

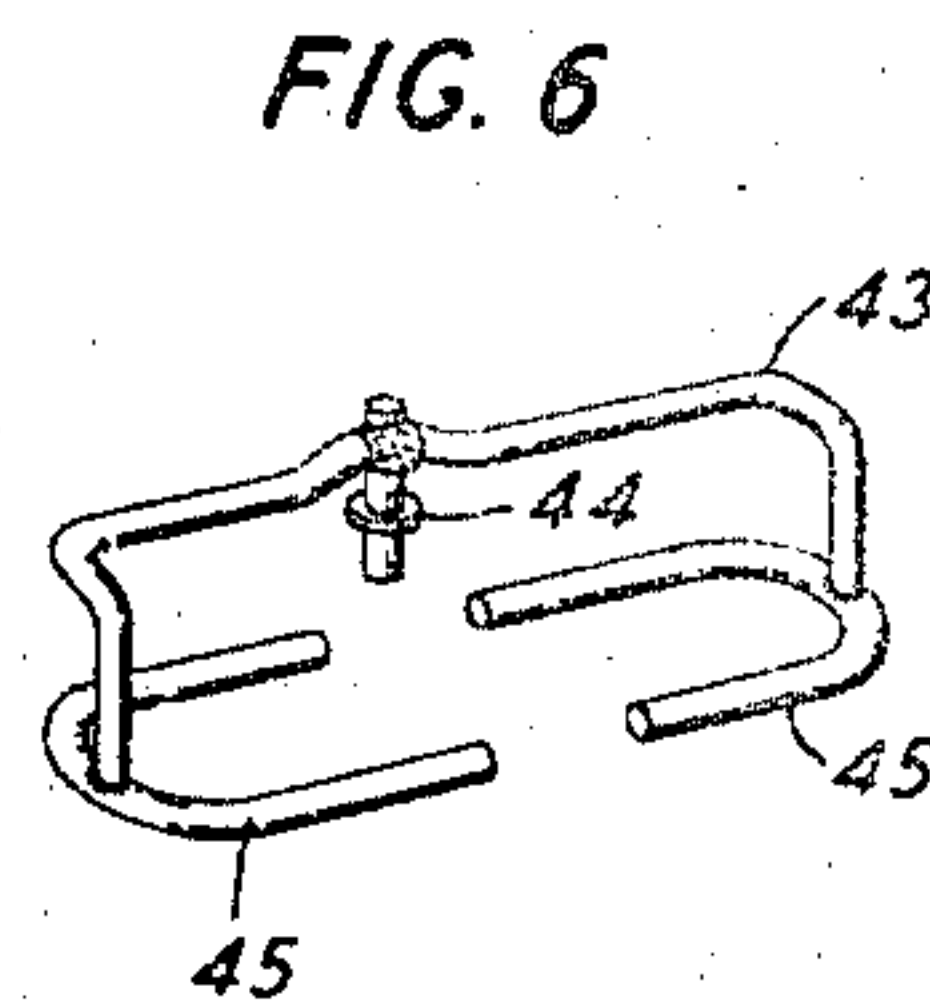
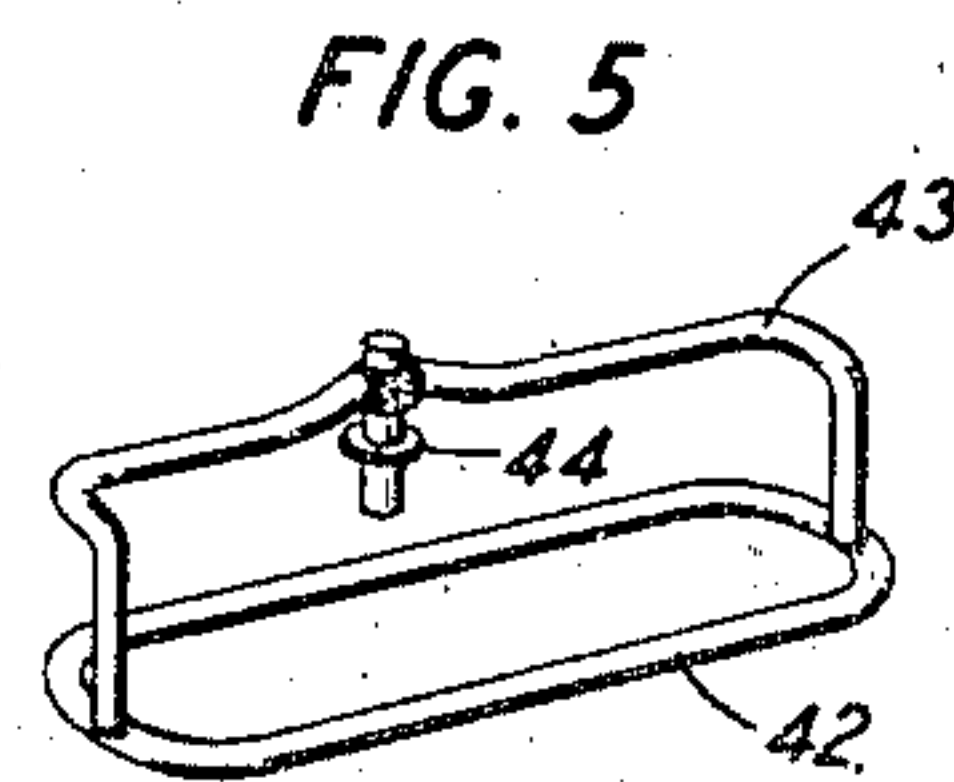
