May 26, 1953 E. TOURATON ET AL **2,640,172**

HYPERFREQUENCY VACUUM TUBE

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Fig. 1.

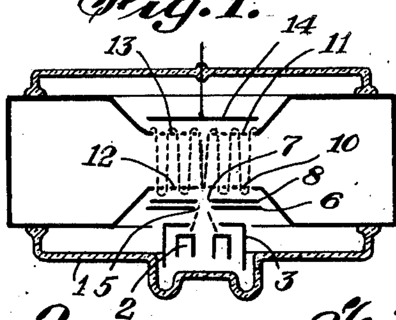

Fig. 2.

Fig. 3.

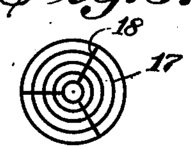

Fig. 4.

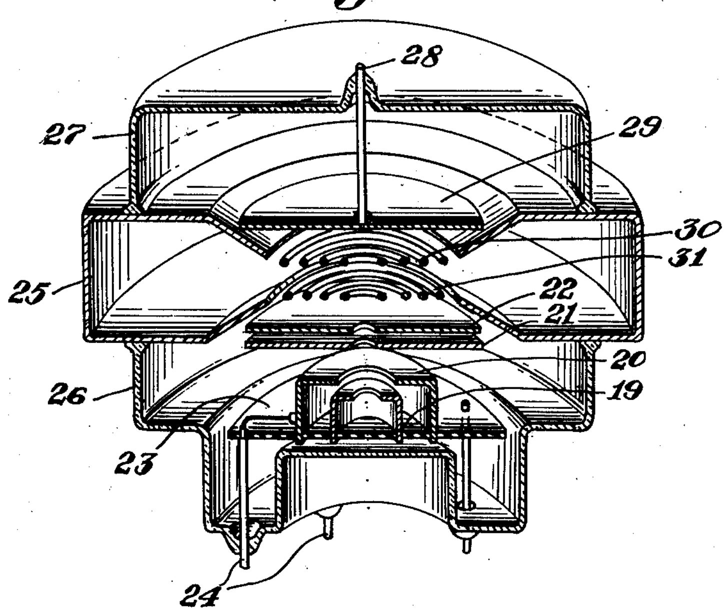

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Fig. 5.

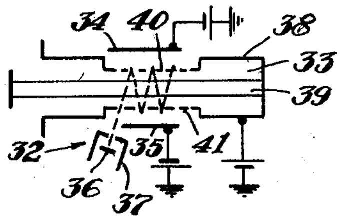


Fig. 6.

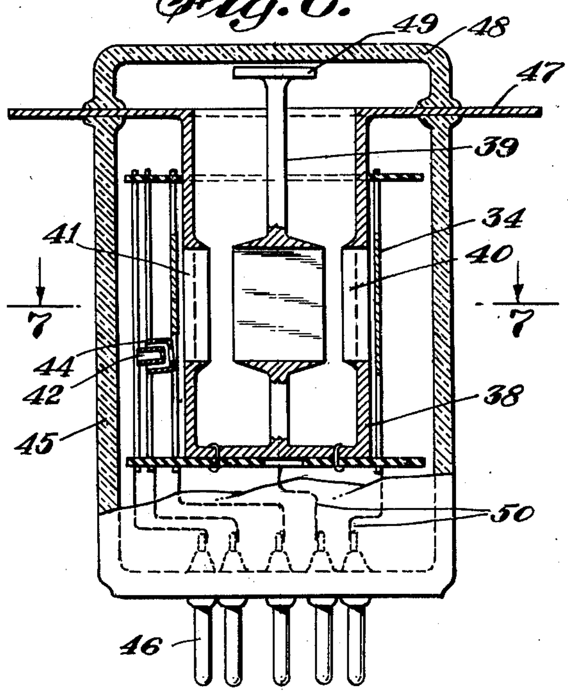
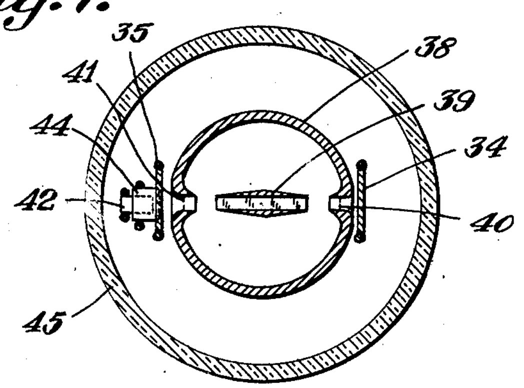


