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R. J. NIELSEN
FABRICATION OF GRID STRUCTURES FOR
ELECTRON DISCHARGE DEVICES

2,921,363

Filed June 30, 1955

2 Sheets-Sheet 1

FIG. 1

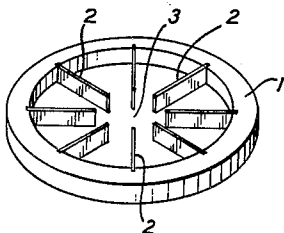


FIG. 2

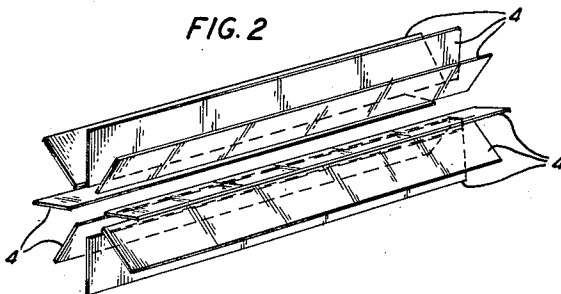


FIG. 3

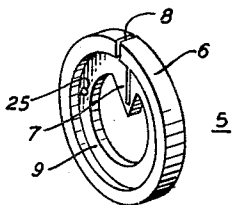


FIG. 4

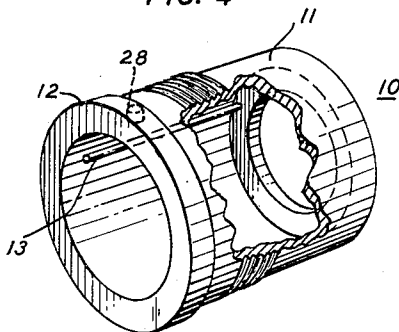
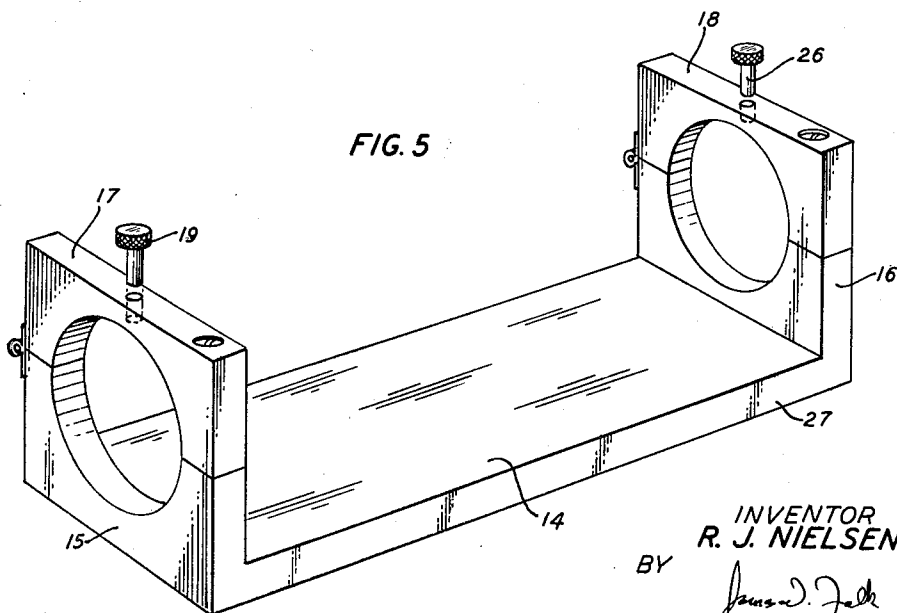


