Jan. 21, 1958 E. L. BAHM 2,820,487

GRID FABRICATION METHOD

Filed March 9, 1956

Fig. 1.

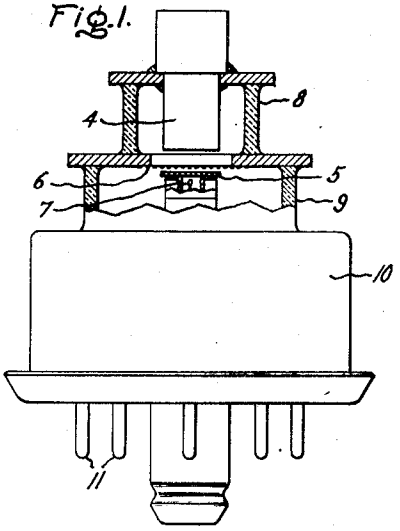


Fig. 4.

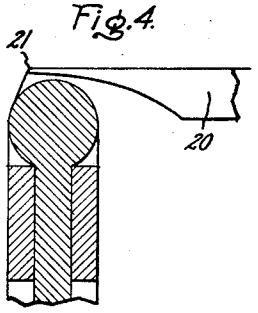


Fig. 2.

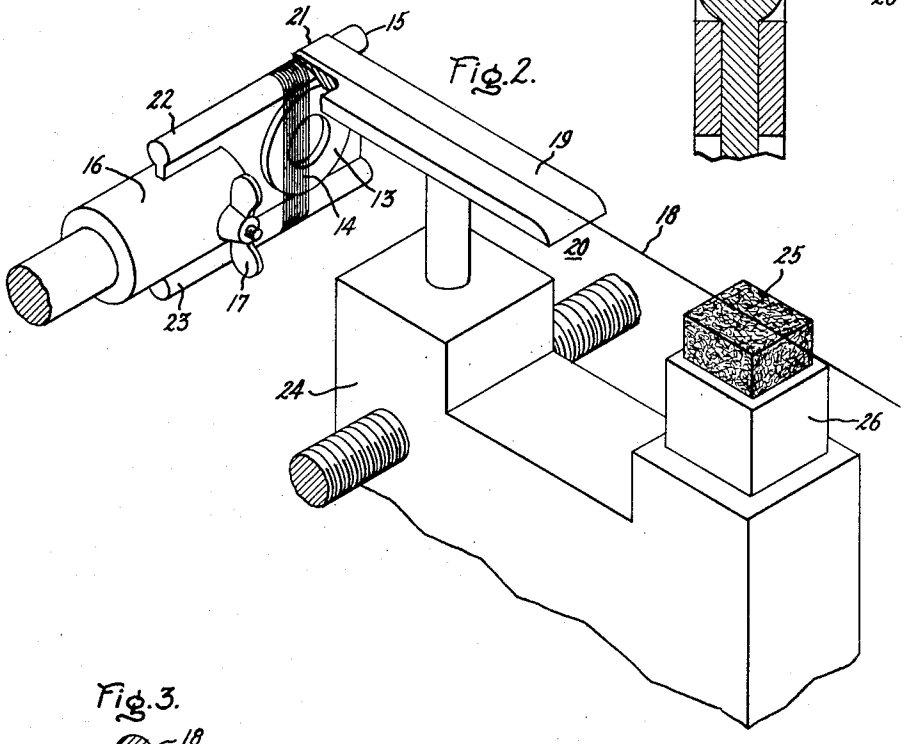
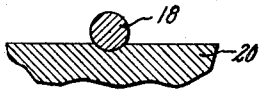


Fig. 3.



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GRID FABRICATION METHOD

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Continuation of application Serial No. 312,287, September 30, 1952. This application March 9, 1956, Serial No. 570,531

3 Claims. (Cl. 140—71.5)

This invention relates to the fabrication of grids for microwave electron discharge devices, and more particularly, to the method of fabrication of such grids from refractory metal wire filaments of very small cross section.

This application is a continuation of, and is assigned to the same assignee as, my copending application, Serial No. 312,287, filed September 30, 1952.

Microwave grids of the general type referred to herein are described in an article "Disc-seal tubes," by E. D. McArthur in "Electronics," vol. 18, February 1945, pp. 98–102, wherein it is stated that the clearances of a grid wire should be only a small fraction of a thousandth of an inch. Departure from a predetermined spacing of the grid elements may change the characteristics of the microwave device and may even result in operational failure. The grid wires or filaments must be mounted under tension on the grid frame and spaced uniformly parallel and closely adjacent to one another, 1,000 to 2,000 per inch.

