

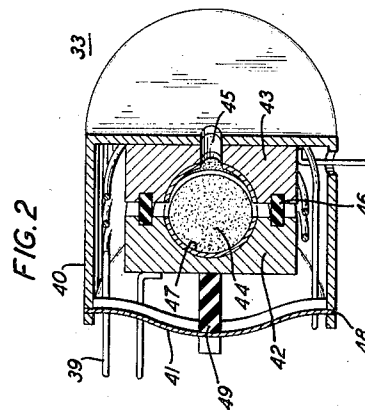
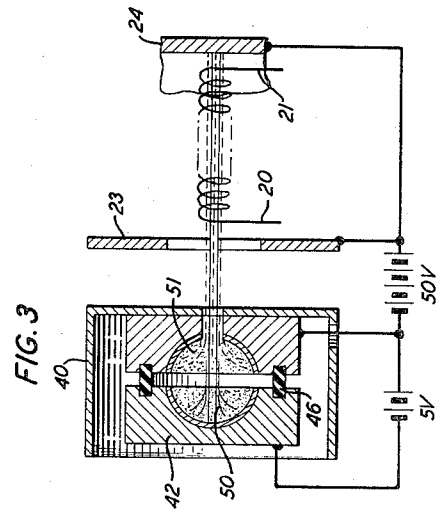
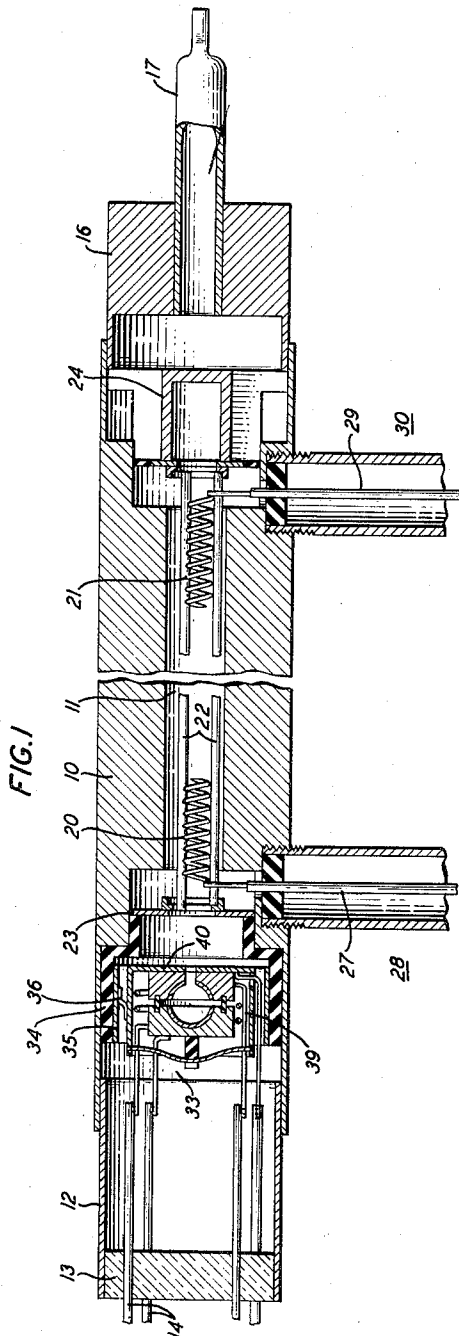
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ELECTRON GUNS

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ELECTRON GUNS

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This invention relates to electron guns and more particularly to electron guns for double stream amplifiers of the type disclosed in the application Serial No. 38,928 of W. B. Hebenstreit and J. R. Pierce, filed July 15, 1948, now Patent No. 2,801,362.

It is presently well established that broad band signal amplification in the microwave frequency range may be obtained through the interaction of an electron beam and a retarded electromagnetic wave within the device known as the traveling wave tube. In usual traveling wave tube design the electrons are in the form of a highly concentrated beam which passes longitudinally through a helix carrying the electromagnetic wave to be amplified.

It is further established that gain can also be obtained in a traveling wave device in which the interaction takes place between a pair of electron beams upon which the electromagnetic wave has been impressed. This latter type of traveling wave tube is known as the double stream amplifier tube, an example of which is disclosed in the Hebenstreit-Pierce patent identified above.

