May 22, 1956 S. O. EKSTRAND ET AL 2,746,123

FABRICATION OF ELECTRODES FOR ELECTRON DISCHARGE DEVICES

Original Filed Aug. 3, 1949 3 Sheets-Sheet 1

FIG. 1

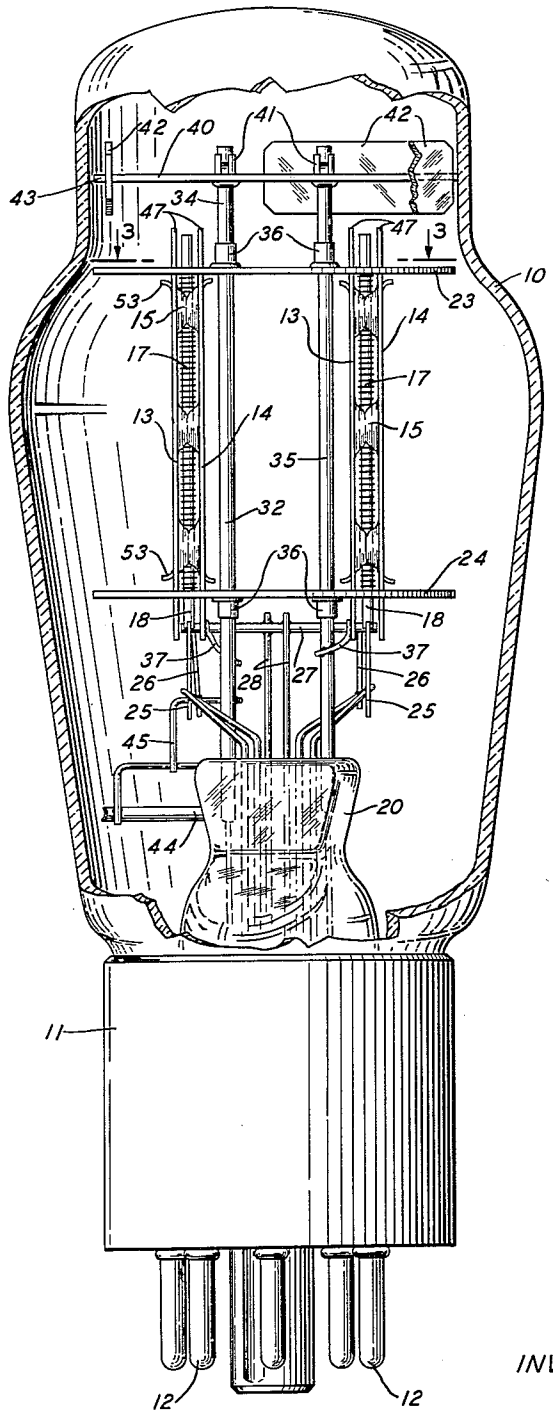
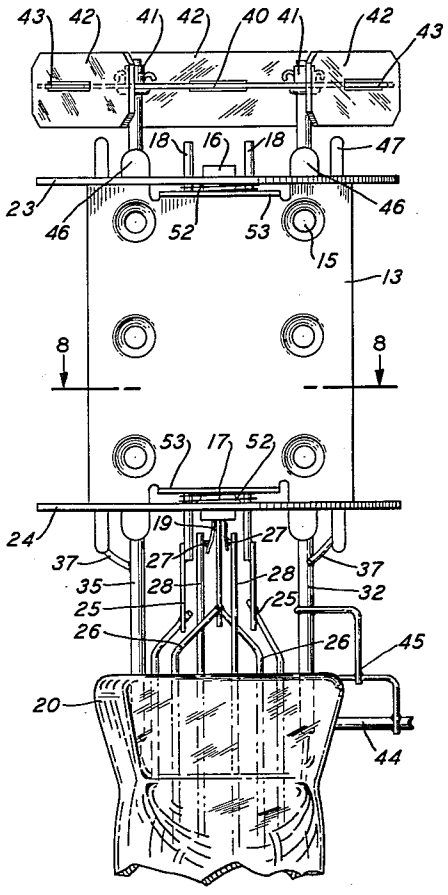


