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COILED FILAMENT AND PROCESS OF MAKING IT

Original Filed June 1, 1922

Fig.1.

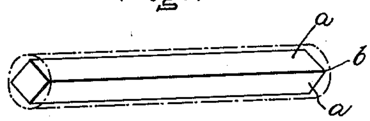


Fig.2.

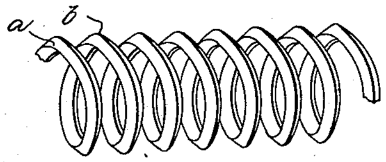
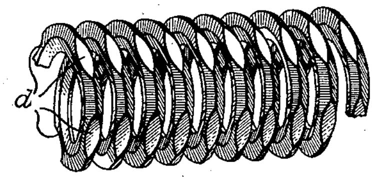


Fig.3.



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UNITED STATES PATENT OFFICE

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COILED FILAMENT AND PROCESS OF MAKING IT

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Helical or coiled filaments for incandescent lamps consisting of a single crystal of high melting metals, such as tungsten, have been made by starting with a wire which consists of a single crystal and winding this single crystal wire into a helix or cylindrical spiral.

Although single crystal wires of high melting metal, such as tungsten, in their use as incandescent lamp filaments in flattened or straight form are distinguished by special stability and by invariability of their mechanical properties, it has been shown that single crystal tungsten wires wound into helices or cylindrical spirals are but little suited for use as filaments for incandescent lamps, because during the burning in the lamp the individual turns of the helix are very much distorted so that the filament loses its original shape. The same thing occurs if coiled or helical filaments are made by winding a wire which consists of a few long crystals which interlock with each other or are overlapping.

The reason for this phenomenon is most probably that in the winding of the wire into a helix or coil, the single crystal or the long crystals constituting the wire undergo a marked bending which causes the outer part of each crystal to be stretched while the inner part is compressed, so that it is no longer in a state of equilibrium but on the contrary in a state of strain from which it endeavors to free itself. This strain produces forces which tend to straighten the bent crystals in an effort to regain equilibrium, these forces in any case sufficing at a sufficiently high temperature to distort the helical or coiled form given the filament and thereby render the incandescent lamp less useful.

Free from this disadvantage are coiled or helical filaments with an undistorted macrocrystalline structure composed of a single crystal or of a few long crystals which have suffered virtually no deformation or distortion from the original state of the crystal, and in particular have suffered no deformation or distortion through the winding of the wire into a helix. Such a coiled or helical filament behaves as though it were cut out of a single crystal or a few crystals laid one over the other. This is recognized if one etches a coiled filament produced in the manner described.

In the accompanying drawings of single crystal filaments etched to develop a characteristic shape or form Fig. 1 shows a straight single crystal wire, Fig. 2 a helix made by coiling a single crystal wire, and Fig. 3 a single crystal helix made in accordance with this invention.

It is known that straight single crystal wires of high melting metals, such as tungsten, upon etching gradually take as shown in Fig. 1, the shape of a prism having flat sides *a* which meet in an etching edge *b*. If one puts in etching fluid a coiled filament, which is formed by winding up such a single crystal filament, the coiled up single crystal wire etches in the same way as the straight one, that is, the etching edges *b* follow the helical turns as shown in Fig. 2. The envelope of the coil remains a cylinder even after the etching.

A filament of high melting metal such as tungsten and made in accordance with this invention, acts in a different way. In this filament the etching edges do not follow the turns of the coil but the etching proceeds much more as though the straight single crystal, out of which the spiral can be thought of as having been cut, were itself eaten away as in Fig. 1, until it becomes prismatic in shape. On the outer sides of all the turns which are formed from a single crystal there appears facet-like surfaces *d* of a size which depends on the duration of the etching, and arranged as shown in Fig. 3, in a regular manner as though they were parts of the flat sides *a* of a prism which is shaped as shown in Fig. 1 and is almost large enough to contain the helix. In other words, the envelope of the etched helix will not be a cylinder, but a body of approximately prismatic form and having facets which extend parallel to the geometrical axis of the helix.

A filament made according to this invention has an undistorted macrocrystalline structure consisting of a single crystal or of long crystals which have undergone no deformation by bending due to winding of the wire, and is found to be in equilibrium. It undergoes no change in form by use in the lamp as the major part of each curved portion of the filament wire is a single crystal which is long enough to hold the curved portion in shape and which is undistorted and free from the strains produced by forcible bending of a single crystal.

