

Nov. 24, 1970

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3,543,047

CONTACT ARC SUPPRESSOR USING VARISTOR ENERGY ABSORBING DEVICE

Filed Dec. 3, 1968

2 Sheets-Sheet 1

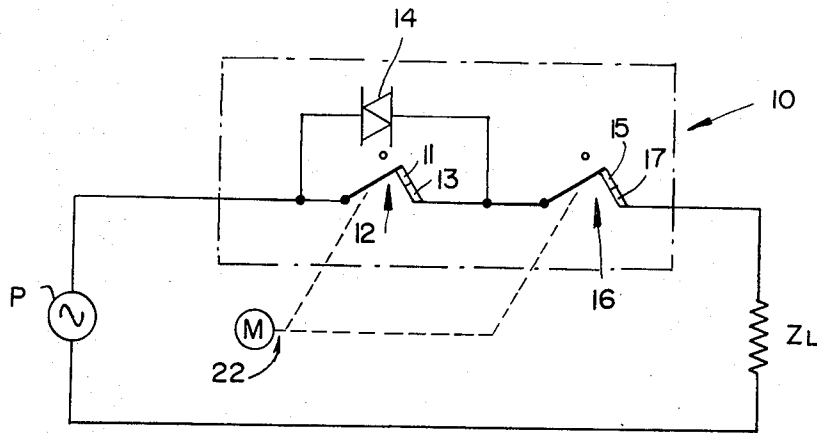


FIG. 1

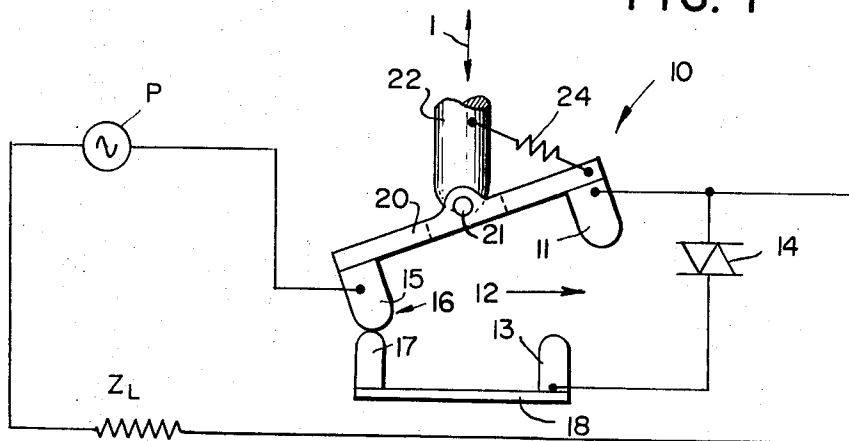


FIG. 1A

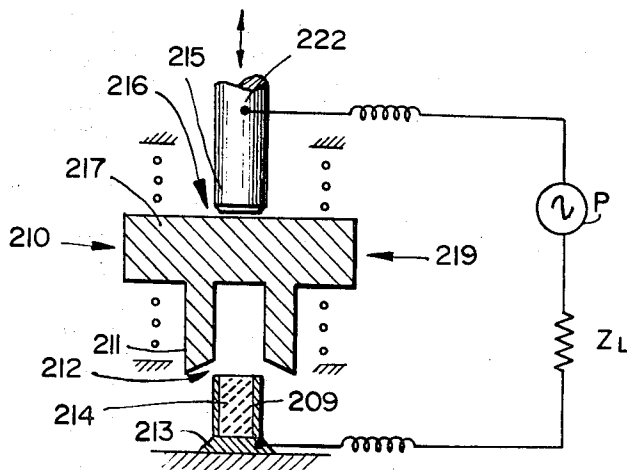


FIG. 2

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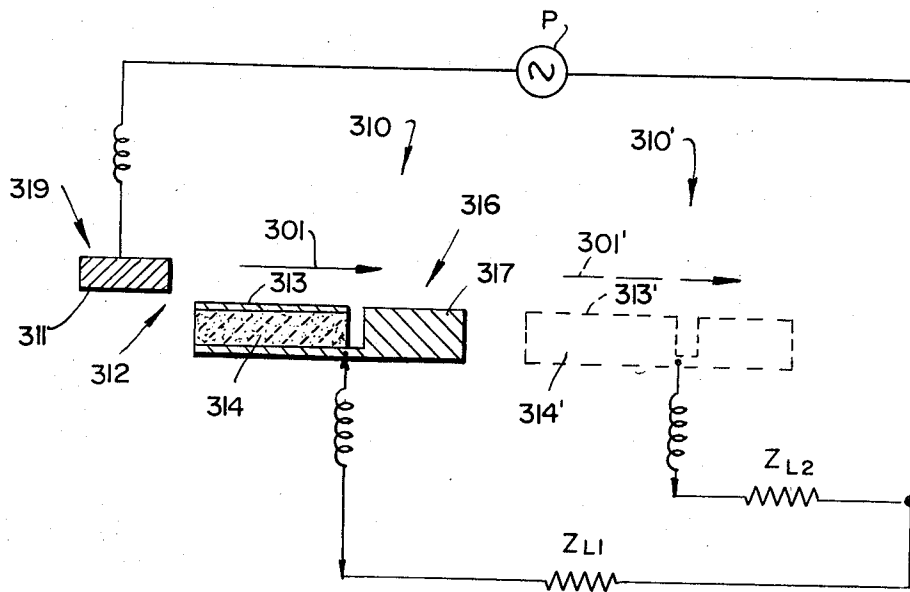


