Oct. 8, 1957 E. C. DENCH 2,809,328

MAGNETRON AMPLIFIERS

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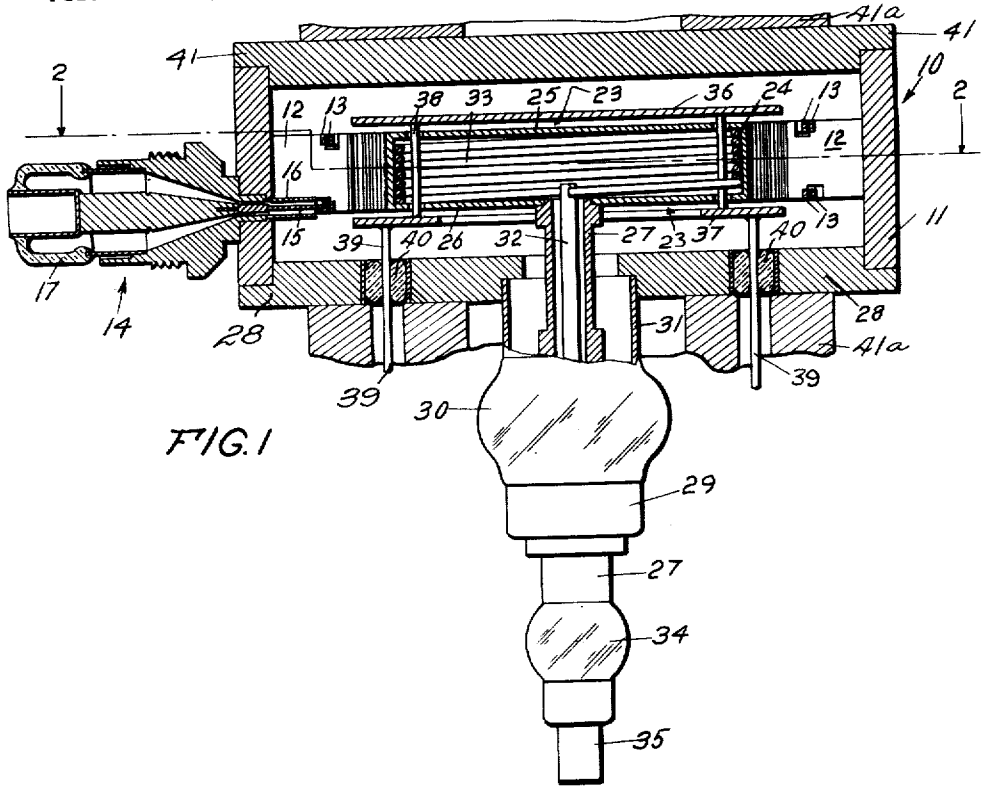