It is expedient to utilize wires of a refractory metal in the fabrication of such grid structures because of the elevated temperatures to which they are subjected in operation. However, as may be observed under the microscope, fine drawn filaments of hard refractory metal, for example tungsten filaments, are rough and irregular. The combination of hardness and roughness in the surface condition of a wire being fabricated into a grid form renders its guidance extremely difficult.

As is commonly known, it is not practicable to draw refractory metal wires down to final diameters less than 0.001 inch in the range from 0.00015 to 0.0003 inch required for the grids of microwave electron tubes. Such wires are drawn down to the smallest practical die diameter and then are etched to reduce their cross section to the final diameter. Since the etching process cannot be controlled precisely, the wires will have diameters varying considerably from the nominal diameter, serrated surfaces and varying cross-sectional configurations.

Heretofore, it was considered necessary to guide such hard, abrasive wire by means of a mechanical implement of still harder material. Although resort was had to expensive materials such as sapphire, experience showed that the grid filaments were not so uniformly aligned as to give desired results even though all possible care was observed in utilizing such guides.

It was thought that the optimum guide should have dimensional stability, a V-shaped groove for example, which supposedly would accommodate changes in wire diameter by causing the wire to ride higher or lower in the groove while remaining symmetrical with the guiding direction. However, it has not been possible to provide a satisfactory guide of a material which is harder than the wire and yet not brittle so as to be chipped or flaked away in the preforming or in use as applied to attenuated refractory metal wire. A guide which has been flaked or chipped into an anomalous configuration does not provide satisfactory lateral constraint even for a wire of constant diameter and cannot compensate for variations in diameter.

Accordingly, it is an object of my invention to provide an efficient and inexpensive method for fabricating uniformly spaced grids for electron discharge devices.

A further object of my invention is to provide an improved method for fabricating grids for microwave electron discharge devices from refractory metal wire less than 0.001 inch in diameter.

A still further object of my invention is to provide a method of fabricating electron discharge device grids of refractory metal wire less than 0.001 inch in diameter whereby there is continuous compensation in the guiding of the wire to accommodate diamensional changes in the wire without distortion in the grid structure.

According to my invention, the method of fabricating a grid of refractory metal wire filaments comprises passing the wire over a surface of a guide of a material less hard than the wire, forming a groove for the lateral constraint of the wire by the wearing away of the guide by the wire, and continuously redimensioning the groove by wearing away of the guide by the passage of the wire so that the groove continuously functions as a lateral constraint for the wire.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which I regard as my invention, it is believed that the invention will be better understood from the following description taken in conjunction with the accompanying drawing, in which:

Fig. 1 is an elevational view of a device containing a microwave grid;

Fig. 2 illustrates, as an example, apparatus for fabricating grids according to the method of my invention;

Fig. 3 shows on an enlarged scale a fragment of a guide tip and a wire travelling in an indentation worn into the guide tip by such wire; and

Fig. 4 is a fragmentary elevation view of a guide tip and winding mandrel on an enlarged scale.

The disk-seal type of microwave tube shown in general outline in Fig. 1 includes an anode 4, a cathode 5 and an intermediate grid 6 which is located between the anode and the cathode. When such a tube is operated the cathode is heated to electron-emitting temperature by a heater 7. The envelope walls at 8, 9 and 10 and also the electric contacts 11 are shown to indicate a complete device in the fabrication of which my invention is applicable.

The grid as shown in Fig. 2 is constituted by an annular frame 13 on which are mounted grid wires 14 in parallel relation and in close juxtaposition. During the winding operation the frame 13 is mounted on a mandrel 15 which during application of the grid wires is clamped on a rotatable chuck 16 by tightening the thumb screw 17. These grid wires which may range in diameter from about 0.00015 to 0.0003 inch are stretched taut across the opening in the washer-like frame 13 and must be accurately and uniformly spaced.

