July 4, 1944. J. E. BEGGS 2,352,933

ELECTRIC DISCHARGE DEVICE AND METHOD OF FABRICATION THEREOF

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Fig. 1.

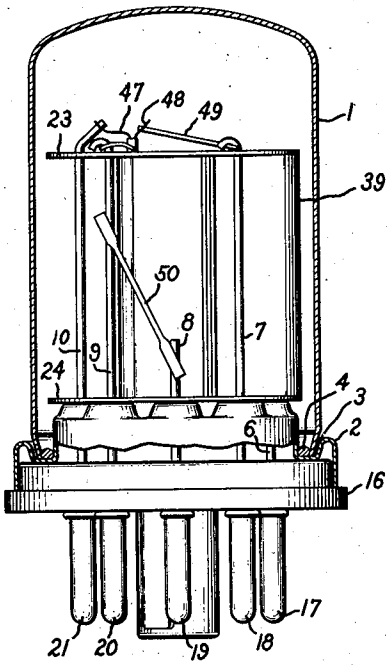


Fig. 4.

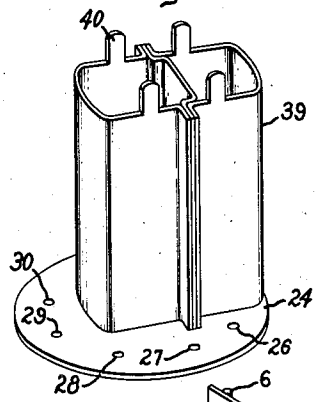


Fig. 2.

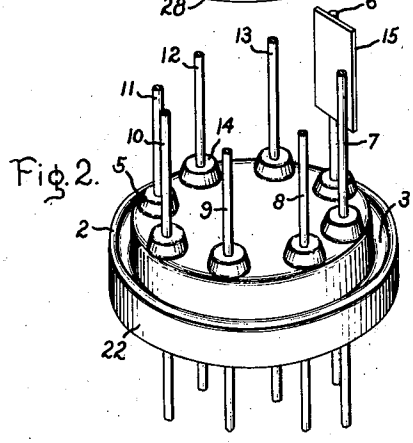


Fig. 5.

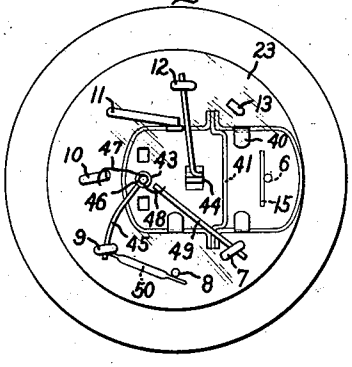


Fig. 6.

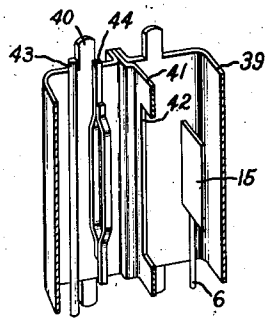
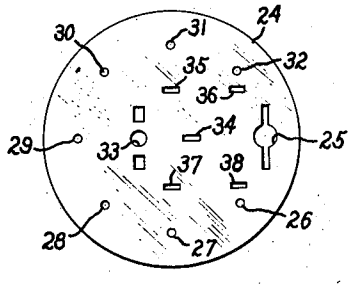


Fig. 3.



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ELECTRIC DISCHARGE DEVICE AND METHOD OF FABRICATION THEREOF

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Fig. 7

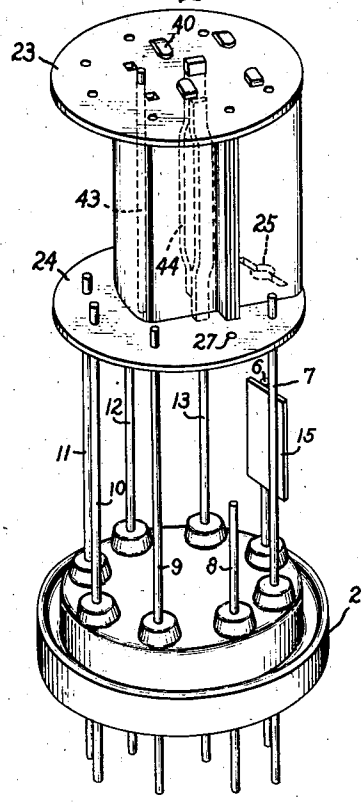


Fig. 8.

