W. D. COOLIDGE.

REFRACTORY METAL TUBE.

APPLICATION FILED FEB. 5, 1916.

1,226,471.

Patented May 15, 1917.

Fig. 1.

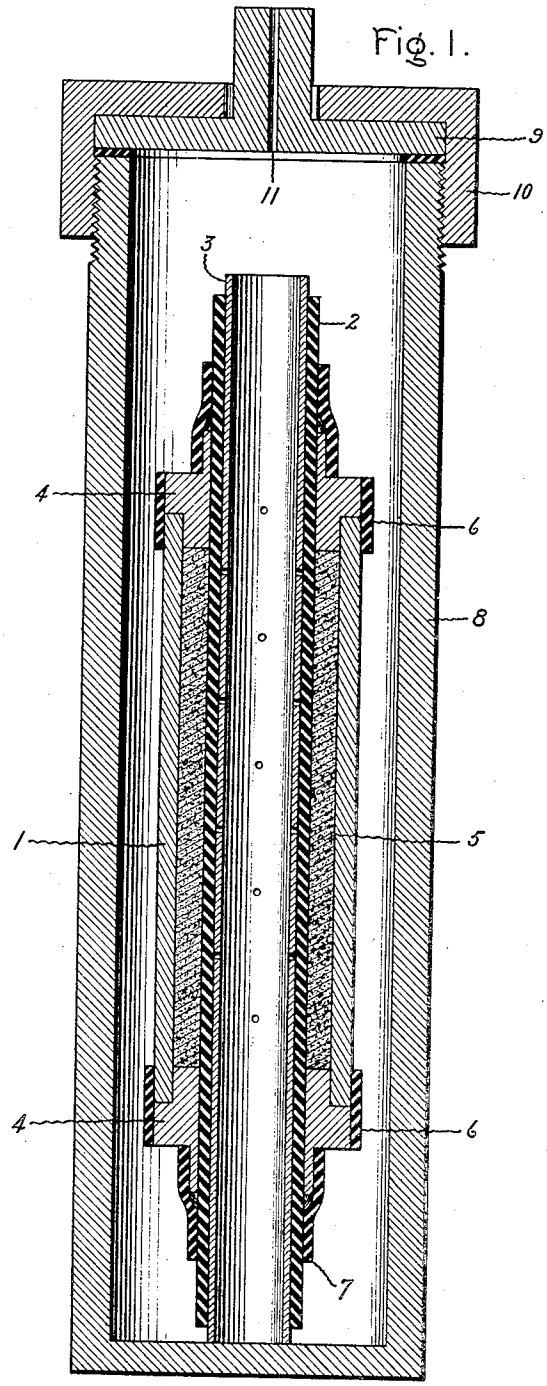
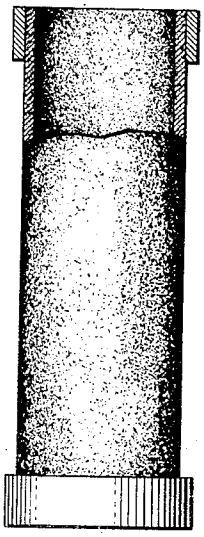


Fig. 2.



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UNITED STATES PATENT OFFICE.

WILLIAM D. COOLIDGE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

REFRACTORY-METAL TUBE.

1,226,471. Specification of Letters Patent. Patented May 15, 1917.

Original application filed February 20, 1915, Serial No. 9,532. Divided and this application filed February 5, 1916. Serial No. 76,351.

To all whom it may concern:

Be it known that I, WILLIAM D. COOLIDGE, 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 Refractory-Metal Tubes, (division of my application, Serial No. 9,532, filed February 20, 1915) of which the following is a specification.

The object of my invention is to provide for the construction of tubes of this nature which will be of uniform and homogeneous structure throughout. A more specific object of my invention is to prepare tubes of refractory material which will be suitable for use in electric furnaces of the resistance tube type such as are shown and described in U. S. Patents #1,004,557 and #1,006,620.

In preparing tubes of such metals it has heretofore been customary to mix powdered material with a plastic binding material, shape the mixture into tubes, subsequently remove the binding material and sinter the residue into a dense homogeneous body. These various steps have been necessary because of the difficulty of compacting the dry powder into a uniform tubular mass of sufficient strength to be handled and which when sintered would be perfectly homogeneous and uniform in thickness. By using my improved apparatus and carrying out my process, however, I am able to overcome the previous difficulties and produce tubes of uniform characteristics directly from the powdered material without the use of any binding material.

