May 29, 1956 W. W. H. CLARKE ET AL 2,748,234

ELECTRIC RESISTORS

Filed Oct. 12, 1953

FIG. 1.

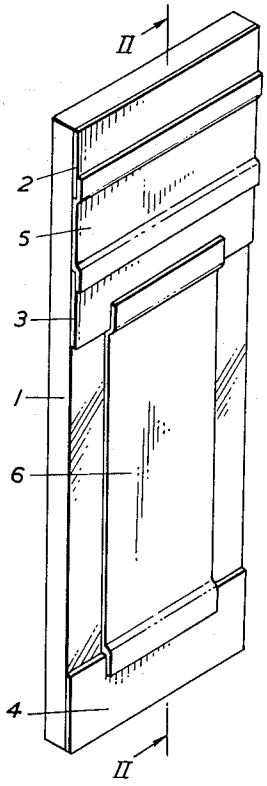
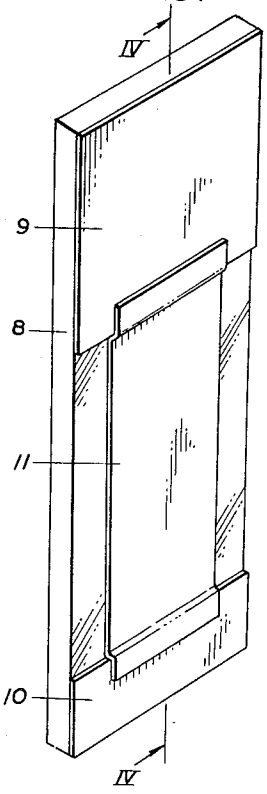


FIG. 3.



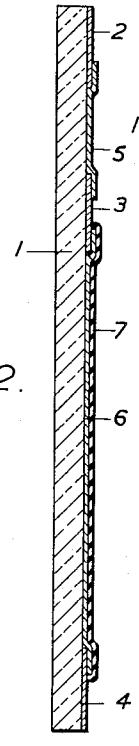


FIG. 2.

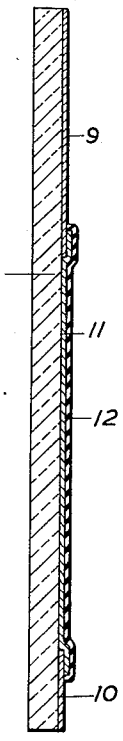


FIG. 4.

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ELECTRIC RESISTORS

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11 Claims. (Cl. 201—73)

This invention relates to resistors of the kind made by depositing on an insulating support, for instance a strip of glass, a thin metallic layer and covering it completely with a protective layer of insulating material, for instance magnesium fluoride. This type of resistor can be given very stable characteristics since the metallic deposit is protected against oxidation and corrosion by the covering layer so that the choice of metal for the layer is independent of the inherent chemical stability thereof. The metal can, accordingly be chosen to have desired properties, for instance to have a very small temperature coefficient of resistance. This characteristic is found in alloys of nickel and chromium, such as are known under the registered trade mark "Nichrome."

The deposits of metal and covering layer are made by evaporation by heat in a vacuum, the two deposits being applied in succession to the support without exposure of the first layer to the atmosphere before the covering layer has been deposited.

It is, however, difficult to make such a resistor suitable for use where a precise value of resistance between the terminals is required, since no adjustment can be made to the value of the resistance after its deposition and the dimensions of the metallic deposit cannot be controlled with precision. The present invention provides a modified form of such a resistor in which, with very little loss of stability, a precise value of resistance can be secured.

In producing the improved resistor there are combined between the terminals on one support a main resistance element of the kind described above and an auxiliary resistance element much smaller in value than the main element and consisting of a conductive layer of good stability when in contact with the atmosphere, the two being permanently connected electrically and the latter being adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of the deposit.

The invention will now be illustrated with reference to the accompanying diagrammatic drawing wherein:

Figure 1 shows a perspective view of an example of one form of resistor in process of manufacture,

Figure 2 shows a longitudinal section of the completed resistor on line II—II of Figure 1,

Figure 3 shows a perspective view of an alternative form of resistor in process of manufacture and

Figure 4 shows a longitudinal section of the completed resistor on line IV—IV of Figure 2.