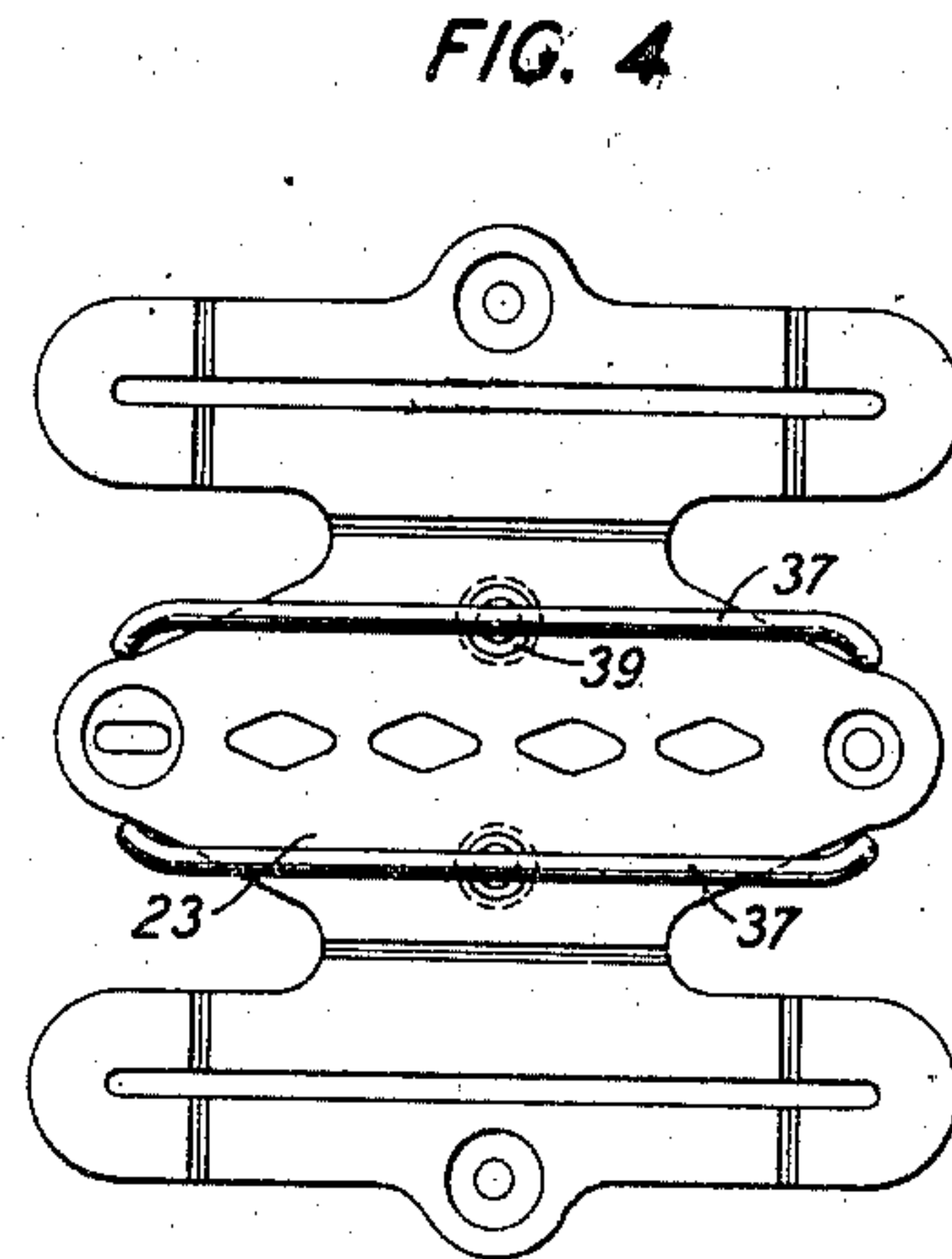
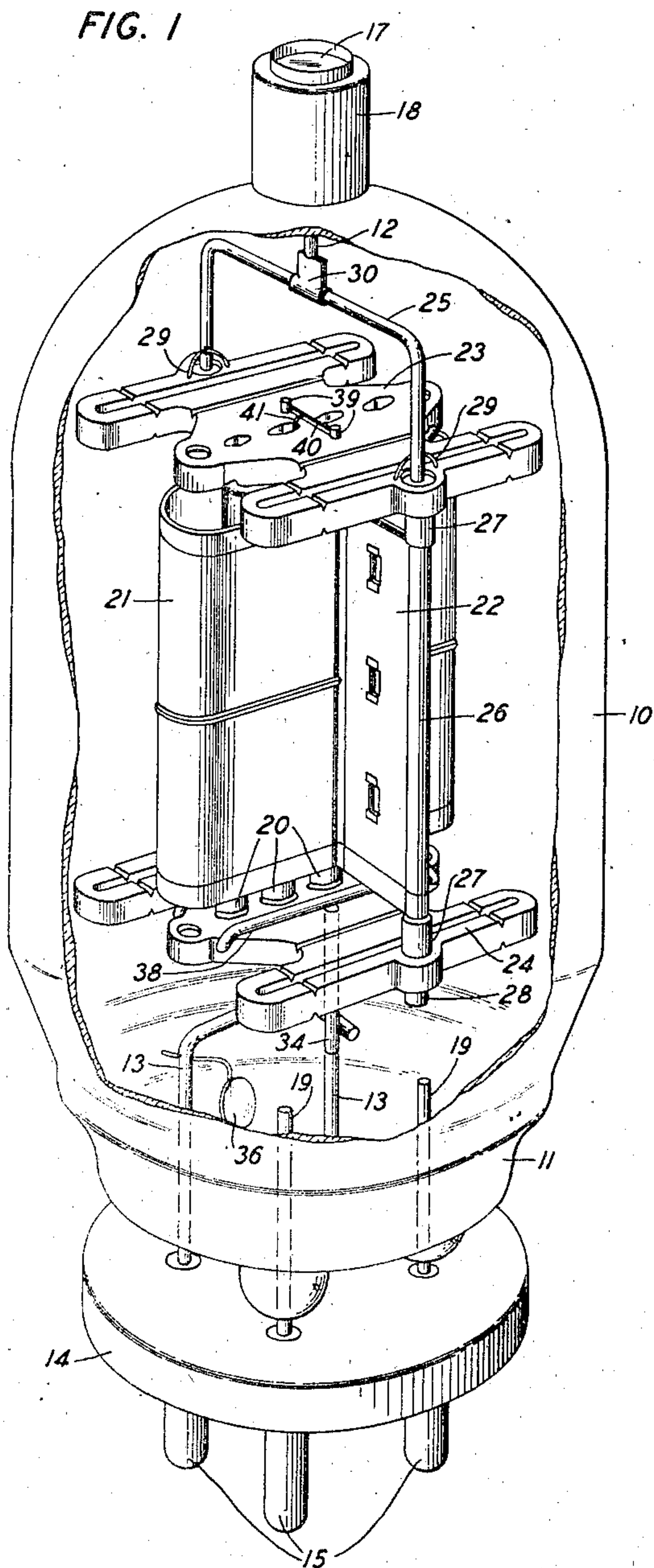
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C. E. FAY ET AL
ELECTRON DISCHARGE DEVICE

