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LOW NOISE TRAVELING-WAVE TUBE

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Fig. 1.

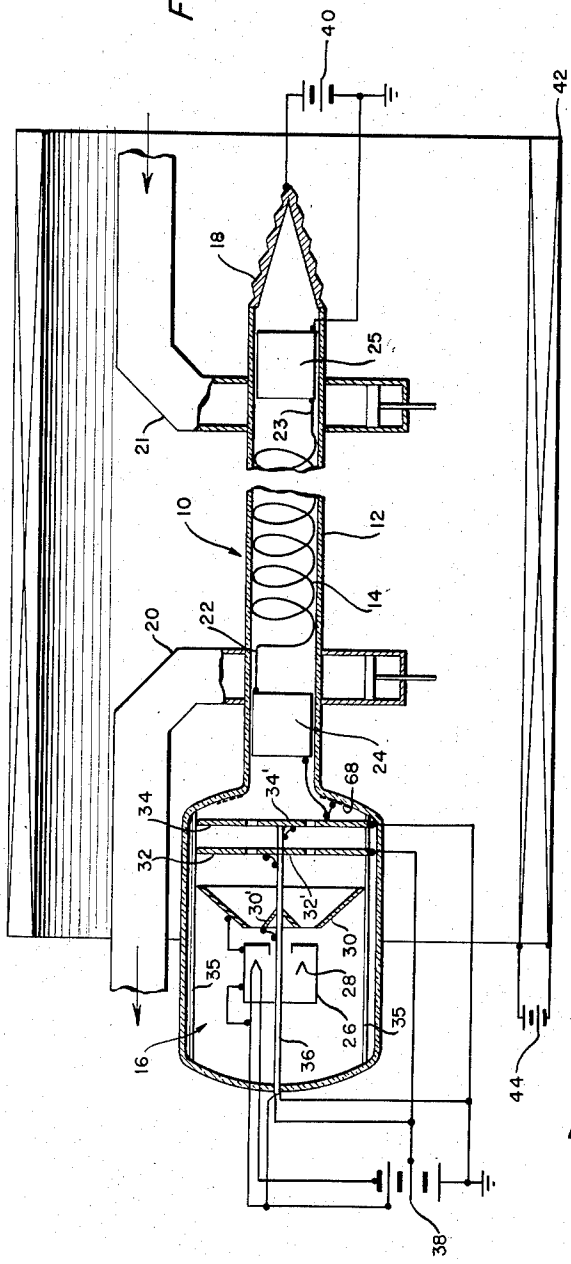
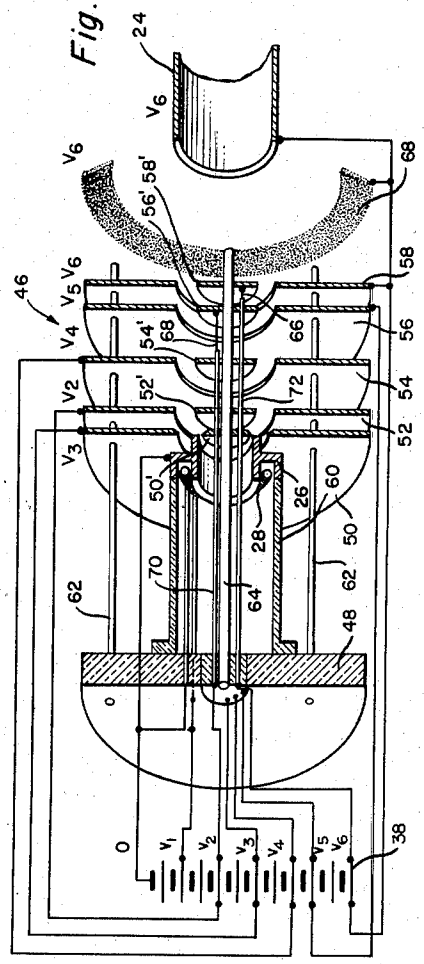


Fig. 2.



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LOW NOISE TRAVELING-WAVE TUBE

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4 Claims. (Cl. 315—3.5)

This invention relates generally to microwave tubes, and more particularly to a traveling-wave tube having a low noise electron gun.