FIG. 5



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FIG. 6

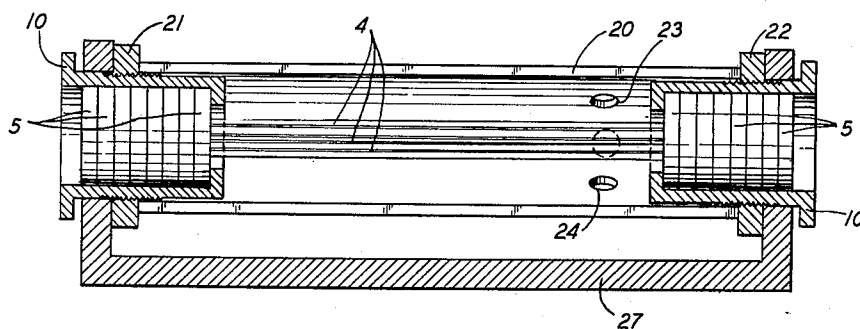
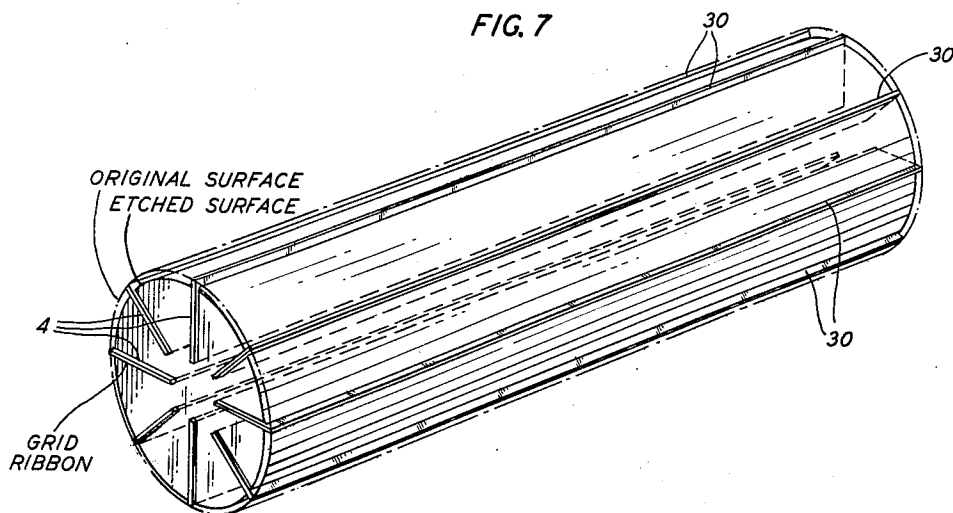


FIG. 7



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FABRICATION OF GRID STRUCTURES FOR ELECTRON DISCHARGE DEVICES

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Application June 30, 1955, Serial No. 519,145

6 Claims. (Cl. 29—25.14)

This invention relates to the fabrication of electrodes for space discharge devices and more particularly, to improvements in the fabrication of grid electrodes for space discharge devices operable at high frequencies.

It generally is desirable for maximum efficiency in circuits employing discharge devices that the grid structures of such devices be constructed to intercept a minimum number of electrons thereby to facilitate the passage therethrough of the electron stream. Such construction further is desirable due to the tendency of such structures to overheat as a result of the collision of intercepted electrons therewith, and to become distorted with use.

Of the many grid structures proposed in the prior art as a solution to this problem, one of the most satisfactory is the so-called radial type grid, that is, a grid which comprises an annular member having a plurality of radially inwardly directed grid bars or elements, which elements preferably are mutually spaced from one another and terminate short of the center of the grid structure thereby to provide an internal central aperture.

The radial type of grid has many distinct advantages, such as:

(1) The grid elements may be made with a favorable ratio of width to depth which, together with the provision of a central aperture, results in a smaller number of electrons intercepted.

(2) The large cross-sectional area of the grid elements provides a good heat dissipation capacity and eliminates the danger of high temperature grid destruction.

(3) Since the electron optical system has axial symmetry, the grid structure will pass either convergent or divergent streams of electrons with fewer collisions between the electrons and the grid walls.

(4) Since one end of each grid element is free, each element may expand or contract in the same plane, and no stresses are set up therein due to heating.

Priorly taught methods of fabricating such radial type grid structures have not proved entirely satisfactory for all of the sizes of grids and types of materials required in the art. For example, it is known to fabricate radial grids by sawing slots in the periphery of a cylindrical iron bar, placing the bar in a suitable receptacle and pouring cast material between the bar and the receptacle to form the grid. Such a method obviously is unsuited for grids made of materials having higher melting points, such as tungsten and the like.

It is further known to make radial grids by brazing formed tungsten details to the inner circumference of a rim member, but such a method is not applicable to the manufacture of smaller space discharge devices and particularly to very high frequency devices of the millimeter and centimeter type.

It is an object of this invention to provide an improved method of fabricating radial grids of the type utilized in high frequency discharge devices.