2,414,805

Filed May 12, 1943

2 Sheets-Sheet 1



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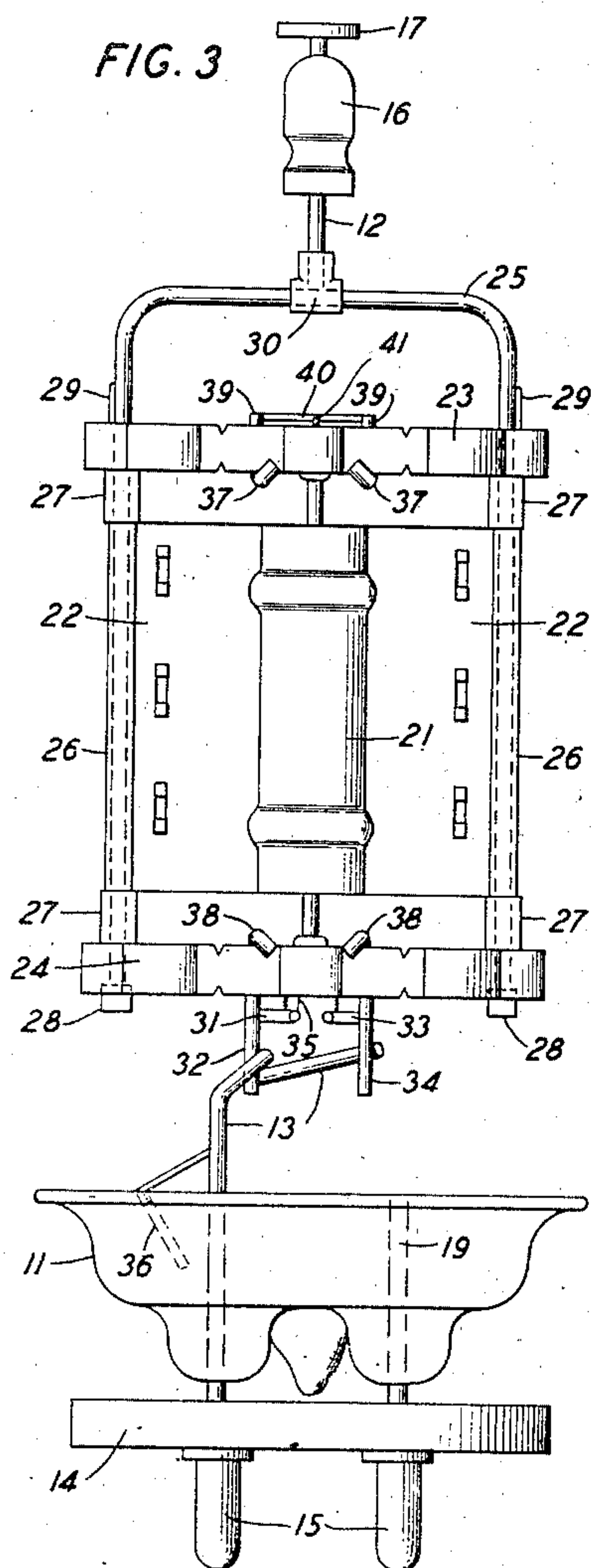
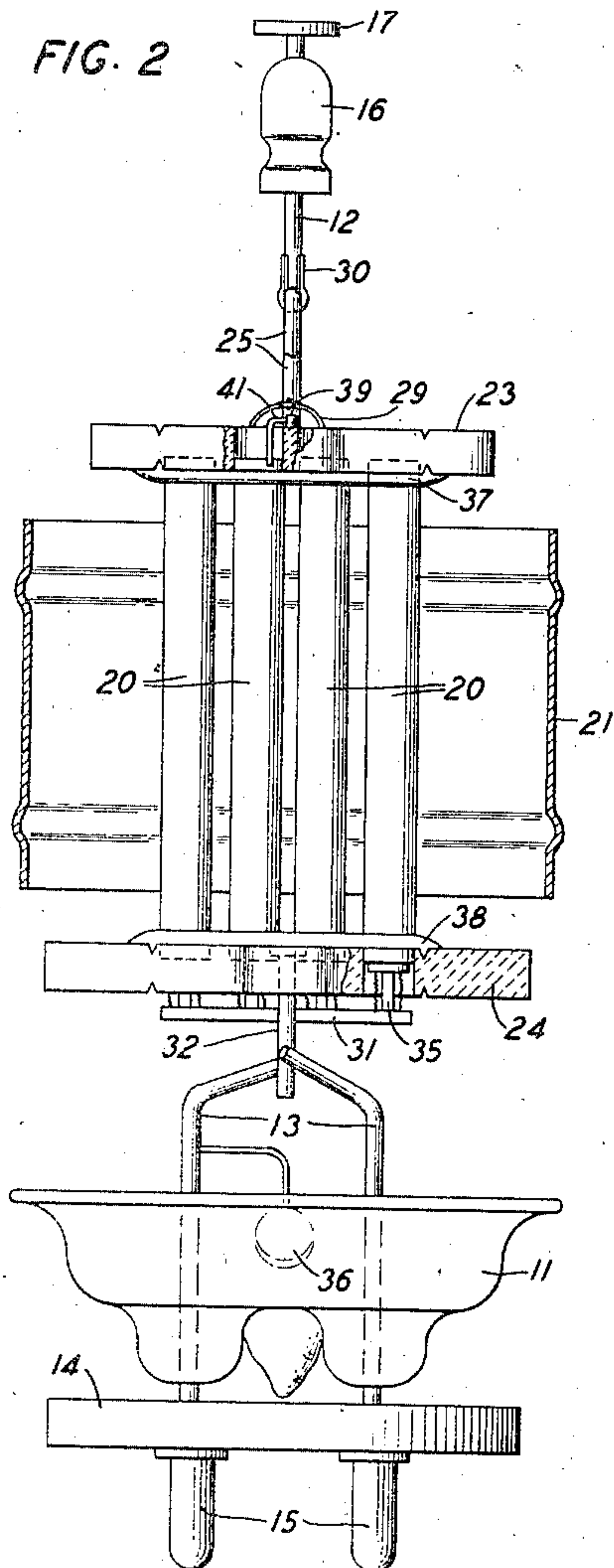
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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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12 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to such devices employed in the rectification of alternating potentials at relatively high energy levels.

