Jan. 23, 1968 C. C. SARTAIN 3,365,692

VARIABLE RESISTOR AND ELEMENT

Filed March 10, 1966

FIG. 1.

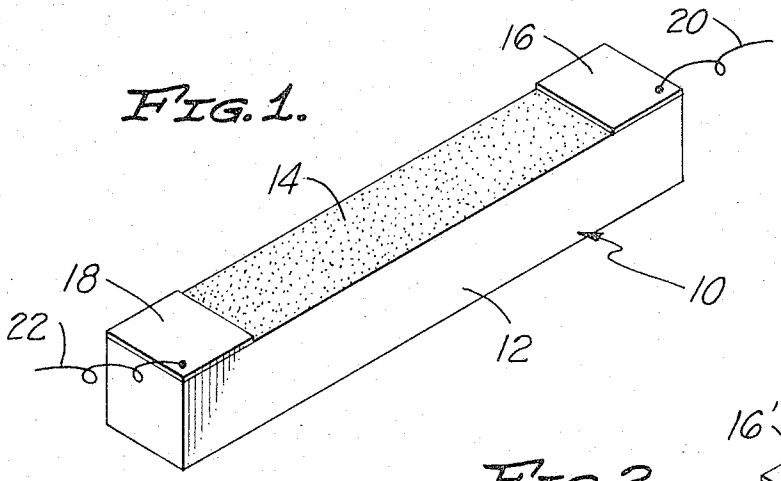


FIG. 2.

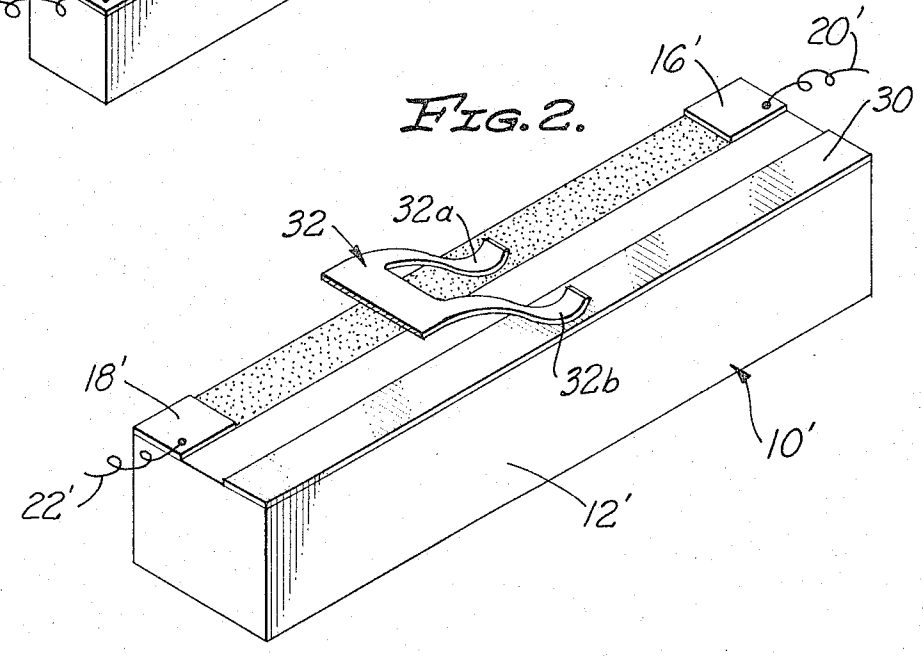
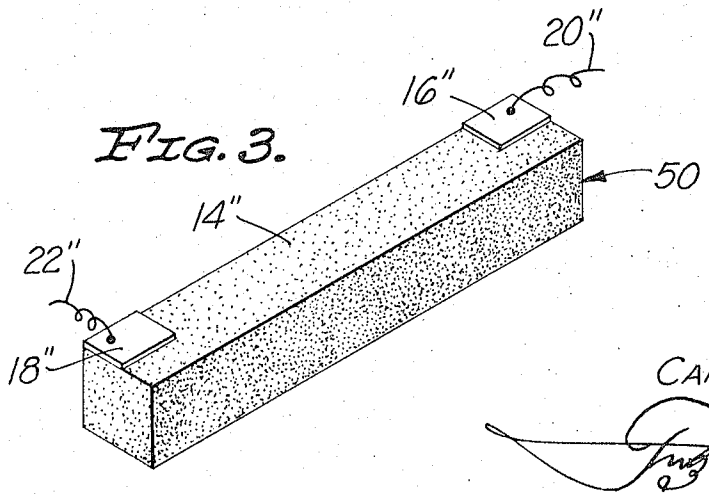


FIG. 3.



