Oct. 25, 1966 G. I. MERRITT 3,280,452

METHOD OF MANUFACTURING HEATERS FOR ELECTRON DISCHARGE DEVICES

Filed Nov. 26, 1963 2 Sheets-Sheet 1

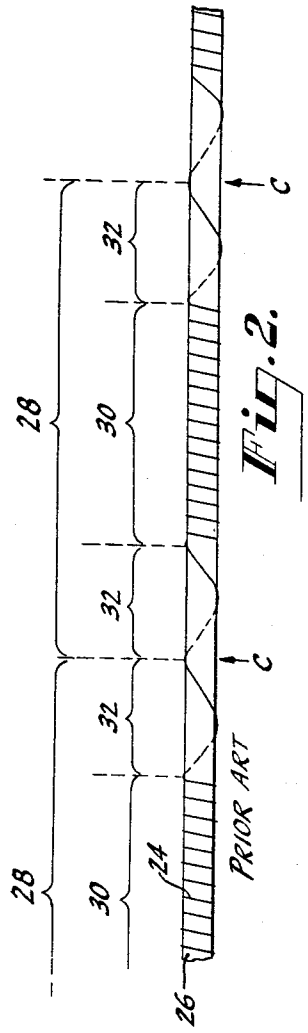

Fig. 2.

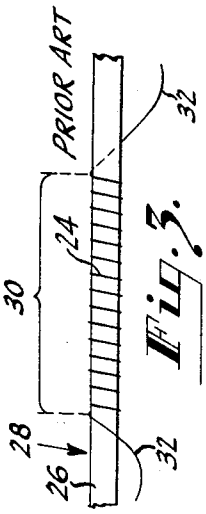

Fig. 3.

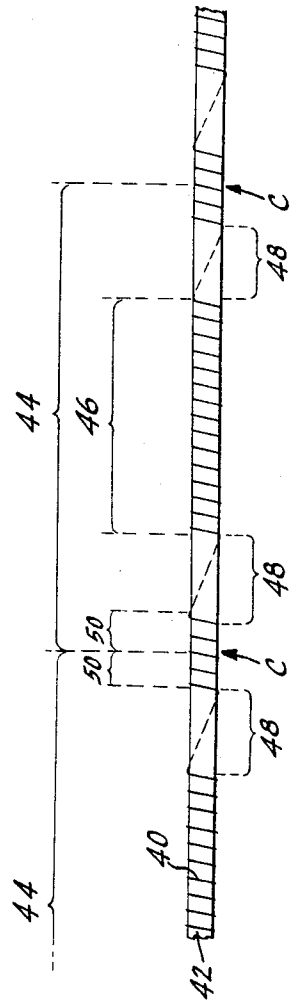

Fig. 4.

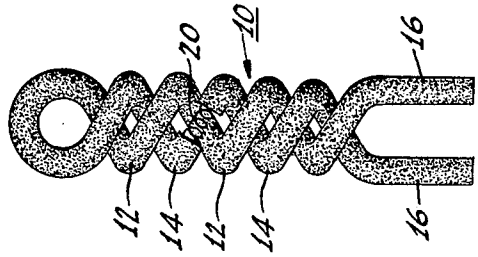

Fig. 1.

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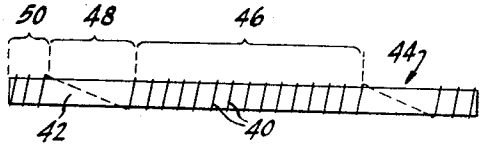


Fig. 5.

Fig. 6.

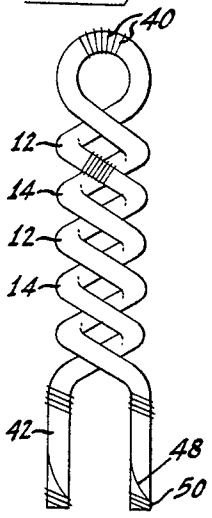


Fig. 7.

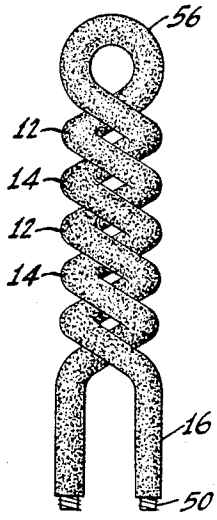
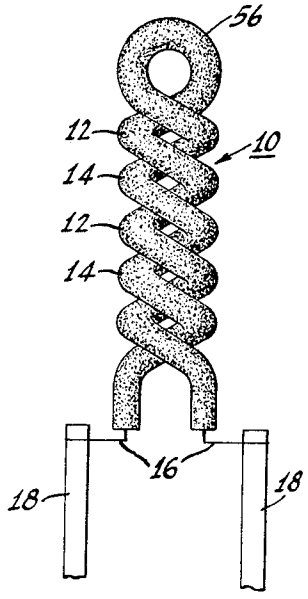


Fig. 8.



