July 18, 1944. E. D. McARTHUR 2,353,743

HIGH FREQUENCY ELECTRONIC DISCHARGE DEVICE

Filed Aug. 26, 1941 2 Sheets-Sheet 1

Fig. 1.

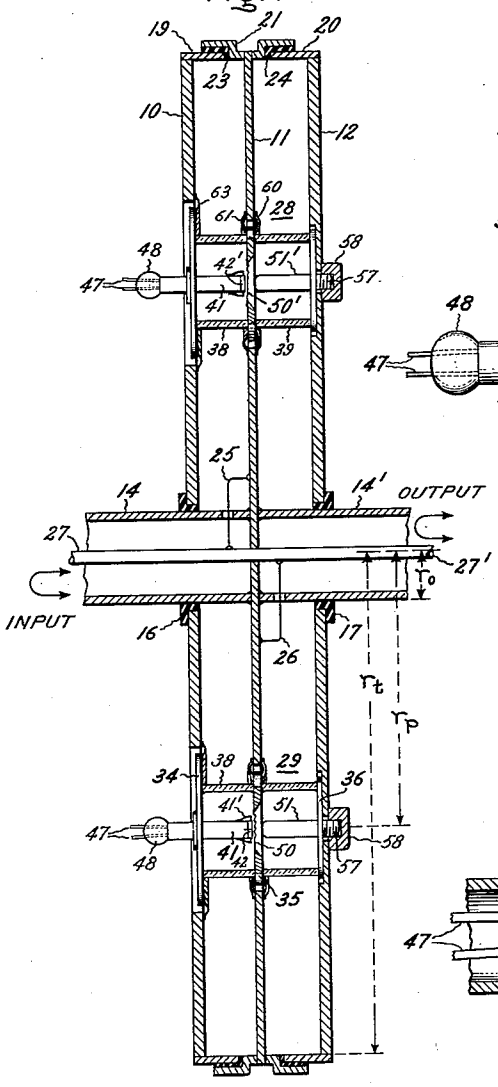


Fig. 2.

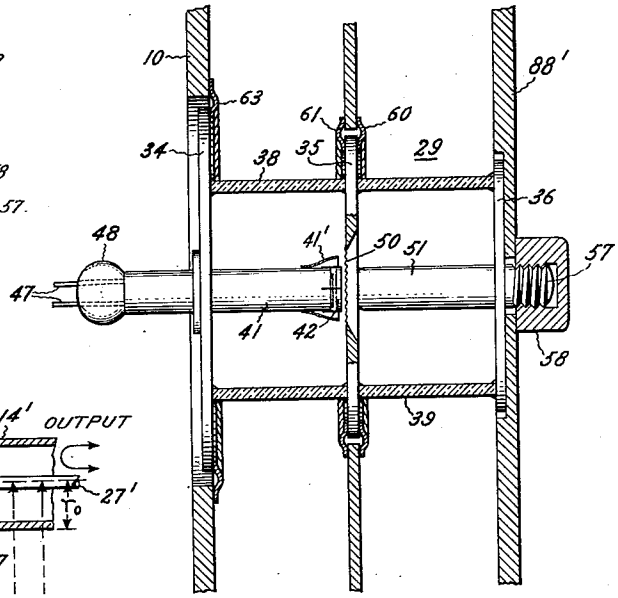
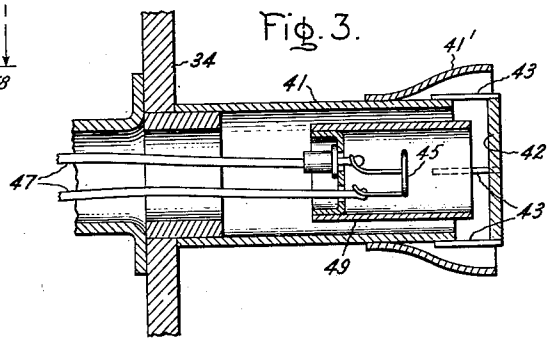


Fig. 3.



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Fig. 4.

