UNITED STATES PATENT OFFICE.

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RESISTANCE ELEMENT.

1,107,233. Specification of Letters Patent. Patented Aug. 11, 1914.

No Drawing. Application filed May 11, 1914. Serial No. 837,873.

To all whom it may concern:

Be it known that I, CHESTER N. MOORE, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Resistance Elements, of which the following is a specification.

My invention relates to resistance elements or the like, and more specifically to resistance elements in which the resistance wire is inclosed within a metallic sheath and separated therefrom by a thin layer of insulating material which is compacted to a high degree. Attempts have been made heretofore to produce a compound wire in which a conductor is surrounded by and insulated from an inclosing metallic tube. For instance, it was early discovered that if a copper wire were inclosed in an iron tube and insulated from it by an insulating material such as glass, that the tube and wire might be reduced in size simultaneously while maintaining the wire concentric with the tube and insulation. Various methods of reducing the size of the tube and its inclosed wire (which for convenience may be called an ingot) were suggested, such as rolling, drawing, etc. It was suggested that the ingot might be heated to melt the glass, and the ingot could then be reduced by forging while hot. All of these methods failed in practice, and, in fact, prior to my invention no wire of this character was ever made in a commercial way. I have found that in order to successfully produce such a wire, especially for resistance purposes where the uniformity of the inner core is extremely important, a condition which approaches as nearly as possible one or homogeneity throughout the wire must exist. That is, the insulating material must be of such a character and must be so treated that it becomes to all intents and purposes a metal having insulating properties. I have discovered that certain granular insulating materials may be compacted so hard that they become practically a unit with the inner wire and outer sheath, and that, when so compacted, the compound wire may be worked like an ordinary metal; that is, it may be drawn and rolled. Unless the insulating material is brought to this condition, the outer sheath will draw or stretch independently of the insulation and the inner core, so that the inner core is liable to break; or, the sheath not being firmly and uniformly supported on its inner side by the insulation, it will wrinkle and split longitudinally.

The object of my invention, therefore, is to produce a compound or "sheath" wire in which the inner core and outer tube are reduced simultaneously and uniformly and in which the insulating material is so hard and compact that the insulation and metal are practically a homogeneous unit. In carrying out my invention I take a tube of suitable material, such as steel or copper, and place centrally within the tube a rod of metal to form the conductor. For resistance purposes, as for instance where the completed wire is to be used for electric heating, the rod will be of suitable resistance metal. It is not necessary that this metal shall be of a non-oxidizing character at high heat, since by my method of manufacture the air is so completely excluded that no oxidation can possibly take place. The outer tube should preferably be of, or coated with, a metal which will withstand a high temperature without deterioration, where it is to be used for a heater. The rod or core is held centrally within the tube, and granular insulating material is packed around it. The particular material which I have found very satisfactory for this purpose is magnesium oxid, although other materials, such as pure lime, may be found suitable. The important thing about the insulating material is that it shall be compressible or compactable to a high degree, so that under the extremely high pressure to which it is subjected it will become practically a solid and for all mechanical purposes a unit with the metal which it surrounds and by which it is inclosed. After the insulating material is packed firmly about the central rod, the ends of the tube are closed and the process of reduction and compacting of the material is begun. Any attempt to reduce the diameter of the sheath and core by rolling or drawing at this stage will be unsuccessful. A reduction will undoubtedly occur, but it will be found that the inner core will draw down thinner in some spots than in others and eventually break, or the sheath will split. I have discovered, however, that by employing a process known as "swaging"

