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ELECTRICAL SURGE ARRESTER

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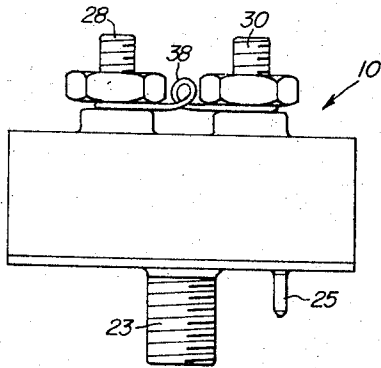


Fig. 1

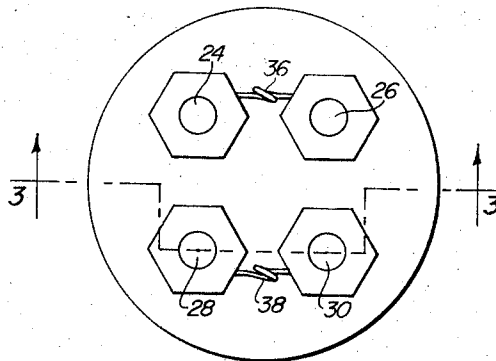


Fig. 2

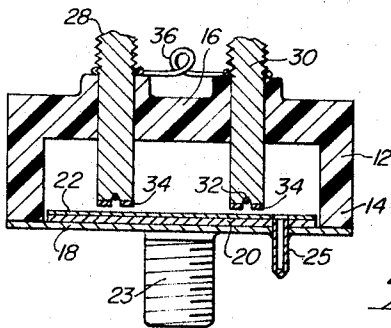


Fig. 3

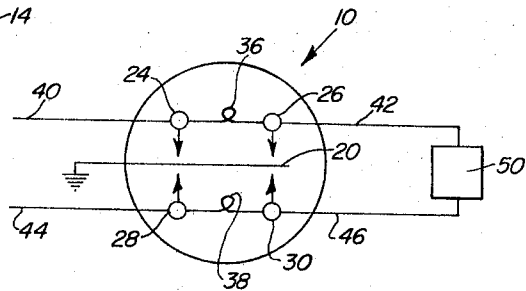


Fig. 4

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ELECTRICAL SURGE ARRESTER

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The present invention relates to an electrical surge arrester and more particularly to a spark gap type of device capable of shunting to ground high voltage transients induced in low voltage transmission circuits such as for communication equipment.

Transients may be induced in transmission lines by either natural or artificial phenomena. Lightning, electrostatic discharges, corona, aurora and the like may induce high voltage transients capable of destroying or injuring communication equipment should they enter the same. Likewise injurious high voltage transients may be induced artificially from adjacent power lines, welding arcs, motor starters, short circuits and the like. Many of these transients are characterized by very fast rise times of the current and associated voltage pulses. For example, the current pulse and associated voltage pulse caused by lightning are extremely fast. Surge currents with peak values of the order of one-half million amperes have been measured and the current rise times average eight thousand to ten thousand amperes per micro-second and maximum values of the order of one hundred thousand amperes per microsecond have been observed. The voltage rise time may exceed five million volts per microsecond.

In addition to primary transients, secondary transients are often caused by reflection and by some types of protective devices themselves.

The advent of semi-conductors and their use in communication equipment has created additional problems in protecting such equipment since semi-conductors and the like do not have the voltage capacity of the items which they replaced and the surge arresters used heretofore such as the carbon block gap have not proved capable of providing sufficient protection. A further problem with the carbon gap and with certain of the other prior art equivalent equipment was that such equipment had extremely short life and could not receive repeated transients. Some also required continual maintenance to keep them operative.

Accordingly, it is an object of the present invention to provide a new and improved spark gap capable of functioning efficiently upon imposition of transients of fast rise time thereupon.

It is another object of the present invention to provide a spark gap type having a substantial electrode spacing but yet having a breakdown voltage of reasonable value and a short ionization time.

