No Model.)

H. G. O'NEILL & H. B. GALE.

ELECTRIC RESISTANCE CONDUCTOR.

No. 599,352. Patented Feb. 22, 1898.

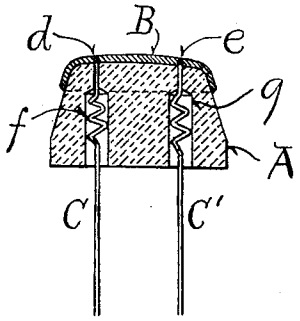

Fig. 1.

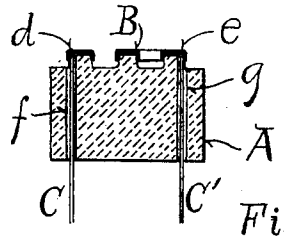

Fig. 3.

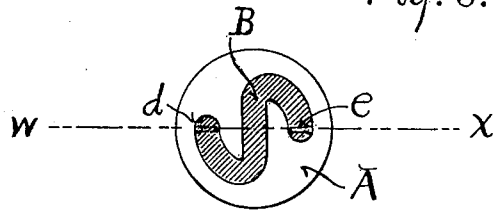

Fig. 4.

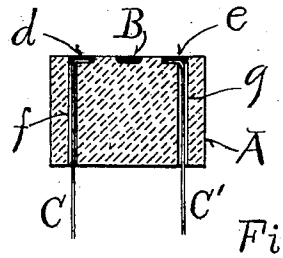

Fig. 5.

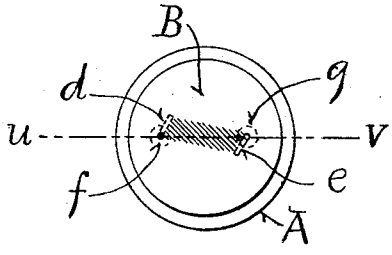

Fig. 2.

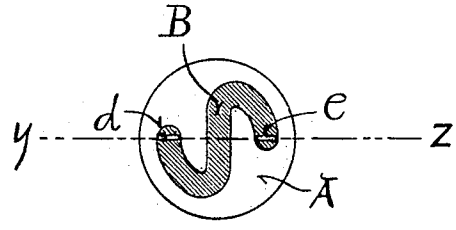

Fig. 6.

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UNITED STATES PATENT OFFICE.

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ELECTRIC RESISTANCE-CONDUCTOR.

SPECIFICATION forming part of Letters Patent No. 599,352, dated February 22, 1898.

Application filed January 4, 1897. Serial No. 617,924. (No model.)

To all whom it may concern:

Be it known that we, HENRY G. O'NEILL, residing at Brookline, in the county of Norfolk, and HORACE B. GALE, residing at Boston, in the county of Suffolk, State of Massachusetts, citizens of the United States, have invented a new and useful Improvement in Electric Conductors and Process of Forming the Same, of which the following is a specification.

This invention relates to electric conducting devices adapted to resist the oxidizing influences of air, moisture, and other oxidizing agents and also to withstand very high temperatures, such as a red or white heat, without suffering any permanent change.

The main object of the invention is to produce a conducting device of moderate cost which shall have the qualities above indicated, which, in addition, may be made of high specific resistance as compared to other devices possessing the qualities aforesaid, (such as platinum wire,) so that a great resistance may be easily concentrated in a small space, and which under such conditions may be given sufficient mechanical strength to enable it to endure the rough treatment to which it may be subjected in use.

Conducting devices made in accordance with this invention are applicable to a wide range of uses, and are especially adapted for use as resistances to be interposed in an electric circuit either for the purpose of controlling the current therein, as in rheostats, or for the generation of heat, more particularly where very high temperatures are required, as in branding, cauterizing, or the production of light by incandescence.

