Sept. 20, 1960 G. GALLET ET AL 2,953,706

ELECTRIC DISCHARGE DEVICE

Filed July 17, 1958

FIG. 1.

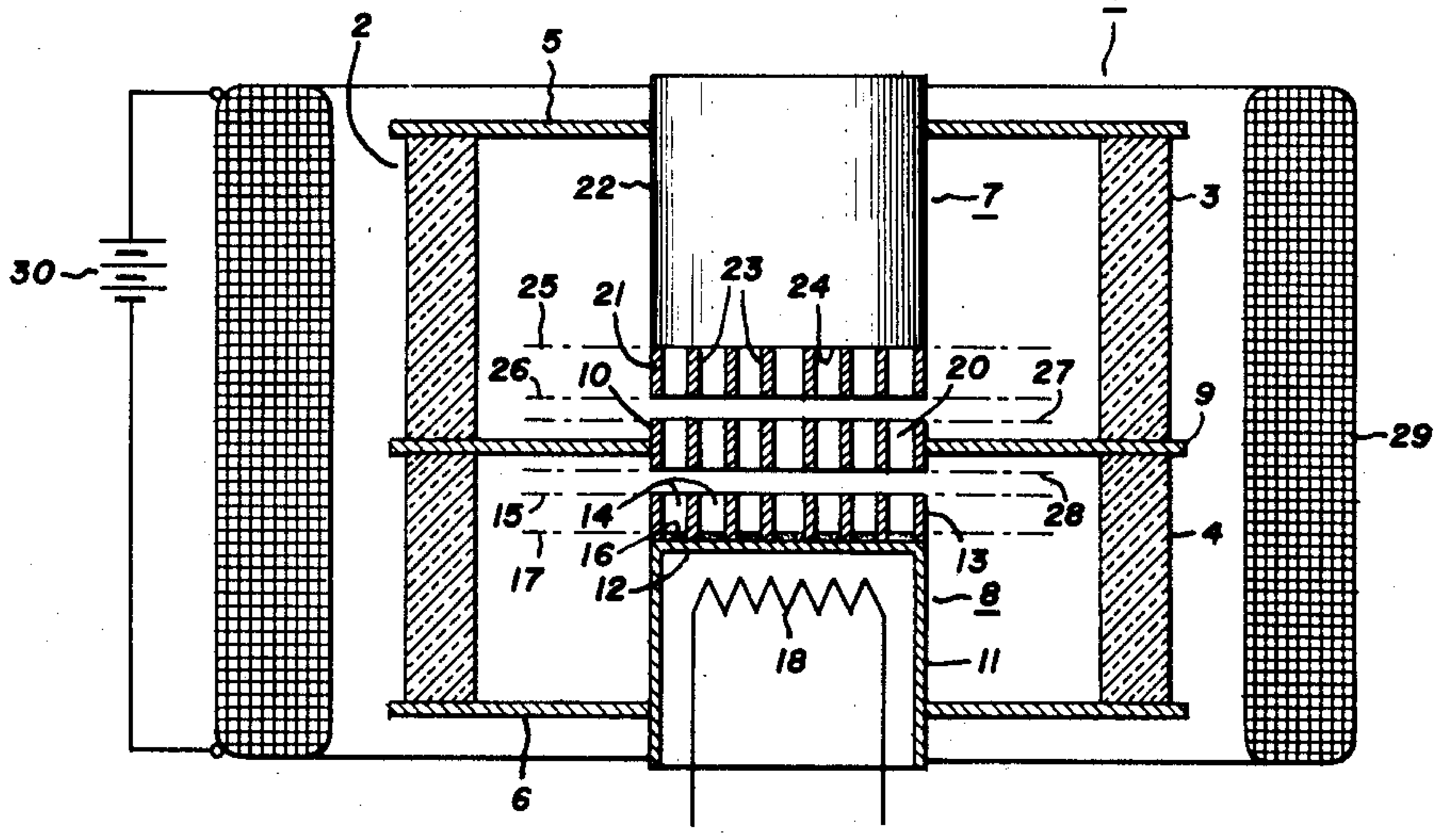


FIG. 3.