FIG. 2



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FABRICATION OF ELECTRODES FOR ELECTRON DISCHARGE DEVICES

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FIG. 7

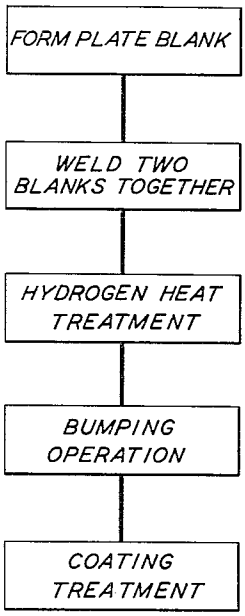

FIG. 3

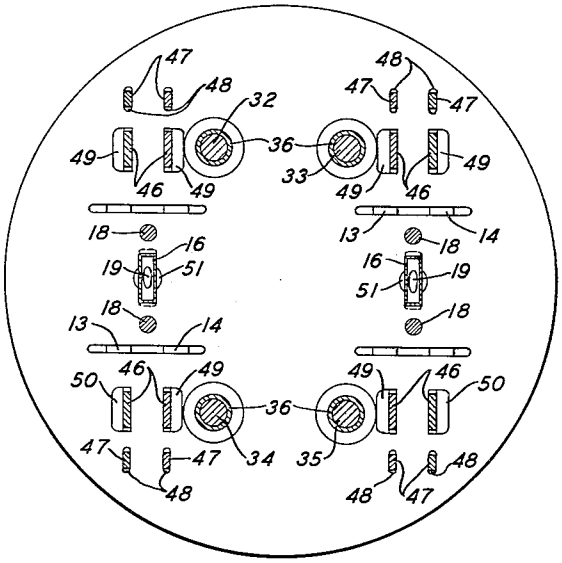

FIG. 8

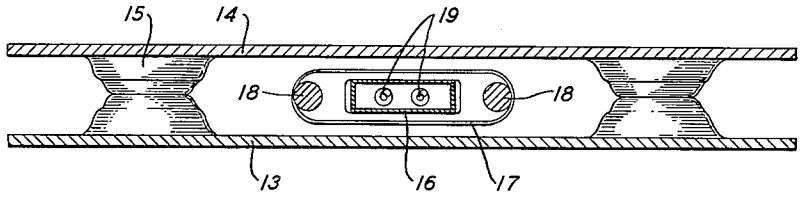

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FIG. 4

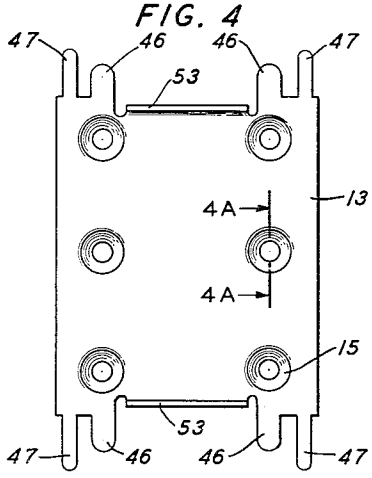


FIG. 4A

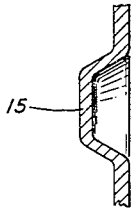


FIG. 5A

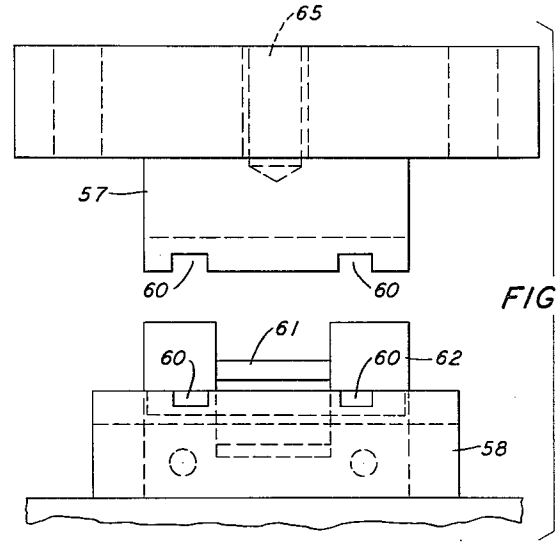


FIG. 5B

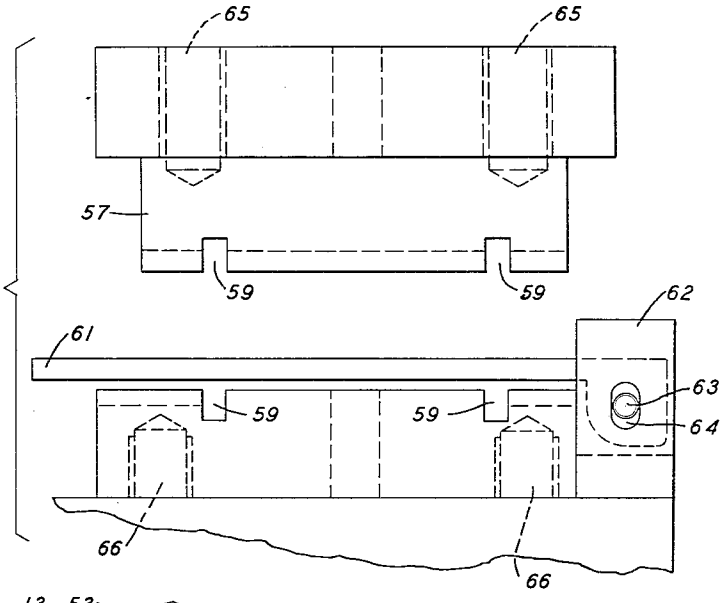
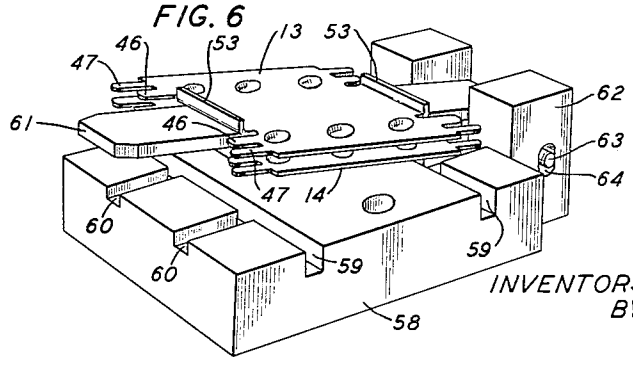


FIG. 6



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2,746,123

FABRICATION OF ELECTRODES FOR ELECTRON DISCHARGE DEVICES

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Original application August 3, 1949, Serial No. 108,356, now Patent No. 2,592,549, dated April 15, 1952. Divided and this application May 19, 1951, Serial No. 227,214

3 Claims. (Cl. 29—25.18)

This invention relates to electron discharge devices and more particularly to electrode structures, especially anode structures, for such devices.

This application is a division of application Serial No. 108,356, filed August 3, 1949, now Patent No. 2,592,549, granted April 15, 1952.

It is well known, of course, that the operating characteristics of electron discharge devices are dependent upon the electrode spacings and that particularly advantageous characteristics may be realized by making these spacings small. For example, close interelectrode spacing, especially small spacing between the grid and anode, leads to small voltage drop and sharp cut-off characteristics. The realization of small spacings, however, entails manifold practical difficulties. Specifically, it is difficult not only to obtain accurate initial small electrode spacings but also to maintain such spacings during operation of the device. Further, the realization of uniformity of product in quantity manufacture of electron discharge devices having closely adjacent electrodes involves obvious complexities. The general problem involved may be appreciated when it is noted that in particular triodes having a nominal grid-to-anode spacing of the order of 0.0085 inch the permissible tolerances in this spacing to meet prescribed operating requirements are of the order of ±0.001 inch.

One general object of this invention is to improve the structure and performance characteristics of electron discharge devices and especially of such devices having very closely spaced electrodes. More specifically, objects of this invention are to facilitate the attainment of prescribed small interelectrode spacings, to expedite the fabrication of devices including very closely spaced electrodes, to minimize variations in the interelectrode spacings during operation of the devices, and to enhance uniformity of product in the quantity manufacture of such devices.