In large power rectifier devices having electron emission cathode surfaces of large area spaced in uniform relation to an output electrode or anode by insulating supports, such as end spacer plates or discs, considerable difficulty is experienced in the sputtering of the emissive coating material from the cathode surfaces. This material is deposited as a conducting or semi-conducting film on the glass wall of the device. In addition to the decrease in the operating life of the device, due to the loss of emission material from the cathodes, the proper function of efficient rectification of voltages is endangered due to the reduction in leakage resistance between the electrode terminals of the device. The loss of energy and, therefore, the diminution of the rectifying efficiency of the device, particularly at high current levels, begin at an early stage of operation and are cumulative in effect so that a relatively short life is the result thereby depreciating the device after a short period of operation.

An object of this invention is to neutralize the high potential difference between the cathode and anode of a rectifier device in order to eliminate sputtering of cathode material to the wall of the device.

Another object of the invention is to preserve the high insulation resistance between the electrodes in the device.

A further object of the invention is to diminish the high potential gradient in the vicinity of the cathode support thereby decreasing the high frequency energy heating of the cathode.

Another object of the invention is to prevent deteriorating effects being established at the point of contact of the cathode surface with the insulating spacer member carried by the anode.

These objects are obtained in accordance with one aspect of this invention by a construction involving multiple parallel cathode surfaces mounted between insulating spacer members and enclosed by a hollow metallic anode which constitutes a unitary electrode assembly or mount supported by rigid conductors within a highly evacuated container or vessel for half-wave rectification of high frequency currents at high energy levels.

The high potential difference between the output electrode or anode and the large surface area of the low potential cathode or electron emission source builds up a high frequency component

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along the insulating surface which attacks the emissive coating of the cathode by a heating effect resulting in vaporizing the coating which sputters from the cathode and is deposited as a conducting film on the wall of the vessel.

This high potential gradient in the vicinity of the cathode and insulating support is neutralized in accordance with this invention by the addition of metallic guards or dissipation shields in the form of wire loops or parallel rods at each end of the mount intermediate the anode and the cathode surfaces, and preferably between the electrodes and the insulating spacer members.

In a specific embodiment of the invention, the guard rods extend parallel to the insulating spacer on opposite sides of the cathodes and at each end thereof, the rods being maintained at the potential of the cathodes. These guard rods which are in the nature of counterpoises redistribute the high potential gradient from the concentrated points of the support of the cathode along the insulating spacer members. Accordingly, the cathode surfaces remain at normal operating temperature and the diffusion of emissive coating material from the cathode surfaces is inhibited.

A feature of this invention relates to a method of protection in which the peak voltage concentrated at the point of contact of the cathodes with the insulating spacers is redistributed over a leakage path to render impotent the heating effect of the high frequency potential gradient, thereby eliminating diffusion of emissive coating material from the cathode surfaces.

Other embodiments and various features of the invention will be apparent from the following detailed description which together with the accompanying drawings represents the concepts of this invention.

Fig. 1 is a perspective view of an electron discharge device embodying the features of this invention, the enclosing vessel being broken away to show the constructional assembly of the internal electrodes;

Fig. 2 is a view in elevation of the device in Fig. 1 with the enclosing vessel removed and the anode shown in cross-section to more clearly visualize the relation of the guard rods to the cathodes and spacer members;

Fig. 3 is a view similar to Fig. 2 but taken from a different angle to show the mounting of the protective shielding rods at the extremities of the cathodes;

Fig. 4 is a plan view of an insulating spacer member employed in the construction of this in-

vention with the parallel guard rods mounted thereon; and

Figs. 5 and 6 show modified forms of the guard members in perspective which may be mounted on the spacers in relation to the electrodes of the device.

