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2,910,609

LOW MICROPHONICS TUBE STRUCTURES

Filed June 7, 1956

FIG. 1.

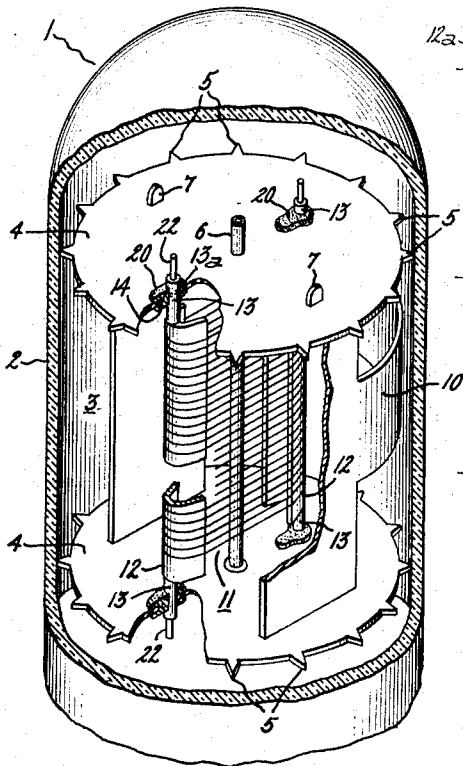


FIG. 6.

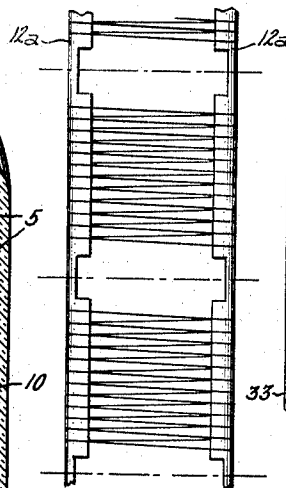


FIG. 8.

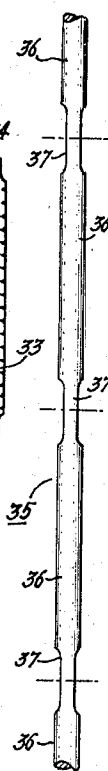


FIG. 7.

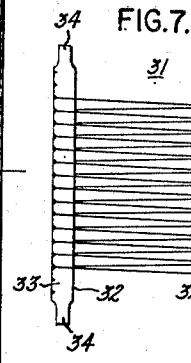


FIG. 9.

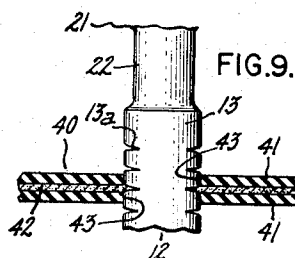


FIG. 2.

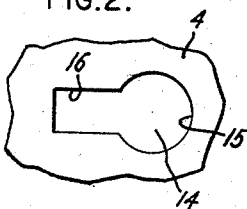


FIG. 5.

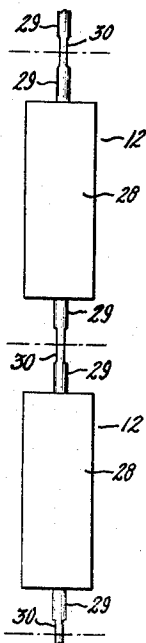


FIG. 3.

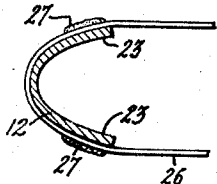


FIG. 4.

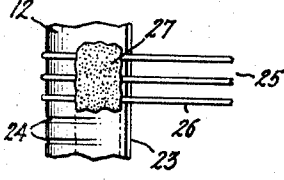


FIG. 10.

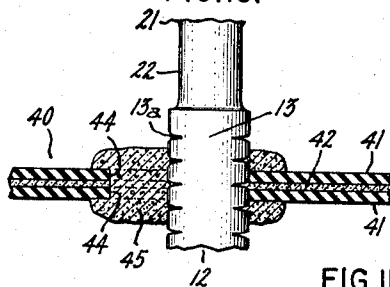
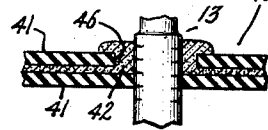


FIG. 11.



