Jan. 7, 1936. E. HABANN 2,027,277

CONTACT DEVICE

Filed Aug. 27, 1930

Fig. 1

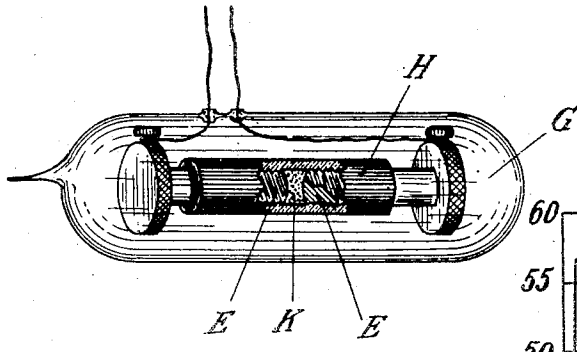


Fig. 2

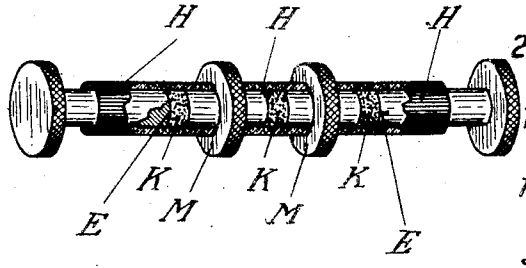
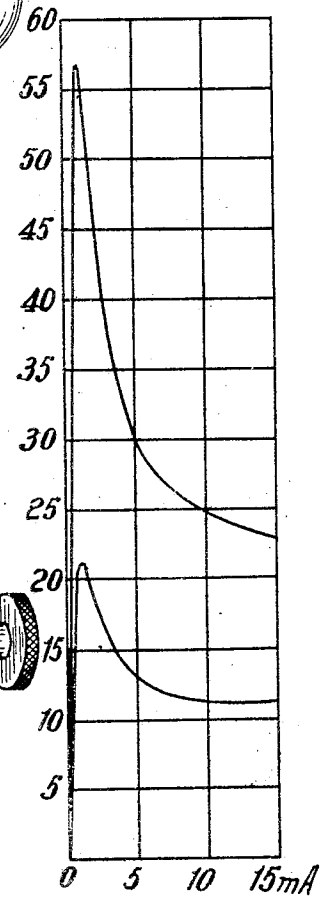


Fig. 3



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CONTACT DEVICE

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12 Claims. (Cl. 201—63)

This invention relates to contact devices, and more particularly to devices adapted to be used in circuits employing a negative resistance characteristic.

There are certain chemical compounds, such as the sulfides of lead and copper and the oxides of titanium, which when placed in contact with a metal and subjected to current flow exhibit a negative resistance characteristic. For example, when lead glance is placed in contact with iron, the iron being in wire form, the glance exhibits a resistance which varies in a manner opposite to the characteristic curve of an ordinary ohmic resistance. It is well known with an ohmic resistance the current varies as a direct function of the voltage and the characteristic current voltage curve is a straight line. In contradistinction to this, negative resistance shows an inverse curve, which follows from the fact that, due to the physico-chemical properties of the compounds employed, there is a variation in the resistance, in such manner that not only the resistance decreases but also the voltage when the current increases.

An object of this invention is to produce a device for the generation and intensification of alternating currents, characterized in that a powdered chemical metal compound which is not decomposed by current and which in compact condition, in single contact with a metal wire, shows a declining characteristic in which the said powder is placed as a contact substance between two electrodes serving as current carriers, and which is so finely grained and compressed to such an extent that, with the temperature kept constant, the powder layer will act as a negative resistance for alternating current even in the area of the declining continuous current characteristic.

Another object of this invention is to provide a contacting device having means adapted for the prevention of a substantial rise in temperature during operation.

Still another object of this invention is to provide resistance media for a contacting device, characterized by the presence of a non-conducting substance herein referred to as a neutral component.

Yet another object of this invention is to provide a contact device characterized by inherent regenerative properties.

Yet another object of this invention is to provide a contact device adapted to operate in a gaseous medium whereby its efficiency is increased.

