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J. R. PIERCE

2,585,582

ELECTRON GUN

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FIG. 1

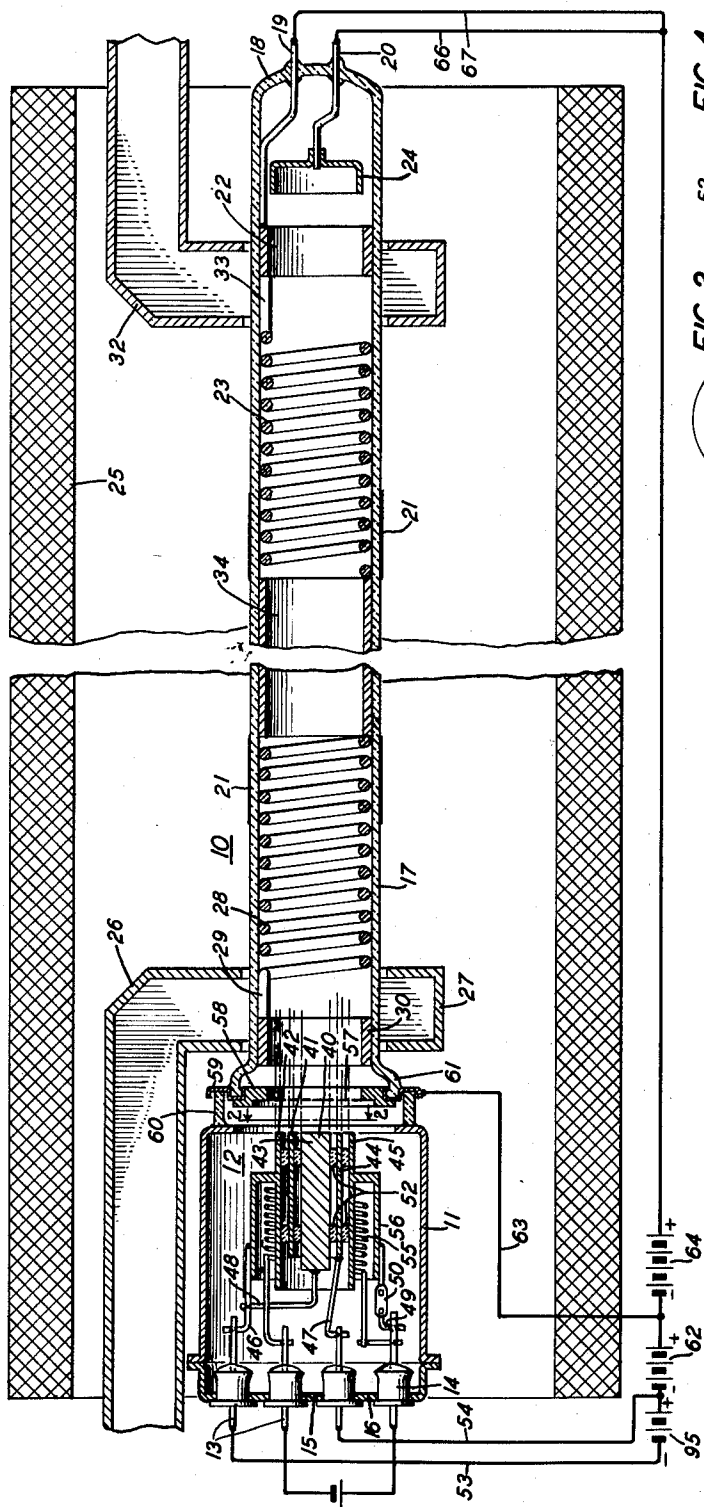


FIG. 4

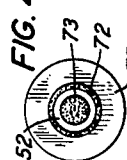


FIG. 2

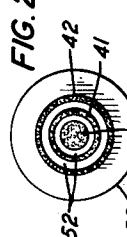


FIG. 6

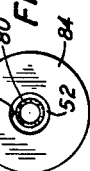


FIG. 5

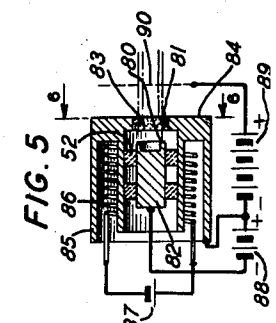
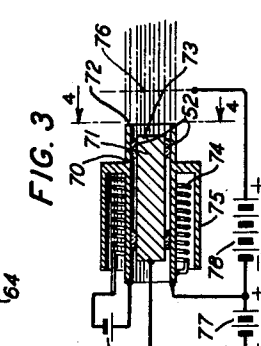


FIG. 3



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ELECTRON GUN

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5 Claims. (Cl. 313—338)

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This invention relates to electron guns and more particularly to electron guns for producing a plurality of electron streams and especially suitable for use in amplifiers of the type disclosed in the application Serial No. 38,928, filed July 15, 1948 of W. B. Hebenstreit and J. R. Pierce.