The conducting element in this invention consists, essentially, of one or more of the permanent refractory oxids, the general term "oxid," as used herein, being understood to include both the simple combinations of oxygen with the basic or metallic elements separately—such as oxid of copper, oxid of silicon, or silica—and also the more complex combinations of oxygen with two or more such elements together—for example, kaolin or clay, often described as a silicate of alumina, which is a combination of oxygen and the two basic elements, silicon and aluminium.

Different oxids have different degrees of electrical conductivity, their conductivity increasing generally with an increase of temperature, and by mixing the oxids of higher with those of lower conductivity in varying proportions compounds are produced having a wide range of conductivity and resistance suitable for different special purposes.

Among the oxids suitable for the purposes of the present invention the protoxid of vanadium appears to be the highest in conductivity, while silica is among the lowest, being classed as an insulator at ordinary temperatures. By fusing these together in proportions varying between the pure protoxid of vanadium to a composition containing one-third of silica a range of intermediate conductivities is obtained sufficient to meet the ordinary demands of practice. The practice of the invention, however, is not restricted to the employment of these or any particular oxids or compositions thereof, as a great variety of them may be used in adapting the device to special requirements. Almost any other metallic oxid may be employed in greater or less proportion in composition with that of vanadium, for example, the principal effect of the substitution of one for another being generally a change in the resistance of the compound. Among the oxids which we have employed as ingredients of the conducting compound are the black oxid of copper, wolframic trioxid or tungstic acid, asbestos, the oxids of chromium, iron, cobalt, and nickel, and the silicates of aluminium, magnesium, and zirconium.

Among the most serious of the practical difficulties which have heretofore hindered the employment of oxid compounds as electrical conductors, especially for high-temperature work, are the extreme brittleness and fragility of the compounds, which, together with the difficulty of attaching them to suitable terminal conductors, have prevented their use in the thin or attenuated forms nec-

essary for the concentration of a very high resistance in a small space.

Our invention consists in a method of treatment of these compounds and their combination with other elements whereby we are able to obtain the conductor in the attenuated form required to give it a very high resistance and at the same time to make it mechanically strong and to provide convenient and reliable means for attaching the terminal connections.

To obtain the conducting-oxid in a sufficiently-attenuated form and at the same time to give it the requisite mechanical strength, we apply it as a film or layer upon the surface of an insulating body or core of hard refractory material, to which it is made to adhere by fusion. The non-conducting core or base provides a firm and unyielding support, both for the coating of conducting-oxid and for the metallic terminal connections, the ends of which are preferably embedded in the conducting compound.

The accompanying drawings illustrate the device in a form in which it may be applied practically—for example, to a cigar-lighter. This special form is shown merely to illustrate and explain the invention, which is capable of many other useful applications.

In the drawings, Figure 1 represents a section on the line *u v* of Fig. 2, which is an end view. Figs. 4 and 6 are end views showing modified forms of the device, and Figs. 3 and 5 are sectional views on the lines *w x* and *y z* of Figs. 4 and 6.

Similar letters indicate corresponding parts in all the views.

A indicates the non-conducting support or core, B the superimposed layer or coating of conducting-oxid, C and C′ the terminal wires, the ends of which are embedded in the conducting-layer B at the points *d* and *e*.

The block or core A may consist of any hard refractory material to which the coating B can be made to adhere. To obtain the best results, its coefficient of expansion by heat should not differ widely from that of the conducting-oxid; otherwise the coating is liable to crack. We prefer to use for the supporting-body A a substance of the same general nature as the coating B—to wit, an oxid compound—but in order that the path of the current may be confined practically to the surface layer the material of the support A should have an electrical resistance very considerably higher than that of the conducting compound B. Fire-clay, porcelain, and asbestos are examples of suitable materials for the support A.

