Significance:
Part 6: Tutorials, textbooks, and reviews

Chapter 1 – Patents issued 1971 – 1984

These patents are included in this chapter of this Part 6 as they “teach” (using the legal term) applications of surge-protective devices. Only the front pages of the patents are included here. Complete copies, of course, would be available from the U.S. Patent Office. Seven of the nine patents included in this chapter were granted for non-conventional structures and applications of the emerging metal-oxide varistor (MOV) technology, fueled by the enthusiasm generated by the possibility of taking advantage of the flexibility of manufacturing MOVs in structures more complex than a simple disc with only two terminal electrodes. A search on the subject of “MOV” in the U.S. Patent Office yields nearly one hundred patents by other inventors.

All of these nine patents were assigned to the General Electric Company, which lost interest in any of them as the electronics-oriented varistor business was sold off by General Electric, the beginning of a succession of divestitures, acquisitions, and licensing of what has now become for several manufacturers primarily a business of manufacturing simple two-terminal structures that are subsequently incorporated into an SPD package by other manufacturers.

Two other patents included in this chapter deal with transient phenomena in power electronics and are cited in several patents issued to other inventors of surge-protection schemes, although these two do not include any claim associated with MOV applications.

Chapter 2 – Retrospective – 1972-2004

As witness to technology evolution and changing business priorities, this chapter of Part 6 begins – as an acknowledgment to the origins of the technology – with an early patent filed in the US, for which GE acquired a license and launched the “GE-MOV®” varistors in 1972, blossoming into a full line of two-terminal devices for low-voltage applications. Next, this chapter shows an excerpt from a product specification bulletin listing the wide range of ratings available by the mid-seventies. On the occasion of its Centennial, GE seemed determined to stay in the business of transient protection, as claimed by an advertisement citing its long roots in the field. However, while expansion of the variety of MOV structures continued, as shown by the covers of successive editions (avatars) of the Transient Voltage Suppression Manual, GE eventually did exit the business of low-voltage MOVs, with Harris Semiconductor taking over. That exit was later followed by yet another divestiture, now apparent as the latest MOV avatar when browsing the Internet for present MOV manufacturers – a long way from the 1970s GE-MOVs.

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1 Then a trademark of the General Electric Company.

2 The MOV applications to high-voltage surge arresters were also developed during that period, but are not covered in this Anthology, except for the seminal Shakshaug et al. paper which is included as an annex of Part 7.
ABSTRACT: When a short circuit or shoot-through occurs in a power circuit having two thyristors in series with commutating circuit inductors, a shunt capacitor isolated from the DC power supply by an impedance automatically resonates with the inductors to turn off both thyristors. A second automatic recovery system for repeated short circuits that occur before the capacitor has recharged operates to temporarily disable the power supply. In a high-voltage inverter the impedance is a resistor functioning to dampen voltage overshoots and to implement a relay or solid state second recovery system.
ABSTRACT: A solid-state voltage regulator constructed with low current rating step changing solid-state switches, or pairs of switches, is protected against overcurrents in the interval before the opening of a slow-acting circuit breaker. The overcurrent is transferred from one switch to another in sequence rapidly to take advantage of the short time current over-capacity, or is diverted to a shunting protective switch which can have other functions. Alternatively, one switch has a high current rating, and the overcurrent is diverted to the heavy-duty switch.
INTEGRAL SENSOR FOR MONITORING A METAL OXIDE VARISTOR

Inventor: Francois D. Martzloff, Schenectady, N.Y.

Assignee: General Electric Company, Schenectady, N.Y.

Filed: Sept. 30, 1971

Appl. No.: 185,184

U.S. Cl. 338/20, 73/362 SC, 338/22

Int. Cl. H01c 7/10

Field of Search 338/13, 20, 21, 324, 338/325, 322; 73/362 SC; 323/68, 69

ABSTRACT

A body of sintered metal oxide material having first and second opposed surfaces and a third surface disposed therebetween has first and second electrodes in contact with the first two opposed surfaces for establishing a main conductive path through the device and a third electrode in contact with one of the two opposed surfaces and spaced very close to the corresponding electrode for establishing a monitoring conductive path for sensing the operating temperature of the body as a function of the resistance thereof. The monitoring path may also be established by a pair of third electrodes positioned on opposite sides of the surface interconnecting the first two surfaces whereby the monitoring path intersects the main conductive path. The sintered metal oxide material has varistor characteristics.

13 Claims, 6 Drawing Figures
SURGE SUPPRESSION TRANSMISSION MEANS

Inventors: Dante M. Tasca, Philadelphia, Pa.; John D. Harnden, Jr.; Francois D. Martzloff, both of Schenectady, N.Y.

