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ELECTRON DISCHARGE DEVICE

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FIG. 1.

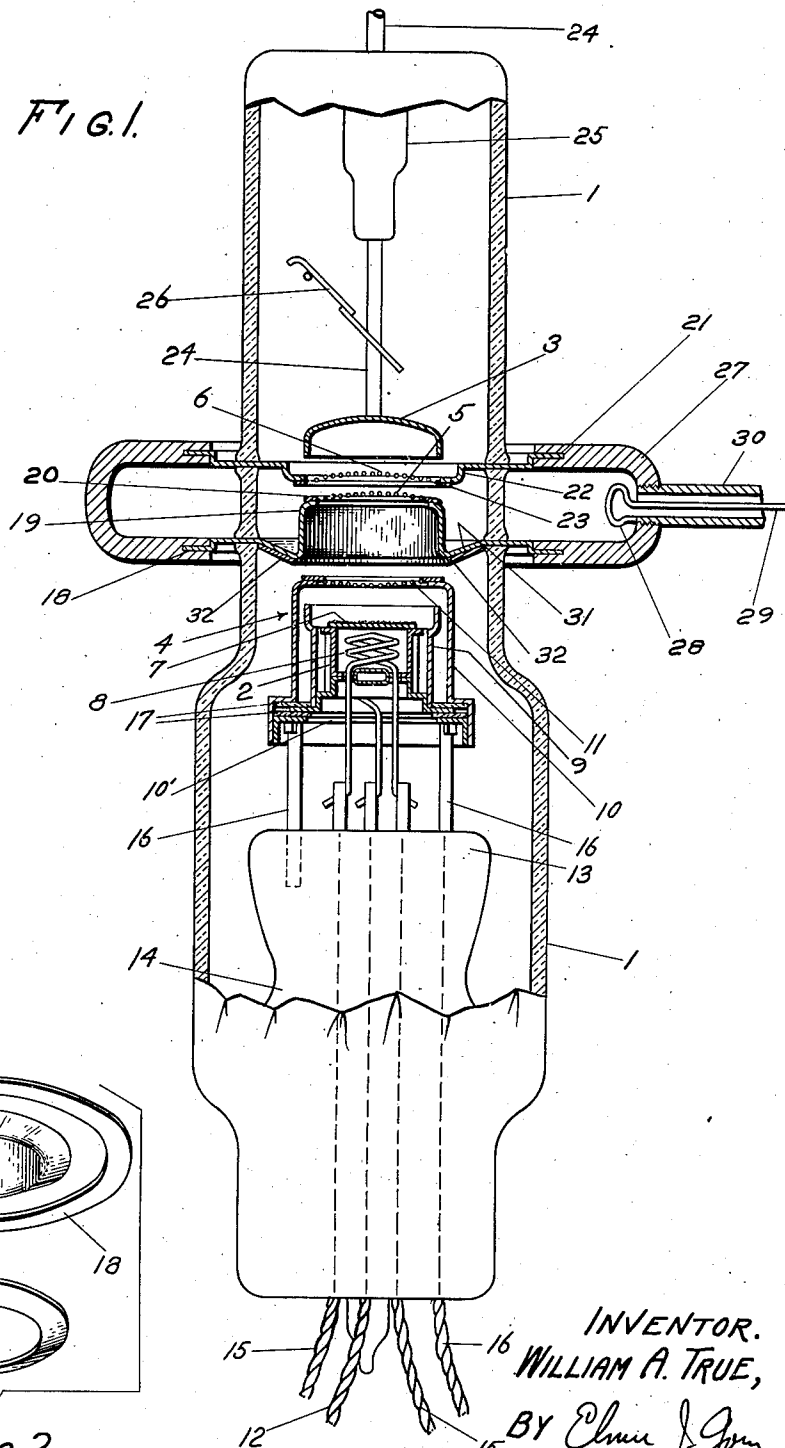
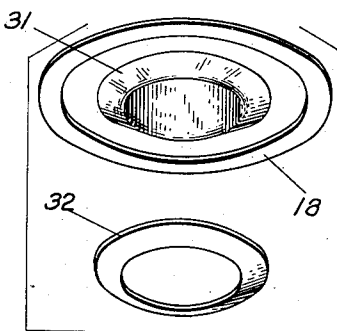


FIG. 2.

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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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9 Claims. (Cl. 250—27.5)

1

This invention relates to ultra-high frequency velocity-modulated tubes, and more particularly to tubes of the type referred to in which a stream of electrons is subjected to bunching and de-bunching effects by passing successively through two control electrodes.

In devices of the type above specified, it is essential that the spacing between the control electrodes be accurately related to the frequency for which the device is intended, and to the voltages impressed upon the device which affects the speed of the electrons passing through the control electrodes, so that the time of transit of the electrons in passing from one control electrode to the other shall bear a definite relation with respect to the period of the oscillations produced by the device. Unless this spacing is maintained constant, the frequency at which the device operates tends to shift or the device drops out of adjustment and fails to operate properly. In many devices of this kind it has been found that during operation changes occurred which required a continuous external control of the voltages and the external circuit constants supplied to the tube in order to keep it operative at the proper frequency and at the proper level of intensity. I have found that such changes have been due in considerable measure to variations in temperature within the tube itself which caused variations in the spacing between the pair of control electrodes.

Such tubes may also be connected to external cavity resonators which when subjected to temperature variations produce a shift in the natural frequency of the assembly which introduces difficulties similar to those described above.

An object of the present invention is substantially to eliminate the effects of temperature upon the frequency and intensity of response of an ultra-high frequency velocity-modulated tube of the foregoing type.

Another object of the present invention is to provide an electron discharge tube of the aforesaid type which comprises simple, reliable means for keeping the frequencies at a constant level under varying temperature conditions.

Another object of the present invention is to provide novel frequency stabilizing means for tubes of the aforesaid type.

These objects and such other aims and objects as may hereinafter appear will be best understood from the following description, taken in connection with the accompanying drawing of one embodiment of the invention herein given for illustrative purposes.

2

In the drawing:

Fig. 1 is a longitudinal cross-section, on an enlarged scale, of an ultra-high frequency velocity-modulated tube incorporating one illustrative embodiment of the present invention; and

Fig. 2 is a perspective view, on an enlarged scale, of a thermostatic device forming part of the arrangement of Fig. 1.

In the illustrative embodiment of the invention shown in the drawing, the tube comprises an evacuated envelope 1 of glass or other suitable material containing a cathode structure 2, a reflecting electrode 3, an accelerating grid 4, adjacent said cathode, and a pair of control electrode elements 5 and 6, interposed between said accelerating grid and said reflecting electrode 3.

The cathode is of the hollow, indirectly-heated type, having a flat upper active surface, preferably coated with an electron-emissive material 7, which may consist of the usual mixture of barium and strontium oxides. Surrounding the hollow cathode is a focusing shield or ring 9 which tends to focus the electrons coming from the coating 7 into a compact beam. Surrounding said focusing ring 9 is an accelerating grid-supporting cylinder 10 having an opening at the upper end thereof across which is supported a perforated grid member 11 consisting of fine conducting wires so as to interpose a minimum of grid surface for intercepting the electrons contained in the electron beam. A cathode lead-in wire 12 is sealed through a press 13 formed upon the upper end of a reentrant stem 14 contained within the envelope 1. The lead-in wire 12 is electrically connected to the cathode 2, thus providing an external electrical connection to the cathode. A pair of heater leads 15 is likewise sealed through said press 13 and is electrically connected to the ends of a heater member 8. A pair of supporting standards 16 is likewise sealed in the press 13, and serves to support the electrode assembly associated with the reentrant stem 14. Both of these standards 16 may be electrically connected to the lower edge of the member 10 through a member 10' which clamps cooperating projections on the associated electrode members between a pair of insulating washers 17, thus spacing the members in proper relation to each other and maintaining these members firmly in position with respect to the reentrant stem 14. The focusing ring 9 may be welded to the lower end of the cathode 2, and thus be electrically connected to said cathode and supported by the latter. One of the standards 16 may continue through said

press 13, so as to provide an external electrical connection to the accelerating grid 4.

The structure described above produces a compact beam of electrons which emerges through the perforated member 11 with the requisite velocity. This electron beam is subjected to the action of the pair of control grids 5 and 6. The structure of the control grid 5 is formed by a lead-in ring 18 which is sealed through the side walls of said envelope 1. The internal edges of the ring 18 are turned upwardly and form a relatively elongated cylindrical member 19 which has an opening at its upper end across which a perforated conducting member 20 is supported. The perforated member 20 is likewise made of fine conducting wires for the same reasons as specified in connection with member 11. The second control grid structure 6 is formed of a conducting ring 21 sealed through the side walls of the envelope 1. The inner ends of the ring 21 are turned downwardly so as to form a relatively short cylindrical member 22 having an opening at the lower end thereof across which is supported a perforated member 23 likewise formed of fine conducting wires.

The reflecting electrode 3 is supported by an anode lead-in conductor 24, sealed through a re-entrant stem 25 formed in the upper end of the envelope 1. A getter assembly 26 may be conveniently supported on the lead 24. It is to be understood that the construction as described above is assembled and evacuated in accordance with standard vacuum tube practice so as to produce a high vacuum within the envelope 1, and to activate the coating 7 so as to provide for copious thermionic emission therefrom.

The outer edges of the rings 18 and 21 form external connections to the grids 5 and 6. In order for the tube, as described above, to generate ultra-high frequency oscillations, a hollow resonant chamber member 27, which may be conveniently in the form of a toroid open along its inner edge, is fastened with its upper and lower edges respectively to the rings 21 and 18. The resonant chamber member 27 is preferably formed of a highly conductive material, such as copper. The oscillations which are produced by the device may be picked up by a coupling loop 28, placed within the chamber 27, and led off by a conductor 29 which conveniently may be surrounded by a pipe 30 fastened into the chamber 27 so as to form a concentric line with the conductor 29.

When the tube is energized with the proper potentials, a beam of electrons coming from the cathode 7 will be accelerated by the grid 11, and pass through the grid structures 5 and 6. As the beam emerges from the grid structure 6, it is reflected by the reflecting electrode 3 back through the pair of control grids 5 and 6. As the reflected beam emerges from the grid 5, it is reflected by the structure below said grid so that it again passes through the control grid members 5 and 6, finally to fall upon the outer surface of the ring 21 with relatively low velocities. As is well known, the initial passage of the beam through the control grids 5 and 6 produces a bunching action, and upon reflection and repassage of the beam through these control electrodes, a debunching action results which feeds ultra-high frequency energy to the resonant circuit formed by the hollow resonant chamber 27, thus setting up ultra-high frequency oscillations which may be led off from the concentric line 29, 30.

It has been recognized as desirable in prior

tubes of this kind that various members of the tube, particularly the grid structures 5 and 6, which carry substantial amounts of ultra-high frequency energy, be made of highly conductive material, such as copper, in order to obtain highly efficient devices.

I have discovered that the various changes noted which prior devices of this kind underwent in operation and which necessitated changes in the voltages and circuit constants applied to the tube in order to keep it operating properly were due to variations in temperature. These variations in temperature, particularly at the cylinder 19 and its associated supporting structure, produced small variations in the dimensions of these elements which resulted in a greatly amplified movement of the upper end of the cylinder 19 with respect to the control member 6. I have found it was, at last partly, the resultant change in the spacing between the perforated members 20 and 23 which caused the difficulties encountered in the prior art.

Also temperature variations within the tube are almost inevitably associated with corresponding variations of the temperature immediately related to the tube, such as at the resonant chamber 27. Such temperature variations produce changes in the size of said chamber 27 which in time tend to produce undesirable variations in the natural frequency of the assembly.

