April 30, 1957 D. A. JENNY 2,790,922

ELECTRON MULTIPLIER TUBE

Filed March 30, 1953 2 Sheets-Sheet 1

Fig. 1.

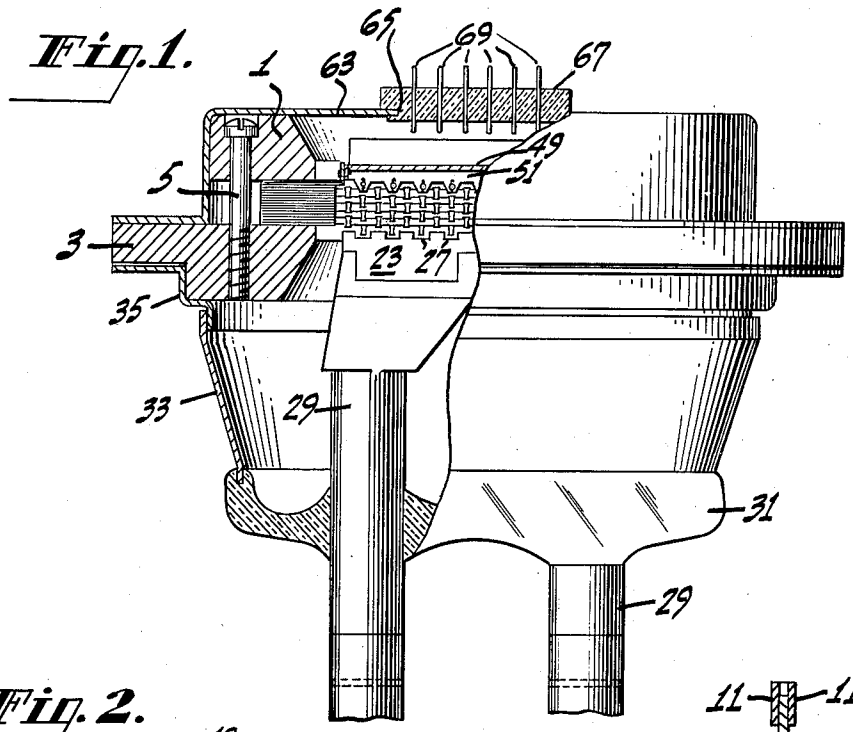


Fig. 2.

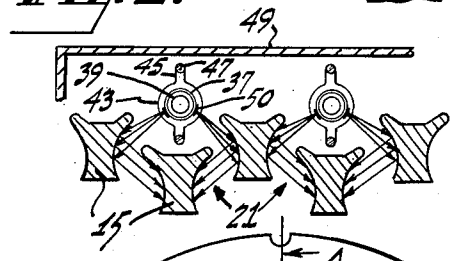
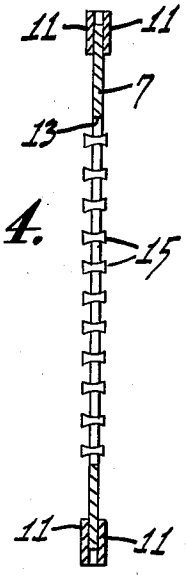


Fig. 4.



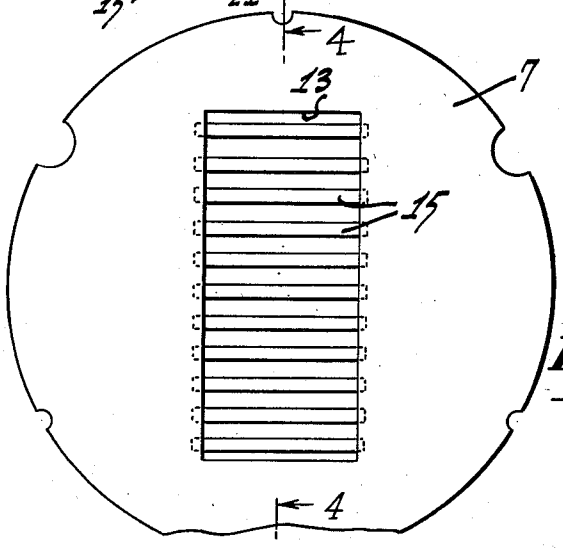


Fig. 3.

