Oct. 29, 1946. L. C. GOODALE 2,410,060

METHOD OF PRODUCING VACUUM TUBE ELECTRODES

Filed March 11, 1942

FIG.1.

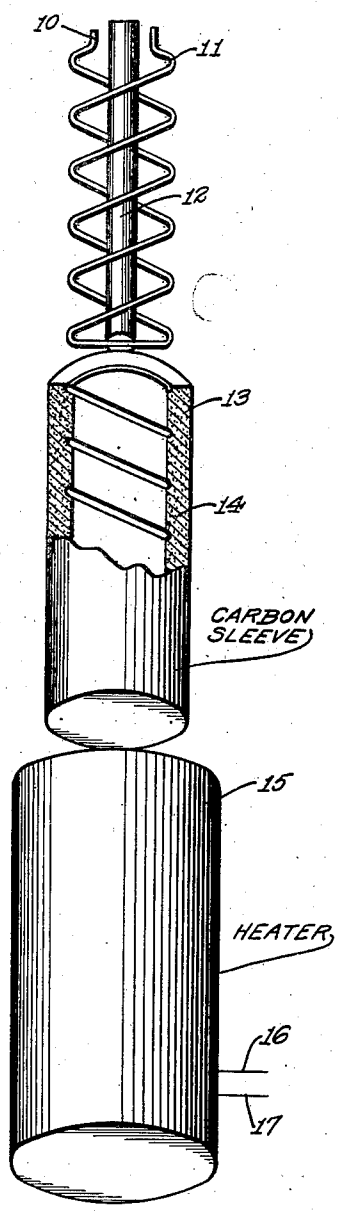


FIG.2.

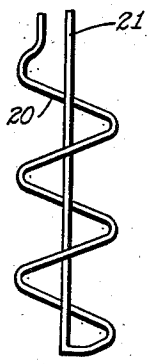


FIG.3.

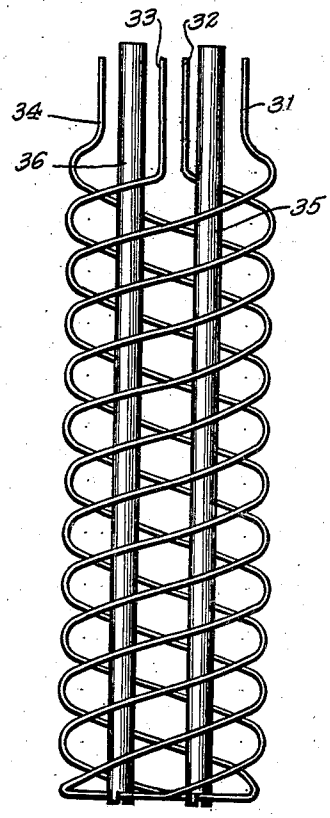


FIG.5.

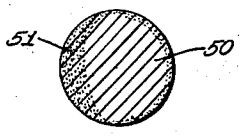
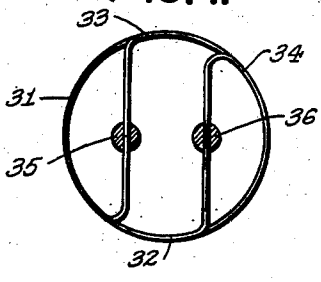


FIG.4.



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METHOD OF PRODUCING VACUUM TUBE ELECTRODES

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9 Claims. (Cl. 148—11.5)

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This invention relates to vacuum tube filaments and more particularly to the method of making spiral vacuum tube filaments and the filaments so made.

In vacuum tube filaments, particularly filamentary cathodes for tubes designed to operate at high frequencies, the spacing requirements of the filament may be very critical. For example, in a certain type of tube the spacing between the filament and grid is in the order of 0.040 inch. In such tubes the filament is generally of relatively fine wire and may warp or sag during carburizing or setting thereof. Such warping or sagging may upset the entire characteristics of the tube.

It is an object of my invention to overcome the above difficulties by use of a new method of producing spiral filaments.

Furthermore, practice of my new method may produce a filament which is carburized only on the outside and a further object of my invention is the production of spiral filaments carburized only on the outer surface of the spiral.

According to a feature of my invention, spiral filaments, single or multispiral, are formed and are then screwed into a sleeve made of carbon or of other material if setting alone is desired, threaded to receive the filament. The whole assembly is then heated to a high temperature. This heating serves to set the filament and if a carbon sleeve is used also carburizes or partially carburizes the filament. Preferably, for carburizing, the spiral filament is lubricated with colloidal graphite while screwing into the sleeve.