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METHOD OF MANUFACTURING HEATERS FOR ELECTRON DISCHARGE DEVICES

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6 Claims. (Cl. 29—155.62)

This invention relates to a method of manufacturing heaters for electron discharge devices, and particularly to a method of manufacturing coiled or helical heaters having accurately positioned leg portions.

In certain types of electron tubes, indirectly heated cathodes are used which are heated by an insulated type of heater known as a "double-helical" heater. Such heaters comprise a suitable heater wire, such as tungsten, which is wound into a helix of relatively fine pitch, the fine pitch helix, in turn, being formed into a pair of interwoven helices of relatively coarse pitch. For making electrical and mechanical connections with the heater, each of the pair of interwoven helices terminates in an extending leg portion which may be secured to a suitable support.

For the purpose of facilitating automatic assembly of such heaters into electron tubes, it is desirable that the extending leg portions of the heaters be accurately disposed with respect to the interwoven helical portions of the heater. Also, for reasons to be described hereinafter, it is perferable that the leg portions comprise relatively straight and non-coiled lengths of wire. In the past, it has been found difficult to fabricate double helical heaters having accurately disposed non-coiled leg portions.

Double-helical heaters are conventionally made by first winding a continuous heater wire onto an elongated mandrel to form a series of connected heater workpieces. Each workpiece is wound with three successive sections of wire including a coarse pitch section from which one leg portion of the heater is formed, a fine pitch section from which the interwoven helices of the heater are formed, and a further coarse pitch section from which the other leg portion of the heater is formed. Thereafter, the mandrel is cut into individual workpieces, each workpiece comprising a length of mandrel having a central portion wound with wire at a fine pitch and end portions wound with wire at a coarse pitch. Each workpiece is then bent into U-shape, and both sides of the U are simultaneously twisted around the longitudinal axis of the U to form the interwoven helices. The end portions are not twisted, and because of the coarse pitch with which they are wound, provide leg portions which are substantially uncoiled. The formed heater workpiece is then coated with a suitable insulating material, and the mandrel then etched from within the coated wire to provide the completed heater.

A problem with the method described is that upon the cutting of the mandrel into individual workipeces, the leg portions of the heater wound at a coarse pitch often unravel from the mandrel and extend away from the mandrel in random directions. This random disposition of the leg portions of the heater resulting from the unraveling of the heater legs is undesirable since it creates problems with respect to automatic locating and positioning of the heaters during automatic assembly of the heaters into electron tubes.

An object of this invention is to provide a new and improved method of fabricating heaters of the type described wherein the disposition of the leg portions of the heater is accurately controlled.

For achieving these objects in accordance with this invention, the above-described method of manufacturing heaters is modified in that each workpiece may be wound with five successive sections including an end portion wound with a relatively fine pitch, a leg portion wound with a relatively coarse pitch, a central portion wound with a relatively fine pitch, a second leg portion wound with a relatively coarse pitch, and a second end portion wound with a relatively fine pitch. After winding, the mandrel is cut to provide individual workpieces. The resulting workpieces each comprise a mandrel having a winding thereon including a central portion wound with a fine pitch, leg portions connected to each end of the central portion and wound with a coarse pitch, and end portions wound with a fine pitch connected to the ends of the leg portions. The end portions each preferably include several turns of wire wound tightly around the mandrel. There is no unraveling of the coarse wound leg portions from the mandrel because the leg portions are held on by the tightly wound end portions. Thereafter, the workpieces are formed into double helical shape. Then they may be coated with insulating material, the mandrels may be etched from within the heaters, and the end portions may be cut from the heaters.

A more detailed description of the invention follows in connection with a description of the drawings wherein:

FIG. 1 shows a double helical heater which may be made according to the method of this invention, portions of the insulation being broken away for greater clarity;

FIG. 2 shows a wire wound mandrel wound according to the prior art method of fabricating heaters;

FIG. 3 shows a heater workpiece made according to the prior art method;

FIG. 4 shows a wire wound mandrel wound according to the method of this invention;

FIG. 5 shows a heater workpiece after the cutting of the wound mandrel shown in FIG. 4;

FIG. 6 shows the heater workpiece of FIG. 5 formed into double helical shape;

FIG. 7 shows the formed heater of FIG. 6 coated with an insulating material; and

FIG. 8 shows a completed heater mounted on a pair of support leads.