With these and other objects in view, which may be incident to my improvements, the invention consists in the parts and combinations to be hereinafter set forth and claimed, with the understanding that the several necessary elements, comprising my invention, may be varied in construction, proportions and arrangement, without departing from the spirit and scope of the appended claims.

The present invention is designed to improve, by rendering more stable, the contacting point between a metallic powdered contacting substance and a metal wire, which is always rather sensitive to vibrations, to such an extent that the contact can be used as negative resistance in various technical applications.

My invention comprehends a contacting device having a granular mass positioned between two electrodes. The mass of the substance is ground so that the individual grains will form individual contacts with each other, the mass in powdered form being poured between the electrodes.

In order to make my invention more clearly understood, I have shown in the accompanying drawing means for carrying the same into practical effect, without limiting the improvements in their useful applications to the particular constructions, which for the purpose of explanation, have been made the subject of illustration.

In the drawing:

Figure 1 is a perspective view of the device; and

Fig. 2 is a perspective view of a modification.

Fig. 3 is a graph showing voltage current characteristic curves, in which 1 shows a high voltage and 2 a low voltage curve.

Referring to Figure 1, two metallic electrodes E are adapted to contact with a granular substance K, positioned between the ends of the electrodes. A suitable sleeve H of insulating material serves as a guide for the electrodes and prevents the powdered contacting substance K from becoming displaced from between the ends of the electrodes. The electrodes E are screw threaded and engage with the internally threaded portion of the sleeve H so that the engaging pressure between the electrodes and the substance K may be varied. G denotes a container suitable for containing a gas.

In order to have the declining characteristic produced as well as reproduced, three conditions must be fulfilled. First, the contact substance must be capable, when in compact condition, of producing a declining characteristic if placed in single contact with a metal. Secondly, the contact substance must be finely grained, and third, the pressure exerted by means of the electrodes must be of a value defined as follows:

As shown by the curve 2 in Figure 3, as a higher pressure acts generally to diminish the voltage, especially the peak voltage, the declining characteristic will become flatter, and will disappear under the influence of a still higher pressure. Consequently, in order to produce the declining characteristic, it is necessary that the grains of the powder be not pressed too strongly against each other. On the other hand, insuf-

ficient pressure brings about the fluctuations referred to at 2, Figure 3, in addition to an increase in voltage.

Prior to my invention, such substances as are herein employed as contacting substances, were not known to exhibit negative resistance, or declining characteristic. While these terms are sometimes used interchangeably, the term "negative resistance" is, technically, much broader than the term "declining characteristic". It is extremely difficult to produce a declining characteristic with most metallic powders. Many powders which can be employed with partial success, however, produce a different declining characteristic and for only certain limited periods of time. I have discovered that for a very small number of powders a declining characteristic of constant shape can be obtained for as long as two years if the method and conditions are employed as are herein disclosed. However, the form of the declining characteristic is usually very changeable. Only when all the conditions are fulfilled is the powder capable of producing oscillations of high frequency and constancy, that is to say, capable of acting as negative resistance, as is the case with the powders herein described. I have found that if the substance is triturated to a high degree, and subjected only to slight pressure when positioned between the electrodes, that negative resistance is exhibited to a marked degree.

It has been found that negative resistance is improved by admixing with the pulverized substance, a metal in powder form such as iron or molybdenum. All of the contacting powders show a certain sensitiveness to impacts, on account of their loose condition. In order to lessen the sensitivity of the substances to impacts, the loose and pulverized substances are mixed with a neutral powder and then firmly pressed between the electrodes. The neutral powder must possess definite and determined chemical and physical properties. Chemically, it must be similar to the contacting substance, that is, if the contacting substance consists of sulfides, for example, PbS and Cu_2S, the neutral powder must also be a sulfide, although of a different metal. Physically, the neutral powder must be of poorer electric conductivity than that of the contacting substance with which it is admixed, and preferably be substantially non-conductive.

I have found that Sb_2S_3 possesses the desired properties as a neutral or non-conductive powder, when mixed with PbS and Cu_2S for the production of negative resistance in a contacting device. The relative amounts of the neutral powder and the pulverized substance is most important in the formation of the negative resistance characteristic of the mixture. I have found that the relationship between the amounts of neutral powder and granular substance is influenced by the size of granules and a definite relation can easily be determined by test.

