March 31, 1942. A. M. SKELLETT 2,277,858

ELECTRONIC DISCHARGE DEVICE

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FIG. 1

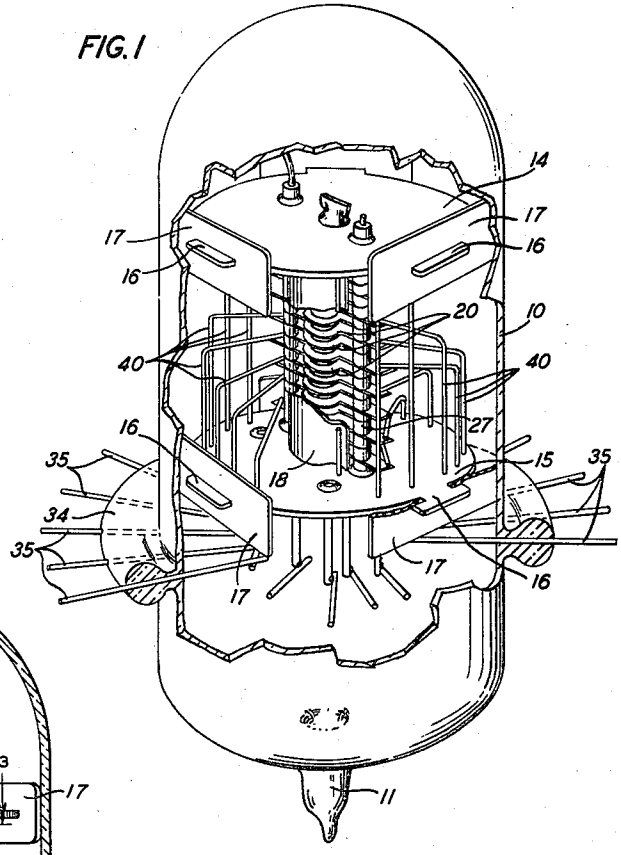
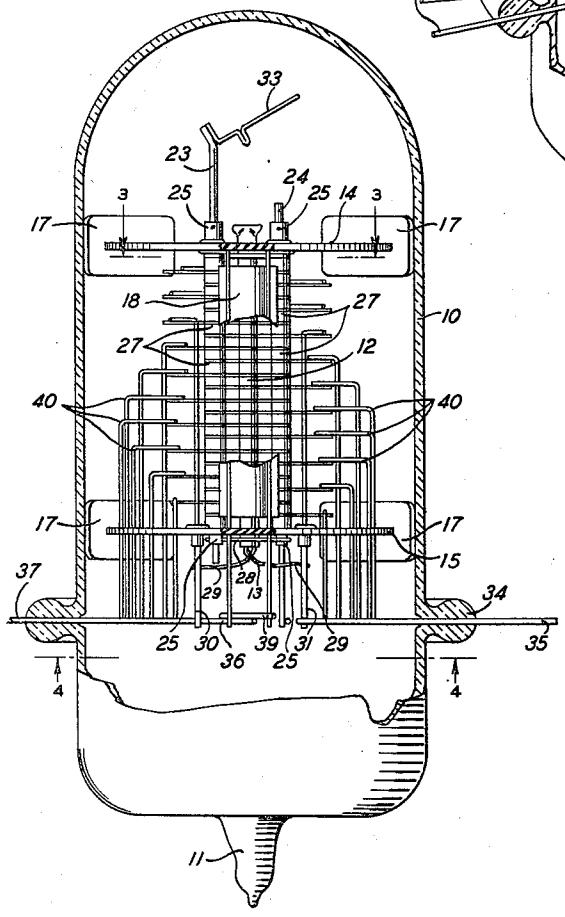


