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SPLIT CATHODE MULTIPLIER TUBE

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ATTORNEYS.
My invention relates to electron multiplier tubes, and more particularly to that type of electron multiplier where electrons are directed to successively impact surface elements to produce a current augmented by secondary emission at each impact.

This application is related to my prior application, Serial No. 80,194, filed May 16, 1935, for a “Means and method for producing electron multiplication” and is also a companion application to my application, Serial No. 132,325, filed March 22, 1937, for a “Split cathode multiplier”, filed simultaneously with the present application.

The present application deals solely with the structure of the multiplier tube, whereas the companion application referred to above claims only the method and system utilized in operating the tube.

Electron multipliers have been roughly divided into two general types. First, the so-called d-c multiplier, where the generation of secondaries takes place by successive impact of an electron stream with a series of emitting elements energized to successively increasing steady potentials; and second, that type of multiplier where repeated impacts are made between a pair of oppositely charged surface elements energized by alternating potentials in proper phase to produce successive impacts.

These two types of multiplier tubes have required totally different physical constructions, but I have found that there are constructions which will separately or simultaneously produce multiplication in either one or both of the modes outlined above.

Among the objects of my invention are: to produce a multiplier tube structure which may be energized with either alternating current, direct current, or both, separately or simultaneously; to provide an electron multiplier tube wherein the electrodes are angularly related in such a manner as to ensure proper electron paths without the necessity of utilizing separate guiding fields; to provide an electron multiplier having conical electrodes; to provide an electron multiplier having input and output electrodes separated by an electron multiplying structure; to provide an electron multiplier tube wherein input and multiplying elements have certain angular relationships; to provide an electron multiplier having a vertical cathode; and to provide a simple, efficient and compact electronic tube structure which is capable of, when properly energized, performing electron multiplication, radio frequency detection, modulation, radio-frequency amplification, and self-oscillation.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

In the drawing, the figure is a longitudinal sectional view of a preferred form of my novel multiplier tube, together with a schematic circuit diagram, indicating one manner in which the tube of my invention may be utilized.

Referring to the drawing, an envelope 1 is provided at one end with a reentrant stem 2. Passing through the stem 2 are a pair of heater leads 4 supporting a heater coil 5, which is of high resistance material, such as tungsten, for example, and which may be raised to incandescent by the passage of current therethrough.

I prefer to form this coil in the shape of a conical spiral. Surrounding the heater coil 5 is a conical electron input source 6, supported by a lead 7, and closed at the open end by an insulator 9 through which heater leads 4 may pass. The source 6 is preferably of metal, and is preferably covered on the outside with a good electron emitter, such as barium and strontium oxides. I prefer, in the embodiment shown, that the longitudinal section of the cone exhibit a cone angle of approximately 23 degrees.

Surrounding the conical electron source, I position a conical grid 10, having the same sectional angle as the cathode, coaxial with and spaced slightly from the source surface. This grid may be in the usual form of a spiral refractory wire wound on supports, or it may be any other apertured control electrode, as is well known in the art.

The side walls of the envelope 1 are utilized to support a pair of secondary emission ring cathodes 11 and 12, these two cathodes being placed one above the other and shaped to describe a truncated cone, the small end of which surrounds an apical portion of the grid structure just described. The lower cathode 11 is supported from the side wall by leads 14 and 15, and the upper cathode 12 is supported in like manner by leads 16 and 17. Leads 15 and 17 are brought entirely through the side walls to afford electrical connection to the two cathodes. The larger cathode 12 is preferably of greater axial length than the smaller.

