July 11, 1939. C. SPAETH 2,165,310

FILAMENT

Filed Aug. 14, 1936

Fig. 1.

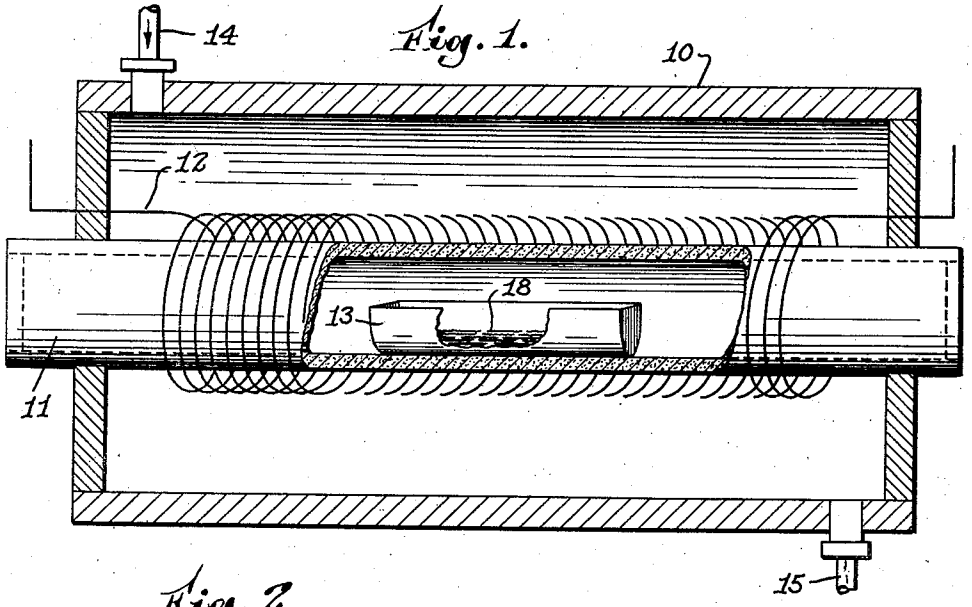


Fig. 2.

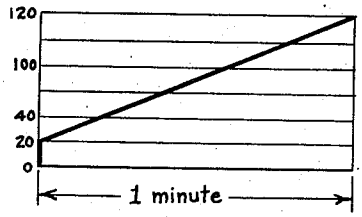


Fig. 3.

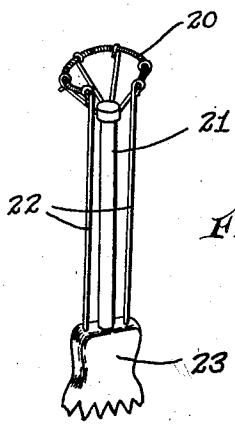


Fig. 4.

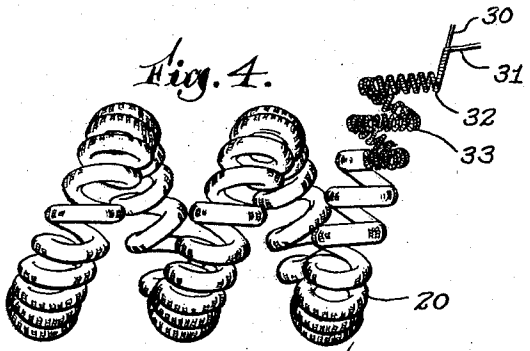
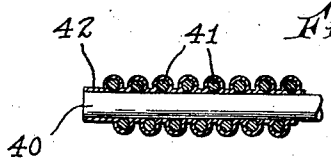


Fig. 5.



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FILAMENT

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Application August 14, 1936, Serial No. 96,040

11 Claims. (Cl. 176—132)

This invention consists in a novel process of making non-sag filaments of tungsten wire for use in incandescent lamps. It includes within its scope the novel filament produced by the process of my invention.

