

March 2, 1965

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3,172,006

COLLECTOR CIRCUIT FOR ELECTRON BEAM DEVICES

Filed Oct. 10, 1960

FIG. 1

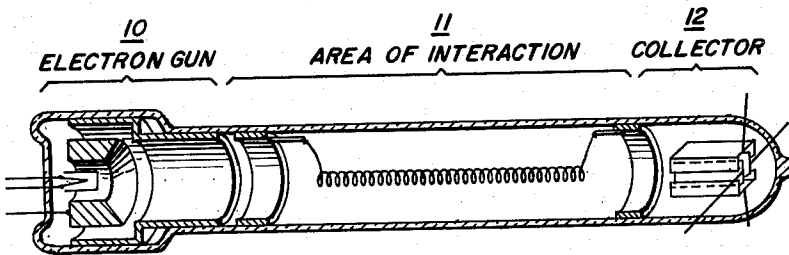
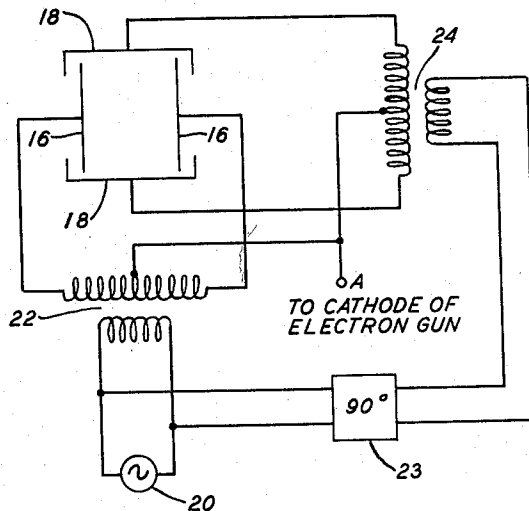


FIG. 2



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3,172,006

COLLECTOR CIRCUIT FOR ELECTRON BEAM DEVICES

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Filed Oct. 10, 1960, Ser. No. 61,506

3 Claims. (Cl. 315-5.38)

This invention relates to electron beam devices and particularly to improvements in collector circuits for electron beam devices.

In electron beam devices, such as traveling wave tubes or quadrupole parametric amplifiers, for example, provision has to be made for the collection of the electrons of the beam after they have been acted upon in the desired manner in the region of an electric and/or magnetic field. Typically, devices of the class here of interest include an electron gun designed to produce a concentrated beam of electrons, an interaction area in which the beam interacts with a field or the like and a collector upon which the electron beam terminates.

For example, in a high-frequency amplifier such as a traveling wave tube of which the disclosure in the U.S. Patent 2,636,948 granted J. R. Pierce on April 28, 1953, is typical, an electron gun supplies an electron beam which passes through a helical wave guide and an electromagnetic wave propagates in the direction of the electron beam along the helical wave guide. An interaction takes place between the electromagnetic wave and electron beam in the area of a magnetic field so that there is amplification of the electromagnetic wave. After traveling through the helical wave guide, the electron beam is collected by the collector which is typically a cylinder closed at the end which is farthest from the electron gun. To negate any interference with the electromagnetic wave by the electron beam once it has passed out of the interaction area within the helical wave guide, this electron beam must be positively collected. Therefore, the collector must at all times have a positive potential with respect to the cathode in the electron gun, thereby ensuring continuous collection of the electron beam.

It has been conventional to meet the above requirements with a collector circuit which comprises a target and a direct-current potential source, the positive terminal of which is connected to the target. To furnish the relatively high direct-current potential required for the collection of the electrons, a power supply is provided in which an alternating-current voltage is transformed from a low voltage to a much higher voltage and then rectified.

In the past, it has been essential that the alternating current be rectified before applying it to the target to collect the electrons. This necessity for rectification or the provision of a direct-current potential in some other manner is obvious from the unitary construction of the collector as exemplified by the disclosure in the Pierce patent. The provision of such a direct-current supply solely for the collector is detrimental to over-all efficiency, particularly in view of the fact that high-voltage alternating-current supplies are already available for other parts of the circuit.

