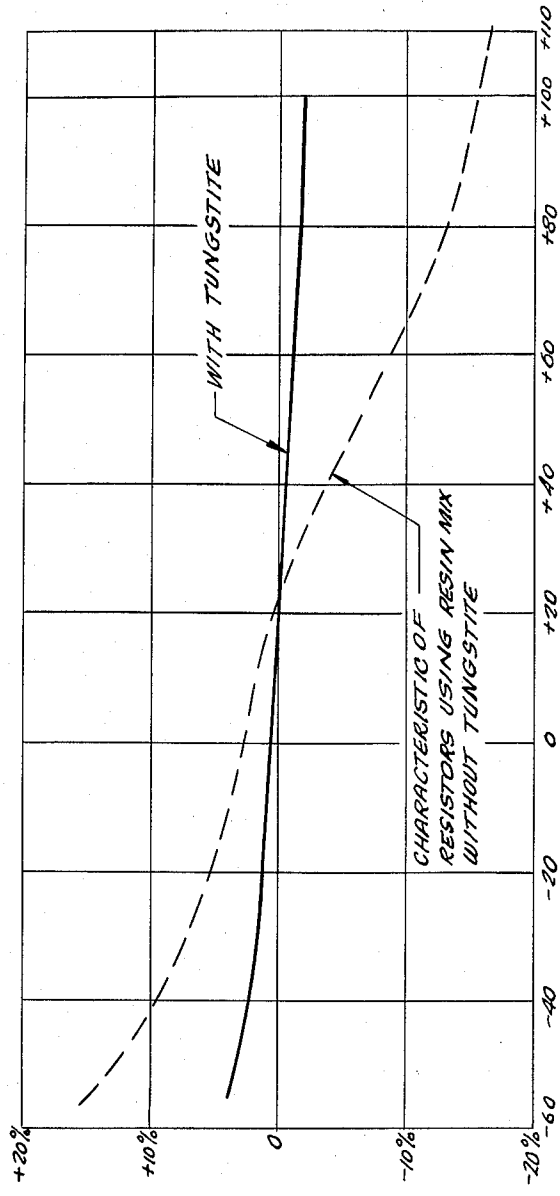
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TEMPERATURE COMPENSATING RESISTOR

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EFFECT OF TUNGSTITE ADDITION TO PHENOL FORMALDEHYDE MIX ON TEMPERATURE COEFFICIENT



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TEMPERATURE COMPENSATING RESISTOR

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This invention relates to a novel resistor composition and more particularly to a composition which will provide a resistor having a relatively low temperature coefficient of resistance and will find particular application in printed-type resistors.

The resistance value of most resistors does not remain constant with a change in temperature. Either the resistance tends to increase or decrease with temperature variations. This effect, the specific measure of which is known as the temperature coefficient of resistance, is quite undesirable in many applications. For example, resistors are often used in equipment which generate heat. The cabinet in which the equipment is enclosed is of such a nature that as heat is generated the temperature inside will rise. If the value of the resistor element inside changes with a variation in temperature, the Q frequency response, or other characteristics of the electrical circuit will also change, thereby greatly impairing the efficiency of such equipment.

One device using printed resistors in which a high temperature coefficient is particularly undesirable is a proximity fuse wherein the circuitry must remain stable in its response to temperature, as such fuses may be used in the tropics or polar regions, and it is vital that the characteristics of the electronic circuit used in the fuse be relatively constant in either of these instances.

Such resistors commonly contain carbon mixed with thermoplastic or thermosetting resins. However, since carbon has a rather high negative temperature coefficient of resistance, the resistance values of these resistors will decrease as the temperature rises. In the case of a thermoplastic resin in a carbon resistor, it has been possible in the prior art to correct their negative temperature coefficient. However, thermoplastic resins have certain drawbacks such as the fact that they are altered by coating with most materials which can be used for protection from the environment.

In this respect, resistors containing thermosetting resins have proven much more satisfactory. Thermosetting resins can be coated with a wide variety of materials which are quite stable, inert, and protect against humidity and physical shock. However, a problem which arises in using this type of resistor is to find a satisfactory method of providing them with a very low temperature coefficient.

It has been found that the temperature coefficient of a resistor comprising a plasticized thermosetting resin, carbon, and a finely-divided semi-conductor may be substantially improved by utilizing therein an oxide or acid of a metal chosen from the elements comprising group VI*a* of the periodic table, i.e. chromium, molybdenum, and tungsten, as the semiconductor. I have found that tungsten oxide and tungstic acid are particularly effective in this respect.

