

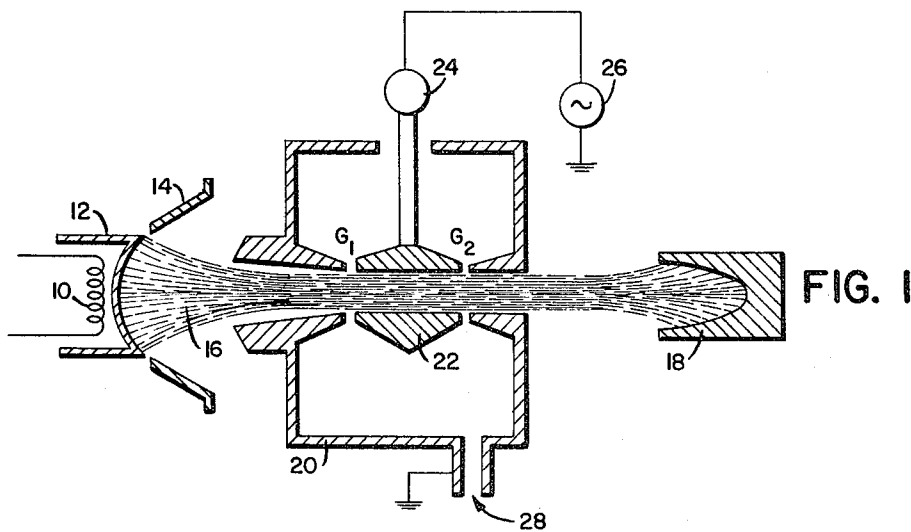
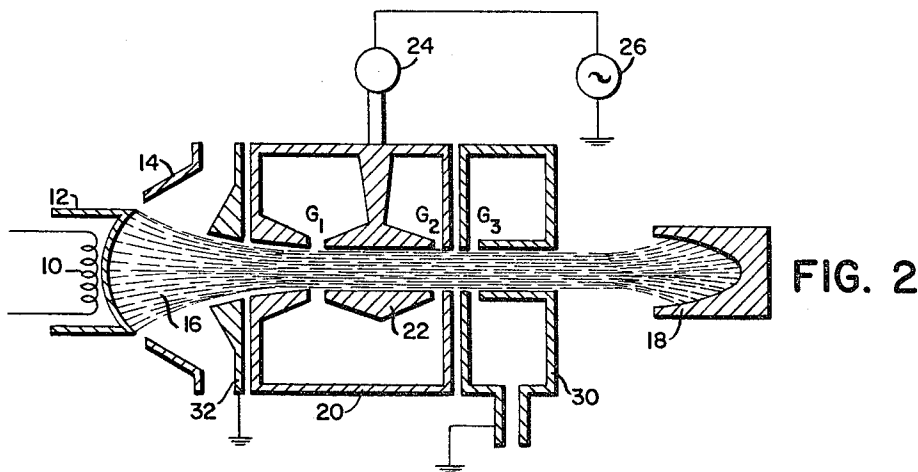
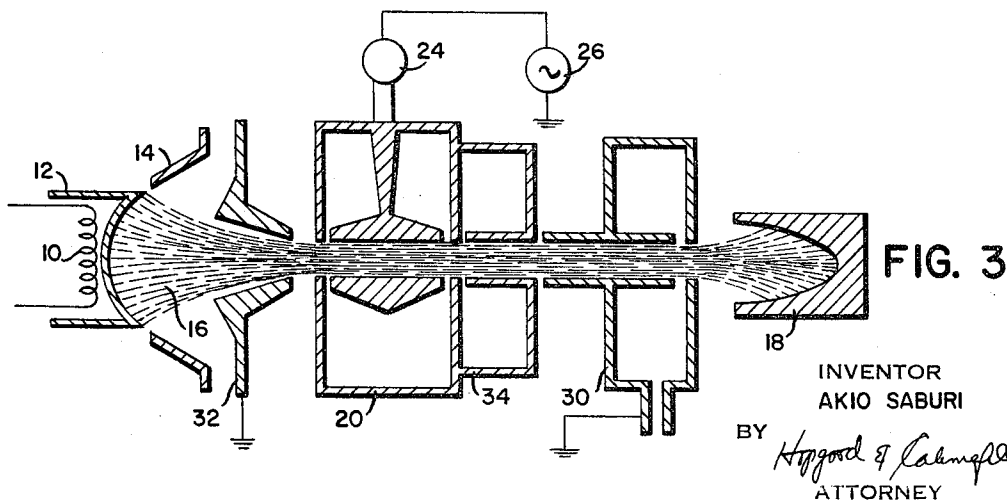
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MICROWAVE ELECTRONIC TUBE

