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REFLEX KLYSTRON OSCILLATOR

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FIG. 1

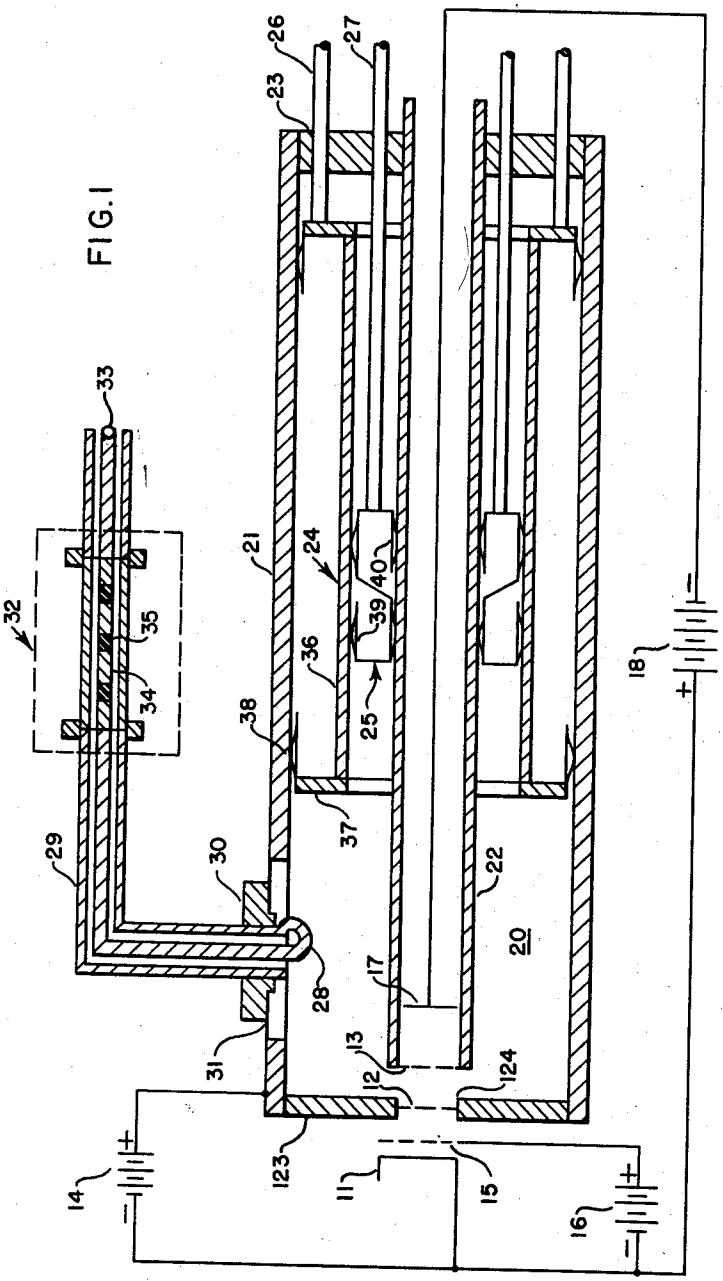
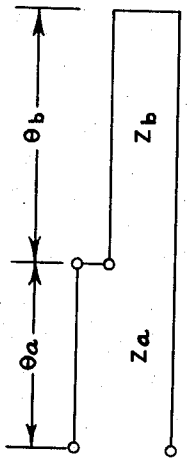


FIG. 2



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REFLEX KLYSTRON OSCILLATOR

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2 Claims. (Cl. 315—5)

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This invention relates generally to a radio frequency oscillator, and, more particularly, to a reflex klystron harmonic oscillator.

In a reflex, velocity-modulated klystron, a cavity resonator is used as the resonant element which determines the frequency of oscillation. Power at the fundamental frequency of oscillation is taken from the cavity by means of a coupling loop and coaxial line. An object of the present invention is to provide a cavity which will be resonant or antiresonant at the fundamental frequency of oscillation and simultaneously resonant or antiresonant at a harmonic of the fundamental frequency and allow power at the harmonic frequency to be extracted from the cavity. The cavity is to be such that the kylstron will operate satisfactorily over a fairly wide range of frequencies. It is intended that the loading afforded by the extraction of the power at the harmonic frequency will not affect the amplitude of oscillation at the fundamental frequency.

