April 16, 1957 P. JANIS 2,789,249

REFLEX KLYSTRONS

Filed June 1, 1951

Fig. 1

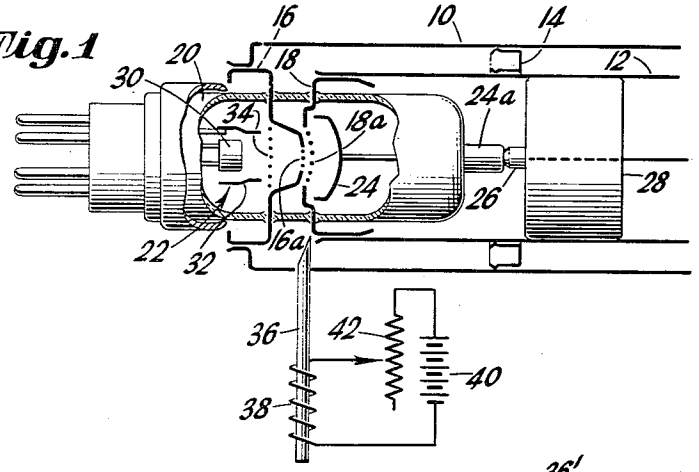
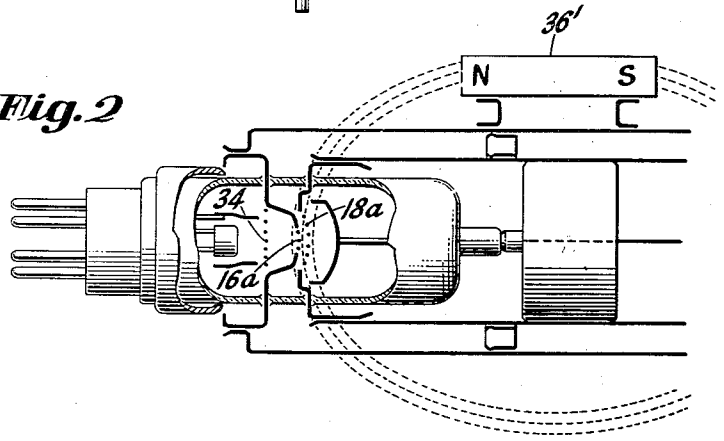


Fig. 2



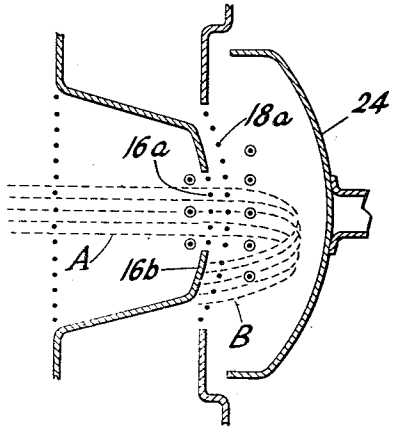


Fig. 3

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United States Patent Office 2,789,249 Patented Apr. 16, 1957

2,789,249

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Application June 1, 1951, Serial No. 229,431

7 Claims. (Cl. 315—5.18)

The present invention relates to a type of electron-beam device commonly termed the klystron and more particularly to that type of klystron in which the electron-beam is passed through the interaction space of a resonator and is then reflected so as to re-enter the resonator for renewed interaction.

In this type of klystron, an electron-beam is ordinarily formed and accelerated by an electron gun, and this beam is passed through two apertured walls forming part of a space resonator, toward a reflector electrode so as to be repelled and reversed in its travel, and to re-enter the interaction space of the same resonator. The physical proportions of the resonator and the voltage on the reflector largely determine the operating frequency of the reflex klystron.

It is desirable that the operating frequency shall be susceptible to definite control, and that a certain definite frequency will result from adjustments made according to a previous calibration. However, with reflex klystrons of a construction commonly employed heretofore, a difficulty has been encountered, termed "moding," i. e., variations in frequency to be effected by changing the operating conditions sometimes do not result, but instead the klystron commences operation at a very different frequency from that intended, the device then operating in a different mode.