Referring to the drawings and particularly to Fig. 1, an example of a rectifier device of this invention is disclosed and comprises an evacuated glass vessel having a bulbous body portion 10 and a molded dish stem 11 in which the electrode assembly or mount is situated and supported at the top by a conductor 12 and at the bottom by conductors 13 which are mounted in a disc base 14, of insulating material, and connected to terminals 15 carried by the base. The conductor 12 at the top of the device is centrally sealed in the dome of the vessel with the aid of a cup-shaped glass bead 16, shown in Fig. 2, and a disc terminal 17 is welded to the end of the conductor adjacent the bead, the disc terminal being secured to the periphery of a sleeve cap 18 which is cemented to the top of the vessel. A pair of dummy rods 19 may be sealed in the stem 11 in uniform space relation to the conductors 13, the rods being attached to separate dummy terminals on the base to rigidly mount the device in relation to the base.

As shown in Fig. 2, the electrode assembly or mount, supported in the vessel and particularly to which this invention appertains, comprises a high voltage rectifier unit for converting relatively high alternating current voltages in the range from 10 to 30 kilovolts to yield a high power output of the order of 10 to 15 amperes at a frequency of high periodicity, such as microseconds. In order to attain this high power output, it is essential to maintain an electron flow of large magnitude to the output electrode or anode and this is attained by mounting multiple cathodes 20 of large surface area, such as oval-shaped metallic sleeves, in parallel relation across one diameter of the unit, the sleeves being provided with the usual electron emissive coating, such as barium and strontium oxides. These sleeves are provided with the usual internal insulated heater elements, not specifically shown, to raise the cathode sleeves to the proper emission temperature whereby a copious supply of electrons is projected to the receiving surface of an output electrode or anode 21. In view of the high voltages encountered in the operation of the device, the anode which is maintained at a high potential should be formed of a highly refractory material, such as molybdenum, and in order to obtain the highest efficiency in output it is desirable to shape the anode in the form of a flat cylinder in surrounding relation to the laterally aligned cathode sleeves 20, the anode being provided with longitudinal central heat radiating fins 22 on opposite sides of the flat surfaces, the fins projecting at right angles to the long dimension of the anode. The anode may also be provided with a black body coating, such as zirconium, to more efficiently radiate heat generated in the operation of the device.

In order to maintain the static and dynamic characteristics of the device constant it is preferable to rigidly support the multiple cathodes 20 and the surrounding anode 21 in uniform space relation by end insulating members or blocks 23 and 24 which are formed of a highly refractory material, such as aluminum oxide, having high dielectric properties. These members, one of which is shown more clearly in Fig. 4, are provided with multiple parallel arms joined by nar-

row waist portions to achieve the greatest surface insulation paths between the supported ends of the electrodes commensurate with the allowable space relation between the electrodes. In addition, these members are provided with slots and ridges in the surfaces thereof to further increase the leakage resistance along the surface and may also be provided with a rough coating of aluminum oxide, to inhibit the formation of a low resistance path along the surfaces due to the deposition of conductive material on the insulating members from the electrodes. The central arm of the insulators is provided with a plurality of diamond-shaped apertures across the long dimension thereof to form supporting sockets for the opposite ends of the cathode sleeves 20, as shown in Fig. 2. The end arms of the blocks on opposite sides of the central arm constitute the supporting portions for the anode 21, the anode being attached thereto by a yoke member 25 carried by the central conductor 12, the yoke having downwardly extending legs which extend through apertures in the insulating blocks and sleeve portions 26 on the ends of the fins 22 of the anode. The ends of the anode 21 are spaced from the surfaces of the blocks adjacent thereto by insulating bushings 27 threaded on the legs of the yoke between the blocks and the sleeves 26, of the anode. The lower block 24 is rigidly fastened to the yoke by a welded sleeve 28 affixed to the end of the yoke leg and the block 23 is rigidly clamped down on the anode assembly by arcuate clamping pieces 29 which are welded to the yoke and have their ends pressing against the top surface of the block 23. The yoke member 25 is attached to the conductor 12 by a connector strap 30. The conductors 13 in the stem are connected to the heaters and cathodes of the electrode assembly, as shown in Figs. 2 and 3. One end of each heater element is connected to a bus wire 31 which is carried by a short stub rod 32 anchored in the lower insulating block 24 while the other end of each heater is connected to a bus wire 33 supported by a stud rod 34 anchored in the insulating member 24 opposite the rod 32, the conductors 13 being connected to the rods 32 and 34. Each cathode 20 is also provided with a metallic strap 35 which is connected to the bus wire 31 so that the cathodes are at the same potential as the negative side of the heater circuit, all the cathodes and heater elements being connected in multiple through the bus wires and the supporting conductors 13 in the vessel. A getter mounting 36 may be attached to one of the conductors 13 and directed at an angle toward the stem, as shown in Fig. 3, the getter being vaporized in the final evacuation process of the device to absorb residual gases in the device.

