

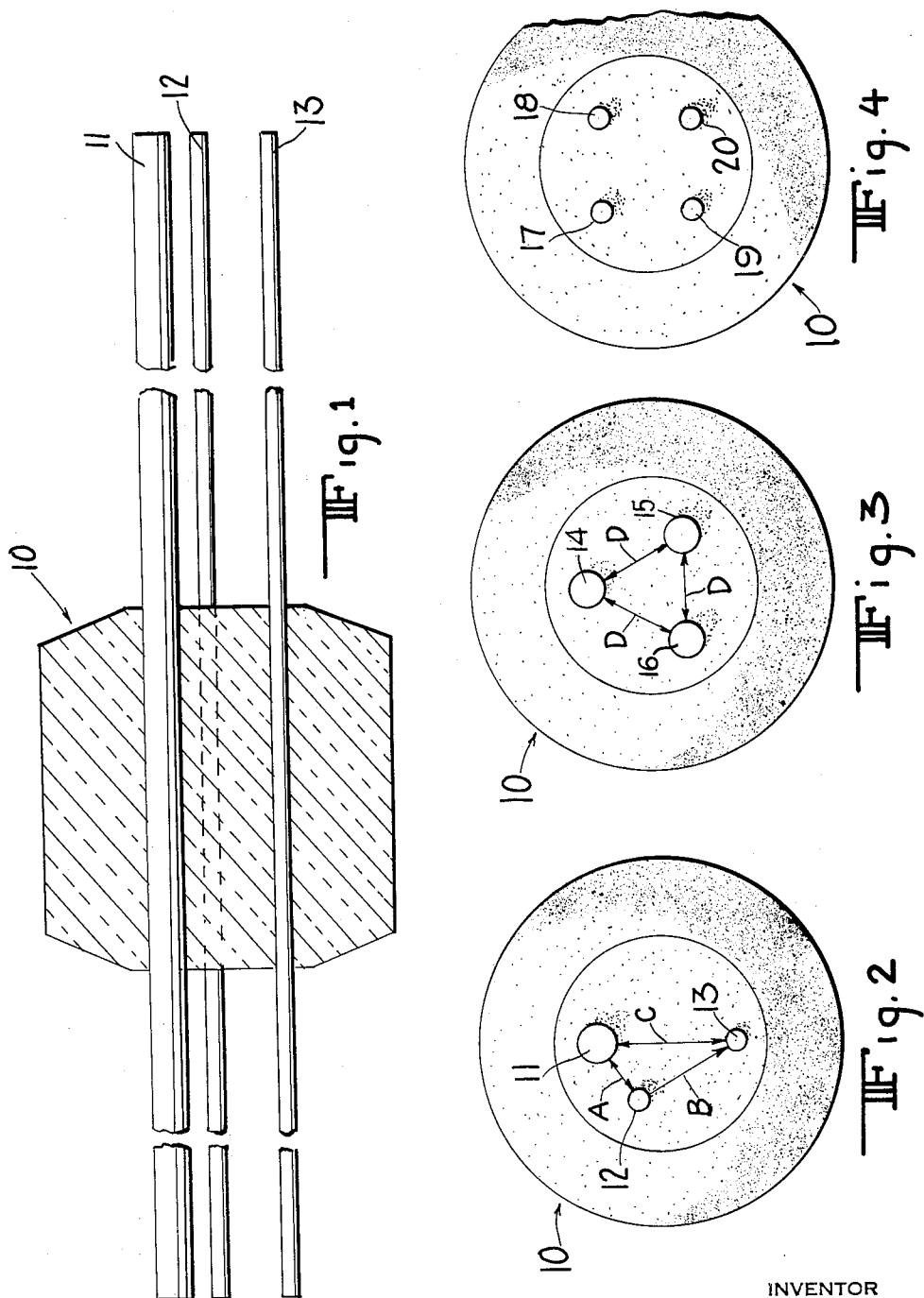
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MULTIPLE RESISTANCE CHARACTERISTIC SEMI-CONDUCTOR ELEMENTS

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MULTIPLE RESISTANCE CHARACTERISTIC
SEMI-CONDUCTOR ELEMENTS

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1 Claim. (Cl. 338—22)

The present invention relates to semi-conductor ele-
ments, and more particularly, to such elements having two
or more resistance values at a given temperature.

Heretofore, it has been proposed to make semiconduc-
tor elements such as thermistors and varistors by em-
bedding a pair of parallel spaced apart electrically con-
ductive terminal wires in a body formed of a resistance
material to provide a known resistance across the wires at
given temperatures. In certain types of networks, a num-
ber of such elements may be required which add to the
cost of the components and the assembly thereof in the
network. Also, since the resistance of each element at a
given temperature is fixed, the elements can only be used
where the particular resistance is called for.

Accordingly, an object of the present invention is to
provide such elements which have more than one resist-
ance value at a given temperature.

Another object is to provide such elements which carry
out the function of two or more previously individually
used elements.

Another object is to provide such elements which have
both thermistor and varistor characteristics.

A further object is to provide such elements in a sim-
ple, practical and economical manner.

Other and further objects of the invention will be ob-
vious upon an understanding of the illustrative embod-
iment about to be described, or will be indicated in the ap-
pended claim, and various advantages not referred to
herein will occur to one skilled in the art upon employ-
ment of the invention in practice.

In the drawing:

FIG. 1 is an enlarged sectional view of a semiconductor
element illustrating one embodiment of the invention.

FIG. 2 is an end elevational view looking at the ele-
ment shown in FIG. 1 from the left.

FIG. 3 is a view similar to FIG. 2 of an element illus-
trating another embodiment of the invention.