Other objects, features and advantages of this invention will suggest themselves to those skilled in the art and will become apparent from the following description of the invention, taken in connection with the accompanying drawings, in which:

Fig. 1 is a cross-sectional view of a reflex klystron, harmonic oscillator embodying the principles of this invention; and

Fig. 2 is a cavity characteristic diagram which will be used in explaining the operation of the circuit of Fig. 1.

In Fig. 1 cavity 20 is used as the resonant element of the klystron. The cavity structure will be described more fully later. An indirectly heated cathode 11 functions as a source of electrons, which are accelerated toward the cavity grids 12 and 13 by virtue of a suitable positive potential from a source designated herein as battery 14 connected between grid and cathode. A control grid 15 which is placed between the cathode and the cavity grids controls the number of electrons that pass through the cavity. A positive potential, less than that applied to the cavity, is applied to the control grid from a suitable source designated herein as battery 16. After leaving the cavity grids, the electrons enter the strong retarding field of the reflector anode 17. The potential of the reflector anode is maintained negative with respect to the cathode by a suitable source of potential connected therebetween and designated herein as battery 18. The

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cavity will become resonant at a fundamental frequency and produce a high frequency alternating voltage variation between grids 12 and 13. The alternating voltage variation velocity modulates the stream of electrons to form bunches of electrons. The bunches of electrons are stopped by virtue of the strong retarding field, their direction is reversed, and they are sent back through the cavity grids. Some of the energy imparted to the electrons during the bunching process is then given to the cavity and oscillations within the cavity are sustained.

Cavity 20 includes an outer conductor 21 concentrically spaced about a center conductor 22. Center conductor 22 is held in place by means of a supporting disc 23 attached to its outer end and also to the outside conductor. Outer conductor 21 is closed at the opposite end by a suitable metallic disc 123 which forms one end of the cavity.

Disc 123 contains a hole 124 directly opposite the inside end of center conductor 22. Cavity grid 12 is mounted in hole 124 in such a manner as to afford electrical continuity between grid and supporting disc. Cavity grid 13 is mounted across the inner end of center conductor 22 so as to afford electrical continuity between the two. The outer end of center conductor 22 projects through a hole in disc 23 to the outside. The end of the cavity adjacent to disc 123 will hereinafter be referred to as the inner end of the cavity.

The outer end of cavity 20 is effectively short-circuited for direct current (D.-C.) potential by means of two sliding annular plungers 24 and 25 coacting between the center conductor 22 and outer conductor 21. Annular plunger 24 may include a cylindrical conductor 36 surrounding center conductor 22, end plates 37, and sliding friction contacts 38, which bear on the inside of outer conductor 21. Annular plunger 25 contains sliding friction contacts 39 bearing on annular plunger 24, and sliding friction contacts 40 bearing on the outside of inner conductor 22. The relative lengths of the two plungers are such that plunger 24 is free to slide over a predetermined distance inside of outer conductor 21, and plunger 25 is free to slide over a predetermined length on plunger 24. The position of both plungers 24 and 25 may be adjusted by suitable means such as rods 26 and 27, respectively, attached thereto and projecting through holes in disc 23 to the outside.

The inner conductor of coaxial line 29 projects

into the cavity where it is bent back and attached to the outer conductor to form the probe **28**. The outer conductor is held secure by coupler **30**. Coupler **30** is fitted into a longitudinal slot **31** in outer conductor **21** of the cavity and is free to slide in order to adjust the position of the probe. The probe is placed at a point in the line where the desired harmonic voltage signal is at a maximum. The probe feeds the load connected to output terminal **33** through a high pass filter **32** which attenuates the fundamental frequency component and passes the harmonic frequency component.

A coaxial filter of the type described in the copending patent application, entitled Electrical Apparatus, by Paul I. Richards, Serial Number 638,897, filed January 3, 1946, now abandoned, may be used. The center conductor of the filter, according to the application referred to, comprises a plurality of short sections of conductor **34** separated by thin pieces of dielectric material **35**. The inner conductor may be separated from the outer conductor by a dielectric material.

The cavity effectively constitutes two sections of coaxial line having different characteristic impedances and coacting in series. The characteristic impedance of a coaxial line is related to the ratio of the inside diameter of the outer conductor and the outside diameter of the inner conductor. The two coaxial lines coacting in series is equivalent to a length, θ_a (at the fundamental frequency), of a coaxial line having a characteristic impedance Z_a, and terminated by a short-circuited length, θ_b (at the fundamental frequency), of a coaxial line having a characteristic impedance equal to Z_b, as shown in Fig. 2.