FIG. 3

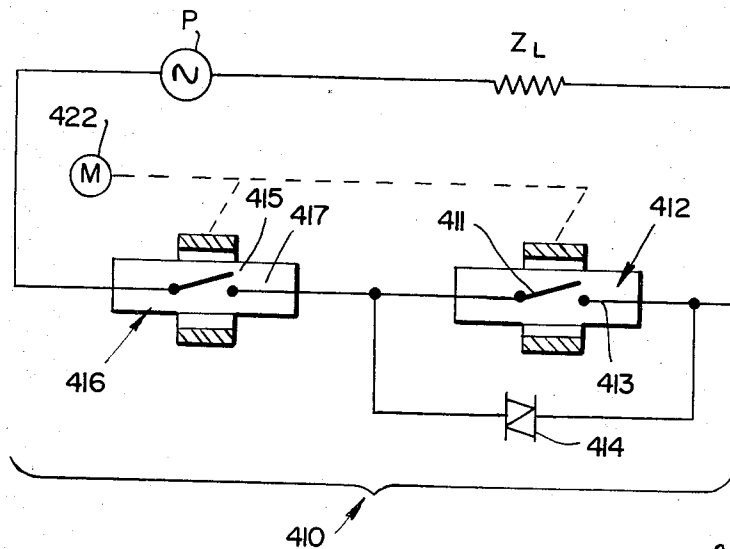


FIG. 4

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Filed Dec. 3, 1968, Ser. No. 780,765
Int. Cl. H01h 9/42

U.S. Cl. 307—136

1 Claim

ABSTRACT OF THE DISCLOSURE

Arcing at switch contacts is suppressed by a two switch arrangement in series with an electrical power source and load. A varistor shunt across one of the switches substantially entirely absorbs the total energy to be interrupted when that switch is opened and attenuates the current to reduce the arcing when the other switch is later opened. The two switches are operated in rapid sequence.

The present invention relates to electric circuit switches for interrupting currents when open and carrying full load currents while closed.

It is the object of the present invention to provide a switching assembly which suppresses switch contact arcing more effectively and with less contact deterioration than prior art devices.

In general, the object of the invention is accomplished as described in the foregoing abstract.

Other objects, features and advantages of the invention will in part be set forth in and will in part be obvious from the following specific description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a circuit diagram of an electrical circuit incorporating the improved switch assembly and FIG. 1A is a diagram of a corresponding mechanical arrangement;

FIGS. 2, 3, 4 are diagrams of alternative switch assembly embodiments.

Referring now to FIG. 1, there is shown an electrical circuit with a power supply P, a load impedance Z_L and a switch assembly 10, all in series. The switch assembly includes a first switch 12 with a varistor 14 connected in shunt with it, and a second switch 16. A common actuating mechanism 22 controls opening and closing of the switches in the sequence described below. Switch 12 includes a movable contact 11 and a fixed contact 13. Switch 16 includes a movable contact 15 and a fixed contact 17. Both switches are shown in closed position so that full load current flows through the switches which are in series with the electrical power source and with each other.

For interrupting the circuit, switch 12 is first opened. Any tendency to arcing at the switch contacts 11 and 13 is limited by the varistor 14 which quickly reduces in resistance to provide an alternate current carrying path. But the resistance is sufficiently high to reduce the series current through it and the voltage appearing across 14 is sufficient to reduce the voltage drop across the second switch 16 to a level which is below the partially open state arc threshold voltage of switch 16 after switch 12 has opened. The second switch 16 is then opened without arcing (in excess of approximately $\frac{1}{4}$ cycle) to interrupt the circuit. For reclosing the circuit, the sequence is reversed. Switch 16 is closed initially and any initial arcing between contacts 15 and 17 is suppressed by the varistor 14 which completes the series path of the circuit and also drops current and voltage drop across switch 12 to a level below the partially open state arcing threshold voltage of contacts 11 and 13. Switch 12 is then closed to com-

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plete the circuit and full load current is restored through the series circuit.

