DISCHARGE DEVICE HAVING ELECTRON GRIDS WITH HEIGHTS RISING SUBSTANTIALLY ABOVE THE GRID SUPPORT RIMS

Original Filed Aug. 11, 1960

FIG. 1

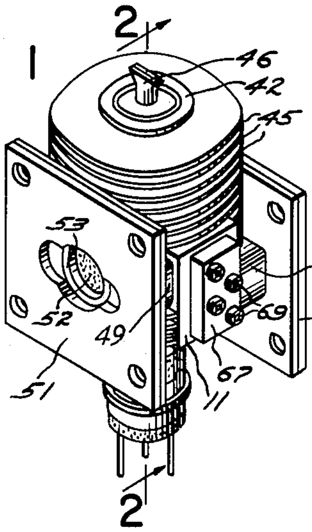


FIG. 2

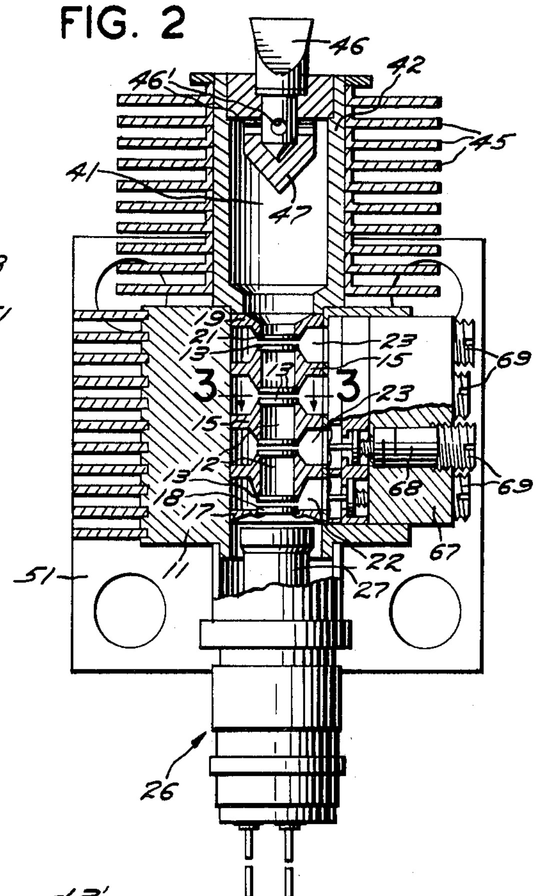
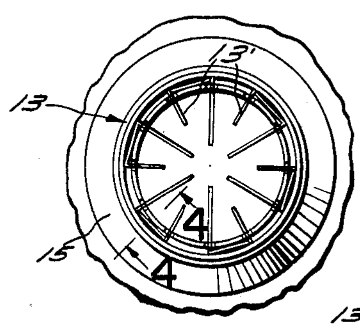


FIG. 3



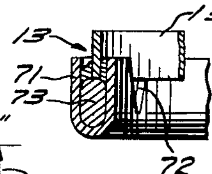
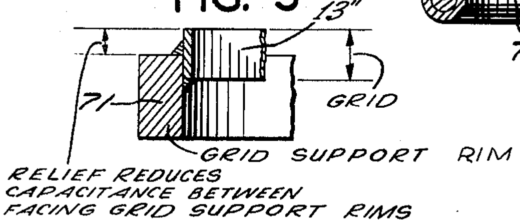


FIG. 4

FIG. 5



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DISCHARGE DEVICE HAVING ELECTRON GRIDS WITH HEIGHTS RISING SUBSTANTIALLY ABOVE THE GRID SUPPORT RIMS

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Original application Aug. 11, 1960, Ser. No. 48,889, now Patent No. 3,104,341, dated Sept. 17, 1963. Divided and this application June 10, 1963, Ser. No. 286,823

5 Claims. (Cl. 315—5.37)

The present application is a division of application of U.S. Serial No. 48,889, now Patent No. 3,104,341 titled "Electron Discharge Device," inventors Adolph J. Fiedor et. al., filed August 11, 1960, and assigned to the same assignee as the present invention.

This invention relates in general to high frequency emissive devices and more particularly to a novel improved electron tube.

The present invention is embodied for the purposes of disclosure in a Ku-band klystron amplifier which, because it is electrostatically focused, and thereby requires no magnet, weighs only about eight ounces and is well suited for aerial navigation systems in which weight is a prime factor. One such tube has been built with four tunable resonator cavities spaced along the electron beam having a C.W. power output from 1–25 watts with a gain of approximately 30 decibels.

In order to produce a tube of such small size with sufficient gain and output power it was necessary to improve the resonator grid structure to obtain enhanced cavity resonator characteristics.

It is, therefore, the main object of the present invention to provide a small, rugged, high power and gain klystron incorporating novel cavity resonator grid structure.