With reference to FIG. 1, a double helical heater **10** comprises a pair of interwoven helices **12** and **14**, each helix terminating in a leg portion **16**. Each helix and the leg portions are coated with an insulating material. As shown in FIG. 8, each leg portion **16** may be stripped of its insulation, bent at a right angle, and secured, as by notching and peening, to support wires **18**. The support wires **18** may extend through a header member (not shown) of an electron tube envelope closure stem. The turns of each helix **12**, **14** are formed from a further helix **20** (FIG. 1) of a suitable heater wire, such as tungsten. Double helical heaters of the type shown in FIGS. 1 and 8 are used because the arrangement of the various helices of wire causes a cancellation of the electrostatic fields produced by the passage of current through the heater wire. Such fields, if not cancelled, cause noise in the output of the electron tubes using the heaters, as known.

The leg portions **16** of the heater are comparatively straight and uncoiled to facilitate automatic handling and accurate bending of the leg portions at right angles. A method and apparatus for stripping the insulation off the leg portions **16**, bending the leg portions **16**, and automatically securing the leg portions to a pair of support wires **18** is described in U.S. Patent 3,013,738, to John Chase for Method of Assembling a Heater Mount.

With reference to FIG. 2, the prior art method of fabricating double helical heaters comprises winding a tungsten heater wire **24** onto a molybdenum mandrel **26**. Each heater workpiece **28** includes a central portion **30** wound with a fine pitch, and leg portions **32** wound with a coarse pitch. The wound mandrel is then cut into individual workpieces by cutting the mandrel through the leg portions **32** at the positions indicated by

the letter "C" in FIG. 2. A resulting workpiece 28 is shown in FIG. 3.

As mentioned, a problem associated with the heaters wound according to the prior art method, is that after cutting of the mandrel, the coarse wound leg portions 32 often unravel from the mandrel 26 and extend from the mandrel in random directions, as shown in FIG. 3. This is undesirable because it interferes with the automatic bending of the leg portions and the assembly of the heater into a heater assembly.

In accordance with an embodiment of this invention, (see FIG. 4), a heater wire 40, such as tungsten, is wound onto a mandrel 42, such as molybdenum, so that each heater workpiece 44 includes a central section 46 wound with a fine pitch, leg portion sections 48 wound with a coarse pitch, and end sections 50 wound with a fine pitch. Since apparatus suitable for winding wire onto successive sections of a mandrel at a plurality of pitches is known, such apparatus is not shown.

The wound mandrel 42 is then cut into individual workpieces 44 (FIG. 5). The mandrel is cut at the positions marked "C" in FIG. 4, these positions being between the end portions 50 of adjacent workpieces 44. For convenience of winding, the end sections 50 of each heater workpiece 44 merge with one another, and the mandrel is cut, as shown, between the end turns of the end sections 50, 50. Alternately, a skip portion, that is, a section of mandrel wound with a coarse winding, may be provided between the end sections 50 of adjacent heater workpieces.

Each cut workpiece 44 (FIG. 5) comprises a length of mandrel 42 having a central portion 46 wound with a fine pitch, leg portions 48 wound with a coarse pitch, and end portions 50 wound with a fine pitch. The end portions 50 preferably include five or more turns.

Upon cutting the wound mandrel 42, the closely wound turns of wire in the end portions 50 do not unravel, hence, prevent unraveling of the coarsely wound leg portions 48. Prior to cutting of the wire wound mandrel 42, the mandrel and wire thereon may be annealed for tempering and setting the wire 40 and further removing the tendency of the wire to unravel.

The workpiece 44 is then formed into the double helical shape as shown in FIG. 6, the leg portions 48 and end portions 50 not being formed into helices. Apparatus for forming the heaters is not shown since such apparatus is known.

Thereafter, the formed heater is coated with a suitable insulating material, such as aluminum oxide. The coating operation may be performed by conventional spraying, cataphoretic or dipping operations. FIG. 7 shows a formed heater workpiece which is insulated by means of a dipping operation. The end portions 50 are not covered with insulation since these portions are held within a clip from which the heater is suspended while being lowered into the insulating material bath.

After the formed heater workpiece is coated with insulating material, it is fired in a hydrogen atmosphere to sinter the coating material and set the wire turns.

In the next operation, the mandrel 42 is etched from within the wound wire. A suitable etchant is used, such as a solution of sulfuric and nitric acids, which attacks molybdenum but not tungsten or aluminum oxide. After etching and removal of the mandrel from within the wound wire the heater workpiece retains its shape due to the fact that the annealed wire has lost most of its spring and because the covering of aluminum oxide is relatively stiff and non-flexible.

The tightly wound end portions 50 are then cut off, thus completing the heater. The leg portions 48 are accurately disposed with respect to the helices 12 and 14 of the heater since, as explained, unraveling of the leg portions 48 after cutting is prevented by the use of the end portions 50.

Thereafter, the heater workpiece is operated on by apparatus which breaks the insulation off the leg portions 48, bends the leg portions at right angles, and secures the leg portions to the support wires 18, as described in the aforementioned U.S. Patent 3,013,738.