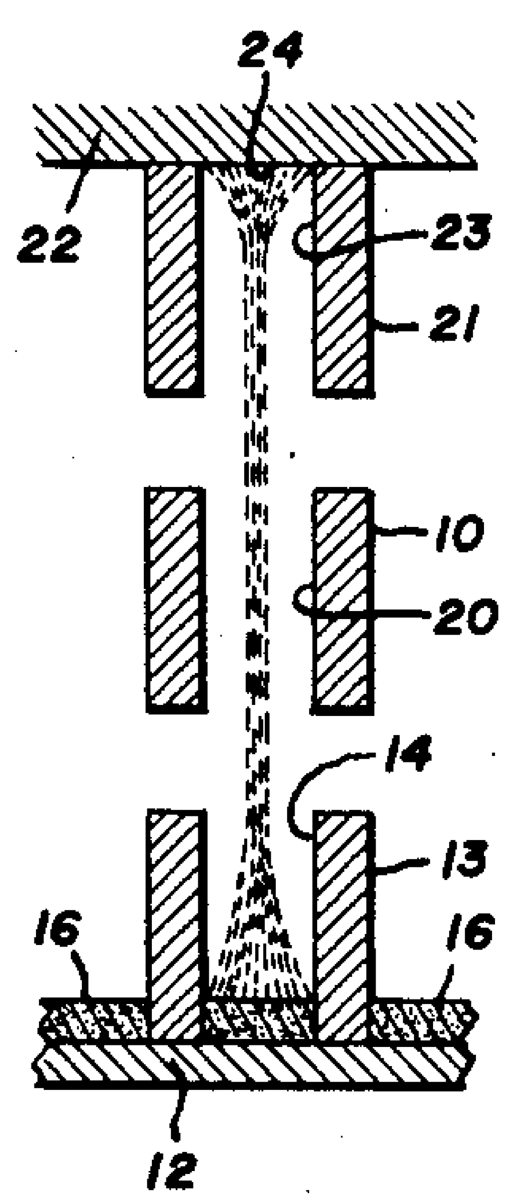
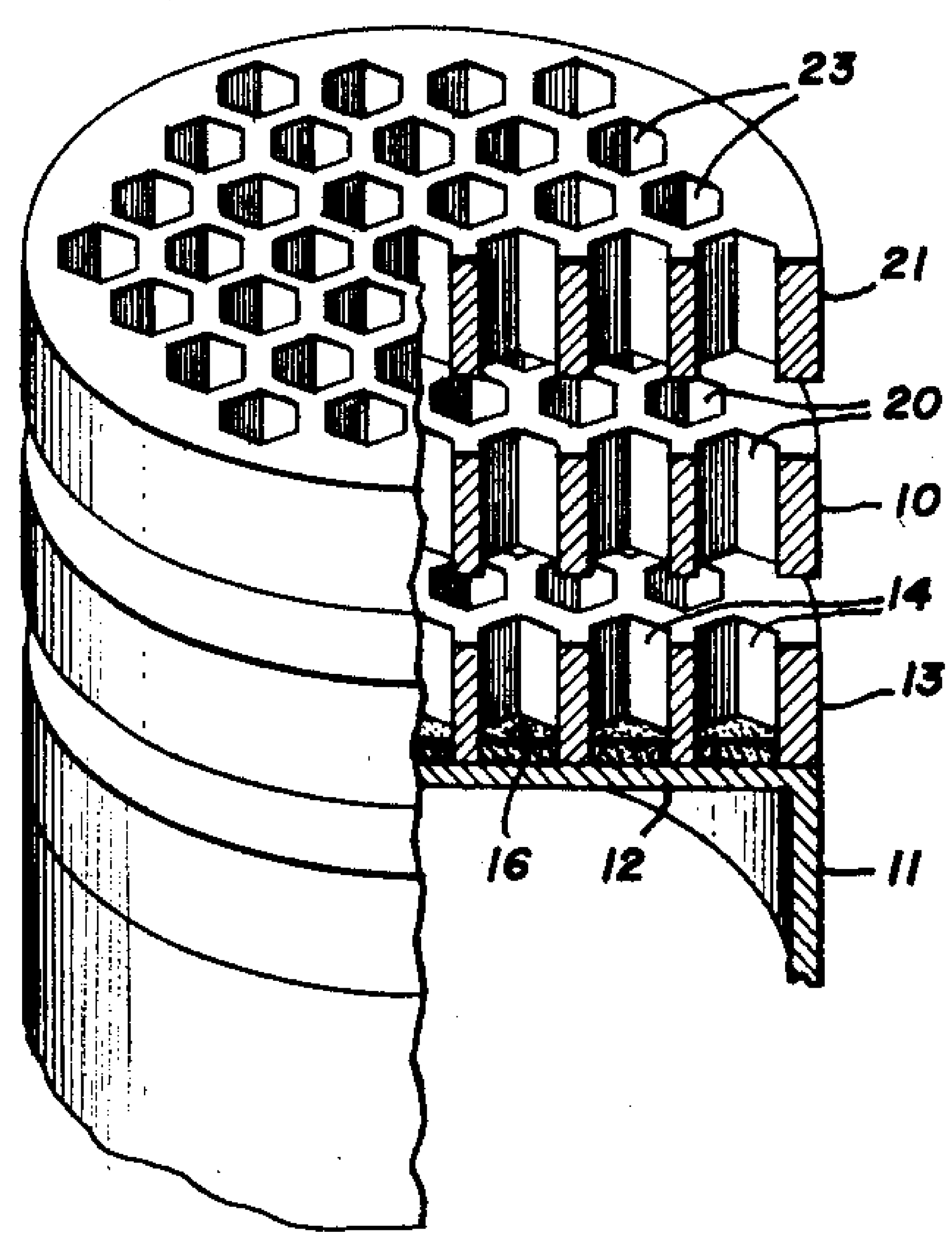