Requisites for efficient amplification in double stream amplifier tubes are that the electron streams have a prescribed electron density; that they have a velocity differential related to the frequency of the wave to be amplified; and that the streams are in such close physical relationship as to make electromagnetic interaction possible.

These requisites impose severe standards upon the electron gun which supplies the double streams. Ideally, to obtain complete interaction between the electron streams, they should be of high density and coincident, i. e. traveling in the same space. Since the electron streams must have different average velocities, each must be subject to a different accelerating potential. The accelerating potentials are obtained by employing a common accelerating electrode and providing different electrical biasing for each cathode of the electron gun. Since the cathodes must be electrically independent, they are necessarily physically displaced from each other.

In the past, electron guns for double stream amplifiers have included a pair of exteriorly coated equipotential cathodes mounted transversely to the beam direction and spaced from each other. In such designs, the electron streams are projected side by side separated by the distance between the surfaces and intermingle only at their edges or more completely at the sacrifice of beam definition. In another type of gun structure, the individual cathodes are displaced longitudinally in the beam direction and require a radial electric field to orient the beams. At best, exteriorly coated cathodes can supply efficiently a stream of limited electron density.

A single high current density electron beam is produced by the electron source known as the hollow cathode disclosed in the applications of D. MacNair, Serial Nos. 361,527, 361,623 and 361,663, filed June 15, 1953, now Patents 2,810,088, 2,810,089 and 2,810,090, respectively.

It is a general object of this invention to realize an improved electron gun for double stream amplifiers.

More specific objects of this invention are to obtain a simple unitary electron gun structure capable of producing a pair of coincident high density electron beams; to facilitate the production of thoroughly intermingled electron beams of different average velocities as emitted from the electron gun; and to realize a hollow cathode dual stream electron gun.

These objects are accomplished in one specific illustrative embodiment of a dual stream amplifier tube, comprising an evacuated cylinder mounting therein an electron gun of this invention, an electron collector associated therewith, and signal input and output lines each connected to a respective helix segment aligned between the electron gun and collector. The electron gun comprises a metallic body comprising a pair of cathode cylinders including mating recesses which define a spherical chamber enclosed within the metallic body save for a single beam exit opening. The surfaces defining this spherical chamber are coated with electron emissive material. A thin vitreous insulating washer lies between the cathode cylinders thereby electrically isolating each cylinder. Separate leads are secured to each cathode so that the two may be electrically biased independently of the other.

In accordance with one feature of this invention the dual stream electron gun comprises a unitary structure of a pair of cathodes.

In accordance with another feature of this invention the cathodes define an enclosed chamber bounded by electron emissive coatings of the cathodes in which chamber intermingling of electrons from both streams takes place.

In accordance with another feature of this invention electron streams from both cathodes emerge as coincident streams through a single opening in the electron gun.

A more complete understanding of this invention may be had from the following detailed description and by reference to the drawing in which:

Fig. 1 comprises an axial section of a double stream amplifier incorporating the electron gun of this invention;

Fig. 2 is an enlarged sectional view of the electron gun of the device of Fig. 1; and

Fig. 3 is a simplified representation of the electrode system of the device of Fig. 1 indicating the path of the electron beams.

Referring now to Fig. 1 there may be seen a double stream amplifier comprising a metal envelope 10 including a central bore 11, an electron gun base member 12 including a vitreous disc 13 sealed thereto and through which terminal ends 14 project, and a collector base member 16 including an exhaust tubulation 17. Within the bore 11 are an input helix 20 and an output helix 21 mounted in spaced alignment from a plurality of ceramic rods 22 which extend between an accelerating grid 23 and an electron collector 24. The input helix 20 is connected to a center conductor 27 of coaxial input line 28 which conducts the electromagnetic wave to be amplified. The output helix 21 is similarly connected to the center conductor 29 of a coaxial output line 30 from which the amplified wave is withdrawn from the device. Aligned with the input helix 20, output helix 21 and collector 24 is an electron gun generally designated 33 which may be seen more clearly in Fig. 2. The electron gun is insulatingly mounted from the envelope 10 by a vitreous collar 34 enclosing a radiation shield 35. The electron gun 33 is mounted from the radiation shield 35 by means of a plurality of metal fingers 36 one of which is shown extending to a heater shield 40 which encloses a heater wire 39.

