GRID ELECTRODES FOR ELECTRON DISCHARGE DEVICES

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1 Claim. (Cl. 29—25.14)

This invention relates to electron discharge devices, and, more particularly, to a method of making and aligning grid electrodes suitable for use in ultra-high frequency electron discharge devices.

A basic problem in the manufacture of ultra-high frequency electron discharge devices is the high degree of precision required for the close spacing of the electrode elements. Typical ultra-high frequency electron discharge devices have cathode-to-grid spacings of 0.005 inch or less and grid wires with a diameter of 0.001 inch or less. When multiple grid electrode ultra-high frequency electron discharge devices are utilized additional problems arise with regard to the necessary accurate alignment of the closely spaced grid wires of one grid electrode with those of another grid electrode.

Prior art methods of aligning elements of grid electrodes involve such things as elaborate optical systems, high precision fixtures and a high degree of operator skill. Also, these prior art methods require that at least one of the grid electrodes being aligned must be joined to the electron discharge device after alignment, which process frequently results in movement of portions of the grid electrode being joined. This movement may be due to stresses created in the joint or to other factors. A slight misalignment of this type in an ultra-high frequency tetrode would cause dangerous overheating of the screen grid electrode, resulting in the test rejection or failure of the tube.

Accordingly, it is an object of this invention to provide an improved method of making grid electrodes. It is another object to provide an improved method of making grid electrodes suitable for use in multiple electrode electron discharge devices.

It is an additional object to provide an improved method of accurately aligning grid electrodes suitable for use in multiple electrode electron discharge devices.

The foregoing and related objects are achieved in accordance with the method of the present invention by using a first grid electrode member as a pattern for a second grid electrode member which is then formed from a photosensitive blank member by a photogravure process, so that accurately aligned and spaced grid electrodes are produced.

In accordance with my invention, a pattern grid electrode member, including opaque portions, is made by conventional methods and mounted in a grid electrode support assembly. A grid electrode blank member is mounted in the grid electrode support assembly and accurately spaced from the first grid electrode. The grid electrode blank member is coated with a photosensitive material which on exposure to light becomes less water soluble. A light source is positioned so that the pattern grid electrode member is between the light source and the grid electrode blank member in such a manner that a shadow of the pattern grid electrode member falls on the photosensitive coating.

After exposure to light, the areas of the photosensitive coating protected by the shadow of the pattern grid electrode member are washed off. The remaining photosensitive coating is further insolubilized as explained in detail below and the uncovered areas of the grid electrode blank member are covered by a coating which is comparatively inert in the etching solution specified below. The remaining photosensitive coating is removed, usually by dissolution, thereby uncovering portions of the grid electrode blank member. These uncovered portions of the grid electrode blank member are completely etched away thus leaving, after their remaining protective covering is removed, a second grid electrode, the elements of which are very accurately spaced and aligned with the elements of the pattern grid electrode member.

The invention is set forth in greater detail in the following description taken in accordance with the accompanying drawings which form a part of this application, and in which:

Figure 1 is a sectional view of an ultra high frequency tetrode electron discharge device embodying grid electrodes made and aligned in accordance with my invention;

Fig. 2 is a partial sectional view of the step of exposing portions of the photosensitive coating on a planar grid electrode blank member to light;

Fig. 3 is a partial sectional view of the step of exposing portions of the photosensitive coating on a demountable planar grid electrode blank member to light;

Fig. 4 is a partial sectional view of the step of exposing portions of the photosensitive coating on a cylindrical grid electrode blank member to light;

Fig. 5 is a partial sectional view of a coated grid electrode blank member;

Fig. 6 is a partial sectional view of a coated grid electrode blank member after the "development" step;

Fig. 7 is a partial sectional view of a coated grid electrode blank member, as shown in Fig. 6, after the uncovered portions of the grid electrode blank member have been coated with a protective material;

Fig. 8 is a partial sectional view of a coated grid electrode blank member, as shown in Fig. 7, after the remaining photosensitive coating has been removed;

Fig. 9 is a partial sectional view of a coated grid electrode blank member, as shown in Fig. 8, during the dissolving action;

Fig. 10 is a partial sectional view of a grid electrode made by the steps shown in Figs. 5 to 9, inclusive before the remaining protective coating is removed;

Fig. 11 is a partial sectional view of a grid electrode with a trapezoidal cross section made by the steps shown in Figs. 5 to 9, inclusive;

Fig. 12 is a partial sectional view of an embodiment of the grid electrode members made in accordance with my invention in which the grid electrode further from the cathode has been used as a pattern and the grid electrode nearer the cathode has been made according to my invention;

Fig. 13 is a partial side view of the grid electrodes of a twin tetrode in which two of the grid electrodes may be made according to my invention, and

Fig. 14 is a partial end view of a grid electrode, as shown in Fig. 13, made according to my invention.

