UNITED STATES PATENT OFFICE.

FRITZ BAUMANN, OF AUGSBURG, GERMANY, ASSIGNOR TO THE FIRM OF WOLFRAM-LAMPEN AKTIENGESELLSCHAFT, OF AUGSBURG, GERMANY.

PROCESS OF MANUFACTURING FILAMENTS FOR INCANDESCENT ELECTRIC LAMPS.

1,205,080. Specification of Letters Patent. Patented Nov. 14, 1916.

No Drawing. Application filed March 8, 1913. Serial No. 753,135.

To all whom it may concern:

Be it known that I, Dr. FRITZ BAUMANN, a citizen of the German Empire, residing at Augsburg, Bavaria, Germany, have invented certain new and useful Improvements in Processes of Manufacturing Filaments for Incandescent Electric Lamps, of which the following is a specification.

My invention relates to a process of manufacturing filaments consisting of tungsten containing small admixtures of metals, such as chromium, vanadium, niobium, tantalum, osmium, ruthenium, zirconium and thorium, for electric incandescent lamps.

Filaments for electric incandescent lamps are well-known which consist of a sintered mixture of metallic tungsten containing small admixtures of metals, such as those mentioned above, which effect the sintering. These filaments are made by finely divided metallic tungsten containing small admixtures of metals or oxids, which cause the sintering of the tungsten or other compounds of these metals, being formed into filaments in known manner after being mixed with a moldable organic binder, whereupon after carbonization the carbon is removed from the filaments likewise in known manner by heating them in an atmosphere of water vapor and hydrogen, whereupon the filaments are exposed for a few seconds to a very high temperature and thereby sintered. Incandescent filaments of great strength and considerable elasticity have been obtained in this manner. Careful tests have, however, shown that by correctly adding the additional metals or compounds and by correspondingly increased sintering, filaments are obtained which are not only sufficiently strong and very elastic, but are immediately ductile and can be bent considerably without rupturing at ordinary temperatures; in other words, these incandescent filaments possess all the properties of a drawn wire. Such ductile incandescent bodies can be obtained by the usual pressing or paste process in sizes such that the same can be used at once in the incandescent lamp for their subsequent employment. The manufacture of filaments by the paste process, however, is found in practice to be very troublesome and expensive besides having many difficulties attached to it.

A primary object of my invention is to provide a process consisting in making tungsten bodies of large dimensions or section containing an admixture of the said metals or metallic compounds, which cause the tungsten to sinter, and in heating said bodies to such a high temperature by the electric current that they are immediately ductile and can be subjected to a drawing process. To this end I very intimately mix powdered metallic tungsten, or an oxid of tungsten, or tungstic acid from which the metal is obtained for example by reduction by means of hydrogen, with one or more of the said auxiliary metals, or with a suitable compound of these metals, or with several thereof, the proportions of the mixture depending entirely on the kind of the metal, or metals, or metallic compounds, and preferably being between 0.1 and 10%. The quantity of the addition, if of metal, will be smaller, than if a compound of a metal is used. It must, in any event, be in such quantity that a substantial amount of the added metal remains in the finished rod or bar. I then press these mixtures in well-known manner into rods or bars, using suitable molds and employing a very high pressure. The molding may be effected with or without the aid of a binder, and the rods or bars may have a round, square or rectangular section. I then heat the metallic bodies thus molded in a reducing atmosphere, *e. g.*, hydrogen, or *in vacuo*, for a considerable time to a temperature between 1000° and 1500° C., when the same noticeably shrink and become more solid. These preliminarily burnt rods or bars are then secured by suitable clamps in metallic receivers through which hydrogen flows, and then alternating current of such a strength is passed through them that they are heated to almost of melting point. The strength of the current and the time during which it flows is dependent, on the one hand, on the selected dimensions of the rod and, on the other hand, on the kind and quantity of the admixed metals or compounds.

As admixtures metallic thorium and compounds of thorium have proved most suitable, and when the conditions are properly selected metallic bodies can be obtained having a square section of from 0.5 to 8 mm. length of side which are directly flexible at ordinary temperatures after the sintering process is completed, and are not decidedly brittle and fragile like those of