FIG. 1

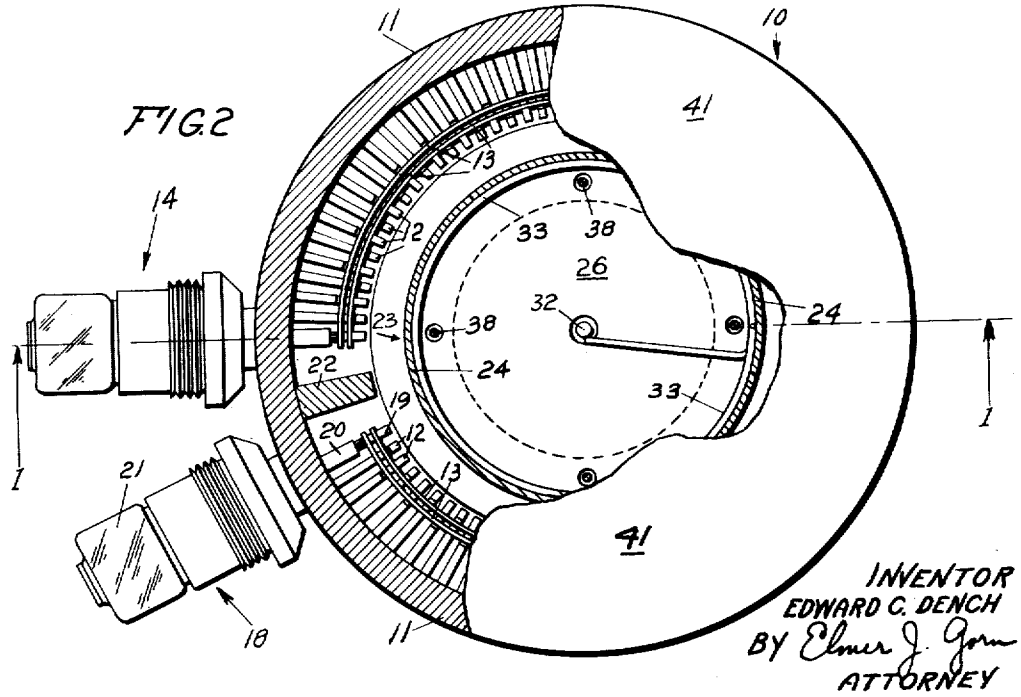


FIG. 2

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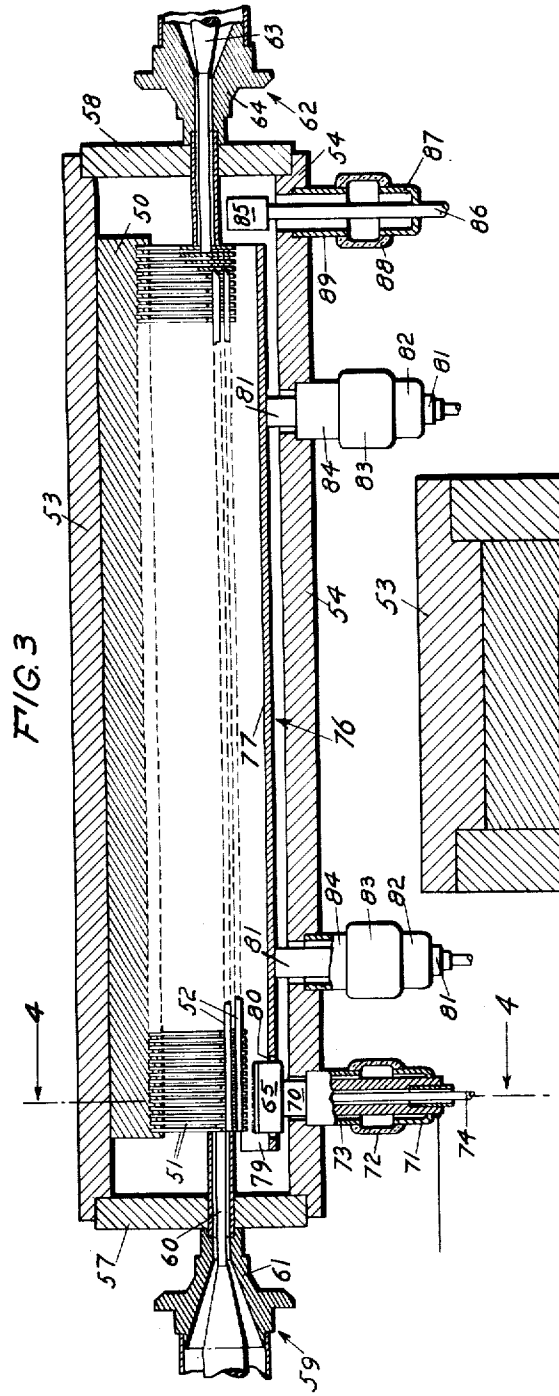


FIG. 3

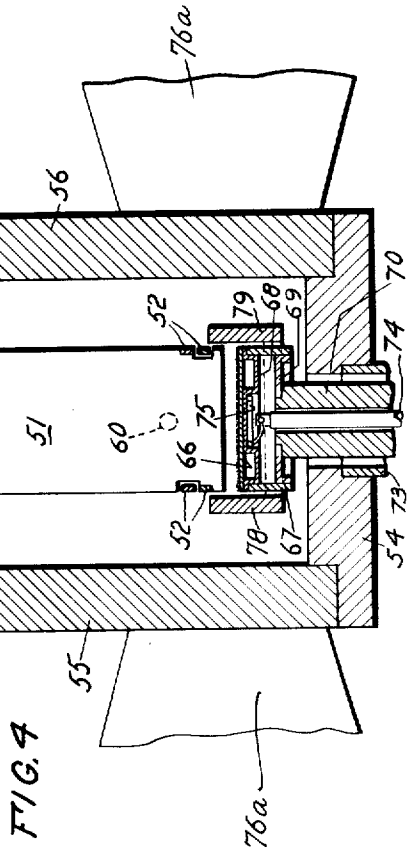


FIG. 4

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MAGNETRON AMPLIFIERS

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6 Claims. (Cl. 315—39.3)

This invention relates to electron discharge devices, and more particularly to discharge devices of the magnetron amplifier type.

