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ELECTRICAL SURGE ARRESTOR

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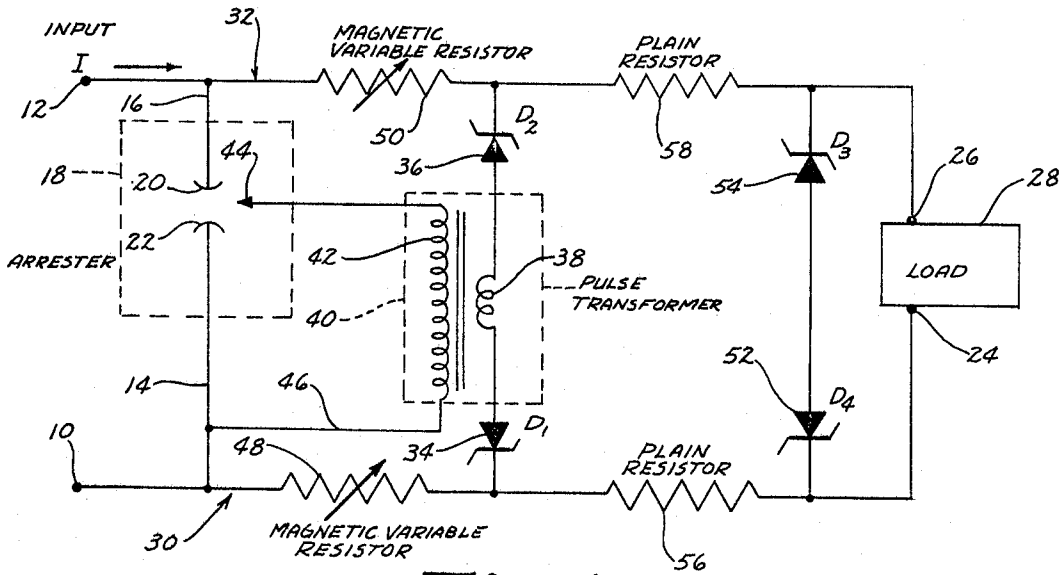


Fig. 1

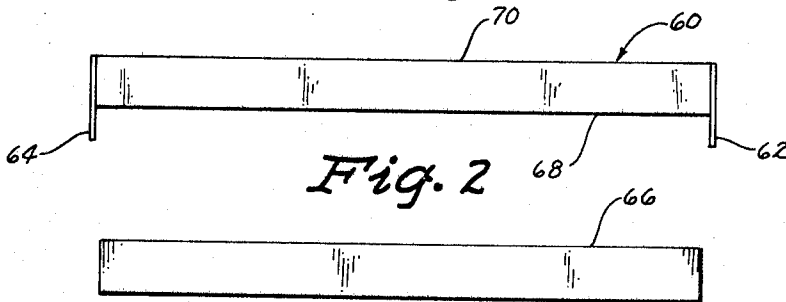


Fig. 2

Fig. 3

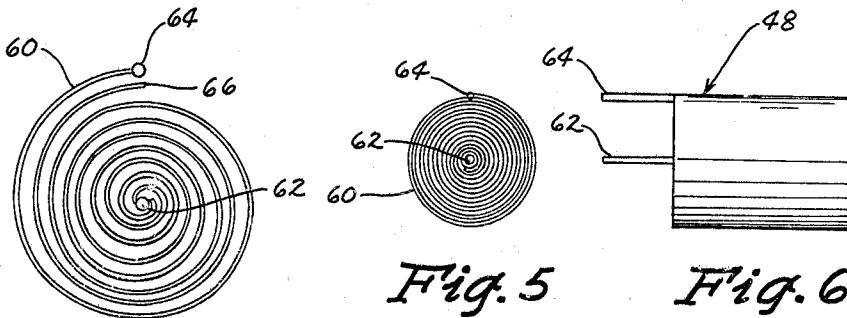


Fig. 4

Fig. 5

Fig. 6

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ELECTRICAL SURGE ARRESTOR

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9 Claims

ABSTRACT OF THE DISCLOSURE

An electrical surge arrestor comprising, a circuit having an input and an output with an arrestor connected across the input having first and second spaced apart terminals. A breakdown voltage regulator diode is connected across the input in parallel with the arrestor. A variable resistor is connected to the input of the diode and has a low resistance at low current frequencies and a high resistance at high current frequencies. Separate leads connect the terminals of the arrestor to the input and output and a pulse transformer is provided between a third terminal and one of the leads and has a primary winding connected in series with the diode.