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LOW MICROPHONICS TUBE STRUCTURES

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14 Claims. (Cl. 313—261)

My invention relates to electric discharge devices and pertains more particularly to new and improved low microphonics tube structures.

In the operation of electronic tubes or electric discharge devices microphonics result generally from variations in output-circuit current as effected by undesirable relative displacement of tube components or portions thereof. This displacement is attributable to both mechanical and electrical forces. For example, in some structures electrode elements or electrode supporting elements are not sufficiently rigidly mounted in support structures therefor. This enables such elements to move relative to others when subject to vibrations. Further, in some structures the individual elements are constructed in such a manner as to effect, upon assembly, conditions which tend to affect adversely the rigidity of structure. Still further, in some electrode structures, for example, helically wound grids, the construction and material thereof, render such structures substantially susceptible to both vibratory displacement and displacements effected by electrostatic fields in inter-electrode regions. In some cases, the resulted microphonics are of high orders of mechanical resonant frequency but are still objectionable in particular tube applications. Where such is the case, it has been recognized that the mechanical resonant frequencies are those of the grid support elements in the laterally extending portions of the turns of the grid wire and that such frequencies can be increased to values above objectionable ranges by utilizing support elements and grid wires which are physically larger, heavier and formed of materials of higher tensile strengths. However, it has been found that these expedients cannot be resorted to in many tube structures wherein they would result in problems owing, for example, to undesired capacitances, unsatisfactory heat conductivity.

Accordingly, the primary object of the present invention is to provide new and improved low microphonics tube structures.

Another object of the present invention is to provide new and improved means for rigidly supporting electrode elements in tube structures.

Another object of the present invention is to provide new and improved tube structures adapted for increased mechanical resonant frequency.

Another object of the present invention is to provide new and improved electrode support elements which are adapted for minimizing conditions tending to cause microphonics.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention I provide spaced support members having apertures therein. Disposed between the support members is a grid structure including spaced substantially parallel grid side-support elements having a grid wire wound and secured thereon.

Intermediate portions of the grid side-support elements are dimensioned for tightly fitting in the apertures in the support members and the end portions are formed to be of reduced cross-sections so that any burrs resulting thereon when such elements are cut to size are ineffective for undesirably enlarging the apertures adapted for having the support elements tightly fitted therein. If a still tighter fit is desired the grid side-support elements may be bonded, as by cementing or the like, to the support members at the apertures. The apertures may be larger in cross-sectional area than the portions of the elements fitted therein so that the bond may extend therethrough and over surface portions of either or both sides of the support members. The support members may each comprise a laminar structure of superposed members bonded together and including substantially registering apertures for receiving portions of the grid side support elements. The means bonding the elements in the laminar structure can be utilized in bonding the grid side support elements to the laminar structure. In this form also the apertures can be such as to permit the bonding means to extend therethrough and engage surface portions of the laminar structure. In the various forms the portions of the grid side-support elements fitted in the apertures may, if desired, be nicked or otherwise formed for increasing the effectiveness of the bonding means. Additionally, if desired, the grid side-support elements may comprise channel-like elements having the oppositely extending edges thereof predeterminedly spaced and having the turns of the grid wire secured thereto substantially immediately adjacent the mentioned edges. The grid structures can be formed by first forming a plurality of elongated elements to include portions adapted for having a grid wire wound thereon and for being tightly fitted in the apertures in the support members, then substantially reducing the cross section of the elements at predetermined intervals, arranging the elements in spaced substantially parallel relation with the reduced portions in corresponding positions, winding and securing the grid wires on the elongated elements between the reduced portions, and cutting off individual grid structures at the reduced portions.

For a better understanding of my invention reference may be had to the accompanying drawing in which:

Figure 1 is an enlarged fragmentary partially broken-away perspective illustration of an electric discharge device incorporating my invention;

Figure 2 is an enlarged fragmentary plan view of an apertured portion of one of the support members;

Figure 3 is an enlarged sectional view of one of the grid side-support elements illustrated in Figure 1;

Figure 4 is an enlarged fragmentary elevational view of one of the grid side-support elements illustrated in Figure 1;

Figure 5 is a fragmentary plan view illustrating a manner in which the grid side-support elements of Figures 1, 3 and 4 may be formed;

Figure 6 illustrates a modified form of grid structure constructed in accordance with the present invention;

Figure 7 illustrates another modified form of grid structure;

Figure 8 is a fragmentary plan view illustrating a manner in which the grid side-support elements of Figure 9 may be constructed;

Figure 9 is an enlarged fragmentary illustration of a modified form of element-supporting arrangement constructed in accordance with the present invention;

Figure 10 illustrates another modified form of element-supporting arrangement; and

Figure 11 illustrates still another modified form of element-supporting arrangement.

