UNITED STATES PATENT OFFICE.

CARL AUER VON WELSBACH, OF VIENNA, AUSTRIA-HUNGARY, ASSIGNOR TO WELSBACH LIGHT COMPANY, OF GLOUCESTER CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

MANUFACTURE OF ELECTRIC FILAMENTS.

976,526. Specification of Letters Patent. Patented Nov. 22, 1910.

No Drawing. Application filed August 9, 1898. Serial No. 688,201.

To all whom it may concern:

Be it known that I, CARL AUER VON WELSBACH, a subject of the Emperor of Austria-Hungary, residing at Vienna, Austria-Hungary, have invented or discovered a certain new and useful Improvement in the Manufacture of Elastic Filaments, of which the following is a specification.

My invention relates to the manufacture of incandescent electric lamps and has for its object the production of illuminating conductors, called filaments, for lamps which can be worked at a very high temperature and which will give forth a very brilliant light. I accomplish this result by constructing the illuminant substantially of the metal osmium, a substance which is readily oxidizable if heated in an atmosphere containing oxygen, but which, especially when pure, can withstand without melting or volatilizing a temperature above the volatilizing temperature of platinum if placed *in vacuo* or in certain protective gases (as, for instance, the gases and vapors incident to the incomplete combustion of illuminating gas, procured by the ignition thereof at the air feed openings of a Bunsen burner, as hereinafter mentioned.) It is therefore capable of being raised to so high a temperature that the light emission bears a high ratio to the consumption of energy and this great efficiency is obtained without destroying the durability of the filament. There are however great difficulties in the use of this metal and up to the present time no means have been found by which it can practically be applied to the above purpose. It is not ductile but on the contrary exceedingly brittle and pulverizable and it cannot be formed into wires either by drawing or pressure. Therefore to utilize it in the manufacture of filaments suited for use in incandescence electric lamps involved the devising of special methods for that purpose.

Osmium was known to be a good conductor of electricity, yet it was not known that it is non-volatilizable, when *in vacuo* or in certain reducing gases, at temperatures at which platinum volatilizes; a discovery which is utilized as one of the bases of the present invention. Now I have discovered that osmium while under the influence of the electric current at very high temperatures, either *in vacuo* or in certain reducing protective gases, assumes a partially fused coherent or cinder like condition which causes an intimate contact of the particles whereby is obtained perfect electric conductivity and requisite flexibility and elasticity, while at the same time resisting a liquefying action even at such high temperatures. This maintaining of its solid form, when the heating is effected in the presence of certain gases or *in vacuo* such as that of the ordinary electric lamp, and the refusal to liquefy or volatilize continuing up to temperatures much higher than that at which the volatilization of platinum occurs, is a discovery utilized in my present invention, and an important fact to keep in mind when it is remembered that the metal osmium (among those of its group of highly infusible metals) is peculiar in that it oxidizes with great readiness when in the presence of free oxygen.

In carrying out my invention I prepare a stiff uniform paste or osmium or its suitable salts, and a binding material which under the influence of heat will resolve itself practically into carbon. I take osmium in a very finely divided condition and a binding material, such as a syrup of sugar, which I thoroughly knead into a smooth stiff paste throughout which the particles are intimately and uniformly distributed. Of the binding material I use only sufficient to hold the particles together during the manufacture of the filament.

If a dry binding material be used a sufficient quantity of water must be used to enable the ingredients to assume the desired pasty condition. Viscous collodion may be used as the binding material in which case the paste after it has been given the filamentary form and before further treatment must be denitrated. This paste, which I shall hereafter designate as my osmium paste—is then given its filamentary form by being forced through a suitably shaped die or in any other suitable manner; I however prefer to form it into what I shall hereafter term my osmium threads by forcing it through a suitable die for that purpose. My osmium threads after drying are then subjected to dry or destructive distillation. The application of heat resolves the organic