Tungsten wire filaments as heretofore constructed have required special treatment to prevent sagging due to crystalline displacement when operated at the temperature of incandescence in electric lamps. The treatment formerly necessary has required heating of the filament wire at a temperature between 1600° and 1700° C. in order to settle the tungsten crystals permanently in shape. Such treatment has been difficult because furnaces capable of operating at such high temperatures have a short life and are not readily available as commercial equipment.

Other expedients relied upon in producing non-sag tungsten filaments have required the use of additives such as thorium oxide, rare earth metal oxides or rare earth metal nitrides which are expensive to procure or require considerable skill and experience in working.

I have discovered that a satisfactory non-sag filament may be produced from substantially pure tungsten wire by certain steps of procedure which obviate the difficulties above discussed. In one aspect my invention consists in reinforcing the structure of the tungsten wire by forming a ferrous, nickel or other reinforcing alloy in surface portions of the wire. This may be readily effected by a series of steps well adapted for processes of commercial manufacture and at little expense and may be advantageously combined with a heat treatment of the filament wherein a preliminary and partial settling of the crystalline structure of the tungsten is effected at a temperature between 1000° and 1300° C., followed by a final heating at higher temperature after the filament has been mounted permanently in the lamp in which it is to serve.

I have found that a satisfactory crystalline adjustment of the tungsten wire filament may be effected by a process having two essential steps, the first step consisting in subjecting the filament for an interval of from 3 to 10 minutes to a temperature of about 1000° to 1300° C. which is a temperature easily secured in commercial furnaces. The treated filament is then cooled and mounted in its position in an incandescent lamp, surrounded by the usual argon or nitrogen gases, heated to a temperature below the temperature used in the previous firing in the furnace and then rapidly raised to a temperature, for example, of approximately 2700° C. for a 300 to 500 watt filament. At about this temperature the final or complete settling of the crystalline structure takes place whereas for filaments of smaller capacity a somewhat lower temperature will suffice.

Preferably the preliminary heating is carried out in an atmosphere of nitrogen, hydrogen or a non-oxidizing gas and in the presence of iron, nickel or some other element having a lower melting point and a higher vapor pressure than tungsten. Under such circumstances the iron or other metal is vaporized and deposited upon surface portions of the filament. The low melting point metal may be present as a core upon which the tungsten wire is wound and deposited simultaneously with the preliminary step of the heat treatment, or iron may be made available by being electrolytically deposited or plated upon the surface of the tungsten wire by any satisfactory plating process. As a practical matter it is convenient to deposit an excess amount of iron or nickel upon the surface of the tungsten wire, and this may be subsequently removed by a suitable acid solvent. If an iron or nickel core has been employed, this may be dissolved at the same time and only so much iron is left in the filament as has entered into the molecular interstices of the tungsten structure.

The filament is completed by subjecting it to steps which complete the settling of the tungsten crystals and cause the iron or nickel to be interalloyed with the tungsten. These two changes of physical characteristics may be effected by mounting the filament in the lamp in which it is to be finally used, then raising the filament to a temperature slightly below that at which the previous heating step left off, and finally rapidly raising the temperature of the filament to approximately 2700° C. This may be conveniently effected by placing the filament in electric circuit, first at a potential of about 20 volts, and then raising the potential rapidly to approximately 120 volts, under which condition the filament is raised to incandescence and goes through the changes above discussed.

The process of my invention is applicable with special advantage to stabilizing coil filaments, for example such as the double or triple coil filaments disclosed in my co-pending application Ser. No. 15,605, filed April 10, 1935. The fact that the new process of my invention in settling or stabilizing the structure of such coiled coil filaments requires lower temperature in the heat treatment of the metal, makes the filament wire less brittle than heretofore. The addition of the reinforcing alloy of iron or the like reduces the

rate of evaporation of the tungsten and this in turn reduces the tendency of blackening the bulb by vaporizated deposit from the filament and therefore results in a better lumen maintenance than it has been possible to secure from lamps heretofore known.