Filaments according to this invention can be made by causing the shaping of the coil or helix to be done before the development of the single crystal or of long crystals into final form. Where the long filament is obtained by first winding drawn wire into the form of a helix and the development of the final crystal form occurs subsequent to the winding of the wire into a helix a single crystal occupying substantially all of the cross-section of the wire may extend through one or more turns of the coil, yet it is not bent or distorted. Its crystallographic axis, the imaginary line between opposite planes, edges or solid angles of that single crystal and to which its faces can be referred, is straight, regardless of geometric form of the turn, because the crystal grew to the limits of the wire constituting that turn and the crystal structure or arrangement of the elements of the crystal with relation to one another were not influenced or changed because the wire was bent so there is no displacement of the elements of the crystal and no distortion of the crystal such as is produced by forcible bending of straight single crystal or long crystal wire during the winding of it into a coil. As an example of one way of carrying out our invention, one may begin with a drawn wire of tungsten having a fibrous structure made in accordance with United States patent to Coolidge, 1,082,933, December 30, 1913, or a wire according to the German patent application by Richard Jacoby and Fritz Koref, filed June 18, 1921, entitled Metalldrahte and verfahren zu ihres herstellung corresponding to United States patent by the same inventors for metal wires and process for their manufacture, No. 1,739,234, issued Dec. 10, 1929.

This wire is brought to the temperature at which destruction of the fibres begins, then by drawing through a diamond die is reduced a little, then wound into a coil or helix and every turn and part of the coil, henceforth unchanged in shape or size, is heated to a much higher temperature which is above that of rapid grain growth, and which is preferably the highest practicable white heat.

One can further so proceed that the wire or the filament is wound, before the conversion of its crystal structure, upon a core or mandrel wire of the same or other high melting metal, whereupon it together with the core wire in a known manner, as for instance as described in United States patent to Schaller, No. 1,256,929, February 19, 1918, may be moved continuously through the temperature zone necessary for the conversion or the growth of the crystals and at the end the core may be removed. As every turn of the helix is supported by the core during the heating of the filament wire to convert it into the desired single crystal or large grain and long crystal structure the conversion takes place while the turns are free from stresses sufficient to produce deformation during the conversion. As a result every part of every turn of the helix is converted into a crystalline structure which resists substantial sagging and offsetting when the filament is operated in an incandescent lamp. The speed of movement is in this case chosen considerably less than for the conversion of a straight wire, corresponding to the shortening due to the coiled form.

The long coiled filament obtained in this manner and consisting of a single crystal or of a few long crystals which are undistorted and free from strain as a result of their growth in the coiled wire may be mounted on the anchors of the incandescent lamp in the usual way. It may be mounted without injury because a filament of this kind has such a large number of turns that each individual turn of the helix and, therefore, the crystal constituting that turn, is not deformed or appreciably affected by the curving of the long coiled filament during mounting. The bending for each turn is insufficient to strain the crystal, being only approximately one degree which is so slight that the crystal is virtually undeformed. In the case of a long straight single crystal which has been wound into a helix the deformation or bending depends upon the angle of curvature of the wire and is ninety degrees for each quarter turn, which is sufficient to distort and severely strain the crystal.

What we claim as new and desire to secure by Letters Patent of the United States, is,—

1. The process of making a coiled tungsten filament composed substantially of a single elongated undistorted crystal of tungsten which consists in first winding the tungsten wire into a helical coil and then treating the coiled wire to develop a single undistorted crystal of sufficient length to constitute a turn of said coil.

2. The process of making a coiled tungsten filament of many turns and of undistorted macrocrystalline structure which consists in first winding a tungsten wire into a helical coil and then heating the coiled wire to the highest practicable white heat to develop in said wire single undistorted tungsten crystals each of sufficient length to constitute a turn of said coil.

3. The process of forming a coiled filament which consists in winding tungsten wire into a helical coil and moving said coil through a zone of such temperature that crystal growth occurs in said coiled wire and at such

a speed that the rate of crystal growth along the coiled wire corresponds to the rate of movement of the wire through said zone, whereby each turn of the coil is converted into an undistorted macrocrystalline structure.

4. The process of making a coiled tungsten filament which consists in winding tungsten wire into a helical coil upon a core of high melting metal and then passing said coil together with the core through a zone of the highest practicable white heat at a rate such that the coiled wire is converted into a macrocrystalline structure of tungsten and then removing the core.

5. A tungsten filament of tungsten wire coiled into a helix and composed essentially of a single undistorted crystal which is longer than the diameter of the filament wire and which constitutes the major part of said turn but is undeformed by bending.

6. A helically coiled tungsten filament having a turn consisting of a single undistorted crystal which constitutes the major portion of the cross-section of the wire of the turn and substantially the entire length of the turn and which is virtually undeformed by bending.

7. The process of making a coiled tungsten filament stable at high temperature which consists in winding tungsten wire into a helix, supporting the turns of said helix so that no deformation of said helix occurs, and subjecting said helix while so supported to a temperature such that every part of said helix is converted into a macrocrystalline structure of tungsten.

In witness whereof, we have hereunto set our hands this 11th day of May, 1922.

FRITZ KOREF.
KURT MOERS.