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ELECTRON TUBE

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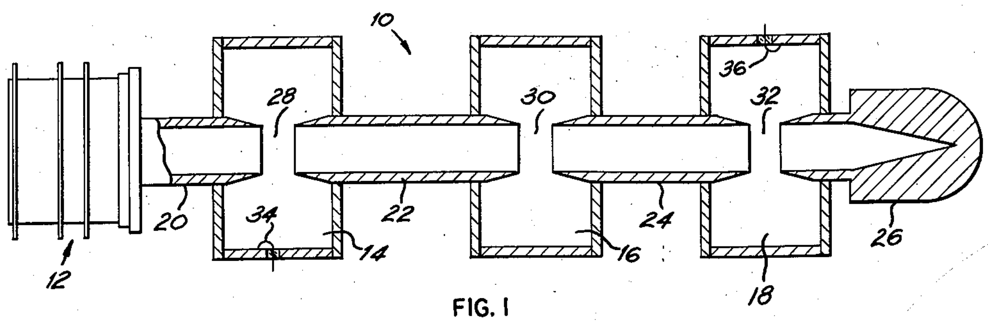

FIG. 1

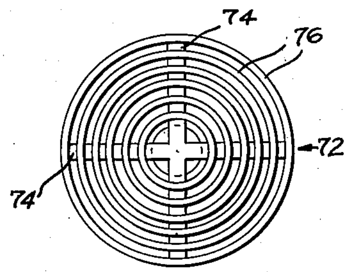

FIG. 3

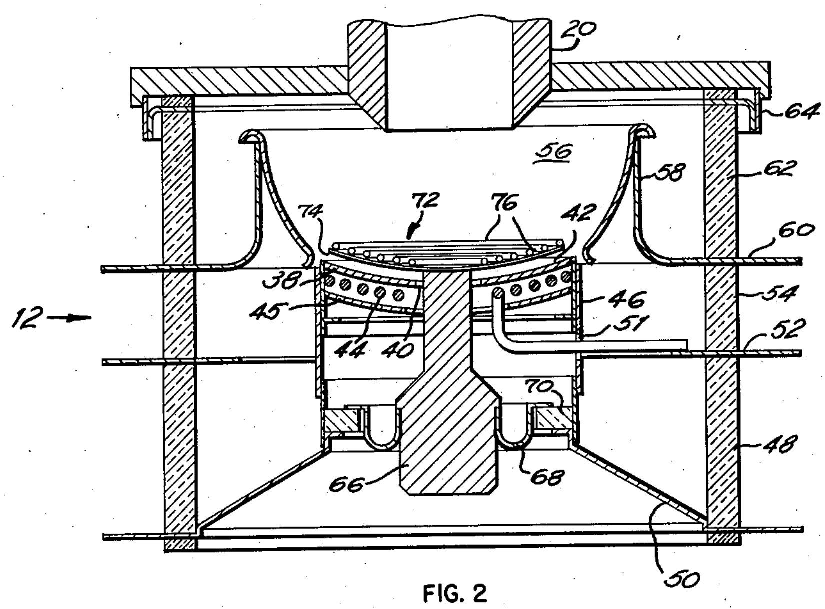

FIG. 2

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ELECTRON TUBE

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This invention relates to electron tubes and particularly to electron tubes of the type referred to as beam tubes.

There are many applications in the electronic industry for electron tubes capable of generating a dense elongated beam of electrons. Such tubes (e.g. klystrons, traveling wave tubes, kinescopes, etc.) usually comprise an elongated envelope containing an electron gun for generating the beam of electrons, means for utilizing the electron beam, and an electrode for collecting the electrons of the beam after the beam has served its purpose.

The electron gun which generates the beam of electrons comprises a cathode and means for focusing the electrons emitted by such cathode into a beam. For certain applications it is desirable to vary the density of the electrons in the beam.

It is an object of this invention to provide an improved electron gun capable of density modulating a focused electron beam.