In accordance with the present invention, the aforesaid difficulties are overcome by the provision of novel stabilizing means. In the illustrative embodiment of the invention shown in the drawing, the stabilizing means employed comprises a device which supports said cylindrical member 19 and consists of a thermostatic stabilizing device, herein illustratively comprising a bimetallic strip including laminae 31 and 32 of different coefficients of expansion. The coefficients of expansion should preferably be considerable and differ substantially; I have found nickel and copper satisfactory. For convenience, I preferably use the flange portion of the copper ring 18 which connects the cylinder 19 to the inner walls of the envelope 2 as the copper lamina 31, the nickel lamina 32 being constituted by a relatively thin flat nickel ring soldered to the underside of said flange portion of said copper ring 18. Said nickel ring 32 may be silver plated and the solder used will preferably be silver or gold solder. For the best results the bimetal electrostatic device should form an angle with the inner cylindrical wall of the envelope 1 and be inclined in the direction in which it is to act and the lamina having the higher coefficient of expansion should preferably face the outer wall of the member 19. Said angle may vary according to circumstances. An angle of 70° is very satisfactory.

A rise in temperature will cause the cylindrical member 19 to expand, thus increasing the interior space of said member and moving the perforated member 20 of the cylindrical member 19 toward said cylindrical member 22, thus decreasing the space between said two perforated members 20 and 23. This rise in temperature also expands the resonant chamber 27. A rise in temperature will therefore decrease the frequency of the tube, but as the copper lamina 31 of the thermostatic device has a higher coefficient of expansion than the nickel lamina 32 of said device, a rise in temperature will tend to bend the end thereof connected to said member 19 downwardly thus lowering said member and increasing the space be-

5

tween said perforated members 20 and 23, thus tending to increase the frequency. A decrease in temperature on the other hand will tend to contract the parts, thus producing an increase in frequency, but this same decrease in temperature causes said bimetallic thermostatic device to act in the opposite direction thus tending to raise said member 19 and decrease the space between the perforated members 20 and 23 to decrease the frequency. By suitably designing said thermostatic device, changes in frequency that would otherwise occur due to variations of temperature will be neutralized by the present invention, not only sufficiently to keep the frequencies within permissible frequency tolerances, but in a manner to eliminate all drift and maintain the frequencies at the constant level desired. In the present embodiment of the invention, the copper lamina has a thickness of about $10/1000$ of an inch and the nickel lamina a thickness of about $5/1000$ of an inch, but a nickel lamina of a thickness of $10/1000$ of an inch also has proved satisfactory.

The present invention calls for a structure of a minimum of parts and also extremely simple in construction so that the risk of its getting out of order is negligible. The bimetal tuning member is of light weight and its operation is independent of and therefore unhampered by the movement of other parts possessing more or less inertia. All this contributes to making the frequency stabilizing device embodying the present invention remarkably sensitive to changes in temperature and therefore promptly responsive to temperature changes and very reliable in operation.

I am aware that the present invention can be embodied in other specific forms without departing from the spirit or essential attributes thereof, and I therefore desire the present description to be considered in all respects as illustrative and not restrictive, reference being had to the appended claims rather than to the aforesaid description to indicate the scope of the invention.

What is claimed is:

1. An electron discharge tube comprising: a plurality of electrodes, and bimetal, thermally-responsive, frequency-stabilizing means supporting one of said electrodes with respect to a cooperating electrode between rigid supporting surfaces, said electrode supported by said frequency-stabilizing means having a substantial thermal coefficient of expansion, said frequency-stabilizing means forming an angle with said supporting surfaces, the metal lamina of said frequency-stabilizing means having the lesser thermal coefficient of expansion facing said supporting surfaces.

2. An electron discharge tube comprising: a plurality of electrodes, one of said electrodes being a grid member supported by a substantial length of a metallic supporting member substantially at right angles to said grid member, and bimetal, thermally-responsive, frequency-stabilizing means supporting said supporting member between rigid supporting surfaces, said supporting member and said grid member having substantial thermal coefficients of expansion, said stabilizing means forming an angle with said supporting surfaces.