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VARIABLE RESISTOR AND ELEMENT

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The invention herein disclosed pertains to variable electrical resistors such as potentiometers, in which the electrical resistance between two terminals may be varied by positional adjustment of a movable contact; and more specifically the invention pertains to improvements in resistance elements for use in such resistors.

Resistance elements as presently made for potentiometers and like variable resistors may be classified in accord with general types of structure, e.g., wirewound, carbon or similar composition, deposited film, etc. Present tendency is to manufacture acceptable resistance elements as small as is feasible, whereby mass and volume of instrumentation may be minimized. Thus as the dimensions of resistance elements are decreased, a limit is reached at which wirewound elements of acceptable total resistance value (TR), temperature coefficient of resistivity (Tc), manufacturing cost, resolution, etc., cannot longer be made. Thus resort is had to solid resistive elements in the form of composition blocks, and to film elements, whereby inherent improvement in resolution, satisfactorily low unit cost of manufacture, and small dimensional size are attained. However, difficulties are encountered in efforts to produce elements of the latter type which are resistant to the wearing or abrading action of the brush or wiper, which have an acceptably low Tc, and which can be readily formed or produced so as to provide elements of the same mechanical characteristics over a wide range of resistance values. Especially is it difficult to produce an acceptable high-temperature resistance element in the resistance-value range from 100 ohms to 2000 ohms.

By the present invention there is provided a resistive material, whereby all of the noted difficulties are obviated, and whereby at low unit cost eminently acceptable resistance elements of divers forms and shapes may be made and which elements are characterized by extremely low Tc and exceptional wear resistance or hardness and which may be of any desired TR within a very wide range of TR values.

Briefly, according to the invention, a resistive material of the character of a semimetallic alloy is provided, which semimetal or alloy has the desired characteristics in respect of resistivity, Tc, hardness (wear resistance), which can be formed into desired shapes, and which may be deposited in thin-film form on a substrate by vacuum evaporation or like operations such as sputtering. The invention will be more fully explained with reference to a presently-preferred exemplary physical embodiment thereof as illustrated in the accompanying drawing forming part of this specification.

The preceding brief general description of the invention makes it evident that it is a principal object of the invention to provide improvements in resistive material for resistance elements.

Another object of the invention is to provide a resistive material having an extremely low temperature coefficient of resistivity.

Another object of the invention is to provide a resistance element presenting a very hard wear-resistant surface and which is characterized by a very low temperature coefficient of resistivity.

Another object of the invention is to provide a resistive material for resistance elements, which material is of higher resistivity than that of commonly-used metals employed in resistance elements, and which material is adaptable to being provided in various physical forms.

Other objects and advantages of the invention are stated or made evident hereinafter in the appended claims and following description of a principal presently-preferred exemplary physical embodiment and modified forms thereof as illustrated in the accompanying drawings.

In the drawings the FIGURE 1 is a pictorial representation, to grossly enlarged scale, of a resistance element adapted for use in a potentiometer, which element comprises a film or surface of resistive material according to the invention;

FIGURE 2 is a view similar to FIGURE 1 but showing a modified form of resistance element device and associated contact; and

FIGURE 3 is a pictorial view of a more elementary form of resistance element according to the invention.

Referring to FIGURE 1, the preferred exemplary resistance element is denoted generally by number **10**. It comprises a base or substrate **12** in the form of a small elongate block-like mass of glass, an adherent thin-film or deposit of semimetal **14**, first and second adherent conductive members **16** and **18** in the form of metallic films, and terminal devices **20** and **22** in the form of conductors conductively bonded to respective ones of metallic films **16** and **18**. While substrate **12** is here chosen as glass because desirable characteristics such as smoothness of surface, low temperature coefficient of expansion and high electrical insulation value are possessed by that material, other suitable insulative substrate materials may be used. Similarly, while for convenience the element terminations are illustrated as metallic fims **16** and **18** with respective bonded conductors **20** and **21**, other suitable terminal means may be used. Further, in certain cases the substrate may be dispensed with and the structure formed principally as a block or the like of the semimetal **14**. As is then evident, the shape or areal configuration of the substrate and/or the exposed surface of semimetal **14** may be of other than rectangular as shown.