As shown in Fig. 2 a fine wire 18 derived under tension from a source (not shown) and held under tension during the winding step travels over the flat smooth side surface 19 of the blade-shaped guide 20. The wire is wound on the mandrel 15 over the frame 13, which is slightly thicker than the edge heading 22 and 23 of the mandrel. The wire is caused to progress slowly from left to right as the mandrel and the frame rotate to cause the successive turns of the wire to embrace the frame 13 closely and to be uniformly spaced thereon by the progression of the guide from side to side. The progression of the guide relative to the face of the mandrel and frame to space accurately the grid elements closely adjacent one another is directed automatically by gears (not shown) timed to drive the travelling support 24 with re-

spect to the chuck **16** at a desired slow rate whereby the feed of the wire moves in a plane at right angles to the face of the grid at a rate adapted to secure desired close spacing of the grid wires. Preferably the wire **18** is wiped free of adhering grit and dust particles by a wiper **25** which is held in a socket **26** located in the path of the wire **18** before it reaches the guide **20**.

As the wire **18** leaves the guide **20** over the tapered edge **21**, the wire continuously wears by attrition of the softer guide material a slight indentation or groove near the tail edge **21** end of the guide as indicated in Fig. 3. This groove is to provide the lateral constraint for guiding the wire as it is moved longitudinally of the mandrel and frame. Since it is apparent that the wearing away of the guide by the harder wire is continuous, the groove is continuously redimensioned symmetrically with the direction in which the wire is travelling to provide constant restraint against anomalous sidewise motion of the wire which would result in misalignment of the grid filaments.

An individual tract or shallow guide groove thus made by the advancing wire on the guide **20** may be used for the fabrication of a number of grids, and as a plurality of grooves may be made on a guide blade, a large number of grids may be prepared without disturbing the guide. When eventually the grooves worn thereon become too deep and too numerous, the guide surface must be removed and smoothed mechanically to eradicate the grooves. The guide may then be used again. A unique feature of the present device is the fact that fine wire of the gossamer-like attenuation suitable for being fabricated into grid structure, will form a guiding groove in a steel guide by a single operation. That is, the guiding groove according to the method of this invention is continually dimensioned during the winding of the grid by passing the wire through the groove in a material less hard than the wire so that the groove continuously functions as a symmetrical lateral constraint for the wire regardless of changes in diameter and cross-sectional configuration.

After assembly of the grid wires on the annular frame has been completed, a small amount of brazing metal, for example, copper, silver or gold is electrolytically deposited on the frame adjacent to and over the ends of the grid wires which overlie and contact with the frame. Thereupon the frame with its assembled parts is heated in hydrogen to melt the brazing metal, thus securely uniting the grid wires with the frame. The grid thus made then may be removed from the mandrel and is ready for assembly into the tube structure for which it is intended.

As a consequence of the present method microwave grids of refractory metal wire may be fabricated having more exact and uniform spacing than was possible heretofore.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of fabricating a wire grid for a microwave electron discharge device from a wire substantially less than .001 inch in diameter and subject to variations in diameter with length of the wire, which method comprises forming a groove in a die of metal of lesser hardness than the wire, changing the dimension of the groove by attrition by the passage of the wire over the guide so that the groove continuously functions as a lateral constraint for the wire as the wire changes in dimension along its length, and moving the guide in a direction parallel to the rotation of a frame to wind the wire about the frame in parallel equally spaced turns.

2. The method of fabricating a grid of refractory metal wire considerably less than 0.001 inch in diameter and subject to variations in diameter with length of the wire, which method comprises passing the wire over a surface of a guide of a material less hard than the wire, forming a groove for the lateral constraint of the wire by the wearing away of the guide by the wire, winding the wire on a frame rotated about an axis in the plane of the frame, moving the guide relative to the frame in a direction parallel to the axis to space apart consecutive turns of the wire and changing the configuration of the groove by wearing away of the guide by the passage of the wire so that the groove continuously functions as a lateral constraint for the wire as the wire changes in diameter to wind the wire on the frame in parallel equally spaced turns.

3. The method of fabricating a grid for a microwave electron discharge device, which method comprises passing a tungsten wire less than 0.001 inch in diameter and subject to variations in diameter with length of the wire over a surface of a guide of a material less hard than the wire, forming a groove for the lateral constraint of the wire by the wearing away of the guide by the wire, winding the wire on a frame rotated about an axis in the plane of the frame, moving the guide relative to the frame in a direction parallel to the axis to space apart consecutive turns of the wire, changing the configuration of the groove by wearing away of the guide by the passage of the wire so that the groove continuously functions as a lateral constraint for the wire as the wire changes in diameter, and brazing the wire to a surface of the frame to form a grid of parallel equally spaced filaments of the wire.

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