Referring to Fig. 2 the makeup of the cathode 33 may be seen more clearly. It comprises a pair of cathode cylinders 42 and 43 of a metal such as nickel including mating recesses which define a chamber 44. The cathode

cylinders are separated by a vitreous ring 46. A spring 41, the ends of which rest in slots 49 of heater shield 40, maintains the assemblage of shield 40, cathodes 42 and 43 and ring 46 through vitreous block 49. The chamber 44 is enclosed within the unitary structure formed by cathode cylinders 42 and 43 and the vitreous ring 46 with the exception of a single electron beam exit aperture 45 in the cathode cylinder 43. The recessed portions of cathodes 42 and 43 are coated with an electron emissive material, for example, a mixture of the oxides of barium, calcium and strontium. The diameter of aperture 45 is small by comparison to the diameter of chamber 44, that is, between five and forty per cent with a preferred value of ten per cent of the chamber diameter. The emissive coating is therefore substantially greater in area than that of the electron beams, the size of which is determined by the transverse dimension of aperture 45. As is disclosed in the D. McNair patents mentioned heretofore, a single high intensity electron beam may be produced from a cavity type cathode. According to this invention the metallic body defining the emissively coated cavity is made up of a pair of independent cathodes each of which is at a different biasing potential.

In Fig. 3 may be seen a representation of the double stream electron gun of this invention in operation. Cathode 42 is maintained at a negative bias with respect to cathode 43, both of which are subject to the accelerating field of the grid 23 which is maintained at a potential positive with respect to both cathodes. Typical electrical biases are: cathode 42, -5 volts; cathode 43, zero volts; accelerating grid 23, +50 volts; collector 24, +50 volts. Under these conditions, electron streams are drawn from each of the cathodes through aperture 45 and in the process are thoroughly intermingled. The electron stream 50 from cathode 42 is represented by solid lines while electron stream 51 from cathode 43 is shown dotted. Electron stream 50 has a higher average velocity than electron stream 51 owing to the greater potential difference between cathode 42 and the accelerating grid 23. After the thoroughly intermingled electron beams emerge from aperture 45 they pass through input helix 20 from which the electromagnetic wave to be amplified is impressed on them. After leaving helix 20 the electron beams pass through a region between the helices 20 and 21 in which amplification takes place. A more complete explanation of the electromechanical interaction between the electron streams resulting in amplification may be had from chapter XVI of "Traveling Wave Tubes" by J. R. Pierce. After traversing the amplification region the electron beams pass through the output helix 21 upon which the amplified wave is removed. The electron streams then continue on and are drawn to the collector 24.

In the electron gun of this invention the cathode 43 is advantageously maintained at a bias potential which is positive with respect to the cathode 42. In this manner cathode 43 does not interfere with the beam formed from cathode 42 but tends to accelerate the beam somewhat. The only exit for emission is the single aperture 45 which is centrally disposed with respect to both emissive surfaces. For operation at greater potential differences between cathodes 42 and 43 the possibility exists that emission from cathode 43 will be suppressed by the negative voltage on cathode 42. Then a single grid of the type disclosed in the Patent 2,810,089 mentioned heretofore or system of such grids to control the emission from each cathode and to shield each from the voltage of the other might be added.

In this embodiment the length of aperture 45 is greater than its traverse dimension, the diameter. Consequently, as was taught in the Patent 2,810,088 a solid electron beam emerges, that is the electron density in a transverse section is substantially uniform. If as is commonly desired the dual streams be not only coincident

but hollow, the aperture dimensions may be modified. In such a case the transverse dimension of aperture 45, the diameter, should be greater than its length including the thickness of heater shield 40.

It is to be understood that the above described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A dual stream electron gun assembly comprising a pair of cathode members, a vitreous insulating washer therebetween, said cathode members including mating recesses defining a cavity substantially enclosed within the assembly and having a single exit for electrons, said exit being small in size in comparison to said mating recesses, a coating of electron emissive material upon substantially all of the recessed portions of said cathode members, and means for heating said material.

2. A dual stream electron gun comprising a pair of cathode elements, an insulating spacer therebetween, said cathode elements including mating recessed portions defining a cavity, a coating of electron emissive material upon substantially all of the recessed portion of each of said cathode elements, one of said cathode elements including an aperture communicating between the cavity and the exterior of said element, said aperture being in size in the order of 5 to 40 percent of the size of said cavity, and a heater for said cathode elements.