A still further object of the invention is to provide a spark gap wherein the arc voltage is substantially reduced upon formation of an arc.

Still another object is to provide a gap construction capable of passing transients of relatively long duration and high peak currents and voltages without injury.

A still further object of the invention is to provide a spark gap construction affording protection to balanced transient lines.

A further object is to provide a gap structure capable of receiving and handling repeated transients without maintenance.

Still other objects and advantages of the present invention will become more apparent hereinafter.

The illustrated embodiment of the invention comprises a device including a sealed housing containing an atmosphere of inert gas, in which housing are mounted a plu-

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rality of electrodes defining four spark gaps. Four anode electrodes are utilized in the illustrated device for connection in the transmission lines to be protected and which anode electrodes are associated with a single plate-like cathode electrode adapted to be connected to electrical ground. The anode electrodes are arranged in two pairs and a delay line is connected between the electrodes of each pair. Such delay lines function to increase the rise time, i.e., decrease the slope of the wave front, of a transient in a transmission line so that if a transient passes the first gap of a pair without firing the same, because the gap was unable to respond rapidly enough, the second gap will be given a greater period of time in which to respond whereafter both gaps may function to discharge the transient to ground.

Preferably a radioactive material is associated with the electrodes to provide an ionized breakdown path and the electrodes are formed with a special alloy surface layer to assist in the creation of a current carrying plasma.

For a more detailed description of the invention, reference is made to the following specification and accompanying drawings wherein

FIG. 1 is a side elevation of a protective device made in accordance with the invention;

FIG. 2 is a top view thereof;

FIG. 3 is a sectional view taken along line 3-3 of FIG. 2; and

FIG. 4 is a schematic drawing of a circuit incorporating a device made in accordance with the invention.

Referring now to the drawings, the embodiment of the invention illustrated in FIGS. 1 to 3 comprises a housing 10 defined by a cup-shaped portion 12 of ceramic or other suitable dielectric and which portion includes a cylindrical side wall 14 and a flat end wall 16. To the open end of the cup is sealed an end wall 18 which may be formed of brass or other suitable conductive metal and to which is secured a cathode electrode 20 preferably formed of a high melting metal such as tungsten or molybdenum. For reasons to be pointed out hereinafter, at least the surface layer indicated at 22 of such electrode is formed of an alloy of a refractory metal such as tungsten or molybdenum and a lower melting metal such as silver or copper. A stud 23 is provided on the wall 18 for making an electrical connection thereto. A tubulation 25 may also be provided on the wall 18 for enabling air to be exhausted from the housing and replaced with a suitable inert gas such as nitrogen or argon or a mixture of inert gases after which the tubulation is sealed off.

Sealed in the end wall 16 and extending therethrough are four rod-like anode electrodes 24, 26, 28 and 30. These likewise may be formed of a high temperature conductive metal such as tungsten or molybdenum. As best shown in FIG. 3, the lower ends of the electrodes 24-30 are each formed with a small cavity 32 in which is positioned a radioactive material, preferably an alpha or beta emitter, whereupon the alpha or beta emissions will tend to ionize any gases in the immediate area between the electrodes 24-30 and the electrode 20, thus, facilitating breakdown in the gaps between such electrodes and the formation of a current carrying arc therebetween. Preferably also the endmost portion of each electrode 24-30 is formed of an alloy of a refractory metal such as tungsten or molybdenum and a lower melting metal such as silver or copper, such layer being indicated at 34.

In accordance with the invention, a pair of delay lines are preferably connected one between each of a separate pair of anode electrodes. Thus, as illustrated, a delay line 36 is connected between the electrodes 24-26 and a delay line 38 is connected between the electrodes 28-30. Delay line is used herein to designate a trans-

mission line portion having impedance characteristics such that greater impedance is imposed by the so-called delay line to transients transmitted therethrough, then is imposed to such transients by the transmission lines in which the delay lines are coupled. More will be said of the desired characteristics of the delay line subsequently.

