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ELECTRODE STRUCTURE FOR VELOCITY MODULATION TUBES

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FIG. 1.

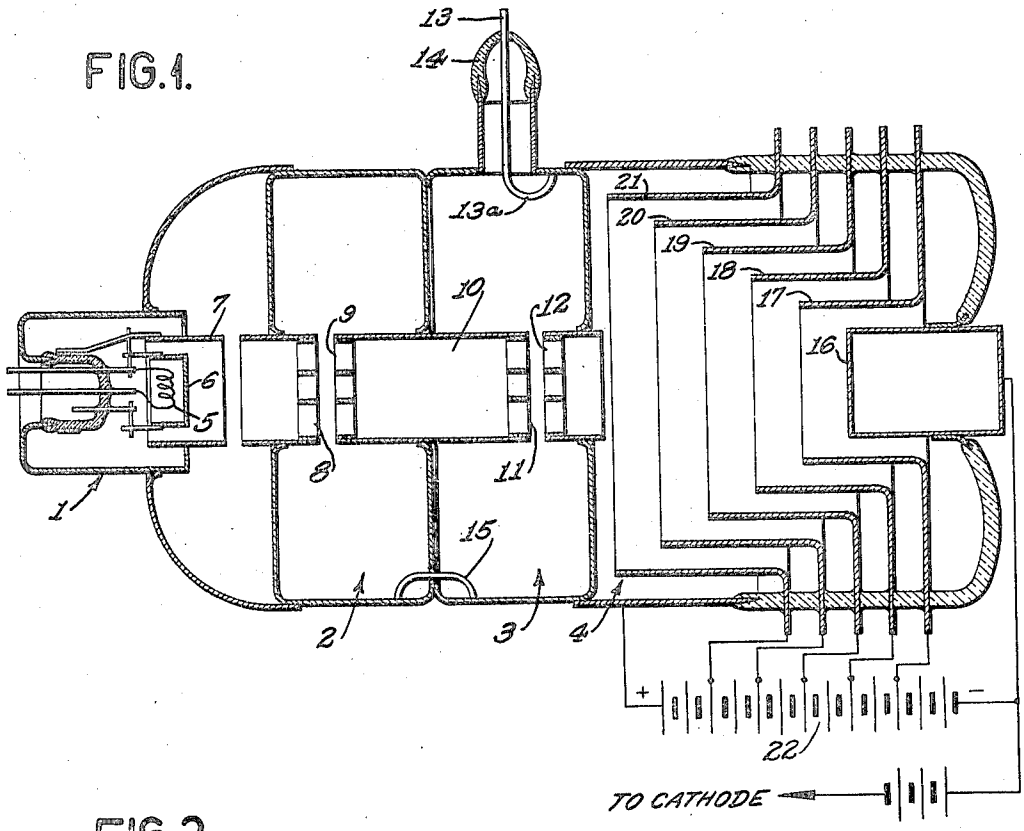
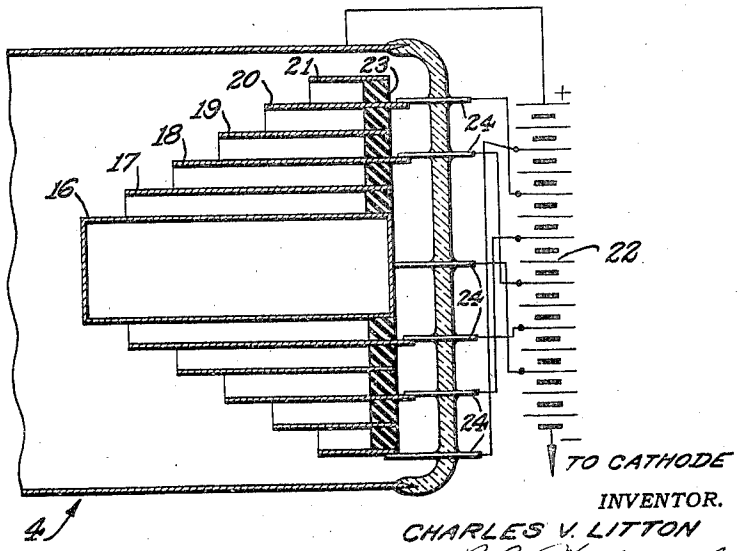


FIG. 2.