3. An electron gun for producing a pair of coincident electron beams comprising a first cathode including a hemispherical recessed portion, a second cathode including a hemispherical recessed portion insulatingly mounted adjacent said first cathode with the recesses in juxtaposition thereby defining a spherical cavity, a coating of electron emissive material upon substantially all of the recesses of said first and second cathodes, said second cathode including an electron beam emitting aperture communicating between the spherical cavity and exterior of second cathode, said aperture having a minimum transverse dimension in the order of 5 to 40 percent of the diameter of said cavity, and a heater for said cathodes.

4. An electron gun for producing a pair of coincident electron beams comprising a first cathode including a recess in a face adjacent the direction of beam travel, and corresponding in shape to the recess in said first cathode; a coating of electron emissive material upon said recess, a second cathode insulatingly mounted adjacent said first cathode, said second cathode including a recess in a face opposite the direction of beam travel, the recesses in said cathodes defining a cavity enclosed within the electron gun except for an electron exit aperture in said second cathode communicating between the cavity and the exterior of said second cathode, said electron exit aperture having a minimum transverse dimension in the order of 10 percent of the transverse dimension of said cavity, a coating of electron emissive material upon the surfaces defining said cavity, a heater for said cathodes, and individual lead means for electrically biasing said cathodes.

5. An electron gun in accordance with claim 4 wherein the recesses of said first cathode defining the cavity are hemispherical in shape and the aperture is centrally located in the recess of said second cathode.

6. An electron gun for producing a plurality of coincident high intensity electron beams comprising a first cathode including a recessed portion, a vitreous washer surrounding said recessed portion, a second cathode mounted adjacent said vitreous washer in the direction of electron beam travel, said second cathode including a recessed portion corresponding in shape and mating with the recessed portion in said first cathode, a coating of electron emissive material upon substantially all of the recessed portions of said first and second cathodes,

5

a common electron beam exit passage in said second cathode for electron streams from said first and second cathodes, means for heating said coatings to emissive temperature, and individual lead means for electrically biasing said cathodes independently.

7. A double stream electron gun comprising a pair of recessed metallic members, an apertured vitreous insulating spacer embraced by said metallic members thereby defining a cavity enclosed therebetween, coatings of electron emissive material upon substantially all of the portions of said metallic members defining the cavity, one of said metallic members including a common electron beam exit in the direction of electron beam travel, said electron beam exit being small in size in comparison to said cavity, means for heating said coatings to electron emission temperature, and individual lead means for electrically biasing said metallic members.

8. An electron gun for producing a pair of coincident electron streams comprising a pair of emissively coated cathode members in opposed facing relationship defining a substantially enclosed electron stream mixing chamber therebetween, one of said cathode members including an electron exit aperture therein through which the electron streams of both of said cathodes emerge and said electron exit aperture having a transverse dimension in the order of five to forty percent of the transverse dimension of said chamber.

9. A dual stream electron gun comprising two cathodes including juxtaposed concave electron emissive surfaces, an insulator separating said cathodes, one of said cathodes including an orifice for the egress of electrons, said orifice being small in area with respect to both of the emissive surfaces, and means for heating said cathodes.

10. A dual stream electron gun comprising two cathodes including concave electron emissive surfaces of substantially the same area, in spaced facing relation-

6

ship, an insulator separating said cathodes, one only of said cathodes including an orifice for the egress of electrons, the area of said orifice being small with respect to the emissive area of each one of said emissive surfaces, and means for heating said cathodes.

11. A dual stream electron gun comprising facing concave electron emissive surfaces, said surfaces being substantially symmetrical with respect to an axis through each surface, an insulator separating said emissive surfaces, one of said emissive surfaces including an aperture coaxial with said axis for the egress of electrons, said aperture being small compared to said emissive surfaces, and means for heating said emissive surfaces.

12. An electron gun for producing a pair of coincident electron beams comprising a cathode structure including two juxtaposed cathode elements, means for insulating said elements from each other, said elements having like recesses in face-to-face relation, the surface of each of said recesses being electron emissive, said elements and insulator defining a continuous enclosure except for an electron egress aperture in one of said elements, and means for heating each element.

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