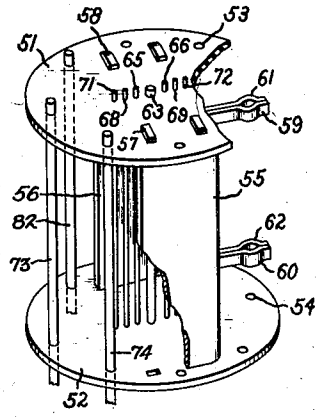


Fig. 10.

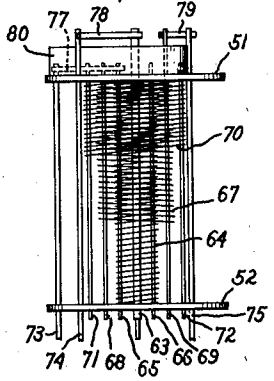


Fig. 9.

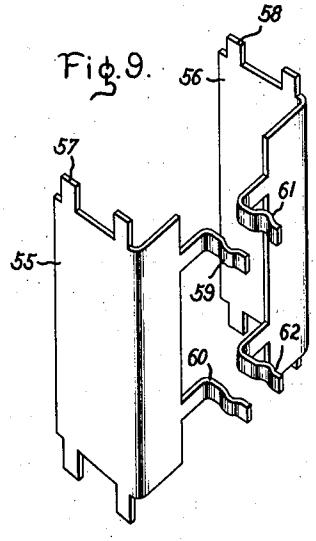
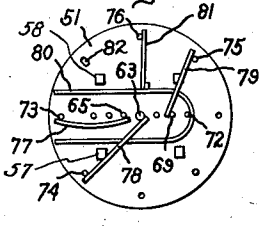


Fig. 11.



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UNITED STATES PATENT OFFICE

2,352,933

ELECTRIC DISCHARGE DEVICE AND METHOD OF FABRICATION THEREOF

James E. Beggs, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Application October 29, 1942, Serial No. 463,784

19 Claims. (Cl. 250—27.5)

My invention relates to electric discharge devices and more particularly to new and improved electric discharge devices and a method of fabrication thereof.

In the construction of electric discharge devices there has been an ever present need for improvements which facilitate the arrangement and assembly of the parts thereof. In accordance with the teachings of my invention described hereinafter, I provide new and improved electric discharge devices and a method of manufacture or fabrication thereof which afford advantages not incident to the prior art arrangements.

It is an object of my invention to provide new and improved electric discharge devices.

It is another object of my invention to provide new and improved construction of electric discharge devices applicable to devices of the high vacuum type, or the type employing an ionizable medium such as a gas or a vapor.

It is still another object of my invention to provide a new and improved method of construction and assembly of electric discharge devices.

It is a still further object of my invention to provide a new and improved construction of electric discharge devices whereby all or a majority of the essential elements and control elements may be assembled as a unitary unit and threaded over supporting members which also serve as conductors for electrode members, whereby the connections between the electrodes and the supporting conductors may be made in a position which is readily accessible in the manufacturing operation.

Briefly stated, in the illustrated embodiments of my invention I provide a new and improved construction for electric discharge devices, and a new and improved method of assembly of the various elements or parts thereof. More particularly, I provide a header supporting a plurality of spaced vertical conductors sealed to the header and which are adapted to be threaded through openings in a pair of horizontal vertically-disposed insulating spacers. All or a majority of the electrodes of the discharge device are assembled with the insulating spacers as a unit, the insulating spacers being rigidly held in position and attached to one of the electrodes which is of rigid construction. The electrode which serves as a rigid supporting member or positioning means for the insulating spacers may comprise a wall-like screen grid, a wall-like anode, or other suitably formed member.

The improved construction of electric discharge device which I provide may be applied with equal facility to discharge devices of various character, such as diodes, triodes, tetrodes or pentodes. In some arrangements where shielding between the elements of the discharge device is desired or required, I provide electrostatic shielding means preferably located above the top insulating spacer and which serves to shield the control elements from the anode.