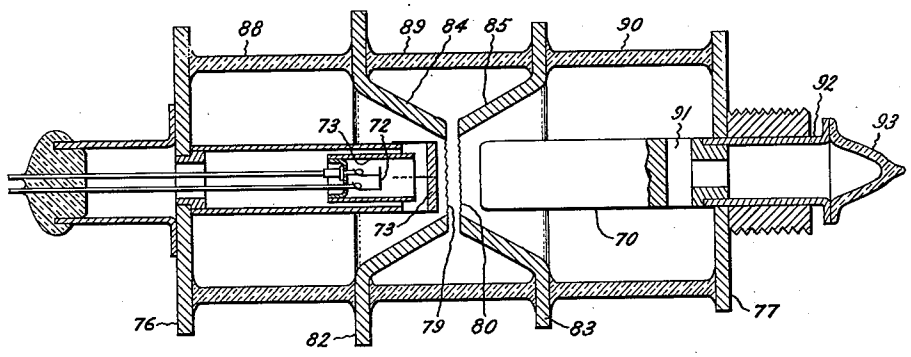
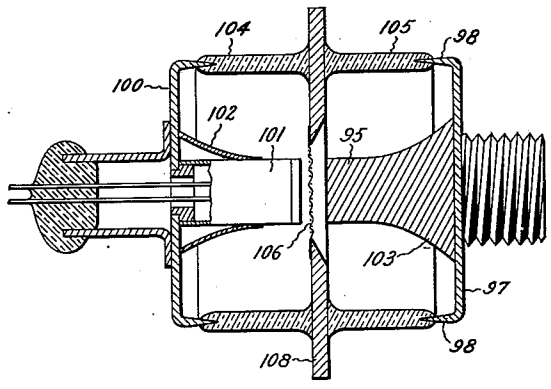


Fig. 5.



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UNITED STATES PATENT OFFICE

2,353,743

HIGH-FREQUENCY ELECTRONIC DISCHARGE DEVICE

Elmer D. McArthur, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application August 26, 1941, Serial No. 408,364

17 Claims. (Cl. 250—27.5)

This is a continuation-in-part of my prior application S. N. 353,132, filed August 17, 1940, for High frequency apparatus, and which matured on May 26, 1942, into United States Letters Patent No. 2,284,405.

The present invention relates to electronic discharge devices and has as its primary object an improved construction for discharge devices adapted for high frequency use.

In the design of ultra-high frequency apparatus it is frequently desirable to incorporate an electronic device in a resonant cavity in such a way that it forms, insofar as possible, an integral part of the cavity structure, both electrically and physically. It is one object of the present invention to provide a form of discharge device which is especially adapted for use in this manner.

In this connection an important feature of the invention consists in the use of a construction in which the terminals for the various electrodes are plate-like elements extending transversely and symmetrically with respect to the principal axis of the discharge enclosure. This permits each terminal to be arranged as a physically continuous part of a resonator wall surface, thus assuring effective electrical cooperation between the discharge device to which the terminal pertains and the resonator as a whole.

Devices constructed in accordance with the invention typically comprise, in their external aspects, a series of disk-like terminal elements insulatingly separated by glass cylinders sealed between them. In addition to the operational advantages noted above, this construction possesses the further practical advantage that its is readily capable of being fabricated by machine processes—a quality which is lacking in the more complex structures heretofore generally employed for high frequency use.

A preferred embodiment of the invention employs cathode and anode structures which are supported in end-to-end relation by means of disk-like terminal elements providing the end walls of the discharge enclosure. The anode and cathode structures have opposed discharge-receiving surfaces of generally similar dimensions, and the remainder of each structure provides a continuous conductive connection between the discharge-receiving surface of that structure and the surface of the terminal element supporting the structure which is at all points of at least as great a perimeter as the discharge-receiving surface itself. A grid, interposed between the anode and cathode, is mounted in the central opening of a metal annulus which extends peripherally through the lateral wall of the enclosure to provide a radially symmetrical terminal for the grid.

Tubes of this construction have been found to operate successfully at frequencies much higher than has been deemed feasible for conventional triodes, a fact which is believed attributable to the extremely low inter-electrode capacitance and lead-in inductance realized by the improved arrangement. In some cases successful operation at the extremely low wavelength of 12 centimeters has been obtained.

In order to permit terminals of the desired form to be sealed into a vacuum-tight discharge enclosure, it is in most cases necessary that they be constituted of a metal which is adapted to be joined directly to glass without any substantial residual strain in the resulting joint. The metals suitable for this use are for the most part of relatively high electrical resistivity and permeability and, therefore, tend to produce objectionable heating and inductive effects when employed as components of a high frequency circuit. A further feature of the present invention consists in the discovery that this difficulty may be overcome by covering the terminal elements in question with a coating of a low resistance metal such as copper, the coating being applied so thinly as not to destroy the glass-sealing properties of the coated elements but being nevertheless effective, because of the well-known "skin effect," to reduce materially the resistance and reactance offered by the elements to the flow of high frequency currents.