FIG. 2



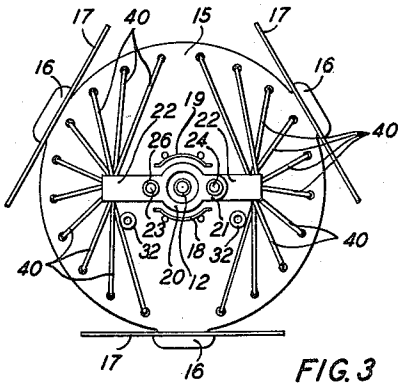


FIG. 3

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FIG. 4

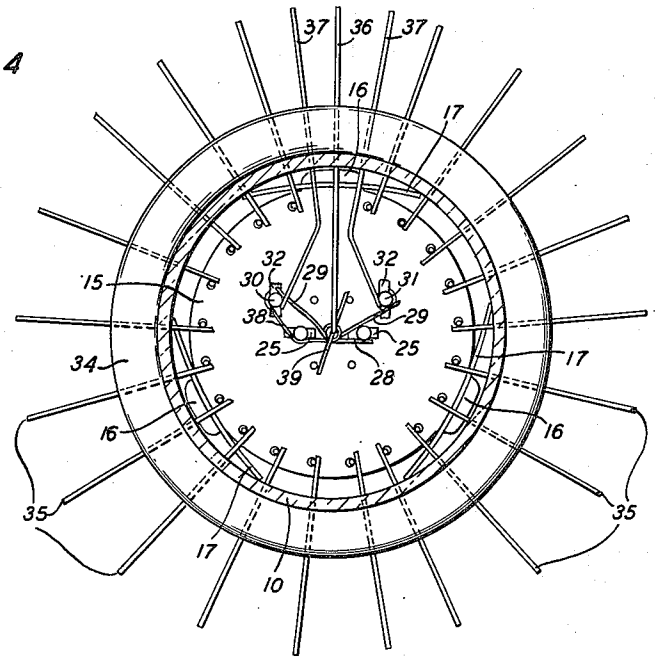

FIG. 5

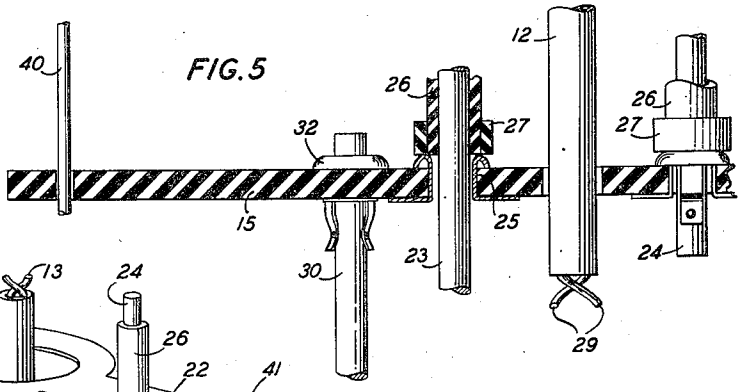

FIG. 6

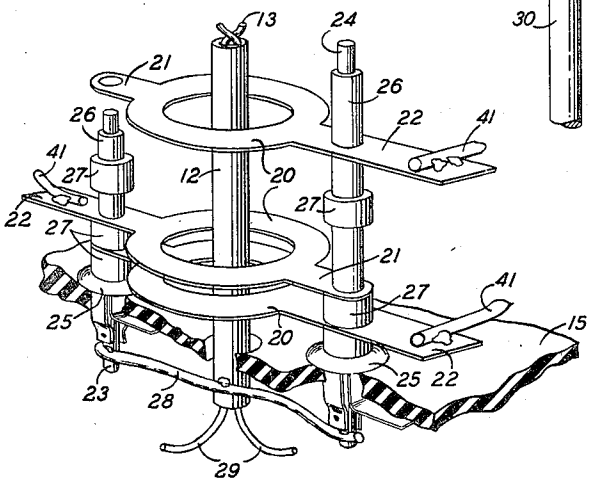

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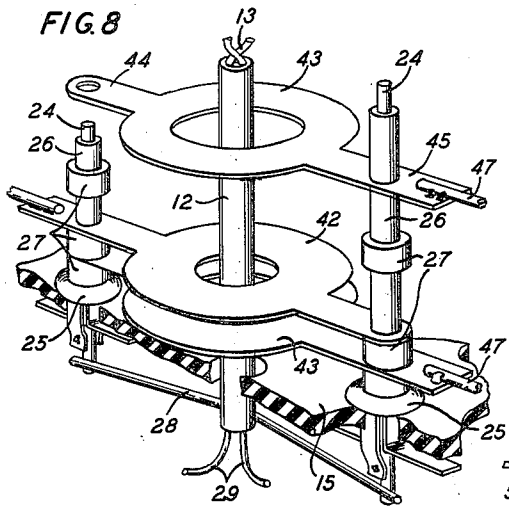
FIG. 8