For a better understanding of my invention, reference may be had to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims. Fig. 1 of the drawings diagrammatically illustrates an assembled view of an electric discharge device built in accordance with my invention, and Figs. 2–6, inclusive, represent certain detailed views of essential aspects of the device shown in Fig. 1. Fig. 7 diagrammatically represents the electrode assembly and the header construction in one step of the assembly or manufacture of the device. Figs. 8–11, inclusive, represent a modification of my invention as applied to a pentode construction.

Referring now to Fig. 1 of the accompanying drawings, I have there illustrated my invention as applied to an electric discharge device of the type comprising a plurality of electrodes enclosed within an envelope 1 which may be constructed of a suitable metal such as iron, and which is seated on and sealed to a metallic header 2, the open end of the envelope 1 being positioned in a trough or annular groove 3. The envelope 1 may be soldered to the header 2. The operation of evacuation or gas-filling may be obtained by the conventional bell-jar arrangement by dropping the envelope 1 into the position illustrated when the desired atmospheric condition is produced, thereby forming a hermetically sealed enclosure for the electrodes of the device. A suitable solder 4 may be positioned in the annular groove 3 to form a continuous seal between the envelope 1 and the header 2.

The details of the header construction may be more fully appreciated by referring to Fig. 2 wherein the metallic header is shown. The header 2 may be constructed of iron and formed by a stamping operation to produce the desired configuration. A plurality of protuberances 5 may be formed in the header 2 by an extrusion operation and serve as a means for positioning a plurality of spaced vertical supporting members or conductors 6–13, inclusive. Conductors 6–13 are sealed to the header 2 by suitable glass-to-metal seals 14 positioned between the various conductors and the extruded portions of the header 2. Where conductors 6–13 are constructed of iron, the glass-to-metal seal may be of the type disclosed and claimed in U. S. Letters Patent No. 2,272,747, granted February 10, 1942 upon an application of Albert W. Hull et al, and which is assigned to the assignee of the present application. In one embodiment of my invention, the anode comprises a substantially plane surface formed by a metal plate 15 which may be welded

to one of the vertical conductors, such as conductor 6.

The ends of conductors 6–13, inclusive, which extend below the header 2, may be supported by an insulating base 16 constructed of a resinous or other suitable material. These conductors may be terminated in and welded or soldered to a plurality of pin contacts which are secured to the base 16. For example, conductors 6–10, inclusive, may be terminated in contact pins 17–21, inclusive, which are secured to base 16. Header 2 and base 16 may be maintained in the position illustrated by providing skirt 22 of header 2 with sufficient resilience and configuration to hold the members rigidly in position, or the skirt 22 may be provided with crimped locks (not shown) which engage base 16 at spaced points.

I provide an electrode assembly which facilitates the fabrication or manufacture of an electric discharge device and which comprises a pair of substantially parallel spaced or vertically-disposed insulating spacers 23 and 24 which may serve as a support for all or a majority of the electrodes of the discharge device, and which may be assembled as a unit prior to positioning upon the header construction. One of the insulating spacers, such as the bottom insulating spacer 24, is shown in detail in Fig. 3. It will be noted that the insulating spacer 24 is provided with a plurality of openings 25–32, inclusive, displaced from the periphery of the spacer, and through which conductors 6–13, inclusive, are threaded. It will be observed that opening 25 has a configuration suitable to permit the passage not only of conductor 6 therethrough but also of plate member 15. In addition, it will be noted that openings 33 and 34 are provided to permit the insertion of the extremities of a cathode and control element therethrough. In this manner, by the proper dimensioning of openings 33 and 34 relative to the size of cathode and control element, the spacer 24 acts as a lower support for the cathode and control element. Insulating spacer 24 is also provided with openings 35–38, inclusive, which receive fastening members comprising part of a rigid electrode construction, such as a screen grid or an anode to be described hereinafter.

In one modification of my invention, the insulating spacers 23 and 24 may be held rigidly in position, thereby effecting a rigid construction for the support of other elements of the discharge device, by employing a wall-like element such as a screen grid 39 shown in detail in Fig. 4. The screen grid 39 may be formed to be a substantially continuous metallic member provided with a plurality of pliable metallic pendants or tabs 40 at both the top and the bottom. The bottom tabs are inserted into openings 35–38 of the insulating spacer 24 and may be turned or bent over on the under surface, thereby securing the electrode 39 firmly against the surface of the spacer 24.