The lengths of the coaxial line sections may be adjusted by means of the rods attached to the plungers and extending to the outside. When the line lengths are adjusted properly, cavity **20** is resonant at the fundamental frequency of oscillation, and simultaneously resonant at a desired harmonic frequency. For the cavity to be resonant at the fundamental frequency of oscillation, the input impedance of the two sections of coaxial line coacting in series should be substantially infinite. This will occur when Equation 1, below, is satisfied:

$$Ctn\ \theta_a = m \tan \theta_b \qquad (1)$$

where m is a factor defined by the ratio Z_b/Z_a.

The electron beam in the reflex tube will contain harmonic frequency components, and if the cavity is simultaneously anti-resonant at this harmonic frequency, harmonic power will be developed. The condition for resonance at the nth harmonic is given by Equation 2 shown below:

$$Ctn\ n\theta_a = m \tan n\theta_b \qquad (2)$$

For example, let $n=2$

$$Ctn\ 2\theta_a = m \tan 2\theta_b \qquad (3)$$

Replacing $Ctn\ 2\theta_a$ and $\tan 2\theta_b$ in Equation 3 by their trigonometric identities gives:

$$\frac{Ctn^2\theta_a - 1}{2Ctn\theta_a} = m\frac{2\tan\theta_b}{1-\tan^2\theta_b} \qquad (4)$$

Solving Equations 1 and 4 simultaneously gives:

$$Ctn^4\theta_a + (3m^2-1)Ctn^2\theta_a + m^2 = 0 \qquad (5)$$

The required θ_a corresponding to any m may be computed, and θ_b subsequently determined from Equations 1 or 2.

$Ctn^2\theta_a$ will be positive and real only if $m \leq 1/3$.

For the critical case when $m=1/3$, the required line lengths of θ_a and θ_b are equal.

Power at a higher frequency than could normally be extracted from a klystron oscillator may be taken from the harmonic oscillator embodying the principles of this invention. When extracting harmonic power from the oscillator described, herein, the fundamental frequency of oscillation is independent of the load imposed by the extraction means. The oscillator possesses excellent amplitude regulation, since loading at the harmonic frequency does not affect the bunching action of the klystron. In tuning the oscillator by the means presented herein, a relatively broad range of oscillating frequencies is possible. By choosing a different harmonic frequency and substituting a corresponding high pass filter, the range may be extended even farther.

While there has been described hereinabove what is at present considered to be a preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A reflex klystron oscillator for high frequency operation comprising a cavity resonator including a first coaxial line having a first characteristic impedance and a second coaxial line coupled across one end of said first line and having a second characteristic impedance, means coupled to both said lines tuning said cavity resonator to a given frequency and to a harmonic frequency thereof, the inner and outer conductors of said first coaxial line being separated from one another by a gap at the end of said first line remote from the end coupled to said second line, said conductors of said first coaxial line being provided with a pair of apertures adjacent said gap, a source of electrons mounted adjacent one of said apertures for projecting electrons across said gap, electron reflecting means mounted adjacent the other of said apertures for reflecting electrons back across said gap in an interval of time to excite said resonator to oscillate at a fundamental frequency equal to said given frequency, and output coupling means positioned in a region of said resonator where energy of said harmonic frequency is a maximum and energy of said given frequency is substantially less than that of said harmonic frequency for providing output energy of said harmonic frequency.

2. A reflex klystron oscillator for high frequency operation comprising a cavity resonator including a first coaxial line having a first ratio of inner-to-outer conductor diameters and a second coaxial line coupled in series across one end of said first line, and having a second ratio of inner-to-outer conductor diameters, a pair of separately movable tuning means one in each of said lines for independently tuning said lines so that the combination of said lines is resonant at a given frequency and at a harmonic frequency thereof, the inner and outer conductors of said first coaxial line being separated from one another by a gap at the end of said first line remote from the end coupled to said second line, said conductors of said first line being provided with apertures adjacent said gap, a source of electrons mounted adjacent one of said apertures for projecting electrons across said gap, electron reflecting means mounted adjacent the other of said

apertures for reflecting electrons back across said gap in an interval of time to excite said resonator to oscillate at a fundamental frequency equal to said given frequency, and movable output coupling means positioned in a region of said resonator where energy of said harmonic frequency is a maximum and energy of said given frequency is substantially less than that of said harmonic frequency for providing output energy of said harmonic frequency.

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