The present invention resides in the discovery of what is believed to be a cause of moding and in the elimination of that difficulty. I have found that if a magnetic field is impressed on the electron-beam transverse to its path as it initially passes through the interaction space of the resonator, the moding can largely be eliminated. From this, I am convinced that moding results from a disturbance in the beam-forming region produced by the bunched electron-beam after being returned by the reflector. The electron-beam, when bent by the transverse magnetic field, operates as intended in respect to velocity modulation, bunching, and interaction with the resonator; but because it does not retrace its original course, the returning electron-beam does not harmfully interact with the newly formed electron-beam in the gun. This effect is further assured by diverting the reflected bunched beam to a region where the returning electrons, after passing through the interaction space, are actually collected before reaching the beam-producing region.

The nature of the invention and its further features of novelty will be better appreciated from the following detailed disclosure of two illustrative embodiments thereof which are shown in the accompanying drawings. In those drawings:

Figure 1 is a lateral view, partly in cross-section, of one illustrative embodiment of the invention and Figure 2 is a similar view of a second embodiment.

Figure 3 is a greatly enlarged view illustrating the theory of operation of the tubes shown in Figures 1 and 2.

Referring now to Figure 1, a resonator is shown having outer wall **10** and an inner wall **12** whose effective axial length is adjusted by slidable tuner **14**. An electron discharge device is mounted within this resonator in this illustrative form so as to have disc-sealed grids **16** and **18** connected as extensions of resonator walls **10** and **12**, respectively. Two apertured regions **16***a* and **18***a* of these grids, preferably formed of wire mesh, may be regarded as electron permeable portions of the resonator wall, or, more generally, as electron permeable walls. Electrodes **16** and **18** are hermetically sealed so as to extend through the wall of an insulating evacuated envelope **20**. An electron gun **22** is disposed at one side of the interaction space **16***a*—**18***a* while at the opposite side of that interaction space a reflector electrode **24** is supported and provided with an external terminal **24***a*. Circuit connection to terminal **24***a* is provided by a button **26** supported in an insulating plug **28** within cylinder **12** of the resonator.

Gun **22** includes a thermionic electron-emissive cathode **30** and a beam forming and focusing shield **32**; and an electron permeable grid **34** extends across the path of the electron-beam between the cathode and the interaction space **16***a*—**18***a*, and acts as an anode for the purpose of accelerating the electrons in the beam. Grid **34** is connected to the grid **16** and operates at the same D.-C. potential. The shield may operate at or near cathode potential, while grids **34**, **16** and **18** operate at a high positive voltage and reflector **24** operates at a suitable negative voltage.

A uniform beam of electrons is accordingly projected from the gun through the interaction space. Instantaneous differences in high frequency potentials, existing between portions **16***a* and **18***a*, impress velocity modulation on the "forward" electron-beam. After emerging from portion **18***a*, this velocity modulated beam is allowed to drift so that the electrons in the beam become bunched. In the reflex form of klystron, the beam is allowed to drift after emerging from grid **18***a*, and is gradually retarded and reversed by the reflector to re-enter the interaction space. The returning beam, becoming bunched while drifting, imparts high frequency energy to the resonator, and the electrons in that beam are collected by the positive electrode structure represented by grids **16**, **18**, and **34**.

By diverting the returning beam away from the course of the incoming beam produced by the gun, I have been successful in largely eliminating moding that has been a persistent trouble in operation of reflex klystrons. This moding seems to be largely eliminated by producing a magnetic field transverse of the normal electron-beam path. My explanation for this effect is that the returning bunched electron-beam which re-enters the interaction space **16***a*—**18***a*, is prevented from interacting with the "forward" beam in the space between grid **34** and electron permeable wall portion **16***a*, and for this reason the "forward" electron-beam entering the interaction space is not disturbed by the bunched electron-beam.

The bending of the electron beam is accomplished by means of an electromagnet in Figure 1, including a sharp-poled magnetic core **36** that is magnetized by a coil **38** adjustably energized with direct current from supply **40** and rheostat **42**.

