Sept. 4, 1951 W. G. SHEPHERD 2,566,584

REFLEX OSCILLATOR

Filed Nov. 27, 1948

FIG. 1

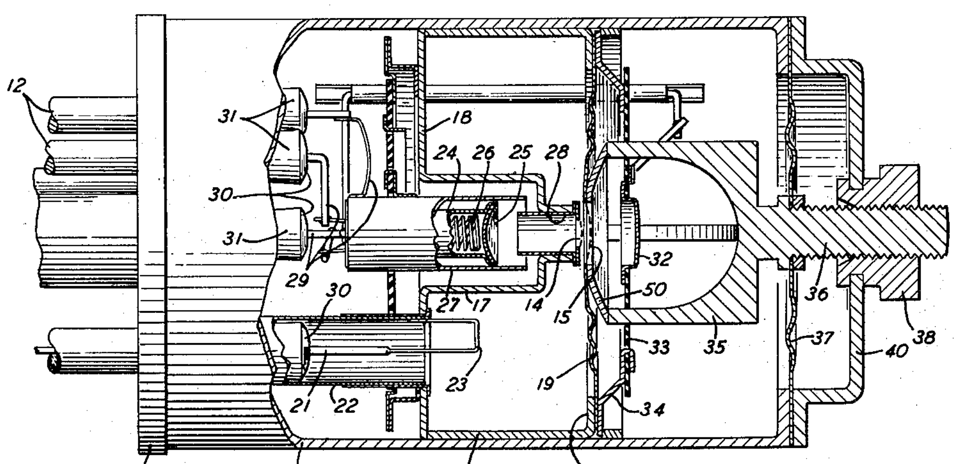


FIG. 2

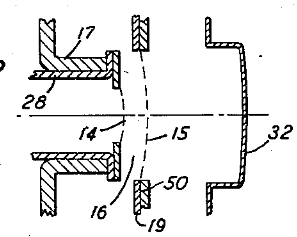
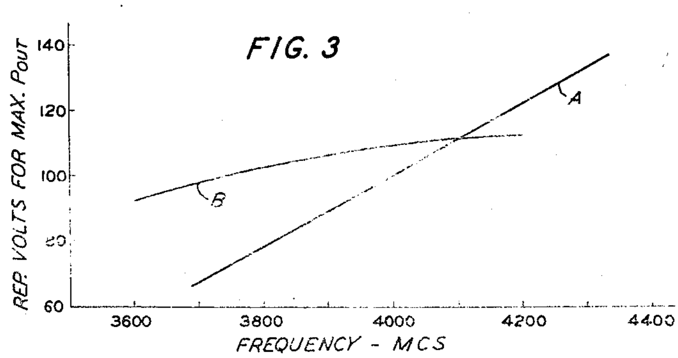


FIG. 3



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REFLEX OSCILLATOR

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2 Claims. (Cl. 315—39)

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This invention relates to electron discharge devices and more particularly to tunable reflex oscillators.

Such oscillators, of which a typical construction is disclosed in Patent 2,411,913, granted December 3, 1946, to John R. Pierce and William G. Shepherd, comprise, in general, a high frequency circuit element, such as a cavity resonator, having a gap therein, an electron gun opposite one end of the gap, and a repeller electrode opposite the other end of the gap. The direct-current electron stream projected by the electron gun is velocity varied in its passage across the gap and the velocity varied stream is reversed in the region between the gap and the repeller electrode and directed into the gap to contribute energy to the field within the high frequency circuit element, thereby to sustain oscillations. The frequency of oscillation may be varied by tuning the circuit element. This may be effected expeditiously in the case where the circuit element is a cavity resonator by flexing a wall of the resonator, specifically by flexing the wall of the resonator opposite the repeller electrode.

The operating characteristics of such a device are dependent upon the transit angle of the electrons in the region between the gap and the repeller electrode, both forward and reverse motion of the electrons being considered. For optimum operation, the transit angle should be substantially equal to $(n-\frac{1}{4})$ cycles of the operating frequency, n being an integer. The transit angle is dependent upon the distance between the gap and the repeller electrode and the potential of this electrode. If the resonator is tuned by flexing a wall thereof as described hereinabove, the gap to repeller electrode distance changes. Heretofore, this has necessitated changing the repeller voltage to obtain optimum operation, specifically maximum output power.

One object of this invention is to simplify the operation of tunable reflex oscillators. More specifically, one object of this invention is to enable attainment of substantially optimum operation of such devices over a wide range of frequencies at a fixed repeller electrode voltage.

In accordance with one feature of this invention, in a tunable reflex oscillator of the general construction described hereinabove, the circuit element and the repeller electrode are so constructed and arranged that the transit time in the gap to repeller region varies inversely in a manner substantially linear with frequency whereby the optimum electron transit angle in this region is obtained for a wide range of frequencies without alteration in the voltage of the repeller electrode.

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The above noted and other features of this invention will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is an elevational view mainly in section of a tunable reflex oscillator illustrative of one embodiment of this invention;

Fig. 2 is a fragmentary view, to an enlarged scale, of the gap defining the repeller electrodes in the device illustrated in Fig. 1; and

Fig. 3 is a graph showing a typical operating characteristic for a device of the construction illustrated in Fig. 1.

Referring now to the drawing, the device illustrated in Fig. 1 comprises an evacuated enclosing vessel **10**, for example of metal, having a base **11** carrying terminal pins **12**. Mounted within the vessel **10** is a cavity resonator **13** bounded in part by a pair of aligned dished grids **14** and **15** which are spaced to define a gap **16**. The grid **14** is mounted upon the end of a cylindrical metallic member **17** extending from a plate **18**; the grid **15** is mounted upon a flexible diaphragm **19** which in turn is supported by a cup-shaped metallic member **20** joined at its edge to the plate **18**. Energy may be taken from the cavity resonator by way of a coaxial line **21**, **22**, the inner conductor **21** of which terminates at its inner end in a coupling loop **23** within the resonator.