FIG. 4 is a view similar to FIGS. 2 and 3 of an element
illustrating still another embodiment of the invention.

Referring to FIGS. 1 and 2 of the drawing in detail,
there is shown a semi-conductor element which generally
comprises a bead-like body 10 and terminal wires 11, 12
and 13 embedded in the body and extending outwardly
therefrom.

The body may be formed of any suitable resistance ma-
terials such as metallic oxides which have thermistor
and/or varistor characteristics. Examples of such ma-
terials are disclosed in United States patent application
Serial No. 6,422, filed February 3, 1960, and assigned to
the assignee of this application. The following examples
are disclosed in the above application:

Example I

	Percent by weight
Manganese dioxide.....	96
Cupric oxide.....	4

Example II

Manganese dioxide.....	90
Cupric oxide.....	10

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Example III

	Percent by weight
Manganese dioxide.....	80
Cupric oxide.....	20

Example IV

Manganese dioxide.....	70
Cupric oxide.....	30

Numerous other suitable resistance materials are well
known in the art and are illustrated by patents in Class
252, subclass 518. In general, suitable resistance ma-
terials having the following ranges of composition are sat-
isfactory:

	Percent by weight
Manganese dioxide.....	70 to 96
Cupric oxide.....	30 to 4

The wires may be formed of platinum; an alloy sold by
The International Nickel Company, Inc. under the trade-
mark "Inconel" and consisting essentially of between
about 6% and about 17% by weight of iron, between
about 11% and about 18% by weight of chromium and
the balance nickel at a minmum of 70% by weight; or an
alloy sold by Driver Harris Co. under the trademark
"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.

In order to provided the element with different resist-
ance characteristics across different pairs of wires as con-
templated by the present invention the wires 11, 12, and
13 may be spaced apart different distances with respect to
each other. For example, the distance A between the
wires 11 and 12, the distance B between the wires 12 and
13, and distance C between the wires 11 and 13 could be
of an increasing magnitude in the order named. The dif-
ference in distance could vary considerably in order to
attain pronounced different resistance, characteristics so
that, for example, the element could be used where one,
two or three units of resistance are required, that is, R,
2R or 3R.

Also, in utilizing certain manufacturing techniques, it
is difficult to reproduce two wire elements having exactly
the same resistance value. Thus, by spacing one pair of
wires (12, 13) the distance calculated to reproduce de-
sired resistance values and spacing one other pair of wires
(11, 13) a slightly greater distance and spacing a third
pair of wires (11, 12) a slightly lesser distance, at least
one of the pairs of wire should provide the resistance
sought to be reproduced.

The foregoing effects also may be accomplished by
varying the diameters of the wires 11, 12 and 13 or by
using wires having different resistivities due to the oxide
formed when sintering the body on the wires. Thus, by
using different combinations of resistivities, different re-
sistances can be provided across different pairs of wires.

In FIG. 3, wires 14, 15 and 16 are shown spaced apart
the same distance D with respect to each other and as
being of equal diameter to provide three equivalent re-
sistances across the wires 14—15, 14—16 and 15—16, re-
spectively. Here again, the resistance values could be
varied by using wires of different diameters or different
materials in a symmetrical arrangement.

Also, in a symmetrical arrangement of wires of like
diameters and materials, a resistance unit could be estab-
lished within the element having one half the resistance
across any pair of wires. This may be accomplished by
connecting any two of the wires at one end, for example,
the wires 14 and 16, so that the wires 14 and 16 provide
a common terminal and the resistances between the wires

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15 and 14 and 15 and 16 are connected in parallel. Thus, from the formula

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2}$$

where r_1 and r_2 are equal and can be expressed as r ,

$$R = \frac{r}{2}$$

Other combinations of individual and parallel resistance values could be provided by asymmetrically arranged wires or wires of dissimilar materials.

In connection with the invention disclosed in the aforementioned patent application, it has been found that, with certain combinations of metallic oxides providing the resistance material of the body such as manganese dioxide and cupric oxide, the material between a pair of platinum or Inconel wires has the characteristics of a thermistor whereas the same material between a pair of Nichrome wires has the characteristics of a varistor. Thus, with an arrangement such as shown in FIG. 4, platinum or Inconel wires 17 and 18 provide a thermistor unit and Nichrome wires 19 and 20 provide a varistor unit in a single element.

While the terminal wires could extend outwardly from both ends of the body of the element to enable the ultimate user to utilize any of the possible combinations that can be made, it may be preferred in some instances to have one pair extend outwardly only at one end and have another pair extend outwardly only at the opposite end so that adjacent pairs indicate that they are to be used in conjunction with each other. For example, in the arrangement shown in FIGS. 1 and 2, one wire (11) could extend outwardly at both ends and the other two wires (12, 13) could each extend outwardly only at an opposite end. Similarly, in the arrangement shown in FIG. 4, the wires 17 and 18 could extend from one end and the wires 19 and 20 could extend from the opposite end.

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From the foregoing description, it will be seen that the present invention provides semi-conductor elements having a plurality of values and/or characteristics in a simple, practical and economical manner.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

I claim:

A semi-conductor 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 a first and second pair of spaced parallel, conductive terminal wires embedded in said body and extending outwardly therefrom, said first pair of wires being 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 and both wires of said second pair of wires being formed of a material selected from the group consisting of platinum and an alloy consisting essentially of between about 6% and about 17% by weight of iron, between about 11% and about 18% by weight of chromium and the balance nickel at a minimum of 70% by weight, said first pair of wires cooperating with said body to provide an element having varistor characteristics and said second pair of wires cooperating with said body to provide an element having thermistor characteristics.

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