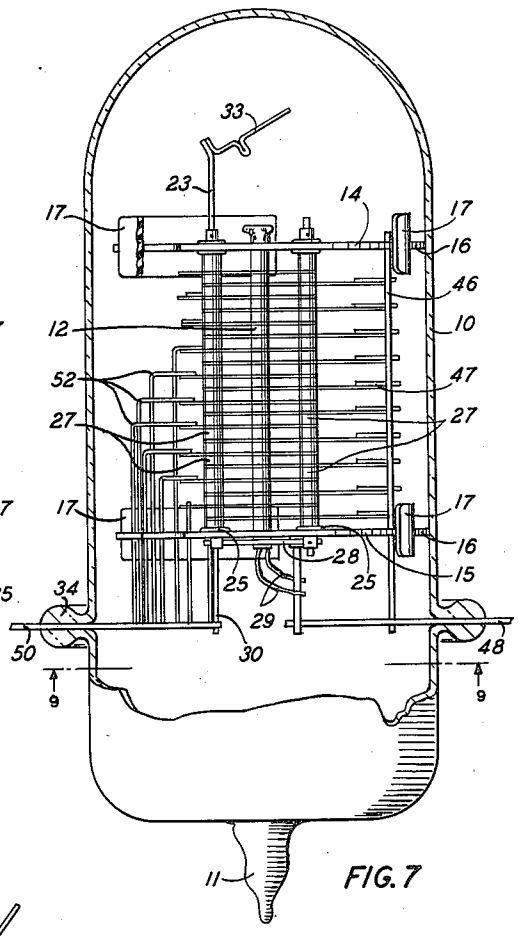
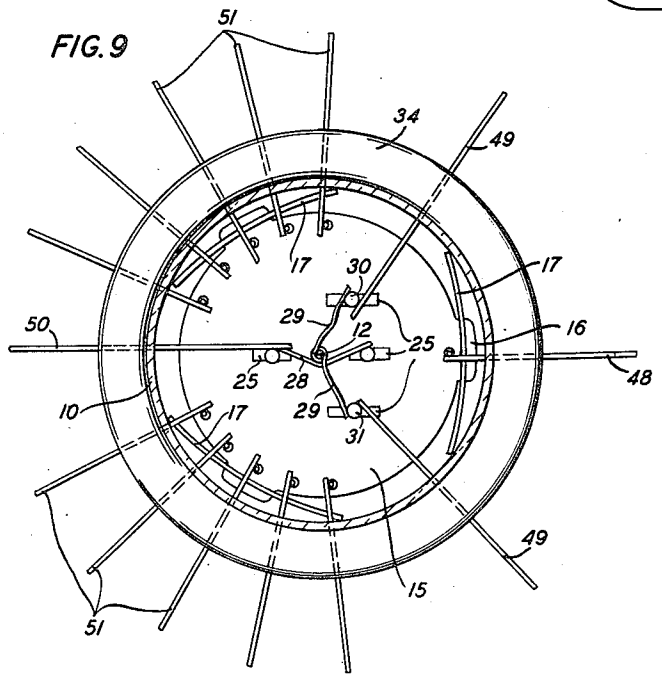


FIG. 7

FIG. 9



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UNITED STATES PATENT OFFICE

2,277,858

ELECTRONIC DISCHARGE DEVICE

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Application May 17, 1941, Serial No. 393,921

11 Claims. (Cl. 250—27.5)

This invention relates to electronic discharge devices and more particularly to devices having multicontrol elements for electronic switching applications in the electric and communications arts.

In prior devices comprehended by this invention, the cathode or electron source is surrounded by an output electrode or anode, the spacing therebetween being maintained at a minimum to achieve the purposes of the device, and intermediate these work electrodes a group of wire control elements or grids are positioned in paraxial relation in a circular boundary, each grid being spaced the same distance from the cathode and anode.

When a large number of wire grid elements are provided and confined to a restricted diameter of the electrode area, the wires are necessarily of small diameter and easily distorted by mechanical handling and heat treatment, thereby materially altering the control characteristics of the device. Furthermore, the wire grid elements are difficult to hold in proper alignment with other associated electrodes.

An object of this invention is to improve the mechanical and electrical efficiencies of multigrid discharge devices.

Another object of the invention is to insure accurate space relationship of the multigrids with other cooperating electrodes.

A further object of the invention is to control the amplification factor and plate resistance characteristics of such devices within certain limits, while maintaining the transconductance substantially constant.