Referring to Figure 1, I have shown an electronic tube

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or electric discharge device generally designated 1 including an envelope 2 containing an electrode mount structure generally designated 3. By means of a suitable base (not shown) the tube 1 is adapted for having electrical connections made between externally disposed circuitry and various electrode elements included in the mount structure 3.

Included in the mount structure 3 is a pair of spaced insulators or electrode support members 4 which in general practice are formed of mica or the like but which can be formed of ceramic or any other suitable insulative material. The support members 4 are illustrated as being disk-like, including circumferentially spaced snubbers or pointed portions 5 for engaging the side walls of the envelope, and as being positioned transversely in the envelope; however, none of these characteristics are to be considered essential to the present invention.

The support members 4 are each formed to include a plurality of apertures for having fitted therein portions of the electrode elements of the mount structure. Centrally disposed apertures are provided for receiving end portions of a cathode structure 6, including a heating element (not shown); and diametrically opposed apertures are provided for receiving tab portions 7 of a plate or anode structure 10. Thus, the cathode 6 and plate 10 are supported between the members 4 in suitable spaced insulated relation.

Also adapted for being supported in the mount structure 3 between the members 4 is a grid structure generally designated 11. The grid structure 11 comprises a pair of spaced parallel grid side-support elements 12. The elements 12 are each formed to include a cylindrical portion 13 adjacent each end thereof and adapted for being tightly fitted in one part of a corresponding multiple-part aperture 14 formed in one of the support members 4. As best seen in Figure 2, the apertures 14 can be key-hole shaped in the manner illustrated for providing a first part 15 which may be substantially circular and adapted for conforming substantially in cross-sectional area to the cross-sectional area of the corresponding portion 13 of one of the grid side-support elements 12. Thus, when the portions 13 are fitted in the parts 15 of the apertures 14 a substantially tight fit is obtained between the corresponding ends of the elements and the support members 4.

Another part 16 of the aperture 14 is provided to permit bonding means generally designated 20 to extend through the aperture and over substantial surface portions of either side of the members 4 in the manner seen in Figure 1.

When the members 4 are formed of mica or the like the bonding means 20 may comprise any suitable cementing material. For example, the cementing material may be composed of such insulating materials as aluminum oxide, magnesium oxide or the like and a suitable binding material such as ethyl silicate, magnesium silicate or any similar suitable binder. These materials may be admixed in quantities such as to provide a paste-like bonding substance of suitable consistency for applying it in globules which will work through the aperture to contact opposite sides of the support members. By way of example, a suitable paste may be obtained by admixing 225 grams of 38-900 Alundum with 100 cc. of hydrolyzed ethyl silicate, comprising 60 ml. ethyl silicate, 32 ml. denatured alcohol and 4 ml. 1.25 normal HNO_3 , and 50 cc. of distilled water.

When the support members 4 are formed of ceramic or the like the just-described cementing material as well as various suitable well-known metallic bonding means may be employed. Thus, the grid side-support elements 12 are more rigidly secured between and support members 4 for avoiding any loose fit therein which would enable displacement of the grid structure relative to other electrode elements in the structure, and thereby any tendency

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toward microphonics during operation of the tube is substantially reduced.

Provided for reinforcing or enhancing the effectiveness of the bond 20 between the portions 13 of the grid side-support elements and the support members 4, I have nicked or notched the surfaces of the portions 13, as at 13a, which provides a better cooperation or gripping effect between the material effecting the bond and the surface of the portions 13.