FIG. 2.



INVENTORS:
GEORGES GALLET,
JEAN EDGAR PICQUENDAR,

BY Philip L. Schlamp
THEIR ATTORNEY.

United States Patent Office

2,953,706

Patented Sept. 20, 1960

2,953,706

ELECTRIC DISCHARGE DEVICE

Georges Gallet, La Celle St-Cloud, and Jean Edgar Picquendar, Rueil Malmaison, France, assignors to Compagnie Francaise Thomson-Houston, Paris, France

Filed July 17, 1958, Ser. No. 749,294

Claims priority, application France Aug. 1, 1957

11 Claims. (Cl. 313—299)

Our invention relates to electric discharge devices and pertains more particularly to ultra-high frequency devices.

As regards ultra-high frequency electric discharge devices, very high gain and short transit time of electrons between cooperating electrodes are generally considered highly desirable. However, in order to obtain high gain and to minimize electron transit time between electrodes it is generally necessary to minimize the spacing between electrodes such, for example, as the spacing between the cathode and grid of the device. In some devices this spacing is desirably very small and such small dimensioning has led the design of extremely small tubes with planar and parallel spaced electrodes. Included in such tubes have been planar grids comprising a plurality of spaced wire elements and it has been found that these wire elements have a tendency at high temperatures to expand and undesirably contact the other electrodes. Various means have been employed for the purpose of minimizing this undesirable tendency, including, for example, the pre-stressing of the grid wires. Fabrication of such elements have proved extremely complex, difficult and costly while prevention of contact between the grid wires in other electrodes was not assured.

Additionally, it is desirable in the presently considered types of electric discharge devices to increase power efficiency by increasing the quantity of electrons which are effectively transmitted from an electron emitter past a grid to a collector or anode. Heretofore, this has been accomplished principally by controlling the size and spacing of the individual wires comprising the grid element, thus to increase the electron permeability or transparency of the grid.

Still further, in the manufacture of ultra-high frequency devices including closely spaced electrodes difficulties have been encountered in connection with the undesirable effects of emission of both primary and secondary electrons from grids and anodes.