One feature of the present invention is a novel grid design which reduces grid capacitance for the same gap length and thus permits an increase in the cavity diameter to obtain more inductance and thereby increase R_{sh}/Q and Q.

Other features and advantages of the present invention will be more apparent upon a perusal of the following specification taken in connection with the accompanying drawing wherein:

FIG. 1 is an isometric view of a klystron tube made in accordance with the present invention,

FIG. 2 is an enlarged cross-section taken along line 2—2 in FIG. 1,

FIG. 3 is an enlarged view of a novel raised grid taken along line 3—3 in FIG. 2 in the direction of the arrows,

FIG. 4 is an enlarged cross-section of the novel raised grid taken along line 4—4 of FIG. 3 in the direction of the arrows, and

FIG. 5 is an enlarged partial cross-section view showing another embodiment of the novel raised grid.

Referring now to FIGS. 1 and 2, the klystron made in accordance with the present invention includes a central body portion **11** which is made from a unitary block of metal having a longitudinal bore extending therethrough. Hollow cylindrical drift tubes **12**, having circular resonator grids **13** on the ends thereof, are positioned within the longitudinal bore of central body portion **11** by outwardly extending annular headers **15**. The walls of drift tubes **12** are parallel to the axis of the electron beam passing therethrough. Fixedly secured as by brazing in one end of the longitudinal bore of the central body portion **11**, is a narrow, annular anode structure **17**, having a resonator grid **18** positioned in the aperture therethrough. Within the other end of central body portion **11** is an annular header **19** with a resonator grid **21** positioned in the aperture therethrough. By positioning the resonator grid **18** within the anode structure **17** the resonator grid **18** serves as an anode portion thereby minimizing the distance a focused electron beam must traverse through the klystron tube.

Within the central body portion **11**, annular anode structure **17** and first annular header **15** on the first drift tube **12** define a single re-entrant first cavity resonator **22**. Three doubly re-entrant cavity resonators **23** are defined by the annular headers **15** and annular header **19**.

Fixedly secured, as by brazing, to the central body portion **11** and sealing off the end thereof adjacent to the anode structure **17** is a beam generating assembly **26** including hollow cylindrical focus electrode **27**.

The beam collector assembly **41** includes a hollow cylindrical end portion **42** closed at its outward end and fixedly secured to the end of central body portion **11** adjacent the annular header **19** by a braze therebetween. Beam collector assembly **41** also includes a fin assembly comprising annular fin members **45** brazed to the cylindrical end portion **42** whereby the tube is air cooled. It is noted that central body portion **11** is provided with a fin assembly to further aid in air cooling the entire device thereby removing the necessity of an internal liquid cooling system. An evacuation pinch-off tube **46** is provided in the closed end portion **42** with four entrants **46'** into the collector cavity for pumping the tube. It is further noted that a conical member **47** is provided at the closed end of beam collector assembly **41** to diffuse the electron beam striking the end of beam collector assembly **41** thereby reducing the possibility of secondary electrons released by impinging primary electrons from entering into the drift tube and cavity section of central body portion **11**.

Identical input and output waveguides **48** and **49** respectively are secured to the central body portion **11** and respectively communicate with the first cavity resonator **22** and the third double re-entrant cavity resonator **23** through milled openings, not shown, within central body portion **11**. The outwardly projecting end of each waveguide is provided with a waveguide flange member **51** which carries a ceramic window **52** sealed therein by a window frame **53**.

Referring now to FIGS. 3 and 4 there is shown a novel grid support structure **70** for mounting the resonator grids **13**, **18** and **21** wherein the grid elements or vanes on opposing drift tube ends are held a certain distance apart while the rim members **71** in which the grid vanes **13'** are mounted are set back thus effecting a greater spatial distance between opposed rim members **71**. The rim members **71** for supporting the grid members **13** consist of steel or nickel bent as to have a U-shaped cross-section with an inner wall, an outer wall and a lower connecting wall formed in a ring. In the present invention a circular ring **73** made of, for example, nickel plated copper wire is positioned in the bottom of the U-shaped channel of rim **71** and brazed therein. In this manner the grid vanes **13'** are mounted within the U-shaped channel of rim member **71** and extend through a plurality of equally spaced openings or slits **72** on the inner side of end cap rim member **71**. The gridded vanes **13'** are now raised or projected upward from the top surface of rim **71** due to circular ring **73**. In this manner the rim **71** when mounted on the end of drift tube **12** will be spaced farther apart from the opposite rim on the opposing drift tube while the spatial relationship between opposing vanes **13'** will be less.

It is noted that the type of member supporting the grid members would be a matter of choice. For example, in FIG. 5 a solid ring end cap member **71'** supports the grid member 13'' as by welding, the important feature being the grids raised above the rim.