Additionally, inasmuch as the initial tight fit of the portions 13 in the parts 15 of the apertures 14 is a contributing factor to the overall rigidity in the mounting of the members 12 between the support members 4, it is desirable that the parts 15 of the apertures not be enlarged from the size in which they are originally formed and adapted for receiving the portions 13 of the elements 12 tightly. Now, generally a plurality of the grid members 11 are formed in long strips and cut to size at spaced intervals. This has been found to result in burrs or rough edges at the ends of the grid side-support elements 12, in the manner illustrated at 21 in Figures 9 and 10. These burred edges have been found to break the edges of the apertures 14 or otherwise enlarge the parts thereof adapted for receiving the portions 13 of the grid side-support elements. To overcome this and thus avoid any changes in size of the aperture which would tend to result in loosened fits of the portions 13 in the apertures, I have reduced the diameter and thus the cross-sectional area of the end portions of the elements 12 in the manner illustrated at 22 in Figures 1, 9 and 10. Thus, any burrs resulting at the end portions 22 are located inwardly of the outside diameter of the portions 13 and are rendered ineffective for enlarging the portions 15 of the apertures 14. In this way the intended tight fit is obtained.

Additionally, as seen in Figures 1, 3 and 4, the grid side-support elements 12 are channel-like or arcuate in cross-section and in the grid structure 11 the elements 12 are arranged oppositely with the edges designated 23 in Figures 3 and 4 predeterminedly spaced apart. The purpose for these particular features of the grid structure 11 will be brought out in detail hereinafter.

The outer surfaces of the member 12 are nicked as at 24 for prelocation of the turns of the grid wire 25 and the individual turns designated 26 are secured in place on the supports in corresponding nicks in any one of the various manners generally employed in the industry. Additionally, I have provided means for securing the turns 26 of the grid wire to the elements 12 substantially immediately adjacent the edges 23. This securing means may take the form of a braze 27 or any other suitable bonding means.

By securing the grid turns 26 to the elements 12 in the manner just-described the mechanical resonant frequency of the grid member 11 is increased substantially. This frequency is further increased substantially by the arcuate configuration of the elements 12 which lends greater rigidity thereto without resorting to substantially large, heavy or massive grid side-support means which would tend to affect adversely various factors such as capacitances, heat conduction, etc. Additionally, it will be seen that in the grid structure 11 the predetermined spacing of the edges 23 of the oppositely disposed elements 12 reduces the portions of the grid turns 26 subject to vibratory and electrical displacement to that which is electronically useful. That is, substantially only those portions of the turns 26 which are necessary to desired tube operating characteristics are subject to vibratory displacement and electrostatic displacement. All other portions of the grid wire 25 are directly and rigidly supported by the elements 12. Thus, in accordance with desired tube characteristics the edges 23 of the oppositely disposed elements 12 may extend toward each other for being spaced predetermined amounts and, accordingly,

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providing for direct support of substantially all but the electronically useful portions of the grid turns.

As seen in Figure 5, a plurality of the elements 12 may be formed in a single flat strip including a large flat portion 28, portions 29 of less width on either end of the portion 28 and portions 30 of still less width intermediate adjacent portions 29. After being so formed the strips may be further formed for rendering the flat portions 28 arcuate in the manner illustrated in Figures 1, 3 and 4 and for making the portions 29 and 30 cylindrical and thus forming them into the portions 13 and 22 above-referred-to. Then the portions 13 may be nicked for the purpose above-described. Thereafter, a pair of the strips may be arranged in predetermined spaced parallel relation and have the grid wire 25 wound thereon and secured in place in the manner also described above. Subsequently, individual grid members 11 may be severed or cut from the strip at the reduced sections 22 for the purpose above-described.

Illustrated in Figure 6 is a modified form of grid structure designated 12a. This form of structure is adapted for use with insulators having arcuate slots or apertures adapted for having arcuate end portions of the grid side-support elements fitted tightly therein. The portions of the side-support elements between adjacent grid members are reduced but arcuate in cross-section instead of having the cylindrical cross-section of the portions 13 of the support members of the grid structure 12. This reduction in cross-section serves substantially the same purpose as described above with regard to the reduced cross-section of the members 12.

In Figure 7 is illustrated a modified form of grid structure generally designated 31. The grid structure 31 may comprise a pair of spaced substantially cylindrical grid side-support elements or rods 32 including portions 33 formed to a predetermined cross-sectional area adapted for effecting a tight fit when inserted in the parts 15 of the apertures 14 in the electrode support members 4. Additionally, the side rods 32 may be formed with end portions 34 of reduced cross-section relative to the portions 33, which end portions 34 are adapted for serving substantially the same purpose as the portions 22 described above with reference to Figure 1.