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April 30, 1957 D. A. JENNY 2,790,922

ELECTRON MULTIPLIER TUBE

Filed March 30, 1953 2 Sheets-Sheet 2

Fig. 5.

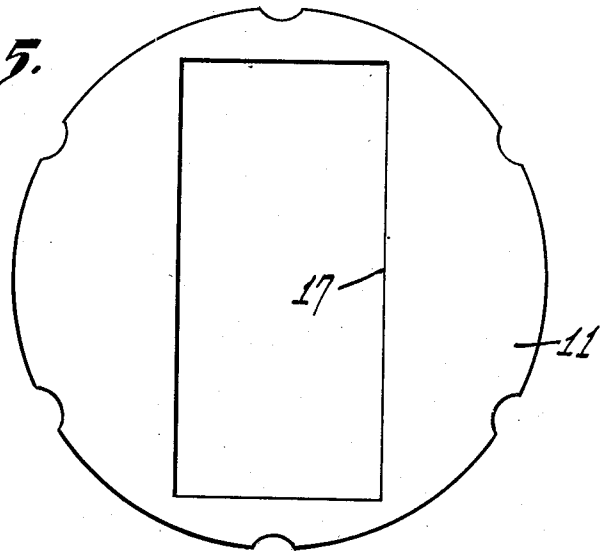
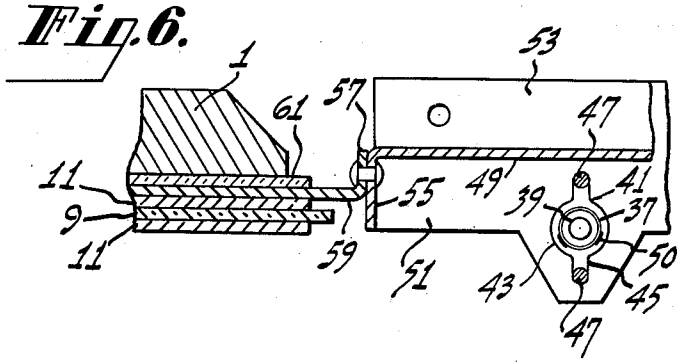


Fig. 6.



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ELECTRON MULTIPLIER TUBE

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Application March 30, 1953, Serial No. 345,301

10 Claims. (Cl. 313—105)

The present invention relates to an improved electron multiplier device or tube, particularly suitable for use as a power tube for translating, amplifying, generating and/or controlling radio frequency power at frequencies above 100 megacycles.

The principal object of the invention is to provide a power electron multiplier tube having an improved input system which reduces transit time effects at high frequencies.

Another object is to provide an improved amplifier tube especially adapted for use at high frequencies.

The invention provides an electron multiplier tube comprising an array of electron multiplier or dynode elements providing a plurality of discrete channels and a plurality of input cathode-grid structures or units mounted adjacent the entrances to the channels to direct a stream of primary electrons into each channel. An embodiment will be described and illustrated, by way of example, in which the primary streams for two adjacent multiplier channels are supplied by a single cathode-grid unit. However, it will be understood that a separate cathode-grid unit may be provided for each channel if desired.

The invention will be illustrated with the type of multiplier structure disclosed and claimed in a copending application of Russell R. Law, Serial No. 43,851, filed August 12, 1948, now Patent No. 2,674,661, dated April 6, 1954, assigned to the same assignee as the present application, but it will be understood that the improved input structure can be used with other types of multiplier structures without departing from the spirit of the present invention.