The layer of conductive oxid B may be applied to the surface of the body A in a number of different ways. For example, the conductive substance may be laid upon the surface of the refractory block in a powdered form and fused thereon by directing an electric arc upon it, after which it is cooled, so as to harden upon the surface, or it may be first melted in a crucible and then poured over the surface of the body A; but the process which we consider best for general use is as follows:

The oxids employed to form the conductor are ground in a powdered form, mixed in the desired proportions, and melted in a crucible. As this requires a very high temperature, it is best done in an electric furnace. The refractory body A, held by means of a pair of tongs or other convenient means, is then dipped into the bath of molten conducting-oxid, so as to submerge as much of its surface as it is desired to cover with the conducting material and immediately withdrawn. A layer of the molten oxid is thus made to adhere to the surface of the body A. On cooling the body A the adherent mass of oxid forms a hard coating or film firmly united to the base by a sort of welding, due probably to partial fusion of the surface of the supporting-body.

It is found generally advantageous to heat the refractory body A nearly to a red heat before dipping it, and also to cause the process of subsequent cooling to proceed somewhat slowly; but good results are often obtained without observing these precautions.

To insure a perfect mechanical and electrical connection between the conducting-film B and the terminals of the conducting-wires C and C′, we prefer to attach the latter to the insulating-body A before the latter is dipped into the bath of molten oxid. As shown in the drawings, the wires C and C′ are passed through holes *f* and *g* in the insulating-block A, and may be fastened therein by cement or other convenient means. The ends are preferably turned down, so as to extend for a short distance along the surface of the body A, as indicated by dotted lines at *d* and *e*. When this is done, the same operation which forms the conducting-coating on the surface of the body A also embeds the ends of the conducting-wires in that coating, forming a strong and durable connection.

The embedded ends of the wires C and C′ may be of copper; but as this is liable to oxidation at the point of junction we prefer to use platinum.

When the outer ends of the leading wires C and C′ are connected to a source of electricity a current depending upon the electromotive force and resistance in the circuit will flow through these wires and through the film of oxid B between the points *d* and *e*.

If the electromotive force and resistance are properly adjusted to each other, a band or strip of the oxid (indicated roughly by the shaded portion of the drawing in Fig. 2) will be heated by the passage of the current to incandescence, and may be applied to light a cigar, or when carried to a sufficiently high temperature to the purpose of illumination.

If the coating of oxid is uniformly spread

over the surface of the supporting-body, the current will naturally take the shortest path in it between the terminals *d* and *e*. By means such as are illustrated in Figs. 3, 4, 5, and 6, however, the current may be made to take a more roundabout path and to follow any prescribed course between the terminals.

In Fig. 4 the shaded portion represents a ridge on the surface of the supporting-block A, which is dipped in the bath of molten oxid only deep enough to form a coating on the raised portion, to which the current is therefore limited.

In Fig. 6 the shaded portion represents a groove filled with the conducting-oxid, as shown sectionally in Fig. 5, whereby a similar result is accomplished. In this case the oxid may be melted in the groove by the application of an electric arc to the surface, may be poured into it, or the whole upper surface of the body A may be first coated and the raised portions afterward ground off, leaving the oxid only in the groove, as is most convenient.

Other variations in the details of the combinations and processes by which our invention may be applied to special purposes may be readily devised, the main elements of the combination remaining the same.

Without limiting ourselves to the details shown and described, what we claim as our invention, and desire to secure Letters Patent, is—

1. In an electric conducting device, the combination, with a non-conductive support, of a layer or film of conductive oxid applied to the said support while in a fused state, substantially as described.

2. In an electric conducting device, the combination with a non-conductive support, of a superimposed layer or coating of conductive oxid, applied to the support while fused, and metallic terminal connections embedded in the layer or coating, substantially as described.

3. In an electric conducting device, the combination with a non-conductive support of a superimposed layer of conductive oxid, applied to the support while fused, and metallic terminal connections passing through the body of the support and having their ends embedded in the conductive-oxid coating, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY G. O'NEILL.
HORACE B. GALE.

Witnesses:
THOMAS J. CUNNINGHAM,
ODEN B. ROBERTS.