It is a further object of this invention to provide an

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improved method of fabricating radial grids comprised of refractory metals, such as tungsten and the like.

It is a still further object of this invention to provide an improved method of fabricating radial grids of small size for use in discharge devices operable in the centimeter and millimeter range.

It is a still further object of this invention to provide an economical method of fabricating small radial grid electrodes in quantity.

These and other objects are realized in a specific illustrative embodiment of this invention wherein a plurality of ribbon-like grid elements are positioned in space in a radial array within a suitable fixture. The array is enclosed by a cylindrical container and the space surrounding the array is filled by a filler material, which advantageously may be a powdered metal. The filler material, when solidified, produces a rod containing the grid elements in the desired radial pattern, which rod may be machined to a desired grid diameter. After the edges of the grid elements are exposed, such as by etching, a rim may be applied thereto by plating the outer surface of the rod with a suitable metal such as nickel, platinum and the like. The rod then is sliced into individual grid discs and the filler material etched out to form the finished grid.

Alternatively, in accordance with another embodiment of the invention, the rod, after being machined and etched, is sliced into individual grid discs and each disc is pressed into a piece of tubing, whereafter the edges of the grid elements are brazed to the tubing. The filler material then is etched out to form the finished grid.

In accordance with a feature of this invention, a radial vane grid is fabricated by positioning a plurality of radially spaced grid elements within a closed container, filling the container with a filler material to form a rod, slicing the rod into discs, and removing the filler material therefrom to form finished grids.

It is a further feature of this invention to fabricate such a radial grid wherein a rim is applied by plating the rod with a suitable metal before the rod is sliced into individual grid discs.

It is a still further feature of this invention to fabricate such a radial grid wherein a rim is applied by pressing each disc cut from the rod into a piece of tubing and brazing the edges of the grid elements in the disc to the interior surface of the tube.

It is a still further feature of this invention that a radial grid may be fabricated of grid elements comprising refractory metals, such as tungsten and the like.

A complete understanding of this invention, together with the above-noted and other features thereof, may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a perspective view of a radial type grid having a central aperture which may be fabricated in accordance with this invention;

Fig. 2 is a perspective view of a radially spaced array of ribbon-like grid elements depicting one step in the method in accordance with this invention;

Fig. 3 is a perspective view of a fixture plate that may be employed in the practice of this invention;

Fig. 4 is a perspective view of a part of a fixture plate holder that may be employed in the practice of this invention;

Fig. 5 is a perspective view of a fixture stand that may be employed in the practice of this invention;

Fig. 6 is an elevational view of the completely assembled fixture utilizing the fixture elements of Figs. 4, 5 and 6 and having the grid elements in place therein as shown in Fig. 2; and

Fig. 7 is a perspective view of a grid rod after the edges

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of the grid elements have been exposed, illustrating another step in one specific embodiment of this invention.

Referring now to the drawing, Fig. 1 depicts a radial grid of the type which may be fabricated in accordance with the instant invention. This grid comprises an annular member 1 and a plurality of radially, inwardly directed, ribbon-like grid elements 2. Grid elements 2 advantageously are uniformly spaced around the inner circumference of the annular member 1, and terminate short of the center of the grid structure to provide an internal central aperture 3. In accordance with an aspect of this invention, the grid elements 2 advantageously comprise ribbons of tungsten or a similar refractory metal in order that the grid may be able successfully to withstand a very intensive electron bombardment as is typical in many types of discharge devices, such as a low voltage, gridded, millimeter klystron. For the reasons enumerated above, a radial grid of the type shown in Fig. 1 permits the use of greater beam powers with less current interception and therefore results in improved efficiency and increased power output.

In accordance with this invention, such radial grids may be fabricated with precision in the small sizes necessary for discharge devices operable in the higher frequency ranges, as, for example, the reflex klystron oscillator disclosed in a copending application of L. B. Luckner and E. D. Reed, Serial No. 437,960, filed June 21, 1954. The grids advantageously are fabricated, in accordance with one specific illustrative embodiment of this invention, by positioning a number of fairly long ribbons of the desired grid material, such as tungsten, in space such that in a plane perpendicular to the axis they form the desired radial grid pattern. Such an array is shown in Fig. 2 of the drawing and comprises a radial pattern of metal ribbons 4, each of which advantageously may be approximately two to three inches long. To position such an array in space a fixture assembly comprising a fixture stand, a plurality of fixture plates, and a pair of plate holders, as hereafter described, advantageously may be employed. However, other equivalent means for positioning the grid elements may be employed and are fully within the scope of the invention.