Accordingly, the primary object of our invention is to provide a new and improved ultra-high frequency electric discharge device adapted for very high gain and short transit time of electrons between cooperating electrodes.

Another object of our invention is to provide an electric discharge device including means for maximizing the quantity of electrons transmitted through a grid electrode from an emitter or to a collector and improving the control of the device.

Another object of our invention is to provide a new and improved cathode structure adapted for serving as a planar emitter and for emitting electrons in a manner adapted for increased transmission of electrons through a grid and to a collector and so as to minimize secondary emission from the grid and collector.

Another object of our invention is to provide a new and improved anode structure adapted for serving effectively as a planar electrode and minimizing secondary emission therefrom.

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

In carrying out the objects of our invention we provide electric discharge device including an electrode assembly having a planar cathode, a planar grid, and a planar anode arranged in closely spaced parallel relationship. The cathode and anode are honeycomb-like in structure and include a plurality of longitudinally elongated cells. The grid is also honeycomb-like in structure and includes a plurality of longitudinally elongated passages. The cells in the cathode include electron emissive material only in the bottom portions thereof and the surfaces in the bottoms of the cells in the anode are coplanar and comprise the active anode surface of this electrode. The cellular structures facilitate electrostatic focusing of electrons emanating from the cathode, passing through the grid and entering the anode. Ideally the cells of the anode and cathode and the passages in the grid are axially aligned. Magnetic field means associated with the device also effects magnetic focusing of the electrons.

For a better understanding of our invention reference may be had to the accompanying drawing wherein:

Figure 1 is a schematic longitudinally sectionalized view of an electric discharge device and associated magnetic field means constructed in accordance with our invention;

Figure 2 is an enlarged fragmentary perspective view of the electrode assembly of Figure 1; and

Figure 3 is an enlarged fragmentary schematic illustration of the electron beam flow between electrodes.

Referring to the drawing, there is illustrated in Figure 1 an ultra-high frequency triode generally designated **1** and constructed in accordance with our invention. From the outset it is to be understood that while we have shown our invention as incorporated in a triode our invention is equally applicable to electric discharge devices including more than three electrodes.

The triode **1** includes a hermetically sealed envelope **2** which, for purposes of illustration, can comprise a pair of ceramic wall sections **3** and **4**. Annular metal end wall sections **5** and **6** serve to close the ends of the envelope and as mounting means and electrical contacts for a cathode and an anode assembly generally designated **7** and **8**, respectively. A third annular metal member **9** is disposed between the ceramic sections and serves to support a grid electrode **10** and for making an electrical contact therewith. The ceramic sections **3** and **4** and the metal members **5**, **6**, and **9** may be hermetically bonded by means of any number of ceramic-to-metal sealing techniques readily available in the prior art.

As also illustrated in Figure 2, the cathode assembly **8** can include a metal cup-like member **11** hermetically brazed adjacent the rim thereof to the edge of an aperture centrally located in the end member **6**. The cup-like member **11** includes a planar bottom **12** and suitably brazed thereto is a planar honeycomb-like metal member **13**, defining a plurality of longitudinally elongated cells **14**. In the embodiment illustrated, the member **13** can be advantageously formed of nickel. Also, while the member **13** is illustrated and described as "honeycomb-like," it is to be understood from the foregoing that the member **13** is cellular or is constructed to provide a plurality of individual longitudinally elongated cells and that it need not be honeycomb-like in the sense that the cells have any particular cross-sectional configuration.

Disposed in the bottoms only of each cell 14 and in spaced relation to a plane 15 defined by the outer edges

of the cell 14 is a quantity of electron emissive material 16. The electron emissive material 16 is arranged in all cells so that the outer surface thereof defines a plane 17, which plane is predeterminedly spaced inwardly of the cell edges or plane 15 and is arranged parallel to the plane 15.

Disposed in the cathode member 11 and illustrated schematically in Figure 1 is a filamentary heater 18. When the heater 18 is energized as by the conduction therethrough of a suffcient current, the bottom 12 of the cup-like member 11 becomes heated which, in turn, heats the material 16 to emissivity.