It is a further object of this invention to provide an improved electron gun structure for an electron tube which comprises a control grid adjacent the cathode thereof without reducing the effectiveness of the focusing means associated with such cathode.

According to the prior art, control grids have been used in beam tubes which grids are supported on leads extending through the side of the envelope. However, all of such structures are characterized by high capacitance since they involve large opposed areas, particularly where annular terminals and supports are used.

Therefore, it is another object of this invention to provide an improved means of density modulating an electron beam which means involves reduced capacitance.

The passage of the electrons in the beam within and along the envelope will tend to ionize any gases which may be present therein and since it is a practical impossibility to remove all gases from within the tube, even through the use of the best possible evacuating methods, there will always be some ions present. Such ions are positively charged and will usually be found at the center of the electron beam. Due to their positive charge the ions will tend to proceed toward the cathode and will bombard the central portion of the surface of the cathode tending to produce uneven heating thereof and to destroy the electron emissive surface thereon. Such uneven heating and destruction will result in unreliable emission of electrons from the central portion of the cathode. Thus the central portion of the cathode is comparatively useless.

Therefore, a still further object of this invention is to provide a grid supporting arrangement for an electron gun which takes advantage of the fact that the center of the cathode thereof is relatively useless and which simultaneously eliminates the possibility of unreliable cathode operation due to the ion bombardment of such central portion of the cathode.

It is yet another object of this invention to provide an improved electron tube capable of generating and controlling a beam of electrons.

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Briefly, an electron tube according to this invention comprises an envelope containing an electron gun, which gun comprises a cathode disk having an aperture through the center thereof, a control grid support rod extending through the aperture in the cathode disk, a control electrode mounted on the end of the support rod and comprising a foraminous or apertured disk co-extensive with the surface of said cathode, and a focusing means adjacent the cathode and grid for forming the electrons emitted by the cathode into a beam.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of the invention. It is to be understood that the invention is not limited to the disclosed species, as variant embodiments thereof are contemplated and may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 is a view partially in elevation and partially in cross-section of a klystron type of electron tube embodying this invention.

Figure 2 is an enlarged cross-sectional view of the electron gun used in the klystron of Figure 1; and

Figure 3 is an end view of the grid shown in Figure 2.

Referring to Figure 1, one type of electron tube to which this invention is applicable is a klystron **10** which comprises an electron gun **12**, a plurality of resonant cavities **14**, **16**, and **18** connected by drift tube sections **20**, **22**, and **24** and a collector electrode **26**. The drift tube sections **20**, **22**, and **24** are separated by interaction gaps **28**, **30**, and **32** within each of the resonant cavities **14**, **16**, and **18**. The electron gun **12** produces a focused beam of electrons which is directed axially through the drift tube sections **20**, **22**, and **24** toward the collector electrode **26**. The electron flow is accomplished by maintaining the drift tube sections and the collector electrode at a positive electrical potential with respect to the cathode of the gun **12** whereby the negative electrons of the beam are attracted along the drift tube to the collector where their energy is dissipated in the form of heat.

The cavity **14** nearest the gun **12** may be excited with radio frequency energy of a desired frequency by means of a loop type induction input means **34**, for example. Such excitation of the cavity **14** produces voltage variations which appear across the interaction gap **28** associated therewith. The voltage variations at the interaction gap **28** will modulate the velocity of the electrons in the beam as they cross the gap, as is well known in the klystron art. The velocity modulation of the electrons of the beam tends to cause bunching of the electrons in the beam, which bunching excites the second cavity **16** as the bunched electrons cross the gap **30** between the drift tube sections at such second cavity **16**. The excitation of the second cavity **16** in turn produces additional velocity modulation of electrons in the beam, which additional velocity modulation produces still further bunching of the electrons in the beam. As the bunched electrons cross the gap **32** between the last drift tube section **24** and the collector **26** at the final or output cavity **18** such output cavity is excited and radio frequency energy is extracted from the output cavity by means of another induction loop **36**, for example.