Referring now more specifically to FIG. 4, the surge arrester 10 is shown connected in a balanced transmission line including a conductor 40 connected to electrode 24, a conductor 42 connected to the electrode 26, a conductor 44 connected to the electrode 28 and a conductor 46 connected to the electrode 30. The conductors 42, 46 are in turn connected to the communication equipment indicated at 50 which it is desired to protect from high voltage surges and the electrode 20 is connected to electrical ground.

The device 10 functions in this manner. Let us presume first that a transient develops in the conductor 40 as, for example, by a lightning stroke striking such conductor or a high voltage transmission line falling upon the same. As the potential develops on the spark gap defined by the electrode 24, the gap will start to ionize but the pulse will also start to feed through the delay line 36 to the electrode 26. If the rise time of the transient is extremely short; that is, if the wave front of the transient is very steep, it is possible that the gap 24 will not fire before the pulse has completely passed or the majority of the pulse has passed the electrode 24, particularly if the pulse is of short duration. The delay line 36 will by reason of its impedance increase the rise time of the pulse; that is, decrease the angle of slope so that the gap 26 has sufficient time fully to ionize and for discharge to initiate thereacross. If the pulse is of short duration substantially all of the discharge may take place solely across the gap 26. However, if the pulse is of long duration, discharge will also take place across the gap 24 since the initiation of the discharge 26 will form a fully ionized atmosphere in the housing 10 and permit discharge across the gap 24 easily to initiate. As will be appreciated, the delay line 36 is matched to the maximum-rise time of expected transients in the conductor 40 versus the time by current factor of the gap 26. In practice the delay line may be formed by a turn or more of No. 14 copper wire.

To protect the equipment 50 against the possibility of damage from in-phase transients moving on both sides of the transmission line, the delay lines 36 and 38 are preferably unbalanced. It should be appreciated that if the transients are in-phase that neither would see the gaps 24, 28 or 26, 30 as they move along the line. However, by slowing one or the other of the transients both will see the second gaps 26, 30 and initiation of firing of the gap by the first transient will cause complete ionization of the atmosphere within the gap to cause both transients to discharge through the gaps on the corresponding side of the transmission line, thus dissipating the power and protecting the equipment 50.

It will be appreciated that the device 10 will also function effectively to discharge any reflected pulses. Such reflection may be a reflection from the gaps 26, 30 or from the equipment 50 but in either case since the atmosphere is fully ionized by reason of the discharge of the primary transient, a reflected pulse will also easily discharge.

The placement of the radioactive material 32 in the electrodes 24-30 facilitates the ionization of the atmosphere so that breakdown more easily occurs. The recess arrangement for retaining the radioactive material helps to collimate the radiation and thus adds a safety factor since radiation outwardly to the side of the device is substantially eliminated by the thick walls of the electrodes and the cup 12 itself. Moreover, the retention of the radioactive material in the recesses also minimizes the possibility of contamination of the surrounding atmosphere and equipment with radioactive material in the

event that the spark gap unit should accidentally blow up.

The formation of the plates 22 and 34 of alloys of silver or copper and tungsten or molybdenum or like alloys serves to protect the electrodes from injury during heating caused by a transient having a large amount of power. The electrodes are, of course, heated by reason of the arc discharge but such heating in the instance of electrodes made in accordance with the invention will cause vaporization of the doping material, that is, the silver or copper. As such metals evaporate, they remove heat from the electrodes thus preventing their overheating. At the same time, the presence of the evaporated metal in the arc between the electrodes reduces the resistance of the arc gap and increases the conductivity which, of course, inhibits further temperature rise. However, upon cessation of the arc, the vaporized metal redepots within the electrodes. Depending upon the time of the arc discharge, the vaporizing metal will be drawn from the electrode cap and may be drawn from as deep as $\frac{1}{16}$ of an inch. It has been found, surprisingly enough, that the vaporized metal remigrates back into the electrode for substantially the depth from which it was initially withdrawn and an alloy of substantially uniform content is reformed upon cessation of the arc. In the case of a tungsten-silver alloy, it has been found that a percentage range of tungsten from sixty to seventy percent and a percentage range of silver from thirty to forty percent is preferred. With such electrodes, it has been found that pitting and cratering is virtually eliminated even after repeated firings of up to sixty times.