These and other features of the invention will be best understood and appreciated from the following description of a preferred embodiment thereof and of one manner in which the process may be carried out, as illustrated in the accompanying drawing, in which—

Fig. 1 is a sectional view, somewhat diagrammatical in form, of a furnace with a number of filament blanks in process of treatment therein.

Fig. 2 is a diagram suggestive of the electrical heating step of the process.

Fig. 3 is a view in perspective showing a mounted coiled filament.

Fig. 4 is a view in elevation on a greatly enlarged scale of a portion of a triple coiled filament, and

Fig. 5 is a sectional view on a still larger scale showing a filament coiled upon its mandrel and coated with an iron deposit.

The filament is first coiled in the shape in which it is to be eventually used in the finished lamp. If a filament of the single coil type is required, tungsten wire 41 may be coiled about an iron mandrel 40 as suggested in Fig. 5. In preparing a double or triple coiled filament the tungsten wire 31 may be first coiled about a tungsten mandrel 30 to form the primary coil, as shown in Fig. 4. The primary coil may then be coiled about an iron mandrel to form secondary coils 32 and the secondary coils, with the enclosed mandrels, may be coiled about another iron mandrel to form tertiary coils 33. A coil of this character is illustrated in Fig. 4.

Having shaped the filament as above outlined, a number of the filament blanks 18 are placed in tray 13 and inserted in a high temperature furnace, such for example as that illustrated in Fig. 1. This furnace is one of a type which is commercially available and comprises an outer casing 10 in which is placed a muffle 11 of alundum or other porous and highly refractory material. A heating coil 12 for the muffle is conventionally represented in Fig. 1. The casing 10 is provided with an inlet pipe 14 at the upper left hand corner and with an outlet pipe 15 at its lower right hand corner by means of which non-oxidizing gases, such as nitrogen or hydrogen, may be supplied to the furnace so that the heat treatment of the filament blanks may be carried out in a non-oxidizing atmosphere. It will be understood that the material of the muffle 11 is sufficiently porous to permit the gas to permeate it. The filament blanks 18 in single, double or triple coiled form are laid side by side in a tray 13 of molybdenum or of a material which is not affected by the temperature of the furnace.

Having placed the filament blanks 18 in the furnace as above explained the temperature of the furnace is raised to between 1000° and 1300° C. and the filament blanks subjected to this temperature for a period of about 5 minutes in an atmosphere of nitrogen or hydrogen preferably which has been passed through a water bath so that it has picked up some moisture. As already explained this step of the process may be carried out in a commercial furnace readily available and having a long life under the circumstances of use outlined.

It will be noted that during this step of the treatment the tungsten wire is wound upon a core of iron, nickel or the like, of a lower melting point and a higher vapor pressure than the tungsten. Accordingly, at a firing temperature of 1000° to 1300° C. an appreciable amount of core material is vaporized and deposited upon the surface of the tungsten wire.

The heat treated blanks are now removed from the furnace and allowed to cool. They are then immersed in a suitable acid, such as hydrochloric, and the iron core or cores dissolved. At the same time any excess amount of iron which may have been deposited upon the wire of the coil is also removed and the coating reduced to a thin ferrous film intimately associated with the surface structure of the tungsten.

Having now subjected the filament blanks to a preliminary heat treatment which is effective partially to settle the crystalline structure of the tungsten, the filaments are given the final shape under which they are to operate and mounted as suggested in Fig. 3. In this figure the coil filament 20 is shown as supported by hooks above the end of a glass rod 21 which projects from the press 23 of the lamp. Lead wires 22 are sealed into the press 23 and connected to the ends of the filament. The filament with its mount is sealed into a lamp bulb, not shown, in the usual manner, the bulb is exhausted and filled with argon gas, an argon-neon mixture or the like and then connected in electric circuit. The filament is now electrically heated to a temperature somewhat below that at which the preliminary heat treatment left off, i. e., approximately to 1000° C. If the filament is intended for a 120 volt lamp the initial voltage of the circuit may be 20 volts as suggested in Fig. 2, and in any case an initial voltage is used which will produce the desired heating condition.

