

May 12, 1953

G. C. SZIKLAI

2,638,561

CATHODE-RAY OSCILLATOR TUBE

Filed Oct. 30, 1946

Fig. 1

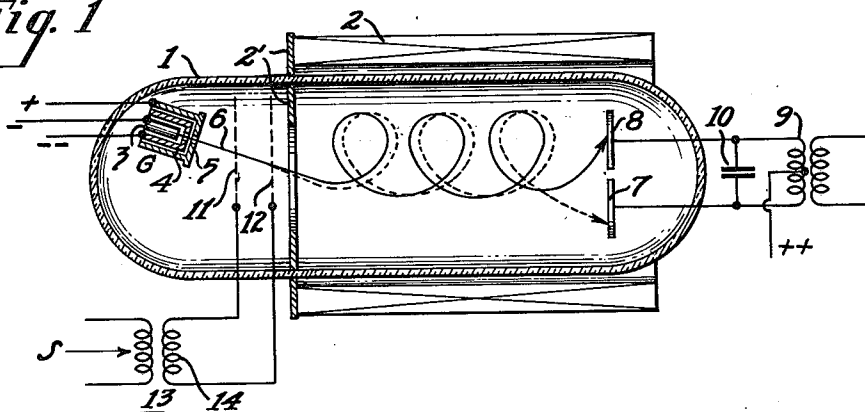


Fig. 2

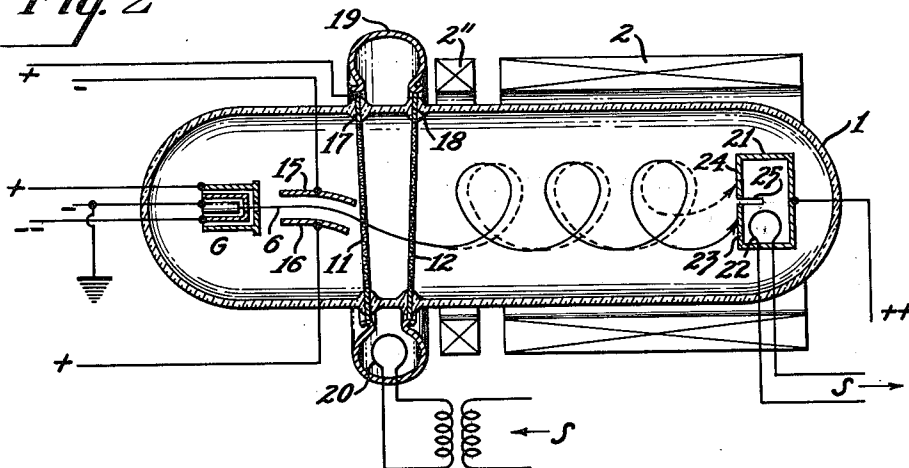


Fig. 3

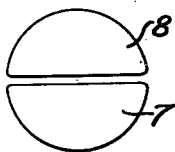
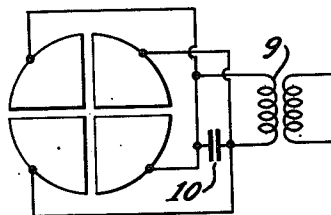


Fig. 4



Inventor

George C. Sziklai

By

William A. Zalesak

Attorney

UNITED STATES PATENT OFFICE

2,638,561

CATHODE-RAY OSCILLATOR TUBE

George C. Sziklai, Princeton, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

Application October 30, 1946, Serial No. 706,698

7 Claims. (Cl. 315—5)

1

This invention relates to the production of high frequency oscillations and more particularly to the control and variation of the frequency thereof.

Cathode ray tubes have heretofore been made to produce oscillations by so introducing the electrons of the beam into a magnetic field that they are caused to spiral around the magnetic lines and land alternately on targets connected to the terminals of a resonant circuit. This type of oscillator is disclosed in the patent granted to Irving Wolff, January 10, 1941, No. 2,244,753. It is an object of this invention to provide means for controlling the frequency of the oscillations of this type of oscillators by an outside agency such as FM signal variations.

Another object of the invention is to provide means in a beam type oscillator tube for frequency modulating the output thereof.

Another object of the invention is to provide a beam type amplifier of high power for frequency modulated waves of low power.

Other objects of the invention will appear in the following description reference being had to the drawings in which:

Fig. 1 is a view of a section of a cathode ray tube diagrammatically illustrating the invention;

Fig. 2 is a view of a modification;

Fig. 3 is a view of the target of the tube of Fig. 1; and

Fig. 4 is a view of a modified form of target.