In copending application, Serial No. 81,804, filed March 16, 1949, by William C. Brown, now Patent No. 2,673,306, dated March 23, 1954, there is disclosed a magnetron amplifier wherein the anode of a cavity type of magnetron structure is constructed as a non-reentrant signal wave transmission network having input and output means connected, respectively, to the ends thereof. It has been found that the operation of devices of this type is quite critical since, if the gain is too high for a given set of impedance matching conditions at the input and output of the device, oscillations may occur.

This invention discloses means whereby the gain and other operating conditions of the device may be adjusted. Briefly, this is accomplished by placing auxiliary electrodes outside the paths of electrons which pass adjacent the signal wave transmission network, portions of said electrodes being positioned adjacent the cathode of the device, and portions of the electrodes extending toward the anode structure of the device. By insulating these electrodes with respect to the anode and the cathode, a biasing potential may be applied thereto, and the gain, as well as other operating conditions of the device, may be adjusted by adjusting said biasing potential.

There is disclosed herein a first embodiment of this invention, wherein the anode structure surrounds a cylindrical cathode structure spaced therefrom such that the cathode structure emits electrons along substantially the entire length of the anode structure from the input to the output thereof. The auxiliary electrodes are in the form of discs positioned at the ends of the cathode structure, insulated therefrom, and extending radially out toward the anode structure. These auxiliary electrode discs take the place of the conventional end shields commonly used in magnetron structures to prevent movement of the electrons in a direction axial to the cylindrical cathode.

There is further disclosed herein a second embodiment of this invention having an anode structure with a cathode positioned adjacent the input end of said anode structure. An auxiliary electrode comprises a trough extending substantially along the length of the anode structure surrounding the path of the electrons as they move along adjacent the anode structure. By varying the potential applied to the trough with respect to the cathode and the anode structures, the density or focusing of the beam of electrons moving past the anode structure may be adjusted.

Other and further objects and advantages of this invention will be apparent as the description thereof progresses, reference being had to the accompanying drawings wherein:

Fig. 1 illustrates a longitudinal, cross-sectional view of a first embodiment of this invention taken along line 1—1 of Fig. 2;

Fig. 2 illustrates a partially broken away, transverse, cross-sectional view of the device shown in Fig. 1;

Fig. 3 illustrates a longitudinal, cross-sectional view of a further embodiment of this invention; and

Fig. 4 illustrates a transverse, cross-sectional view of the device shown in Fig. 3 taken along line 4—4 of Fig. 3.

Referring now to Figs. 1 and 2, there is shown an anode structure **10** comprising an anode cylinder **11**. Extending radially inwardly from the inner surface of anode cylinder **11** is a plurality of anode members **12** comprising substantially rectangular planar members which lie parallel to the axis of cylinder **11**. Members **12** are alternately connected at points near their inner ends on the upper and lower edges thereof by conductive straps **13**, in a well-known manner, such that the straps **13**, the anode members **12**, and the spaces defined therebetween constitute a signal wave transmission network having a high-frequency pass filter characteristic. At one point in the anode structure, the members **12** and the conductive strapping **13** have been eliminated such that the transmission network is of a non-reentrant type. A signal input coupling structure **14** is connected to one end of the signal wave transmission network by connecting one of the conductive straps **13** to the inner conductor **15** of a coaxial line having an outer conductor **16**. The coaxial line comprising conductors **15** and **16** extends outwardly through an aperture in anode cylinder **11** with outer conductor **16** being sealed to said aperture. Outer conductor **16** is sealed to inner conductor **15** through a ceramic seal **17** which insulatedly supports inner conductor **15** with respect to outer conductor **16**. The other end of the transmission line is connected to an output coupling device **18** comprising an inner conductor **19**, an outer conductor **20**, and a ceramic seal **21** similar, respectively, to members **15**, **16** and **17** of input coupling device **14**.

Extending inwardly from anode cylinder **11**, in the space between the ends of the signal wave transmission network, is a conductive member **22**. Member **22** extends inwardly from anode cylinder **11** for substantially the same distance as anode members **12**, and is appropriately dimensioned to serve as a radio frequency choke, thereby preventing coupling of signal waves appearing at the output device directly across to the input device.