In many applications of electronic amplifiers, the amplifying device, though it have an effective magnitude of amplification, is limited in its usefulness by its inherent internal noise generation. This is true in traveling-wave tubes, as well as in electron tube devices in general. However, the problem is a particularly acute one in the traveling-wave tube field because very high amplifications are achieved in a single tube with a relatively high power beam of electrons; and it is an exceedingly complex problem to generate, project and focus a well-defined, high perveance, stream of electrons which has a low level of radio-frequency noise associated with it. A further and even more troublesome problem presents itself when it is attempted to provide a hollow electron beam such as is desirable in most backward-wave traveling-wave tubes. A complex set of focusing and accelerating electrodes must be arrenged about the meam in the electron gun region of the tube. Because the beam is hollow, it has been found to be desirable to employ with each of several of the electrodes an associated center disc disposed within the hollow electron beam for providing better formation and smoother acceleration of the beam and to keep potential distributions across the beam as flat as possible. It has been the practice in the past to support the center discs by means of thin grid wires which extend radially between the discs and the associated outer electrode. Such configurations are in general satisfactory; however, in applications where an extremely low noise figure associated with the electron stream is desired, the grid wires, because they inherently intercept electrons, cause an appreciable contribution to the total noise figure of the tube, such as in fact to cause the tube to be inoperable in such an application.

It is, therefore, an object of the present invention to provide a hollow beam traveling-wave tube having an extremely low noise figure.

It is another object to provide such a traveling-wave tube in which the center discs in the electron gun electrode arrangement need not be supported by means which intercept stream electrons.

These and other objects are achieved in the present invention by supporting the center discs for a hollow beam electron gun by a rigid center column supported through the non-emissive center portion of the cathode. The center column also carries wires or other conductors back through the cathode so that each center portion or disc may be electrically connected to its respective outer portion.

These and other novel features which are uniquely characteristic of this invention, both as to its structure and operation, together with further objects and advantages, will become apparent to one skilled in the traveling-wave tube art from the following detailed description and and drawing.

In the drawing:

Fig. 1 is a schematic view, partially in section, of a backward-wave tube constructed in accordance with the present invention; and

Fig. 2 is a more detailed cutaway view, on an enlarged scale, of an electron gun as utilized by the present invention.

Referring with more particularity to the drawing, Fig. 1 depicts a backward-wave amplifier tube **10** as an example of a hollow beam device, constructed in accordance with the present invention. An evacuated glass envelope **12** houses a slow-wave structure **14**, illustrated here as a single helix and extending along a major portion of the length of the tube, and an electron gun **16** within its enlarged left-hand extremity. Electron gun **16** projects a hollow stream of electrons toward the right through the slow-wave structure **14** which eventually impinges upon the inner surface of a collector electrode **18** disposed at the right-hand extremity of envelope **12**. In the particular example chosen, the stream current and other parameters are adjusted such that waves of electromagnetic energy are amplified along the length of slow-wave structure **14**. An output waveguide **20** is electromagnetically coupled in a conventional fashion to the output end of slow-wave structure **14** by a pickup lead **22** which is connected between slow-wave structure **14** and a matching ferrule **24**.

Similarly, at the collector end of tube **10**, an input waveguide **21** is coupled to that end of slow-wave structure **14** via a pickup lead **23** which is connected between an input matching ferrule **25** and slow-wave structure **14**. Electron gun **16** includes an annular cathode **26** heated as by a filament **28** causing the emission from the cathode of a suitable current of electrons. A beam-focusing electrode **30**, having an outer portion in the shape of a hollow truncated cone and an inner portion described below, is electrically connected to cathode **28** and aids in forming a beam of electrons which is accelerated by a first anode **32** and thence by a subsequent anode **34**. Electrode **30** and anodes **32** and **34** are supported by rods **35** to the base end of tube **10**. Projecting along the axis of the tube through the center of cathode **28** is a rigid dielectric rod **36** which supports a center portion **30'** of focusing electrode **30**. Center portion **30'** is the shape substantially of a small cone. Further along rod **36**, and in line with accelerating electrode **32**, there is supported on the rod an inner portion, or center disc, **32'**, and similarly further along the rod, and coplanar with electrode **34**, there is supported its inner portion, or disc, **34'**. The radial dimension of the annular space between respectively electrodes **30** and **30'**, **32** and **32'** and **34** and **34'** is just sufficient to allow passage of the desired hollow electron beam with no interference or interruption therewith.