Opposite the grid **14** and aligned therewith is an electron gun which comprises a cathode **24** having a concave face **25** at one end coated with electron emissive material, and a heater element **26** within the cylindrical part of the cathode. The electron gun comprises also a cylindrical beam forming or focussing electrode **27** and a cylindrical accelerating anode **28**, which is coaxial with the electrode **27** and fitted within and electrically integral with the reduced end portion of the member **17**. The cathode **24**, heater element **26** and electrode **27** are connected to the terminal pins **12** through lead-in conductors **29** hermetically sealed, by vitreous beads **30**, in eyelets **31** on the base of the vessel **10**.

A dished repeller electrode **32** is mounted opposite and in alignment with the grid **15** by an insulating disc or plate **33** which is mounted rigidly from the resonator member **20** by a support **34**.

Tuning of the cavity resonator may be effected by flexing the diaphragm **19**. The tuning mechanism includes a spider or bracket **35** the arms of which are connected to a rigid annulus **50** affixed to the diaphragm and the base of which is joined to a stem **36** in turn joined to a diaphragm **37** sealed to the vessel **10**. Longitudinal motion of the stem 36 with consequent displacement of the diaphragm 19 and alteration in the natural frequency of the resonator 13 may be accomplished by a nut 38 threaded upon the stem 36 and fixed against axial displacement by a support 40.

In brief, in operation of the device, the resonator 13 is biased positive relative to the cathode 24 and the repeller electrode 32 is biased negative relative to the cathode. A concentrated electron stream is projected by the gun, across the gap 16 whereat the stream is velocity varied. The velocity varied stream enters the region between the grid 15 and repeller electrode 32, is reversed in direction because of the potential of this electrode and injected again in to the gap, thereby to contribute energy to the field within the resonator.

As has been pointed out heretofore, the operating characteristics of such a device are dependent upon the total transit time of the electrons in the gap to repeller region. Optimum operation, specifically maximum power output, requires that the transit angle bear a definite relation to the operating frequency. The transit angle depends upon both the gap to repeller electrode distance and the voltage of the repeller electrode.

It is evident that if the diaphragm 19 is displaced to tune the resonator to a desired frequency, the distance between the gap and the repeller electrode will be varied. In devices of construction known heretofore, this has necessitated adjustment of the voltage of the repeller electrode to obtain maximum power output. The nature of the variation in a typical, well designed prior art device is illustrated by line A in the graph of Fig. 3 wherein the abscissae are operating frequency and the ordinates are repeller electrode voltage requisite for maximum power output.

In accordance with a feature of this invention, such variation is minimized whereby a substantially maximum output is obtained over a wide range of frequencies for a fixed repeller electrode voltage. Specifically, this is realized by correlating the gap to repeller electrode spacing and the frequency so that the transit time in the region between the gap and the repeller varies inversely substantially linearly with frequency over a desired band of frequencies.

The relation involved is given to a high degree of accuracy by the equation

$$l=\frac{\delta}{1-\frac{f_L}{f_H}} \qquad (1)$$

where

l is the gap to repeller spacing for the mid-frequency in the desired band,

f_L is the lower frequency of the desired band,

f_H is the upper frequency of the desired band, and

δ is the difference between effective gap to repeller spacing for the frequencies, f_L and f_H.

By "effective" gap to repeller spacing is meant the distance from a point on the axis of the device midway between grids 14 and 15 to the repeller. This definition also implies that δ is half the total displacement of grid 15 relative to the repeller electrode required to tune the tube from f_L to f_H.

A typical frequency-repeller electrode voltage characteristic for a device constructed in accordance with Equation 1 is illustrated by curve B

in Fig. 3. The improvement achieved by this invention is evident from a comparison of graphs A and B. In a specific device constructed in accordance with this invention, over the range of 3800 to 4200 megacycles per second, the maximum variation in repeller voltage for maximum output was found to be 10 volts (113–103) whereas for a device corresponding to graph A the corresponding variation for the same frequency range was found to be 42 volts (122–80).

Thus, in devices constructed in accordance with this invention, substantially maximum output may be obtained over a band of operating frequencies at a fixed repeller electrode voltage.

What is claimed is:

1. A reflex oscillator comprising a cavity resonator including a pair of juxtaposed members defining a gap, means opposite one of said members for projecting an electron stream across said gap, a repeller electrode opposite the other of said members, and means connected to said other of said members for displacing said other member to vary the length of said gap thereby to tune said resonator over a preassigned band of frequencies, said repeller electrode being spaced from said gap substantially in accordance with the relation

$$l=\frac{\delta}{1-\frac{f_L}{f_H}}$$

where l is the distance from the center of gap to the repeller electrode at the mid-frequency of said band, f_L and f_H are the extreme frequencies in said band, and δ is half the displacement of said one member requisite to tune said resonator over said range.

2. A reflex oscillator comprising a cavity resonator including a pair of juxtaposed electron permeable portions defining a gap, an electron gun opposite one of said portions for projecting an electron stream across said gap, means connected to the other of said portions for moving said other portion toward or away from said one portion thereby to tune said resonator over a preassigned frequency range, and a repeller electrode opposite said other portion and spaced from said gap according to the relation

$$l=\frac{\delta}{1-\frac{f_L}{f_H}}$$

where l is the distance from center of gap to the repeller electrode at the mid-frequency in said range, f_L and f_H are the extreme frequencies in said range, and δ is half the displacement of said portion requisite to tune said resonator over said range.

WILLIAM G. SHEPHERD.

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