UNITED STATES PATENT OFFICE.

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PRODUCING METAL FILAMENTS.

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To all whom it may concern:

Be it known that I, WILLIAM C. ARSEM, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Producing Metal Filaments, of which the following is a specification.

This invention relates to the manufacture of incandescing conductors such as are used in incandescent lamps, resistance furnaces and similar apparatus.

It comprises a process for the manufacture of ductile alloys, and a method of producing filament shaped conductors of proper size and shape and of proper material for operating in incandescent lamps at high temperatures and consequently at high efficiencies.

My improved method is applicable in the treatment of those high melting metals which are obtainable in the form of powder. Refractory metals of this kind, such as tungsten, thorium, and molybdenum cannot be readily shaped into lamp filaments without some special treatment.

According to my present invention, the refractory metal is mixed with a less refractory metal and the mixture is heated to such a temperature that the less refractory metal fuses. An alloy of the metals may thereby be formed, even though the temperature of fusion is very much lower than the melting point of the more refractory component. Alloys so produced are in some instances ductile so that they can be rolled and worked into filaments. The more volatile metal may then be driven off by heat or may be otherwise removed to leave behind a filament shaped conductor of pure refractory metal. It is to be understood, however, that the formation of an alloy is not essential to my invention, since in the manner hereinafter set forth a workable coherent body from which filaments capable of being freely handled and manipulated may be produced by various ordinary methods of metal working can be obtained without the formation of an alloy. Nor is the correctness of any particular theory as to the relation of the metals of prime importance, since the advantages of my invention in its broader aspects are independent of whether or not the metals are alloyed.

Although my invention is applicable to the treatment of tungsten, molybdenum and various other of the well-known refractory metals, I will describe the process as applied to molybdenum, and it is to be understood that the same general process is applicable to tungsten and other metals.

Molybdenum in the form of a dry, finely divided powder is mixed with an equal part of a ductile metal, such as finely divided or comminuted copper, and the mixture is compressed into a solid lump by heavy pressure. In this cohesive mass each particle of the powdered or comminuted molybdenum is, as it were, surrounded with a casing of copper. This lump is then heated to such a temperature that the ductile metal fuses. An alloy is probably formed, owing to the molecular mobility at the high temperature which causes the metals to mix uniformly. This cohesive mass or alloy is then rolled, or drawn through a die, or otherwise worked to produce wires of the proper shape and cross section for lamp filaments. The compressed lump, before heating, is copper-red in color, but after firing it becomes silver colored with a faint pinkish tinge. It can be rolled into thin foil and will take a permanent set when bent slightly.

The filament shaped conductors obtained as above described are heated in a vacuum or in an inert atmosphere to drive out the copper or other ductile metal of the cohesive mass or alloy. This leaves behind pure molybdenum in a form suitable for mounting in globes or incandescent lamps. The molybdenum is not left porous by the vaporization of the copper, but on the other hand seems to solidify into a dense product. Whether this is due to the drawing together of the molecules, or is some other complex phenomenon I will not attempt to state, but whatever the cause, the filament is dense as above described. It is malleable and strong and is otherwise well suited for the manufacture of commercial lamps.

To effect the vaporization of copper the filaments may be heated by current passed through the filament, or they may be treated to radiant heat in any suitable vacuum furnace. The temperature of this treatment is somewhat above the vaporizing point of copper. The decomposition of the alloy if an alloy has been formed seems to result from a boiling away of the ductile metal at

a temperature lower than the melting point of the alloy. It will thus be seen that the ductile metal serves as a means to draw together the fine particles of the original molybdenum or other powder, and subsequently passes off as vapor and leaves these particles cemented together into a strong homogeneous malleable product.

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

1. The process which consists in mixing refractory metal powder with ductile metal, heating to fuse the ductile metal, and subsequently heating to a higher temperature to vaporize the ductile metal and produce a coherent body of the refractory metal.

2. The process which consists in mixing refractory metal in powdered form with less refractory metal, heating to fuse the less refractory metal and produce a cohesive mass, working said mass into a predetermined shape, then vaporizing the less refractory metal to leave behind a coherent body of refractory metal.

3. The process which consists in mixing highly refractory metal in powdered form, with less refractory metal, heating to produce a union between said metals, and then heating to a higher temperature to vaporize said less refractory metal and produce a coherent product of pure refractory metal suitable for use as an incandescing conductor.

4. The process which consists in mixing finely divided molybdenum with finely divided copper, compressing said mixture into a block, heating the block until the copper is fused, working the product into the desired shape, and then vaporizing the copper in a non-oxidizing atmosphere to produce a refractory conductor stable at high temperatures.

5. The process which consists in fusing low melting metal in contact with finely divided refractory metal, and subsequently heating to a higher temperature to vaporize the low melting metal and produce a coherent body of the refractory metal.

6. The process which consists in fusing ductile metal in contact with finely divided refractory metal, shaping the product so formed into wires, and heating said wires to vaporize the ductile metal and produce a coherent filament of the refractory metal.

7. The process of fusing ductile metal in the presence of non-ductile refractory metal to produce a ductile product, working said product into a predetermined shape and removing said ductile metal to leave a refractory residue conforming to said shape.

8. The process which consists in fusing ductile material in the presence of finely divided refractory metal, shaping the product so formed into wire and heating the wires to drive out the more volatile components.

9. The process which consists in fusing low melting metal in contact with finely divided refractory metal, shaping the product so formed, and heating to a higher temperature to vaporize the low melting metal and consolidate the residue into a coherent conductor.

10. A method of manufacturing filaments of highly refractory metals for electric lamps consisting in surrounding each particle of the comminuted concerned metals with a casing of another ductile metal and forming a cohesive mass of the metals and in forming the mass into filaments.

11. A method of manufacturing filaments of highly refractory metals for electric lamps consisting in comminuting another ductile metal, in mixing the comminuted concerned metals intimately together and uniting the same into a cohesive mass in such a manner that each particle of the highly refractory metals is surrounded with a casing of the ductile metal, and in forming the mass into filaments.

12. The process which consists in incorporating together refractory metal and other metal to form a cohesive workable mass, shaping filaments from said mass, and treating such filaments to eliminate said other metal and consolidate the residue of refractory metal.

13. The process which consists in forming a coherent mass consisting of finely divided particles of refractory metal mixed with and held together by other metal, heating said mass to a temperature sufficient to fuse said other metal, shaping filaments from the product, and heating said filaments by the passage of current through them to vaporize and expel said other metal and consolidate the residue of refractory metal.

14. The process which consists in incorporating together into a cohesive workable mass finely divided refractory metal and other metal, shaping filaments from the mass, and heating such filaments to expel said other metal and consolidate the residue of refractory metal into coherent refractory filaments.

In witness whereof I have hereunto set my hand this 8th day of May, 1906.

WILLIAM C. ARSEM.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.