In the drawing the thickness of the metal and insulating layers has been exaggerated for convenience of illustration.

Referring to Figures 1 and 2, the insulating support 1 is a strip of glass provided with three conductive terminal layers 2, 3 and 4 spaced apart in the length of support. These may be layers of silver applied by means of one of the silvering liquids used in the ceramic industry which is painted on the support and fired. Between the end terminal 2 and the intermediate terminal 3 is applied a layer 5 of a noble metal, for instance an alloy of gold and platinum, which overlaps the terminals 2 and 3. This layer of noble metal may be formed, for instance, by painting on a suspension of the metal or metals and firing. Between the other end terminal 4 and the intermediate terminal 3 is applied the main resistive layer 6 (for instance of Nichrome) which is covered with a protective layer, for example of magnesium fluoride 7. The main resistive layer and protective layer are preferably applied by vapour deposition, the auxiliary resistance 5 being shielded from the successive vapour streams by a screen close to the glass strip but preferably not touching it.

Figure 4 illustrates a modified form of construction in which two of the terminals and the auxiliary resistance between them are formed by a single deposit of noble metal. In this example the glass strip 8 supports a layer 9 of noble metal and, spaced apart from this layer, a conductive terminal layer 10. The main resistive layer 11 overlaps layers 9 and 10; it is covered with a protective layer 12.

The auxiliary resistor will, in most cases, be of shorter length than the main resistor and will in all cases provide a minor part of the resistance, for instance 5% or less. For example in one resistor the value of the main resistance element was 65 ohms and the value of the auxiliary resistance element before adjustment was 1 ohm. Since the auxiliary layer is not covered by a protective layer it may be adjusted in the upward direction of value by removing part of the metallic deposit. This adjustment can be carried out with great precision.

The auxiliary resistor although not so stable, either in time or temperature, as the main resistor, is of good stability and, since it forms only a small part of the whole, its variations will have only a very small proportionate effect on the total value of the main and auxiliary resistances arranged in series between the two outer terminals.

The insulating support need not necessarily be in strip form, other shapes are equally suitable. For example satisfactory resistors have been made using tubular glass formers.

What we claim as our invention is:

1. A resistor comprising an insulating support, a terminal carried by said support, a main resistance element, consisting of a thin layer of metal liable to be corroded or oxidized by the atmosphere carried by said support, electrically connected at one end to said terminal, a protective layer of insulating material applied to said layer of metal before it has been exposed to the atmosphere, and an auxiliary resistance element consisting of a layer of second metal of better stability when in contact with the atmosphere than the metal of the main resistance element, and adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said second metal, carried by said support and electrically connected to the end of said main resistance element opposite to that connected to said terminal.

2. A resistor comprising an insulating support, two terminals carried by said support, a main resistance element, consisting of a thin layer of metal liable to be corroded or oxidized by the atmosphere carried by said support, electrically connected to one of said terminals, a protective layer of insulating material applied to said layer of metal before it has been exposed to the atmosphere, and an auxiliary resistance element, consisting of a layer of a second metal, of better stability when in contact with the atmosphere than the metal of the main resistance element, and adapted for fine and accurate adjustment in value by the removal of an appro-

priate quantity of said second-metal, carried by said support and electrically connected in series between said main resistance element and the other of said terminals.

3. A resistor comprising an insulating support, two terminals carried by said support, a main resistance element, consisting of a thin layer liable to be corroded or oxidized by the atmosphere of high resistance nickel alloy having a small temperature coefficient of resistance carried by said support, electrically connected to one of said terminals, a protective layer of insulating material applied to said layer of nickel alloy before it has been exposed to the atmosphere and an auxiliary resistance element, consisting of a layer of noble metal and adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said noble metal, carried by said support and electrically connected in series between said main resistance element and the other of said terminals.

4. A resistor comprising an insulating support, a terminal carried by said support, a main resistance element, consisting of a thin layer liable to be corroded or oxidized by the atmosphere of a high resistance nickel alloy having a small temperature coefficient of resistance carried by said support, electrically connected at one end to said terminal, a protective layer of insulating material applied to said layer of nickel alloy before it has been exposed to the atmosphere and an auxiliary resistance element consisting of a layer of noble metal adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said noble metal, carried by said support, and electrically connected to the end of said main resistance element opposite to that connected to said terminal.