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ELECTRODE STRUCTURE FOR VELOCITY MODULATION TUBES

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11 Claims. (Cl. 250—27)

The present invention relates to vacuum tubes and more particularly to vacuum tubes for ultra-high frequency operation known as velocity modulation tubes wherein a stream of electrons is accelerated longitudinally for the purpose of generating or amplifying high frequency oscillations.

In known forms of velocity modulated tubes a collector electrode is provided in the path of the electron stream to collect the electrons after they have passed grouping and extracting electrodes. It has hitherto been common practice to form this collector electrode as a single electrode or plate and as such it has been necessary to absorb and dissipate the impact energy of all the electrons at a single electrode.

It has heretofore been proposed to provide a strongly positive cylindrical collector electrode with a coaxial ring of still higher positive potential in front of it and a negatively biased central needle-like "splitter" electrode within. In such structures, however, the splitter serves only to produce a diverging field and collects substantially no electrons, while the outer ring serves merely to receive secondary electrons emitted from the cylindrical collector. Thus only the cylindrical electrode of such structure serves as a collector of the main primary electron stream.

The electrons in the electron stream are traveling at different speeds as they approach the collector electrode. The slower moving electrons tend to follow a curved path away from the center of the stream under the influence of electron repulsion, while the high speed electrons tend to follow a straight line path along the axis of the stream or parallel to the axis. The potential applied to the collector electrode must be sufficiently high to insure that none of the slow moving electrons are stopped before reaching the collector and it also should be as low as possible to regain the greatest possible amount of energy from the high speed electrons by decelerating these almost to zero velocity. These two potential requirements conflict; and in an ordinary single-collector type of tube the potential applied to the collector electrode must usually be chosen according to the former requirement.

According to one feature of my invention the collector electrode consists of a plurality of electrodes having their major surfaces substantially parallel to the axis of the electron stream, each of said electrodes being positioned or biased to collect the electrons from said stream. The ends of these electrodes facing the electron stream preferably terminate in a single plane perpendicular to the axis of the electron stream but the electrodes may terminate in planes spaced toward or away from the electron source.

According to a further feature of my invention the collector electrode comprises a plurality of coaxial electrodes of successively increasing diameters arranged in the path of said stream. Where this type of construction is used increased electrode area and hence increased electron absorbing and heat dissipating area may be obtained.

According to a further feature of my invention, successively higher positive potentials are applied to the electrodes of successively increasing diameters, the electrode of smallest diameter having the lowest positive potential. With this distribution of potentials it is possible to attract electrons of different speed to different electrodes and thereby increase the efficiency of operation of the tube.

According to a further feature the different potentials applied to the different collector electrodes are such that the electrons directed to each electrode are brought to a low velocity before reaching such electrode whereby the maximum amount of energy is recovered from the electrons. Thus, for example, the electrode which is to receive the fastest electrons may have a potential approximating that of the cathode so as to bring these fastest electrons nearly to rest before they strike. Similarly, the electrode for receiving those electrons which emerge from the grouping and extracting portion of the tube with very low velocities may have a potential approximately equal to that of the last extracting electrode so as not to stop these slow electrons in transit.

The grouping and extracting electrodes of a velocity modulated tube are desirably operated at a positive potential with respect to the collector electrode.

Electrons striking the collector electrode may have sufficient velocity to dislodge secondary electrons, and these secondary electrons may be attracted to the grouping and extracting electrodes and may unduly heat these electrodes or adversely affect the tube oscillations.

According to a further feature of my invention the collector electrode comprises a plurality of coaxial electrodes of successively increasing diameters arranged in planes spaced in the direction of the electron source, the electrode of largest diameter being nearest the electron source. Secondary electrons leaving the electrodes of smaller diameters, the electrodes from

which secondary electron emission is most likely to occur, are attracted to the electrodes of larger diameters by means of potentials increasing positively from the electrode of smallest diameter to the electrode of largest diameter.