Although the precautions established to insure that the dielectric resistance between the electrodes is constant and of a high order over an extended operating period, so that a leakage conductive path is not formed across the surfaces of the end insulating spacer blocks of the unit or mount, the large difference of potential between the cathodes and the anode, which occurs during the portion of the operating cycle when the anode becomes negative with respect to the cathodes by a high potential, of the order of 10 to 30 kilovolts, introduces other destructive effects which endanger the efficient operation of the device notwithstanding the high insulating resistance path between the electrodes.

The high potential gradient established under

these conditions of operation between the anode and the multiple cathodes, particularly in the rectification of currents of ultra-high pulsations, of the order of microseconds, creates injurious effects of great intensity which attack the cathodes and eventually destroy or greatly diminish the emissive coating material thereon. Under these effects the cathodes are heated abnormally, especially at the points of support in the spacer blocks at opposite ends of the unit so that active material is vaporized or sputters from the cathode surfaces and is projected to the glass wall of the vessel. The deposition of the material on the glass wall eventually reduces the insulating path between the terminals of the electrodes thereby causing rapid deterioration of the device for useful operation at the normal rated voltages or, if permitted to continue, finally destroys the device due to short-circuit between the anode and cathode.

The sputtering effect of the cathode is attributable to the establishment of a high frequency field in the vicinity of the points of support of the cathodes on the insulators since these points are subject to the highest potential gradient in the unit. This field creates a high heating effect which causes abnormal heating of the cathode at these points and the emissive material of the cathodes is diffused or vaporized therefrom and is deposited on the wall of the vessel.

The injurious effects of the high potential gradient resulting between the electrodes across the insulating spacers and the concentration of the leakage current at the points of support of the cathodes are overcome in accordance with this invention by redistributing and dissipating the high frequency potential, whereby the cathodes are protected from abnormal heating which might engender sputtering of the cathode material. This is accomplished by the introduction of metallic guard elements at opposite ends of the cathodes adjacent the insulating spacer blocks to neutralize the effect of the potential gradient and dissipate the destructive heating field. These elements serve as redistribution shields or counter-poles which absorb the high frequency current and render it impotent to attack the cathode material.

As shown in Figs. 1, 3 and 4, the guard elements, in accordance with one aspect of this invention, comprise pairs of parallel rods 37 and 38 positioned on opposite sides of the laterally mounted cathodes 20 and at each end thereof. The rods 37 situated below the top insulating block 23 are supported at a central point by stub wires 39 which are connected together on the top of the block by a strap 40, the strap being connected to one of the cathode sleeves 20 by a flexible connector 41 so that the rods are at ground or zero potential. The guard rods, therefore, extend crosswise along the long dimension of the center arm of the insulating block 23. The ends of the rods are bent or curved upwardly toward the edges of the central arm at each end to prevent reciprocal or swinging movement of the guards interfering with the multiple cathode surfaces. The pair of rods 38 at the lower end of the unit are mounted in similar fashion above the lower insulating block 24 in uniform parallel relation to the series of cathode surfaces mounted between them. However, in this position the rods 33 may be adequately supported by the anchor studs 32 and 34 which may be extended through the insulating block 24 to be welded to the center

of the rods 38. The rods 38 will, therefore, be at the same potential as the cathodes and heater elements which are connected to the bus wires 31 and 33 carried by the anchor studs 32 and 34. This arrangement of the parallel guard rods in close juxtaposition to the ends of the cathodes mounted in the insulating blocks distributes the high frequency field established by the potential gradient between the electrodes and dissipates the field to prevent the concentration of high heating energy at the points of support of the cathodes and materially enhances the operation of the device over a long life without substantial vaporization of the coating material on the cathode surfaces. The efficiency of the cathodes is maintained more constant while the leakage resistance along the glass wall of the vessel is greatly improved due to the absence of conductive material thereon.

The same effect can be accomplished by a construction as shown in Fig. 5 in which a metallic loop 42 may surround the multiple cathodes in the same position as the parallel rods and this loop may be supported on the insulating block by a yoke member 43 which has short leg portions extending through the block and a long link portion extending across the opposite side of the block, the central portion thereof being welded or attached to an anchor post 44 secured to the block in offset position with respect to the linear alignment of the cathode supporting apertures, for instance, the post 44 may replace one of the stub wires 39, as shown in Fig. 1. If desired, the link portion of the yoke 43 may be utilized as one of the bus wires for the cathodes and heaters situated below the lower insulating block 24. The closed loop guard member 42 may be modified, as shown in Fig. 6, by removing a central portion of each long dimension to provide a pair of opposed U-shaped portions 45 which present a discontinuous structure not affected by high frequency induction heating which is usually employed during the manufacturing process of the device, to remove occluded gases from the electrodes to attain a high vacuum condition in the device.