The large end or base of the truncated cone described by the cathodes is surrounded by a 55
shield 20 provided with a central aperture 21, the entire shield being supported on support wires 22 and 24, the latter passing through the side walls of the tube for electrical connection. The aperture 21 is closed by a relatively coarse meshed output screen 25, and extending downwardly, attached to the shield 20, is an accelerating anode 26 formed of relatively fine meshed screen shaped into a truncated cone positioned coaxially with relation to cathodes 41 and 12, and having the side walls relatively close to the inner surface of the cathodes. The accelerating anode extends the full length of both cathodes, and I prefer to form the body of the accelerating anode of small diameter wire, so that the total aperture area is greater than the total wire area. Just above the output screen 25 I position a collecting anode 27, supported from the end of the tube by lead 29, passing through the wall of the envelope. I prefer to shape collector 27 to have a concave surface presented to the aperture screen, and to stiffen its edge by rolling a flange 30 thereon. The concave surface is preferably treated to prevent secondary emission, and for this purpose may be carbonized if desired. I prefer, when the angle of the input source is approximately 25 degrees or less, to make the angle of the secondary emissive cathode approximately 25 degrees, and, as can readily be seen in the drawing, the angles are opposite. The final step in the processing of the tube I have just described is the sensitization of cathodes 11 and 12 to be secondarily emissive when impacted by an electron traveling at the proper speed. As it is advantageous to obtain as many secondaries as possible from one electron impact, I prefer to sensitize the inner surface of the cathodes 11 and 12 with materials of extremely low work function for secondary emission, such as, for example, caesium or caesium on silver oxide, processed to have as high a secondary emission function as possible. I have found that a caesium-silver oxide surface may be processed to give a high secondary electron generation impact, and when similarly treated. A coaxial cone shaped electron generating surface having its apex entering the small end of said anode 26, and through the opposite apertures of the anode to impact the second cathode 12, which is also secondarily emissive. The secondaries emitted from the second cathode 12 are accelerated back into the space inside of anode 26, and out of the space through output screen 25 and are then drawn to collecting electrode 27. Inasmuch as all anode and secondary cathode potentials remain constant, the number of electrons reaching collecting electrode 27 is a function of the number which pass through grid 10 at the input end of the device. As I have been able to obtain an emission of ten or twelve secondaries at each impact, and as the aperture areas in anode 26 are relatively large, I have been able to obtain a net secondary generation of more than six electrons per impact. It should be noted that the angles involved are such that when electrons leave cathode 6 they take an upward direction to impact first secondary cathode 11, and that when they leave this cathode the angle is such that they will be certain to impact the second cathode 12, as they follow radial perpendicular to the emitting surface. There will thus be but one impact per cathode, and therefore, when used in this manner all secondary generating impacts, and cone angles and sizes may be arranged to insure arrival of secondaries on the next larger cathode ring. The tube herewith described can be used not only with direct energization of the cathodes 11 and 12, but will operate equally well with alternating current on the cathodes. Inasmuch as the circuits form no part of the instant invention, reference should be made to the companion application, mentioned above, for information regarding additional circuits in which the tube of the instant invention may be employed. I claim:

1. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, electron generating means positioned adjacent the small ends of said cones, and electron collecting means adjacent the large end of said cone.

2. An electron tube comprising an envelope containing a fine mesh screen anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, electron generating means positioned adjacent the small ends of said cones, and electron collecting means adjacent the large end of said cone.

3. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, a coaxial cone-shaped electron generating surface having its apex entering the small end of said anode, and...
electron collecting means adjacent the large end of said cone.

4. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, a coaxial cone-shaped electron generating surface having its apex entering the small end of said anode, a coaxial cone-shaped control electrode surrounding said electron generating surface, and electron collecting means adjacent the large end of said cone.

5. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, a coaxial cone-shaped electron generating surface having its apex entering the small end of said anode, and a coaxial cone-shaped control electrode surrounding said electron generating surface the anode cone angle being greater than the angle of the electron generating surface.

6. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, a coaxial cone-shaped electron generating surface having its apex entering the small end of said anode, and a coaxial cone-shaped control electrode surrounding said electron generating surface, the angles of all of said cones being between 20° and 30°.

7. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, a coaxial cone-shaped electron generating surface having its apex entering the small end of said anode, a coaxial cone-shaped control electrode surrounding said electron generating surface, the anode cone angle being approximately 28° and the cone angle of said electron generating surface being approximately 23°, and electron collecting means adjacent the large end of said cone.

8. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, electron generating means positioned adjacent the small ends of said cones, an apertured shield across the large end of said anode, and a collecting electrode positioned above said shield.

9. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, electron generating means positioned adjacent the small ends of said cones, an apertured shield across the large end of said anode, and a collecting electrode presenting a concave face to said shield.

10. An electron tube comprising an envelope containing an apertured anode shaped as a hollow truncated cone, a plurality of electrically separate cathode rings surrounding said anode and mounted one above the other to define a truncated cone coaxial with said anode and of substantially the same extent, electron generating means positioned adjacent the small ends of said cones, an apertured shield across the large end of said anode, and a collecting electrode being spaced from said shield a greater distance than that between said rings and said anode.

11. An electronic tube comprising an envelope containing cathodes comprising a plurality of superimposed rings describing a truncated cone, electron generating means adjacent the small end of the described cone, electron collecting means adjacent the large end of said cone, and a coaxial accelerating electrode enclosed by said rings.

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