In accordance with this invention, the difficulties of prior devices are overcome and the above objects are attained, in one aspect of the invention, in which a central cathode or electron source is surrounded by stacked annular disc-like control elements, each being individually provided with a conductor sealed in the vessel wall to impress a suitable potential thereon. The rigid assembly of the stacked discs insures strength and positive alignment both with respect to each other and to other electrodes associated therewith. Furthermore, the control elements may be increased to any desired number dependent on the length of the assembly and the spacing between the elements without sacrificing accurate spatial relation with respect to the cathode. The anode output electrode may surround the stacked grid elements or may be formed of a plurality of disc sections similar to the grid elements and positioned in alternating relation with the grid elements, the anode discs being connected to a common terminal conductor sealed into the vessel.

A feature of the invention relates to the unitary mounting of the assembly involving multi-disc-like grids and anode elements in which the elements are supported in rigid spatial relation by end spacer members carrying cushion spacers engaging the wall of the vessel, the elements being coupled to conductors radially sealed through an annular rim of the vessel.

Another feature of the invention relates to the stacking of the elements in coaxial relation to a central cathode to insure positive interspatial relation therebetween and provide accurate alignment and definite symmetry between the cooperating electrodes of the unit. This is accomplished by forming the disc-like elements with an annular central portion of suitable dimensions and outwardly projecting ears or tabs punched to receiving insulating pillars and intermediate spacers between the elements to rigidly fix the location of the electrodes.

These and other features of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings:

Fig. 1 is a perspective view of one embodiment of the invention with parts of the vessel and the internal electrodes broken away to clearly illustrate the assembly of the unit.

Fig. 2 is a view in elevation of the device of Fig. 1 with the vessel mostly in cross-section to illustrate the relationship of the electrodes in the unit and the provision of the individual conductors for the multigrid elements.

Fig. 3 is a plan view of the device of the invention taken on line 3—3 of Fig. 2 showing the disposition of the conductors with respect to the stacked electrodes of the unit.

Fig. 4 is a plan view of the lower end of the device taken on line 4—4 of Fig. 2.

Fig. 5 is an enlarged fragmentary view of the various details entering into the support of the elements in the lower spacer member.

Fig. 6 is an enlarged view in perspective partly in section showing details of stacking the control elements in the unit.

Fig. 7 illustrates in elevation a modification of the invention in which the anode is formed of discs similar to the control elements.

Fig. 8 is an enlarged perspective view of details of the elements of Fig. 7, in which the grid and anode disc elements are shown in partly assembled relation; and,

Fig. 9 is a plan view of the lower end of the unit assembly of Fig. 7.

Referring to the drawings and particularly to Figs. 1 and 2, the electronic switching device of this invention is embodied in a highly evacuated vitreous vessel 10 having an exhaust tubulation at the lower end which is sealed after the device is completely evacuated. This vessel forms a housing for the electronic switching unit assembly supported therein. This unit includes a central cathode or electron emitter 12 of the equipotential type which involves a metallic sleeve carrier coated with electron emissive material, such as the oxides of alkaline earth, and an internal heater element 13 for energizing the cathode coating by conduction to facilitate the emission of electrons from the coating. The cathode is centrally supported at opposite ends by circular spacing discs 14 and 15 of suitable insulating material, such as mica, the discs being provided with spaced outwardly projecting ears 16 which carry vertical insulating strips of mica 17 so that the flexible ends of the strips contact the inner wall of the vessel 10 and contribute to the support of the unit.

Opposed to the cathode and longitudinally positioned on opposite sides thereof are two curved plate sections 18 and 19 which are secured to pairs of upright wires extending through the spacing discs 14 and 15. These plate sections form the anode or output electrode of the unit. Between the cathode and the anode, a plurality of annular disc-like elements 20 are positioned to coaxially surround the cathode and form multicontrol elements. By varying the potentials on any one of the elements, the electrons in its vicinity may be controlled in their travel from the cathode to the anode so that suitable switching problems may be achieved by electrostatic control of the electron discharges in the device.