Positioned in the space defined by the inner ends of the anode members **12** is a cathode structure **23** comprising a cathode cylinder **24** whose outer surface is covered with electron-emissive material. The upper and lower ends of cathode cylinder **24** are covered by upper and lower end plates **25** and **26**, respectively. Rigidly attached to lower end plate **26** is a cathode support cylinder **27** which extends downwardly through an aperture in a lower end cover **28** which is hermetically sealed to the lower end of anode cylinder **11**. Support cylinder **27** is rigidly attached to a cup member **29**, which, in turn, is sealed to a ceramic seal **30** surrounding anode support cylinder **27**. Seal **30** is, in turn, attached to a cylindrical conductive member **31** surrounding support member **27** spaced therefrom, and sealed into a recess surrounding the aperture in cover plate **28** through which support member **27** passes. Positioned inside support member **27**, which is hollow, is a conductive rod **32** which is spaced from support member **27**, one end of which extends into cathode cylinder **24** where it is connected to one end of a heater coil **33**, the other end of heater coil **33** being connected to the cathode cylinder **24**. Conductor **32** extends outwardly through the lower end of support member **27**, and is insulatedly sealed thereto by means of a ceramic seal **34** in a well-known manner. By application of a potential between a connector **35** attached to conductor **32** after it passes seal **34**, and sup-

port cylinder 27 which is connected through lower end plate 26 to the cathode cylinder 24, a current may be caused to flow through the heater coil 33, thereby heating the cathode cylinder 24 to electron-emitting temperature.

Positioned above and below the cathode structure 23 are conductive discs 36 and 37, respectively, said discs extending outwardly to a point near the inner ends of anode members 12. Discs 36 and 37 are spaced from the cathode 23, and are rigidly attached together through conductive rods 38, which extend through apertures in end plates 25 and 26, respectively, spaced therefrom. Lower disk 37 has an aperture therein to allow the passage of support cylinder 27 therethrough without contact therewith. The auxiliary electrode structure comprising discs 36 and 37 is rigidly supported with respect to the anode structure 10, and the cathode structure 23, by means of rods 39 rigidly attached to lower disc 37 and passing through apertures in lower cover plate 28, rigidly sealed thereto by means of ceramic buttons 40 positioned in the apertures in cover plate 28, surrounding and sealed to rods 39. By application of a suitable potential to the lead-in support rods 39, the auxiliary electrode comprising discs 36 and 37 may be maintained at any desired potential with respect to the cathode structure 23 or the anode structure 10.

While it is preferable that the auxiliary electrode structure be biased somewhat negative with respect to the cathode structure 23, it is to be clearly understood that this invention is not limited thereto since, if a certain amount of electron collection by the auxiliary electrode structure may be tolerated, an improvement in gain may be possible by biasing the auxiliary electrode structure positive with respect to the cathode structure 23.

The upper end of the anode cylinder 11 is closed by an upper cover plate 41, and a magnetic field is produced in the space between the inner ends of the anode members 12 and the cathode cylinder 24 by any desired means, such as a permanent magnet or an electromagnet 41*a*.

Referring now to Figs. 3 and 4, there is shown a further embodiment of this invention wherein the anode structure is linear in form with the cathode structure positioned adjacent one end thereof.

Extending downwardly from a backing member 50 is a plurality of anode members 51, which are substantially rectangular in form, and are rigidly connected to member 50. The lower ends of the members 51 are alternately connected by conductive strapping 52 at points on the edges thereof, thereby producing essentially the same type of signal wave transmission structure disclosed in Figs. 1 and 2, but linear in form. The anode structure comprising member 51 and backing member 50 are contained in a long box of conductive material having upper and lower sides 53 and 54, respectively, and vertical side walls 55 and 56, respectively, and end walls 57 and 58, respectively. Backing member 50 is rigidly attached to the upper wall 53 and the remainder of the anode structure is spaced from the remaining walls. An input coupling device 59 comprising an inner conductor 60 and an outer conductor 61 extends through end plate 57 with outer conductor 61 being attached to the first anode member 51, and the inner conductor 60 extending through an aperture in the first anode member 51, and being connected to the second anode member. An output coupling structure 62 comprising inner and outer coaxial conductors 63 and 64, respectively, extends through end plate 58, and is connected to the last and next to last anode members 51, respectively, in substantially the same manner as the input coupling device 59. The inner conductors of the coupling devices are insulatedly sealed to the outer conductors by means of ceramic seals, not shown, in a well-known manner.