the desired result is obtained. The swaging process is well known, and need not be described in detail further than to explain that it consists in delivering a rapid succession of hammer blows to dies which surround the wire. Swaging machines for performing this operation are now available. The ingot is passed through the machine repeatedly, each time reducing the diameter of the inclosing sheath as well as the diameter of the inner core, and at the same time compacting or compressing the insulating material. After the ingot has been passed through the swaging machine a few times the metal of the sheath and core becomes so hard and brittle that annealing is necessary. This is done by heating in a furnace and allowing it to cool. It is of the utmost importance that this annealing be done thoroughly so as to insure that the inner core is properly annealed, since otherwise the wire core might be hard and brittle in spots and this would result in a non-uniform core which would be destroyed by burn-outs at the reduced portions. The process, therefore, consists in passing the ingot through the swaging machine repeatedly, each time reducing it a small amount and annealing it after each few passes. It has been found that by this swaging process not only is the inner wire reduced uniformly, but the insulating material is compressed or compacted so densely around the wire that it becomes almost of the hardness of the metal. It has been found that when the ingot has been reduced to a relatively small wire, it is practically homogeneous and may be worked and treated like an ordinary wire, and in practice I prefer, after the wire has been swaged down to this condition, to then complete the reduction by rolling, as this operation can be performed more cheaply than swaging. It will be understood, however, that the complete reduction may be made, if desired, by swaging. The combination of the swaging and rolling processes has the added advantage that enlarged terminals may be made for the resistance wire much more readily than they can be made when the swaging process alone is used. The advantages of a terminal of this character are fully set forth in a patent, No. 1,093,512, which was issued to Willis R. Whitney, April 14th, 1914, and the advantages of such a terminal need not, therefore, be here specifically enumerated. It may be stated, however, that one of the principal difficulties attending the use of sheathed wire which is suitable for use in heating devices has been the fact that it is necessary to secure terminals for making contact with the supply circuit and the end of the resistance wire, as this latter is ordinarily very small and is liable to be broken, and it is, therefore, very desirable to have enlarged terminals which are integral with the resistance wire, the enlarged portion being surrounded by insulating material. Terminals of this character may be very readily made by reducing the compound wire to such dimensions as will give to the resistance wire a size suitable for a terminal, and then further reducing the wire by rolling the same and beginning the rolling at a sufficient distance from the ends to permit suitable terminals to be formed. Terminals of the same character may be made when the reduction of the wire is made by swaging alone, but this is attended with greater difficulty.

I have found that satisfactory resistance wire may be made in the following manner: An ingot is formed by placing a core of resistance material about one-eighth of an inch in diameter centrally within a mild steel tube having an external diameter of about one inch and an internal diameter of about three-fourths of an inch and about one foot in length. The space between the core and tube is then firmly packed with magnesium oxid, and the ends of the tube are plugged or sealed. The ingot is then swaged down in the manner indicated above, the wire being thoroughly annealed after a certain number of passes through the swager, usually after three passes, until it approximates as nearly as possible a homogeneous condition and, ordinarily, until the diameter of the core wire is suitable for a terminal. In practice I have usually found that these conditions are fulfilled when the external diameter of the wire is about a quarter of an inch. From this point on I prefer to complete the reduction by rolling, and this can best be accomplished by means of rolls having grooves with angles of about ninety degrees. The wire should be turned through an angle of ninety degrees between the successive passes, and the same precautions must be taken as to annealing during the rolling as are observed in swaging. For ordinary heating work it will be found that the resistance wire is of about the proper diameter when the external diameter of the outer sheath is about one-tenth of an inch square. In accordance with my process, however, the wire may be reduced to a diameter of .040 inch or even lower if necessary.

The inner core is just as uniform in cross-section when completed as it was before the operation started, the tube is likewise uniformly reduced and is intact, while the insulating material has become nearly as dense as the metals themselves, so that the core, sheath, and insulation are practically a unit. The compacting of the insulating material has the effect of rendering it more heat conductive. The insulating layer should have a minimum thickness consistent with good insulation, and the denser the material the

greater will be its conductivity for heat. This is obviously of very great advantage in an electric heater, since the heat will be readily conducted to the place where it is required, and the sheath may be run at a higher temperature without danger of burning out the resistance conductor.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The process of making resistance elements which consists in locating a resistance conductor centrally within a closed metallic tube filled with granular insulating material, subjecting the tube to successive swaging operations to reduce the diameter of the tube and conductor and compact the insulating material, then heating the tube to a high temperature to thoroughly anneal the same and the inclosed conductor, again swaging the tube, and continuing these operations until the tube and inclosed core are elongated and reduced to a relatively small diameter and the insulating material compressed to a high degree.

2. The process of making resistance elements which consists in locating a resistance conductor centrally within a closed metallic tube filled with comminuted insulating material, subjecting the tube to successive swaging operations to reduce the diameter of the tube and conductor, and to compact the insulating material until the resistance core has attained a diameter suitable for a terminal, and then completing the reduction by rolling or drawing.

3. A compound or sheath wire comprising an inner core of resistance metal, an outer metallic sheath concentric with the core, and a layer of insulating material of minimum thickness between the sheath and the core composed of a granular material compressed to a density such that it has maximum heat conductivity and the wire is practically homogeneous throughout and may be worked like a metal.

In witness whereof, I have hereunto set my hand this 9th day of May, 1914.

CHESTER N. MOORE.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.