According to this invention the output of the klystron is modulated through the use of a control grid incorporated into the electron gun. Such control grid is used to vary the density of the electrons in the beam which proceeds along the klystron. It will be seen that the radio frequency signal induced in the output cavity **18** will vary in direct relation to the density of the beam.

Referring to Figure 2, an electron gun **12** constructed according to this invention comprises a concave or dished cathode disk **38** having an aperture **40** through the center thereof. The concave surface 42 of the cathode disk 38 is coated with an electron emissive material and is presented toward the collector electrode 26. A heating element 44 in the form of a spiral of wire having a central opening is disposed adjacent to the opposite side of the cathode disk 38 from the collector electrode 26. A heat shield 45 is positioned below the heating element 44. The cathode disk 38 is supported in one end of a composite tubular metallic member 46 which extends downwardly from the cathode disk 38 and surrounds the heating element 44.

A first ceramic cylinder 48 surrounds the lower end of the tubular metallic member 46 and the lower end of the ceramic cylinder 48 is sealed to an outwardly extending flange 50 at the lower end of the tubular metallic member 46. One end of the heating element 44 is electrically connected to the tubular metallic member 46. Member 46 is of course electrically connected to flange 50 which thus serves as an electrical terminal for both the cathode and the heater. The other end of the heating element 44 extends through an opening 51 in the side wall of the tubular metallic member 46 in spaced relation to the edges thereof and is electrically connected to an annular metallic terminal member 52 which serves as the other terminal for the heating element 44. The terminal member 52 is sealed between the upper end of the first ceramic cylinder 48 and the lower end of a second ceramic cylinder 54 arranged in co-axial relation to the first ceramic cylinder.

A tubular focusing electrode 56 is arranged co-axially with the cathode disk 38, having one end surrounding the outer periphery of the cathode disk 38 and the remainder thereof extending toward the collector 26. The focusing electrode 56 is supported by a tubular metallic member 58 which surrounds the focusing electrode 56 and is mechanically and electrically connected thereto at their upper ends. An outwardly extending flange 60 on the lower end of the tubular metallic member 58 is sealed between the upper end of the second ceramic cylinder 54 and the lower end of a third ceramic cylinder 62 and extends outwardly therefrom to serve as a terminal for said focusing electrode 56. The upper end of the ceramic cylinder 62 is sealed to the end of the anodic drift tube section 20 by means of a special sealing arrangement 64 to compensate for differences in thermal coefficients of expansion between the ceramic cylinder 62 and the drift tube 20.

A control grid supporting structure is mounted within the tubular metallic member 46 and comprises a relatively heavy metal supporting rod 66. An annular metallic sealing ring 68 is sealed about the outer periphery of the supporting rod 66 adjacent the lower end thereof, enough of the supporting rod 66 projecting below the sealing ring 68 to act as an electrical terminal for the control grid. The sealing ring 68 is sealed to a ceramic insulating ring 70 which is in turn sealed about the inner surface of the tubular cathode support 46 thus completing the vacuum tight envelope.

The control grid 72 comprises a foraminous or apertured disk mounted on the end of the support rod 66 which extends through the aperture 40 in the cathode disk 38. The control grid 72 has a dished shape complementary to the dished shape of the cathode disk 38 and is co-extensive therewith. The control grid 72 may be constructed in a number of ways, one of which has been chosen for illustration and is best shown in Figure 3. The structure there shown comprises a pair of curved cross-arms 74, the intersection or cross-over point of which is mounted on the end of the support rod 66. The curve of the cross-arms match the curve of the concave emissive surface 42 of the cathode disk 38. A plurality of wire rings 76 of increasing diameter are co-axially mounted on the cross-arms 74 on the side thereof removed from the cathode disk 38. It will be seen that electrons emanating from the emissive surface 42 of the cathode disk 38 will pass through the spaces between the rings 76 of wire and will be formed into a beam by the focusing electrode 56. The number of electrons which pass through the control grid 72 will, of course, depend on the potential difference between the control grid 72 and the cathode disk 38 as is well known in the art.