Assignee: General Electric Company

Filed: Oct. 21, 1971

Appl. No.: 191,216


Int. Cl. H01p 1/00, H01p 1/22, H01c 7/12

Field of Search 333/97 R, 81 AB, 17, 13, 24.2, 333/2, 96, 97 S; 338/20-21, 216, 220; 317/61.5; 339/147; 329/161-162

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2,498,335 2/1950 Hunt.................. 329/162
2,548,881 4/1951 Ferrill, Jr................ 333/96 X
2,602,828 7/1952 Norton.................. 338/20 X
2,798,207 7/1957 Reggia.................. 338/81 A
2,911,601 11/1959 Gunn et al...................... 333/81 B
3,014,188 12/1961 Chester et al........ 333/98 S
3,096,494 7/1963 Jacobs et al........ 329/161 X
3,259,857 7/1966 Garstang........ 333/79

3,611,073 10/1971 Hamamoto et al........ 338/20 X
3,663,458 5/1972 Masuyama et al........ 252/518

OTHER PUBLICATIONS


Primary Examiner—Eli Lieberman

Assistant Examiner—Wm. H. Punter

Attorney—Frank L. Neuhauser et al.

ABSTRACT

In a coaxial connector a generally toroidal shaped member of metal oxide varistor material is connected between the inner and outer conductors of the connector. The metal oxide varistor material has an alpha in excess of 10 in the current density range of from $10^{-3}$ to $10^2$ amperes per square centimeter. The spacing of the peripheral portions of the member is set so that a high impedance is presented to normal applied voltage between the peripheral portions. For voltages applied between the peripheral portions progressively in excess of the normal voltage rapidly decreasing impedance is presented by the toroidal member in accordance with the alpha of the material thereby limiting the variation in voltage between the peripheral portions of the toroidal shaped member.

11 Claims, 13 Drawing Figures
A polycrystalline varistor of the bulk effect zinc oxide base type adapted for use in voltage surge suppression on VHF signal lines is disclosed. The device comprises a unitary body including a spiral inductor electrically in series with the varistor element to prevent capacitive loading of the protected signal line.

9 Claims, 3 Drawing Figures
A polycrystalline varistor of the bulk effect zinc oxide base type adapted for use in voltage surge suppression on VHF signal lines is disclosed. The device comprises a connector having a housing attached thereto containing a polycrystalline varistor and a conductive spring member. The spring member is configured to provide for the proper mechanical positioning of the varistor and to provide an electrical inductance in series with the varistor to prevent capacitive loading of the protected signal line.

9 Claims, 2 Drawing Figures
Reconstituted metal oxide varistors are formed by hot pressing powdered metal oxide varistor ceramic with plastic resin. Metal electrodes may be pressed directly into the ceramic-plastic composite to provide improved contact characteristics.
MULTI-TERMINAL VARISTOR CONFIGURATION

Inventor: Francois D. Martzloff, Schenectady, N.Y.

Assignee: General Electric Company, Schenectady, N.Y.

Appl. No.: 972,448

Filed: Dec. 22, 1978

Int. Cl.2 H02H 1/04

U.S. Cl. 361/127; 338/21; 361/56

Field of Search 361/56, 91, 127; 338/20, 21

References Cited

U.S. PATENT DOCUMENTS
2,935,712 5/1960 Oppenheim et al. 338/20
3,764,854 10/1973 Craddock 361/127

FOREIGN PATENT DOCUMENTS
7507645 1/1976 Netherlands 338/21

ABSTRACT

A pair of varistor disks, each having one face thereof coated substantially entirely with electrode material and another face thereof coated with spaced-apart electrode material, such as in two semicircular patches, are joined together so that said faces coated with a single electrode are coincident. This configuration reduces by a factor of two the over-all area required for equal current density as compared with certain prior varistor configurations. The varistor of the present invention also exhibits a lower diameter-to-thickness ratio and hence provides a significantly stronger mechanical structure. Additionally, the varistors of the present configuration may be readily provided with grooves between electrode surfaces so as to increase the inter-electrode spacing, without significantly reducing the mechanical strength of the device. The invention of the present structure also permits flexible lead configurations.

10 Claims, 4 Drawing Figures
CURRENT-LIMITED SPARK GAP FOR TRANSIENT PROTECTION

Inventors: Milton D. Bloomer; Francois D. Martzloff, both of Schenectady, N.Y.

Assignee: General Electric Company, Schenectady, N.Y.

