

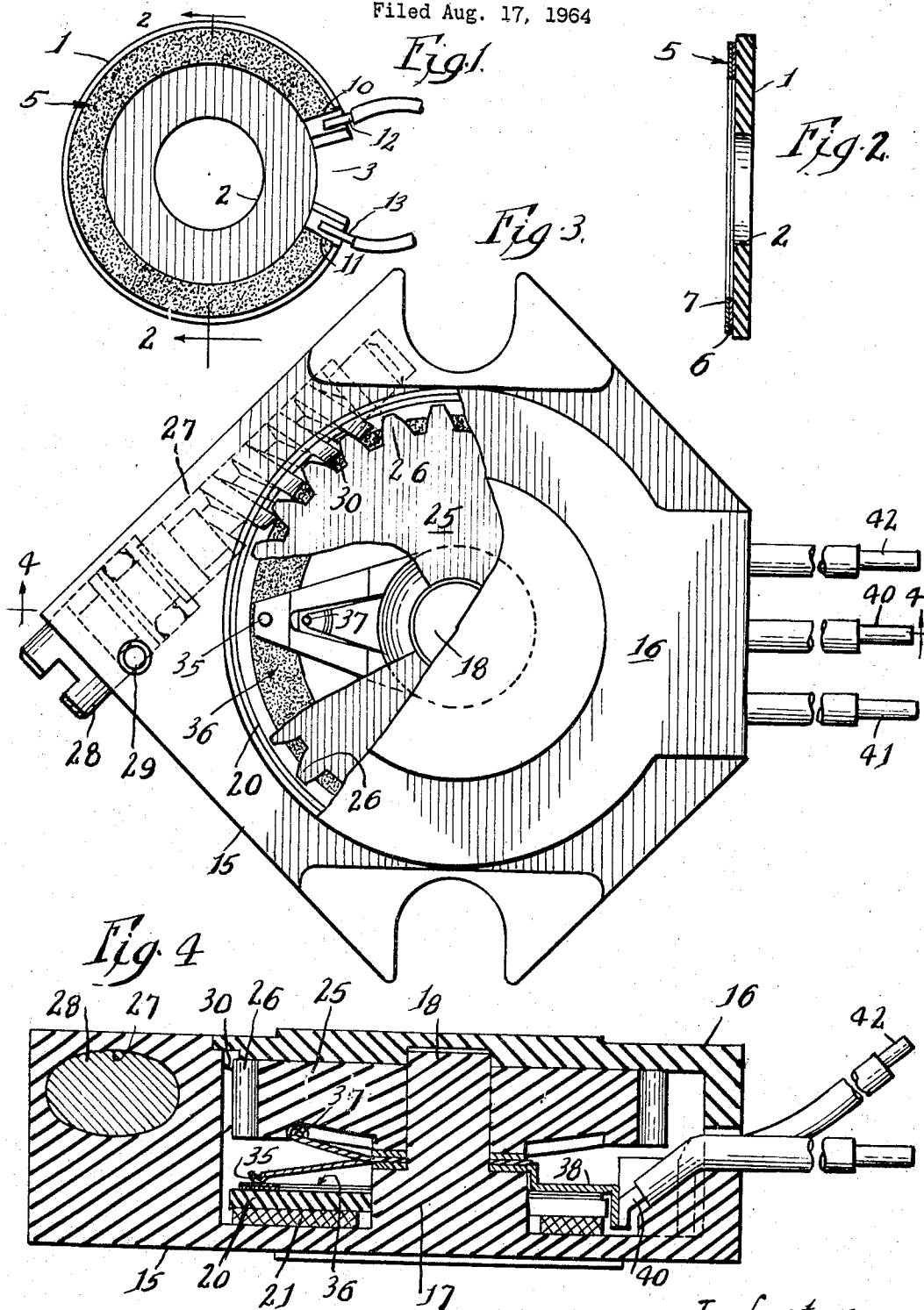
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RESISTIVE ELEMENT AND VARIABLE RESISTOR

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RESISTIVE ELEMENT AND VARIABLE RESISTOR
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ABSTRACT OF THE DISCLOSURE

A resistive element has a circular base of insulating material provided with a central opening and a recess in the periphery. Adjacent the periphery the base has a thin resistance coating of a nickel-chromium-iron alloy ranging in composition by weight from 20–65 percent nickel, 15–75 percent chromium and the remainder iron, such as 5–25 percent. Overlying the resistance coating is a thin film coating of a noble metal which may be platinum, rhodium, or iridium. A variable resistor of the trimmer type embodies the aforesaid resistive element within a suitable housing and employs a movable contact element of gold-palladium alloy consisting of about 10 percent gold and 35 percent palladium, the remainder including silver, copper and platinum. A contact of carbon or carbon resin also is contemplated.