The electrons emanate from the cathode in a plurality of individual bundles or beams, as shown in Figure 3. This emanation of individual electron beams is the result of the separation of the emissive areas by the cellular or honeycomb-like construction of the member 13 and an electrostatic focusing effect of the metal portions of the cell walls between the planes 15 and 17. In a manner which will be described in greater detail hereinafter this focusing effect increases the transparency or electron permeability of the grid element 10 and minimizes secondary emission from the grid element and the electrode assembly 7. Additionally, since it minimizes electron impingement upon the edges and side walls of the passages of the grid 10, it minimizes undesirable heating thereof which, in turn, minimizes the cooling required and minimizes the emission of primary electrons therefrom.

Further, the honeycomb-like construction of the member 13 rigidizes it such that the member 13 will not be subject to any appreciable thermal distortion even under extremely high filament temperatures. This enables the member 13 to be disposed extremely close to another element without danger of contact thereof with such other element.

Cooperating with the cathode is the above-mentioned grid element 10. The grid element 10 comprises a honeycomb-like member also and is of sufficient thickness that individual passages or openings 20 defined thereby are longitudinally elongated in relation with the widths of the cells. The passages 20 of the grid 10 also need not have any particular cross-sectional configuration. The grid can be copper and can be advantageously formed by compressing a bundle of copper coated aluminum wires until the copper coatings of adjacent wires become fused together, then slicing a disk of the proper thickness from the bundle and thereafter dissolving the aluminum from the disk with an appropriate agent so as to leave only the honeycomb-like copper grid. The passages 20 preferably correspond in number to the cells 14 in the cathode and ideally are axially aligned therewith. The honeycomb-like construction of the grid rigidizes it also, and adapts it for being extremely closely spaced to another electrode, such as the cathode, without danger of contact therebetween due to thermal distortion. Thus, the opposing surfaces of the grid and other electrode on either side can be disposed extremely close and maintained substantially parallel and separated at substantially high operating temperatures. This enables a substantial reduction of the transit time of electrons between electrodes without danger of undesirable contacting between electrodes.

Additionally, the electron passages 20 of the grid 10 adapt it for electrostatically focusing the bundles or beams of electrons emanating from the cathode. This focusing is also illustrated in Figure 2. The axial alignment of the cells 14 of the cathode and the passages 20 of the grid and the mentioned electrostatic focusing effect by these elements on electrons passing therethrough adapt the assembly for greater grid transparency or electron permeability since substantially all the electrons emanating from the cathode will pass through the passages 20 of the grid without any substantial interception of electrons by the grid, even when the latter is positive. With this type of arrangement we have been able to obtain extremely high grid transparencies such, for example as 95% transparency. This increases the gain capabilities of the device and minimizes heating of the grid and both primary and secondary emission due to electron impingement on the grid.

Included in the device on the side opposite the grid is a planar anode member 21 which is suitably brazed to the inner end of an anode block 22 included in the assembly 7 and brazed adjacent its outer end in an aperture in the member 5. The anode member 21 is also honeycomb-like in construction for defining a plurality of individual cells 23. As regards the anode member 21 the cells need only be longitudinally elongated and need not have any particular cross-sectional configuration. Ideally the cells 23 correspond in number with the cells and passages of the cathode and grid, respectively, and are axially aligned therewith. The active anode surfaces of the anode comprise the bottoms 24 of the individual cells 23. These bottoms or active anode surfaces are coplanar in a plane indicated by 25 and are predeterminedly spaced from the outer edge of the cells or a plane indicated by the line 26 defined by the outer side of the anode member 21. Additionally, the plane 25 and, therefore, the active anode surfaces 24, are predeterminedly closely spaced from and in parallel relation with planes 27 and 28 defined by the corresponding sides of the grid 10.