pure metallic tungsten. The final product obtained after heating to such a high temperature must be considered to be an alloy or a solid solution of tungsten and the mentioned metal, thus, *e. g.*, when thorium is used, a tungsten-thorium alloy. The surprising fact that metallic tungsten which is naturally so brittle is obtained ductile and, in addition, in such large dimensions in the described manner by heating it for a suitably long time and at a suitably high temperature in a suitable atmosphere can be explained only on the assumption that the admixed metals distributed exceedingly finely and homogeneously in the powdered tungsten so intimately weld together the particles of tungsten, by forming an alloy or a solid solution, that their physical or molecular properties are thereby completely changed. The mere appearance of these metallic bodies proves this. In contradistinction to rods of pure tungsten which are sintered in a similar manner and have a decided crystalline structure and a rather rough surface, these metallic bodies have no trace of granulation or crystallization and have an absolutely smooth surface of very great brilliance. It is particularly important to employ a suitable starting material, to which the said metals or metallic compounds are to be added in a state of fine distribution. A number of tests have shown that the sintering process takes place most readily when amorphous tungsten is employed as starting material. The sintering can however be effected until ductility is obtained also with all gradations of fineness of the metal from fine to coarse crystalline. It is, however, clear that the sintering process is then rather more difficult and slower when it is wished to attain the same end. These rods which are already ductile can be directly subjected to the drawing process when they have relatively small dimensions. If rods or bars of larger dimensions are employed, however, for increasing capacity or for other reasons, it is necessary to reduce them previously to smaller dimensions. This can be simply done in well-known manner by rolling or hammering, and the reducing operation can take place at ordinary temperatures, or it may be performed more rapidly than at ordinary temperatures when an increased temperature is employed. Thus whereas in the otherwise customary process of manufacturing ductile wire of pure metallic tungsten, the same must be so changed in its physical and molecular properties after the sintering by repeated mechanical treatment, such as rolling, hammering and the like, increased temperatures being constantly employed, that it gradually becomes ductile even at ordinary temperatures, according to the present process by means of the suitably conducted sintering process I obtain ductile metallic bodies which contain a high percentage of tungsten and can be readily drawn into the finest wires. This denotes considerable progress in the art and material simplification and reduction of cost of the process.

The real drawing process may be carried out from the beginning without employing high temperatures, but, of course, particularly at first, the process is facilitated by simultaneously using increased temperatures. The drawn wires are exceedingly strong and their tensile strength is greater than that of pure tungsten wire. The result, *i. e.*, the possibility of making ductile metallic bodies containing such a high percentage of tungsten in the described manner, was the more surprising owing to numerous tests having shown that, when these bodies are used as filaments for electric incandescent lamps, in contradistinction to drawn pure tungsten wire they do not suffer any molecular changes and do not become brittle, like the latter, after long heating. Even after burning for a thousand and more hours the new wires can be bent at ordinary temperatures without breaking. Whereas drawn wire composed of pure tungsten has the great disadvantage that its structure changes completely after it has burnt for a relatively short time, as it again assumes the structure of the starting material and thereby becomes brittle and fragile, in the ductile metallic bodies made according to my improved process this phenomenon is not met with, this being an additional proof that metallic tungsten has experienced during the sintering process, and owing to the admixtures, a thorough physical change owing to the formation of an alloy or a solid solution which no longer allows the tungsten to recover its original non-ductile condition. At first it was feared that when these wires were heated for a long time in incandescent lamps, the auxiliary metals would be gradually distilled out and that the lamp bulbs would be blackened and the light diminished. A series of electric, photometric and chemical investigations has, however, shown that this is not the case, but that the admixtures quantitatively remain in the wire. On the contrary, it has been found that these wires offer greater resistance to atomization than pure tungsten wire and consequently can be more severely loaded, so that lamps can be made with them possessing a specific consumption of energy less than 1.0 watts per Hefner candle-power.

I claim:—

1. The process of manufacturing a ductile rod or bar containing a large percentage of metallic tungsten and alloyed therewith a small admixture of an auxiliary, preferably highly refractory metal, which consists in intimately mixing finely-divided tungsten

or a compound thereof with a small proportion, from 0.1 per cent. to ten per cent., of such finely-divided auxiliary metal or a compound thereof, in pressing the mixture thus obtained into the form of a bar, then heating the bar in a non-oxidizing atmosphere for a considerable time to a temperature between 1000° and 1500° C. to shrink and solidify the bar, and then heating the bar now consisting of tungsten alloyed with the auxiliary metal almost to the melting point in a reducing atmosphere, whereby the bar is sintered and on cooling can be stretched, rolled or drawn.

2. The process of manufacturing a ductile rod or bar containing a large percentage of metallic tungsten and a small admixture of metallic thorium, which consists in intimately mixing finely-divided tungsten or a compound thereof with a small proportion, from 0.1 per cent. to ten per cent., of thorium or a compound thereof, in pressing the mixture thus obtained into the form of a bar, then heating the bar in a non-oxidizing atmosphere for a considerable time to a temperature between 1000° and 1500° C. to shrink and solidify the bar, and then heating the bar now consisting of tungsten alloyed with thorium almost to the melting point in a reducing atmosphere, whereby the bar is sintered and on cooling can be stretched, rolled or drawn.

3. The process of manufacturing a ductile rod or bar containing a large percentage of metallic tungsten and a small admixture of metallic thorium, which consists in intimately mixing finely-divided amorphous tungsten with a small proportion, from 0.1 per cent. to ten per cent., of thorium or a compound thereof, in pressing the mixture thus obtained into the form of a bar, then heating the bar in a non-oxidizing atmosphere for a considerable time to a temperature between 1000° and 1500° C. to shrink and solidify the bar, and then heating the bar almost to the melting point in a reducing atmosphere, whereby the bar is sintered and on cooling can be stretched, rolled or drawn.

In testimony whereof I affix my signature in presence of two witnesses.

DR. FRITZ BAUMANN.

Witnesses:
RICHARD LEMP,
JOHANNA STERN.