A protector that uses a spark gap type arrestor does not fire as rapidly as desired when fast rising voltage transients are applied to the input terminals of the arrestor and therefore the equipment attached to the output terminals of the circuit are frequently damaged by the spurts of high voltage.

This invention involves a surge arrestor circuit having a spark gap arrestor connected across the input and being in parallel with a breakdown voltage regulator diode. The output of the surge arrestor is then connected directly to the input with the two devices in parallel with one another across the input and output. This circuit allows the diode to filter or clamp the voltages appearing on the output of the breakdown voltage of the diode. This tends to filter out the spurt of voltage that would appear across the output due to the fact that the arrestor does not fire instantaneously. The breakdown of the main electrodes of the arrestor shorts out the transmission line and the voltage across the output terminals is essentially reduced to zero, and as a consequence, protection of the equipment connected to the output is provided.

This invention further involves the use of a pulse transformer where the primary coil of the transformer is connected in series with the Zener diodes and the secondary coil is connected to the third element of the surge arrestor. The surge arrestor's main electrodes will then be initiated by the small breakdown occurring between the third element and one of the main electrodes caused by the pulse of voltage coming from the pulse transformer when the Zener diodes break down.

Preferred breakdown regulator diode used in the surge arrestor circuit is a Zener diode that has a characteristic of maintaining very small current flow through it until the breakdown or Zener voltage has been reached, whereupon the diode starts conducting and continues to conduct while the voltage across the diode remains substantially constant. This sharp rising current through the pulse transformer causes a pulse of voltage to appear across the main electrode and the third electrode of the surge arrestor which causes breakdown, which in turn causes the ionization of the main gap in the arrestor.

This invention further involves the use of a variable resistor for protecting the breakdown voltage diode whereby upon the voltage across the diode reaching the breakdown level a sharp rise in the current through the variable resistor occurs which causes an increase in the

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resistance of the variable resistor. The variable resistor offers little resistance to constant value currents but increases substantially in resistance as the rate of change of current increases. The increase in energy then stored in the resistor is dissipated and thus protects the diode. Accordingly, the variable resistor which is preferably a magnetic resistor permits D.C. current or low frequency A.C. current to flow through the arrestor without appreciable voltage drop, but yet allows high voltage drop to appear across the magnetic resistor during the time the diode is passing current.

The variable magnetic resistor employed preferably involves a coil of conductive permeable material having terminals at opposite ends of the conductive sheet material whereby upon the passage of current therethrough the phenomena of skin effect occurs which involves the current being forced to the outer edges of the sheet material when there is a high rate of change in the current level. The faster the change of current the faster the change of the magnetic field in the resistor and thus the greater the resistance to flow of current since the current is forced to the outer edges of the sheet material. The operation of the variable magnetic resistor is somewhat similar to an inductor except that the resistor does not store the energy to be later applied to the circuit but rather dissipates it within the resistor.

Another feature of this invention is to provide two pairs of diodes connected in parallel with resistors in between the pairs of diodes and the breakdown voltage of the first pair nearest the input and having the primary coil of the pulse transformer therebetween being the highest and the voltage across the second pair of diodes next to the output being the value desired for the output connected to the equipment. Any time the voltage across the load and the second set of diodes reaches the breakdown voltage of the second set of diodes, the diodes fire and thereby maintain the constant predetermined desired voltage. The first set of diodes must fire first and consequently the resistors between the first and second set of diodes causes a voltage drop therebetween assuring that a high voltage is applied across the first set of diodes relative to the voltage across the second set of diodes.

Thus this invention consists in the construction, arrangements, and combination of the various parts of the invention, whereby the purposes contemplated are attained as hereinafter more fully set forth, specifically pointed out in the claims, and illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic drawing of the electrical circuitry of the electrical surge arrestor;

FIG. 2 is a plan view of the conductive permeable material of the variable magnetic resistor;

FIG. 3 is a plan view of the insulative material employed in the variable magnetic resistor;

FIG. 4 is an end view of the variable magnetic resistor in a loosely coiled condition;

FIG. 5 is an end view of the assembled magnetic variable resistor; and

FIG. 6 is a side elevation view of the magnetic variable resistor.

