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METHOD OF MANUFACTURE OF GRID STRUCTURES

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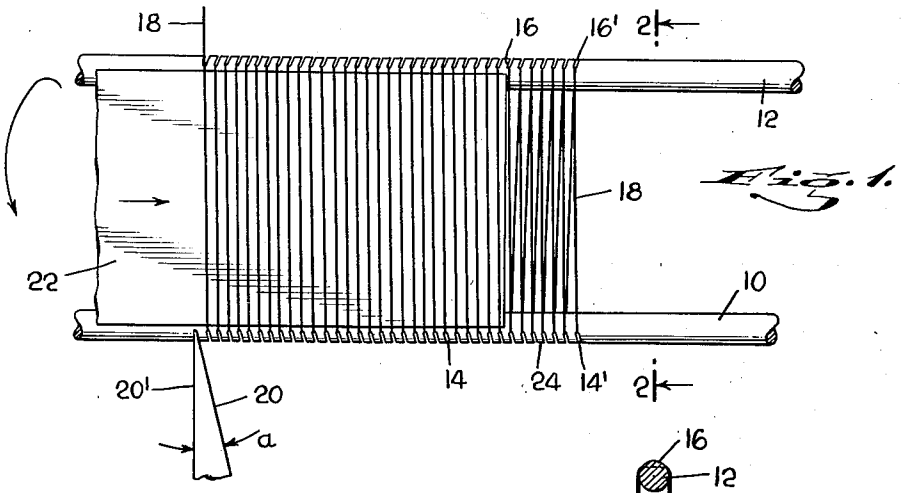


Fig. 1.

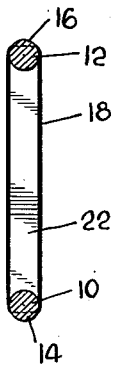
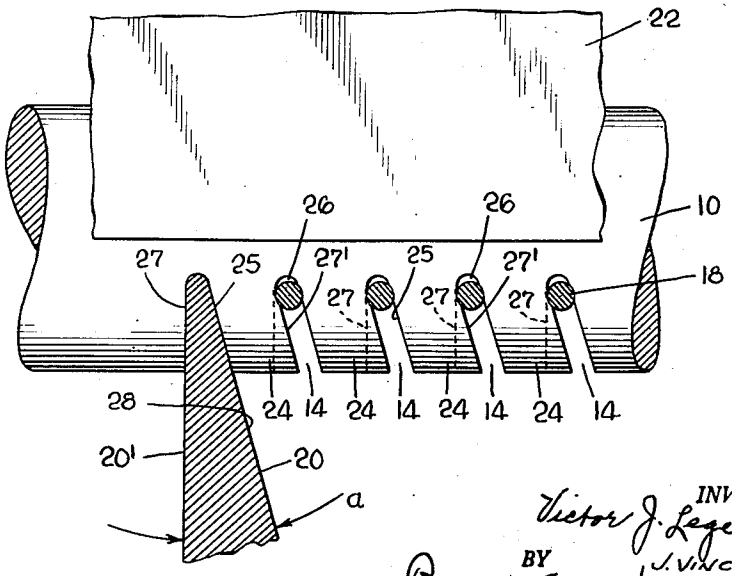


Fig. 2.

Fig. 3.



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METHOD OF MANUFACTURE OF GRID STRUCTURES

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This invention relates to the manufacture of wire grids and is particularly useful for the fabrication of grid structures for electron tubes wherein grids of a very fine pitch are required, although certain features of the invention have other usefulness.

To our knowledge the conventional method for the fabrication of grid structures consists generally of positioning grid supports or posts on a suitable preshaped mandrel, notching or cutting each of the posts by a circular revolving cutting disc, feeding the grid wire to the revolving mandrel with the wire disposed in the preformed notches or cuts, and then swedging the notches by a revolving disc of a given width to secure the wire in the notches.

In the making of a fine pitch grid of say 120 turns per inch or more, the swedger must be of an accurate and narrow width and line up perfectly over the center of the notches or cuts. As the pitch increases, the dimensions become difficult and impracticable to hold, with the result that a substantial number of loose turns are encountered and the rejects become unduly large.

With our invention we have been able to overcome the difficulties encountered with the present method of grid fabrication and in addition have greatly simplified the manufacturing procedure and apparatus as well as effected a material saving in time and cost through reduction of rejects and increased rate of manufacture, and, moreover, have obtained an improved grid.

The above and other objects of the invention will become more apparent from the following description and accompanying drawings illustrating one embodiment of the invention.