It will be seen that according to this invention the controlling voltage may be applied to the control grid 72 by means of a co-axial line or cavity connected between the support rod 66 and the cathode terminal 50. This will enable the application of very high frequency voltages to the control grid 72. Furthermore, it will be seen that due to the relatively small area of the control grid support rod 66 and the large spacing between the control grid support rod 66 and the tubular cathode support 46 the capacitance of the input circuit will be very small.

The gun structure according to this invention also has an advantage with respect to the effect of reverse ion bombardment on the cathode. Since it is impossible to remove all residual gases from within the envelope of an electron tube it has been found that ions are invariably produced by the passage of the electron beam within and along the tube. Such ions have a positive charge and thus are attracted to the most negative electrode of the tube which, in the case of a klystron, is the cathode. The ions bombard the cathode tending to produce localized heating and to destroy the electron emissive surface of the cathode. Due to the focusing action of the various electrodes of a klystron these ions are focused upon the center of the cathode. Therefore, the removal of the center of the cathode to provide an aperture through which a support for the control grid may project not only takes advantage of an otherwise useless portion of the cathode but also provides a nonemissive surface upon which the ions may impinge without producing damage or affecting the operation of the device. Furthermore, in a structure according to this invention, simple circuit connections can be made to grid rod 66 for sampling such ionic bombardment thus enabling determination of the relative merits of individual tubes with respect to residual gases.

It is believed that those skilled in the art will find many applications for an electron gun constructed in accordance with my invention. It should be remembered that the teaching of this invention is not limited to electron guns for klystrons but is equally applicable to electron guns for any beam tube such as traveling wave tubes or kinescopes, for example.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. An electron tube comprising an envelope containing an electron gun, said electron gun comprising a drift tube section a cathode disk having an emissive surface facing said drift tube section and an aperture through the center thereof, a control grid support rod extending through said aperture and terminating adjacent the emissive surface of said cathode, a control grid mounted on the end of said support rod adjacent said emissive surface of said cathode, said control grid comprising an apertured disk co-extensive with said emissive surface of said cathode, and a focusing electrode adjacent said cathode and grid, a portion of said focusing electrode being positioned intermediate said control grid and said drift tube section.

2. An electron tube comprising an envelope containing an electron gun, said electron gun comprising a drift tube section, a cathode disk having an aperture through the center thereof and a concave emissive surface facing said drift tube section, a control grid support rod extending through said aperture in said cathode disk to provide an inner end terminating on the emissive side of said cathode disk, the other outer end of said rod being rigidly supported on the envelope, a control grid mounted on the inner end of said support rod adjacent said emissive surface of said cathode disk, said control grid comprising an apertured disk co-extensive with the cathode

disk and having a shape complementary to that of said cathode disk whereby a convex surface of said control-grid disk faces the concave surface of said cathode disk in close spaced relation thereto, and a focusing electrode having a portion positioned intermediate said grid and said drift tube section for forming the electrons emittetd by said cathode and density modulated by said grid into a beam.

3. An electron tube comprising an envelope containing an electron gun, said electron gun comprising a drift tube section, a tubular cathode supporting member extending co-axially within said envelope, the end of said tubular supporting member adjacent the end of said envelope having a flange extending radially outward therefrom and forming a part of the end wall of said envelope, a cathode disk mounted in the inner end of said tubular cathode supporting member, said cathode disk being dished to provide an exterior concave emissive surface facing said drift tube section, said cathode disk having an aperture through the center thereof, a spiral of heater wire mounted within said tubular supporting member adjacent the inner surface of said cathode disk, said spiral having an opening at the center thereof, a control grid support rod extending co-axially within said tubular supporting member, the inner end of said support rod projecting through said opening in said spiral of heater wire and through said aperture in said cathode disk, sealing means hermetically interposed between said support rod and said supporting cylinder and forming part of the end wall of said envelope, a control grid mounted on said inner end of said support rod adjacent the emissive surface of said cathode disk, said control grid comprising a pair of cross arms and a plurality of turns of wire mounted on said cross arms, and a tubular focusing electrode intermediate said cathode and said drift tube section and having one end surrounding said cathode disk and said control grid, said tubular focusing electrode extending co-axially away from the emissive surface of said cathode and toward said drift tube section.