Referring to Fig. 1, the tube embodying the invention may take various forms but by way of example I have shown an evacuated glass envelope 1 around which is a coil 2 for producing a direct current magnetic field, preferably parallel to the axis of the tube. Iron or steel discs 2' may be used to substantially eliminate the fringe field. A gun G comprising a cathode 3, grid 4 and first anode 5 produces a beam of electrons 6 in a given direction at an angle to the tube axis into the magnetic field produced by coil 2. At the end of the tube opposite the gun G in a plane normal to the tube axis are positioned two spaced second anodes or targets 7 and 8 of suitable form, flat semi-circular plates being shown (Fig. 3). These targets are connected to a tuned circuit comprising the secondary coil 9 and condenser 10. The potential center of the tuned circuit is connected to the positive terminal of a voltage source, to the negative terminal of which is connected the cathode 3. The grid 4 may be connected to a slightly more negative terminal than the cathode as is usual in the art.

2

The first anode 5 should be connected to a positive terminal of this source of less potential than that connected to the tuned circuit. Two spaced screens 11 and 12 are placed so as to be in the path of the beam. They may be positioned perpendicular to the axis of the tube or alternately to the axis of the gun. A signal source typified by a transformer 13 may have its secondary coil 14 connected between the two screens.

The operation of the invention may be described as follows:

The beam enters the axial magnetic field in a given direction at an angle thereto and this gives the electrons a radial component of velocity which causes them to spiral around the magnetic lines of force and land, say on target 8. The landing velocity or the target material may be such that the ratio between secondary and primary electrons is less than unity so the target 8 goes negative and this causes the target 7 to swing positive. The electrons of the beam are then repelled and spiral around and land on target 7, whereupon the action is repeated. By correlating the period of resonance of the circuit 9, 10 connected to the targets with the period of revolution of the electrons in a complete spiral, oscillations will be sustained and oscillating current will be produced in the circuit 9, 10.

The signal input to screens 11 and 12 which may be a frequency modulated wave produces a varying high frequency field in a portion of the path of the beam electron. This velocity modulates the beam and the spiral paths of the electrons are in effect compressed and expanded in synchronism with the FM signal variations of the input of the tube. These vary the landing of the electrons on the targets so that the frequency of oscillation in the output is varied. The tuning may be made broad enough to permit the signal field variation to trigger the oscillations somewhat similar to the locking-in of oscillations in feedback oscillators. Thus, the FM signal input of low power is amplified at the output 9, 10.

In the modification of Fig. 2, the gun introduces the beam 6 into the magnetic focusing field parallel to the magnetic lines and the radial velocity component is produced by the electrostatic deflecting plates 15, 16 which are connected to positive and negative terminals of a direct current source of sufficient potential difference to deflect the beam into the magnetic field at the desired angle. A bucking coil 2'' may be used to reduce the fringe field of the coil 2.

Due to the curvature of the plates 15, 16 the electrons of the beam are velocity sorted as in my application filed August 25, 1945, Serial No. 612,651, which is now U. S. Patent #2,534,537 granted December 19, 1950. In this figure the two grids 11, 12 are connected to rings 17, 18 sealed in the envelope 1 and contacting the capacity edges of a cavity resonator 19 of "tire casing" form. The screens converge downward in Fig. 2 so that the field varies inversely with the velocity of the electrons. That is, the strongest field oscillates the slow electrons and the weakest field oscillates the fastest electrons. The signal may be introduced by coil 20. The targets may also be a slitted hollow box which forms a cavity resonator 21 from which the signal is taken at 22. The half sides 23, 24 formed by the slot 25 constitute the targets similar to 7 and 8 of Fig. 1.

The operation of the tube in Fig. 2 is as follows:

The beam containing electrons of a range of velocities according to the Maxwellian law is subjected to the electric field of plates 15, 16 which deflects them along curved paths. The fast electrons are deflected least and the slow ones are deflected most. This causes the electrons of different velocities to enter the field between the screens 11 and 12 of the cavity resonator 19 in such position that they are equally acted upon by the field. This is because the converging screens vary the field inversely with the velocity of the electrons therein. The electrons after leaving the screen 12 of the cavity resonator drift in the accelerating field and the slow electrons fall behind and bunch up with the succeeding fast electrons so that they arrive together at the cavity resonator 21, which is correctly positioned for this purpose. The oscillation frequency of the beam is controlled by the input signal of 20 in the same way as in Fig. 1. That is, weak FM input signals are amplified to strong signals at output coil 22.

The advantage of the tube of Fig. 2 over that of Fig. 1 is that substantially all electrons arrive at the output resonator in phase and maximum effects are produced.

The high frequency energy of the beam is introduced into the cavity resonator by the electromagnetic field of the electrons as they spiral across the slot 25 in their travel from plate 24 to plate 23 and vice versa. The field produces high frequency alternating potentialities on the inside surfaces adjacent the slot and the current flow produced thereby sets up an electromagnetic field passing through output coil 22.

Instead of introducing a frequency modulated carrier wave into the tube for amplification one may introduce AM signals in the input circuit and these then will frequency modulate the oscillations of the beam at the output.

By constructing the target in four sections, as shown in Fig. 4 the frequency will be doubled by proper choice of parameters of the tube. The frequency may be multiplied as much as desired by multiplying the sectors of the target, alternate sectors being connected together with each series of sectors connected to a side of the tuned circuit 9, 10.

Various other modifications may be used without departing from the spirit of the invention.

What I claim as new is:

1. A cathode ray beam amplifier tube comprising a tuned circuit having target plates, means for producing a uniform magnetic field in the

tube having lines of force substantially perpendicular to the plane of said plates, means directed in a given direction at an angle to said magnetic field for projecting a beam of electrons into said field toward said target plates and including means for velocity sorting the electrons of said beam so that electrons of the same velocity occupy substantially exclusively the same path, a cavity resonator adjacent said last means, means for introducing an electric signal field into said cavity resonator and mesh screens connected to the capacity members of said cavity resonator and converging toward the paths of the slowest electrons, to subject the electrons to electric signal fields inversely varying with their velocity, said target plates being located where the electrons of various velocities are bunched together by fast electrons overtaking slow electrons.

2. A cathode ray tube having means for producing a magnetic field axially thereof, means including an electron gun for projecting an electron beam into said magnetic field in a given direction at an angle to the tube axis with one velocity component in the direction of the lines of said field and another velocity component perpendicular thereto, a pair of spaced anodes mounted in said field in a plane normal to the tube axis, a pair of screens between said electron gun means and said anodes and spaced apart along the lines of said magnetic field, output terminals coupled to said anodes and input terminals coupled to said screens.

3. A cathode ray tube having means for producing a magnetic field axially thereof, a cathode ray gun mounted in said tube at an angle to the longitudinal axis thereof to project electrons into said field in a given direction with velocity components in the direction of and perpendicular to the lines thereof, a pair of spaced anodes mounted in said field in a plane normal to the tube axis, a pair of screens between said cathode ray gun and said anodes and spaced apart along the lines of said field, output terminals connected to said anodes and input terminals connected to said screens.

4. A cathode ray tube comprising a coil for producing a magnetic field axially thereof, a cathode ray gun mounted in said tube at an angle to the longitudinal axis thereof to project electrons into said field in a given direction with one velocity component in the direction of the lines thereof, and another velocity component perpendicular thereto, a pair of spaced anodes mounted at one end of said coil in a plane normal to the tube axis, a pair of screens between said gun and the other end of said coil, input terminals connected to said screen and output terminals connected to said anodes.

5. A cathode ray tube comprising means for producing a magnetic field axially thereof, a pair of curved electrodes spaced apart and inclined to the lines of said field, a cathode ray gun adapted to project a beam of electrons between said electrodes and into said field in a given direction at an angle thereto with one velocity component in the direction of the lines of said field and another component perpendicular thereto, a pair of output anodes in said field in a plane normal to the tube axis, a cavity resonator between the output anodes and said electrodes, screens connected to the capacity members of said cavity resonator converging towards each other at one side thereof, an input coil in said cavity resonator and an output coil coupled to said anodes.

6. An oscillator including means for produc-

ing a magnetic field, means including an electron gun for projecting a beam of electrons into said magnetic field in a given direction at an angle thereto with one velocity component in the direction of the lines thereof and another velocity component perpendicular thereto, a pair of spaced anodes mounted in said field in a plane normal to said field, a tuned output circuit coupled between said anodes, whereby during operation of said oscillator the beam is caused to spiral around the lines of said magnetic field and lands on one of said anodes until repelled thereby and caused to land on the other anode, thus generating oscillations in said tuned circuit, and means for varying the velocity of the electrons of said beam prior to entrance into said magnetic field, to vary the frequency of said oscillations.

7. An oscillator according to claim 6, wherein said last named means comprises a pair of electron-permeable screens spaced along the beam

path between said electron gun and said anodes, and means for applying a modulating voltage between said screens.

GEORGE C. SZIKLAI.

References Cited in the file of this patent
UNITED STATES PATENTS

Number	Name	Date
2,096,460	Llewellyn -----	Oct. 19, 1937
2,214,729	Hickok -----	Sept. 27, 1940
2,232,050	Clavier et al. -----	Feb. 18, 1941
2,272,165	Varian et al. -----	Feb. 3, 1942
2,390,250	Hansell -----	Dec. 4, 1945
2,409,222	Morton -----	Oct. 15, 1946
2,413,276	Wolff -----	Dec. 24, 1946

FOREIGN PATENTS

Number	Country	Date
508,354	Great Britain -----	Nov. 4, 1938