Having brought the filament to an initial temperature of approximately 1000° C. the voltage is raised gradually and progressively to a point at which the filament is heated to approximately 2700° C. at which temperature a complete settling of the crystalline structure takes place and also a complete alloying of the iron or nickel coating with the tungsten of the filament. This final heat treatment of the coil may be effected in a period of about one minute as suggested in Fig. 2.

Fig. 5 is suggestive of the alternative step of electrolytically providing the coiled filament with a coating of iron, nickel or the like. In this instance the tungsten wire 41 coiled upon a mandrel 40 is immersed in a solution of ferrous chloride and sodium tungstate and placed in an electric circuit as the anode of a plating system. The iron from the solution is thus deposited in a film or coating 42 upon the core 40 and the coil 41. Subsequently the thickness of the coating may be reduced to a surface film, or merely to traces of iron in the surface structure of the tungsten, and it is this iron which is subsequently alloyed with the tungsten by the heat treating steps above set forth.

It may be noted that if an ordinary coiled coil filament is heated to 1000° to 1300° C. and the mandrel on which it was wound is dissolved by an acid, that coil does not maintain its shape but is likely to alter in pitch, turns per inch, internal diameter, etc., because the temperature to which it has been subjected is too low to settle the crystalline structure of the wire. The result is that under these circumstances the coil

will uncoil itself and acquire a distorted shape. The process of my invention as above described is fully effective in settling the crystalline structure of the tungsten so that the coils will maintain their form as originally determined by the coiling machine because the vaporized ferrous coating tends to hold the coils in the shape originally imparted to them, and all this is effected without requiring a furnace treatment of over 1300° C.

Among the numerous advantages resulting from the process of my invention is that of reducing the brittleness of the treated filament as compared with filaments of this kind heretofore known. When the crystalline structure of a tungsten filament is stabilized at a temperature of 1600° to 1700° C. it is rendered brittle to an extent that causes an objectionable amount of breakage due to vibration in handling, in mounting, or in shipment. The preliminary heat treatment at lower temperature, followed by the final treatment at higher temperature in accordance with my novel process results in a more ductile product well adapted to withstand the shocks and vibrations of handling and shipping.

Another important advantage is in increased life of filament. This is due to the fact that the metal alloyed with the surface of the tungsten wire substantially reduces the rate of vaporization of the filament material in use. This not only reduces waste from the filament itself but reduces blackening of the bulb and thus increases the useful life of the lamp to a marked extent as well as its burn-out life compared on a basis of equal initial efficiency in lumens per watt with lamps heretofore known.

I have described the process of my invention having in mind particularly the treatment of filaments for a 300 to 500 watt lamp and while the temperatures and intervals mentioned are satisfactory for the treatment of such filaments, it will be understood that some variation in these respects is permitted and expected. For example, in treating filaments for smaller lamps a final temperature of 2300° or 2400° C. may be adequate. The time of treatment moreover may vary from a few seconds to several minutes depending somewhat upon the size of the filament being treated.

While it is desirable in general to carry out the heat treatment of the filament in a non-oxidizing atmosphere, it may be advantageous in some cases to include a small amount of water vapor, particularly for the purpose of removing any graphite lubricant which may be present upon the surface of the tungsten wire. If water vapor is present it is decomposed into hydrogen and oxygen and the oxygen will immediately combine with any traces of graphite present on the wire forming carbon monoxide or carbon dioxide which are washed out by the hydrogen. This not only cleans the wire but prevents the formation of surface carbides which tend to make the filament brittle.

