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ARRANGEMENT FOR AMPLIFYING ALTERNATING CURRENTS

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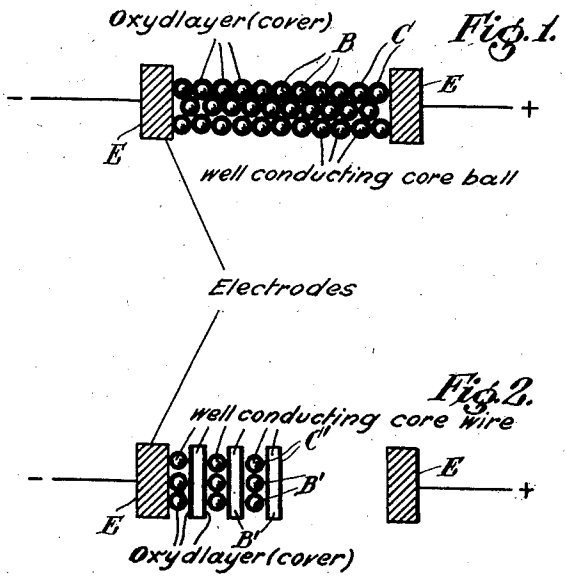


Fig. 1.

Fig. 2.

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ARRANGEMENT FOR AMPLIFYING ALTERNATING CURRENTS

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This invention relates to devices or systems for generating or amplifying alternating currents with the aid of so-called negative resistance elements, that is to say, elements the resistance of which to the passage of an electric current decreases as the intensity of such current increases. There have been used or proposed as such negative resistance elements, substances of certain characteristics (generally metal oxides) used either singly or as mixtures of two or more of them. These substances have been powdered and then compacted by pressure between two electrodes. Upon the passage of an electric current through such compacted or compressed substances by way of said electrodes, there is observed, during an increase of the current, first a rise and then a drop in the voltage. Such behavior of the voltage may be plotted as a characteristic curve having an ascending portion and a descending portion. In the region corresponding to the descending portion of this characteristic curve, such a negative resistance element is adapted, as is well-known, to produce and to amplify oscillations, in a manner similar to the action of an electric arc. The voltage drop in the descending portion of the characteristic curve is due to traces of gas (air) contained in the powder and charged negatively, such gas particles changing their relative position according to the strength of the current. The proper operation of such devices therefore requires that the oxide, for instance vanadium pentoxide (V_2O_5), should be able to absorb the air or other gas. The state of fine subdivision which is obtained by pulverizing the substance constituting the negative resistance element greatly intensifies the absorptive effect of the particular oxide employed. Furthermore, a large number of contact points between the numerous particles of the powder provides a large number of individual paths for the current, and thus insures a reliable operation generally not obtainable when a single contact is employed. To these advantages of the multiple contacts is opposed the disadvantage of a low frequency limit which is at about 3000 to 4000 cycles. Below this limit oscillations are produced with good efficiency, but no oscillations will occur above this limit. The reason for this phenomenon has been found in the fact that the heat generated by the electric current within the powder is not dissipated quickly enough. Therefore it is possible to raise the frequency limit by strongly cooling the powder from the outside, and particularly by strongly cooling the electrodes with the use of low outside temperatures and the employment of very thin powder layers, in order that the heat in the powder may be conveyed quickly to the cooled electrodes.

This invention relates to a novel way for internally cooling powder of the character referred to. This novel way can be used either as a substitute for the methods described above, or in conjunction therewith. According to the invention each particle of the powder or at least the majority of these particles contain a core of a material which is a good conductor of heat and electricity, that is, such material should be a better conductor of heat and electricity than the powder itself. In its simplest form, the core is a very small metal ball, for instance, a ball of platinum, the entire surface of which is covered by a thin and firmly adherent skin of the particular active oxide employed. The very small metal balls with the active skin are subjected to further treatment in the same manner as has been customary with the above described powder particles. If, for instance, the powder consists of a mixture of two metal oxides (for instance V_2O_5 and Mn_2O_3) in a certain quantitative relation, I would produce first small metal balls which have an active skin of the one metal oxide (for instance V_2O_5), and then in the same manner other small metal balls having an active skin of the other metal oxide (Mn_2O_3). Now, instead of using a mixture of the above described powder particles as has been done hitherto, I mix these two kinds of coated ball-particles in the same relative amounts which have been found suitable when using a mixture of powder particles. Therefore the electric effect is analogous to that observed with powder particles (without cores). But because the current passes from one ball to another only at the point of contact and this contact point is small in relation to the entire surface of the ball, the ball is able to absorb quickly the heat developed at the contact point, and also, on account of its relatively large surface, to radiate quickly the heat thus absorbed. The consequence of these two effects is the elimination of the harmful heat and a raising of the frequency limit far into the region of high frequency currents.

It is to be noted that the effect obtained according to my invention depends on the observance of the following conditions: First, the active skin on the core should not be too thick, in order that the absorptive power of the skin may become fully effective. It is well known that this power is strongest with skin layers of a thickness within the colloidal range. Sec-

ondly, the core should not be too small, in order that the heat may be radiated quickly enough. Cores having a diameter below 1/100 millimeter show hardly any improvement in heat-dissipating action. The larger the core, the better will be the heat-radiating effect. Large balls, however, make it difficult to obtain the desired large number of contact points, which requires a relatively large number of balls. A diameter about $\frac{1}{10}$ millimeter has been found to yield very good results.