Other objects and advantages of my invention will be apparent from the particular description thereof made in connection with the accompanying drawing, in which:

Fig. 1 illustrates a preferred arrangement of a velocity modulated tube employing a collector electrode of my invention;

Fig. 2 illustrates a portion of a velocity modulated tube and a collector electrode constructed in accordance with my invention.

A sectional view of a velocity modulated tube incorporating a collector electrode of my invention is shown in Fig. 1. This tube comprises a cathode assembly 1, a grouping grid and circuit assembly 2, an extracting grid and circuit assembly 3, and a collector electrode 4. The cathode comprises a filament 5 which is preferably non-inductively wound, an indirectly heated cathode 6, and a potential distributing shield 7. Electrons from the indirectly heated cathode 6 pass through bunching grids 8 and 9, drift column 10, and extracting grids 11 and 12, and are finally collected by the collector electrode 4. Circuits 2 and 3 are commonly tuned to the operating frequency of the tube. The output of the tube is taken from circuit 3 by means of loop 13a connected to the lead 13 sealed to the tube by seal 14. Feedback between the circuits 2 and 3 in the case of an oscillator may be obtained by means of the conductor 15. The details of operation of velocity modulated tubes of the type shown are well known, and no further description of the operation thereof is necessary.

According to my invention the collector electrode 4 comprises a plurality of coaxial electrodes 16, 17, 18, 19, 20 and 21 of successively increasing diameters arranged in the path of electrons emitted from the cathode 6. As shown, these coaxial electrodes may be cylinders of copper or tantalum with flanged ends which extend through the wall of the tube. The flanged ends may extend a considerable distance beyond the wall of the tube so that they may be employed as cooling fins or they may terminate at the wall of the tube. It is also possible to separate the cylinders by insulation and mount them as a unitary structure without the flanged ends, the electrodes in this case being supported in the tube by lead wires or other separate supports. It is also possible to form the collector electrode of a plurality of coaxial annular plates or coplanar cylinders or of a plurality of parallel flat or L shaped plates having their major surfaces substantially parallel to the axis of the electron stream, but in the preferred form the collector electrode is formed by a plurality of cylinders displaced in the manner shown in Fig. 1, since improved results are obtained by this type of construction.

After the electron stream passes through the grids 11 and 12, the slow speed electrons which follow a diverging path will strike against the electrodes 18, 19, 20 and 21, and the high speed electrons will strike against the electrodes 16 and 17. As a result the electrons are distributed over a number of surfaces and the power handling capacity of the tube is increased. Water cooling may also be employed with the electrodes to aid in dissipating the heat arising from the impact of the electrons.

Although electrons will tend to strike different electrodes due to their differences in speed, the electrons may be distributed more widely by the application of suitable potentials to the individual electrodes. According to a further feature of my invention successively higher positive potentials from a source 22 are applied to the electrodes 16, 17, 18, 19, 20 and 21 of successively increasing diameters, the electrodes 16 of smallest diameter having the lowest positive potential.

Each of the collector electrodes of differing potential preferably receives principally those electrons whose velocity has such value that they will just strike such electrode with a small kinetic energy. Thus the most positive collector electrode should receive principally the low velocity electrons. The positioning of the electrodes with the most positive one farthest out from the axis of the stream produces such a condition. Thus the highest possible recovery of energy from each of the different classes of electrons is effected. The positioning shown in Fig. 1 with the innermost, most negative electrode farthest from the cathode is particularly advantageous since it insures a more reliable collection, by the more positive outer electrodes of any electrons which may approach the central electrode but may have insufficient velocity to reach the latter.

A further advantage of the arrangement is that the electrons diverge more widely from the axis of the tube, and fewer electrons strike the electrode 16. This latter result has the advantage that the electrode 16 which receives the high speed electrons becomes less hot, and hence the rating of the tube may be increased.