The details of the configuration of the screen grid construction 39 may be more fully appreciated by referring to Fig. 6. It will be noted that the screen grid 39 is provided with a transverse metallic partition 41 having therein an opening 42 to provide a communicating path between a vertically disposed thermionic cathode 43 and the anode member 15. The lower extremity of the thermionic cathode 43 may be maintained in and supported by openings 33 of the lower insulating spacer 24. In like manner, a control element or grid 44 may be maintained in a vertical position by having one extremity extending into the opening 34 of the lower spacer 24. Of course, it will be appreciated that the upper extremities of cathode 43 and control element 44 also extend into suitable openings of the top insulating spacer 23, so that these elements are maintained in the desired spaced relation with respect to each other as well as to the other elements of the discharge device.

Fig. 5 represents a top view of the electrode assembly and the connections between the various elements thereof and the vertical or upright conductors. One advantage of employing this type of construction is that the connections to all of the elements thereof may be made at a point readily accessible, that is in the top position or the region lying directly above the top insulating spacer 23. An additional advantage is the ease with which the insulating spacer 23 is secured in position. For example, the conductor 13, which in the tetrode construction illustrated is not needed for an electrical connection, may be bent over and pressed against the top surface of the spacer 23, thereby acting as an additional securing member.

Cathode 43 may be connected to the vertical conductor 9 by means of a conductor means or connection 45 which is welded or soldered at its extremities to the cathode and conductor 9, respectively. Cathode 43 may be of the indirectly heated type comprising a wound heating coil 46 within the cylindrical construction, and the cathode heating terminals or conductors 47 and 48 are electrically connected to vertical conductors 10 and 7, respectively. In order to effect a rigid construction to prevent undesired flexing of the connection, a rigid conductor 49 may extend from terminal 48 to conductor 7. It will be noted that the upper extremities of the vertical conductors above the surface of top insulating spacer 23 may be bent over to act as additional means for securing the spacer in place and to facilitate welding or soldering the various connections to the conductors.

Where it is desired to employ a directly heated gettering material, such a gettering material may be connected between one of the vertical conductors, such as conductor 9, and one of the other conductors, such as conductor 8, which may be provided specifically for this purpose. For example, in Figs. 1 and 5 I have illustrated a directly heated gettering material which may comprise barium or barium-strontium strip or ribbon 50 supported on a nickel base and connected directly between conductors 8 and 9.

Advantages of the type of construction for an electric discharge device which I provide may be more readily appreciated by referring to Fig. 7 wherein the method of threading the electrode assembly over the conductors is shown at that stage in the construction where the vertical conductors have just been threaded through the lower vertical spacer 24. The ease of assembly is believed obvious and the facility with which the connections between the conductors 7–13, inclusive, and control elements of the discharge device may be made is believed equally apparent.

The type of construction described above lends itself with equal facility to discharge devices of the pure electron type or to the arc discharge type employing an ionizable medium such as a gas or a vapor. For example in the construction of the latter type device, I have found that the ionizable medium may be any suitable inert gas such as argon or xenon.

Figs. 8–11, inclusive, represent a modification

of my invention as applied to a pentode construction. Fig. 8 is a partially cut-away view of an electrode assembly comprising a pair of vertically displaced parallel conducting spacers 51 and 52 provided with a plurality of openings 53 and 54 adapted to receive vertical conductors (not shown) similar in arrangement and construction to the conductors shown in Figs. 2 and 7. In this modification of my invention, the insulating spacers 51 and 52 may be supported in the position illustrated principally by means of a wall-like or plate-like electrode comprising parts or sections 55 and 56 which may constitute the anode of the discharge device. The details of the anode construction are shown in Fig. 9. Sections 55 and 56 of the anode construction may each include pliable metallic pendants or tabs 57 and 58 which extend through openings in the top and bottom spacers 51 and 52 and may be turned over to secure the spacers and the anode sections rigidly together as shown in Fig. 8. Anode sections 55 and 56 are provided with arms 59, 60 and 61, 62 which serve as connecting means between the anode sections and one of the vertical conductors which extends through the lower insulating spacer 52 so that a connection, or a pair of connections to the anode sections may be made within the space between the insulating spacers 51 and 52. It will be noted that arms 59 and 61 and arms 61 and 62 are positioned to cooperate and are provided with substantially semi-cylindrical deformations to facilitate engagement with a cylindrical vertical conductor. The arms may be welded or soldered to the connecting vertical conductor.