Since the spiral filament is held firmly in place by the grooved sleeve, the filament has no opportunity to sag or warp during the heating. Furthermore, since only the outer surface of the filament spiral is in contact with the block or sleeve, this outer surface is carburized to a greater extent than the inner surface when a carbon block is used.

A better understanding of my invention and the objects and features thereof may be had from the particular description thereof made with reference to the accompanying drawing, in which

Fig. 1 illustrates an arrangement for practicing the process and producing filaments in accordance with my invention;

Fig. 2 is an illustration of a single spiral filament;

Figs. 3 and 4 are elevations and end views respectively of quadra-filar filament, and

Fig. 5 is a cross-sectional view of a filament wire indicating the carburization effect on the outer surface.

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Turning first to Fig. 1, 10 and 11 represent two spiral filament wires connected together in series at one end to provide a known form of bi-filar filament winding. These wires are generally supported by a supporting member 12 extending inside of the spiral and fastened at one end to the connected ends of the filament. In many power tubes the filament wires are made of tungsten and often they are thoriated for the purpose of increasing their electron emission. The wires may be in ductile form as originally wound, and it is then desirable to have them set before incorporating them in the vacuum tube to prevent distortion or warping of the wires due to strains that may exist therein. This so-called setting of the wires is accomplished by heating the wires to a temperature near the melting point of the wires or at least to incandescense. After such a heat treatment, tungsten wires in particular, are found to be more rigid than previously although they are also more brittle. Furthermore, in the case of thoriated tungsten filaments it is often desired to treat these filaments to produce carburization. This treatment also calls for heating at a relatively high temperature after the wire has been covered with a carbon composition. During such heat treatment the filament may sag or deform, thus producing errors in the spacing of the filament with respect to other electrodes in the vacuum tubes. Since, in many tubes these spacings between electrodes are relatively small and very critical, this variation in spacing tends to produce errors in the characteristics of the tubes.

In accordance with my invention in order to prevent these faults in filaments, the spiral filament consisting of coils 10 and 11, is screwed into a previously prepared block or sleeve 13, which is provided with an internal threaded groove 14 of the proper dimension and pitch to receive the spiral and hold it in place during heating. The entire unit is then inserted into a heater 15, which may be for example, a coil supplied with heating energy over leads 16, 17. During the heating process the spiral grooves 14 hold the wires firmly in place so that after the wire has been set it will be shaped properly and not deformed.

If sleeve 13 is made of carbon then the filament 10, 11 is carburized at the same time that the setting takes place. When carburization is desired the wire filaments are preferably lubricated with a colloidal graphite suspension at the time they are threaded into the blocks 14.

It is further to be noted that a filament treated in accordance with my invention will generally

be carburized primarily on the outer surface of the cylindrical spiral. In Fig. 5 is shown a cross-sectional view of a filament wire greatly enlarged to illustrate this feature. In this figure it is shown that the filament wire **50** will be carburized on a section **51** corresponding to the outer edge of the spiral coil. Of course, a certain degree of carburization may take place on the inner surface of the coil as well, due to the graphite lubrication. However, the greatest heat is on the outside as well as the greatest quantity of carbon and for this reason the carburization will be largely on the outer surface of the spiral filament.

It is clear that the blocks or sleeves used for carburizing the filament may be reused for treatment of a plurality of individual filaments and need not be replaced new for each filament to be treated.

It should be noted that in many cases the wire filaments might tend to expand upon attempt to screw them into the sleeve in the manner of certain forms of spring clutches. In order to avoid this difficulty should the wires be sufficiently flexible to tend to expand in this manner, it is advisable that the threading action be taken at the leading edge of the spiral so that instead of producing a tendency to expand the tendency will be to contract the filament as it is screwed into place. In many cases the supporting rods **12** will have sufficient rigidity to serve this purpose. However, in event the supporting rods are not sufficiently rigid for this purpose, a special tool may be provided which will be fastened to the filament at the leading edge for inserting it into the sleeve.

Fig. 2 illustrates a single spiral filament. It is clear that the features of my invention may be applied not only to bi-filar filaments of the double spiral, as shown in Fig. 1, but to any spiral filaments regardless of the number of spirals therein. In this figure the single spiral is shown at **20**, provided with a supporting rod and return lead **21** for the filament.