matter into carbon and volatile constituents which are driven off, so that the filament now comprises a mixture of carbon and osmium. The carbon is then removed from the mixture by subjecting the incomplete filament to the influence of a moderate heat obtained by an electric current in an atmosphere of gases capable of taking up or removing the carbon without oxidizing the osmium, and the osmium particles are partially fused or cemented together by continuing the current to the development of a heat at which platinum would volatilize. Such an atmosphere should contain carbonic acid or vapor water to take up the carbon, but, as these gases would attack the osmium more or less, the atmosphere should also contain a reducing gas, such, for instance, as hydrogen, carbon monoxid, or hydro-carbons. The simplest composition of such an atmosphere would be hydrogen containing water vap r, or carbonic acid, or a mixture of carbon-monoxid and carbonic acid. A very suitable mixture for that atmosphere may be derived, for instance, from the mixture of gases and vapors incident to the incomplete combustion of illuminating gas procured by the ignition thereof at the base of air feed openings of a Bunsen burner, the said mixture of gases and vapors being collected from the burner tube.

In practice I mount the incomplete filament in a suitable container filled with the described gas and then apply the electric current for the elimination of the carbon at a moderate heat and the consolidation and cementation of the particles into a dense, compact and coherent filament of osmium at a heat at which platinum would volatilize. Thus by the action of the electric current and the heat developed thereby, while the filament is in the presence of an atmosphere of the protective gas, the carbon is eliminated and the osmium particles cemented into a complete dense coherent filament which incandesces at a temperature above that at which platinum volatilizes and is consequently of great efficiency as an incandescent electric filament. The filaments thus produced are readily distinguishable in that they are free from carbon, extremely dense and coherent, have the necessary flexibility and resiliency or elasticity, and depend upon osmium not only for their conductivity, but for the incandescence which is produced at a temperature at which platinum would be melted.

The osmium short of absolute purity contains certain oxids as impurities which are not entirely volatile even when brought to dazzling incandescence in an atmosphere of protective gas, yet they may be volatilized from the osmium in the presence of other oxids, such as titanic acid, alumina, magnesia, and the like which are more volatile, and volatilize when brought to incandescence.

With osmium in a state of absolute purity the metallic particles are more readily and thoroughly consolidated and cemented into a stable, dense, homogeneous, coherent and elastic filament, so it is of the greatest importance to eliminate all such oxids from the osmium of my osmium threads to permit of a more intimate contact of the metallic particles and that I do by adding to my osmium paste a suitable quantity of titanic acid or an oxid which volatilizes when brought to incandescence and then treating the threads made therefrom in the same manner as my hereinbefore described osmium threads in which treatment the titanic acid, or other oxid used for the purpose will be volatilized and the impurities eliminated by their volatilization when the filament has reached a dazzling incandescence in the protective gas following the elimination of the carbon from the binding material which takes place at a lower temperature.

In carrying out this process of refining the osmium and the consolidation of its particles I prefer to use titanic acid though there may be used to advantage all oxids of a more basic character which will volatilize when brought to incandescence as for example alumina and magnesia. Silicic acid will not answer the purpose. However thoria and zirconia may be used for the removal of the impurities in which case these oxids would appear as a coating firmly united to the surface of the osmium. I take the titanic acid, or oxid used, in a very finely divided condition and add it to the very finely divided osmium and binding material that it may be thoroughly and intimately incorporated therewith into a smooth, stiff, uniform paste consisting of osmium, titanic acid, or whatever oxid may be used, and a suitable binding material, using of osmium and titanic acid, or of the oxid used, their corresponding chemical equivalent in weights, as for example ten parts in weight of osmium and four parts in weight of titanic acid. The paste is then given its filamentary thread-like form as hereinbefore fully set forth.