The construction of the multicontrol elements may be more clearly understood from a reference to Fig. 6 which shows an annular disc-like element 20 having an integral ear 21 extending radially from the circumference of the element and an elongated extension 22 diametrically opposite the ear 21, the extension 22 being provided with an aperture equally spaced from the circumference of the element, the same as the ear 21. These disc-like elements are mounted in coaxial relation with respect to the cathode with the long extension 22 projecting in opposite directions in alternate tiers and the ears 21 alternating with the extensions 22 of adjacent elements. These elements may be punched from sheet metal, such as nickel or aluminum, with a suitable die to insure accurate similarity between all the elements. The multidisc elements are mounted or stacked on suitable parallel rods 23 and 24 which are coextensive with the cathode 12 between the spacing discs 14 and 15 and are mounted therein by metallic eyelets 25 secured in accurate position in the discs. The upright rods are surrounded by insulating sleeves 26, of aluminum oxide or similar insulating material, and of such diameter to pass through the apertures in the disc-like elements 20 thereby insulating the elements from the support rods 23 and 24. The elements are stacked in successive relation and equally spaced with respect to each other by spacing collars 27, of insulating material similar to the sleeves. This construction insures accurate alignment of the disc-like elements with respect to each other and also with respect to the cathode and anode of the device and insures proper segregation of the multielements embodied in the unit so that leakage between them is eliminated. Furthermore, the stacking arrangement insures rigidity in the whole assembly and increases the efficiency of operation and constancy in the characteristics of the device. This construction of the multicontrol elements of the device and the mounting thereof also insures the alignment and coaxial relation of the control elements, so that uniform control conditions are realized regardless of the number of control elements embodied in a given assembly. The short collars 27 insure accurate and uniform space relationship between all of the control elements and adequately insulate the respective elements from each other and the remaining components in the unit. Furthermore, the insulation encased standards 23 and 24 arranged on opposite sides of the cathode facilitate the staggering of the long extensions of the elements to segregate the numerous elements and enable the coupling of multiple conductors carried by the vessel to the individual elements. The stacked assembly provides constant concentricity of the control elements 20 with respect to the cathode and also eliminates distortion of the annular portion of the elements with respect to the long extensions 22 which project laterally from opposite sides of the stacked assembly. The cathode 12 is also supported from the parallel standards by a strap 28 mounted below the lower insulator 15, the cathode being connected to the centre of the strap and the ends thereof being welded to the eyelets 25 below the disc 15. The terminations of the heater element 13 extend to short rods 30 and 31 and are welded thereto, the rods being secured to the insulating disc 15 by eyelets 32.

After the unit is assembled as heretofore described, it is placed in the vessel 10 with the top of the unit spaced from the dome of the vessel by the contacting edges of the spacers 17 at opposite ends of the unit, the dome of the vessel preferably being coated with an opaque film of magnesium which is vaporized from a getter material supported in the crimped portion of the plate 33 mounted on an extension of the standard 23. The lower end of the vessel is provided with a rim seal 34 which is in the form of an annular rib projecting from the circumference of the vessel. This rib forms a sealed joint for a plurality of radially directed conductors such as 35, equal in number to the annular disc-like grid elements 20 in the electrode unit, the conductors being distributed in spatial relation with their outer ends spaced apart a greater distance than the ends within the vessel as shown in Fig. 4. Since there are twenty grids in the device as shown in Fig. 2, it is necessary to provide the same number of conductors 35 in the rib seal to facilitate individual connection to the grids and accomplish the multi-switching action capable of being performed in accordance with this invention. The rib seal also includes a suitable conductor, such as 36, for the anode 18 and conductors 37 for supplying energy to the heating element 13 of the cathode, the cathode also being connected to one of the heater leading-in conductors 37 by a wire connection 38 coupled between the eyelet 25 and the rod 30 to which the conductor 37 is attached. The radial conductor 36, as shown in Fig. 4, is connected to the center of the crosspiece 39 which bridges the support rods for the anode 18 extending below the insulator 15. The grid elements 20 are coupled to their respective leading-in conductors 35 through angle-shaped

connectors 40 which have their short ends 41, as shown in Fig. 6, secured to the long extension 22 of the grid element and their long extensions projecting vertically through apertures arranged adjacent the periphery of the lower disc 15 and are welded to the conductors 35 which bisect the angle connectors 40 in the plane of the conductor 35 adjacent the seal 34 of the vessel. The combined mounting of the unit in the vessel and its support therein by the side spacers 17 and the radial conductors provides a compact and efficient assembly for the multioperating functions of the device. Furthermore, the radial disposition of the grid element conductors insures adequate insulation between the various elements so that leakage or short-circuit does not easily occur in the operation of the device.