4. In an electron tube having an envelope, an electron gun at one end of said envelope and a collector electrode at the other end of said envelope, and interaction means interposed in said envelope between said electron gun and said collector, said electron gun comprising a drift tube section, a cathode disk having an aperture therethrough and a concave emissive surface facing said drift tube section, a control grid support rod extending through said aperture in said cathode disk and terminating in the space defined by said concave emissive surface and a plane passing through said peripheral edge of the cathode disk, a control grid mounted on the end of said support rod adjacent said emissive surface of said cathode disk, said control grid comprising a foraminous disk coextensive with the cathode disk and having a shape complementary to that of said cathode disk whereby a convex surface of said control grid disk faces the concave surface of said cathode disk in close spaced relation thereto, and a focusing electrode having a portion intermediate said grid and said drift tube section for forming the electrons emitted by said cathode and density modulated by said grid into a beam.

5. A klystron comprising an envelope, an electron gun at one end of said envelope, a collector electrode at the other end of said envelope, a plurality of co-axial drift tube sections spaced from each other to provide interaction gaps in said envelope between said electron gun and said collector electrode, said electron gun comprising a cathode disk having an aperture through the center thereof and a concave emissive surface facing said drift tube sections and said collector electrode, a control grid support rod extending through said aperture in said cathode disk, a control grid mounted on the end of said support rod adjacent said emissive surface of said cathode disk, said control grid comprising an apertured disk coextensive with the cathode disk whereby a convex surface of said control grid disk faces the concave surface of said cathode disk in closed spaced relation thereto, and a focusing electrode intermediate said grid and said drift tube sections and adjacent said cathode and grid for forming the electrons emitted by said cathode and density modulated by said grid into a beam.

6. An electron tube comprising an envelope containing an electron gun, said electron gun comprising an anode, a tubular cathode support member, a cathode disk mounted in the end of said tubular cathode support, said cathode disk being dished to provide a concave emissive surface facing said anode, an aperture through the center of said cathode disk, a control grid support rod mounted within said tubular cathode support member and extending co-axially thereof, one end of said rod extending through said aperture in said cathode disk, a control grid mounted on said one end of said support rod adjacent said emissive surface of said cathode disk, said control grid comprising a foraminous disk co-extensive with said cathode disk and having a shape complementary to that of said cathode disk whereby a convex surface of said control grid disk faces the concave surface of said cathode disk in close spaced relation thereto and the end of said support rod extending through the aperture in the cathode is bonded to a central portion of said convex surface of the grid, and a tubular focusing electrode, one end of said focusing electrode surrounding said cathode disk and said control grid, said focusing electrode extending into the envelope and away from said emissive surface of said cathode disk and being in co-axial alignment with said cathode disk and said grid.

References Cited in the file of this patent

UNITED STATES PATENTS

2,268,165	Parker et al.	Dec. 30, 1941
2,316,264	Litton	Apr. 13, 1943
2,444,749	Pearce et al.	July 6, 1948
2,610,305	Watrous	Sept. 9, 1952
2,622,225	Linder	Dec. 16, 1952
2,679,613	Garbuny	May 25, 1954
2,735,032	Bradley	Feb. 14, 1956
2,750,535	Doolittle et al.	June 12, 1956
2,782,339	Nergaard	Feb. 19, 1957
2,811,663	Brewer et al.	Oct. 29, 1957
2,889,478	Rogers	June 2, 1959