Filed: Feb. 18, 1983

ABSTRACT

High voltage transients are effectively clamped by means of a spark gap, in parallel connection with a load to be protected, and having a capacitor in series with the paralleled load-spark gap combination. The series capacitor limits follow-through current through the spark gap to a level permitting survival of the spark gap. Where the load is an incandescent lamp, the spark gap is formed by shaping the lamp internal lead structure, such that an additional external spark gap component is not required.

13 Claims, 2 Drawing Figures
VOLTAGE DEPENDENT RESISTORS
IN A BULK TYPE

Michio Matsuno, Takeshi Muyayama, and Yoshio Iida, Osaka-fu, Japan, assignors to Matsushita Electric Indu-
strial Co., Ltd., Osaka, Japan

Filed Dec. 1, 1970, Ser. No. 93,971

Claims priority, application Japan, Dec. 12, 1969, 44/100,447; Dec. 16, 1969, 44/102,203, 44/102,204, 44/
102,205, 44/102,206; Dec. 23, 1969, 44/569; Apr. 6, 1970, 45/29,988

Int. Cl. H0B 1/05

U.S. Cl. 252—518

5 Claims

ABSTRACT OF THE DISCLOSURE

A voltage dependent resistor of the bulk type. The resistor has a sintered body consisting essentially of, as
a major part, zinc oxide (ZnO) and, as an additive, 0.05 to 10.0 mole percent of beryllium oxide (BeO) and 0.05
to 10.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide
(Bi2O3), cobalt oxide (CoO) manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead
oxide (PbO). Electrodes are provided which are in contact with said body.

This invention relates to voltage dependent resistors having non-ohmic resistance due to the bulk thereof
and more particularly to varistors comprising zinc oxide and beryllium oxide.

Various voltage dependent resistors such as silicon carbide varistors, selenium rectifiers and germanium
and voltage dependent resistors contemplated by the invention comprises a composition consisting of zinc
oxide with or without additives and silver lead oxide (PbO) and electrodes in contact with said body.

The pressed bodies are attached conductively to the electrodes 2 and 3, respectively. The desired value of C
depends upon the sintering of said sintered body and silver paint electrode.

Voltage dependent resistors comprising sintered bodies of zinc oxide with or without additives and silver
paint electrodes applied thereto, have previously been disclosed. The non-linearity of such varistors is attrib-
uted to the interface between the sintered body of zinc oxide with or without additives and the silver paint
electrode and is controlled mainly by changing the compositions of said sintered body and silver paint electrode.

Therefore, it is not easy to control the C-value over a wide range after the sintered body is prepared. Similarly,
in varistors comprising germanium or silicon p-n junction diodes, it is difficult to control the C-value over
a wide range because the non-linearity of these varistors is not attributed to the bulk but to the p-n junction.

On the other hand, the silicon carbide varistors have non-linearity due to the contacts among the individual
grain of silicon carbide bonded together by a ceramic binding material, i.e., to the bulk, and the C-value is controlled
by changing a dimension in the direction in which the current flows through the varistors. The silicon carbide
varistors, however, have a relatively low n-value ranging from 3 to 6 and are prepared by firing in non-oxidizing
atmosphere, especially for the purpose of obtaining a low C-value.

Another object of the present invention is to provide a method for making a voltage dependent resistor having
the non-linearity due to the bulk thereof and being characterized by a high n-value.

These objects are achieved by providing a voltage dependent resistor comprising a sintered body consisting essentially of, as a major part, zinc oxide (ZnO), and, as an additive, 0.05 to 10.0 mole percent of beryllium oxide (BeO) and 0.05 to 110.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi2O3), cobalt oxide (CoO), manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO), and electrodes in contact with said body.

These and other objects of the invention will become apparent upon consideration of the following description taken together with the accompanying drawing, in which the single figure is a partly cross-sectional view through a voltage dependent resistor in accordance with the invention.

Before proceeding with a detailed description of the voltage dependent resistors contemplated by the inven-
tion, their construction will be described with reference to the aforesaid drawing wherein reference character 10
designates, as a whole, a voltage dependent resistor comprising, as its active element, a sintered body having a pair of electrodes 2 and 3 applied to opposite surfaces thereof. Said sintered body 1 is prepared as manner hereinafter set forth and is in any form such as circular, square or rectangular plate form. Wire leads 5 and 6 are attached conductively to the electrodes 2 and 3, respectively, by a connection means 4 such as solder or the like.

The sintered body 1 of the voltage dependent resistor according to the invention comprises a composition con-sisting essentially of, as a major part, zinc oxide (ZnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO) and, as an additive, 0.05 to 10.0 mole percent of beryllium oxide (BeO) and 0.05 to 110.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi2O3), cobalt oxide (CoO), manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO), and electrodes in contact with said body.

