

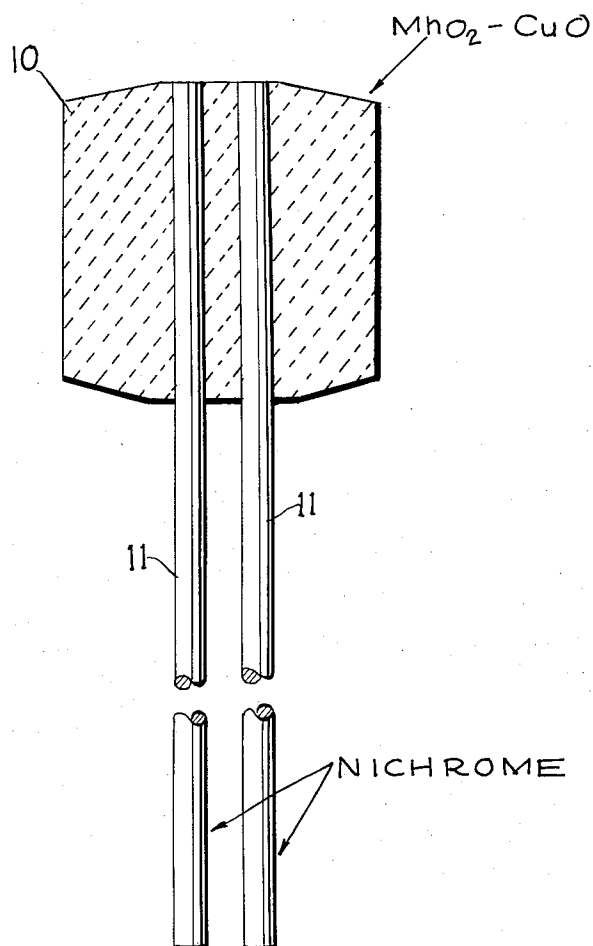
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J. E. ROLLINS ETAL

3,024,435

SEMI-CONDUCTIVE ELEMENT

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INVENTORS
JAMES E. ROLLINS
ALEXANDER J. RAKOWSKI
JOHN CONRAD ZENOBIA, JR.

By *J. William Carson*
ATTORNEY

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3,024,435

SEMI-CONDUCTIVE ELEMENT

James Edgar Rollins, Newark, Alexander Joseph Rakowski, Towaca, and John Conrad Zenobia, Jr., Belleville, N.J., assignors to Specialties Development Corporation, Belleville, N.J., a corporation of New Jersey
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5 Claims. (Cl. 338—20)

The present invention relates to semi-conductive elements such as varistors, and, more particularly, to the composition of the body of resistance material and the terminal wires for the body.

In an attempt to use terminal wires which are less expensive than platinum in the production of thermistor elements wherein a body of resistance material consisting essentially of manganese dioxide and cupric oxide is utilized, it was discovered, that by placing such resistance material on wires formed of an alloy sold by Driver Harris Co. under the tradename "Nichrome" and consisting essentially of between about 80% and about 85% by weight of nickel and between about 20% and about 15% by weight of chromium, an element was produced which was so highly voltage sensitive that it could be utilized as a varistor.

Accordingly, the primary object of the present invention is to provide such a varistor element in a simple, practical and economical manner.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the present invention, the foregoing objects can be accomplished by providing a varistor element comprising a body formed of a resistance material consisting essentially of between about 70% and about 96% by weight of manganese dioxide and between about 30% and about 4% by weight of cupric oxide and spaced parallel conductive terminal wires formed of "Nichrome."

In the drawing, the single FIGURE is a greatly enlarged longitudinal sectional view of a semi-conductor such as a varistor embodying the present invention.

Referring to the drawing in detail, the element shown by way of example comprises a cylindrical body or bead 10 having a pair of spaced apart parallel terminal wires 11 embedded therein. This element has the following dimensions:

	Inches
Body length	0.0625
Body diameter	0.0625
Wire diameter	0.0100
Space between wires	0.0100

EXAMPLE I

An element having the foregoing dimensions was constructed by forming the body 10 of thoroughly admixed fine particles consisting essentially of 96% by weight of manganese dioxide and 4% by weight of cupric oxide and by extruding the same on wires 11 formed of an alloy consisting essentially of 80% by weight of nickel and 20% by weight of chromium. The body was fired to adhere the same onto the wires.

EXAMPLE II

Another element was similarly constructed by forming the body of a mixture consisting essentially of 90% by weight of manganese dioxide and 10% by weight of

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cupric oxide and by extruding the same on wires of the same composition as mentioned in Example I.

EXAMPLE III

Another element was similarly constructed by forming the body of a mixture consisting essentially of 80% by weight of manganese dioxide and 20% by weight of cupric oxide and by extruding the same on wires of the same composition as mentioned in Example I.

EXAMPLE IV

Another element was similarly constructed by forming the body of a mixture consisting essentially of 70% by weight of manganese dioxide and 30% by weight of cupric oxide and by extruding the same on wires of the same composition as mentioned in Example I.