In the drawing:

Fig. 1 is a longitudinal sectional view of an electron multiplier tube embodying the invention;

Fig. 2 is an enlarged detail sectional view showing two of the cathode-grid units and the adjacent dynode elements defining the entrances of four of the multiplier channels;

Figs. 3 and 4 are plan and sectional views of a dynode supporting disc;

Fig. 5 is a plan view of a spacer disc used in the dynode assembly; and

Fig. 6 is a detail view showing a portion of the cathode-grid structure and its supporting means.

Referring to Fig. 1, the tube includes a pair of heavy copper rings 1 and 3 between which are clamped, by bolts 5, a stack of metal dynode-supporting discs 7 separated by insulating mica discs 9 and metal spacer discs 11. As shown in Figs. 3 and 4, each disc 7 has a rectangular aperture 13 across which are mounted a row of metal dynode elements 15 in spaced, parallel relation. The spacer discs 11 have rectangular apertures 17 which are larger than the apertures 13. Each disc 7 is sandwiched between two spacer discs 11, and each such group of three discs is insulated from the next group by a mica disc 9. The mica discs 9 have rectangular apertures smaller than the apertures 13 in the spacer discs 11 to provide long leakage paths between the metal discs. The dynode

elements of adjacent rows are staggered, as shown in Fig. 1 and in the enlarged view of Fig. 2, with the elements of alternate rows in alignment, to provide a plurality of parallel, discrete, electron multiplier channels 21 each having as many secondary emission stages as there are transverse rows of elements. Each of the dynode elements 15 is roughly rectangular in cross section with inwardly curving secondary emitting surfaces to provide a suitable electric field for directing the secondary electrons from element to element in each channel. In the tube shown, the output of the tube is taken from two collector electrodes 23 mounted adjacent the outer side of the last row of dynode elements 15, preferably with transverse grooves 27 in which portions of the last dynode elements are located. The collector electrodes are mounted on metal lead-in and supporting rods 29 sealed through an insulating disc 31. A pair of metal rings 33 and 35 are sealed between the heavy ring 3 and the disc 31 to form part of the tube envelope.

The structure described so far is substantially identical with that shown in Fig. 10 of said copending Law application. In said application the input structure included a single cathode and means for deflecting the beam of primary electrons therefrom between one half and the other half of the multiplier structure, to produce push-pull output from the two collector electrodes. This type of input structure involves appreciable transit time effects, particularly at very high frequencies, due to the unequal distances between the center of deflection and the different portions of the electron multiplier, and also due to the differing path lengths of electrons over the beam cross-section between the focal points of the beam, which limit the effectiveness of the tube.

In accordance with the present invention, an input structure, comprising a separate cathode or emitting surface and closely-spaced control grid, is mounted near the entrance of each multiplier channel, or pair of adjacent channels.

In Fig. 1, there are eight multiplier channels in each half of the multiplier section, fed by four input cathode-grid structures for each half. As shown best in Fig. 6, each input structure comprises a cathode sleeve 37 indirectly heated by an internal heater wire or coil 39 and a wire wound control grid 41. The cathodes and grids extend along the dynode elements 15 and are mounted in front of the dynode elements of the second row and between those of the first row. In transverse section, the grid 41 comprises a central circular portion 43, concentric with the cathode sleeve 37 and closely and uniformly spaced therefrom, and two outwardly-extending end portions or loops 45 through which a pair of grid support rods or wires 47 extend. A reflector electrode 49 in the form of a flat metal plate is mounted close behind the cathode-grid structures to direct the primary electrons from each cathode 37 toward the first dynode element 15 of each channel. If desired, due to the provision of the reflector electrode 49, the entire surface of the cathode sleeve 37 may be coated with conventional electron emitting oxides. However, it is preferable to coat only those surfaces 50 of the cathode sleeve 37 which face toward the multiplier channels, to conserve input power by eliminating unnecessary grid current.