The aspects of the invention which I desire to protect herein are pointed out with particularity in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the drawings in which Fig. 1 is a sectional view of a high frequency apparatus incorporating electronic discharge devices which embody the invention; Fig. 2 is an enlarged detail view of one of the electronic devices shown in Fig. 1; Fig. 3 is a still further enlarged representation illustrating the cathode structure of the device of Fig. 2; and Figs. 4 and 5 show alternative embodiments of the invention.

Referring particularly to Fig. 1, there is shown a resonant structure which includes a series of three generally planar conductive members 10, 11 and 12 arranged in face-to-face relation to define a pair of resonant cavities between them. These members are of circular (disk-like) configuration

and are coaxially arranged so as to have a common line of centers. The members may suitably be constituted of copper, brass or other highly conductive metal.

At their central portion the disk-like members 10, 11 and 12 are associated with a conductive hub having separate parts 14 and 14' which are joined to the member 11 and which respectively extend through the members 10 and 12. The hub parts 14 and 14' are insulated from the members 10 and 12 by means of insulating bushings 16 and 17, but because of capacitance effects, may be assumed to provide an electrical short-circuit between the various members as far as high frequency currents are concerned.

In order to obtain the desired operation of this structure, it is important that the hub parts 14 and 14' be sufficiently short so that their lumped inductive effect is negligible in comparison with the lumped capacitive effect of the members 10, 11 and 12 at the resonant frequency of the system. This may be assumed to be the case as long as the conductive hub reactance is on the order of or less than 10% of the lumped capacitive reactance of the members.

Further structure is provided for the purpose of peripherally short-circuiting the members 10, 11 and 12 without establishing a path for direct currents between them. This is accomplished by providing inwardly directed flanges 19 and 20 in connection with the members 10 and 12 respectively and by attaching to the central member a double flange structure 21 which overlaps the flanges 19 and 20, being separated from them by insulating spacers 23 and 24.

It has been shown in my aforementioned application S. N. 353,132 that a resonant cavity of the type under consideration may be made to resonate at a particular frequency provided the radius of the connecting hub structure is properly correlated to the radial dimensions of the cavity-forming members. In particular, this correlation requires the fulfillment of the following relationship:

$$\frac{J_0(2\pi r_o/\lambda)}{N_0(2\pi r_o/\lambda)} = \frac{J_0(2\pi r_t/\lambda)}{N_0(2\pi r_t/\lambda)}$$

where J_0 and N_0 respectively represent Bessel functions of the first and second kinds and zero order, r_o represents the radius of the hub, r_t the common radius of the cavity-forming members, and λ represents a wavelength corresponding to the desired operating frequency. With these conditions realized, radially propagated standing waves may be developed within the resonant cavity thus defined, such waves having nodal points at the hub and at the periphery of the cavity and an antinodal point at a distance r_p from the hub determined by the following relationship:

$$\frac{J_0(2\pi r_o/\lambda)}{N_0(2\pi r_o/\lambda)} = \frac{J_1(2\pi r_p/\lambda)}{N_1(2\pi r_p/\lambda)}$$

where J_1 represents a Bessel function of the first kind and of the first order, N_1 represents a Bessel function of the second kind and of the first order, and the other quantities correspond to the conventions adopted above.

High frequency power may be supplied to and taken from the resonant structure of Fig. 1 by means of inductive loops 25 and 26 which are respectively coupled into the two cavities and which are terminally connected to conductors 27 and 27' positioned within the hub parts 14 and 14'. With this arrangement, conductors 27 and 14 and 27' and 14' form a pair of concentric conductor transmission lines well adapted for the transfer of high frequency power to and from the cavity-forming structure. Other inductive or capacitive coupling arrangements may be alternatively employed in connection with the various cavities.

In order to employ the properties of a resonant system of the type under consideration in the production of useful energy conversion effects, it is necessary to associate with the cavity-forming structure one or more electronic discharge devices adapted to function at the ultra-high frequencies to which the cavities are responsive. In the apparatus of Fig. 1, the tubes used in this connection (indicated at 28 and 29) are of the improved construction which characterizes my present invention. They are energized by D. C. potentials impressed between the disks 10, 11 and 12 from an appropriate source (not shown), and, in the arrangement shown, are adapted to amplify high frequency signals derived from an input source associated with the transmission line 14, 27.