In accordance with the illustrative embodiment described herein, each ribbon element 4 is held by a pair of fixture plates 5, of the type shown in Fig. 3 of the drawing. Each fixture plate 5 comprises a ring 6 having an internal flange member 9 and a slotted triangular projection 7 through which the grid ribbon 4 is threaded. Each slot 8 of the triangular projection 7 ends a predetermined distance from the center of the fixture plate 5, and thereby establishes the diameter of the aperture at the center of the grid. The included angle of the triangular projection 7 is chosen so that the grid ribbons can pass through other fixture plates unobstructed. Fixture plate 5 further comprises an index hole 25 for enabling the fixture plate to be secured in position by an index pin in a fixture plate holder. Except for the location of the index hole 25 and the length of the radial slot 8, all of the fixture plates 5 are of identical construction.

When all of the grid ribbons 4 are each assembled in a pair of fixture plates 5 in the desired radial pattern, the plates are assembled in a fixture plate holder 10, of the type shown in partial form in Fig. 4 of the drawing. Each plate holder 10 comprises a hollow cylindrical body 11 having a flange 12 at one end thereof, and an index pin 13 connected to its interior surface for properly aligning the fixture plates 5. Each holder 10 further comprises an index pin hole 28 for securing the holder in a fixture stand.

The stand 27 into which the fixture plate holders 10 are assembled is shown in Fig. 5, and comprises a horizontal base member 14, a pair of vertical members 15 and 16 connected at each end of the base member 14, and a pair of top plates 17 and 18 hinged to the vertical members 15 and 16, respectively. Each vertical member

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and top plate defines an aperture through which a fixture plate holder 10 may be inserted, the top plates 17 and 18 being opened at this time to facilitate the insertion. Index pins 19 and 26 are located on the upper surfaces of the top plates 17 and 18 to position and secure the pair of fixture plate holders 10 to the stand 27.

Each grid ribbon 4, which advantageously may be of any grid material such as tungsten, molybdenum or copper, may be assembled in a fixture plate 5 by sliding the ribbon 4 into the slot 8 of the fixture plate and anchoring the end of the ribbon by welding a cross wire to the ribbon, or by other suitable means. The fixture plate then is assembled in a fixture plate holder 10 at one end of the stand by sliding the index pin 13 through the index pin hole 25. The ribbon 4 then is fed through an identical fixture plate 5 and holder 10 in the other end of the stand. The ribbon 4 is pulled taut and attached to the second fixture plate 5 by anchoring the ribbon in the same manner as before. Using the same procedure, the remainder of the grid ribbons 4 are assembled in the pair of fixture plate holders.

After all of the grid ribbons 4 have been assembled, the fixture plate holders 10 are enclosed within a split cylinder 20. This entire assembly is shown in Fig. 6 of the drawing. The split cylinder halves may be held together with wire or clamps as is known in the art. A pair of hexagonal nuts 21 and 22 are located between the ends of the cylinder 20 and the vertical stand members, and are tightened against the ends of the cylinder to tension the grid ribbons 4. The assembly then may be removed from the stand 27 and a filler material, which advantageously can be any base material such as iron, zinc, tin, lead or Woods metal, may be poured in through filler holes 23 and 24 located in the cylinder 20. In accordance with an aspect of this invention, the filler material may be in a molten state or in powdered form. If powdered metal is used for a filler it is sintered in a furnace or by passing the cylinder through a radio frequency coil, as is known in the art. After the filler metal has solidified, the two halves of a cylinder 20 are opened, and the resultant rod is removed. The rod then may be reduced to its final diameter by turning or grinding on a lathe or by centerless grinding, if preferred.

At this point, the fabrication advantageously may proceed in either of two ways, in accordance with two specific embodiments of this invention, the essential difference being in a method of the application of the outer rim of the grid. In one embodiment, the outer rim first is plated onto the rod and the rod cut into discs; in the other embodiment the rod first is cut into discs, which discs then are brazed into a tube.