A higher n-value can be obtained when said additive consists essentially of 1.0 to 8.0 mole percent of beryll-
ium oxide (BeO) and 0.1 to 3.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi2O3), cobalt oxide (CoO), manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO).

Table 1 shows the optimal compositions of said additives for producing a voltage dependent resistor having a high n-value, low C-value and high stability with respect to temperature, radiation, etc.
GE has been helping customers solve transient voltage problems since the introduction of GE-MOV® varistors in 1972. The GE-MOV® team is constantly researching the causes and effects of transients and developing new solutions to meet all types of transient suppression needs; committed to innovation beyond today's technology.

As the field of electronics has grown rapidly through the use of solid-state components, so have the applications for surge suppressors to protect these transient-sensitive devices. Innovations such as surface-mount technology have also altered the demand profile by adding packaging considerations to functional ones.

As a result of innovation and research, the GE-MOV® line of metal-oxide varistors has expanded to include surface-mount devices, new high-energy packages, connector-pin varistors, and high-temperature, low-profile varistors. These new products supplement the GE-MOV® line of radial, axial, and high-energy packaged varistors, already the broadest in the industry.

**GE-MOV® Features**

**FAMILY FEATURES:**
- Wide Voltage/Energy Range
- Excellent Clamp Ratio
- Power
- No Follow-On Current
- Fast Response Time
- Low Standby
- UL Recognized

**TYPE FEATURES:**

**CH/SM Series**
- Surface Mount Varistors
  - Better Performance
  - Higher Reliability
  - Lower Equipment Cost
  - Saves on Board
  - Height/Bulk/Weight

**ZA Series**
- Radial Package
- Low Voltage Operation

**LA Series**
- Radial Package
- Line Voltage Operation
- UL Recognized

**RA Series**
- Low Profile
- High Temperature Capability
- Precise Seating Plane
- In-Line Leads

**PA Series**
- Rigid Mountdown
- NEMA Creep and Strike Distance
- Quick Connect Terminal
- UL Recognized

**DA,DB,BA, BB Series**
- High Energy Capability
- Rigid Terminals
- Isolated
- Low Inductance
- Improved Creep and Strike
- UL Recognized

**CP Series**
- Connector Pin Varistors
  - Provides transient protection in connectors
  - Available in 22, 20, and 16 gauge sizes

**MA Series**
- Axial Package
- Wide Voltage Range
- Automatic Insertion

**CA Series**
- Industrial Discs

**Hi Reliability Series**
- 100% Prescreened
- 100% Process Conditioning
- Meets Military Specifications
Most people recognize GE-MOV® varistors as the ultimate in system transient protection. With good reason. These metal oxide varistors, or movistors, are the result of research and experience that stems from the early years of General Electric, celebrating in 1978 its 100th birthday.

You may have shared our excitement along the GE path to leadership. Steinmetz’ lightning generator demonstration in 1922. Anderson’s lightning measurements on the Empire State Building in the 1930’s. The definitive study of surge voltages in residential and industrial circuits formulated by Martzloff and Hahn of GE’s Corporate R&D Center in 1970. And, of course, GE’s $10 million investment relating to the introduction of GE-MOV® varistors six years ago.

But in our view, the best is yet to come. GE’s R&D work on transient protection continues to find more sophisticated materials, better measurements and standardization. Soon, you’ll be able to put the resulting new products and new ideas to work for you.

Experience, Innovation. Staying power. It’s what you’ve come to expect, and can expect from GE when you need transient protection.

For the full story on GE-MOV® varistors, call your local authorized GE semiconductor distributor, or write General Electric Co., Electronics Park 7-49, Syracuse, N.Y. 13221.

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There’s more to GE semiconductors than meets the eye

GENERAL ELECTRIC
Avatars of the GE Transient Voltage Suppression Manual
1976 - 2004

1976 – First Edition
(A collector’s item)

1978 – Second Edition
The line expands

1982 – Third Edition
Bigger is better

1983 – Fourth Edition
(More big discs/)

1986 – Fifth Edition
Last Hurrah for GE-MOV

1992 – Same Text
A New Home

Browsing the Web in 2004 for varistor vendors delivers the following message:

**Divested Product Family**

The product you’re searching for is part of a family that is no longer in the Intersil Corporation product portfolio.

**TRANSIENT VOLTAGE PRODUCTS**
The former Harris Semiconductor and RCA Solid State family of transient voltage products (Radial Varistors, Multi-Layer Varistors, Industrial MOVs, Diode Arrays and Surjector TVS Thyristors) were sold to Littlefuse, Inc. These include products with prefixes of LA, ZA, CIII, MLA, MLE, AUML, RA, BB, MA, HA, NA and SP.