Referring to Fig. 2, which represents the discharge device 29 on an enlarged scale, it will be seen that the device comprises a cylindrical construction which includes a series of three planar disk-like elements 34, 35 and 36, insulatingly separated by vitreous (glass) cylinders 38 and 39 sealed between the elements. As is shown more clearly in Fig. 3, the disk 34 is provided centrally with a protuberant cathode structure comprising a hollow metal cylinder 41 bearing at its extremity a circular plate 42. The plate 42, which may suitably consist of molybdenum, is mounted on a series of wire supports 43 and is coated on its outer surface with an electron emissive material such as thoria (thorium oxide). In operation, the emissive part 42 is maintained at a temperature of thermal emissivity by bombardment from an auxiliary cathode 45 in the form of an incandescible filament supported in spaced relation with reference to the part 42. The element 45 may be maintained in heated condition by passage of current through lead-in conductors 47 which are sealed into the discharge enclosure through a glass-to-metal seal indicated at 48 (Fig. 2). The electrons projected from the filament are focused against the inner surface of the part 42 by means of a metal cylinder 49 which is directly connected to one of the filament leads. In the use of the apparatus, a unidirectional potential is impressed between the filament 45 and the part 42 so as to produce a discharge between them. In order to prevent the electrons forming this auxiliary discharge from escaping into the principal discharge space, the cathode is preferably provided with a tubular skirt or shield 41' (Fig. 3) or, alternatively, the wire support rods 43 may be replaced by a continuous metal foil (not illustrated) completely closing the gap between the cylinder 41 and the emissive plate 42.

At the other end of the tube and projecting from the central area of the terminal disk 36 there is provided a substantially solid metal cylinder 51 which extends into relatively close proximity with the emitting disk 42 and which is adapted to serve as an anode element.

The anode 51 and the cathode part 42 are separated by means of a grid 50, suitably of molybdenum or tungsten, which extends across a circular aperture formed in the disk 35.

The tube 28 is provided with a cathode 42', a grid 50' and an anode 51' which correspond in

all particulars to the similar elements of tube 29.

The disks 34, 35 and 36 of the tube 29 are so related that their spacing corresponds to the spacing of the resonator parts 10, 11 and 12, and in the arrangement illustrated the disks are coplanar with these parts so as to form substantially continuous extensions of them. In order to make this arrangement possible, the disks interfit with corresponding openings provided in the various cavity-forming members and are peripherally electrically connected to the surrounding metallic structure of the members.

In order to permit assembly of the device 29 in the resonator system, the disks 34, 35 and 36 and the resonator openings with which they are associated are of graduated sizes, the smallest disk being the anode terminal and the largest disk being that connected with the cathode structure. The anode disk 36 is provided on its outer surface with a screw threaded stud 57 which cooperates with a correspondingly threaded nut 58. In initially positioning the discharge tube in the resonator system, the anode end of the tube is passed through the openings provided in the cavity-forming members 10 and 11 and is brought into such position as to permit the application of the nut 58. The dimensions of the parts are such that when the nut 58 is tightened, the outer edge of the disk 35 simultaneously engages a resilient dentate annulus 60 which is secured to one surface of the member 11. The disk 35 is itself provided with a circular spring annulus 61 which is rigidly secured thereto and which engages a face of the resonator member 11 when the parts are in the assembly shown in Fig. 2. Finally, the disk 34 engages a resilient annulus 63 which is secured to the resonator part 10.

With the arrangement described above, it will be seen that the only lead-in connections to the various electrodes of each tube are the disks 34, 35 and 36, which constitute, in effect, integral parts of the various cavity-forming members. As a result, all lead inductance to the grid 50 is absorbed as a useful and necessary part of the resonant system itself, and all inductance in the cathode and anode circuits is similarly absorbed except that due to the cathode cylinder 41 and to the axially extending portion of the anode 51. Moreover, all the interelectrode capacitance is usefully incorporated into the oscillating circuit except the relatively insignificant capacitance existing between the extremity of the cathode cylinder and the grid and between the grid and the end of the anode. As a consequence, operation of these tubes at wavelengths as low as 9 cms. has been found possible, and even this value appears not to constitute an ultimate limit.