The electrical surge arrestor circuit includes a pair of input terminals 10 and 12 with leads 14 and 16 connected to an arrestor unit 18 having a pair of primary terminals 20 and 22 in spaced apart relationship.

A pair of output terminals 24 and 26 are connected to a load 28. The input terminals 10 and 12 are connected to the output terminals 24 and 26 by conductor lines 30 and 32.

Extending between the conductor lines 30 and 32 are a pair of Zener diodes 34 and 36 having their output sides connected to opposite sides of a primary coil 38 included

in a pulse transformer 40. The pulse transformer 40 includes a secondary coil 42 having one lead connected to a third terminal 44 in spaced relationship to the primary terminals 20 and 22 in the arrestor unit 18. The other lead 46 of the secondary coil is connected to the line 14.

A pair of magnetic variable resistors 48 and 50 are placed in the lines 30 and 32 between the arrestor 18 and the Zener diodes 34 and 36.

A second pair of Zener diodes 52 and 54 interconnected in series are connected across the conductor lines 30 and 32 in parallel relationship to the first set of Zener diodes 34 and 36. A pair of resistors 56 and 58 are positioned between the two sets of diodes to produce a voltage drop from the first set to the second set.

The magnetic variable resistors 48 and 50 are shown in detail in FIGS. 2, 3, 4, 5 and 6. They each include a sheet of conductive permeable material 60 having terminal pins 62 and 64 at opposite ends thereof as seen in FIG. 2. A sheet of insulative material 66 is shown in FIG. 3 and is coiled with the conductive material 60 as shown in FIG. 4. In FIGS. 5 and 6 the magnetic variable resistor 48 is shown in its completed form relatively tightly wound compared to the loosely wound unit in FIG. 4.

The variable magnetic resistors increase in resistance when the frequency of the current through the resistors increase. This is known as the skin effect and it is enhanced by the shape of the resistor and the permeability of the resistor element. When low frequency A.C. current or direct current is flowing through the resistor there is very little magnetic field produced and therefore the resistance of the resistor is very low. However, as the frequency of the current changes the magnetic field increases thereby forcing the current passing through the resistor to the outer edges 68 and 70 (FIG. 2) where there is a relatively small area compared to the flat surface area of the conductive sheet material 60 and consequently the resistance is substantially increased. The resistor provides no inductive impedance but instead dissipates completely all energy that is stored in it as a result of a change in the current frequency. It is apparent then that as the rate of change of the current increases the resistance value of the resistor will also increase and accordingly the resistance of the resistor is a function of the current frequency.

The operation of the electrical surge arrestor circuit involves the following sequence. The normal voltage for the load 28 is applied to the input terminals 10 and 12. The object of the surge arrestor circuit is to protect the load 28 by maintaining a constant voltage across the terminals 24 and 26 at the load 28. When a transient voltage such as a charge of lightning or the like appears across the input terminals 10 and 12, the Zener diodes 34 and 36 will break down when this transient voltage exceeds the breakdown voltage of these diodes. At the breakdown voltage of the diodes a heavy current is drawn through the diodes and the primary coil 38 of the pulse transformer 40 and the magnetic resistors. The rise time of this current is relatively fast due to the sharp knee in the voltage characteristics of the Zener diodes. This sharp rise in current through the pulse transformer causes a pulse or voltage to appear across the two electrodes 44 and 22 of the arrestor 18. This voltage causes these two electrodes to break down thereby ionizing the gap between the two terminals 20 and 22 because the voltage across the arrestor at this time is high enough to sustain the arc between the two main electrodes 20 and 22. This breakdown of the main electrodes 20 and 22 essentially shorts out the transmission lines 30 and 32 thus causing the voltage across the output terminals 24 and 26 to be reduced to zero thereby providing the protection for the load unit 28 that is desired.

The magnetic resistors 48 and 50 allow the D.C. current or low frequency A.C. current to flow through the arrestor without appreciable voltage drop, but yet allow a high voltage drop to appear across them during the

time the Zener diodes 34 and 36 are fired. The increase in energy then stored in the variable resistors 48 and 50 is dissipated in the increased resistance caused by the skin effect. And thereby the diodes 34 and 36 are protected against damage from the transient voltage applied to the input terminals 10 and 12. It is to be noted that an inductor if substituted for the variable resistors 48 and 50 would only hold the energy and later discharge it thereby causing the undesired damage to the Zener diodes 34 and 36.