In Fig. 1 there is shown an ultra-high frequency disk seal electron discharge device in which either the control grid electrode 15 or the screen grid electrode 17 may be made and aligned according to my invention. Included are an indirectly heated cathode 11 and anode 13 and a control grid electrode 15 between said cathode 11 and said anode 13. A screen grid electrode 17 is positioned...
between the control grid electrode 15 and the anode 13. The cathode 11 is heated by a heater member 18 and the anode 13 is cooled by a cooling assembly 19 including a plurality of cooling fins 21. An evacuated envelope 23 including glass insulator portions 25, metal grid support members 27 and 29, cathode support members 31 and anode support members 33 encloses the electrode elements of the electron discharge device.

In Fig. 2 there is shown the step of “exposing” a planar grid electrode blank member including a pattern grid electrode member 39, having opaque portions 40, and a grid electrode blank member 35 mounted in a grid electrode support assembly including glass insulator portions 41. The grid electrode blank member 35 is coated with a photosensitive coating 37. When the grid electrode blank member 35 is exposed to light rays 42, portions of the photosensitive coating 37 are not exposed to light due to the shadows 43 of the opaque portions 40 of the pattern grid electrode member. In this way the photosensitive coating 37 is made up of light exposed or undesired portions 59 and shadow protected or desired portions 57. The shadow protected or desired portions 57 are accurately aligned with the opaque portions 40 of the pattern grid electrode member 39.

In Fig. 3 there is shown the step of “exposing” a demountable planar grid electrode blank member including a grid electrode member 53 and a grid electrode member 47. The pattern grid electrode member 53 is mounted on a pattern grid electrode support member 69. The grid electrode blank member is fixedly positioned on a second grid electrode support member 71 by a pin member 65. In this manner, after the photosensitive coating 61 is exposed to the light rays 77, the grid electrode blank member may be demounted and treated without exposing the mounting assembly to the etching action described below. Also, if desired, the grid electrode blank member 47 may be turned over after one side has been exposed to light and the coating 49 on the other side of the grid electrode blank member 47 may be exposed to the light 77 in a similar manner. Also shown are the cathode support member 75, the anode support member 73, and insulator portions 67.

In Fig. 4 there is shown the step of “exposing” a cylindrical grid electrode blank member including a cylindrical grid pattern electrode member 59, a cylindrical grid electrode blank member 93 with a photosensitive coating 95. A light source 54 is placed at the axis of the cylinder and light rays 56 expose portions of the photosensitive coating 95 in a manner similar to that shown in Figs. 2 and 3.

In Fig. 5 there is shown a second grid electrode blank member 79 upon which a photosensitive coating 81 has been deposited. Before the second grid electrode blank member 79 is used, it should be cleaned by boiling in a 5% sodium hydroxide solution, rinsed, boiled in distilled water and kept in distilled water until ready for use.

In general, the photosensitive coating 81 is of the type that becomes less water soluble on exposure to light. A suitable photosensitive coating 81 may be prepared as follows. A stock solution composed of 57 grams of egg albumen, 240 ml of water, 0.1 ml of chloroform, and 4 drops of ammonium hydroxide (specific gravity 0.90) is allowed to stand overnight and is filtered through absorbent cotton. 30 ml of ammonium dichromate solution (22 grams per 100 ml of solution) is added to the stock solution which is then diluted with water to a volume of 230 ml. A resist solution is made up of 54 grams of photoengravers' glue (a specially purified fish glue suitable for photoengraving), 22.4 ml of the above stock solution, 41 ml of ammonium dichromate solution (22 grams per 100 ml of solution) and 100 ml of water. The ammonium dichromate solution should be diluted with water before the addition of the glue and the stock solution. Then the resist solution is diluted with water to a volume at 300 ml. The solutions should be protected from light during storage and may not work satisfactorily if more than a week old. Immediately before use, the resist solution is filtered through absorbent cotton in a funnel directly into the container to be used for coating the blank members. Blank members are dipped into the resist solution and held horizontally for 5 seconds, then immediately re-dipped and held horizontally for 20 seconds. Then the blank members are hung vertically to drain and partially dry. After an hour they are again dipped in the same manner as before. Then the blank members are allowed to dry until dry. The coating should be applied in a place where there is a minimum of light, particularly direct light. Also, the coated members may be kept in the dark for 24 hours without damage but if kept for longer periods they may be difficult to use properly.

After exposure to light, as shown in Figs. 2, 3 and 4, the exposed grid member is “developed” by moving it back and forth in room temperature water for one minute and then rinsing in clean water. The developed grid member is then immersed for three minutes in a 3% ammonium dichromate solution. After rinsing, the exposed grid member is dried and baked at a temperature of 300° C. for eight minutes to harden and further insolubilize the coating.

Fig. 6 shows the second grid electrode blank member 79 after the exposure step and the “development” step, explained above. Uncovered portions 85 of the second grid electrode blank member 79 are shown as well as remaining portions 83 of the photosensitive coating.

Next, the second grid electrode blank member 79 is coated with a material which is comparatively inert in the electrolytic etching process described below. A suitable material is gold, which may be applied by electropolishing. Also, other portions of the second grid electrode blank member 79 and adjacent members may be plated with gold to protect them during the etching process.