One particular mechanical design for the switch assembly 10 is shown in FIG. 1A. The movable contacts 11, 15 of switches 12, 16 respectively are carried on, a common movable member 20 which is pivotally mounted (at pivot 21) on an actuating rod 22 which is movable as indicated by the bi-directional arrow 1. The fixed contacts 13, 17 of switches 12, 16 respectively are mounted on a common fixed member 18. The varistor 14 is connected across contacts 11, 13 of switch 12. A tension spring 24 is connected between actuator rod 22 and a side of member 24 which holds contact 11 to control switching sequence as described above in connection with FIG. 1. In closing the circuit (by moving rod 22 down) switch 16 is initially closed and subsequently switch 12 is closed. In opening the circuit (by lifting rod 22) switch 12 initially opens and switch 16 opens subsequently.

The timing of the sequence of opening and closing of the first and second switches is controlled to be between about .01 to .10 second and preferably .02-.03 second or 1-2 cycles for 60 cycle alternating current. This is a switching time which can be achieved by mechanical means without resort to pneumatically blown switch contacts. It allows full use of unique varistor capabilities in absorbing high instantaneous power loads for gradual dissipation by cooling between switching cycles rather than dissipating such energy in arcing. The timing also allows the varistor to be fully available for unusually high circuit interruption energy peaks which might occur in a circuit containing inductive elements. However, an excessively lengthy switching time would cause thermal degradation of the varistor exponent or require selection of higher rated varistor making the combination less economical. For instance, Thyrite brand 3 inch varistor assembly models 9RV3A1 and 9RV3A2 have the same continuous operating voltage ratings (about 6 volts D.C., 5.4 volts A.C.). But the latter has a rated discharge capacity of 2200 watt-seconds compared to 1100 watt-seconds for the former and is priced over 50% higher than the former.

The proper selection of varistor device for use in the present combination will be tailored to the partially open state arc voltage threshold of the contacts of the first and second switches, the timing of the switch opening (and closing) sequence and the energy to be interrupted in the electrical circuit. The varistor device must have a threshold voltage for non-linear resistivity which is below the contact arc threshold voltage as previously described. The varistor must be able to carry the full load current of the circuit for a period of time up to a tenth of a second corresponding to actuation time for both switches as stated above, and absorb the full stored energy of the circuit.

As an example of accounting for stored energy to be handled by the varistor in a switch opening sequence, consider the typical case of a motor with a 20 ampere load current and exciting current of 20% of load (4 amperes) operating at 220 volts, single phase, 60 cycle A.C. If 2 cycles represent the time interval between initially opening the first switch and complete opening of the second switch, then the stored energy the varistor must contend with is .03 second times 880 watts, or 26.40 watt-seconds.

Referring now to FIGS. 2, 3, and 4 other embodiments of the invention are shown wherein parts equivalent to those of the FIG. 1-1A embodiment are designated by the same reference plus 200 for the FIG. 2 embodiment, plus 300 for the FIG. 3 embodiment, plus 400 for the FIG. 4 embodiment. The components are listed in Table I. In all three embodiments, P and Z_L indicate electric power and load impedance. In FIG. 4, 261

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indicates a first impedance load connected to the power source via switch assembly 310 and 262 indicates a second impedance load connected.

TABLE I

Assembly or component	FIG. 2	FIG. 3	FIG. 4
Switch assembly	210	310 (and 310')	410
"First" switch	212	312	(1)
Contacts	211, 213	311, 313	411, 413
Varistor	(2)	(3)	414
"Second" switch	216	316	(4)
Contacts	215, 217	311, 317	415, 417
Actuator	222	(5)	422
Common member for both switches	217	319	-----

¹ Reed relay 412.

² Silicon carbide cylinder 214 with wear resistant chrome coating 209.

³ Disk 314.

⁴ Reed relay 416.

⁵ Not shown.

Still other variations will be obvious to those skilled in the art once given the benefit of the present disclosure. Accordingly, it is intended that the above specification shall be read as illustrative and not in a limiting sense.

What is claimed is:

1. A switching assembly for connection in series between an electrical power supply and a load and comprising first and second switches in series with each other and with the source and load, and an energy absorb-

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ing electrical varistor device in shunt with said first switch, said device being selected to be able to carry the full load current of said circuit over a period of time on the order of a tenth of a second or less and absorb the full stored energy of the circuit and being selected to have a voltage corresponding to its lower limit of non-linear resistivity which is below the partially open state arc threshold voltage of said first and second switches and means for operating said first and second switches in rapid sequence so that the second switch opens after the first switch and closes before the first switch within a time period of at least one-tenth of a second and greater than .01 second in either case.

References Cited

UNITED STATES PATENTS

3,284,648	11/1966	Koppelman	307—136
3,430,062	2/1969	Roth	307—136
3,431,466	3/1969	Watanabe et al.	317—11

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U.S. Cl. X.R.

317—11