A voltage source **38**, having its positive end grounded, is tapped at various points which are connected in conventional manner to cathode heater **28**, cathode **26** and accelerating electrodes **32** and **34**. A voltage source **40** is connected between collector electrode **18** and ground, and is of a positive magnitude such that secondarily emitted electrons from the collector will be held or returned to the collector and not be allowed to traverse any portion of slow-wave structure **14**. Attached to dielectric rod **36** are conductors, such as wires, for electrically connecting electrode **30** to **30'**, **32** and **32'** and **34** and **34'**. Such wires pass back along rod **36** and are externally connected to the respective outer portions of the electrodes. In this manner, although the inner portions are electrically connected to the outer portions, no wires interfere or interrupt the electron stream.

A solenoid **42** substantially surrounds traveling-wave

tube 10 and produces an axial magnetic field to aid in constraining and confining the electron stream into the desired hollow form. Solenoid 42 is shown energized by electric source 44.

A practical embodiment of a low noise electron gun 46 is shown in Fig. 2 which illustrates a typical electron gun to be utilized in accordance with the present invention. A nonconductive base support 48, which may be the base end of envelope 12, would be supported by envelope 12 (not otherwise shown in Fig. 2) and supports and holds in alignment the various electrodes of gun 46. These include cathode 26 and accelerating and beam-forming electrodes 50, 52, 54, 56 and 58. Cathode 26 is secured to base 48 by a hollow cylindrical support 60, and electrodes 50, 52, 54, 56 and 58 are each secured to base 48 by means of a series of axial dielectric rods 62 disposed about the periphery of base 48. A dielectric rod 64, extending along the axis of gun 46 and supported by base 48, similar to rod 36 of Fig. 1, secures and supports, coplanarly, respective center portions, or inner discs, of electrodes 50, 52, 54, 56 and 58. These center portions are designated by primed numerals corresponding to those of the outer portion of each electrode.

The inner portions of the electrodes are electrically connected to their respective outer portions by means of fine conductive wires, such as 66 and 68, each of which are insulated from each other and from the other electrodes by means of lengths of quartz capillary tubes, such as 70 and 72. There would of course be one such wire for each electrode, although only two are shown in the figure. Voltage source 38 is tapped in this example at six different points to provide seven different potentials, the most negative of which is designated as zero, and the most positive of which is designated by V_6. Cathode 26 and one side of filament 28 are connected to the zero point; the other end of filament 28 is connected to the V_1 point; electrode 52 and its inner portion 52' are connected to the V_2 point; electrode 50 is similarly connected to the V_3 point; electrode 54 is connected to the V_4 point; electrode 56 is connected to the V_5 point; and electrode 58 is connected to the V_6 point. An aquadag coating 68 is placed on the interior surface of the neck of envelope 12, as shown in Fig. 1, and is also connected to the V_6 point, as would normally be matching ferrule 24 and slow-wave structure 14.

It is to be noted that electrode 52 is at a more negative potential than is electrode 50. The reasons for this and the exact structure of this portion of the electron gun are disclosed and claimed in a co-pending application Serial No. 631,129 by Malcolm R. Currie and Donald C. Forster, which invention is assigned to the assignee of the present invention and filed concurrently herewith. It is to be stressed that the present invention resides in the manner of supporting the inner portions of the various disc electrodes and the combination thereof with a low noise traveling-wave tube.

In operation it may be seen that the hollow beam emitted by cathode 26 may traverse the entire electron gun wtih no interruption or interference, as by grid wires which are conventionally used to support the inner portions of the various electrodes. Such conventional supports severely limit the available minimum noise figure in a low noise traveling-wave tube, even though satisfactory in other applications where a low noise figure in the tube is not critical.

What has here been disclosed are two embodiments of the present invention, viz., those shown in Fig. 1 and Fig. 2. The embodiment of Fig. 2 includes a more complex arrangement of electrodes, while Fig. 1 is a simplified version submitted for purposes of explanation. Obviously, the degree of complexity of electrode arrangement, as well as the structure of the accompanying traveling-wave tube, may be varied within a large range.

