

UNITED STATES PATENT OFFICE.

ERNST AUGUST KRÜGER, OF SEEHAUSEN, ALTMARK, GERMANY.

PROCESS OF PRODUCING TUNGSTEN FILAMENTS.

1,154,701.

Specification of Letters Patent.

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No Drawing.

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To all whom it may concern:

Be it known that I, ERNST AUGUST KRÜGER, a citizen of the German Empire, residing at Seehausen, Altmark, in Germany, have invented certain new and useful Improvements in the Process of Producing Tungsten Filaments, of which the following is a specification.

The object of this invention is to provide an improved process of producing wire and filaments of tungsten and tungsten alloy. In my invention I use, as raw material for the filament, a mixture of powdered tungsten with a small proportion of carbon and boracic acid or other compound of boron.

My invention consists in a particular manner of carrying out the process of manufacture with the raw material indicated.

According to the invention I first produce a rod consisting of powdered tungsten with a small proportion of carbon and a boron compound, preferably boracic acid, less than 1% of the latter being usually sufficient and only a small trace of carbon, about 0.1%. I may use the boracic acid in the form of powder. I moisten the mixture with water. I may also mix the tungsten powder and carbon alone, and form a rod of this mixture, by pressure, and then impregnate the rod *in vacuo* with a concentrated solution of boracic acid. The rod is then heated to about 1000 or 1200° C. whereby the boracic acid is caused to slowly swell and expel the air or other gas present from the minute interstices between the tungsten particles. This expulsion of gas is highly important for the purpose of obtaining nonporous wire. The melting boracic acid cements the metal particles to each other, and at the same time the superficial oxid layers dissolved by the boracic acid. Thus purely metallic tungsten particles come into intimate contact with each other, and can by subsequent treatment be sweated or fused together to produce a perfectly homogeneous structure. When the temperature reaches its higher values the boracic acid is probably reduced to boron, or causes carbide of boron to be formed, with the result that an alloy of tungsten and boron or boron carbide is obtained. This is accompanied by considerable shrinkage of the mass. After the rod has been kept for some time at the temperature mentioned, I heat it to a temperature between 1200 and 2000° C. by means of electric current, in a stream of hydrogen, whereby the metal par-

ticles are fused together, and a very homogeneous structure, free from cavities or crevices, is obtained. The rod is then formed into wire by suitable mechanical treatment adapted for this purpose. The presence of the boron reduces the liability to attack by oxygen, so that there is no necessity for careful exclusion of atmospheric air in the course of the mechanical treatment. The rod being free from cavities, the wire obtained is free from those crevices which always occur in forming wire of pure tungsten.

The wire or filament obtained can be used in the manufacture of electric glow lamps.

Inasmuch as the filament of tungsten alloy is quite as efficient as pure tungsten filament, for glow lamp purposes, it is in general not necessary to eliminate the boron by special treatment. As a matter of fact, the heating of the filament in the lamp to a large extent eliminates the boron, which does not blacken the bulb, but forms a thin transparent deposit. The expulsion of the boron from the filament in the bulb also improves the vacuum, the residual air being mechanically deposited, and perhaps in part chemically combined.

If it is desired to have a pure tungsten filament, I heat the filament to incandescence for a lengthy period, *in vacuo*, say to a temperature of 2000 or 2200° C. and then again hammer or roll and draw the filament, with heat.

The process described has very considerable advantages over the process of producing filament from pure tungsten. Particles of metallic tungsten are always coated with oxid, which renders it very difficult to bake them together, and the result is that minute cavities are left, into which air penetrates and causes further oxidation. Admixture to the tungsten powder, such as silver and nickel, which have been proposed, do not result in the production of perfectly homogeneous wire, and when such admixtures are expelled they leave the rod in a porous or spongy state, and when the rod is drawn out, to a filament, the latter is found to have cracks and crevices.

I am aware that it has heretofore been proposed to manufacture filaments for incandescent lamps by mixing metals such as tungsten and molybdenum with oxides of boron and a binding agent containing carbon, the mixture being heated to carbonize

the binding agent, and then heated to white heat by current, in a stream of hydrogen. In this process only so much of the metal is used as will render the mixture conductive
5 at ordinary temperatures, so that the whole of the tungsten or molybdenum becomes alloyed with boron.

Having now particularly described and ascertained the nature of my said invention
10 and in what manner the same is to be performed, I declare that what I claim is:

The process of producing a filament of tungsten or tungsten alloy, which consists in forming, by pressure, a rod consisting
15 of a mixture of powdered tungsten with a

small proportion of carbon and boracic acid or other boron compound, heating said rod to a temperature of about 1000 to 1200° C. at which the particles cake together, then heating the rod to incandescence by electric
20 current in a stream of hydrogen, and then reducing the rod to wire by mechanical treatment.

In witness whereof I have signed this specification in the presence of two wit-
25 nesses.

ERNST AUGUST KRÜGER.

Witnesses:

WOLDEMAR HAUPT,
HENRY HASPER.