The anode member 21 is dimensioned such that the cells 23 are longer than the transverse dimension or diameter of the areas 24. Thus, the walls of the cells 23 have an electron focusing effect on the individual bundles or beams of electrons received therein from the cathode and through the grid, as also seen in Figure 3. Additionally, this relatively deep disposition of the active anode areas 24 effect entrapment of secondary electrons tending to leave the anode. Further, the focusing effect of the elementary electrons by the grid just before the anode and by the portion of the anode cell walls between the planes 25 and 26 have the desirable effect of minimizing electron impingement on the walls of the cells including the edges of the cells in the plane 26. This has the resultant desired effect of minimizing secondary emission and avoiding secondary emission in a region, such as between the planes 26 and 27 or adjacent the grid 10. Thus, it will be seen from the foregoing that our present construction enables extremely close spacing between the grid and anode because of the relative remote spacing of the active anode surfaces 24 from the grid and the cellular or honeycomb-like construction of the grid and anode which minimizes any tendency toward secondary emission from the anode toward the interelectrode spacing between the grid and anode.

We have found it possible to construct electric discharge devices with extremely close interelectrode spacings of orders not obtainable with prior art teachings. Additionally, we have found it possible to operate a device constructed according to our invention with a positive grid which enables the achievement of extremely short cathode-to-grid transit times of the electrons and which, in turn, lead to extremely high frequency for a given grid-to-cathode spacing.

We have also found it possible to increase the operating efficiency of the above-described device by placing it in a magnetic field with the field aligned axially with the cells and passages of the electrodes. This can be accomplished, for example, by disposing the device longitudinally in a magnetic coil of the type schematically illustrated in Figure 1. When the coil 29 is energized as by means of a suitable source 30, the resultant magnetic field has the desirable effect of increasing the focusing of the individual electron beams emanating from the cathode cells 14, thus to facilitate passage through the grid and into the cells 23 of the anode for being collected by the active anode surfaces 24 with minimal electron impingement on the walls of the grid passages 20 and the anode cells 23.

In the foregoing, we have stated that ideally the cells of the grid and cathode and the passages of the grid correspond in number and are axially aligned. It is to be understood that for some purposes correspondence in number and axial alignment will not be necessary for satisfactory operation.

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

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

1. An electrode structure comprising a planar cellular metal member defining a plurality of parallel individual cells, the bottom surfaces of said cells being coplanar and constituting the active electrode surfaces of said structure, and said cells being longitudinally elongated in a direction perpendicular to said bottom cells and having a longitudinal dimension greater than the transverse dimensions thereof.

2. An electrode structure according to claim 1, wherein magnetic means define a magnetic field extending longitudinally through said individual cells and substantially perpendicular to each said bottom surfaces of said cells.

3. An electrode assembly comprising a first electrode including a planar cellular member comprising a plurality of parallel individual cells, the bottom surfaces of said cells being coplanar and constituting the active electrode surfaces of said structure, said cells being longitudinally elongated in a direction perpendicular to said bottom surfaces and having a longitudinal dimension greater than the transverse dimensions of said cells, a planar hollow cellular second electrode defining a plurality of electron passages longitudinally elongated in a direction perpendicular to the plane of said second electrode, and said first and second electrodes being in closely spaced parallel relation.

4. An electrode assembly according to claim 3, wherein magnetic means define a magnetic field extending longitudinally through said individual cells and substantially perpendicular to the plane of said first and second electrodes.

5. An electrode assembly comprising a planar grid, and a planar honeycomb-like anode, said anode including a plurality of longitudinally elongated individual cells, said cells having bottom surfaces constituting the active surfaces of said anode, said cells having a depth dimension greater than the transverse dimension of said bottom surfaces thereof, and said active anode surfaces being in coplanar and closely spaced relation to said grid.

6. An anode structure comprising a planar honeycomb-like metal member defining a plurality of individual cells longitudinally elongated in a direction perpendicular to the plane of said structure, each of said cells having a closed bottom, the closed bottoms of said cells constituting the active surfaces of said anode, and said active surfaces each being smaller in diameter than the depth dimension of said cells, whereby secondary electrons are entrapped in said cells and interception of electrons by the walls of said cells is minimized by an electrostatic focusing effect of the longitudinally elongated walls of said cells.