A modification of the invention is disclosed in Figs. 7 to 9, inclusive, in which the grid control elements are slightly modified as shown at 42 in which the aperture therein is smaller than described in connection with the previous figures to attain a higher transconductance characteristic by reducing the space relation between the cathode and the grid elements. The anode in this embodiment is formed of a plurality of ring-like elements 43 having outwardly extending portions 44 and 45 which are stacked alternately with the grid elements on the support standards 23 and 24, the anode elements having a larger internal diameter than the grids 42 so that the space discharge is equally distributed along the whole length of the cathode in relation to the grid elements and the anode elements. The anode elements 43 are connected to a longitudinal wire 46 extending through the end insulators of the unit by short stub wires 47, the longitudinal support wire 46 being connected to a radial conductor 48, as shown in Fig. 9. The conductors 49 extend radially below the unit and are attached to the support rods 30 to which the terminations 29 of the heater are connected. The cathode is attached to a radial conductor 50 which extends diametrically opposite to the anode conductor 48 in the rib seal 34, the remaining ten radial conductors 51 being provided for the ten grid elements in the unit shown in Fig. 7 through the angle connectors 52 similar to the grid connectors 40 in Fig. 1. By the modification of the elements of the interleaved or stacked anode and grid elements, a large range of plate resistance and amplification factor may be realized with substantially constant transconductance.

In the operation of the devices of this invention for multiswitching applications, the grid elements are normally biased at —40 volts with a plate voltage of 120 volts. Then if one of the grids is grounded by suitable circuit facilities connected to the grid a current of 2.5 milliamperes is realized in the anode circuit for producing the switching operation desired. The advantage of this construction is that the grid elements have uniform characteristics due to their rigid construction and assembly in electronic switching problems in the communication arts in which mechanical switching difficulties are adequately overcome by devices as set forth herein.

While the invention has been disclosed with respect to particular structural arrangements of the compact unit of this invention, it is, of course, understood that various modifications may be made in the detailed elements without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electronic switching device comprising an enclosing vessel, a unitary mount within said vessel containing a central electron emitting cathode, a plurality of control elements adjacent said cathode, said elements having central apertured disc portion coaxially surrounding said cathode and outwardly extending portions fixed in linear and superimposed relation on opposite sides of said cathode, insulating means spacing said elements and mounted coextensive with said cathode, anode means cooperating with said cathode and control elements, and conductors passing through the wall of said vessel connected to said cathode, anode and control elements.

2. An electronic switching device comprising an enclosing vessel, a unitary mount within said vessel containing a central electron emitting cathode, a plurality of annular flat control elements insulatingly stacked in successive spaced layers about said cathode, an anode member cooperating with said cathode and said control elements, spacer discs on opposite ends of said cathode, control elements and anode, a plurality of current conductors radially sealed through a circumferential portion of said vessel, and connectors passing through one of said discs near the periphery thereof and coupled to said conductors and said elements.

3. An electronic switching device comprising an enclosing vessel, a central cathode therein, a plurality of control elements cooperating with said cathode, said elements having a central apertured disc portion coaxially surrounding said cathode and outwardly extending portions fixed in linear and superimposed relation on opposite sides of said cathode, insulating means spacing said elements and mounted coextensive with said cathode, the extending portions of alternate elements projecting beyond said insulating means on opposite sides of said cathode, an anode cooperating with said cathode and control elements, and radial conductors in said vessel joined respectively to the alternate extending portions of said elements.

4. An electronic switching device comprising an enclosing vessel, a unitary mount within said vessel containing a central electron emitting cathode, a plurality of annular flat control elements insulatingly stacked in successive spaced layers about said cathode, an anode member cooperating with said cathode and said control elements, a plurality of current conductors radially sealed through a circumferential portion of said vessel, and a plurality of connectors extending laterally upward from said conductors and having the ends thereof bent towards the elements in successive planes.

5. An electronic switching device comprising an enclosing vessel having an annular rim near one end thereof, a central cathode in said vessel, insulating spacers at opposite ends of said cathode, parallel supports connected to said spacers and positioned on opposite sides of said cathode, a plurality of annular flat metallic grid members surrounding said cathode, said members having outwardly extending arms secured to said supports, insulating collars interposed between adjacent members on said supports to insulate and stack said members in coaxial alignment, and anode formed of arcuate plate sections longitudinally supported by said insulating spacers and partially surrounding said cathode and said grid members, a plurality of radially disposed conductors sealed into said annular rim, and a plu-

rality of connecting wires between said conductors and said grid members.

