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GRID STRUCTURE FOR ELECTRON DISCHARGE TUBES

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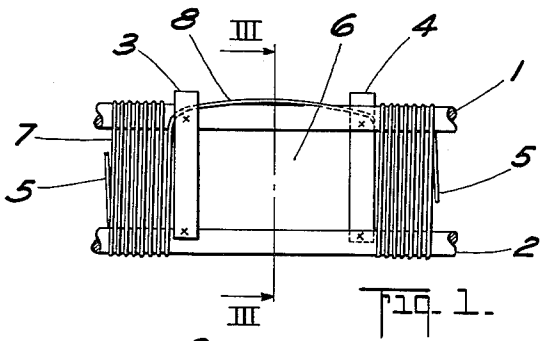


FIG. 1.

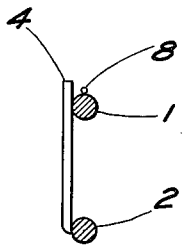


FIG. 3.

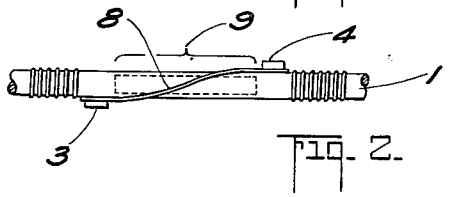


FIG. 2.

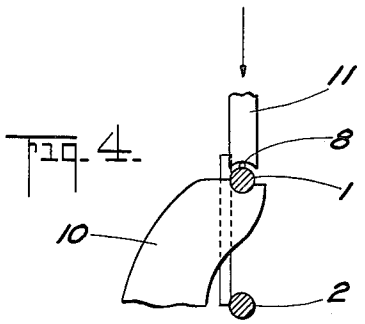


FIG. 4.

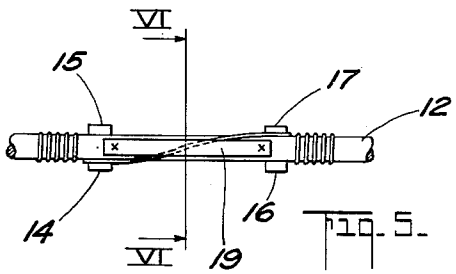


FIG. 5.

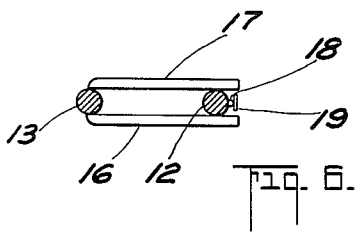


FIG. 6.

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GRID STRUCTURE FOR ELECTRON DISCHARGE TUBES

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6 Claims. (Cl. 140—71.5)

This invention relates to grid structures for electron discharge tubes and to a method of making them.

It has been found that grid structures for vacuum tubes and particularly for special vacuum tubes, such as those in which long life and reliability are of prime importance, can be made with greater uniformity and improved reliability of operation if the grid wires are exceedingly thin so as to be incapable of self support and are wound on relatively sturdy side, or stay, rods that also determine the spacing of the sires from other elements of the tube. Grids of this type have been formed heretofore by winding very fine wire on a structure in the form of an open rectangular frame and sealing the wires to the frame at each point of contact, i.e., twice per turn.

According to the invention a long pair of stay rods is connected by cross-bars in a ladder-like structure with alternate cross-bars being attached to opposite sides of the structure and extending out beyond one of the stay rods so that the wire can be hooked into the notch between the rod and the cross-bar. The wire may then be hooked into the notch between the rod and the first cross-bar, wound in a number of turns to the second cross-bar on the opposite side of the stay rods, hooked into the notch between the second cross-bar and the rod, led along the rod to the third cross-bar and hooked into the notch between the latter cross-bar and the stay rod and so on, repetitively for the length of the rods. In this way the resultant structure is a succession of grid windings, each bounded at each end by a cross-bar and separated from one another by spaces in which there are no windings. Instead of soldering the wire to the stay rods at each point of contact, the fine wire is attached only in the section of the rod between adjacent wound sections. Attachment may be made by welding a small metal strip lengthwise on the stay rod in the interval between adjacent wound sections so as to press the fine wire against the stay rod and hold it in place. Alternatively, and particularly if the stay rods are made of molybdenum and the fine wire is made of tungsten, the wire may be pressed into the stay rods in the interval between wound sections.

The primary object of the invention is to provide improved grid structures and an easier method of forming them.

Other objects will be apparent from the following specification together with the drawings in which

FIG. 1 shows a section of a ladder-like structure including portions of two wound sections and the interval between;

FIG. 2 shows a top view of the structure in FIG. 1;

FIG. 3 shows an end cross-sectional view of the structure in FIG. 1;

FIG. 4 shows the structure of FIG. 3 positioned in a press;

FIG. 5 shows an alternate embodiment of the structure shown in FIG. 2; and

FIG. 6 shows a cross-sectional end view of the alternate embodiment in FIG. 5.