In order to keep the interelectrode capacitance at as low a value as possible, it is important to make the opposed discharge-receiving surfaces of the anode and cathode structures no larger in area than is necessary to provide for effective emission and collection of the desired amount of electron current. On the other hand, in order to minimize the lead-in inductance, it is desirable that the conductive paths between the discharge-receiving surfaces of the respective electrodes and the terminal elements which support the electrodes shall be of as large cross-section as possible. For the fulfillment of this latter condition it is advisable that the perimeter of the conductive link between the discharge-receiving surface of each electrode and its associated terminal shall be at all points at least as great as the perimeter of the said surface itself, this being a requisite which is obviously fulfilled by the cylindrical electrode construction of Fig. 2.

A further feature of the illustrated construction which is of great practical importance is the separation of electrical and heat energy flow which occurs at the anode terminal. It will be readily understood that in the illustrated application of the invention, electrical energy is directed or diverted from the surface of the anode to the inside surface of the resonant cavity. Thermal energy, on the other hand, is not diverted, but is conducted to the outside of the anode terminal by way of the anode stud 57 where it can be dissipated by a radiator or other cooling means (not shown) which is not limited in its performance by having to be small or shaped particularly to fit a high frequency circuit. This enables the tube to have a relatively much higher current-carrying capacity than has heretofore been deemed feasible in connection with tubes intended for use in the ultra-high frequency range.

In order to make possible a tube construction such as that illustrated in Fig. 2, it is necessary to select for the material of the terminal disks a metal which is capable of being sealed directly to glass. In this connection, one may use, for example, an alloy of nickel, iron and cobalt which contains approximately 54% iron, 31% nickel, and 15% cobalt, this alloy having expansion characteristics which are substantially the same as Corning 705A0 glass. Alternatively, the disks may be constituted of iron (that is to say a commercial form of low carbon steel), and may be sealed to one of the iron-matching glasses described in Hull and Navias application S. N. 266,604, filed April 7, 1939, and assigned to the same assignee as the present application. A particular glass which is useful in this connection has approximately the following composition:

	Per cent
SiO_2	45
K_2O	12
Na_2O	6
PbO	32
CaF_2	5

Each of the sealing metals referred to in the foregoing is of relatively low electrical conductivity and is therefore not inherently well adapted for use in a high frequency system. In order to overcome this difficulty, it is advantageous in some cases to provide the active surfaces of the terminal disks with a plating of a highly conductive material, for example, silver or copper. For instance, in connection with terminal disks consisting of nickel-cobalt-iron alloy, the disks may be plated with copper to a thickness on the order of from 1 to 4 mils by electrolytic means, and, after heating to from 900° to 1,000° C. to eliminate porosity in the copper plating, the disks are sealed to the glass parts of the discharge enclosure. It is found that the addition of a plating of copper of the thinness specified does not modify to any significant degree the expansion characteristics of the treated parts. However, where the disks are of nickel-iron-cobalt alloy, it is desirable to interpose a thin layer of a fluxing glass between the copper covered surface and the 705A0 glass in order to assure satisfactory adherence of the joined parts. A fluxing glass which may be used in this connection has approximately the following oxide composition: 56% SiO_2, 10% B_2O_3, 3% Al_2O_3, 28% PbO, 3% K_2O. In the case of iron disks plated with cop-

per, this intermediate glass may be omitted, since the iron-sealing glass described above is also capable of adhering to copper.

In spite of the extreme thinness of the copper layer thus provided, it is found that the conductivity of the terminal disks with respect to high frequency currents is much increased by its use. This is attributable to the fact that such currents tend to flow mainly in regions very near the surface of the conductive parts by which they are carried, this being the well-known "skin effect."

Due to the simple form of the structural parts and the end-to-end arrangement of the electrodes, tubes of my invention may be readily fabricated by machine procedures requiring a minimum of human supervision. For example, once the various electrodes are secured to their appropriate terminal disks, it is a relatively simple matter to establish a desired spacing between the disks (and hence between the electrodes) by means of accurately formed jigs and to maintain this spacing while the intermediate glass cylinders are fused in place by induction heating apparatus or the like. For this reason the construction in question represents a material improvement in ease of manufacture over all-glass structures or other tube types in which the close attention of a skilled workman is required to secure accurate alignment of the various electrode parts.