What is claimed is:

1. In a traveling-wave tube, a low-noise hollow beam electron gun comprising: a mounting baseplate extending across the electron gun end of said traveling-wave tube substantially in a plane perpendicular to the axis thereof; an annular cathode having an axial passageway and supported symmetrically with respect to said axis on said baseplate; an inner rigid dielectric supporting rod attached to said baseplate and extending axially along said traveling-wave tube from the electron gun end thereof through and beyond said passageway in said annular cathode; a plurality of outer dielectric supporting rods spaced about the periphery of said cathode and attached to said baseplate; a plurality of beam-forming and accelerating electrodes disposed perpendicularly to said axis, each comprising an outer annular member for surrounding said hollow beam and a circular inner member disposed within said hollow beam, said outer annular member being supported by said outer supporting rods, and said inner members being supported coplanarly by said inner dielectric supporting rod; and a plurality of electrical conductor means connecting each of said inner members to respective ones of said outer members, each of said conductor means being connected to one of said inner members and extending along said inner supporting rod through said baseplate and thence to an associated outer member, said inner members being thus supported on said inner rod in a manner such that said hollow beam passes between respective associated members of each electrode without interference or interception thereby, whereby an exceedingly low-noise hollow electron beam is produced.

2. In a backward-wave traveling-wave tube, a low-noise hollow beam electron gun comprising: a mounting baseplate extending across the electron gun end of said traveling-wave tube substantially in a plane perpendicular to the axis thereof; an annular cathode having an axial passageway and supported symmetrically with respect to said axis on said baseplate; an inner rigid dielectric supporting rod attached to said baseplate and extending axially along said traveling-wave tube from the electron gun end thereof through and beyond said passageway in said annular cathode; a plurality of outer dielectric supporting rods attached to said baseplate and spaced about the periphery of said cathode; a plurality of profile-shaping and accelerating electrodes disposed perpendicularly to said axis, each comprising an outer annular member for surrounding said hollow beam and a circular inner member disposed within said hollow beam, said outer annular member being supported by said outer supporting rods, and said inner members being supported coplanarly by said inner dielectric supporting rod; and a plurality of electrical conductor means connecting each of said inner members to respective ones of said outer members, each of said conductor means being connected to one of said inner members and extending along said inner supporting rod through said baseplate and thence to an associated outer member, said inner members being thus supported on said inner rod in a manner such that said hollow beam passes between respective associated members of each electrode without interference or interception thereby, whereby an exceedingly low-noise hollow electron beam is produced.

3. In a backward-wave traveling-wave amplifier tube, a low-noise hollow beam electron gun comprising: a mounting baseplate extending across the electron gun end of said traveling-wave tube substantially in a plane perpendicular to the axis thereof; an annular cathode having an axial passageway and supported symmetrically with respect to said axis on said baseplate; an inner rigid dielectric supporting rod attached to said baseplate and extending axially along said traveling-wave tube from the electron gun end thereof through and beyond said passageway in said annular cathode; a plurality of outer dielectric supporting rods attached to said baseplate and spaced

about the periphery of said cathode; a plurality of profile-shaping and accelerating electrodes disposed perpendicularly to said axis, each comprising an outer annular member for surrounding said hollow beam and a circular inner member disposed within said hollow beam, said outer annular member being supported by said outer supporting rods, and said inner members being supported coplanarly by said inner dielectric supporting rod; and a plurality of electrical conductor means connecting each of said inner members to respective ones of said outer members, each of said conductor means being connected to one of said inner members and extending along said inner supporting rod through said baseplate and thence to an associated outer member, said inner members being thus supported on said inner rod in a manner such that said hollow beam passes between respective associated members of each electrode without interference or interception thereby, whereby an exceedingly low-noise hollow electron beam is produced.

4. In a beam type electron tube, a hollow electron beam gun comprising: mounting means extending across at least a portion of the electron gun and of said electron tube; an annular cathode having an axial passageway and supported concentrically with respect to the axis of said tube from said mounting means; an inner rigid dielectric supporting rod supported from said mounting means and

extending axially along said electron tube from the electron gun end thereof through and beyond said passageway in said annular cathode; a plurality of critically disposed beam forming and accelerating electrodes spaced along and concentrically about said axis, each comprising an outer annular member for contiguously surrounding said hollow beam and a circular inner member disposed substantially co-planarly with said outer annular member contiguously within said hollow beam, said inner co-planar members being supported by said inner dielectric supporting rod in axial sequence therealong; and a plurality of electrical conductor means connecting each of said inner members to respective ones of said outer members, each of said conductor means being connected to one of said inner members and extending along said inner supporting rod to said mounting means and thence to its associated outer member, said hollow beam passing through the annular space between the inner and outer respective associated members of each electrode without interception or interference thereby, whereby an exceedingly low noise hollow electron beam is produced.

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