Although not limited thereto, the various electrodes of the assembly may be supported by a plurality of pins arranged in alinement and extending through appropriately alined openings in the top and bottom spacers 51 and 52. For example, a thermionic cathode 63 may be centrally located relative to the supporting pins, and a control grid 64 may be supported by a pair of pins 65 and 66; a screen grid 67 is supported by a pair of pins 68 and 69, and a suppressor grid 70 is supported by a pair of pins 71 and 72, the details of the grids and the supporting pin construction being shown in Fig. 10.

The arrangement of the connections to the control elements of the discharge device will be better understood by referring to Figs. 9 and 10 wherein vertical conductors 73—76 are shown. It will be noted that conductor 73 is connected to control grid 64, particularly pin 65, by means of a conductor or metallic strap 77 which lies relatively close to the upper surfaces of insulating spacer 51. Cathode 63 is connected to conductor 74 by means of a metallic strap 78, and is spaced at a relatively greater distance above the surface of the insulating spacer 51. In like manner, screen grid 67 is connected to conductor 75 by a strap 79 at a substantial distance above the top surface of spacer 51.

In order to provide electrostatic shielding between the anode pendants 57 and 58 which extend above the surface of the insulating spacer 51, I provide a metallic shield 80 which may have a substantial U-shaped configuration and which may be connected at the closed end thereof to the shield grid pin 72. For example, the pin 72 may be welded to the metallic shield 80 and be positioned between the control element pins and the pendants 57 and 58, thereby completely shielding the control elements including the control grid and the screen grid from any electrostatic effects which may be present due to the anode extensions or tabs above the insulating spacer 51. As an alternative arrangement, if desired, where a great deal of precision is required, the shield member 80 may extend through the insulating spacer 51 and directly engage the wires of the suppressor grid 70.

Suppressor grid 67 may be connected to one of the vertical conductors, such as conductor 76 shown in Fig. 11, by means of a metallic strap conductor 81 which extends between conductor 76 and the shield 80 to minimize the length of the conductor and to obviate crossover of the conductor connecting means.

The above type of construction is readily applicable to rectify and triode types electric discharge devices. In discharge devices of the tetrode and pentode types and other types requiring shielding between certain of the control elements, the above described construction is assembled in accordance with the above described procedure by separating the conductors or lead-in wires to be shielded by suitable interspaced or grounded shielding means such as the shield 80.

As an additional feature, in order to protect or shield the vertical conductor 73 connected to control grid 64 from the electrostatic effects of the anode parts 55 and 56, I provide an optimum spacing and positioning of the grounded vertical conductors. For example, inasmuch as the cathode vertical conductor 74 is grounded, it may be positioned relative to anode part 55 and the grid vertical conductor 73 to shield the latter therefrom as illustrated in Fig. 8. In like manner, I provide an additional grounded vertical conductor 82, shown in Figs. 8 and 11, which may extend through the upper insulating spacer 51 and be turned over and positioned opposite the end of anode part 56, thereby shielding the grid vertical conductor 73 from the latter. This interspacing of the grounded vertical conductors 74 and 82 to shield the conductor 73 electrostatically from the anode parts within the region defined by spacers 51 and 52 is particularly important in those electric discharge devices where the enclosing envelope is metal in an arrangement such as that shown in Fig. 1 where a metallic envelope 1 completely surrounds the electrode assembly and electrodes.

If a relatively short or low-inductance connection to an electrode is desired, a tab may be connected to the lower end of the electrode assembly and brought out to the lead-in conductor in a position near the header, either as the only connection or in conjunction with the connection at the top of the unit assembly.

While I have shown and described my invention as applied to particular devices diagrammatically shown, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. An electric discharge device comprising a header supporting a plurality of spaced vertical conductors, an electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising a wall-like electrode for maintaining said spacers

in position and having a plurality of metallic tabs extending through and bent over said spacers to form a rigid assembly, and conductor means positioned above the top insulating spacer for connecting electrodes to said vertical conductors.