Fig. 4 represents the application of the invention in connection with a four-electrode tube construction. In this case, the tube includes an anode 70 and a cathode structure which combines an emitting disk 71, an auxiliary filament 72, and a focusing cylinder 73, the anode and cathode structures both being of generally cylindrical form and being respectively supported by disk-like terminal elements 76 and 77. Between the emitting surface of the cathode part 71 and the juxtaposed extremity of the anode 70 there are provided a pair of mesh electrodes 79 and 80 adapted to serve respectively as a control grid and as a screen grid. The terminal elements for the grids 79 and 80 are in the form of circular members 82 and 83, each being provided peripherally with an annular flattened portion and each having a conically tapered flange (84, 85) by means of which the grids are supported in close proximity to one another. This particular construction of the grid terminal elements has the advantage that it permits the grids to be in relatively close juxtaposition, while the externally exposed parts of the terminal elements are relatively widely spaced so as to minimize the likelihood of electrical breakdown between them and also to facilitate their inclusion in cavity-forming structures. Glass cylinders 88 to 90 are sealed between the various terminal elements so as to maintain them in appropriately spaced relationship. In order to permit evacuation of the discharge enclosure, the anode 70 is provided near one end with an opening 91 communicating with an exhaust tubulation 92 which extends outwardly from the extremity of the discharge device, the end of the exhaust tubulation being closed by means of a glass seal-off tip 93. A threaded collar 94 which surrounds the tubulation 92 provides a convenient means for securing the tube to a mounting structure.

The tube construction just described may be employed, for example, in a high frequency amplifier (not illustrated) having two separate resonant cavities, the first, or input cavity, being made up of two opposed disks respectively associated with and forming extensions of the terminals 76 and 82, and the second, or output cavity, being composed of similar disks respectively connected to the terminals 77 and 83. In this use of the tube the cathode disk and the screen grid disk should be maintained at a common A. C. potential.

Fig. 5 represents a still further modification of the invention which is similar to the construction of Fig. 2 except for the nature of the terminal elements associated with the cathode and anode structures. In this instance the anode, indicated at 95, is supported on a disk-like element 97 which is of essentially planar character but which is provided at its periphery with a transversely bent flange 98 having a tapered edge. A generally similar terminal element 100 is provided in connection with the cathode structure 101. A flared skirt 102 provided in connection with the cathode structure and a somewhat similar skirt 103 formed integrally with the anode structure serve still further to decrease the lead-in inductance of these electrodes and to minimize the effect of the discontinuity between the electrodes and the terminal elements 97 and 100 with which they are associated.

The peripheral edges of the terminal elements 97 and 100 are sealed into cylinders 104 and 105 which are constituted of a matching glass and which serve to maintain the anode and cathode in appropriately spaced relation with respect to one another and with respect to a grid 106 interposed between them. As in the constructions previously described, the grid 106 is provided with a flat annular terminal element 108 which extends peripherally from the lateral wall surface of the tube, being sealed between the extremities of the glass cylinders 104 and 105.

The construction of Fig. 5 possesses the advantages previously noted in connection with the structure of Fig. 2 and, in addition, has the virtue that the anode and cathode seals which it employs are easier to fabricate, especially where a structure of relatively large size is desired.

While the invention has been described by reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the invention. I, therefore, aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

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

1. A high frequency electronic discharge device comprising an evacuated enclosure, a pair of metal members forming the end walls of the enclosure, said members being insulatingly separated by hollow vitreous spacing means which forms the lateral wall of the enclosure, an anode structure and a cathode structure respectively supported by said members in end-to-end relation within the enclosure and having opposed discharge surfaces of generally similar dimensions, each of said structures providing a continuous conductive connection between the discharge surface of such structure and the wall-forming member supporting the structure, said conductive connection being at all points of at least as great a perimeter as the said discharge-receiving surface itself, and a control electrode positioned between said anode and cathode structures.

2. A high frequency electronic discharge device

comprising an evacuated enclosure, a pair of metal members forming the end walls of the enclosure, said members being insulatingly separated by hollow vitreous spacing means which forms the lateral wall of the enclosure, an anode structure and a cathode structure respectively supported by said members in end-to-end relation within the enclosure and having opposed discharge surfaces of generally similar dimensions, each of said structures providing a continuous conductive connection between the discharge surface of such structure and the wall-forming member supporting the structure, said conductive connection being at all points of at least as great a perimeter as the said discharge surface itself, a centrally apertured metal body extending through the said lateral wall of the enclosure around substantially its entire circumference, and a grid mounted in the central aperture of said body and supported by the body between the anode and cathode structures.