The surface of the threads or whatever the form may be, should be smooth and nearly brilliant, otherwise they should be rolled between mirror-glasses which are parallel to, and of a certain distance from each other and coated with smooth paper or similar material. Then the filamentary threads are while still in a flexible condition formed into the required shape, although they may at a subsequent stage in the treatment be given their final desired form and treated through-

out in the manner hereinbefore set forth. In carrying out that treatment after the osmium thread has been placed in the electric current, in a suitable protective gas such as heretofore described, I apply the current, first slowly and until the carbon of the binding material has been eliminated, but afterward intensely heated to a condition of dazzling incandescence when the titanic acid is volatilized and the impurities eliminated,—this should not be effected too quickly,—leaving the osmium in a state of purity as a stable, dense, homogeneous, coherent and elastic filament of great durability suitable for use as the filament in an electric lamp when placed *in vacuo* or suitable protective gas and heated to incandescence at a temperature above that at which platinum volatilizes when it will emit an intensely brilliant light. A peculiarity of my osmium filament is that it will for a long time withstand a temperature above that at which platinum volatilizes. The completed filament is now ready for mounting in the lamp bulb,—being connected to the leading-in wires by an osmium cement as set forth in my application of even date herewith,—which is filled with the protective gas, and the filament should be heated to high incandescence and kept so while the bulb is being evacuated.

My osmium filament may be coated with an enamel-like coating of thoria, zirconia or like oxids, and that may be accomplished by either changing the ingredients of the paste from which the untreated osmium threads are made, or by applying a coating to the thread and subjecting it to high incandescence in a protective gas, in either case the oxid appearing as a firmly united enamel-like coating on the surface of the osmium. Taking thoria as the example I would, if it is to be added to the paste, make use of, for example, three parts osmium, one part thoria, and three tenths parts alumina with the necessary suitable binding material, thereafter treating the paste and the threads made therefrom the same as hereinbefore set forth, and I find that when brought to high incandescence in the protective gas the alumina is in whole or part volatilized, the impurities eliminated, while the thoria appears as a firmly united enamel-like coating on the surface of a dense, coherent core or wire of osmium, thus producing a strong and durable osmium-thoria-coated filament, that will incandesce at temperatures above that at which platinum volatilizes and emitting an intensely brilliant light.

While I prefer to use alumina it may however be omitted as an ingredient in the last mentioned paste the thoria alone acting as the purifying agent. If zirconia be substituted either in whole or part for the thoria it should as an example be used in correspondingly chemical equivalent in weight. If applied as a coating to the already formed osmium filament I make a smooth uniform paste of a cream-like consistency of, for example, three parts thoria and one part alumina which I apply to the filament with a brush or in any other suitable or convenient way so long as the filament is uniformly coated with the paste, and so coated I again subject the filament to high incandescence in a protective gas which under the influence of the heat and the electric current leaves the oxid firmly united or cemented as an enamel-like coating on the surface of the osmium filament producing as in the former case a dense coherent osmium-thoria-coated filament possessing the properties and characteristics heretofore mentioned. Zirconia may be substituted for the thoria using it for example in corresponding chemical equivalent weight. The alumina may, as in the case of the paste, be omitted. The osmium thread may before it is subjected to electrical treatment, be coated in like manner and then electrically treated as herein specified for the production of an osmium filament.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:—

1. An incandescent filament for an electric lamp consisting of osmium in a dense, coherent and elastic condition incandescing at a temperature at which platinum volatilizes substantially as set forth.

2. An incandescent filament for an electric lamp composed of particles of osmium cemented together by the action of the electric current and heat, at a temperature above the melting point of platinum into a self sustaining thread or wire like filament substantially as set forth.

3. A filament for an electric incandescent lamp composed of a series of osmium particles electrically welded into a dense coherent and elastic self sustaining strip or thread which will incandesce at a temperature above that at which platinum melts substantially as set forth.

4. A dense, coherent and elastic strip or thread of osmium which when used as the filament in an electric incandescent lamp will incandesce at a temperature above the melting point of platinum substantially as set forth.

5. A filament for an electric incandescent lamp composed of osmium and a coating of thoria, substantially as set forth.

6. The process of producing filaments for incandescent electric lamps, which consists in forming a threadlike body from a paste containing a refractory metal and an agglu-

tinating material, eliminating from said thread-like body the agglutinating constituent thereof in a protecting environment, thereby leaving a corresponding thread-like body of metallic particles, and progressively consolidating and uniting said particles into a compact, coherent, elastic final filament, by the passage therethrough of an electric current at a heat finally reaching dazzling incandescence; substantially as described.