An arrangement such as this has a considerable advantage. In the prior series of tubes the gap spacing between both the rims and the grid vanes has been 0.015 inch. In the present invention the gap spacing between grid vanes is the same, 0.015 inch, while the spacing between the rims has been increased to 0.035 inch. The result of this arrangement is that the capacitance between opposing rims is reduced greater than ½. Now, as the capacitance has been reduced, in order to maintain a constant frequency and at a fixed gap spacing it is necessary to increase the inductance within the cavity. This is accomplished by increasing the dimensions of the cavity which will increase the R_{sh}/Q and Q of each of the cavities resulting in a better overall Q for the entire tube output.

It is herein noted that there are several different configurations of grid vanes 13 available which may be substituted for those shown. Reference is made to U.S. Patent 2,738,438 issued to G. S. Shepherd on March 13, 1956, for several other types of grid configurations available depending upon the beam interception desired.

What has been shown is a new klystron amplifier having no increase in weight or size over the previous light weight C.W. medium power level tubes yet an increase in gain has been accomplished due to increasing beam bunching by increasing the number of cavities within the tube structure. Further better power and gain have been accomplished through the use of a new grid structure.

It is here noted that the novel raised grid structure may be equally well adapted and used in other types of klystrons.

Since many changes could be made in the above construction, and many apparently widely different embodiments of this invention could be made without departing from the scope thereof it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A high frequency electron tube apparatus including, means for forming and projecting a beam of electrons over an elongated beam path, means arranged along the beam path in energy exchanging relationship therewith, said energy exchanging means including an electron permeable metallic grid structure, said grid structure including a plurality of metallic vanes projecting into said beam path, said vanes being of sheet-like geometry, a supporting rim structure surrounding the beam path for directly supporting said vanes directly connected thereto and with said vanes projecting into the beam from said support rim structure, and said vanes having a height where affixed to said support rim structure substantially rising above said support rim structure in an axial direction to decrease the stray capacity of said support rim structure.

2. A high frequency electron tube apparatus including, means for forming and projecting a beam of electrons over an elongated beam path, means arranged along the beam path in energy exchanging relationship therewith, said energy exchanging means including an electron permeable metallic grid structure, said grid structure including a plurality of metallic vanes projecting into said beam path, said vanes being of sheet-like geometry, a plurality of said vanes having an elongated main body portion projecting into the beam and a shorter base support portion turned at a substantial angle to the main body portion for supporting said vanes in position, a support ring surrounding said beam path and directly carrying said vanes from said base portions with said main body portions of said

vanes projecting radially inwardly of said beam path, said vanes terminating internally of the beam path, and said base portions of said vanes having a preponderance of their height rising above said support ring in an axial direction to reduce the stray capacity of said vane support ring.

3. High frequency electron tube apparatus including, means for forming and projecting a beam of electrons over an elongated beam path, a cavity resonator arranged along the beam path in energy exchanging relationship with the beam, said cavity resonator having a pair of mutually opposed electron permeable wall portions for passage of the electron beam through said cavity resonator, said electron permeable wall portions of said cavity resonator including a pair of mutually opposed grid structures, said grid structures including a plurality of metallic vanes projecting into said beam path, said vanes being of sheet-like geometry with a maximum height taken in the direction of the beam path of at least five times their thickness and disposed with the plane of said sheet vanes being substantially parallel to the direction of the beam path, a support ring surrounding said beam path and said vanes for supporting said vanes directly and carrying said vanes such as to project radially inwardly of said beam path and said supporting ring, said vanes terminating internally of the beam path and said vanes having an axial preponderance of their maximum height rising above said support ring taken in a direction toward the opposing grid structure to reduce the stray capacity of said support ring.

4. The apparatus according to claim 3 wherein a plurality of said vanes have an elongated main body portion projecting into the beam and a shorter base support portion turned at a substantial angle to the main body portion for supporting said vane in position from said support ring.

5. A high frequency tube apparatus including, means for forming and projecting a beam of electrons over an elongated beam path, a cavity resonator positioned along the beam path for interaction with the beam passable therethrough, said cavity resonator having a pair of electron permeable wall portions axially spaced apart in the direction of the beam path for passage of the beam through said resonator, said pair of electron permeable wall portions being defined by a pair of metallic grid structures, each of said grid structures including a plurality of sheet-like vanes having central body portions projecting inwardly of the beam path from a support ring structure which surrounds root end portions of said vanes and directly supports said vanes, and said inwardly projecting central body portions of said vanes being mounted in a raised fashion in the axial direction from said surrounding support ring structure such that the axial spacing in the direction of the beam path between opposed central body portions of said grid structures is substantially less than the axial spacing between opposed surrounding support ring structures in order to reduce stray capacity of said support ring structures.

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