7. An anode structure comprising a planar honeycomb-like metal member defining a plurality of individual cells longitudinally elongated in a direction perpendicular to the plane of said structure, the bottom surfaces of said cells constituting active anode surfaces, said active anode surfaces being smaller in diameter than the depth dimension of said cells, whereby secondary electrons are entrapped in said cells and interception of electrons by the walls of said cells is minimized by an electrostatic focusing effect of said walls, and means effecting a magnetic field extending substantially perpendicular to said bottom surfaces of said cells for assisting in focusing said electrons.

8. An electrode assembly comprising a planar honeycomb-like grid including a plurality of longitudinally elongated passages, a planar honeycomb-like anode including a plurality of longitudinally elongated individual cells corresponding to and axially aligned with said individual passages of said grid, said cells of said anode having bottom surfaces comprising the active anode surfaces, and said active anode surfaces being coplanar and closely spaced relative to said grid.

9. A high frequency electric discharge device comprising an envelope, a plurality of mutually insulated electrode elements contained in said envelope, said electrode elements including a cathode comprising a planar cellular metal member defining a plurality of longitudinally elongated individual cells, and electron emissive material on only the bottom surfaces of said cells and spaced inwardly from the edges thereof, whereby the walls of said cells are adapted for electrostatically focusing electrons emanating from said electron emissive material, a planar hollow cellular grid in closely spaced parallel relation with said cathode, said grid defining a plurality of longitudinally elongated electron passages, and a planar cellular anode in closely spaced and parallel relation to said grid defining a plurality of individual longitudinally elongated cells, said cells of said anode having coplanar bottoms comprising the active anode surfaces and being smaller in diameter than the depth dimension of said cells, whereby secondary electrons are entrapped in said anode and collection of electrons on the walls of said anode cells is minimized by electrostatic focusing.

10. A high frequency electric discharge device comprising an envelope, a plurality of mutually insulated electrode elements contained in said envelope, said electrode elements including a cathode comprising a planar honeycomb-like metal member defining a plurality of mutually parallel longitudinally elongated individual cells extending substantially perpendicular to the plane of said metal member, and electron emissive material in only the bottoms of said cells and spaced inwardly from the edges thereof, whereby the walls of said cells are adapted for electrostatically focusing electrons emanating from said electron emissive material, a planar honeycomb-like grid in closely spaced parallel relation with said honeycomb-like member of said cathode, said grid defining a plurality of longitudinally elongated electron passages extending perpendicular to the plane of said grid and corresponding to and axially aligned with said cells of said cathode, and a planar honeycomb-like anode in closely spaced and parallel relation to said grid defining a plurality of individual mutually parallel longitudinally elongated cells extending perpendicular to the plane of said anode and corresponding to and axially aligned with said passages in said grid, said cells of said anode having coplanar bottoms comprising the active anode surfaces and being smaller in diameter than the depth dimension of said cells, whereby secondary electrons are entrapped in said anode and collection of electrons on the walls of said anode cells in minimized by electrostatic focusing.

11. High frequency apparatus including an electric discharge device constructed according to claim 9 and magnetic means establishing a magnetic field extending longitudinally through said cells and passages of said electrode elements and substantially perpendicular to said bottoms of said cathode and anode cells for magnetically focusing electrons emanating from said cells of said cathode and extending through said passages of said grid into said cells of said anode.

(References on following page)

References Cited in the file of this patent

UNITED STATES PATENTS

2,018,362	Herold	Oct. 22, 1935
2,058,878	Holst	Oct. 27, 1936
2,358,542	Thompson	Sept. 19, 1944
2,410,054	Fremlin	Oct. 29, 1946
2,636,142	Garner	Apr. 21, 1953
2,748,307	Hickey	May 29, 1956

FOREIGN PATENTS

49,790	Netherlands	Jan. 15, 1941
952,893	France	May 9, 1949
995,370	France	Aug. 14, 1951