Positioned adjacent the input end of the anode structure comprising anode members 51 is a cathode structure 65 having a metallic member 66 having a surface presented to the lower ends of the anode members 51, said surface being coated with electron-emissive material. Metallic member 66 is supported by means of a cylindrical support member 67, and a corrugated disc member 68, positioned below member 66. The lower end of support cylinder 67 is attached through a cup member 69 to a lead-in cylinder 70 which extends downwardly through an aperture in lower plate 54 spaced therefrom. Support cylinder 70 is rigidly supported with respect to plate 54 by being connected to a metallic cup member 71 which surrounds cylinder 70 and in turn is rigidly sealed to a ceramic cylindrical seal 72 surrounding support cylinder 70, and in turn sealed to a conductive cylindrical member 73 surrounding support cylinder 70 spaced therefrom. Cylinder 73 is rigidly sealed to the aperture in plate 54 through which support cylinder 70 passes. A central conductor 74 extends upwardly through support cylinder 70, which is hollow, spaced therefrom into the support cylinder 67 where it is connected to one end of a heater coil 75 positioned in a corrugation in support member 68, closest to the member 66, on which is positioned electron-emissive material. The other end of the heater coil 75 is connected to the corrugated member.

An auxiliary electrode 76 is positioned along the lower ends of the anode members 51 spaced therefrom. Electrode 76 comprises a substantially U-shaped trough having a bottom member 77 and side members 78 and 79, respectively. The bottom member 77 is positioned somewhat lower than the electron-emissive surface of cathode 65, and is substantially parallel to the lower edges of the anode members 51. The sides 78 and 79 of the auxiliary electrode are spaced outside the edges of the cathode structure 65, and extend upwardly to a point slightly above the lower edges of the anode members 51. A suitable aperture 80 is provided in the bottom member 77 to allow the cathode structure to pass therethrough without contact therewith.

The auxiliary electrode is supported with respect to the remainder of the tube structure by means of a pair of support rods 81 which are rigidly attached to bottom member 77, and which extend downwardly through apertures in lower plate 54. Rods 81 are rigidly and insulatedly supported with respect to plate 54 by means of metallic cup members 82 connected to rods 81, cup members 82 being, in turn, sealed to ceramic seals 83 surrounding rods 81. Seals 83 are, in turn, attached to conductive cylinders 84 surrounding rods 81 and spaced therefrom, and rigidly attached to recesses in plate 54 surrounding the apertures through which the rods 81 pass. Positioned beyond the end of auxiliary electrode structure 76, adjacent the output device 62, is a catcher electrode 85 comprising a conductive member which substantially blocks the path taken by electrons as they pass from the cathode 68 along the trough formed by auxiliary electrode 76 adjacent the anode structure. Collector electrode 85 is rigidly supported by means of a lead-in rod 86 which extends through an aperture in plate 54 spaced therefrom, and rigidly supported with respect thereto by means of a conductive cup 87, a ceramic cylinder 88, and a metallic cylinder 89 surrounding rod 86, and sealed together in substantially the same manner as the support devices comprising elements 81 through 84.

A magnetic field may be produced in the space between the anode structure and the auxiliary electrode 76 in a direction substantially perpendicular to the paths of electrons, and parallel to the bottom member 77 of auxiliary electrode 76 by any desired means, such as a permanent magnet 76*a*. The intensity and polarity of the magnetic field are such that electrons emitted from the cathode 65, and attracted toward the anode structure by a positive potential impressed thereon with respect to the cathode structure 65, will move toward the collector electrode 85 along paths adjacent the lower edges of the anode members 51. Under these conditions, interaction of the electrons with the signal impressed on the signal wave transmission network comprising the anode structure will occur, and, upon delivering energy to the

anode structure through amplification of the wave traveling in the anode structure, the electrons will move closer to the anode structure.

This completes the description of the embodiments of the invention described herein. However, many modifications thereof will be apparent to persons skilled in the art. For example, the use of a cathode adjacent only one portion of the anode structure, as shown in the linear device of Figs. 3 and 4, could be used in a circular device of the type shown in Figs. 1 and 2, and similarly the continuous cathode structure adjacent substantially all portions of the anode structure where interaction occurs, as is shown in the device illustrated in Figs. 1 and 2, could be used in a linear embodiment of the invention of the type illustrated in Figs. 3 and 4. Furthermore, if desired a blocking member could be attached to the cathode structure in the device of Figs. 1 and 2, at a point adjacent the radio frequency choke member 22, to prevent electrons from continuing around the cathode from the output of the device to the input. Accordingly, it is desired that this invention be not limited to the particular details of the embodiments illustrated herein, except as defined by the appended claims.