Three parts of powder to one part of the neutral substance has given excellent results.

Since the negative resistance of the composite powder is materially lessened by an increase in temperature from prolonged usage, I embed metal discs M as shown in Fig. 2, in the substance, perpendicular to the axis of the device, as a cooling means. Obviously, the metal discs should not be allowed to come in contact with each other. Special advantages are obtained if the plates are immersed in oil, since conduction of heat is thereby facilitated and improved.

Investigation has shown that certain oxides, for example, anhydrous titanic acid, manganese oxide, zinc oxide, chromium oxide, ferric oxide, tungsten acid anhydride, cuprous oxide and stannous oxide are better suited, in many instances, than sulfides. Of those mentioned, titanic acid anhydride, has been found to give best results. Although good results may be obtained by using one oxide, better results as regards durability, constancy of frequency and efficiency will be produced from employing a mixture of two or more.

The negative resistance produced from such oxides may be used particularly for the generation of alternating currents, whereby it is possible to obtain alternating currents having frequencies above those of ordinary speech and whereby no sign of fatigue will become noticeable.

However, moist oxides, for example Cu_2O, which in a sintered state exhibits high conductivity, if ground to a fine powder, or employed in powdered condition without preliminary sintering, do not ordinarily possess the property of conductivity. But experiments have shown, that when such a powder is placed in a tube of glass or material of similar non-conductivity, substantially of 1 m. m. in diameter, and there held between the ends of two metal electrodes introduced into the tube, current of low voltage can not be made to flow. However, it has been found, that if a voltage of more than 300 volts is applied and if the thickness of the powder is not more than from substantially 1 to 2 m. m., a "puncture" will occur, after which the powder not only permanently exhibits relatively high conductance even at conditions of low voltage, but also negative resistance to an extraordinary degree.

The addition of a metal powder, such as for example, powdered zinc, copper, or iron, to either the sulfides or oxides give improved results.

Up to the present, the cause of negative resistance or inclining characteristic was believed to have been due to the effect of temperature on the contacting metal portions of the device, in that, as an increase in current caused an increase in temperature, a higher temperature was expected to have produced greater conductivity of the contacting portions. But, as stated above, a condition of increased temperature is a disturbing influence and must be avoided by cooling means.

Experimental tests have shown the following fact, regarding the cause of negative resistance effects. I have found that at the points of contact which the granules make with each other the gas is adsorbed, the adsorption occurring at the cathodic or anodic points of granular contact in accordance with the substances used. It is well known that conductivity of the point of contact is caused by electrons passing from the cathode to the anode, and those portions of an electrode covered by a layer of gas will emit less electrons than those portions which are free from such gas.

It has been found that there is a considerable decrease in current flow if the cathodic contact is permitted to become covered with a layer of gas. However, an increase in voltage will remove the obstructing gaseous layer and subsequently the voltage will drop as the current increases.

If there is only a very slight current flowing through the contacting point, a considerable portion of the cathode is covered by a layer of adsorbed gas and the emission of the cathode is

slight. For a certain weak current a comparatively high voltage is necessary, and as soon as the electron current increases, which is emitted by the cathode, the enveloping gaseous layer is lifted from the cathode by the said electron current, whereupon the cathode is enabled to emit electrons to an increased degree. The voltage will drop as the current increases, for by proper control of the gaseous adsorption, voltage can be caused to increase with a decrease in current.

On the basis of the above noted effects, the negative resistance of the contacting device comprehended by this invention can be materially improved.

The contacts consisting of a mixture of powder, having the property of a negative resistance were tested in different gases. There were found, as was expected, characteristic differences. For instance, in hydrogen which constitutes an indispensable part of the Poulsen lamp of an electric arc generator in which the electric arc, burning in a hydrogen atmosphere between two carbon electrodes was used for the generation of electric oscillations, an inclining characteristic of considerably less degree was obtained while in oxygen the characteristic was highest. According to the invention, oxygen surrounds the contacts at a pressure of more than one atmosphere.