As seen in Figure 8, a plurality of the side rods 32 may be formed in a single elongated element 35 including elongated cylindrical portions 36 of predetermined diameter and intermediate portions 37 of reduced diameter. The grid structure of Figure 7 may be formed utilizing a plurality of the elements 35 in a manner substantially similar to that described above with reference to Figure 5 and the construction of the electrode structures 12.

As illustrated in Figure 9 the supporting means for the grid side supporting elements, whether such elements be of the types illustrated and designated 12, 12a or the type in the grid structure designated 31 in Figure 7, can comprise a laminar structure generally designated 40. The structure 40 includes two or more superposed insulative support members 41 which can be similar in material, configuration and function to the support members 4 in Figure 1. The members 31 can be suitably bonded or adhered together by an interpositioned layer of bonding material 42. The bonding material 42 can be identical to that described above and designated 20 in Figure 1. Additionally, each of the members 41 is provided with substantially registering apertures 43 which are adapted for receiving the portions 13 of the grid side-support elements 12 with a substantially tight fit. In this structure the bonding material 42 is interposed between the portions 13 of the members 12 and the individual members 41 of the laminar support structure 40 at the apertures 43. Additionally, the surface of the portion 13 may be nicked at 13a to reinforce the bond.

In Figure 10 is illustrated the laminar support structure 40 of Figure 9 modified to include registering apertures 44 which can be identical to the aperture 14 shown

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in Figure 2. In this structure the grid side supporting element 12 is fitted and secured in place in a laminar support structure similar to that described with respect to Figure 9. Additionally, in the presently described structure a bond 45 may be provided which extends through the appropriate portions of the apertures 44 for extending over opposite surface portions of the laminar structure in a manner similar to that illustrated in Figure 1. The bond 45 may be formed of the same material as the bond 20 in Figure 1. Additionally, as seen in Figure 10, the surface of the portion 13 of the grid side-support 12 may be nicked as at 13a for enhancing the effectiveness of the bonding material in rigidly securing the support 12 in the laminar support structure.

In Figure 11 is illustrated a laminar support structure similar to that of Figure 9 except the aperture in the lower member 41 is a tight fit while a substantially enlarged aperture 46 is provided in the upper one of the members 41 to cause a loose fit. This enables the bonding material 42 to flow upwardly through the aperture 46 and to extend along the element and over the upper surface of the upper member 41.

It will be seen that my invention is not limited to the mounting of grid structures but may be employed in securing rigidly in a mount structure any or all of the electrode elements therein. For example, it could be effectively employed in securing the cathode structure in place where it is desired that one or both ends hereof be securely anchored to a support member. In this case it might be desirable to adapt the cathode structure for low thermal expansion, as by special construction or use of particular low expansion materials, thereby to insure against any deleterious effects of thermal expansion or contraction on the bonds between the electrode and support member.

While I have shown and described specific forms of my invention I do not desire my invention to be limited to the particular form shown and described, and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

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

1. A low microphonics tube structure comprising spaced insulators having apertures therein, a pair of spaced grid supporting elements, said supporting elements including portions extending through said apertures in said insulators, cementing material bonding said portions of said elements to said insulators at said apertures, at least the portions of said supporting elements intermediate said insulators being channel-like and each having edges predeterminedly spaced from and extending toward the edges of the other, a grid wire wound on and conforming to the channel-like portions, and means bonding the turns of said wire to said grid supporting elements at least substantially immediately adjacent said edges whereby substantially all but the portions of said grid wires intermediate said edges are directly supported by said grid supporting element.

2. A low microphonics tube structure comprising spaced insulators having multiple-part apertures therein, a pair of spaced grid supporting elements having a grid wire wound thereon, said supporting elements including portions extending through and frictionally engaging the edges of parts of said apertures in said insulators, cementing material bonding said portions of said elements to said insulators at said apertures, said last-mentioned means extending through other portions of said apertures and over both opposed surface portions of each of said insulators, and portions of said grid wire supporting elements intermediate said insulators providing substantial surface contact with and direct support for each turn of said grid wire.

3. In an electric discharge device, an electrode supporting element, a support member having a multiple-part aperture, a portion of said element being tightly

fitted in one part of said aperture, cementing material effecting a bond between said portion of said element and said support member at said aperture, and said cementing material extending through the other part of said aperture and over a substantial portion of at least one surface of said support member adjacent said aperture to reinforce said bond.