The eight cathode-grid structures are supported at their ends by two mica plates 51 which are attached to outwardly extending flanges on the reflector plate 49. The plate 49, as shown in Fig. 6, is mounted by means of end flanges 55 attached to lateral flanges 57 extending along the short sides of a rectangular aperture in a metal disc 59 which is similar to the dynode element supporting discs 7 and is also clamped between the heavy rings 1 and 3. A mica disc 61 insulates the disc 59 from the ring 1.

The envelope of the tube is completed by a cup-shaped metal member **63** soldered or welded to the heavy ring **1** and having a central aperture **65** in which is sealed a glass plate **67**. At least six leads **69** are sealed through the glass plate **67** for connection to the cathodes **37**, heaters **39**, grids **41**, and reflector electrode **49**. All of the cathodes **37** are connected together and to a single lead **69**. The grids **41** are connected together in two groups with separate leads, one for each half of the multiplier section, to permit push-pull operation of the tube. However, it will be understood that the tube may be used as a simple amplifier with all of the grids connected together, internally or externally, for high power operation with the sixteen multiplier channels in parallel. Direct current leads for applying successively increasing positive potentials to the different rows of dynode elements **15** may be led out through the glass plate **67**, or in any other conventional manner.

As an example, in operation the tube electrodes may be provided with direct current bias potentials as follows: cathodes —1500 v.; grids, —1 to 10 volts negative with respect to the cathodes; reflector, about —1800 volts, adjustable to produce maximum input efficiency; first dynodes, —1200 volts; last dynodes, zero volts (ground); collectors, several hundred to several thousand volts positive; and intermediate dynodes, suitable negative potentials between —1200 and zero volts, depending upon the number of rows or stages of secondary emission used.

The input system of the invention reduces the transit time effects, in the tube as compared to a single cathode-deflection input system, or a single cathode-single grid input structure for all of the multiplier channels, by providing short and uniform electron paths between the cathodes and associated grids and also between the grids and the first dynodes.

What I claim is:

1. An electron tube comprising an anode, means including a plurality of electron-emitting cathodes spaced from said anode for producing a like number of primary electron streams, a control grid disposed closely adjacent to each cathode for modulating each stream, and at least one separate electron multiplier section disposed in the path of each stream in the space between said grids and said anode.

2. An electron multiplier tube comprising a plurality of electron-emitting cathodes, a plurality of control grids each positioned closely adjacent to one of said cathodes, an electron multiplier adjacent to said grids and including a plurality of dynode elements providing a plurality of discrete electron multiplier channels, at least one channel for each cathode, and an anode in position to receive secondary electrons from all of said multiplier channels.

3. A tube as in claim 2, wherein each multiplier channel includes at least three dynode elements.

4. A tube as in claim 2, wherein each of said cathodes is located near the entrances to two adjacent multiplier channels in position to supply primary electrons to both channels.

5. A tube as in claim 2, further including reflector electrode means located on the opposite side of each cathode from said electron multiplier.

6. A tube as in claim 2, wherein said cathodes and dynode elements are arranged in parallel rows with adjacent rows staggered to provide zig-zag electron paths through said channels to said anode.

7. A tube as in claim 6, wherein each of said dynode elements comprises a pair of oppositely-facing concave surfaces forming secondary electron emitting surfaces of two adjacent electron multiplier channels.

8. A tube as in claim 6, further including a reflector electrode parallel to said row of cathodes and located on the opposite side of said cathode from said dynode elements.

9. A tube as in claim 2, wherein each cathode comprises an elongated cylindrical sleeve containing a heater element and each control grid comprising an elongated wire-wound grid having a transverse cross section including a circular portion concentric with and closely and uniformly spaced from one of said cathodes.

10. A tube as in claim 9, wherein said transverse cross-section of each of said grids further includes outwardly-extending support portions located outside the paths of primary electrons from said cathode to said channel.

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