If the engaging pressure of the electrodes upon the contact powder is too low, the powder will gradually become non-conductive within the range of useful voltages. If the pressure is too high, the gas will not easily diffuse from the outer space back into the contacting chamber, in which case, very little regeneration is produced by the contact. For each gas pressure, there must be provided a suitable pressure between the electrodes and the mixture of powder.

As the granular particles of the negative resistance unit will adsorb oxygen, it is proposed either to coat one or both of the electrodes with black platinum or to admix a small quantity of platinum oxide with the powder between the electrodes. Since there is a possibility that the admixed black platinum will form bridges due to the coherer action and cause an internal short circuit of the negative resistance, a neutral non-conductive substance is added. Good results are obtainable if finely triturated Al_2O_3 or Sb_2O_3 is mixed with the powder between the electrodes. Catalysts, such as thorium or cerium oxides admixed with the powder have been employed with advantageous results.

In addition to platinum, other materials capable of absorption, such as, charcoal, cuprous oxide, osmium, vanadium may be used. The oxides of vanadium, uranium, osmium, manganese, cobalt, nickel, tungsten and chromium are particularly well adapted. This group of catalytic oxides (and preferably cuprous oxide, oxide of uranium and anhydrous vanadic acid), which per se possess only a slightly inclining characteristic, must be distinguished from the group of oxides referred to above, which can form a good negative resistance. If an oxide of this group is mixed with an oxide of the other catalytically acting group, negative resistances are obtained, which will answer all requirements as regards life, safety in operation, overloading and constancy.

The proportion by weight is not so much of importance as the proportion by volume. But this is rather manifest with mixtures, which consist of one oxide of the first group by adding a little oxide of the catalytic group.

Regarding the frequency limit to be obtained, it may be said that for a powder having a declining characteristic, the frequency limit depends upon the thickness of the powdered layer, that is to say, the thinner the layer of powder between the two electrodes, the higher will be the frequency. In order to produce oscillations in the sound domain and above, the thickness of the layer must not exceed 1 m. m. If, with predetermined currents and voltages, thicker layers are to be used, it is necessary to either connect a plurality of powder resistances in series, or to use a powder resistance as illustrated in Figure 2, in which the entire thickness of the layer is subdivided by means of metal plates, so that each layer is not thicker than 1 m. m. But the frequency limit does not depend exclusively upon the thickness of the layer, but also upon the material. It is, for instance, impossible to produce sound oscillations by means of a 1 m. m. layer of metallic sulfides. But sound oscillations can easily be obtained by means of a 1 m. m. layer of metallic oxides.

As stated above, contact substances, freshly prepared and consisting of powder are at first non-conductive. In addition it was also stated, that at a sufficiently high voltage a puncture would take place and the substance will thus form a conductor having the property of a negative resistance. It was found that the puncture impulse will cause trouble with the substances for the reason that it induces the catalyzers to release a larger quantity of the absorbed medium. In order to avoid this, the substance is at first subjected to very weak puncture impulses, and it will then always resume its non-conductive state until the intensity of the puncturing current, when gradually increased, effects puncturing whereupon the disc will remain conductive after puncturing, at a definite current intensity.

While I have shown and described the preferred embodiment of my invention, I wish it to be understood that I do not confine myself to the precise details of construction herein set forth, by way of illustration, as it is apparent that many changes and variations may be made therein, by those skilled in the art, without departing from the spirit of the invention, or exceeding the scope of the appended claims.

What I claim is:

1. A contact device having negative resistance character, comprising two terminal electrodes, and between said electrodes, a body of at least one substance selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, the thickness of said body being less than one millimeter, said body consisting of individual particles of the substance of such fineness and pressed together with such a force that the contacts between the individual particles of the body will impart to the layer a decreasing current characteristic at constant temperature, said body being located in an atmosphere of oxygen at a pressure higher than atmospheric pressure, whereby regeneration of the material of the body is obtained.

2. A contact device having negative resistance character, comprising two terminal electrodes, and between said electrodes, a body of at least one substance selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing an oxygen absorbing catalytic agent, the thickness of said body

being less than one millimeter, said body consisting of individual particles of the substance of such fineness and pressed together with such a force that the contacts between the individual particles of the body will impart to the layer a decreasing current characteristic at constant temperature, said body being located in an atmosphere of oxygen at a pressure higher than atmospheric pressure, whereby regeneration of the material of the body is obtained.