The invention relates to a resistive element, and more particularly to a resistive element suitable for use in a variable resistor, and to a variable resistor using the resistive element.

Heretofore variable resistors such as trimmers, for example, have used as resistive elements a nickel-chromium-iron alloy coated on a base of insulating material. The nickel-chromium-iron alloy is subject to oxidation, however, giving an objectionable noise characteristic. Attempts have been made to minimize noise by using platinum instead of the nickel-chromium-iron alloy, but this resulted in poor electrical properties. Also, certain cermets have been tried, yielding non-uniform and poor results compared to the nickel-chromium-iron coating. Thus, variable resistors, particularly trimmers, designed for 500 to 20,000 ohms have continued to use the nickel-chromium-iron alloy coating despite objectionable noise.

An object of this invention is to provide a resistive element which eliminates the noise encountered with the conventional nickel-chromium-iron alloy coating while retaining the good electrical characteristics of this alloy.

Another object is to provide a variable resistor including the resistive element of the invention and a movable contact element that cooperate to minimize objectionable noise.

Other objects, advantages and details of the invention will be apparent as the description proceeds, reference being had to the accompanying drawing wherein resistance devices embodying the invention are shown. It will be understood that the description and drawing are illustrative only, and that the scope of the invention is to be measured by the appended claims.

In the drawing:

FIG. 1 is a plan view of a resistive element embodying the invention.

FIG. 2 is a sectional view on line 2—2 of FIG. 1, the thickness of the coating portions exaggerated for clarity.

FIG. 3 is an enlarged plan view, partly broken away, of an exemplary variable resistor embodying the invention.

FIG. 4 is a sectional view on line 4—4 of FIG. 3.

Referring to FIGS. 1 and 2 of the drawing, a typical

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resistive element embodying the invention includes a base 1 of insulating material. As shown, base 1 is a thin circular disk having a central opening 2 and a recess 3 in the periphery (FIG. 1).

Base 1 has a double coating 5 on one surface adjacent the periphery, coating 5 consisting of a nickel-chromium-iron alloy coating 6 (FIG. 2) and an overlying thin film coating 7 of a noble metal which may be platinum, rhodium, or iridium.

As shown in FIG. 1, double coating 5 extends to recess 3, and the coating ends are provided with metallic terminals 10 and 11 to which are connected conductors 12 and 13. In certain applications conductors 12 and 13 are of gold.

The resistive element of FIGS. 1 and 2 is shown embodied in a variable resistor of the trimmer type in FIGS. 3 and 4. Briefly, the illustrated variable resistor includes a case 15 and an associated closure 16 made of suitable plastic insulating material such as diallyl phthalate.

Case 15 has a hollow interior, and includes a central boss 17 having a reduced end portion 18 extending upwardly from the case bottom. A resistive element 20 of the type described above surrounds boss 17 and rests on a spacer 21 (FIG. 4). Element 20 is fixed against rotation.

A circular gear 25 of insulating material having teeth 26 is mounted on reduced end portion 18 of boss 17, as best shown in FIG. 4. One edge portion of base 15 has a bore 27 that receives a screw 28 which is free to rotate within the bore. A pin 29 in case 15 engages screw 28 and restrains same against axial movement.

Threads 30 of screw 28 engage teeth 26 of gear 25. Thus, gear 25 rotates in response to adjustment of screw 28.

A movable contact element 35 engages double coating 36 of resistive element 20, the element 35 having a portion 37 that engages gear 25 and rotates therewith. A terminal 38 (FIG. 4) associated with contact element 35 is connected to conductor 40. Conductors 41 and 42 are connected to the ends of double coating 36 as previously described with reference to the resistive element shown in FIGS. 1 and 2.

The compositions of the insulation material of base 1, the resistive coatings and the movable contact element 35 that characterize the invention now will be described.

Base 1 may be any suitable insulating material, such as phenolic resins, epoxy resins and other insulating plastics, but preferably is a ceramic such as steatite, alumina, berylia, glass, quartz and the like. Ordinary soda glass preferably should be coated first with silicon dioxide, but borosilicate glass and other high temperature insulating glass are highly satisfactory without the silicon dioxide coating. Steatite and alumina are satisfactory and economical ceramic bases.

The effective surface of insulating base 1 should be smooth so as to support and retain the thin double coating 5 without producing irregularities.

The nickel-chromium-iron alloy for base coating 6 may range in composition by weight from 26–65 percent nickel, 15–75 percent chromium and the remainder iron, such as 5–25 percent. Examples of suitable alloys in percent by weight are 36 Ni—48 Cr—16 Fe; 30 Ni—63 Cr—7 Fe; 20 Ni—75 Cr—5 Fe; and 60 Ni—16 Cr—24 Fe. An alloy coating which has given particularly satisfactory results is 36 percent nickel, 48 percent chromium and 16 percent iron for resistive elements of 20,000 ohms. For elements of 500 ohms a highly satisfactory alloy is 20 percent nickel, 75 percent chromium and 5 percent iron.