3. A high frequency electronic device comprising a discharge enclosure, a pair of metal members having surfaces which provide end walls for the enclosure, said members being insulatingly separated by hollow vitreous spacing means forming the lateral wall of the enclosure, an anode structure and a cathode structure extending toward one another from the ends of said enclosure and having opposed discharge surfaces of generally similar dimensions, said structures being respectively supported at their remote extremities by said metal members and each structure providing a continuous high frequency current path between the discharge surface of such structure and the associated metal member which, at all points along its length, is of at least as great a perimeter as the discharge surface itself.

4. A high frequency electronic discharge device comprising a cylindrical enclosure, a pair of generally planar metal members forming the end walls of the enclosure, said members being insulatingly separated by hollow cylindrical vitreous spacing means which forms the lateral wall of the enclosure, a solid cylindrical metal body of uniform diameter extending inwardly from the central portion of one of said end walls and forming an anode, a hollow cylindrical cathode structure of uniform diameter centrally secured to the inner surface of the other end wall of the enclosure, heating means enclosed by said cathode structure, said cathode structure being closed at its inwardly directed extremity by a circular member which is in close proximity to the end surface of said anode and which is adapted to be maintained thermally emissive by the said heating means, and a control electrode interposed between said cathode structure and anode.

5. A high frequency electronic discharge device comprising a cylindrical enclosure, a pair of disk-like metal members respectively forming the end walls of the enclosure, said members being insulatingly separated by vitreous cylinders which form the lateral wall of the enclosure, an anode structure and a cathode structure respectively supported by said members in end-to-end relation within the enclosure and having opposed discharge surfaces of generally similar dimensions, each of said structures providing a continuous conductive connection between the discharge surface of such structure and the wall-forming member supporting the structure, said conductive connection being at all points of at least as great a perimeter as the discharge surface itself, a third disk-like member extending through the said lateral wall of the enclosure throughout substantially its entire circumference, said third disk-like member having a central opening, and a grid mounted in said opening and positioned between said anode and cathode structures.

6. A high frequency electronic discharge device comprising four plate-like metal members mounted in mutually spaced parallel planes, hollow insulating bodies respectively sealed between the various members and defining in combination with them a vacuum-tight discharge enclosure having two of the members as its end walls and the structure of said insulating bodies as its lateral walls, the intermediate members extending peripherally from a lateral wall and each such member being provided with a central opening, a pair of grids respectively supported in the central openings of the said intermediate members, an anode structure projecting inwardly from the central portion of one of said end walls and extending into close proximity with one of said grids, and a cathode structure projecting inwardly from the other of said end walls and extending into close proximity to the other grid.

7. A high frequency electrical device including an enclosure which consists at least in part of glass, energy-translating means within the enclosure, a plate-like member sealed to said glass part and forming a part of the enclosure and providing a current-supply connection of large surface area for said energy-translating means, said energy translating means being connected with said member, said member consisting mainly of a high resistance metal the expansion characteristics of which are matched to those of the said glass, and a thin coating of a low resistance metal covering substantially the entire surface of the said member including the region of the seal between said member and said glass for facilitating the flow of high frequency currents to and from the energy-translating means connected to the member.

8. A high frequency electrical device including a vacuum-tight enclosure the lateral walls of which are of glass, energy-translating means within the enclosure, a current-supply connection for said means comprising a metal body extending peripherally from the enclosure throughout its circumference, said body consisting mainly of a relatively high resistance metal and being sealed in extensive surface engagement with said glass and forming a portion of the enclosure, and a thin coating of relatively low resistance metal covering substantially the entire current-carrying portion of the said body for facilitating the flow of high frequency currents between said body and the energy-translating means within said enclosure.

9. A high frequency electronic discharge device comprising a hollow cylindrical glass structure providing the lateral wall of a discharge enclosure, a pair of disk-like members of a relatively high resistance metal sealed to the respective extremities of the said structure providing the end walls of the discharge enclosure, said members being substantially entirely covered on their inwardly directed surfaces with a low resistance metal to facilitate radial flow of high frequency currents carried by the members, an anode structure projecting inwardly from the central portion of one of the said members, and a cathode structure projecting inwardly from the central portion of the other of the members and extending into proximity with the said anode.