The elements were tested by applying measured potentials only for a short duration to prevent appreciable self-heating effects, and measuring the resistance of the elements with a bridge or a null detector.

The following readings were taken:

Table I

Example	Reading	V	R	Percent of original R (reading 1)	Percent decrease of original R (reading 1)
I	1	1.6v	1.6m		
	2	3	1.14	.71	29
	3	4	0.890	.55	45
	4	6	0.732	.46	54
	5	10	0.595	.37	63
	6	12	0.570	.35	65
	7	15	0.500	.31	69
	8	20	0.435	.28	72
	9	30	0.341	.21	79
II	10	40	0.276	.17	83
	1	.18v	180k		
	2	.30	146	80	20
	3	.60	100	55	45
	4	1.0	74.0	41	59
	5	1.5	55.6	30	70
	6	2.0	41.7	22	78
	7	3.0	27.2	14	86
	8	4.0	17.4	10	90
III	9	5.0	11.9	7	93
	1	.10v	100k	1.0	0
	2	.30	43	.43	57
	3	.60	21	.21	79
	4	1.0	12	.12	88
	5	1.5	7.2	.072	93
	6	2.0	4.6	.046	95
	7	3.0	2.2	.022	98
	8	4.0	1.2	.012	99
IV	9	5.0	.9	.009	99
	1	.10v	100k	1.0	0
	2	.30	43	.43	57
	3	.60	21	.21	79
	4	1.0	12	.12	88
	5	1.5	7.2	.072	93
	6	2.0	4.6	.046	95
	7	3.0	2.2	.022	98
	8	4.0	1.2	.012	99
	9	5.0	.9	.009	99

From the foregoing table, it will be seen that the compositions of the higher cupric oxide content exhibited greater voltage sensitivity than the compositions of the lower cupric oxide content.

The sensitivity exhibited by these elements is of an order which characterizes the elements as varistors and renders them useful for that purpose.

For example, if the elements in accordance with Examples I to IV are used in a network with a potential of 2.0 volt applied thereto and the potential suddenly

changes the percentage of change in resistance will be as shown in the following table:

Table II

E.M.F.	Percent change in E.M.F.	Percent change in resistance			
		Ex. I	Ex. II	Ex. III	Ex. IV
1.5v-----	-25	+13	+29	+49.5	+40.5
2.0-----	-25	-15	-20.5	-33	-33
2.5-----	+50	-22.5	-34.5	-52	-52
3.0-----	+100	-33	-58	-74	-74
4.0-----	+150	-38	-72	-89	-89
5.0-----					

Further tests have indicated that the characteristics of the elements can be reliably reproduced.

The expression "voltage sensitivity" and expressions of similar context mean that the resistance of the body material appreciably decreases as the voltage applied across the terminal wires increases.

From the foregoing tables it will be seen that compositions of higher cupric oxide content exhibited greater voltage sensitivity than compositions of lower cupric oxide content, however, apparently reaching a uniform or minimum value at between 20% and 30% cupric oxide.

From the foregoing description, it will be seen that the present invention provides a varistor which can be produced in a simple, practical and economical manner.

It will be understood that the details and examples hereinbefore set forth are illustrative only and that the invention as broadly described and claimed is in no way limited thereby.

We claim:

1. A semi-conductor having the characteristics of a varistor comprising a body formed of a resistance mate-

rial consisting essentially of between about 70% and about 96% by weight of manganese dioxide and between about 30% and about 4% by weight cupric oxide; and spaced parallel conductive terminal wires embedded in said body formed of an alloy consisting essentially of between about 80% and about 85% by weight of nickel and between about 20% and about 15% by weight of chromium.

2. A semi-conductor according to claim 1, wherein the resistance material consists essentially of about 96% by weight of manganese dioxide and about 4% by weight of cupric oxide.

3. A semi-conductor according to claim 1, wherein the resistance material consists essentially of about 90% by weight of manganese dioxide and about 10% by weight of cupric oxide.

4. A semi-conductor according to claim 1, wherein the resistance material consists essentially of about 80% by weight of manganese dioxide and about 20% by weight of cupric oxide.

5. A semi-conductor according to claim 1, wherein the resistance material consists essentially of about 70% by weight of manganese dioxide and about 30% by weight of cupric oxide.

References Cited in the file of this patent

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,024,435

March 6 1962

James Edgar Rollins et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, Table I, column 5, the figures for Examples I, III and IV thereof, should appear as shown below instead of as in the patent:

Example I	Example III	Example IV
-----	-----	-----
71	43	43
55	21	21
46	12	12
37	7.2	7.2
35	4.6	4.6
31	2.2	2.2
28	1.2	1.2
21	0.9	0.9
17		

same Table I, column 6, lines 20 and 29 thereof, for "O", each occurrence, read -- ----- --.

Signed and sealed this 13th day of November 1962.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner
of Patents