4. In an electric discharge device, an electrode element, a support member having a multiple-part aperture receiving a portion of said element being tightly fitted in one part of said aperture, cementing material further bonding said portion of said element to said support member at said aperture and extending through the other part of said aperture and over at least one surface of said support member, and said portion of said element being substantially nicked for increased effectiveness of said bonding means.

5. In an electric discharge device, an electrode element, a support member having a multiple-part aperture, a portion of said electrode element being tightly fitted in one part of said aperture and cementing material bonding said element to said support member at said aperture, said cementing material extending through another part of said aperture and over and bonded to both opposed surface portions of said support member.

6. In an electric discharge device an electrode element, a plurality of superposed support members including substantially registering apertures receiving a portion of said element, cementing material bonding said support members together to provide a laminar support structure, and said cementing material being further effective to bond said electrode element to said support structure at said apertures.

7. In an electric discharge device an electrode element, a plurality of superposed members including substantially coaxial apertures receiving a portion of said element, cementing material extending between and bonding said support members together to provide a laminar support structure, said cementing material also bonding said element to said support structure, the aperture in one of said members receiving said element with a substantially tight fit, the aperture in the other of said members receiving said element with a loose fit, and said cementing material extending through said last-mentioned aperture for extending longitudinally along said element and over a surface portion of said member including said last-mentioned aperture.

8. In an electric discharge device, an electrode element, a plurality of superposed support members including substantially registering apertures receiving a portion of said element, cementing material extending between and bonding said support members to provide a laminar support structure, said cementing material being further effective to cement said electrode element to said support structure at said apertures, and said portion of said element received in said apertures being substantially nicked for increased effectiveness of said cementing material.

9. In an electric discharge device, an electrode element, a plurality of superposed support members including substantially registering apertures receiving a portion of said electrode element and each defining an area larger than the cross-sectional area of said portion of said element, cementing material extending between and bonding said support members to provide a laminar support structure, and said cementing material extending into said apertures and effecting a cement bond between said element and said support structure, said cementing material extending through said apertures and over both opposed surface portions of said support structure to reinforce said cement bond.

10. A grid structure adapted for being supported between spaced support members by having portions thereof fitted in apertures in said support members comprising a pair of spaced substantially parallel channel-like elements

each having the edges thereof each extending toward the edges of the other in predetermined spaced relation, said elements including portions conforming substantially in cross-section to said apertures for being tightly fitted therein, a grid wire wound on and conforming to the surface of intermediate portions of said channel-like elements, and means securing the turns of said grid wires to said elements substantially immediately adjacent said edges thereof.

11. A grid structure adapted for being supported between spaced support members by having portions thereof fitted in apertures in said support members comprising a pair of spaced substantially parallel channel-like elements each having the edges thereof extending toward the edges of the other in predetermined spaced relation, said elements including portions conforming substantially in cross-section to said apertures for being tightly fitted therein, a grid wire wound on said elements, means securing the turns of said wires to said elements adjacent said edges thereof, said elements having end portions of substantially reduced cross-section relative to said first-mentioned portions and said end portions having enlarged extremal edge portions confined within the cross-sectional dimensions of said first-mentioned portions whereby said enlarged edge portions are located for avoiding enlargement of said apertures in said support members upon fitting of said elements therein.

12. In an electric discharge device, an insulator having a keyhole-shaped aperture, an electrode support element tightly fitted in the circular portion of said aperture, cementing material extending through the other portion of said aperture and bonded to the portion of said element in said aperture and to a surface of said insulator about said aperture.

13. In an electric discharge device, a laminar insulator comprising a plurality of superposed members including substantially registering apertures, at least one of said apertures being keyhole-shaped, an electrode support element tightly fitted in the circular portion of said keyhole-shaped aperture and the aperture of said other member, and cementing material between and bonding said support members together and extending through the other portion of said keyhole-shaped aperture and bonded to the portion of said element in said aperture and to a surface of said insulator about said keyhole-shaped aperture.

14. In an electric discharge device, a laminar insulator comprising a plurality of superposed members including registering keyhole-shaped apertures, an electrode support element tightly fitted in the circular portions of said keyhole-shaped apertures, and cementing material between and bonding said members together and extending through the other portions of said keyhole-shaped apertures and bonded to the portion of said element in said aperture and to the surface portions of said insulator about said keyhole-shaped apertures and on both opposed sides of said laminar structure.

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