10. A high frequency electronic discharge device including a series of three disk-like metal members maintained in mutually spaced parallel relation by a pair of glass cylinders sealed between the members and forming in combination with them a vacuum-tight enclosure, said members being composed mainly of a high resistance ferrous metal the expansion characteristics of which are matched to those of the said glass, a cathode, a grid and an anode within the said enclosure and respectively electrically connected to said members, and a coating of copper covering substantially the entire surfaces of the said members for facilitating the flow of high frequency currents to and from the said cathode, grid and anode.

11. A high frequency electronic discharge device comprising a series of three disk-like metal elements mounted in mutually spaced parallel relation, cylindrical glass bodies respectively sealed between said members and forming with the members a vacuum-tight discharge enclosure, the end walls of the enclosure being formed by two of said members, and a third one of the members extending peripherally from the lateral wall of the enclosure and being provided with a central opening within the enclosure, an anode projecting inwardly from one of the said end walls of the enclosure, a cathode structure projecting inwardly from the other end wall of the enclosure, and a grid mounted in the central opening of the said third disk-like member and supported thereby between the anode and cathode structure, said disk-like members being covered superficially with a high conductive metal to facilitate radial flow to and from the said anode, cathode and grid of high frequency currents carried by the members.

12. A high frequency electronic device comprising a discharge enclosure, a pair of circular metal members which provide end walls for the enclosure, said members being insulatingly separated by hollow vitreous spacing means forming the lateral wall of the enclosure, a cylindrical cathode structure extending inwardly from the central portion of one of said members and terminating in a planar active portion, an anode structure in the form of a solid metal cylinder extending inwardly from the central portion of the other of said members and terminating in a planar portion of substantially the same dimensions as said active cathode portion, a generally planar grid between said planar anode and cathode portions and a third metal member extending peripherally through said lateral enclosure wall and providing a support and terminal for said grid.

13. A high frequency electronic device comprising a discharge enclosure, an anode structure and a cathode structure having opposed discharge surfaces of generally similar dimensions within the enclosure, and a pair of mutually insulated metal members forming end walls for the enclosure and respectively providing high frequency terminals for said anode and cathode structures, each of said structures being of progressively increasing diameter in a direction taken from the discharge surface of such structure toward its terminal thereby to avoid any substantial discontinuity between said discharge surface and said terminal.

14. A high frequency electronic device comprising a discharge-enclosure, an anode and a cathode having opposed discharge surfaces within the enclosure, mutually insulated metallic members forming end walls for the enclosure and a tapering metallic connection between each of said discharge surfaces and the central portion of a corresponding one of said members, whereby a symmetrical high frequency current path having no substantial electrical discontinuity is provided from each of said members to its discharge surface.

15. A high frequency electronic device comprising a discharge enclosure, a pair of circular metal members having planar surfaces which respectively provide end walls for the enclosure, said members being insulatingly separated by hollow vitreous spacing means forming the lateral wall of the enclosure, an anode structure and a cathode structure supported in end-to-end relation within the enclosure and having opposed circular discharge surfaces of generally similar dimensions, said circular metal members respectively providing high frequency terminals for the remote extremities of said anode and cathode structures, each of said structures being of progressively increasing diameter in a direction taken from the discharge surface of such structure toward its terminal, a third circular member extending through the lateral wall of the enclosure throughout substantially its entire circumference, said third circular member having a central opening and grid mounted in said opening and positioned between said anode and cathode structures.

16. A high frequency electronic device comprising a discharge enclosure, an anode and a cathode having opposed discharge surfaces within the enclosure, a pair of mutually insulated metallic members forming end walls for the enclosure and respectively providing high frequency terminals for the said anode and cathode, and means forming a current path of progressively increasing diameter between the discharge surface of the cathode and its terminal.

17. A high frequency electronic discharge device including a series of three circular metal members having planar surfaces mounted in mutually spaced parallel relation, said members being composed mainly of a high resistance ferrous metal capable of being sealed to glass, cylindrical glass bodies respectively sealed between the various members and forming with the members a vacuum tight enclosure, the end-walls of the enclosure being formed by two of said members and a third one of the members extending peripherally from the lateral wall of the enclosure, an anode projecting inwardly from one of the said walls of the enclosure, a cathode structure projecting inwardly from the other end wall of the enclosure, and a grid mounted in the central opening of the said third member and supported thereby between the anode and the cathode structure, the various members being covered superficially with a highly conductive metal to facilitate radial flow to and from the said anode, cathode and grid of high frequency currents carried by the members.

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