7. The process of producing filaments for incandescent electric lamps, which consists in forming a thread-like body containing a refractory metal, subjecting it to the action of an electric current until it is converted into a series of metallic particles preliminarily sintered together, and then progressively raising the temperature of said body by a gradual increase of the current until the preliminarily sintered particles are united into a compact, coherent, elastic filament; substantially as described.

8. The herein described process of making filaments for incandescent electric lamps from a thread composed of a carbonaceous material, and osmium, consisting in distilling off the volatile constituents of the carbonaceous matter, and then removing the carbon by subjecting the material to the action of an electric current in the presence of a gas which will combine with the carbon but which is inert with respect to the metal, and by the action of electric current causing the particles to cohere substantially as set forth.

9. The process of making filaments for incandescent electric lamps, which consists in forming a paste containing carbonaceous matter and osmium, forming said paste into the desired filamentary shape, distilling off the volatile constituents of the carbonaceous matter, and then removing the carbon by subjecting the material to the action of an electric current in the presence of a gas which will combine with the carbon but which is inert with respect to the metal and by the continuous action of the current causing the particles to cohere into a thread or wire like filament substantially as set forth.

10. The process of making filaments for incandescent electric lamps, from a paste of collodion, and osmium, which consists in forming the incandescent body therefrom, denitrating the collodion and subjecting the same to the action of the electric current in the presence of a gas which unites with the carbon and which will be inert to the metal, and by continuing the current cementing the metallic particles into a self sustaining filament, substantially as set forth.

11. The herein described process of making filaments for incandescent electric lamps from a paste of osmium, thorium, alumina and a binding material, consisting in molding the paste into a suitable wire or thread like form, subjecting the same to dry distillation and afterward eliminating the binding material by the heat of an electric current passing through the filament in the presence of a suitable atmosphere of gases, and by the continuous action of the electric current causing the particles to cohere into a dense, coherent and elastic incandescent filament substantially as set forth.

12. The herein described process of making a filament for incandescent electric lamps from a paste of osium, titanic acid and a binding material, consisting in molding the paste into a suitable wire or thread like form, subjecting the same to dry distillation in a protective gas and eliminating the binding material by the heat of an electric current passing through the filament in the presence of a suitable atmosphere, and by the continuous action of the electric current and at a temperature above the melting point of platinum volatilizing the titanic acid and eliminating the impurities and causing the particles to cohere into a dense, coherent and elastic incandescent filament substantially as set forth.

13. The process of making a filament for incandescent electric lamps from a paste of osmium, an oxid of more basic character which volatilizes when brought to incandescence and a binding material, consisting in molding the paste into a suitable wire or thread like form, subjecting the same to dry distillation in a protective gas and eliminating the binding material by the heat of an electric current passing through the filament in the presence of a suitable atmosphere, and by an increase of the electric current developing a heat at which the oxid volatilizes and eliminates the impurities and causes the particles to cohere into a dense, coherent and elastic incandescent filament substantially as set forth.

14. The herein described process of making filaments for electric incandescent lamps from a paste of osmium, an oxid which will volatilize when brought to incandescence and a carbonaceous binding material, consisting in molding the paste into threads or the desired filamentary form, subjecting the same to dry distillation, then applying the electric current first slowly and until the carbon of the binding material has been eliminated at a comparatively low heat, then increasing the current until the filament is heated to dazzling incandescence when the oxid used, is volatilized and the impurities eliminated and the osmium cemented into a state of purity as a stable, dense, homogeneous, coherent and elastic filament substantially as set forth.

15. The process of making filaments for

incandescent electric lamps, which consists in producing a thread-like body of loosely-coherent metallic particles, and then progressively raising the temperature of said body to dazzling incandescence, by the passage therethrough of an electric current until said particles are united into a compact, coherent elastic filament; substantially as described.

Signed this 27th day of July 1898.

CARL AUER VON WELSBACH.

Witnesses:

LUDWIG HAITINGE,

ADOLF GALLIA.