The nickel-chromium-iron alloy coating 6 may vary from one having a resistance of 500 ohms to 20,000 ohms with an actual thickness of 2,000 to 100 Angstrom units

(7.9×10^{-6} inches to 0.4×10^{-6} inches), which also may be expressed as 21.7 ohms per square to 870 ohms per square.

Noble metal coating 7 may be platinum, rhodium, or iridium. The thickness of this coating is that of a thin film of less than 100 Angstrom units, the thickness being such that the coating has a resistance density of between 8,000 to 13,000 ohms per square. I have discovered that these metals in such thickness act as lubricants and allow the variable resistor to act without noise and with the good electrical properties of the nickel-chromium-iron coating beneath them. The noble metal coating wears off only very slowly when engaged by contact element 35. This is particularly so when contact element 35 is a gold-palladium alloy consisting essentially of no less than 10 percent gold and no less than 10 percent palladium, preferably about 10 percent gold and 35 percent palladium, the remainder including silver, copper and platinum. A carbon contact and also a carbon-tetrafluoroethylene resin contact also have been found highly satisfactory.

The nickel-chromium-iron coating 6 and also the noble metal coating 7 are preferably applied by the well known vacuum deposition technique. Terminals 10 and 11 also may be a nickel-chromium vacuum deposition. Conductors 12 and 13 may be welded or otherwise secured thereto in conventional manner.

The resistive element of the invention may be used as a fixed resistor, but is particularly useful combined with a movable contact element to produce a variable resistor of the type shown in FIGS. 3 and 4. Such variable resistors serve as trimmers in miniaturized test equipment, computers and the like. They have an extremely low temperature coefficient (order of 50 p.p.m./° C. in the range -60° C. to $+175^{\circ}$ C.) and a substantially zero noise level at trimmed position. Even during adjustment the noise level is negligible in most applications.

From the above description it is thought that the construction and advantages of this invention will be readily apparent to those skilled in the art. Various changes in detail may be made without departing from the spirit or losing the advantages of the invention.

Having thus described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. A resistive element comprising an insulating base coated with an electrical resistance alloy consisting essentially of 20 to 65 percent nickel, 15 to 75 percent chromium and the remainder iron, having a film coating thereon of a noble metal selected from the group consisting of platinum, rhodium, and iridium, said nickel-chromium-iron coating having a thickness of between 100 and 2,000 Angstrom units, and said film coating having a thickness such that the resistance density thereof is between 8,000 and 13,000 ohms per square.

2. A resistive element comprising an insulating base coated with an electrical resistance alloy consisting essentially of 20 to 65 percent nickel, 15 to 75 percent chro-

mium and the remainder iron, having a film coating thereon of a platinum metal, said film coating of platinum having a thickness of less than 100 Angstrom units.

3. A resistive element comprising an insulating base coated with an electrical resistance alloy consisting essentially of 20 to 65 percent nickel, 15 to 75 percent chromium and the remainder iron, having a film coating thereon of a platinum metal, said nickel-chromium-iron coating having a thickness of between 100 and 2,000 Angstrom units and said platinum film coating having a thickness such that the resistance density thereof is between 8,000 and 13,000 ohms per square.

4. A resistive element comprising a steatite ceramic base coated with an alloy consisting essentially of approximately 20 to 65 percent nickel, 15 to 75 percent chromium, and the remainder iron, having a film coating of platinum on said nickel-chromium-iron coating, the thickness of said platinum coating being less than 100 Angstrom units and the thickness of the nickel-chromium-iron coating being between 100 and 2,000 Angstrom units.

5. In a variable resistor having a resistive element and a movable contact element engaging the surface of the resistive element, the improvement wherein the surface of the resistive element for engagement with said contact element is a film of a noble metal selected from the group consisting of platinum, rhodium, and iridium coated on a layer of an electrical resistance alloy consisting essentially of nickel, chromium and iron, said film coating being coextensive with said resistance alloy, and wherein the contact element consists essentially of a gold-palladium alloy.

6. In a variable resistor having a resistive element and a movable contact element engaging the surface of the resistive element, the improvement wherein the surface of the resistive element for engagement with said contact element is a film of a noble metal selected from the group consisting of platinum, rhodium, and iridium coated on a layer of an electrical resistance alloy consisting essentially of nickel, chromium and iron, said film coating being coextensive with said resistance alloy, and wherein the contact element consists essentially of carbon.

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