pair of electrical contacts.

2. In combination, circuit means including a pair of electrical contacts which are adapted to be opened and closed in operation, and a circuit element for protecting said contacts during operation comprising a magnetic core, a conductive winding surrounding said core for connection in series with the pair of electrical contacts, and a conductive sheath intermediate the magnetic core and the conductive winding and insulated therefrom for forming with the conductive winding a capacitive means for connection in parallel across the pair of electrical contacts, the conductive sheath having an effective width which varies with distance along the winding for providing to the element a surge impedance which progressively increases with distance along the winding.

3. In combination, a voltage source, circuit means including a pair of electrical contacts which are adapted to

be opened and closed in operation, and a circuit element for protecting said contacts during operation connected intermediate between the voltage source and the pair of electrical contacts comprising a magnetic core, a conductive winding surrounding said core for connection in series with a pair of electrical contacts, and a conductive sheath adjacent the conductive winding and insulated therefrom for forming therewith a capacitive means for connection in parallel with the pair of electrical contacts, the circuit element being characterized by a surge impedance which progressively increases with distance along the winding toward the pair of electrical contacts for inserting an impedance mismatch at radio frequencies between the pair of electrical contacts and the voltage source.

4. A relay contact protection element comprising a core of magnetic material, a conductive sheath adjacent a surface portion of said core, a conductive winding surrounding the core and sheath and insulated therefrom, the effective width of the conductive sheath and the effective

radius of the winding varying in opposite senses with distance in the same direction along the core for progressively varying the surge impedance of the element, and separate terminal connections to the two ends of the winding and the conductive sheath.

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