In the drawings—

Fig. 1 is a side elevation of a grid structure formed in accordance with and embodying the invention;

Fig. 2 is a sectional view of the grid structure of Fig. 1 taken along the line 2—2 thereof; and

Fig. 3 is an enlarged fragmentary section of Fig. 1 to more clearly illustrate the invention.

In the manufacture of radio or electron tubes, a grid structure comprising a plurality of turns of fine closely spaced wires placed about the filament or cathode and the spacing of these wires from the filament or cathode as well as the spacing of the wires has a pronounced effect upon the operating characteristics of the tube. In many present-day applications of vacuum tubes exceedingly close tolerances must be maintained, and to accomplish this even closer tolerances must be maintained on the individual elements to achieve the desired tube uniformity to enable

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substitution of tubes without upsetting delicate circuits in which the tubes may be used.

We have succeeded with our invention in being able to produce more uniform, well formed grids than can be obtained with the conventional practice and we also are able to reduce the number of steps by eliminating entirely the separate swedging operation and obtain grids whose support wires are not swedged, with other accompanying advantages appearing below.

In Fig. 1 we have illustrated a grid in the process of fabrication according to our invention. The grid comprises at least two supporting posts or wires 10 and 12 having a plurality of notches or cuts 14 and 16, respectively. The grid wire 18 is spirally wound about the support wires and the end loops of the wires are positioned in the notches 14 and 16 which are spaced evenly and uniformly throughout the length of the grid. A cutting tool 20 in accordance with our invention is illustrated at the left of Fig. 1 in fragmentary form and is actually circular in shape with the cutting edge formed in an angle α and with the leading edge 20' of the cutter being preferably substantially perpendicular to the support posts or wires 10 and 12.

The supports 10 and 12 are supported in spaced relationship during the notching and winding operation by a pre-shaped mandrel 22 which is mounted for rotation about a central longitudinal axis. The notches 14 and 16 are cut successively, one in one support and one in the other as the mandrel is rotated.

The grooves or notches 14 and 16 are simultaneously formed with the winding of the grid wire 18; that is, we form the first notch, say 14 in support 10 and then rotate the mandrel 180° to cut the second notch 16 in 12, the notches in the two support wires being successively formed and being staggered with respect to each other a distance equal to the longitudinal advance of mandrel 22 through 180° rotation. The wire 18 is fed into the uppermost notches (Fig. 1), that is, into each notch 180° after its formation by the cutter or notcher.

We have found that the troublesome swedging operation may be entirely eliminated by forming the notches or cuts 14 and 16 of the shape more particularly illustrated in Fig. 3, each notch having a trailing wall 25 and a leading wall surface 27 with the bottom 26 of the notch or cut having a dimension slightly smaller than the diameter of the grid wire 18, and by forming the notches or cuts so as to move the wall surface rearwardly to occupy a position 27' by the notching or cutting action in forming the next succeed-

ing notch or cut in a support wire. Thus each preceding notch or cut in a support wire is partially closed by the cutting or notching action of the tool to firmly grip the grid wire 18 without the necessity of any conventional swedging action or operation and, moreover, without upsetting to any appreciable extent the surface of the grid support wire.

In the particular embodiment shown, the leading edge or face 20' of the cutter or notcher 20 is disposed substantially at right angles to the axis of rotation of the mandrel 22 while the trailing edge or face 28 is disposed at an acute angle alpha to the leading face 20', and we have obtained particularly good results with this arrangement though slight departures therefrom may be made without sacrificing the principle of the invention, one aspect of which resides in the utilization of the notching and cutting operations to close, or partially close, the notches or cuts upon the previously fed grid wire so as to firmly grip and hold the same in the desired position in the grid structure. When the grid wire is fed into the grooves or notches formed by the notcher or cutter they are firmly set against the side walls of the notches to leave small spaces therebetween and the bottoms 26 of the notches as shown in Fig. 3, the grid wire being of slightly smaller diameter than the width of the notches at their bottom.

It is evident from the drawings that the notches 14 and 16 formed by the particular cutter 20 here shown for illustration purposes are triangular in shape but the shape of these notches is changed by the formation of the next successive notches which move the body of material 24 to the right to clamp the wire 18 firmly and securely in place. The movement of the bodies of material 14 at the outer surface of a support wire is represented by the angle between 27 and 27'.

In forming the cutter 20 we prefer to form it with an end or edge portion about .0005'' smaller than the diameter of the grid wire to be used in forming the grid so that the wire 18 will firmly seat against the side walls of the notches during winding and leave a small space at the base or innermost part 26 of the notch as seen in Fig. 3. This is to obtain an initial wedging of the wire in the cut and creating greater pressure in the peening by narrowing the final width of the cut. With this procedure the movement of the bodies of material 24 more firmly anchors the wire 18 in the slot.