In accordance with the first method and embodiment above mentioned, the rod is completely immersed in an acid etch in order to expose the outer edges 30 of the grid ribbons 4, as shown in Fig. 7 of the drawing. These exposed edges then are surrounded by a plating that is deposited on the rod. This plating will form the outer rim of the grid and advantageously may be nickel, platinum, or any other metal that will not be attacked by the final etch. The thickness of the plating will be determined by the desired thickness of the rim. Additional material may be plated on the rod in order that the outside diameter thereof may be turned to the final required size if desired.

After plating, the rod may be cut into discs of the required thickness. When the required thickness has been obtained, the discs are immersed in an etching solution of the type which will actively attack the filler material and leave the grid ribbons 4 solidly embedded in the outer rim. After cleaning, the grids then are ready to be incorporated in their associated discharge devices.

In the above-mentioned second method and embodiment of fabricating a rim, a tube of suitable metal is used for the rim material. The rod first is reduced to its final diameter and then is sliced into discs, each disc

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being thicker than the desired finished grid thickness. The upper end of the tube may be flared with a suitable tool so that the discs may easily be inserted. Each disc then is forced down into the tubing, such as with a small hand press, and is brazed into the tube to form the grid structure. The tube then is cut off flush with the top of the grid, and lapped to the required final thickness. The grids then are immersed in an etching solution to remove the filler material, and the finished grids cleaned in the same manner as described above.

While this invention has been disclosed in several particular embodiments and methods of fabrication, it will be understood by those skilled in the art that various other modifications may be made in the materials, shapes and methods of processing to achieve the results of the invention.

What is claimed is:

1. The method of fabricating a grid structure comprising the steps of assembling a plurality of metal ribbons in a predetermined spatial pattern, enclosing said ribbons in a container, filling said container with a filler material to form a rod, applying a rim to the outer surface of the rod, slicing the rod into individual grid discs, and etching the filler material out of each disc to form a grid.

2. The method of fabricating radial grids for use in high frequency discharge devices comprising the steps of assembling a plurality of ribbon-like grid elements in a radial array, placing said array within a container, filling the space around said array with a filler material to form a solid rod, plating the surface of said rod to form a rim for said grid elements, dividing the rod into a plurality of grid discs, and removing the filler material from each grid disc to form a finished radial grid.

3. The method of fabricating grid structures of the type utilized in high power klystron discharge devices comprising the steps of assembling a plurality of refractory metallic ribbons in a spatial array, forming a rod of etchable material having said array embedded there-within, reducing the diameter of said rod to expose the edges of said ribbons, plating the outer surface of said

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rod to form a rim for said ribbons, dividing the rod into a plurality of individual grid discs, and removing the etchable material from said grid discs.

4. The method of fabricating grid structures which comprises the steps of assembling a plurality of grid elements in a predetermined spatial pattern, enclosing said grid elements within a cylindrical container, filling said container with a powdered metal filler, sintering said metal filler to form a solid rod, reducing the diameter of said rod to expose the edges of said grid elements, plating said rod to form a rim for said grid elements, slicing said rod into a plurality of individual grid wafers, and removing said metal filler from said grid wafers.

5. The method of fabricating grid structures of the type utilized in high frequency discharge devices which comprises the steps of assembling a plurality of grid elements in a spatial array, enclosing said elements within a cylindrical container, filling said container with a filler material to form a rod, reducing the diameter of said rod to expose the edges of the grid elements, dividing the rod into a plurality of grid discs, brazing the exposed edges of each disc to the inner surface of a rim member, and removing said filler material from each disc.

6. The method of fabricating a grid structure which comprises the steps of assembling a plurality of grid elements in a predetermined spatial pattern, enclosing said grid elements within a container, filling said container with a powdered metal filler, sintering said metal filler to form a solid rod, reducing the diameter of said rod to expose the edges of said grid elements, dividing the rod into a plurality of discs, placing each disc within a rim structure and securing the exposed grid elements thereto, and removing the metal filler from each disc.

References Cited in the file of this patent

UNITED STATES PATENTS

1,551,342	Steenstrup	Aug. 25, 1925
2,511,962	Barnes	June 20, 1950
2,515,267	Salisbury	July 18, 1950
2,619,438	Varian et al.	Nov. 25, 1952
2,721,952	Kenyon	Oct. 25, 1955