2. An electric discharge device comprising a metallic header having sealed thereto a plurality of upright conductors, and an electrode assembly comprising a plurality of electrodes and a pair of insulating spacers provided with a plurality of openings through which said upright conductors are threaded and comprising a screen grid constituting a closed metallic wall having tabs for maintaining said spacers in position, and means for connecting said upright conductors to said electrodes above the top spacer.

3. An electric discharge device comprising a plurality of enclosed electrodes and including a metallic header having a plurality of spaced vertical conductors sealed to said header, an electrode assembly comprising a plurality of electrodes and a pair of horizontal insulating spacers provided with a plurality of openings through which said conductors are threaded, one of said electrodes being of wall-like construction provided with a plurality of pendants which are threaded through the top and bottom spacers and bent over to secure said spacers to said one electrode, and conductor means above the top insulating spacer for connecting said electrodes to said conductors.

4. An electric discharge device comprising a plurality of enclosed electrodes and including a metallic header having a plurality of upright conductors sealed to said header, a unitary electrode assembly comprising a pair of vertically-displaced parallel spacers provided with openings through which said conductors are threaded, a wall-like metallic electrode between said spacers and having a plurality of metallic pendants adapted for extending through and maintaining said spacers in position thereagainst, a plurality of conductors positioned above the top spacer for connecting said electrodes to said conductors, and an envelope surrounding said conductors and said assembly and sealed to said header.

5. An electric discharge device comprising a metallic header supporting a plurality of spaced vertical conductors, a unitary electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising a wall-like metallic grid structure for maintaining said spacers in position and having a plurality of tabs which are inserted through said spacers and bent over to form a rigid assembly, and conductor means for connecting the electrodes to said vertical conductors above the top horizontal spacer.

6. An electric discharge device comprising a metallic header supporting a plurality of spaced upright conductors, an electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, a screen grid structure comprising a closed metallic wall provided with tabs for engaging said spacers and for maintaining said spacers and said screen grid structure in juxtaposition, and conductor means for connecting the electrodes of said device to said upright conductors above the top horizontal spacer.

7. An electric discharge device comprising a plurality of enclosed electrodes and a metallic header provided with a plurality of spaced vertical conductors sealed to said header, a cathode and control member assembly including a pair of vertically-spaced parallel insulating spacers provided with openings through which said conductors are threaded, said cathode and said control members being supported by said spacers and one of said electrodes being of a wall-like configuration provided with metallic pendants adapted to extend through and be bent over to maintain said spacers against said one electrode, a metallic plate attached to one of said conductors and constituting an anode within the enclosure provided by said one electrode, and conductors positioned above the top insulating spacer for connecting said cathode and said control members to the first mentioned conductors.

8. An electric discharge device comprising a metallic header supporting a plurality of spaced vertical conductors which are sealed to said header, a unitary electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, a plurality of electrodes comprising a screen grid having a wall-like metallic structure for maintaining said spacers in position and having a plurality of metallic tabs which extend through said spacers and are bent over to secure said spacers to said one electrode, said insulating spacers serving as a support for other spaced electrodes, and conductor means positioned above the top insulating spacer for connecting the electrodes to said vertical conductors.

9. An electric discharge device comprising a metallic header supporting a plurality of spaced vertical conductors which are sealed to said header, a unitary electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, a plurality of electrodes one of which comprises a wall-like metallic structure for maintaining said spacers in position and having a plurality of pendants threaded through said spacers and turned over to secure said spacers and said one electrode firmly in position, said spacers serving to support in vertical position other electrodes, and conductor means positioned above the top insulating spacer for connecting the electrodes to said vertical conductors.

10. An electric discharge device comprising a header supporting a plurality of spaced vertical conductors, an electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, one of said conductors being provided with a substantial surface to constitute an anode, said electrode assembly comprising a wall-like electrode for securing and maintaining said spacers in position to form a rigid construction, and conductor means positioned above the top insulating spacer for connecting the electrodes to said vertical conductors.

11. An electric discharge device comprising a header supporting a plurality of spaced vertical conductors, an electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising a substantial wall-like anode construction which anode construction includes means for maintaining said spacers in position, the electrodes being supported by said spacers including a cathode and a control element, and conductor means positioned above the top insulating spacer for

connecting said cathode and said control element to predetermined different vertical conductors.