Fig. 7 shows the second grid electrode blank member including remaining portions of the photosensitive coating 83 after the plating operation described above has deposited a protective material 87 on the portions of the second grid electrode blank member not covered by the photosensitive coating 83.

Fig. 8 shows the second grid electrode blank member 79 after the remaining portions 83 of the photosensitive coating have been removed, leaving portions 89 of the protective material 87 and uncovered portions 85 of the second grid electrode blank member 79. The protective coating may be removed by boiling in a solution of 5% sodium hydroxide.

In the next step, bare portions of the second grid electrode blank member 79 are dissolved. A suitable method for doing this is by electrolytic etching with acid salts, such as ferric chloride and sodium acid sulfate, or with acids, such as a 50% by weight sulfuric acid solution. Another suitable method is by acid etching.

Fig. 9 shows the grid electrode member 79 with the protective material 87 during the etching action.

In Fig. 10 there is shown a completed grid electrode including the grid electrode elements 91 with the protective material 87 still remaining. This remaining protective material 87 may be removed by suitable methods, which methods depend on the composition of the material 87.

Fig. 11 shows the final grid electrode after the removal of the protective material 87. As can be seen, the individual grid electrode elements 91 have a somewhat trapezoidal cross section. If the second grid electrode blank member 47, as shown in Fig. 3, is treated on both sides, the cross section of the individual grid electrode elements will, of course, not be trapezoidal, but may vary, depending on how long the elements are etched.
In Fig. 12 there is shown a portion of a tetrode including a portion of a cathode 103 and a portion of an anode 101. In this case the grid electrode 105 further from the cathode 103 has been used as the pattern from which the grid electrode 107 positioned nearer to the cathode has been made. Used in this way, the trapezoidal cross section of the elements 98 of the control grid electrode 107 has been found to be very desirable because of the smaller current pickup since electrons miss the recessed rear portion 97 of the control grid electrode elements 98. The electron pickup by a control grid electrode 107 having elements 98 with a trapezoidal cross section has been found to be less than that of a grid electrode having elements with a circular cross section if both grid electrodes have the same control characteristics.

In Fig. 13 there is shown a portion of a twin tetrode including an insulator support member 169 upon which grid electrode support members 111 and 115 are mounted. The outer grid electrodes 117 are used as patterns for the inner grid electrodes 113. This requires two exposures to light, the first being light 129 from one side, the second being light 131 from the other side.

In Fig. 14 there is shown an end view of a grid electrode, such as those shown in Fig. 13, including insulator support members 127, a grid electrode support member 121 and a grid electrode member 123 including openings 125 in the grid electrode member 123.

If desired, a nitrocellulose film may be used in Figs. 5 through 10 as a protective and support member. This nitrocellulose film may be removed by rinsing in solvent. Nickel is a suitable metal for the grid electrode blank members. Also copper-nickel alloys and stainless steels are suitable. As mentioned above, any metal surfaces, such as the first grid member and support assemblies, may be plated with a material such as gold to protect them from etching. This gold plating need not be removed in some cases as it is helpful to provide high radio frequency conductivity in high frequency tubes. The gold plating also prevents thermionic emission due to electron emissive materials which have been evaporated onto the grid electrodes on oxide coated cathode tubes. Other methods of protecting metal surfaces from etching include coating with lacquer, nitrocellulose or similar materials.

If a photosensitive coating 81 of the type that becomes more water soluble on exposure to light is used, the disclosed process may be modified by omitting the steps shown in Figs. 7 and 8, as the uncovered portions 85 in Fig. 6 would be covered and the areas covered by the remaining portions 83 of the photosensitive coating would be bare, thus eliminating the steps involving the protective material 87.

Grid electrodes constructed and aligned in accordance with my invention have many advantages. Some of these advantages include elimination of a joining operation after grid alignment, elimination of the need for operator's skill during alignment, the ease of reproducing characteristics from tube to tube, and cheaper tube assemblies due to the speed of the alignment operation. My invention also permits simple design and improves electrical characteristics of the "average" tube because of the better alignment.

While the present invention has been shown in a few forms only, it will be obvious to those skilled in the art that it is not so limited but it is susceptible of various changes and modifications without departing from the spirit and scope thereof. For example, my invention is applicable to a large number of electron discharge device geometries and sizes. My invention is also applicable to any multiple grid electron discharge devices including pentodes, tetrodes and triodes of the type in which two aligned grid electrodes are used in place of a single grid.

I claim as my invention:

In the art of manufacturing an electron discharge device having a first grid electrode having a plurality of apertures and a second grid electrode having a plurality of apertures with the apertures in said first grid electrode aligned with the apertures in said second grid electrode, the steps comprising permanently mounting said first grid electrode member within an electrode mount structure, permanently mounting a photosensitive blank member within said electrode mount structure from which said second grid electrode member is to be formed, providing a photosensitive coating on said blank member facing said first grid electrode member, projecting light through the apertures in said first grid electrode member to define a light pattern on said blank member corresponding to the aperture pattern in said first grid electrode member, and removing the portions of the blank member defined by said light pattern to form said second grid electrode member such that the apertures in said second grid electrode member are accurately aligned with the apertures in said first grid electrode member.

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