In accordance with one feature of this invention, an anode for electron discharge devices of the type having portions or sections on opposite sides of another electrode, such as a cathode or grid, is constructed of two parallel plate sections having spaced embossments, the embossments on the two sections being jointed in abutting relation to fix the spacing between the sections.

In accordance with another feature of this invention, the anode sections are provided with extensions or ears constructed and arranged so that they may be readily associated with spacer members, such as insulating discs, to mount and position the anode in prescribed relation to other electrodes and to maintain the anode position during operation of the device.

In accordance with a further feature of this invention the anode, after assembly, is heat treated to relieve stresses resulting from the joining of the anode sections, whereby these sections maintain their proper relationship.

In accordance with a still further feature of this invention the anode sections are subjected to a bumping operation to insure uniformity of spacing and parallelism between the plate sections.

These and other desirable features are incorporated in one illustrative embodiment of this invention in a twin triode in which the twin electrode elements are mounted in parallel relation between mica spacers supported in spaced relation on two rigid posts extending from an inwardly projecting stem, the spacers being attached to the posts as by eyelets. The twin cathodes are heater type rectangular-shaped sleeves with a pair of embossments on the short sides at opposite ends to locate the cathodes properly between the spacers. The insulated heater elements are mounted by a pair of horizontal wires connecting the heaters in parallel with each wire attached to a vertical lead-in wire in the stem. The cathodes are separately connected to other lead-in wires in the stem. The grids are wound on side rods of the swedged type and the windings or laterals are in parallel relation to the greater dimensions of the cathode surface. The anode is formed of two parallel plates with circular embossments adjacent the longitudinal edges. The embossments in each plate project inwardly and are aligned with the cooperating embossments of the other plate to which they are locally welded. The anodes are also provided with different sized pairs of ears at each corner to lock the anodes in the mica spacers, the large ears mounting the anodes from the spacers and one of the narrower ears forming a lead connection for each anode.

Further in one illustrative procedure for preparing the anode structures in accordance with this invention whereby they will have very accurate spacing, the anode plates are first formed with the embossments and ears. The embossments are then aligned with cooperating embossments on the other plate and the two welded together, following which the welded anode structure is hydrogen heat treated to obtain a stress-free surface. The anode structure is then bumped in a bumping die whereby the embossment columns are crushed to obtain a uniform spacing between the two anode plate sections. The anode is then coated with a black-body gas-absorbing coating.

A complete understanding of these and other desirable features of this invention may be gained from consideration of the following detailed description and the accompanying drawings, in which:

Fig. 1 is an elevational view of a twin triode electron discharge device embodying an anode structure illustrative of this invention, a portion of the enclosing vessel being broken away to show the internal assembly;

Fig. 2 is a side view in elevation of the elements as mounted in the stem of the device shown in Fig. 1;

Fig. 3 is a sectional view of the device taken along line 3—3 of Fig. 1;

Fig. 4 is an elevational view of an anode section illustrative of one embodiment of this invention;

Fig. 4A is a sectional view along line 4A—4A of Fig. 4;

Fig. 5A is an end view of a die used in the preparation of the anode structure in accordance with this invention;

Fig. 5B is a side view of the die of Fig. 5A;

Fig. 6 is a perspective view of one die member of Fig. 5, showing the anode structure mounted on the mandrel;

Fig. 7 is a diagram illustrating the steps to be taken in the preparation of the anode structure; and

Fig. 8 is a sectional view of one triode structure taken along line 8—8 of Fig. 2.