In Figs. 3 and 4 is shown what is called a quadra-filar filament. In this arrangement there is provided four separate spirals **31**, **32**, **33**, and **34**. Spirals **31**, **32**, together with a supporting rod **35** form one bi-filar filament winding similar to that shown in Fig. 1. Filaments **33** and **34**, together with supporting rods **36**, form a second bi-filar filament similar to that shown in Fig. 1. The two filament elements are then threaded together to form the complete bi-filar unit as shown in Figs. 3 and 4. In practice, the four separate filament leads of **31**, **32**, **33** and **34**, and the separate supporting rod leads are often brought out of the tube socket to form fixed terminals. Usually then, the two double spirals which are provided are then connected in series, for example, by connecting together wires **32** and **33** in the socket, and the energy is supplied across leads **31** and **34**. The quadra-filar filament then forms a four-threaded spiral which may be screwed into a sleeve or block in a manner similar to that described previously, and the entire units may be treated in the same manner.

I have found that spiral filaments treated in the manner described herein, particularly thoriated tungsten filaments when treated with a carbon sleeve so as to produce carburized thoriated tungsten filaments not only are improved in operation, due to the lack of distortion that usually accompanies the normal heating and setting of the filaments, but they produce an improved

emission which in some cases is equivalent to almost twice that of the emission from a filament formed and carburized in the ordinary way.

It should, of course, be understood that the above description merely described a preferred manner in making and using my invention. Also, it should be understood that in most cases the filament wires will not be made of as heavy material as shown in the drawing and will generally be of a smaller size.

The carburization may be achieved by supporting the filament on a central mandrel of carbon or some other material such as ceramics which will withstand the necessary heat. The unit may then be painted with colloidal graphite or imbedded in granulated carbon and heated to carburizing temperature. Threads or other depressions in the mandrel may be provided and the filament thus held in position during the simultaneous heating and carburization.

It should, also, be distinctly understood that my invention includes not only treatment of spiral filaments in this manner, but the simultaneous carburization and setting of filaments by insertion in any properly formed carbon block and subsequent heat treatment or by other treatments as explained above regardless of the filament form.

While the specific description has been directed to filamentary cathodes, it should be understood that the invention applies to any form of filamentary electrodes, for example to filamentary grid electrodes.

Many other modifications and examples of my invention will be apparent to those skilled in the art.

What is claimed is:

1. The method of producing spiral filamentary electrodes comprising forming a spiral of filament wire, screwing said spiral into a carbonaceous sleeve provided with a spiral groove to receive said filament spiral, and heating the assembled filament and sleeve to a temperature sufficiently high to set said spiral and thus remove internal stresses which might cause deformation of said filament, and to cause carburization of at least that portion of the filament which is in contact with the sleeve.

2. The method of simultaneously carburizing and setting a vacuum tube filamentary electrode which comprises forming the desired shape of filament from ductile filament wire, placing the shaped filament wire in a carbon retaining means previously formed to retain said filament in said desired shape, and heating said assembled filament and retaining means to carburizing temperature.

3. The method of producing carburized spiral filaments comprising forming a spiral of the desired shape of thoriated filament wire, screwing said spiral into a previously prepared carbon sleeve provided with a spiral groove to fit said filament spiral, and heating the assembled filament and sleeve to produce at least a partial carburization of said filament wire.

4. The method according to claim 3 further comprising the step of lubricating said spiral with colloidal graphite as it is screwed into said sleeve.

5. The method according to claim 3, wherein said spiral is held at the leading end thereof during the process of screwing said spiral into said sleeve.

6. The method according to claim 3, wherein said spiral is formed in the shape of a bi-filar filament winding.

7. The method according to claim 3, wherein said spiral is formed in the shape of a quadrafilar filament winding.

8. The method of carburizing filamentary vacuum tube electrodes, which comprises forming the filamentary electrode in the shape of a spiral, supporting the electrode by engagement of the outer surface of said electrode with interior portions of a hollow member formed of carbon and subjecting the whole assembly to a carburizing heat, whereby the outer surface of said electrode is carburized.

9. In the manufacture of a vacuum tube electrode, a method for producing limited superficial carburization of a preselected discrete surface area of said electrode that comprises substantially rigidly supporting the electrode by engagement with interior parts of a tubular member formed of a carbonaceous substance in a manner such that the surface area to be carburized is in contact with the carbonaceous substance, and heating the electrode while so supported at a temperature sufficient to effect carburization of said area.

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