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

1. The process of making non-sag tungsten filaments, which is characterized by winding a tungsten wire upon an iron core to form a helix upon the core, heating to cause iron from the core to vaporize and deposit upon the tungsten wire of the filament, dissolving the core, and then heating to cause the remaining iron and tungsten to become alloyed.

2. The process of making non-sag tungsten filaments, which consists in coiling tungsten wire to form a filament, heating the coiled filament to a temperature of between 1000° C. and 1300° C. to effect a partial settling of the crystalline structure of the tungsten, cooling the filament, then heating it to approximately 1000° C., and finally rapidly raising its temperature to approximately 2700° C. to effect further settling of its crystalline structure.

3. The process of reinforcing and settling the crystalline structure of coiled tungsten filaments, which consists in preliminarily heating the tungsten wire of a coiled filament in the presence of iron simultaneously to effect a partial settling of the crystalline structure and to cause the deposition of iron vapor upon the surface of the wire, cooling the filament, and then heating it sufficiently to effect a further settling of its crystalline structure and to cause the iron thereon to become alloyed with the tungsten.

4. The process of making tungsten filaments, which consists in bending tungsten wire into substantially the shape of the finished filament, heating the filament thus formed to a temperature between about 1000° C. and 1300° C. in the presence of iron and in a substantially non-oxidizing atmosphere, allowing the filament to cool, and then raising its temperature to approximately 2700° C.

5. The process of making tungsten filaments, which consists in bending tungsten wire into substantially the shape of the finished filament for a 110 volt lamp, coating the filament with iron, heating it to a temperature between 1000° C. and 1300° C., allowing it to cool, and then electrically heating it by including it in a circuit wherein the potential is raised from approximately 20 volts to approximately 120 volts.

6. The process of making non-sag tungsten filaments, which consists in winding tungsten wire to form a coil, depositing a surface film of a metal of this iron-nickel group upon the coil, heating the coated coil to a temperature between 1000° C. and 1300° C., cooling the coil, then again heating it to approximately 1000° C., and finally raising said temperature to above 2200° C.

7. The process of making non-sag tungsten filaments which consists in winding tungsten wire on a core of metal having a lower melting point and a higher vapor pressure than tungsten, firing the coil to cause the core metal to vaporize and deposit upon the tungsten wire, then cooling the coil, and finally heating to a temperature alloying the two metals together.

8. The process of making tungsten filaments which consists in coiling tungsten wire into substantially the shape of the finished filament, coating the coil with metal of a lower melting point and higher vapor pressure than tungsten, heating the coated wire to a temperature of about 1000° to 1300° C., allowing the filament to cool and then alloying said metal and tungsten by including the filament in an electric circuit wherein the potential is sufficient to heat the filament to about 2300° to 2700° C.

9. The process of making non-sagging tungsten filaments, which consists in winding a tungsten wire upon a tungsten core to form a primary helix, winding the primary helix with its core upon an iron core, heating to cause iron from the iron core to vaporize and deposit upon the tungsten wire of the filament, removing the iron core, and then further heating to cause the de-

posited iron to become alloyed with the tungsten wire.

10. The process of making non-sagging tungsten filaments, which consists in winding a tungsten wire upon a refractory core to form a primary helix, winding the primary helix with its core upon an iron core to form a secondary helix, winding the secondary core upon another iron core to form a tertiary helix, heating to cause iron from said cores to deposit upon the tungsten wire of the filament, removing the iron cores, and then further heating to cause the deposited iron to become alloyed with the tungsten wire.

11. The process of making non-sag coiled coil tungsten filaments, which consists in winding a tungsten wire upon an iron core to form a helix, winding said helix with its core upon a second iron core, heating to cause iron from the iron cores to vaporize and deposit upon the tungsten wire of the filament, removing both the iron cores, and then further heating to cause the remaining deposited iron to become alloyed with the tungsten wire.

CHARLES SPAETH.