While the invention has been disclosed with respect to various constructions to accomplish the purposes of this invention it is, of course, understood that various modifications may be made in the form and support of the guard elements in the unit without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including a cathode and an anode, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, and metallic guard elements supported adjacent said cathode at opposite ends thereof to neutralize the high potential gradient between said anode and cathode at the points of support of said cathode on said insulating members.

2. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including an electron emissive cathode and an anode, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, and metallic means mounted near and connected to said cathode at opposite ends of said anode adjacent said insulating mem-

bers to inhibit diffusion of material from said cathode to the wall of said vessel.

3. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including a cathode and an anode, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, and metallic rods mounted in parallel relation on opposite sides and ends of said cathode adjacent the ends of said anode and supported on said insulating members.

4. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including a cathode and an anode, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, and metallic rods extending across said insulating members parallel to the ends of said anode, said rods having the end portions bent towards said members to prevent reciprocal movement.

5. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including a cathode and an anode, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, metallic rods extending across said insulating members parallel to the ends of said anode, and posts extending through said insulating members centrally supporting said rods in position close to the surface of said members facing said electrodes.

6. An electron discharge device comprising an enclosing vessel, an electrode mount supported therein including an emissive cathode and an anode surrounding the cathode, spacing insulators supporting said cathode and anode at opposite ends, and metallic wire members disposed in parallel relation intermediate the ends of the electrodes and between said insulators, to inhibit sputtering of material from said cathode and deposition on the wall of said vessel, said members removing the high potential gradient from the contact points of said cathode and said insulators.

7. The method of protecting a cathode of a high voltage rectifying device against high potential gradient effects which cause sputtering of active cathode material therefrom and deposition on the wall of said device which comprises mounting said cathode in relation to an anode by insulating spacer members at opposite ends, and positioning metallic shielding rods adjacent the ends of said cathode for neutralizing the peak voltage gradient at the points of contact of said cathode with said members to redistribute and dissipate the high frequency heating field in the vicinity of the cathode surface.

8. The method of protecting an emissive cathode of a high voltage electron discharge device against high potential gradient effects which cause sputtering of material therefrom and deposition on the wall of said device which comprises mounting said cathode in relation to an anode by insulating spacer members at opposite ends, and mounting counterpoise elements at the extremities of said cathode in shielding relation to

the portion thereof exposed to said anode across said members to render impotent the effect of the potential gradient established across said members between said cathode and anode.

9. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including a plurality of cathodes in parallel relation and an anode, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, and a wire loop member surrounding said cathodes at each end intermediate said anode and said insulating members.

10. An electron discharge device comprising an enclosing vessel, an electrode assembly therein including a plurality of parallel cathodes, an anode surrounding said cathodes, insulating members at opposite ends of the electrodes and supporting them in uniform space relation, means supporting said assembly within said vessel, split loop guard members disposed about the ends of said cathodes, and a connecting yoke extending through said insulating members supporting said guard members.

11. A high voltage rectifier device comprising an evacuated vessel containing an electrode mount including a plurality of heater type parallel tubular cathodes, insulating spacer members engaging opposite ends of said cathodes, a tubular anode surrounding said cathodes, said anode having flange portions extending from the parallel sides thereof, a supporting yoke attached to one end of said vessel and extending through said spacer members and flange portions, connectors extending across one end of said mount for said heater type cathodes, conductors in the opposite end of said vessel attached to said connectors, and pairs of guard rods supported laterally between said spacer members and the ends of said anode adjacent the ends of said cathodes projecting into said spacer members.

12. A high voltage rectifier device comprising an evacuated vessel containing an electrode mount including a plurality of heater type parallel tubular cathodes, insulating spacer members engaging opposite ends of said cathodes, a tubular anode surrounding said cathodes, said anode having flange portions extending from the parallel sides thereof, a supporting yoke attached to one end of said vessel and extending through said spacer members and flange portions, connectors extending across one end of said mount for said heater type cathodes, pairs of posts anchored in said insulating spacer members on opposite sides of said cathodes, a pair of metallic rods extending crosswise along opposite sides of said cathodes at one end and attached to one pair of posts, said posts being coupled to a cathode surface, and another pair of transverse rods on opposite sides of said cathodes at the other end, said connectors and said transverse rods being carried by the other pair of posts, conductors in the opposite end of said vessel connected to said last-mentioned posts, all of said rods having the end portions turned toward the edges of said insulating spacer members to prevent swinging movement thereof.

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