One general object of this invention is to improve electron guns for producing a plurality of electron beams. More specifically, objects of this invention are to simplify the structure and facilitate the construction of electron guns for producing a plurality of electron beams.

In accordance with one feature of this invention, an electron gun comprises two or more spaced electron emissive members or surfaces each adapted to serve as the source of an individual electron stream, the members or surfaces being in intimate thermal relation whereby all may be heated to the temperature requisite for copious emission by a single heater element, one member being heated directly and the other or others by radiation from the first.

In one specific construction illustrative of this invention, the electron gun comprises a unitary assembly including three cylindrical cathode members mounted in closely spaced relation one within another, the cathode members having substantially concentric electron emissive coatings, and a single heater element encompassing the outermost of the cathode members.

The invention and the aforementioned and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a sectioned elevational view of an electron discharge device having a plurality of interacting electron beams generated in a gun constructed in accordance with one embodiment of this invention;

Fig. 2 is a plan view of the gun of Fig. 1 taken along the line 2—2 of Fig. 1;

Fig. 3 is a sectioned elevational view of another embodiment of this invention suitable for incorporation into a discharge device of the type shown in Fig. 1;

Fig. 4 is a plan view of the gun of Fig. 3 taken along the line 4—4 of Fig. 3;

Fig. 5 is a sectioned elevation of an electron gun illustrative of another embodiment of this invention; and

Fig. 6 is a plan view of the gun of Fig. 5 taken along the line 6—6 of Fig. 5.

Referring now to the drawing, the electron discharge device shown in Fig. 1 comprises an elongated evacuated enclosing vessel 10 having at one end thereof a metallic portion 11 enclosing and supporting an electron gun structure 12 on a plurality of lead-in conductors 13 sealed through glass beads 14 which in turn are sealed through apertures 15 in the base 16. Sealed to the metallic portion 11 is an elongated electron discharge space tube 17, which may be of glass, having a stem 18 at its opposite end through which lead-in conductors 19 and 20 supporting respectively a collar 22, forming a base for the output helix 23, and a collector electrode 24. The assembly 10 is surrounded by a solenoid 25 which produces an axial magnetic field for the purpose of focusing the electron beams of the gun 12.

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The focused electron beams are controlled by an electromagnetic field traveling along a portion of the length of the discharge space in tube 17 and fed to the device by means of a wave guide 26 which has a shorted termination 27. The guide carries a signal which is coupled to the input helix 28 by the extension of that helix 29 running parallel to the axis of the electron stream and mechanically supported by the collar 30. The signal traveling down the helix 28 effects one of the electron streams which in turn interacts with the adjacent stream in a manner set forth in the Hebenstreit-Pierce application mentioned above to produce an amplification of the input signal. The output of the tube is picked up in the inverse manner to that of the input, namely, the electromagnetic field traveling down the electron discharge space inside the helix 23 is picked up by that helix and fed to the output wave guide 32 by the straight section 33 at the end of the helix.

It is to be noted that the input and output helices 28 and 23 are connected by an electrically conductive sleeve 34 thereby imposing the direct-current collector potential on the ring 30 to provide an accelerating field for the electron gun. In order to isolate the input and output signals of the device it is therefore necessary to effectively terminate the ends of the helices 28 and 23 with their characteristic impedance, thereby, in effect, providing an open circuit to the signal frequencies. This is done by coating the exterior of the tubular portion of the envelope 17 with some loss material 21, such as a colloidal suspension of graphite, in the area adjacent the ends of the helices.

The electron gun 12 as shown in Fig. 1 comprises three cathodes 40, 41 and 42 formed by coating the ends of the central metal cylinder 43 and the two enclosing metal sleeves 44 and 45

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with a material having good thermionic emission characteristics. These cathodes are supported on each other and the lead-in connectors 13 by straps 46, 47 and 48, which also provide electrical connections to the sleeves 45 and 46 and the cylinder 43 respectively, the strap 49, which by means of the glass bead 50 is electrically isolated from the cathode sleeve 45, and ceramic spacers 52, for example rings, which center sleeve 44 in sleeve 45 and cylinder 43 in sleeve 44. The intimate mechanical relationship of the cathode bodies 43, 44 and 45 when supported in this manner enables high emission to be attained from each cathode without the necessity for individual heaters. Thus, in the gun of Fig. 1, one heater 55 which may be in the form of a helix of suitably insulated high resistance wire mounted concentric with the sleeve 45 and enclosed in an annular compartment formed by auxiliary sleeve 56 on sleeve 45, heats the sleeve 45 directly and by radiant heat the adjacent sleeve 44 and cylinder 43 so that all are at a sufficiently high temperature to provide copious thermionic emission from the surfaces 40, 41 and 42.