3. A contact device having negative resistance character, comprising two terminal electrodes, and between said electrodes, a body of at least one substance selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing a non-conductive oxygen absorbing catalytic agent selected from the group consisting of cerium oxide and thorium oxide, the thickness of said body being less than one millimeter, said body consisting of individual particles of the substance of such fineness and pressed together with such a force that the contacts between the individual particles of the body will impart to the layer a decreasing current characteristic at constant temperature, said body being located in an atmosphere of oxygen at a pressure higher than atmospheric pressure, whereby regeneration of the material of the body is obtained.

4. A contact device having negative resistance character, comprising two terminal electrodes, and between said electrodes, a body of at least one substance selected from the group consisting of TiO_2, MnO_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing an electrically conductive oxygen absorbing catalytic agent selected from the group consisting of cuprous oxide, uranium oxide and vanadium oxide, the thickness of said body being less than one millimeter, said body consisting of individual particles of the substance of such fineness and pressed together with such a force that the contacts between the individual particles of the body will impart to the layer a decreasing current characteristic at constant temperature, said body being located in an atmosphere of oxygen at a pressure higher than atmospheric pressure, whereby regeneration of the material of the body is obtained.

5. A contact device having negative resistance character, comprising two terminal electrodes, and between said electrodes, a body of at least one substance selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing conductive metal powder, the thickness of said body being less than one millimeter, said body consisting of individual particles of the substance of such fineness and pressed together with such a force that the contacts between the individual particles of the body will impart to the layer a decreasing current characteristic at constant temperature, said body being located in an atmosphere of oxygen at a pressure higher than atmospheric pressure, whereby regeneration of the material of the body is obtained.

6. The method of producing negative resistance elements which consists in compressing a body of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and passing through said body a high voltage electric current of low initial but slowly increasing intensity until puncturing of said body occurs, whereby the non-conductivity of said body is changed permanently into conductivity.

7. The method of producing negative resistance elements which consists of compressing a layer of a thickness not exceeding one millimeter of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and passing through said layer a high voltage electric current of low initial but slowly increasing intensity until puncturing of said layer occurs, whereby the non-conductivity of said layer is changed permanently into conductivity.

8. The method of producing negative resistance elements which consists in comprising a body of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, enclosing said body in an atmosphere of oxygen and passing through said body a high voltage electric current of low initial but slowly increasing intensity until puncturing of said body occurs, whereby the non-conductivity of said body is changed permanently into conductivity.

9. The method of producing negative resistance elements which consists in comprising a body of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing an oxygen absorbing catalytic agent, enclosing said body in an atmosphere of oxygen and passing through said body a high voltage electric current of low initial but slowly increasing intensity until puncturing of said body occurs, whereby the non-conductivity of said body is changed permanently into conductivity.

10. The method of producing negative resistance elements which consists in compressing a body of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing a non-conductive oxygen absorbing catalytic agent selected from the group consisting of cerium oxide and thorium oxide, and passing through said body a high voltage electric current of low initial but slowly increasing intensity until puncturing of said body occurs, whereby the non-conductivity of said body is changed permanently into conductivity.

11. The method of producing negative resistance elements which consists in compressing a body of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, WO_3, CuO and SnO_2, and further containing an electrically conductive oxygen absorbing catalytic agent selected from the group consisting of cuprous oxide, uranium oxide and vanadium oxide, and passing through said body a high voltage electric current of low initial but slowly increasing intensity until puncturing of said body occurs, whereby the nonconductivity of said body is changed permanently into conductivity.

12. The method of producing negative resistance elements which consists in compressing a body of discrete particles of at least one material selected from the group consisting of TiO_2, Mn_2O_3, ZnO, Cr_2O_3, Fe_2O_3, Wo_3, CuO and SnO_2, and containing further a conductive metal powder, and passing through said body a high voltage electric current of low initial but slowly increasing intensity until puncturing of said body occurs, whereby the non-conductivity of said body is changed permanently into conductivity.

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