What is claimed is:

1. An electron discharge device comprising an evacuated envelope containing an electron source, a nonreentrant conductive signal energy wave transmission network structure spaced from said source, means adjacent said network structure for directing electrons from said source along paths adjacent said network structure, and an auxiliary electrode structure positioned outside the path of electrons from said source, said auxiliary electrode structure having a first portion arranged substantially parallel to said network structure substantially throughout the length thereof and portions extending from opposite edges of said first portion toward said network structure, said electrode structure being insulated from said source.

2. An electron discharge device comprising an electron source, a non-reentrant conductive signal energy wave transmission network structure spaced from said source, means adjacent said network structure for directing electrons from said source along paths adjacent said network structure, an auxiliary electrode structure positioned outside the path of electrons from said source, said auxiliary electrode structure having a first portion arranged substantially parallel to said network structure substantially throughout the length thereof and portions extending from opposite edges of said first portion toward said network structure, said electrode structure being insulated from said source, and means for applying a potential to said electrode structure.

3. An electron discharge device comprising a substantially non-reentrant signal energy wave transmission network structure, signal input and output means coupled to said network at points spaced along said network structure, a cathode spaced from said network structure, means adjacent said network structure for directing electrons from said cathode along paths adjacent said network structure, and an auxiliary electrode structure positioned outside the path of electrons from said cathode, said auxiliary electrode structure having a first portion arranged substantially parallel to said network structure substantially throughout the length thereof and solid electrically conductive portions extending from opposite edges of said first portion toward said network structure, said electrode structure being insulated from said cathode.

4. An electron discharge device comprising a substantially non-reentrant signal energy wave transmission network structure, a cathode spaced from said network structure adjacent one end thereof, means adjacent said network structure for directing electrons from said cathode along paths adjacent said network structure, and an auxiliary electrode structure positioned outside the path of electrons from said cathode, said auxiliary electrode structure having a first portion arranged substantially parallel to said network structure substantially throughout the length thereof and portions extending generally perpendicularly to said first portion toward said network structure, said means for directing including means for producing an electric field in the region between said auxiliary electrode structure and said network structure and means for producing a magnetic field in said region substantially perpendicular to said electric field, said electrode structure being insulated from said cathode, means for applying a potential to said auxiliary electrode structure for influencing the electric field between said auxiliary structure and said network structure.

5. An electron discharge device comprising a conductive substantially non-reentrant signal energy wave transmission network structure, a cathode spaced from said network adjacent one end thereof, means adjacent said network for directing electrons from said cathode along paths adjacent said network comprising means for producing a magnetic field in the region between said cathode and said network structure, an auxiliary electrode structure positioned outside the path of electrons from said cathode, said auxiliary electrode structure having a first portion arranged substantially parallel to said network structure substantially throughout the length thereof and portions extending from opposite edges of said first portion toward said network structure, said electrode structure having a first portion arranged substantially parallel to said network structure and portions extending from said first portion toward said network structure, said electrode structure further being insulated from said cathode, and means for applying a potential to said electrode structure with respect to said cathode.

6. An electron discharge device comprising an electron source, a nonreentrant conductive signal energy wave transmission network structure spaced from said source, means adjacent said network structure for directing electrons from said source along paths adjacent said network structure, and an auxiliary electrode structure positioned outside the path of electrons from said source, said auxiliary electrode structure having a first portion spaced from and arranged substantially coextensive with said network structure and having portions extending from said first portion toward said network structure.

References Cited in the file of this patent

UNITED STATES PATENTS

1,657,574	Hazeltine	Jan. 31, 1928
1,775,886	Carpenter	Sept. 16, 1930
2,013,093	Frantz	Sept. 3, 1935
2,130,510	Samuel	Sept. 20, 1938
2,213,543	Brett	Sept. 3, 1940
2,248,712	Litton	July 8, 1941
2,269,613	Von Boeyer et al.	Jan. 13, 1942
2,412,372	Usselman	Dec. 10, 1946
2,462,137	Smith	Feb. 22, 1949
2,611,878	Coleman	Sept. 23, 1952
2,620,458	Spencer	Dec. 2, 1952
2,673,306	Brown	Mar. 23, 1954