12. An electric discharge device comprising a header supporting a plurality of spaced vertical conductors, an electrode assembly comprising a pair of parallel insulating spacers provided with openings to which said conductors are threaded, said electrode assembly comprising a wall-like anode construction including means for maintaining said spacers in position, the electrodes supported by said spacers including a cathode and a control element, said anode being connected to one of said vertical conductors at a point intermediate said spacers, and conductor means positioned above the top insulating spacer for connecting said cathode and said control element to different vertical conductors.

13. An electric discharge device comprising a metallic header supporting a plurality of spaced vertical conductors sealed to said header, a unitary electrode assembly comprising a plurality of horizontal insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising a wall-like metallic structure for maintaining said spacers in position and having a plurality of metallic pendants which extend through said spacers and maintain said structure and said spacers in position, a cathode maintained in a vertical position by said horizontal spacers by extending through openings therein, a control electrode supported in a vertical position by said horizontal spacers, an anode constituting a plate member attached to one of said vertical conductors and positioned within said wall-like structure, and conductor means positioned above the top insulating spacer for connecting said cathode, said control electrode and said wall-like structure individually to predetermined different vertical conductors.

14. An electric discharge device comprising a metallic header supporting a plurality of spaced vertical conductors, an electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising a wall-like anode construction including means for maintaining said spacers in position, the electrodes supported by said spacers including a cathode and a plurality of control elements, said anode being connected to one of the vertical conductors at a point intermediate said spacers, conductor means for connecting said control elements supported by said spacers to different predetermined vertical conductors, and shielding means above the top spacer for shielding said conductor means and the supported electrodes.

15. An electric discharge device comprising a plurality of enclosed electrodes and including a metallic header having a plurality of spaced vertical conductors sealed to said header, an electrode assembly comprising a pair of horizontal insulating spacers provided with a plurality of openings through which said conductors are individually threaded, said electrodes comprising a cathode, an electrostatic control element and an anode constituting two opposed plate-surfaces, said plate-surfaces being provided with a plurality of bent-over metallic pendants extending through said surfaces to maintain said plate members and said surfaces in position, said plate-surfaces being connected to one of the first mentioned conductors within the region between said spacers, conductor means positioned above the top spacer for connecting said cathode and said control element to predetermined conductors of the first-mentioned conductors, and electrostatic shielding means positioned between said anode and said control element and associated connecting conductor.

16. An electric discharge device comprising a metallic header supporting a plurality of spaced upright conductors, an electrode assembly comprising a pair of horizontal insulating spacers provided with openings through which said conductors are threaded, said electrodes comprising an anode, a cathode and a control element, said anode comprising a wall-like member having metallic pendants adapted to extend through said spacers to maintain said spacers in juxtaposition to said anode, conductor means positioned above the top insulating spacer for connecting said cathode and said control element to predetermined conductors of said plurality of conductors, and shielding means positioned near the top of said anode and lying between said pendants and the conductor connected to said control element for electrostatically shielding said control element and associated conductor.

17. An electric discharge device comprising a header supporting a plurality of spaced vertical conductors, and an electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising an anode comprising two opposing members and at least one control element in spaced relation with said members and a pair of grounded metal conductors interposed between the anode members and the vertical conductor connected to said control element.

18. An electric discharge device comprising a metallic header having sealed thereto a plurality of upright conductors, and a unitary electrode assembly comprising a pair of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising a cathode and a pair of oppositely disposed anode members for maintaining said spacers in position and a control element positioned between said pair of anode members, and a metallic envelope enclosing said electrode assembly, said conductors being arranged so that grounded conductors are interposed between said anode members and the grid conductor thereby shielding said grid conductor electrostatically from said anode members within the region intermediate said spacers.

19. An electric discharge device comprising a metallic header supporting a plurality of spaced vertical conductors, a unitary electrode assembly comprising a plurality of parallel insulating spacers provided with openings through which said conductors are threaded, said electrode assembly comprising an anode including two opposing plate-like members for maintaining said spacers in position, a cathode and a control element intermediate said plate-like members, and a metallic envelope enclosing said electrode assembly and sealed to said header, said vertical conductors being arranged so that grounded vertical conductors are positioned opposite the ends of said plate-like members and interposed between said plate-like members and the grid vertical conductor thereby shielding the latter from the anode construction within the region intermediate said spacers.

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