In one embodiment of this invention, by way of example, the central portions 46 (FIG. 4) are wound with a pitch of 400 turns per inch, for a length of 14 mm., leg portions 48 wound at 16 turns per inch, for a length of 7 mm., and end portions 50 wound at 400 turns per inch for a length of 2.5 mm. The wound mandrel workpieces 44 (FIG. 5) are wound into a pair of helices 12, 14 (FIG. 6) each having a pitch of 30 turns per inch.

Although the invention has been described in connection with the manufacture of double helical heaters, it is clear that the invention has a utility with other types of heaters formed from helices of wire. Thus, for example, "hairpin" heaters, which comprise a helix of wire bent into V-shape and having extending leg portions, can also be made utilizing the method of this invention.

It will be understood that the expressions "fine pitch" and "coarse pitch" are terms which relate to the pitch of the various mandrel sections for a given heater. Each heater employs different winding pitches dependent upon the size of the heater, the electrical characteristics desired in the heater, and the materials used. Also, although it is preferable to use several turns in end sections 50, it has been found that a single turn will serve to lock the wire to the mandrel and prevent unraveling of the wire.

What is claimed is:

1. A method of manufacturing a helical heater comprising a helical portion and a leg portion extending from each end of said helical portion, said method including the steps of winding a wire along a mandrel at a first relatively fine pitch from which the helical portion of said heater is formed, winding said wire at a relatively coarse pitch on said mandrel to form leg portions adqacent each end of said fine pitch winding, winding said wire at a second relatively fine pitch adjacent an end of each of said leg portions, and cutting the mandrel for providing a heater workpiece comprising a mandrel section having a centrally disposed length of wire wound at said first fine pitch, leg portions wound with said coarse pitch adjacent each side of said central length, and end portions wound at said second fine pitch adjacent each of said leg portions.

2. A method of manufacturing a helical heater comprisin a helical portion and a leg portion extending from each end of said helical portion, said method including the steps of winding a wire with a relatvely fine pitch on a mandrel to form the helical portion of said heater, winding said wire with a relatively coarse pitch on said mandrel to form the leg portions of said heater, winding said wire with a relatively fine pitch along sections of said mandrel adjacent an end of each of said leg portions, and cutting said mandrel intermediate the end turns of said last-named wound sections for providing a heater workpiece having accurately disposed leg portions.

3. A method of manufacturing an insulated helical heater comprising a helical portion and a leg portion extending from each end of said helical portion, said method including the steps of winding a wire with a relatively fine pitch on a mandrel to form the helical portion of said heater, winding said wire on said mandrel with a relatively coarse pitch to form the leg portions of said heater, winding said wire with a relatively fine pitch along sections of said mandrel adjacent an end of each of said leg portions, cutting said mandrel adjacent said last-named wound sections for providing a heater workpiece including said last-named winding, forming said workpiece into preselected shape, coating said workpiece with a brittle insulating material, removing said mandrel from within said wound wire, and cutting said last-named winding from said leg portions.

4. A method of manufacturing a helical heater comprising a helical portion and a leg portion extending from each end of said helical portion, said method including the steps of winding a wire with a relatively fine pitch on a mandrel to form the helical portion of said heater, winding said wire on said mandrel with a relatively coarse pitch to form the leg portions of said heater, winding said wire with a relatvely fine pitch along sections of said mandrel adjacent an end of each of said leg portions, annealing said wound wire, cutting said mandrel adjacent said last-named wound sections for providing a heater workpiece including said last-named winding, forming said workpiece into preselected shape, coating said workpiece with a brittle insulating material, etching said mandrel from within said wound wire, and cutting said last-named winding from said leg portions.

5. A method of producing helical heaters having a central helical portion and a substantially straight leg portion extending from each end of said helical portion, the steps including winding a heater wire along a mandrel to form a plurality of connected workpieces and in a sequence including a first length of said wire wound with a relatively fine pitch, a second length of said wire wound with a relatively coarse pitch, a third length of said wire woud with a relatively fine pitch, a fourth length of said wire wound with a relatively coarse pitch, and a fifth length of said wire wound with a relatively fine pitch, and cutting said mandrel between the first and fifth lengths of adjacent workpieces.

6. A method of producing helical heaters having a central helical portion and a substantially straight leg portion extending from each end of said helical portion, the steps including winding a heater wire along a mandrel to form a plurality of connected workpieces and in a sequence including a first length of said wire wound with a relatively fine pitch, a second length of said wire wound with a relatively coarse pitch, a third length of said wire wound with a relatively fine pitch, a fourth length of said wire wound with a relatively coarse pitch, and a fifth length of said wire wound with relatively fine pitch, cutting said mandrel between the first and fifth lengths of adjacent workpieces, forming the cut workpieces into preselected shape, coating said workpieces with a brittle insulating material, etching said mandrel from within said wound wire, and cutting said first and fifth windings from said workpieces.

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