Therefore, it is an object of this invention to provide a collector circuit wherein the available alternating-current potential can be used directly without conversion to direct current.

In accordance with the invention, a plurality of plates or collector elements are disposed about the axis of the electron beam in the collector region and alternating voltages of approximately high potential are applied to the plates in such relative phases that at least one of the plates is always positive with respect to the cathode in

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the electron gun and will therefore collect the electrons in the electron beam.

The present invention, its objects and advantages can be more clearly and fully understood upon consideration of the following specification taken in connection with the drawing in which:

FIG. 1 is a schematic diagram showing a collector structure according to the invention, and its position with relation to other elements of a typical electron beam device, and

FIG. 2 is a schematic circuit diagram showing the connection of the alternating-current potentials to the collector of FIG. 1.

In FIG. 1 there are shown the basic components of an electron beam device of the class contemplated herein comprising an electron gun 10, an area of interaction 11, and a collector 12, in accordance with the invention. The area of interaction 11 may be comprised of various structures and fields such as helical wave guide surrounded by a magnetic field as in a traveling wave tube, of which the disclosure in the Pierce patent is typical, or it may be an electric field as in a quadrupole parametric amplifier, of which the disclosure in the Proceedings of the Institute of Radio Engineers, vol. 47, No. 10, starting at page 1713 is typical. After the electron stream emitted from the electron gun 10 has been acted upon in the desired manner in the area of interaction 11, it is collected by the collector 12 which comprises the pair of plates 16 and the pair of plates 18.

The collector of FIG. 1 is operatively connected in the electron beam device circuit as shown in FIG. 2. The alternating-current potential from a source 20 is applied directly after transformation to a higher voltage by a transformer 22 to the pair of plates 16. In parallel with the primary of transformer 22 is a phase shifter 23, which shifts the phase of the alternating-current voltage from the source 20 by 90 degrees and applies this voltage to the pair of plates 18 after it is transformed to a higher voltage by a transformer 24. The return path for the electrons collected by the plates is through center taps on the secondaries of the respective transformers to point A which is conductively connected to the cathode of the electron gun.

When the alternating-current potential from source 20 is applied to the circuit the voltage applied to plates 18 will be 90 degrees out of phase with the voltage applied to plates 16. Consequently, a rotating field is set up in the collector region whereby one of the plates is always positive with respect to point A so that the electrons will be continuously collected.

It will be obvious that the principles of the invention may be extended to arrangements having a different number of collector plates. It is necessary only that the phases of the alternating-current voltages applied to the individual plates of the collector be so chosen that at any time, at least one of the plates is at a positive potential with respect to the cathode of the electron gun.

What is claimed is:

1. In an electron beam device, means for collecting the electron base including first and second orthogonally disposed sets of opposed collector plates surrounding the axis of said electron beam, first and second sources of alternating-current voltage, and means for applying the voltages from said sources in quadrature to said first and second sets of plates, respectively, to collect said electron beam.

2. In an electron beam device, a cathode, and a collector circuit comprising first and second pairs of plates, each pair of plates having a plate on opposite sides of the axis of the electron beam in said device and the plates of said first pair lying in planes perpendicular to the planes

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of said second pair of plates, a source of alternating-current potential, means for applying said alternating-current potential to said pairs of plates in phase quadrature, the pairs of plates being connected to a common junction point, and means for connecting said common point to said cathode.

3. In a traveling wave tube, the combination comprising an electron gun, a helical wave guide through which the electron beam from said electron gun will pass, a collector circuit comprising first and second orthogonally disposed sets of opposed plates surrounding the axis of said electron beam, and means for applying quadrature

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alternating-current voltages to said sets of plates to provide a rotating electric field within the collector region so that said electron beam will be collected.

References Cited in the file of this patent

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,172,006

March 2, 1965

Hunter L. McDowell

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 61, for "base" read -- beam --.

Signed and sealed this 3rd day of August 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents