March 22, 1949. B. C. GARDNER 2,464,801

VELOCITY MODULATED ELECTRON-DISCHARGE DEVICE

Filed April 23, 1946

FIG. 1.

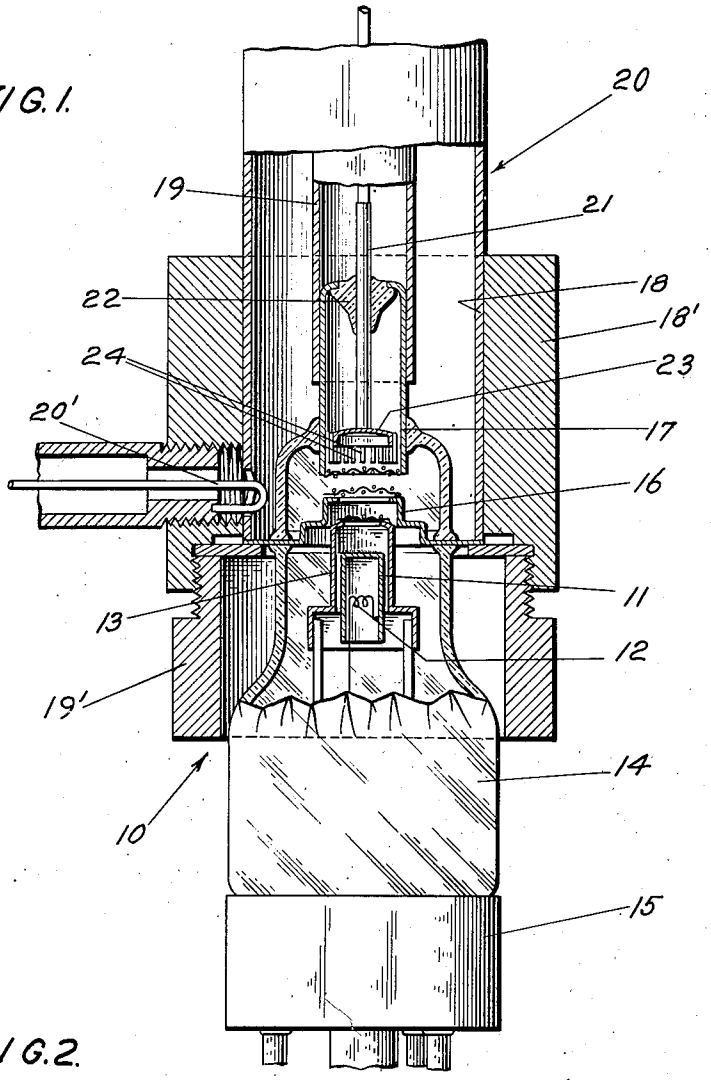


FIG. 2.

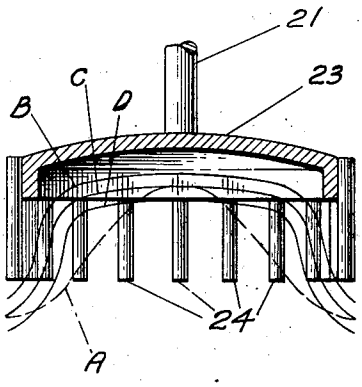
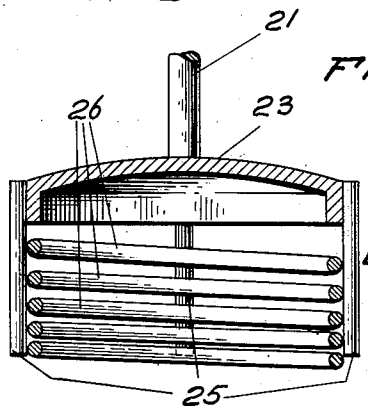


FIG. 3.



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VELOCITY-MODULATED ELECTRON-DISCHARGE DEVICE

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6 Claims. (Cl. 250—27.5)

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This invention relates to electron-discharge devices, and more particularly to electron-discharge devices of the velocity-modulated type, commonly known as reflex Klystrons.

It is desirable that devices of the general character indicated lend themselves to a variety of operating conditions which require different distances of penetration of their electron beams into the retarding electric fields thereof. In other words, it is desirable that such devices operate efficiently over a wide range of frequencies.

Where space is at a premium in electron-discharge devices of the type to which reference has been made, the above-mentioned results can be obtained only over a limited range of operating conditions, corresponding to a relatively narrow band of frequencies. Attempts to operate outside this limited range result in greatly decreased output.

It is, therefore, the main object of the present invention to provide a relatively small electron-discharge device of the reflex Klystron type which is capable of efficient operation over a relatively wide range of frequencies.

It is a further object of the present invention to accomplish the foregoing in a simple and inexpensive manner.

These, and other objects of the present invention, which will become more apparent as the detailed description thereof progresses, are attained, briefly, in the following manner:

The device includes an electron gun, a pair of grids spaced from said gun and adapted to be connected, respectively, to the opposite terminals of a tuned circuit, and a repeller electrode spaced from said grids and adapted to have a retarding electric field established between itself and said gun. In such a device, the shape of the retarding field is generally such that the transit time for electrons approaching the repeller electrode at different angles varies considerably, especially, where the penetration of the field is intended to be large, as at the the low-frequency end of the band over which it is desired to operate. This is caused by the shielding effect of portions of said repeller electrode upon other portions thereof. This varying transit time causes inefficient electron bunching for any given field intensity with a consequent loss of power.

In accordance with the present invention, the repeller electrode is provided with means, for example, a perforate wall, extending therefrom in the direction of the retarding field, for eliminating the above referred to shielding effect and so shaping said field as to cause the same to be composed of substantially parallel lamellae which are equipotential over areas substantially coextensive with the surface of said repeller electrode. Under these conditions, substantially all of the electrons entering the retarding field penetrate the same to like extent regardless of the angles at which they approach the repeller electrode. Consequently, they all have substantially the same transit time for any given field intensity, and efficient bunching and increased power result over a relatively wide frequency band.

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In the accompany specification there shall be described, and in the annexed drawing shown, two illustrative embodiments of the electron-discharge devices of the present invention. It is, however, to be clearly understood that the present invention is not to be limited to the details hereinshown and described for purposes of illustration only, inasmuch as changes therein may be made without the exercise of invention, and within the true spirit and scope of the claims hereto appended.

In said drawing:

Fig. 1 is a longitudinal sectional view taken through the center of an electron-discharge device incorporating the principles of the present invention.

Fig. 2 is a similar, enlarged view of one form of repeller electrode which may be utilized in said device; and

Fig. 3 is a view similar to Fig. 2 of another form of repeller electrode which may be utilized to obtain like results.

Referring now more in detail to the present invention, with particular reference to the illustrative embodiment thereof shown in Figs. 1 and 2 of the drawing, the numeral 10 generally designates an electron-discharge device of the velocity-modulated type, known as a Klystron, more especially, a reflex Klystron.

As is well known, in a device of this type, a beam of electrons is acted upon by an alternating voltage to cause some of said electrons to be accelerated and others to be decelerated. By permitting the electrons so acted upon to thereafter drift, the accelerated electrons overtake those which were decelerated, resulting in a beam in which bunches of electrons are spaced by regions in which there are relatively few electrons. The beam thus velocity modulated is caused to act upon a resonant circuit and give up thereto the energy represented by the modulation. In the reflex Klystron, a single resonant circuit modulates the electron beam and, subsequently, is energized thereby, the beam, after passing the resonant circuit a first time and becoming velocity modulated, being caused by an appropriate electric field to substantially retrace its path and pass by the resonant circuit a second time to energize the same.

In the device under consideration, the electron beam is obtained from a gun, which may consist of a suitably coated cathode 11, heated, by a filament 12, to a temperature resulting in copious electron emission, and surrounded by an accel-

erating electrode 13, said cathode 11 and electrode 13 being supported, for example, from a reentrant press, not shown, formed in the bottom of an evacuated glass envelope 14 mounted upon a base 15. The beam thus obtained passes through a pair of spaced grid structures 16 and 17 which may be supported as by being sealed through the walls of the envelope 14, said grid structures being connected, externally of the device, to any desired tuned circuit, as herein shown, respectively, to the outer and inner conductors 18 and 19 of a coaxial cavity resonator 20 from which power may be extracted by means of a coupling loop 20'. The cavity resonator 20 is secured to the tube portions of the device by means of the interengaged supporting members 18' and 19'.

Spaced from the grid structures 16 and 17, and supported, for example, from a lead-in conductor 21 passing through the inner conductor 19 of the coaxial cavity resonator 20, and entering the envelope 14 through a glass bead 22 in the grid structure 17, is a repeller electrode 23 which, when supplied with a suitable potential, causes the electron beam approaching the same after having passed through the grids to turn about and reapproach said grids.

Such a repeller electrode is generally in the form of a shallow dish-like member which, because of its shallowness, permits penetration of the electron beam only over a limited range. Greater range of penetration can be obtained by making the repeller electrode deeper, but then the retarding field is caused to have the shape indicated by the broken line A in Fig. 2 of the drawing. This shape is the result of the shielding of the corner portions of the repeller electrode by the flange portion thereof. It will be apparent that electrons entering such a field and approaching such a repeller electrode at different angles penetrate said field to different distances before retracing their paths, as a result of which the above-referred to inefficient bunching takes place.

However, in the present invention, this disadvantage is overcome by distorting the field indicated by the broken line A in Fig. 2 so as to cause the same to be composed of substantially parallel lamellae which are equipotential over areas substantially coextensive with the repeller electrode surface, as indicated by the full lines B, C and D in said Fig. 2. This is accomplished by securing about the periphery of the repeller electrode a perforate wall, for example, a plurality of uniformly spaced conductive rods 24 which, as here shown, lie in the surface of a cylinder projecting at right angles to the surface of said repeller electrode. Such a wall deepens the electrode so as to permit a wide range of electron beam penetration and at the same time destroys the above-mentioned shielding of the corners of the electrode. With the field thus shaped, substantially all of the electrons entering the same penetrate to like distances for any given field intensity, and therefore have substantially similar transit times. Efficient bunching results over a wide range of frequencies, and a much more useful tube is thereby obtained.

Instead of employing the multiplicity of rods 24 shown in Figs. 1 and 2 of the drawing, a similar result can be produced by supporting, from a few relatively separated rods 25 extending from the

periphery of the repeller electrode 23, a spiral conductive member 26 the turns of which may be equally or unequally spaced from each other, depending upon the exact shape of field desired, and, as here shown, lying in the surface of a cylinder projecting at right angles to the surface of said repeller electrode. Such a construction is shown in Fig. 3 of the drawing. While the spacing of the turns of the spiral member 26 decreases from top to bottom as here illustrated, it is to be understood that other forms of unequal spacing or, as stated, equal spacing can be employed.

This completes the description of the aforesaid illustrative embodiments of the present invention. It will be noted from all of the foregoing that the present invention provides simple and inexpensive means for so shaping the retarding field of a reflex Klystron as to enable efficient electron bunching over a wide range of frequencies.

Other objects and advantages of the present invention will readily occur to those skilled in the art to which the same relates.

What is claimed is:

1. A repeller electrode for an electron-discharge device of the reflex Klystron type comprising a plurality of conductive members disposed about the periphery of said repeller electrode, and projecting substantially at right angles to the surface thereof.

2. A repeller electrode for an electron-discharge device of the reflex Klystron type comprising a plurality of uniformly spaced conductive rods disposed about the periphery of said repeller electrode, and projecting substantially at right angles to the surface thereof.

3. A repeller electrode for an electron-discharge device of the reflex Klystron type comprising a spiral conductive member the turns of which lie in the surface of a cylinder projecting at right angles to the surface of said repeller electrode.

4. A repeller electrode for an electron-discharge device of the reflex Klystron type comprising a spiral conductive member the turns of which are unequally spaced from each other and lie in the surface of a cylinder projecting at right angles to the surfaces of said repeller electrode.

5. A repeller electrode for an electron-discharge device or the reflex Klystron type comprising a dish-shaped member having a bottom wall extending substantially transverse to the direction of the retarding electric field of said device, and a perforated side wall extending from said bottom wall substantially parallel to the direction of said electric field.

6. A repeller electrode for an electron-discharge device of the reflex Klystron type comprising a cylindrical member open at one end and closed at the other, the portion of said member lying in the surface of a cylinder being perforated.

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