UNITED STATES PATENT OFFICE.

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DUCTILE FILAMENT.

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To all whom it may concern:

Be it known that I, ORLANDO M. THOWLESS, a subject of the King of Great Britain, residing at Newark, in the county of Essex and State of New Jersey, have invented new and useful Improvements in Ductile Filaments, of which the following is a specification.

My invention relates to the manufacture of ductile filaments made of refractory metals and more especially filaments made of tungsten.

The object of my invention is to produce filaments to be used in electrical incandescent lamps which shall be of practically pure material, shall not darken the bulbs while lighted and which shall remain ductile during the operative life of such filaments, although wire suitable for other purposes may be made by means of my method.

To attain this object I first produce what I will term the parent filament, that being a filament formed of one or more metals flashed on a core and the flashing and core drawn down through reducing holes to a filamentary diameter ready to receive a deposit of metal in its turn, in some instances after the core has been removed from the original flashing, which is preferably done previously to the drawing. For instance, to make a tungsten wire filament of substantially pure metal and one that will be ductile during its operative life with slight discoloring of the bulbs, I take a filament or rod which may be of molybdenum, tantalum or of tungsten or of some other substance capable of withstanding a high temperature without causing any injury to metal afterward deposited thereon and on such a filament or rod (which for future reference I will term the core) I cause to be deposited a more or less heavy coating of tungsten. This is accomplished by mounting the core between electric terminals in a flashing-jar or other similar vessel and, after exhausting the air therefrom, admitting therein a mixture of the vapor of a halogen salt of tungsten and a decomposing gas such as dry hydrogen, then causing an electric current to traverse the core to the extent of raising it to a temperature sufficient to cause a decomposition of the mixed vapors and produce a flashing of tungsten on the core. A halogen salt of tungsten such as the pentachlorid WCL_5 or the hexachlorid WCL_6 will be found suitable for the purpose. The flashing may be continued to any desired extent so that a coating of any thickness may be built up as long as the heating is maintained and the supply of the mixed vapors kept up. The flashed core may then be placed in a lathe or other suitable receptacle and the core drilled, bored or reamed out or otherwise removed, such as by acid or other solvents, so that only a tube of tungsten remains, which, if pure materials have been used will be of pure tungsten free from carbon, oxids or other impurities. This tungsten tube is then wrought—that is, heated and worked, swaged and hammered repeatedly while in the heated condition until it loses its crystalline structure, becomes fibrous in character, ductile at normal atmospheric temperatures and is then reduced to filamentary diameter by drawing it through reducing holes while it is in a heated condition. The heating and working of the tungsten tube results in forming it into a structurally solid body which may then be drawn down to filamentary diameter. The above is a description of the method by which the parent filament is made and on pieces of the parent filament, other filaments may be built up by depositing metal thereon and from these, when they are reduced to the proper diameter, other filaments may be produced in like manner and so on indefinitely, one parent filament being all that is necessary in the production of any number of the filaments for use, so that with only the first flashed metal will a basic core be present requiring to be removed. As an illustration of this—I take one of the parent filaments, connect it with electric terminals in the flashing-jar and deposit a coating of tungsten thereon from the vapors hereinbefore set forth, until the flashing is of the thickness required. I then hot work it and draw it while heated to a diameter suitable for electrical incandescent lamps, reserving a little of the reduced wire on which to flash deposits of tungsten to form other filaments.

Instead of removing the basic core from the parent filament, it may remain and be drawn down with the flashed deposit and serve as a support for it and to enhance its ductility or the core may be eliminated by drawing the flashed core to filamentary diameter, a flashed deposit made thereon and this drawn down and filaments taken from this secondary batch which in their

turn receive a deposit and are drawn down. This may be again and again repeated until the original core of the parent filament can no longer be traced under the flashing of the later filaments.

The wire may be cut into proper lengths, shaped into filaments for electrical incandescent lamps, and, if necessary, may receive a finishing flashing of metal to equalize their resistance should any inequalities of resistance appear after the drawing.

Tungsten deposition only has herein been described but other refractory metals capable of being deposited may be used—even ductile metals such as tantalum and molybdenum—as the method described produces pure metal, which has important characteristics such as uniformity and solidity of construction with a closeness of grain.

The tungsten flashing consists of long crystals, lying radially, the metal being deposited with a dense formation, the purity of the deposit insuring its freedom from carbon and oxids, thereby preventing darkening of the bulbs and the fact of the crystals of the deposit being long, the metal is more easily made into a fibrous body and this together with its purity causes filaments made by this method to remain ductile throughout their operative life.