Referring to the drawing, the electrode assembly is mounted in an enclosing vessel 10 which is sealed in a base 11, provided with a plurality of terminal pins 12

mounted in parallel relation in a circle. The electrode unit, which for purposes of illustration is shown as a twin triode, comprises a pair of parallelly arranged groups of electrodes, the similar elements of each group being identified by the same numeral. The anode of the triode is composed of parallel plates 13 and 14, joined together by embossments 15, and encompassing cathode 16, a helical grid 17 which is wound on support rods 18, and a cathode heater 19, best seen in Fig. 8. The electrodes are mounted between insulating spacer discs 23 and 24 and are connected through the stem 20 to the pins 12 by appropriate leads. Thus the two grids 17 are independently connected to two pins 12 by the leads 25 attached each to a grid rod 18, and the cathodes 16 are connected to pins 12 by two leads 26, the leads being composed of a ribbon portion attached to the electrode and a wire portion attached to the pin, the two portions being joined together as by welding. The heater elements 19 are connected to two leads 28 by cross wires 27, the two heater elements thus being connected in parallel. The insulating discs 23 and 24 are supported in spaced relation by a plurality of rigid posts 32, 33, 34 and 35, two of which extend from the inwardly projecting stem 20. The insulating discs are attached to the posts as by eyelets 36. A short lead 37 connects one anode to the post 32 and another lead 37 the other anode to post 35, the two posts extending into the stem 20 and being in turn connected to appropriate pins 12. Thus the cathodes, grids and anodes are individually connected externally through the pins 12 for applying suitable potentials to the various electrodes.

The cathode 16, as shown best in Fig. 8, comprises a rectangular sleeve, as of nickel, which is coated on the outside with electroemissive material, such as a finely divided barium-strontium-calcium carbonate in amyl acetate solution of nitrocellulose plasticized with butyl cellosolve. The grids 17 may be of the swedge type with laterals formed of molybdenum wire and gold-plated to reduce emission from the grids. The spacer discs 22 and 23 may be of mica.

An insulation disc 40, which may also be of mica, is supported above the electrode assemblies by the posts 32, 33, 34, and 35, to which it is attached by eyelets 41. Side strips 42, which may also be of mica, are attached to the disc 40 and held in position by ears 43 evenly spaced around the periphery of the disc 40. The disc 40 and side strips 43 serve to prevent vibration of the top end of the electrode assembly.

A getter wire 44 is mounted by a getter support assembly 45 attached to one of the posts, such as 32.

The anode sections 13 and 14, as shown in Fig. 4, are provided with different sized pairs of ears 46 and 47 to lock the anodes in the spacer discs 23 and 24. The large ears 46 provide the rigid mounting of the plates and one of the narrow ears 47 is connected to lead 37 to provide the connection to the post and thus the pin 12. While only one ear 47 is used for each anode the plates are stamped with the ears at all corners to simplify the assembly and thereby avoid selection of parts for the fabrication of the anodes. The anode sections are also formed with end flanges 53 between the ears 46 at both ends of the section.

The various electrodes are supported in fixed position by the spacer discs 23 and 24, as best seen in Fig. 3 with reference to disc 23. The disc is provided with apertures 48 through which the narrow ears 47 extend and with apertures 49 and 50 through which the larger ears 46 extend. The apertures 49 are slightly larger than the ears 46 so that the ears float in them, but the apertures 50 are of almost the same width as the ears 46 so that the ears are tightly held thereby. A short section of the ears 46 is flat and parallel to the plane of the anode section to accomplish location in the disc 23. The remaining parts of the ears 46 are bent slightly to facilitate entrance into the respective slots in the disc 23 and to clearly define the ear

sections in which parallelism must be maintained. Apertures 51 are provided in the disc 23 through which the cathode sleeve 16 closely fits, the sleeve being formed with embossments 52, best seen in Fig. 2, directly beneath the disc 23 and above the disc 24, to hold the cathode firmly in position. Other apertures are provided in the disc members through which the posts and rods 18 extend.

In the construction of the anode, each anode section 13 and 14 is first blanked and formed in a press, the embossments 15, ears 46 and 47, and end flanges 53 being formed with the sections. The sections are then placed in a welding jig in which the sections can be rapidly aligned. The embossments 15 on section 13 are then welded to the embossments on section 14; all six welds may be made at one time, or singly if preferred. The welded assembly is then heated treated in a hydrogen atmosphere to relieve all strains from the welding operation and the original forming operation. It has been found advantageous to heat the assembly at around 1000° C. for about 10 to 15 minutes.