Accordingly, it is an object of my invention to provide a resistor composition whose resistance will remain relatively constant at both elevated and subnormal temperatures.

Another object is to provide a resistor having a relatively low temperature coefficient of resistivity.

Still another object is to provide a mixture from which a novel printed resistor containing a thermosetting resin, carbon, and a finely ground semi-conductor can be made.

Still a further object is to provide a resistor composition containing a thermosetting resin, carbon black, and an acid or oxide of a metal of group VI*a* of the periodic table, such as tungstic acid or tungstic oxide.

These and other objects of my invention will become apparent in the drawing and description which follow and in which the drawing shows graphically the effect on the temperature coefficient of a resistor composition which comprises a phenol-formaldehyde resin and carbon, when tungstite is added thereto. The particular composition to establish these data is hereinafter referred to in more detail.

The thermosetting resin in my resistor may comprise any such resins which are commonly used in resistors. Typical of these are phenol-formaldehyde, urea formaldehyde, other phenolic resins, and melamine formaldehyde. In this group I also intend to include the themosetting silicones.

To these resins is added a high-boiling ester type plasticizer such as dibutyl phthalate and/or Carbitol acetate.

The carbon is introduced into my composition in a dry powdered form, the particle range being between ten and eighty millimicrons. The size of the carbon particles should ordinarily be below $\frac{1}{10}$ of a micron because below this point it is more readily incorporated into the mixture.

The semi-conductor as hereinbefore mentioned may include oxides or acids of metals of group VI*a* of the periodic table. I prefer to use finely ground tungstic oxide (WO_3) or tungstic acid, (H_2WO_4) which, when added to the resistor mixture compensates for the negative temperature coefficient inherent in the carbon. The other group VI oxides, although they also compensate for a negative coefficient, are less desirable because of their oxidizing effect.

The proportions of the above-mentioned components in the resistor mix before curing may vary, but the following range is preferred:

	Percent
Resin	45–95
Carbon black	2–30
Tungsten oxide or acid	1–40
Plasticizer or solvent	0–80

After the materials are combined, the mix is cured at elevated temperatures. The cured mix, as a resistor composition, has been found not to vary more than ±3% over a range of temperature of 150° C., i.e., from —50° C. to 100° C. Apparently this increased stability is due to a change in the chemical nature of the resin as related to the carbon in the final composition, as the resulting low temperature coefficient is a synergistic effect and not a result that would ordinarily be expected from the addition of a group VI metal oxide or acid to the resistor mix.

Specific example

Eighty parts of Durez 13823 (trademark for phenol-formaldehyde resin) were mixed with twenty parts of butyl Cellosolve. To half of this mixture was added 14 parts of tungstite. The tungstite and the resin were ball milled together for 14 days. At the same time the remainder of the resin was ball milled with about 9 parts of halo carbon black which had been calcined at 2000° F. for 6 hours. These two mixtures were then mixed together and ball milled together for 72 hours under vacuum. During all of the mixing operations the temperature was kept below 80° F. The mix was then cured

at about 350° F. and the resulting composition, when made into a resistor, exhibited the characteristics illustrated in the drawing. It will be apparent from the drawing that adding the tungstite to the resistor mixture greatly compensates for the negative temperature coefficient present in a resistor made from the same materials but without the addition of tungstite.

In the foregoing I have described my invention in connection with a specific embodiment thereof. Since many variations and modifications of the invention will now be obvious to those skilled in the art, I prefer to be bound not by the specific disclosures herein contained but only by the appended claims.

I claim:

1. A resistor composition consisting essentially of 45–95% of a thermosetting resin, 2–30% carbon black, 1–40% of a compound from the group consisting of tungstic oxide and tungstic acid and plasticizer in an amount up to 80%.

2. A temperature compensating resistor consisting essentially of 45–95% of a thermosetting resin, 2–30% carbon black, and 1–40% of a compound from the group consisting of tungstic oxide and tungstic acid.

3. A temperature compensating resistor consisting essentially of 80 parts phenol-formaldehyde resin, 14 parts tungstic acid, and 9 parts carbon black.

4. A temperature compensating resistor consisting essentially of 45–95% of a plasticized thermosetting resin from the group consisting of phenol-formaldehydre, urea formaldehyde, and melamine formaldehyde, 2–30% carbon black, and 10–20% tungstic acid.

5. A temperature compensating resistor consisting essentially of 45–95% of a plasticized thermosetting resin from the group consisting of phenol-formaldehyde, urea formaldehyde, and melamine formaldehyde, 2–30% carbon black, and 10–20% tungstic oxide.

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