While the illustrated embodiment of the invention is shown as having four anode electrodes connected in a balanced transmission line, it will be apparent that the same embodiment could be utilized to protect a pair of unbalanced lines by connecting each such line across one pair of gaps. Likewise, the device may be constructed with only two gaps or with more than four gaps and other physical arrangements may be utilized.

Having, then, illustrated a preferred embodiment of the invention, it will be apparent that the invention permits of modification in arrangement and detail. I claim as my invention all such modifications as come within the true spirit and scope of the appended claims.

I claim:

1. A protective device for use in a balanced signal transmission line, said device comprising a sealed housing, four anode electrodes and cooperating cathode electrode means defining four spark gaps within said housing, an inert gaseous atmosphere in said housing, a first delay line connecting one pair of said anode electrodes and a second delay line connecting the other pair of said anode electrodes, said delay lines having different impedances.
2. A protective device for discharging transient high voltage impulses of high frequency induced in a balanced signal transmission system, said device including two pairs of anode electrodes for connection one pair in series in each side of said balanced line transmission system, a ground electrode for connection to electrical ground operatively arranged with said pairs of electrodes to define an arc gap between each electrode of said pairs and said ground electrode, and a pair of delay lines connected one between each pair of said anode electrodes of said pair, said delay lines having impedance characteristics such that signals normally transmitted through said system are substantially unaffected by said delay lines but such that the rise time of high voltage transients appearing in said system is increased to facilitate the creation of an arc discharge across said gaps by said high voltage impulses, said delay lines having dissimilar impedances.

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3. A surge arrester comprising:
 a sealed housing including a cup-shaped portion of dielectric material,
 said portion having a flat first end wall and a tubular side wall joined integrally at one end thereof to said end wall,
 a second end wall sealed to the opposite end of said side wall,
 a planar plate-like electrode mounted on the inner surface of said second end wall,
 means extending outwardly of said housing for connecting said plate-like electrode to ground,
 four rod-like electrodes extending through said first end wall and each defining a spark gap with said plate-like electrode,
 and an inert gas filling said housing.

4. A surge arrester comprising:
 a sealed housing including a cup-shaped portion of dielectric material,
 said portion having a flat first end wall and a tubular side wall joined integrally at one end thereof to said end wall,
 a second end wall sealed to the opposite end of said side wall,
 a planar plate-like electrode mounted on the inner surface of said second end wall,
 means extending outwardly of said housing for connecting said plate-like electrode to ground,
 four rod-like electrodes extending through said first end wall and each defining a spark gap with said plate-like electrode,
 a pair of delay lines of different impedances connected one each between separate pairs of said rod-like electrodes,

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and an inert gas filling said housing.

5. The invention of claim 4 wherein each of said rod-like electrodes is formed with a recess in the end thereof opposing said plate-like electrode and a radioactive material is deposited in said recess.

6. The invention of claim 4 wherein the endmost surface portions of said rod-like electrodes opposing said plate-like electrode are formed of an alloy of a refractory metal and a metal of lower melting point.

7. The invention of claim 6 wherein said metal of lower melting point is selected from the class consisting of silver or copper.

8. A spark gap unit comprising a pair of opposed electrodes,
 said electrodes each having a surface layer formed of an alloy of a metal selected from the class consisting of tungsten and molybdenum and a metal selected from the class consisting of silver and copper.

9. A spark gap unit comprising a pair of electrodes each comprising a surface layer formed of an alloy comprising between about sixty to seventy percent tungsten and between about thirty to forty percent silver.

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