Semimetal **14** is a homogeneous mass of the character of an alloy composed of iron, cobalt and silicon in proportions according to the formula $Fe_x Co_{1-x}Si$ wherein x is of numerical value at or between 0.07 and 0.09. The semimetal is of homogeneous character, presenting a very hard, wear-resistant, surface, and is characterized by a very low Tc in the temperature range fom −65° C. to +175° C. Since the three components all "evaporate" or sublimate in a vacuum within a small temperature range, the material is well adapted for forming vacuum-deposited resistive films. In exemplary practice, the noted proportions of the components, all in finely divided form, are thoroughly mixed and placed on a tungsten heating element in a vacuum chamber, the chamber evacuated, the substrate heated, e.g. to 350° C., and the material evaporated to the extent necessary to produce a film of the desired TR value. Following cooling, metal termination films may be applied, and other conductors added. The resistive film presents a surface that is optically smooth as well as very hard, which makes it very desirable from the standpoint of resolution. Thus, in general, the smoother the substrate surface, the smoother will be the surface of a deposited film of the semimetal material.

It has been found that in certain instances, apparently because of the exceptional hardness of the film, electrical noisiness in a variable resistor or potentiometer comprising an element of the resistive material may be reduced by applying a film of the material to the movable contact as well. This is especially true in those instances in which the movable contact is made of a much softer alloy or metal. Thus, in the exemplary arrange-

ment illustrated in FIGURE 2, an element 10' comprising an insulative substrate 12' bearing an elongate resistive stripe or deposit 14' of the aforedescribed semimetal material terminated by metal-film and conductor termination devices 16', 18', 20' and 22' has thereon an elongate conductor 30 formed as a conductive deposit or strip and which serves as a return or collector. The arrangement includes in cooperative electrical contact with material 14' and with collector 30, a metallic contact 32 which is movable longitudinally along the contacted portions of element 10'. Contact 32 may be of various shapes and configurations such as those of contacts used in leadscrew-adjusted potentiometers, but differs therefrom in having at least those surface areas which brush on semimetal deposit 14' made of, or covered with a film of, the same semimetal material. The semimetal material 14' is of composition previously described in respect of semimetal 14; that is, of composition conforming to the formula $Fe_xCo_{1-x}Si$ wherein x is of value in the range 0.07–0.09. The structure used for moving contact 32 relative to material 14' is not per se of the present invention and hence is neither herein shown nor described, since it may be of any of many forms well known in the prior art.

As is evident, a resistance element according to the invention need not comprise a substrate, and may be a solid unitary block of the semimetal conforming to the previously stated formula. Thus, in FIGURE 3 there is illustrated such a resistance element, denoted generally by the number 50, the element comprising a block-like mass of semimetal 14'' and having applied metallic terminal means 16'', 18'', 20'' and 22'' of the character of those previously mentioned in connection with FIGURES 1 and 2. As is evident, the mass may be formed in accord with known methods of forming and shaping alloys and like compositions, and hence may be of any desirable shape. Also, the terminals may be applied to ends of the mass rather than as shown.

In the light of the preceding disclosure, changes within the true spirit and scope of the invention will occur to those skilled in the art, and hence it is not desired to restrict the invention except as required by the appended claims.

I claim:

1. A resistance element for use in variable resistors such as potentiometers, said element comprising a mass of stable shape and a surface composed of homogeneous material conforming to the formula $Fe_xCo_{1-x}Si$, wherein

Fe, Co and Si represent iron, cobalt and silicon, respectively, and wherein x is a numerical value within the range 0.07 to 0.09.

2. A resistance element according to claim 1, said element comprising an electrically nonconductive block-like base bearing said surface composed of homogeneous material thereon.

3. A resistance element according to claim 1, said element including conductors bonded to portions of said surface composed of homogeneous material, whereby to provide electrical connections thereto.

4. A resistance element according to claim 1, in which said stable mass is of the same composition as said surface composed of homogeneous material.

5. A resistance element according to claim 4, including separated conductive means each bonded to a respective different portion of said mass to provide electrical terminals for said element.

6. A variable resistor arrangement comprising:

first means, including means presenting a stable surface composed of homogeneous material conforming to the formula $Fe_xCo_{1-x}Si$, wherein Fe, Co and Si represent iron, cobalt and silicon, respectively, and wherein x is a numerical value within the range 0.07 to 0.09; and

second means, including conductive contact means arranged to brush said stable surface, said contact means comprising over the area thereof in contact with said stable surface, at least a brushing surface composed of said material conforming to the formula $Fe_xCo_{1-x}Si$.

7. A variable resistor arrangement according to claim 6, in which said stable surface composed of homogeneous material conforming to the formula $Fe_xCo_{1-x}Si$ is supported by an electrically nonconductive base.

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