3. A high frequency tube comprising: an electron-emissive cathode, means adjacent said cathode for accelerating a beam of electrons from said cathode, a pair of control grids mounted in the path of said beam, an additional electrode,

6

said pair of control grids being adapted to be connected to a resonant circuit to impart velocity modulation to the electrons in said beam, a supporting member, one of said grids being spaced from the other by a substantial length of said supporting member, and bimetal, thermally-responsive, frequency-stabilizing means supporting said supporting member between rigid supporting surfaces, said frequency stabilizing means having substantial thermal coefficients of expansion.

4. A high frequency tube comprising: an electron-emissive cathode, means adjacent said cathode for accelerating a beam of electrons from said cathode, a pair of control grids mounted in the path of said beam, an additional electrode, said pair of control grids being adapted to be connected to a resonant circuit to impart velocity modulation to the electrons in said beam, a supporting member, one of said grids being spaced from the other by a substantial length of said supporting member, and bimetal, thermally-responsive, frequency-stabilizing means supporting said supporting member between rigid supporting surfaces, said frequency stabilizing means having substantial thermal coefficients of expansion, and forming an angle with said supporting surfaces.

5. A high frequency tube comprising: an envelope containing an electron-emissive cathode, means adjacent said cathode for accelerating a beam of electrons from said cathode, a pair of control grids mounted in the path of said beam, an additional electrode, said pair of control grids being adapted to be connected to a resonant circuit to impart velocity modulation to the electrons in said beam, one of said grids being mounted at one end of a tubular supporting member, and a bimetal, thermally-responsive, frequency-stabilizing annulus supporting said last-named grid and its tubular supporting member and interconnecting the other end of said tubular supporting member and the inner wall of said envelope, said tubular supporting member having a substantial thermal coefficient of expansion, said annulus forming an angle with the inner wall of said envelope, the metal lamina of said annulus having the lesser thermal coefficient of expansion facing the inner wall of said envelope.

6. An electron discharge tube comprising: an envelope, a plurality of electrodes within said envelope, a tubular supporting member supporting one of said electrodes at one end of said member with respect to an adjacent cooperating electrode, and a bimetal, thermally-responsive, frequency-stabilizing annulus supporting said tubular member and the electrode supported thereby and interconnecting the other end of said tubular member and the inner wall of said envelope, said tubular supporting member having a substantial thermal coefficient of expansion, said annulus forming an angle with the inner wall of said envelope, the metal lamina of said annulus having the lesser coefficient of expansion facing the inner wall of said envelope.

7. An electron discharge tube comprising: an envelope, a plurality of electrodes within said envelope, a substantially flat annular member of copper, a second relatively thin annular member of nickel soldered to one surface of said first-named annular member, said two annular members thus constituting bimetal, thermally-responsive, frequency-stabilizing means connected at its outer edge to the inner wall of said envelope

and at its inner edge supporting one of said electrodes with respect to an adjacent cooperating electrode, said electrode supported by said stabilizing means having a substantial coefficient of expansion, said stabilizing means forming an angle of about 70° with the inner wall of said envelope, said nickel lamina facing the inner wall of said envelope.

8. An electron-discharge device comprising: an envelope, a plurality of electrodes enclosed in said envelope, and inter-electrode space stabilizing means supporting one of said electrodes from the walls of said envelope, said inter-electrode space stabilizing means comprising a pair of members having substantially different temperature coefficients of expansion, one of said members comprising a portion of said one of said electrodes.

9. An electron-discharge device comprising: an envelope, a plurality of electrodes enclosed in said envelope, and inter-electrode space stabilizing means supporting one of said electrodes from the walls of said envelope, said inter-electrode space stabilizing means including a pair of members having substantially different temperature coefficients of expansion, one of said members comprising a portion of said one of said electrodes.

prising a portion of said one of said electrodes, and the other of said members comprising a backing secured over one of the surfaces of said one of said members

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