Electrically, the gun of Fig. 1 is arranged so that the outer and inner cathodes 40 and 42 are connected to the negative terminal of the battery 95 by means of lead 53, strap 46 and strap 48. The intermediate cathode 41 is held at a somewhat higher potential relative to the accelerating electrodes than the cathodes 40 and 42 by the battery 95 connected thereto through the lead 54 and the strap 47 thereby producing a slower stream of electrons intermediate those streams from the cathodes 40 and 42.

An accelerating electrode 57 is mounted immediately ahead of the cathodes 40, 41 and 42 on a metallic ring 58 which in turn is secured to a metallic annulus 59 of Kovar or other metal which can be conveniently sealed to glass. This annulus is sealed between the tubular glass section 60 and the enlarged base portion 61 of the tube 17, and serves as a conductor from the battery 62 through the lead 63 to the accelerating electrode. The collar 30, as pointed out heretofore, is held at the collector potential by the battery 64 which is connected to the collector lead-in 20 and the collar lead-in 19 by the parallel leads 66 and 67. Thus substantially all the acceleration of the electron beams due to the direct-current potential of the batteries 95, 62 and 64 take place in the space between the cathode and the ring 30.

While the embodiment of the gun of Fig. 1 produces three concentric electron streams, or two intermingled streams, traveling at different speeds down the length of the tube 17, for some applications two concentric streams may be desirable. Figs. 3, 4, 5 and 6 disclose double cathodes for single heater electron guns suitable for incorporation into a device such as that shown in Fig. 1.

The cathode structure illustrated in Figs. 3 and 4 comprises a concentric metal sleeve 70 and metal cylinder 71, the ends of which are coated with a suitable thermionic emissive material to produce cathode surfaces 72 and 73. Depending from the sleeve 70 and enclosing the helical heater 74 concentric therewith is a second metal sleeve 75. This sleeve in combination with the intimate relationship between the sleeve 70 and the cylinder 71 concentrates the heat produced by heater 74 and enables sufficient heat transfer to take place between the cathode structures to

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provide suitable thermionic emission from both surfaces while employing only a single heater.

The accelerating electrode 76 and the heater and cathode leads are shown in schematic form in Fig. 3 it being understood that the assemblage could be supported in an envelope in a manner similar to the gun assembly 12 of Fig. 1. This gun is arranged so that the inner beam is of higher speed than the outer beam by putting a higher potential differential between the accelerating electrode 76 and the cathode 73 than exists between the electrode and the cathode 72, this being done by placing batteries 77 and 78 in series between the cathode 73 and electrode 76, and only battery 78 between cathode 72 and electrode 76. Battery 79 supplies power for the heater 74.

The embodiment of Figs. 5 and 6 differs from the structure of Fig. 3 in that the cathodes are formed in a pair of coaxial cylindrical emissive surfaces 80 and 81, one on the end of a central cylinder 82, and the other on the wall of the aperture 83 in the closed end of the double-walled sleeve 84, the outer wall 85 of which forms the housing for the heater 86. Here again, the battery 87 provides the power for the heater and the batteries 88 and 89 establish the accelerating potentials between the accelerating electrode 90 and the cathodes.

What is claimed is:

30 1. An electron gun comprising a first cathode having an annular end wall and spaced inner and outer cylindrical members extending from said wall, an electron emissive coating on said first cathode, a heater element between said inner and outer members, and a second cathode heated solely by radiation from said first cathode and having an electron emissive end portion adjacent said end wall, said second cathode being mounted in proximity to and encompassed by said inner member.

45 2. An electron gun comprising a first cathode having an annular end wall and spaced inner and outer cylindrical members extending from said wall, an electron emissive coating on said end wall, a heater element between said inner and outer members, a second cathode heated solely by radiation from said first cathode and having an electron emissive end portion adjacent said end wall, and a third cathode mounted within and heated solely by radiation from said second cathode and having an electron emissive end portion adjacent said second emissive surface, said second cathode being mounted in proximity to and encompassed by said inner member and said third cathode being mounted in proximity to and encompassed by said second cathode.

50 3. An electron gun comprising a plurality of closely adjacent cylindrical cathode members mounted one within another, said members having substantially coplanar faces at one end thereof, electron emissive coatings upon said faces, and means for heating said coatings consisting of a heater element encompassing the outermost of said members.

65 4. An electron gun comprising a pair of cylindrical cathode members arranged in intimate heat transfer relationship and mounted one within the other in spaced substantially coaxial relation, insulating spacers between the adjacent cathode members and adjacent the end of the inner cathode member, electron emissive coatings at one end of each of said members, the coated ends being in proximity to one another, a single heater filament for the cathode members, said filament encompassing the outermost

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cathode member, and heat shield means encompassing said filament.

5. An electron gun comprising a first metallic cathode member having a cylindrical recess in one end thereof, an electron emissive coating on the cylindrical wall of said recess, a second metallic cathode member disposed about said first cathode member and having at one end thereof a cylindrical aperture, opposite, coaxial with and of greater diameter than said recess, an electron emissive coating on the cylindrical bounding wall of said aperture, and a single means for heating said cathode members.

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