6. An electronic switching device comprising an enclosing vessel having an annular rim at one end thereof, a central cathode therein, insulating spacers at opposite ends of said cathode, parallel supports connected to said spacers and positioned on opposite sides of said cathode, a plurality of annular flat metallic grid members surrounding said cathode, said members having outwardly extending arms secured to said supports, an anode formed of arcuate plate sections longitudinally supported by said insulating spacers and partially surrounding said cathode and grid members, a plurality of radially disposed conductors sealed into said annular rim, and a plurality of connecting wires between said conductors and said grid members, said wires extending through one of said insulating spacers near the periphery thereof in transverse relation to the respective radial conductors, the other end of each wire being bent inwardly in the plane of its respective grid member and attached to an arm thereof.

7. An electronic switching device comprising an enclosing vessel having an annular rim near one end thereof, a central tubular cathode, a heater element within said cathode, insulating spacers at opposite ends of said cathode, a plurality of annular flat metallic grid members insulatingly stacked in successive spaced layers about said cathode, an anode formed of arcuate plate sections longitudinally supported by said insulating spacers and partially surrounding said cathode and grid elements, a pair of rigid rods extending below the lower insulating spacer, said heater element being connected to said rods, means for coupling said arcuate plate sections, a plurality of radially disposed conductors sealed into said annular rim, certain of said conductors being connected to said rods and coupling means for said anode, and a plurality of connecting wires joining said elements to the remaining conductors.

8. An electronic switching device comprising an enclosing vessel having an annular rim near one end thereof, a central cathode therein, insulating spacers at opposite ends of said cathode, parallel supports connected to said spacers and positioned on opposite sides of said cathode, a plurality of annular flat metallic grid elements surrounding said cathode, said members having outwardly extending arms secured to said supports in insulated and stacked spaced relation, an anode longitudinally supported by said insulated spacers and partially surrounding said cathode and grid elements, a plurality of radially disposed conductors sealed into said annular rim, and a plurality of connecting wires between said conductors and said grid elements, said wires extending through one of said spacers near the periphery thereof in a circular boundary, the wires located in one half of the spacer being connected to the arms of alternate grid members on one side thereof and the wires in the other half of the spacer being connected to the arms of the remaining grid members on the opposite side thereof.

9. An electronic discharge device comprising an enclosing vessel, a central cathode within said vessel, a plurality of apertured disc grids encircling said cathode and mounted in spaced relation along the length of said cathode, a plurality of apertured disc anode elements alternately spaced around said cathode with respect to said grids, the apertured edges of said elements being spaced a greater distance from said cathode than the inner edges of said grids, a common terminal connection for said elements sealed through the wall of said vessel, and separate lead-in conductors for each of said grids sealed through the wall of said vessel in the plane of said terminal connection.

10. An electronic switching device comprising an enclosing vessel having an annular rim, a central cathode therein, insulating spacers at opposite ends of said cathode, a pair of parallel supports connected to said spacers and positioned on opposite sides of said cathode, a plurality of annular flat metallic grid members surrounding said cathode, said members having integral arms secured to said supports, a plurality of annular flat metallic anode elements interposed alternately between said grid members and having integral arms secured to said supports, insulating collars surrounding said supports and spacing said grid members from said anode elements in coaxial relation, a plurality of radially disposed conductors sealed into said annular rim, means for coupling all of said anode elements together, said means being connected to one of said conductors, and a plurality of connecting wires between the other conductors and said grid members.

11. An electronic switching device comprising an enclosing vessel having an annular rim seal, a plurality of radial conductors extending through said seal, an electrode mount in said vessel positioned beyond said seal, said mount comprising a pair of insulating discs held in spaced relation, a pair of parallel supports extending between said discs, said supports having insulating sleeves thereon, a plurality of annular thin metallic control members coaxially positioned between said supports, each of said members having a short integral arm on one side and a long integral arm on the other side, said arm engaging said sleeves in alternate relation, insulating collars spacing adjacent members on said sleeves, a tubular cathode within said annular members and equally spaced from the respective members, an anode mounted longitudinally between said insulating discs in cooperative relation to said cathode and control members and positioned outside of said members, and a plurality of connecting wires coupled to a majority of said radial conductors and extending vertically through the lower disc, said wires having their ends bent at an inward angle in the plane of the respective control members and coupled to the long arms thereof.

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