5. A resistor comprising an insulating support, a terminal carried by said support, a main resistance element, consisting of a vacuum-deposited layer of metal liable to be corroded or oxidized by the atmosphere carried by said support, electrically connected at one end to said terminal, a protective layer of insulating material applied by vacuum deposition to said layer of metal before it has been exposed to the atmosphere, and an auxiliary resistance element consisting of a layer of second metal of better stability when in contact with the atmosphere than the metal of the main resisance element, and adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said second metal, carried by said support and electrically connected to the end of said main resistance element opposite to that connected to said terminal.

6. A resistor comprising an insulating support, two terminals carried by said support, a main resistance element, consisting of a vacuum-deposited layer of metal liable to be corroded or oxidized by the atmosphere carried by said support, electrically connected to one of said terminals, a protective layer of insulating material applied by vacuum deposition to said layer of metal before it has been exposed to the atmosphere, and an auxiliary resistance element, consisting of a layer of a second metal, of better stability when in contact with the atmosphere than the metal of the main resistance element, and adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said second metal, carried by said support and electrically connected in series between said main resistance element and the other of said terminals.

7. A resistor comprising an insulating support, two terminals carried by said support, a main resistance element, consisting of a vacuum-deposited layer liable to be corroded or oxidized by the atmosphere, of high resistance nickel alloy having a small temperature coefficient of resistance carried by said support, electrically connected to one of said terminals, a protective layer of insulated material applied by vacuum deposition to said layer of nickel alloy before it has been exposed to the

atmosphere and an auxiliary resistance element, consisting of a layer of noble metal and adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said noble metal, carried by said support and electrically connected in series between said main resistance element and the other of said terminals.

8. A resistor comprising an insulating support, a terminal carried by said support, a main resistance element, consisting of a vacuum-deposited layer liable to be corroded or oxidized by the atmosphere of a high resistance nickel alloy having a small temperature coefficient of resistance carried by said support, electrically connected at one end to said terminal, a protective layer of insulating material applied by vacuum deposition to said layer of nickel alloy before it has been exposed to the atmosphere and an auxiliary resistance element consisting of a layer of noble metal adapted for fine and accurate adjustment in value by the removal of an appropriate quantity of said noble metal, carried by said support, and electrically connected to the end of said main resistance element opposite to that connected to said terminal.

9. A method of making a resistor which comprises providing on an insulating support three conductive terminal layers spaced apart in the length of support, applying by evaporation by heat in a vacuum between one of the end terminals and the intermediate terminal and overlapping these, a layer of metal liable to be oxidized or corroded by the atmosphere to form the main resistive element, without exposing said layer of metal to the atmosphere applying to it by evaporation by heat in a vacuum a protective layer of insulating material, applying between the other end terminal and the intermediate terminal and overlapping these a layer of a noble metal and adjusting the value of the resistor by the removal of an appropriate quantity of the noble metal.

10. A method of making a resistor which comprises applying to an insulating support a layer of noble metal and spaced apart from it a conductive terminal layer, applying by evaporation by heat in a vacuum between and overlapping these two layers a layer of metal liable to be oxidized or corroded by the atmosphere to form a main resistive element without exposing said layer of metal to the atmosphere applying to it by evaporation by heat in a vacuum a protective layer of insulating material, and adjusting the value of the resistor by the removal of an appropriate quantity of the noble metal.

11. A method of making a resistor which comprises forming three terminals spaced apart in the length of an insulating support by applying to the support three separate layers of silver paint and firing the layers to form conductive silver deposits, applying a layer of paint containing a noble metal on to the support and overlapping one of the end terminals and the intermediate terminal, firing the layer to form a conductive layer of noble metal, applying by evaporation by heat in a vacuum to the support between and overlapping the other end terminal and the intermediate terminal a layer of nickel alloy having a small temperature coefficient of resistance, applying to this layer by evaporation by heat in a vacuum before it has been exposed to the atmosphere a protective layer of insulating material and adjusting the value of the resistor by the removal of an appropriate quantity of the noble metal.

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