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UNITED STATES PATENT OFFICE.

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METHOD OF WORKING REFRACTORY METALS.

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(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

My invention relates to the mechanical working of tungsten, molybdenum and other refractory metals for the production therefrom of wires such as are employed as filaments of incandescent electric lamps, and it has for its object to provide a method of treating refractory metals of the above-indicated character, whereby the metal may be obtained in a ductile condition and free from flaws, and which shall require the use of moderate working temperatures only.

In the production of wires from refractory metals, such as tungsten and molybdenum, the process heretofore employed has comprised the swaging, rolling, drawing or other mechanical working of a coherent initial body of the metal, such working being carried out while the metal under treatment is at a white heat. It has heretofore been considered necessary to work the metal at a white heat in order to maintain the coherence of the ingot during the severe mechanical treatment involved in the working process. Attempts have been made to work tungsten and other refractory metals at a red heat in order to eliminate the necessity for taking special precautions to protect the metal from oxidation, such precautions being required at a white heat, but not at a red heat, but such prior attempts to work these metals have not been successful because the treatment at a red heat frequently causes the ingots to split and break.

According to my present invention, I provide a method of satisfactorily working tungsten, molybdenum and other refractory metals at a red heat which consists in reheating the partially worked metal between the successive working steps. Such intermediate heat treatment should be carried far enough to raise the temperature of the metal above the temperature at which the mechanical working is performed, the precise temperature being selected in accordance with the dimensions or other properties of the ingot under treatment. In general the metal should be heated not substantially lower than 1000° C.

The intermediate heat treatments are preferably carried out in an atmosphere of hydrogen, or other non-oxidizing gas which does not attack the metal under treatment, and the heating should not be long continued, it being sufficient to raise the metal to the desired temperature and immediately to permit it to cool down, and the mechanical working may then be continued at red heat, which is the preferable temperature. The metal may be heat treated in the manner described above at any convenient intervals during the mechanical working and either one or several such treatments may be applied to a given ingot in the course of its reduction to fine wire. It is to be appreciated, however, that the heat-treatment contemplated may be practiced as a continuous process or as separate steps of such a process, it being largely dependent upon a matter of convenience.

The foregoing process produces refractory wires of great ductility without the formation of the cracks and other faults which have characterized the wires and rods that have heretofore been produced by mechanical working at temperatures below white heat. My process has the additional advantages that shrinkage is almost entirely eliminated and the swaging, rolling and drawing tools are subjected to much less wear than in processes which treat the refractory metals at white heat.

While I have specifically mentioned tungsten and molybdenum as the metals to be treated in accordance with my invention, it is to be understood that my method is also applicable to the treatment of other refractory metals of the tungsten type. It is also to be understood that my method is not restricted to the use of any particular apparatus and that its steps may be variously modified by persons skilled in the metal-working art without departing from my invention, which is to be limited only by the scope of the appended claims.

I claim as my invention:

1. The method of imparting ductility to a body of refractory metal which consists in alternately working the metal in a coherent form at approximately a red heat and heating the metal above the temperature at which the working is performed.

2. The method of imparting ductility to a body of refractory metal which consists in alternately working the metal in a coherent

form at approximately a red heat and heating the metal to a temperature above 1000° C.

3. The process of manufacturing wires of refractory metals that comprises mechanically working the metal in a plurality of steps and at approximately a red heat, and heating the metal between at least two of the working steps, the said intermediate heating being sufficient to raise the temperature of the metal above the temperature at which the working steps are performed.

4. The process of making wires of refractory metals that comprises mechanically working the metal at approximately a red heat, interrupting the working operation and heating the metal above the working temperature, cooling the metal to approximately a red heat and again working the metal.

5. The process of making wires of refractory metal that comprises mechanically working the metal at approximately a red heat, interrupting the working treatment, heating the metal to a temperature above 1000° C., cooling the metal to approximately a red heat and again mechanically working the metal.

6. The method of imparting ductility to a body of refractory metal which consists in alternately working the metal in a coherent form at approximately a red heat and heating the metal in a non-oxidizing atmosphere above the temperature at which the working is performed.

7. The method of imparting ductility to a body of refractory metal which consists in alternately working the metal in a coherent form at approximately a red heat and heating the metal in a reducing atmosphere above the temperature at which the working is performed.

8. The process of making wires of refractory metal that comprises mechanically working the metal at approximately a red heat, interrupting the working treatment, heating the metal to a temperature above 1000° C. in a non-oxidizing atmosphere, cooling the metal to approximately a red heat and again mechanically working the metal.

9. The process of making wires of refractory metal that comprises mechanically working the metal at approximately a red heat, interrupting the working treatment, heating the metal to a temperature above 1000° C. in a reducing atmosphere, cooling the metal to approximately a red heat and again mechanically working the metal.

10. A body of refractory metal of the tungsten group having the properties of ductility and softness at a red heat throughout the working range of the metal.

11. A body of tungsten having the properties of ductility and pliability at red heat and capable of being worked at said temperature throughout the entire working range.

12. A large size wire of tungsten having the properties of ductility and workability at a red heat.

In testimony whereof, I have hereunto subscribed my name this 28th day of June, 1921.

ANTON LEDERER.