As cores I employ substances of a conductivity for heat and electricity as high as possible. Metals are particularly suitable for this purpose. They also enable a very convenient method to be used for applying the desired layer of oxide when the oxide and the core contain the same metal. If, for instance, a layer of copper oxide is to be applied on a metal core, it is preferable to use pure copper metal for the core. In this case it will be sufficient to oxidize the surface of this copper core by any well known or approved galvanic or thermic treatment. Generally such oxide layers will adhere to the core very firmly.

Reference is to be had to the accompanying drawing, in which Figs. 1 and 2 illustrate two electrodes in section, with two forms of my improved negative resistance elements interposed between the electrodes and compressed to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said elements.

The electrodes are designated by E, while B (Fig. 1) are the balls made of a material which is a better conductor of heat and electricity than the skin or coating C, here indicated as oxide layers.

Sometimes it is desirable that the layer or skin on a metal core should not consist of one oxide only but of one definite mixture of two or more oxides, for instance zinc oxide and copper oxide. In this event I should use as a core the proper alloy of the metals employed (in this case zinc and copper) in the same relative amounts as intended for the oxides and oxidize the alloy (brass) superficially. As such cores, I could use brass balls of a type readily obtainable on the market, where they are sold for soldering purposes.

As another instance of my invention, I will describe the use of cores of precious metals with a skin or cover of V_2O_5 or ZnO. Cold platinum wire of a diameter of $\frac{1}{10}$ millimeter is drawn through molten (liquid) V_2O_5. According to the velocity with which platinum wire is passed through such molten bath a more or less thin layer of V_2O_5 will adhere to the wire. Instead of this, platinum wire may be sprayed with liquid V_2O_5. It is also possible to pass the platinum wire through a concentrated aqueous solution of NH_4VO_3, subsequently allowing the solution to evaporate and decomposing the NH_4VO_3 by cautious heating. Or it is also possible to draw the platinum wire through the solution while passing an electric current therethrough, the wire serving as an anode. In this case, the current decomposes NH_4VO_3 electrolytically, oxygen and V_2O_5 being separated at the anode. In similar manner zincates may be used to produce a cover of zinc oxide on an anode of platinum wire. Furthermore, if cold platinum wire is led over strongly heated zinc oxide, the subliming zinc will become deposited on this wire and form a cover adhering thereto. Finally, a wire of precious metal, such as platinum, can readily be coated with the oxide of another metal in exactly predetermined quantity by first depositing the other metal in pure form on the platinum wire, for instance galvanically, and subsequently oxidizing the metal thus deposited, in which case the chemical inertness of the precious metal to oxidizing agents is a special advantage.

Wires thus prepared are then cut into suitable short pieces. Such wires, as shown in Fig. 2, constitute cores B' each covered largely with an active oxide layer C'. The wires, however, may be cut into longer pieces if desired. As long as the wires are disposed in layers or arranged to that the current passes through them transversely to their length, it is possible to produce a large number of contacts within a relatively small space. The cooling and therewith the raising of the frequency limit can be further increased with such an arrangement if the laterally projecting ends of the wires are made to dip into a cooling liquid which, of course, should be an electrical insulator. The preferred way of arranging the wires in layers is to cross them in alternate layers (Fig. 2), all the crossing points of the same layer being superposed. The current will then pass exclusively through the crossing points. Such an arrangement has the advantage of offering to the electrical current very little possibility of passing through by capacitance. Even with resistances consisting of powder alone the passage of the current by capacitance between the particles of powder constitutes a kind of short circuit for high frequency oscillations. Consequently it has been the practice, when employing resistances consisting of powder alone, to make them of as small a cross section as possible and in this manner reduce the posibility of the current passing through by capacitance. The same process may be used to advantage with particles containing a core according to this invention, and, in case of wires, preferably in the arrangement of alternate layers disposed crosswise of each other as described.

I claim:

1. A negative resistance element comprising a plurality of cores made of a material which is a good conductor of heat and electricity, and covers adhering to said cores, such covers being of a material which has a negative resistance and conducts heat and electricity, but not so well as said cores, the particles of said element being under compression to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

2. A negative resistance element comprising a plurality of cores made of a material which is a good conductor of heat and electricity, and covers adhering to said cores, such covers being of a material which has a negative resistance and conducts heat and electricity, but not so well as said cores, and electrodes between which the particles of said element are compressed to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

3. A negative resistance element comprising a plurality of metal cores and covers adhering to said cores and consisting of oxidized material which has a negative resistance and conducts heat and electricity, but not so well as said metal cores, the particles of said element being under

compression to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

4. A negative resistance element comprising a plurality of cores having a diameter of the order of about 1/10 millimeter and made of a material which is a good conductor of heat and electricity, and covers adhering to said cores, such covers being of a material which has a negative resistance and conducts heat and electricity, but not so well as said cores, the particles of said element being under compression to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

5. A negative resistance element comprising a plurality of metal balls covered with superficial oxide layers which have a negative resistance and conduct heat and electricity, but not so well as said metal balls, the particles of said element being under compression to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

6. A negative resistance element comprising a plurality of wires made of a material which is a good conductor of heat and electricity, and covers adhering to said wires, such covers being of a material which has a negative resistance and conducts heat and electricity, but not so well as said wires, and electrodes between which the particles of said element are compressed to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

7. A negative resistance element comprising a plurality of wires sundry of which are arranged crosswise of the others, said wires being good conductors of heat and electricity, and covers adhering to said wires, such covers being of a material which has a negative resistance and conducts heat and electricity, but not so well as said wires, and electrodes between which the particles of said element are compressed to such an extent that a decreasing volt-ampere characteristic will result upon the increase of a current passing through said element.

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