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MICROWAVE ELECTRONIC TUBE

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3 Claims. (Cl. 315-5)

This invention relates to electron tubes and particularly to such tubes for generating high frequency oscillations in the microwave region.

As those knowledgeable in the art are aware, a floating-drift-tube klystron tube has superior characteristics as an oscillator at microwave frequencies. This tube comprises a cavity with two gaps, and is somewhat similar to a reflex klystron. It is capable of electronic tuning, it is characterized by having negligible hysteresis, and it is capable of operating at high efficiency. It is similar to a two-cavity klystron and is capable of delivering relatively large output power. However, it has the disadvantage that the drift tube, which is located between the two gaps, must be insulated from the surrounding walls of the cavity in order that the tube functions with the most favorable tuning characteristics. For this reason and due to the complex structure of the tube, it is very difficult to construct a tube capable of operating at extremely-high frequencies e.g. in the millimeter wave frequencies.

Accordingly, it is an object of this invention to eliminate the above-mentioned defects and to provide a floating-drift-tube klystron capable of operating with high efficiency at millimeter wave frequencies.

All of the objects, features and advantages of the invention and the invention itself will be best understood from a reading of the specification taken in conjunction with the accompanying drawings, in which

FIGURE 1 is a vertical section of a floating-drift-tube klystron useful in illustrating the fundamental principle thereof,

FIGURE 2 is a drawing of a tube constructed in accordance with the principles of this invention, and

FIGURE 3 illustrates a modification of the construction shown in FIGURE 2.

In the various figures, like numerals indicate like parts.

Referring now to FIGURE 1, there is shown a conventional floating-drift-tube klystron in which the numeral 10 indicates the heater, numeral 12 indicates the cathode, numeral 14 indicates the beam forming electrode, numeral 16 indicates the electron beam, numeral 18 indicates the collector, numeral 20 indicates the cavity resonator for oscillation serving as an anode for the electron gun, numeral 22 indicates a floating-drift-tube and numeral 24 indicates a terminal for connecting a modulating signal from a suitable source 26 to the drift tube 22. The cavity resonator 20 is coupled to the electron beam at the two gaps G1 and G2 which are formed between the resonator 20 and the drift tube 22. The electron beam 16 is velocity modulated at the gap G1 due to the radio frequency electric field within the resonator 20, and as it travels through the drift tube 22 it develops abundant radio frequency current components as a result of the bunching action. When the bunched beam passes through the gap G2, if the phase of the electric field in the region of the gap G2 is proper, the beam will emit radio frequency energy, and through feedback to the gap G1, the electron beam will be modulated more intensely, resulting in oscillation. Oscillation is related to the phase angle in the circuit from the gap G2 to the gap G1 and also to the electron transit angle of the elec-

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tron beam passing through the drift tube from the gap G1 to the gap G2.

When the cavity 20 resonates in such a mode that the direction of the electric field produced in the gap G2 is equal to that in the gap G1, the electron transit angle θ should have the following relation:

$$\theta = 2\pi(n - 1/4) \quad (\text{where } n = 1, 2, 3 \dots)$$

Assuming now that θ is varied, a phase difference will occur between the electric fields in the gaps G1 and G2 which will cause the frequency to automatically deviate in a direction for correction of the variation. Now if the drift length is indicated by l , the beam voltage by V , the frequency by f , and the charge to mass ratio of an electron by r , then the electron transit angle θ is given by the formula

$$\theta = 2\pi fl / \sqrt{2rV}$$

Accordingly, variation of the transit angle in the drift tube can be attained by varying the beam voltage V . Thus, by supplying a signal voltage to the drift tube, electronic tuning can be achieved.