We have found in actual practice that with our new and improved method as described above, grid wire spacings of as high as 350 turns per inch and even higher are readily and easily attainable and without appreciable distortion of either the supporting wires or the wire spacing. Moreover, the operation has been reduced to only two essential steps and these are carried out simultaneously with a considerable saving in both time and cost.

In general, the angle a of the cutting tool 20 for best results varies with the pitch of the grid and we have found that for pitches of about 120 to 150 turns per inch an angle of about 25° produces good results, while an angle of 15° is preferable for pitches of 150 to 350 turns per inch and 7° for pitches above 350. We have also found that copper or other soft materials are preferred for the support wires 10 and 12, although it is apparent that somewhat harder materials can also be used.

At the completion of the winding operation we prefer to retract the cutter 20 and permit a few extra turns to be wound on the support wires before severing the wire 18 to allow for the loose turns, leaving the support wires completely clean of any cuts.

The starting of the winding of the grid, or series of grids, may be effected in any suitable or convenient manner. In Fig. 1 we have shown the first notch 14' as formed in the support wire 10 and the second notch 16' formed in the support wire 12. The support wires 10 and 12 may be of any suitable diameter as, for example, .025 inch, and the spacing of the support wires should be as is required. With the support wire of the above indicated diameter and with a rotary cutter having an angle alpha equal roughly to 15°, with a width at the cutting edge of .0015 inch, notches of a depth of .007 inch are suitable, the diameter of the grid wire being roughly .002 inch.

With the elimination of the swedging operation, distortion of the support wires 10 and 12 is avoided and a more secure and tighter fit in the holes in the mica grid supports customarily used in the fabrication of radio tubes is obtained.

The elimination of the swedging tool greatly simplifies the winding apparatus, eliminates the element which requires most frequent replacement and exceedingly fine adjustment, and as previously mentioned avoids distortion of the supporting posts.

Moreover, our new and improved cutter has a much larger cutting angle a than conventional cutters and thereby has greatly increased life, and the entire setup is materially simplified since the winding of the wire follows the cutting by about ½ revolution and no correlation or fine adjustment of a swedging tool need be made with respect to the cutter.

Another important advantage results in the facility with which exceedingly fine grid structures may be fabricated and which were not possible or practical with prior methods with which we are acquainted.

Other advantages of the invention include a simplified set-up, with reduction in maintenance, negligible reeling time of loose turns of the grid wire, clean grid legs so as to provide for a tighter fit in the mica holes, increased life of the cutting or notching tool due to the grid angle, and the pitch or number of turns per inch of the grid wire being limited only by the size of the support wire and the accuracy of the equipment used.

We claim:

1. The method of making a grid structure for electronic tubes comprising the steps of supporting at least two support rods of soft metal in spaced parallel relation, forming a notch in one of said supports, forming a notch in the other of said supports and while forming said last mentioned notch placing the wire forming the grid in the first said notch, forming a second notch in said one support sufficiently close to said first notch as to force the body of material between said first and second notches in said one support toward the first notch to secure the wire therein and at the same time feeding the wire into the first notch in said other support, forming a second notch in said other support at a similar distance from the first notch in said other support to force the body of material between the first and second notches toward the first notch to secure the wire therein and continuing the process to complete the grid, said notches in

each support having a depth greater than the distance between adjacent notches.

2. The method of fastening successive sections of grid wire to a copper grid support rod comprising forming successively at least 120 like V shaped slots per inch in said rod with the edge of the slot remote from the preceding slot each slot normal to the line of slots and with the angle of the walls of each slot between 7° and 25°, placing wires in the successive slots as they are formed whereupon the formation of each succeeding slot will close the preceding slot to clinch the wire therein.

3. The method of fastening successive sections of wire according to claim 2 wherein the root of the slot is smaller than the diameter of the wire to be clinched therein.

4. The method of clinching grid wires in successively formed slots in a support rod of soft material wherein each slot is disposed transversely of the line of slots, comprising forming a first V-shaped slot with one side perpendicular to the line of slots to be formed and the other side inclined thereto, placing a wire in said first slot and then forming a second slot on said one side of the first slot in the same manner as the

first slot and sufficiently close to the first slot to cause the inclined side of the second slot to displace the material between said slots to clinch the wire in the first slot, and repeating the procedure until the desired number of wires are fastened to the support rod.

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