It has also been found advantageous that the assembly in this stage have a spacing between the two sections 13 and 14 which is slightly larger than that required by the tube geometry. It has been found that the different assemblies after the heat treatment have larger variations in the spacing between sections from one assembly to the next than can be tolerated. In order to insure uniformity of spacing in the assemblies and parallelism between the sections 13 and 14 each assembly is subject to a bumping operation in a die such as shown in Figs. 5 and 6.

The bumping die shown in Figs. 5 and 6 comprises an upper die member 57 and a lower die member 58 the die faces of which are hardened, ground, and parallel. Both die members have two parallel slots 59 across their width and four shorter slots 60 extending lengthwise from these parallel slots to the edges of the die. A tongue or mandrel 61, which is hardened and ground with parallel faces, is hinged to an end portion 62 of the lower die member 58, as on a pivot rod 63 extending through apertures 64 in the end portion 62. The die members may be held in the press by screws extending into the threaded apertures 65 in the upper member 57 and 66 in the lower member 58.

The assembled anode is first inserted on the tongue 61, as shown in Fig. 6. When the tongue 61 is lowered so that the anode section 14 is directly on top of the face of the lower die 58, the end flanges 53 fit into the slots 59 and the ears 46 into the slots 60. The end flanges 53 thus serve to position the assembly in the die. The upper die member is then brought down pressing the anode assembly between the two die faces.

This operation results in the plate being squeezed to an inside dimension equivalent to the tongue thickness plus spring back. Since the only support existing between the plate sections is that of the six columns made up of the welded bosses, the plate is brought to proper size by crushing these columns. Thus the finished bumped plate assembly is still practically free of stress in the flat areas of the plate, which were not affected by this bumping operation, and hence does not lose the minor axis dimensional accuracy in subsequent operations.

When the assembly is thus brought to proper size it is then treated with a black-body and gas absorbing coating, such as a zirconium hydride.

These steps in the preparation of an anode assembly in accordance with this invention are diagramed in Fig. 7, the steps being the making of the form plate blank and the bending of the flanges 53 and ears 46, the joining of the two sections 13 and 14 together by welding the embossments 15 together, the hydrogen treatment of the welded assembly to relieve stress, the bumping operation in a bumping die to accurately form the anode assembly, and the coating treated onto the anode assembly.

When the anode is assembled in the tube the dimensions between it and the other electrodes are held to close tolerances by the design of the ears 46 and the apertures

49 and 50. Motion of the anode assembly perpendicular to the plane of the major axis of the cathode 16 is restricted by the inside of ears 46 inserted in the apertures 49, 50. Motion parallel to the cathode's major axis is restricted by the ears 46 and the apertures 50, these being formed with a close tolerance so that the ears 46 have an interference fit in the discs 23 and 24 while the ears 46 located in apertures 49 are allowed to float in the apertures 49 in this direction. This floating of the ears at one end of the anode assembly permits of wider piece part tolerances in the dimensions between the ears.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. The method of preparing an electrode assembly for electron discharge devices, said assembly comprising two similar flat plate sections each having inwardly extending embossments, comprising welding said embossments, heat treating said assmebly to relieve stress, and subsequent to said heat treatment compressing said assembly down to a predetermined spacing between said sections by crushing the welded embossments.

2. The method of preparing an anode assembly for electron discharge devices which comprises forming two anode sections with spaced inwardly extending embossments adjacent parallel edges, placing the embossments of one section in abutting relation to those of the other section, locally welding said embossments together thereby to form a plurality of spaced columns integral with the planar portions of said anode sections and extending therebetween, heat treating said assembly in a hydrogen atmosphere and bumping said assembly after said heat treatment by compressing the welded embossments evenly to a predetermined spacing between sections.

3. The method of preparing an electrode assembly for electron discharge devices comprising a pair of flat plate sections having inwardly projecting embossments adjacent parallel edges, which comprises positioning the flat plate sections with the embossments of one plate in abutting relation to the embossments of the second plate, welding the abutting embossments together to form a plurality of columns integral with said flat plate sections and extending therebetween, heating the electrode assembly in a hydrogen atmosphere, and applying pressure evenly to both sections to crush the columns to a predetermined spacing between sections subsequent to the heating of said electrode assembly.

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