The above manner of applying potentials to the electrodes has the further advantage that secondary electrons emitted from electrodes such as 16 and 17 are almost entirely absorbed by the electrodes 18, 19, 20 and 21. The secondary electrons are thus prevented from reaching the grids 11 and 12 and the resonant circuit 3. Due to the small difference in potential between adjacent electrodes, only a small amount of energy is lost due to the absorption of the electrons.

Fig. 2 illustrates a modification of the collector electrode of Fig. 1. This electrode is substantially the same as that in Fig. 1, except that the electrodes 16 through 21 are coaxial cylinders separated by insulation 23 and supported by the leads 24. In this embodiment the electrodes of successively increasing diameters are arranged in planes spaced in a direction away from the electron source. Although this type of electrode construction is not as efficient in collecting secondary electrons as the structure shown in Fig. 1, it is desirable because of a saving in electrode material. The electrodes of successively increasing diameters are shorter in length and although the surface area is decreased it may be noted that the larger diameter electrodes collect the slow speed electrons and hence it is not necessary that these electrodes dissipate as much heat as the electrodes of smaller diameter.

While I have described particular embodiments of my invention for purposes of illustration, it will be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

What is claimed is:

1. A velocity modulated tube comprising a cathode, means for grouping electrons from said cathode, means for extracting energy from said electrons, and a collector electrode arranged in the path of said electrons for collecting said elec-

trons comprising a plurality of open-ended, generally cylindrical, coaxial electrodes having their major surfaces substantially parallel to the axis of said path and successively spaced from said axis, each of said electrodes being adapted to collect said electrons.

2. A collector electrode according to claim 1 wherein said electrodes are overlapping.

3. A velocity-modulated device according to claim 1, further comprising means for applying successively differing potentials to said electrodes.

4. A collector electrode according to claim 1, further comprising means for applying successively differing potentials to said electrodes, said potentials being applied successively higher positively to the electrodes of successively increasing diameter, the electrode of smallest diameter having the lowest potential.

5. A velocity-modulated tube comprising a cathode, means for grouping electrons from said cathode, means for extracting energy from said electrons, and means for collecting said electrons comprising a plurality of coaxial electrodes of successively increasing diameters arranged in the path of said electrons in planes spaced in the direction of said cathode, the electrode of largest diameter being nearest the cathode and each of said electrodes being adapted to collect electrons from said stream.

6. A velocity-modulated tube comprising a cathode, means for grouping electrons from said cathode, means for extracting energy from said electrons, and means for collecting said electrons comprising a plurality of coaxial electrodes of successively increasing diameters arranged in the path of said electrons and in planes spaced in a direction away from said cathode, the electrode of smallest diameter being nearest the cathode and each of said electrodes being adapted to collect electrons from said stream.

7. In a velocity-modulated tube having a cathode, means for grouping electrons from said cathode, means for extracting energy from said electrons, and an envelope having a wall portion, means for collecting electrons from said cathode comprising a plurality of coaxial cylinders of successively increasing diameters arranged in the path of said electrons and in planes spaced in the direction of the cathode, the electrode of largest diameter being nearest the cathode, and annular flanges attached to the ends of said cylinders remote from said cathode and extending through the wall portion of said tube.

8. A collector electrode structure for collecting electrons from a beam of electrons, said structure including a plurality of open-ended, coaxial, generally cylindrical electrodes of successively increasing diameters arranged in the path of said electrons and also spaced generally longitudinally with respect to the electron path, and means for electrically interconnecting said cylindrical electrodes.

9. A collector electrode structure according to claim 8, in which said electrodes are disposed in cascade, the electrode of smallest diameter being first met by said beam of electrons.

10. A collector electrode structure according to claim 8, in which said electrodes are disposed in cascade, the electrode of smallest diameter being the last of said electrons intercepted by said beam along the axis of said beam.

11. A collector electrode structure according to claim 8, in which successive electrodes of said structure are impressed with successively increasing positive potentials.

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