It will be appreciated that electronic tuning can also be achieved by varying the acceleration voltage in the electron gun. This also causes the beam current to vary. An additional anode may be added to the gun in order to maintain the beam current constant making it a three-electrode electron gun, in which event the modulation signals must modulate the entire electron gun, and its power sources. This results in an increase of earth capacity because the final anode, i.e. the cavity resonator itself, is generally grounded. Consequently modulation at high frequencies becomes difficult, and a special power source is also necessary.

To eliminate these difficulties, a three electrode gun is employed to maintain the beam current constant, and the modulation signals are supplied to the cavity resonator 20 and to the drift tube 22. The cavity resonator 20 of FIGURE 1 is connected to an external circuit as at 28, to supply output power, and therefore the oscillating circuit, which is at a high positive potential must be insulated from the output circuit, which necessarily makes the capacitance between the oscillation circuit and ground quite large.

FIGURE 2 shows the vertical section of an electron tube designed in accordance with this invention to eliminate the above mentioned disadvantages. In this construction, the outer casing, the beam focussing system, etc., have been removed to show only the important parts. As noted above, the numerals in FIGURE 2 indicate like parts as in FIGURE 1, and a cavity resonator 30 adjacent the cavity resonator 20 is also provided to supply output to an external circuit as at 28. It will be noted that the cavity 20 is not electrically connected to the cavity 30 and the output circuit. The drift tube 22 is physically and electrically connected or fixed to the cavity 20 and a modulation signal is supplied thereto by the signal source 26. An anode 32 is added to the electron gun and the beam current is controlled by this electrode. When a converging type electron gun is employed with a focussing magnetic field, this anode can also serve as a magnetic shield.

The principle of oscillation of the tube construction of FIGURE 2 is identical to the floating-drift-tube klystron described above. Additionally, however, the modulated electron beam will excite the gap G3 of the output cavity 30, as well as the gap G2. This construction has the advantage that the greater part of the radio frequency energy can be supplied to the gap G3, because the gap G2 requires only sufficient energy to maintain oscillation. It is desirable to locate the gap G3 as close as possible to the gap G2. It is also possible, to separate the output

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cavity 30 from the cavity 20 by providing an intermediate cavity 34, in order to reduce the ground capacity. Such construction is illustrated in FIGURE 3.

In the klystron according to this invention, the drift tube 22 and the cavity 20 are made as a single body, and it is therefore comparatively easy to produce a miniature construction for use in the millimeter wave region. As noted, electronic tuning is achieved by supplying a modulation signal to the oscillating cavity itself. By means of my construction it will be apparent that the superior characteristics of a floating-drift-tube klystron have been retained. Additionally, the fact that the construction is of a miniature type, is effective in reducing the ground capacity. Furthermore, as the output circuit and the oscillating circuit are isolated from or independent of each other, the oscillating characteristic will not be affected by the load and will therefore be more stable.

The principles taught herein are also applicable to a self-excited frequency multiplier employing a floating drift-tube klystron. In such case, the output cavity 30 in FIGURE 2 is designed to tune to the desired harmonic of the oscillating frequency of the cavity 20.

While the foregoing description sets forth the principles of the invention in connection with specific apparatus, it is to be understood that the description is made only by way of example and not as a limitation of the scope of the invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A klystron type electronic tube comprising an electron emitting source and a collector spaced therefrom for producing an electron beam between said source and said collector, first means disposed in the path of said beam for generating oscillations including a pair of gaps disposed at spaced points along said beam, said first means including a cavity resonator body of generally annular shape in which said gaps are formed between portions of said resonator body and

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a drift tube located entirely within said body, said drift tube also being electrically connected to said body,

second means disposed in the path of said beam between said first means and said collector for developing output power from said beam, said second means being electrically independent of said first means,

a control electrode disposed in the path of said beam for maintaining the beam current substantially constant,

and means for connecting a source of modulating potential across said first means and said second means whereby electronic tuning is effected by varying the transit angle between said gaps.

2. The invention recited in claim 1 wherein said second means comprises a cavity forming an annular member immediately adjacent said first means, said second means further including a gap adjacent said electron beam and means for delivering the output power developed therein to an external circuit.

3. The invention recited in claim 1 wherein said second means is spaced a predetermined distance from said first means, and an intermediate cavity disposed in said space between said first and second means.

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