In carrying my invention into effect I provide a mold of tubular form in which the powder may be placed loosely. This mold is so constructed that a uniform heavy pressure may be applied internally in a radial direction to the entire mass whereby it may be compressed against the outer wall of the mold. This outer wall of the mold may then be utilized as a support for the tubular mass until it has been partially sintered and is strong enough to be handled.

My invention with further objects and advantages will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 illustrates one embodiment of the apparatus which may be employed in carrying my invention into effect, and Fig. 2 shows a finished tube adapted for use as a heating element for electric furnaces.

As shown in Fig. 1 my mold comprises an outer wall 1 of tubular form which may consist of a tube of porcelain or other refractory material of the desired length. The inner wall 2 should be of flexible material and may consist of a length of rubber tubing. A perforated metal tube 3 may be placed inside the rubber tubing in order to make it retain the desired form. In carrying out the molding operation one of the end pieces 4 of the mold and the outer wall 1 are positioned around the inner wall 2 and the space 5 between the walls is filled with the powdered material. The other end piece is then slipped over the inner wall and sections of rubber tubing 6, 6 and 7, 7 may be placed over the joints between the end pieces and the walls to make them liquid tight. When the mold has been filled in this way it may be placed in the metallic casing 8 which is filled with a liquid and the removable end 9 of the casing secured by means of the screw cap 10. Hydraulic pressure may then be applied to the liquid in the casing in any convenient way through the opening 11 in the removable end 9. The pressure thus applied acts upon the inner wall 2 of the mold through the perforations in the pipe 3 and is distributed uniformly in a radial direction over the entire area of this inner wall. As a result the powder in the space 5 is compressed in a uniform layer against the outer wall 1 of the mold.

After sufficient pressure has been applied to compress the powdered mass to the desired degree the mold may be taken from the casing 8 and the end pieces 4 and the inner wall 2 removed. The inner wall having been expanded by the pressure applied and being elastic will contract as soon as the pressure has been removed and shrink away from the compressed mass of powder. The outer wall 1 with the compressed mass adhering thereto may then be placed in a suitable furnace and heated to a temperature sufficient to partially sinter together the particles of which it is composed. This sintering operation will cause the mass to contract and separate from the wall 1 and will also give the tube sufficient strength so that it can be handled without breaking. The partially sintered tube may then be placed in a hydro-

gen atmosphere and current passed through it to heat it to a temperature sufficiently high to complete the sintering operation. The resulting tube will be of uniform thickness and have a dense homogeneous structure. To adapt such tubes for use in a furnace it is usually desirable to provide them with suitable terminals such as those indicated in Fig. 2. Difficulty has been experienced heretofore in the construction of heating elements of tungsten in securing a satisfactory electrical contact between the tungsten and the supply conductors. I have completely overcome this difficulty, however, by casting a copper terminal around the end of the tube in a suitable mold. The casting operation should be carried on in a vacuum furnace to prevent oxidation of the tungsten. I also find it desirable to use copper which has been treated previous to casting with an oxidizable boron material such as elemental boron, boron suboxid, or boron carbid, as described in Weintraub Patent #1,023,604. In this way I secure a terminal which has a high electrical conductivity and which is autogenously joined to the metal of the tube.

When making tungsten tubes in this way the powder used may be either pure tungsten prepared as described in my prior Patent #1,082,933, or tungsten powder prepared with certain additions as described in that patent. The process may also be employed in making tubes of molybdenum or other refractory metals, and if desired powdered refractory materials, such, for example, as thorium oxid may be mixed with the metal powder to vary the characteristics of the finished product.

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

1. A homogeneous tubular mass of refractory metal having copper terminals autogenously united thereto.

2. A homogeneous mass of tungsten of tubular form having copper terminals autogenously united thereto at each end.

3. A resistance element for an electric furnace consisting of a homogeneous mass of tungsten of tubular form having copper terminals autogenously united thereto at each end.

4. A heating element for an electric furnace consisting of a homogeneous tubular mass of pressed and sintered tungsten having copper terminals autogenously united thereto.

In witness whereof, I have hereunto set my hand this 2nd day of February, 1916.

WILLIAM D. COOLIDGE.