For convenience FIG. 1 shows only a small portion of grid structures formed according to the invention at the stage of formation immediately preceding the step of cutting the formation into individual grid structures.

In FIG. 1 the stay rods 1 and 2 are only short fragments of their actual length. These rods are connected together in accurately spaced relation by cross-bars 3 and 4 which are attached to opposite sides of the rods 1 and 2 by any convenient means, such as by spot welding. Portions of two grid structures 5 are shown, one to the left of the cross-bar 3 and the other to the right of cross-bar 4. These are spaced apart by the interval 6 which is the interval in which the rods 1 and 2 will eventually be cut to separate the grid structures 5 from each other.

The grid structures 5 are formed by winding very fine wire 7, for example wire having a diameter of the order of 7.5 microns, in a series of closely spaced turns. Assuming for the purpose of illustration that the wire 7 is wound from left to right, the last turn in the left hand section 5 will bring the wire 7 up against the cross-bar 3 which extends beyond the stay rod 1 on the same side thereof as the last part of the turn wire 7 so that wire 7 can be fitted into a notch between the cross-bar 3 and the stay rod 1 and pulled practically directly along the stay rod 1 to the cross-bar 4 which is on the opposite side of cross-bar 3. The wire 7 then fits into a notch between cross-bar 4 and rod 1 and is wound in another series of closely spaced turns to make the right hand section 5. Any convenient number of sections 5 can be formed in this way at one winding, and the spacing between adjacent turns may be varied as desired.

It is necessary to wind the wire 7 with relatively high tension so that subsequently heat treatment during the formation of the tube will not cause the wire to go slack in the structures 5. It has been found that the tension should be of the order of 60% of the tensile strength of the wire. For example, grids made of tungsten wire having a diameter of 10 microns have been wound using a winding tension of 15 to 17 grams which is about 50 to 60% of the 30 to 34 gram tensile strength of the wire. After annealing, the wire in sections 5 of grids so formed was found to be reduced to about 1.5 to 3 grams, which, however, is still sufficient to cause the wire in sections 5 to remain taut, thereby maintaining the spacing between adjacent turns of the wire and also between elements in the tube, such as the cathode and anode.

FIGS. 2 and 3 show the way the wire 7 crosses over the stay rod 1 in the region 8 and the dotted rectangle 9 indicates the region in which the wire may be pressed into the stay rod 1 to keep the wire from becoming unwound when the individual grid structures are cut apart.

FIG. 4 shows an example of a press including an anvil 10 and a die 11 that moves in the direction of the arrow to press the wire section 8 into rod 1. After the step of pressing has been completed, the individual grid structures may be cut apart, for example, by cutting the rods 1 and 2 half way between the cross-bars 3 and 4 (FIG. 1).

FIGS. 5 and 6 show an alternate structure in which additional cross-bars are used so as to obtain a symmetrical structure. In this case the stay rods 12 and 13 are held firmly by means of cross-bars 14–17 so that there is no tendency for the stay rods 12 and 13 to twist and thereby alter the spacing between them under the tension of the winding of the grid wire.

FIGS. 5 and 6 also illustrate a different way of permanently securing the wire to the stay rods. In this case a metal strip, for example, of nickel, is placed lengthwise of the say rod 12 in the region between the cross-bars 14, 15 and the cross-bars 16, 17 and spot welded at several points as indicated by the x's. Again the grid structures may be separated by cutting the stay rods somewhere between cross-bars 14, 15 and cross-bars 16, 17.

As an illustration of a typical embodiment of the invention, grid structures 5 have been made as shown in FIG. 1 with a wound length of 7.5 mm. and a spacing 6

of about 3.4 mm., using 7.5 micron wire wound with a pitch of 70 microns on stay rods 8 mm. in diameter and spaced apart by 3.2 mm.

Modifications of the embodiments shown may be made within the scope of the invention as defined by the following claims.

What is claimed is:

1. A method of making a grid electrode which comprises the steps of providing a pair of spaced parallel stay-rods, placing cross-bar members over the stay-rods thereby providing spaced notches between said stay-rods and said cross-bars, tautly winding a wire of small diameter over the stay-rods, passing the wire between one cross-bar and the stay-rod through the notch therebetween, passing the wire in the direction of the stay-rod to the next cross-bar, passing the wire between the latter cross-bar and the stay-rod through the notch therebetween, resuming winding of the wire over the stay-rods, securing the wire to the stay-rod outside the effective length of the grid electrode, and severing the stay-rods between successive cross-bars to form individual grid structures.

2. A method as claimed in claim 1, in which the grid wire is secured to the stay rod only with its portion extending between two wound parts and along the stay rod.

3. A method as claimed in claim 2 in which the grid wire is clamped between the stay rod and a strip welded to it.

4. A method as claimed in claim 2 in which the grid wire is mechanically pressed into the material of the stay rods and is thus secured to it.

5. A method as claimed in claim 4 in which the grid wire consists of tungsten and the stay rod is made from molybdenum.

6. A method as claimed in claim 4 in which the wire is less than 15 microns thick and its pitch is less than 75 microns.

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