As shown in Figure 3, the "forward" electron-beam, according to my reasoning, traverses an initial path A which approaches grid or electron-permeable wall **16***a* to enter the interaction space **16***a*—**18***a*. Because of interaction of the beam and the resonator, this beam is bunched; and when it emerges from grid **18***a* and is reversed by the negative electrostatic potential on reflector **24**, the magnetic field produced by core **36**, extending transverse of the interaction space and the drift space between grid **18***a* and reflector **24**, diverts the returning electrons to a path laterally off-set relative to the initial path A. Returning electron beam B then re-enters the

interaction space only to be collected on a solid portion **16***b* of grid **16**.

The returning electron path B (Figure 3) is laterally offset from that of the "forward" electron-beam path A so as to prevent the possibility of modulation of the beam energy from the gun by interaction with the returning bunched beam; and as an additional separate factor preventing such interaction, a solid portion **16***b* is provided opposed to a perforate portion of grid **18***a* for collecting the returning bunched electrons after their interaction with the resonator.

The particular construction shown in Figure 1 for impressing a transverse magnetic field on the interaction space is effective, but it will be apparent that such transverse magnetic field can, in the alternative, be supplied by a magnet whose axis is parallel to the electron path in the gun (Figure 2) but whose field in the interaction space is curved so as to be substantially perpendicular to the path of the electron-beam.

The parts in Figure 2 are, with the exception of the magnetic structure, identical to those in Figure 1 and their description, therefore, is not repeated. However, in place of the electromagnet, a permanent magnet **36'** is shown mounted in any convenient manner for adjustment along the exterior of resonator wall **10**. The magnetic field represented by the dotted lines in Figure 2 is shown to extend transverse of the electron path thru walls **16***a* and **18***a*; and while the field must necessarily extend past the path of the beam in the region of the gun and the reflector space, such effects evidently contribute to the result described. From Figure 3 it will be clear that the transverse field is everywhere perpendicular to the plane of the beam that is curved by that magnetic field, being perhaps more effective in the drift space where the electrons remain for a relatively long portion of their travel time.

The theory of mode suppression as advanced above is what I presently consider correct. The substantial elimination of moding is in actual practice achieved when either orientation of magnet is employed.

The foregoing embodiments of the invention will naturally be found susceptible to a latitude of varied design and application, and accordingly, the appended claims should be accorded that broad interpretation that is consistent with the spirit and scope of the invention.

What is claimed is:

1. A reflex klystron including a cathode, beam forming electrodes, a first perforate resonator wall, a second perforate resonator wall, and a reflector disposed along an axis in the order named, and magnetic means normally fixedly positioned adjacent said klystron to direct a substantial electron-deflection transverse magnetic field at the axis in the region of said perforate resonator walls.

2. A klystron in accordance with claim 1, wherein said perforate electrodes and said reflector are symmetrical about said axis.

3. A klystron in accordance with claim 2, wherein the perforate region of said first perforate resonator wall is of smaller transverse extent than the perforate region of said second perforate resonator wall and said first perforate resonator wall embodies an electron collecting imperforate area surrounding the perforate region, said imperforate area being opposed to a perforate wall portion of the second perforate wall.

4. A reflex klystron in accordance with claim 1, wherein said magnet means comprises an electromagnet.

5. Apparatus in accordance with claim 1, wherein said magnetic means comprises an electromagnet extending transverse to the initial electron path in the region of said perforate resonator wall portions.

6. A reflex klystron in accordance with claim 1, wherein said magnetic means includes a magnet disposed in a position axially displaced from the perforate walls and offset in relation to the initial path of the electron-beam, whereby a magnetic field is established transverse of the electron-beam path in the region of the perforate wall portions.

7. A reflex klystron including a pair of opposed electron permeable walls and means including a cathode and reflecting means on opposite sides of the opposed walls for projecting an electron beam towards the walls and for reflecting the beam back toward the electron permeable walls, and magnetic means normally fixedly positioned adjacent said klystron to direct a substantial electron-deflection, the electron permeable wall adjacent said cathode having an extension positioned in the path of the returning reflected electron beam, said extension being an imperforate electrode structure.

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