In some cases it may be desirable to have a coating of two or more refractory metals on the core, either in the form of a flashed alloy or in layers. The flashing of the alloy may be accomplished by mixing vapors of the halogen salts of two or more metals with the dry hydrogen and proceeding as previously set forth. For instance, titanium tetrachlorid $TiCl_4$ may be mixed with hexachlorid or pentachlorid of tungsten and hydrogen, or one of the tungsten chlorids may be mixed with tantalum chlorid $TaCl_5$ and hydrogen to form the flashing of an alloy on the core. To flash metals in layers, one of the metals mentioned above may be flashed on the core and then a second metal may be flashed upon the first flashed metal. This may be accomplished by first flashing one metal in a flashing jar and when it is of sufficient thickness exhausting the jar and allowing the vapors of the halogen salt of another metal with hydrogen to enter the jar and proceed as before, or, after the first metal has been flashed on the core, it may be transferred to another jar to receive the second metal flashing and this may be repeatedly done until the desired thickness is attained, when it may be hot worked and operated upon the same as described for the deposit of tungsten. Other metals besides those mentioned may be used and any number of different layers of metal may be flashed on the core.

During the deposition of the flashing, the core should be raised to a high incandescent temperature as the metal appears to have a closer grain when deposited at such a temperature. It is also necessary to have pure materials and to see that the reducing gas is dried before mixing it with the vapor of the metal salt.

It will be seen that the above method shows that the filaments are not made from metal in a powdered form and held together by a binder and that no sintering or fritting of the particles of the metal is involved, therefore no impurities will enter into its construction provided pure halogen salts of the metals are used and only hydrogen mixed therewith as the reducing agent. The filament will, therefore, be free from carbon or oxid.

The term "metal" is to be understood as applying equally to one metal or a mixture of two or more metals or to layers of metal, unless otherwise provided for. Also in all cases, the core may remain and form part of the filament if it is considered advisable.

What I claim is:

1. The method of making ductile filaments which consists in flashing refractory metal on a conductor and reducing the diameter of the flashed conductor to filamentary size.

2. The method of making ductile filaments which consists in depositing refractory metal on a conductive core, removing the core therefrom and reducing the deposit to a filamentary diameter.

3. The method of making ductile filaments consisting in flashing a deposit of refractory metal on a conductor reducing this to a smaller diameter, flashing metal thereon and drawing the resulting body to a filamentary size.

4. The method of making ductile filaments consisting in flashing a deposit of refractory metal on a metal core, removing the metal core therefrom, reducing the resulting tube to a smaller diameter, flashing a deposit of refractory metal thereon and reducing this body to a filamentary size.

5. The method of making ductile filaments which consists in flashing a deposit of refractory metal on a metallic conductor, removing the metallic conductor therefrom, drawing the resulting tube to a reduced diameter, heating and working it until it becomes a substantially solid body and reducing it to a filamentary diameter.

6. The method of making ductile filaments which consists in flashing refractory metal on a core, removing the core therefrom, raising the resultant tube to a high temperature, working it into a substantially solid wire and reducing it to a smaller diameter.

7. The method of making ductile filaments which consists in flashing a deposit of refractory metal on a conductive core, reducing the diameter of the flashed core to a smaller diameter, selecting lengths there-

from and flashing metal thereon, drawing these flashed lengths to a smaller diameter and alternately repeating these operations until the core is substantially eliminated.

8. The method of making ductile filaments which consists in decomposing a mixture of hydrogen and the vapor of a halogen salt of tungsten in an air-tight vessel in the presence of a heated core, causing a flashing of tungsten to form on the core, removing the core therefrom, working the resultant tube in a heated condition into a fibrous structure and drawing it to a filamentary size.

9. The method of making ductile filaments which consists in forming a flashing of refractory metal on a conductive core, hot working the flashed body until it becomes fibrous in structure and then reducing its diameter further by hot drawing it through reducing holes.

10. The method of making ductile filaments which consists in forming a dense, coherent and structurally solid flashing of pure tungsten on a conductive core, hot working this flashed body until it becomes fibrous in structure and then reducing it to a filamentary diameter.

11. In the manufacture of ductile filaments the steps which consist in flashing metal on a core and hot working the flashed body until it becomes fibrous in structure.

12. The method of making filaments which consists in flashing a refractory metal on a conductive core, then flashing a different metal on the first flashing, eliminating the core therefrom and reducing the resultant tube to a filamentary diameter.

13. In the manufacture of ductile filaments the steps which consist in flashing metal on a conductive core, flashing a different metal on the first flashing and hot working the flashed body until it becomes fibrous in structure.

14. The method of making filaments which consists in decomposing a mixture of the vapors of two or more halogen salts of refractory metals and hydrogen in the presence of a heated core, causing a deposit of the metals to form upon the core, eliminating the core therefrom, working the resultant metal into a fibrous structure and drawing it to a filamentary size.

15. The method of making filaments which consists in depositing an alloy of two or more refractory metals on a metallic core, hot working it into a fibrous condition and reducing it to a filamentary diameter.

16. A wrought filament composed entirely of refractory metal flashing.

17. A filament composed of a wrought refractory metal flashing.

18. A wrought filament composed essentially of a flashing of tungsten.

19. A filament composed of a conductive core having thereon a wrought refractory metal flashing.

20. A wrought filament composed of a conductive core having thereon a drawn flashing of refractory metal.

21. A wrought filament composed of a metallic core and having thereon a deposit of more than one refractory metal.

22. A wrought filament composed of more than one layer of refractory metal.

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Witnesses:
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