The Zener diodes 52 and 54 are connected across the output to insure that the voltage on the output terminals never exceeds the rated voltage that the load unit 28 connected to the output terminals 24 and 26 can withstand. These are required because the voltages that will appear across the first set of Zener diodes 34 and 36 will be slightly higher than the breakdown voltages of the second set of Zener diodes 52 and 54 because of the primary coil 38 of the pulse transformer 40 causing a small voltage drop. This pulse that will appear across the first set of Zener diodes 34 and 36 will be of low magnitude and of short duration and will easily be dissipated by the Zener diodes 52 and 54. The Zener diodes 52 and 54 must have a slightly lower breakdown voltage than the Zener diodes 34 and 36, however, the Zener diodes 34 and 36 must break down first before the Zener diodes 52 and 54. Accordingly, it is necessary to have the resistors 56 and 58 to insure this occurrence. The second set of Zener diodes 52 and 54 would be selected on the basis of having a breakdown voltage equal to the desired voltage across the output terminals 24 and 26 such that when the breakdown voltage is reached the voltage will not be increased due to the firing of the diodes and consequently maintaining the constant voltage across the diodes and the output terminals.

I claim:

1. A surge arrestor, comprising a circuit having an input and an output, an arrestor connected across the input having first and second spaced apart terminals, and a breakdown voltage regulator diode connected across said input in parallel with said arrestor, a variable resistor connected to the input of said diode, said resistor having a low resistance at low current frequencies and a high resistance at high current frequencies.

2. The structure of claim 1 wherein separate electrical leads connect said terminals of said arrestor to said input and output, respectively of said circuit, a pulse transformer provided between a third terminal and one of said electrical leads and being in spaced relationship to the terminals of said arrestor, said transformer having a primary winding connected in series with said diode.

3. The structure of claim 2 wherein a second breakdown voltage regulator diode is connected in series with said primary winding opposite said first diode.

4. The structure of claim 1 wherein a resistor is connected at one end to the input of said diode and a second voltage breakdown voltage regulator diode is connected on its input side to the other side of said resistor, said second diode being connected across said output of said circuit and being in parallel with a load connected to the output of said circuit.

5. The structure of claim 1 wherein said variable resistor includes a sheet of conductive material and a sheet of insulation wound together and a terminal at each end of said sheet of conductive material.

6. A surge arrestor, comprising a pair of input terminals and a pair of output terminals, a pair of conductor lines connecting said input terminals to said output terminals, an arrestor connected between said conductor lines adjacent said input, said arrestor having first and second spaced apart terminals adapted to be interconnected by a charge of a predetermined voltage, a first pair of breakdown voltage regulator diodes interconnected on their output sides in series to a primary coil of a pulse transformer, the input sides of said first pair of diodes being con-

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5 nected to said pair of conductor lines in parallel with said arrestor, said transformer having a secondary coil with one lead connected to a third terminal in said arrestor, said third terminal being in spaced relation to said first and second terminals in said arrestor, the other terminal of said secondary coil being connected to one of said pair of conductors, a magnetic variable resistance resistor in each of said conductors between the arrestor and the input of the adjacent diode, a second pair of breakdown voltage regulator diodes connected in series and connected to said conductor lines adjacent the pair of output terminals in parallel with said first pair of diodes, and a resistor in each of said conductor leads between adjacent ends of adjacent diodes.

15 7. The structure of claim 6 wherein said diodes are Zener diodes and said second pair of diodes have a breakdown voltage corresponding substantially to the desired output voltage across the output terminals.

20 8. A surge arrestor, comprising:

a circuit having an input and an output,
an arrestor connected across the input and having first and second spaced apart terminals,

a breakdown voltage regulator diode connected across said input in parallel with said arrestor,

25 a variable resistor connected to the input of said diode, said resistor having a low resistance at low current frequencies and a high resistance at high current frequencies,

30 a resistor connected at one end to the input of said diode,

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a second voltage breakdown voltage regulator diode connected on its input side to the other side of said resistor,

said second diode being connected across said output of said circuit and being in parallel with a load connected to the output of said circuit,

said first diode having a breakdown voltage greater than said second diode,

said second diode breakdown voltage being set at the approximate desired voltage for said load.

9. The structure of claim 8 wherein said first and second diodes are Zener diodes.

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