Fig. 7.



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HYPERFREQUENCY VACUUM TUBE

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4 Claims. (Cl. 315—5)

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The present invention relates to ultra high frequency tubes and particularly to tubes of the velocity modulation type operating as oscillators.

Oscillator tubes of the velocity modulation type sometimes comprise an electron gun generating an electron beam which flows through either input and output resonators or a coaxial resonator and strikes a collector electrode. Such vacuum tubes usually have a small modulation band and a low efficiency.

Reflect oscillator vacuum tubes are well known in the art. Such vacuum tubes usually comprise an electron gun generating an electron beam which flows firstly through a resonator, is reflected at the output of said resonator and then flows a second time through this resonator in the opposite direction. During its first passage through the resonator the electron beam is velocity modulated, the electrons of the beam are bunched at the output of the resonator and give up part of their energy during their second passage through the resonator. Such vacuum tubes have a narrow modulation frequency band and, owing to their low efficiency, it is not possible to damp sufficiently the resonating volume in order to increase the band-width. On the other hand due to the fact that the electrons flow back towards the cathode there is a risk of deterioration of the cathode and of generating secondary emission which increases the background noise of the tube.

One object of the present invention is the manufacture of a very wide band oscillator tube of the velocity modulator type for extremely high frequencies. An increase in the efficiency makes it possible to widen the useful frequency band by damping the resonating cavity.

One object of the invention is a coaxial type vacuum tube having a very wide band width at very high frequencies.

According to features of the invention, the electron beam flows several times through the coaxial resonator while it progressively draws away from its initial course under the action of two reflecting electrodes.

Another object of the invention is to provide a wide band velocity modulation type oscillator of the reflex type.

According to one feature of the invention the electron beam is successively reflected between the output and input of the cavity resonator. The electron beam thus flows several times through the resonator, drawing away from its original direction. In this way it is also possible to avoid the return of the electrons towards the emissive cathode.

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The above mentioned and other features and objects of this invention will become more apparent, and the invention itself, though not necessarily defined by said features and objects, will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a schematic cross section of a vacuum tube incorporating features of the invention.

Figs. 2 and 3 show schematically grids which may be used in the vacuum tube shown in Fig. 1; and

Fig. 4 is a large scale cross section of a vacuum tube incorporating features of the invention.

Fig. 5 shows a schematic cross section of a vacuum tube incorporating features of the invention.

Fig. 6 shows an enlarged longitudinal cross section of an embodiment incorporating features of the invention, and

Fig. 7 is a cross section along line 7—7 of Fig. 6.

Referring now to Fig. 1, 1 is a glass vessel which can be evacuated, inside this glass envelope is an electron gun comprising an annular emissive cathode 2, whose potential will be considered as the reference potential for the remainder of the description and a concentrating electrode 3 brought to an appropriate potential. The central longitudinal axis of the electron beam generated by the electron gun is also the axis of symmetry of the tube structure. The electron beam converges into an opening 5 provided in an electrode 6, brought to a positive potential, and into an opening 7 provided in an electrode 8, brought to a negative potential and located after electrode 6 and at a short distance therefrom. The electron beam then diverges and flows a first time through a resonating cavity 9 through two of the openings 10 and 11. Grids 12 and 13 are respectively mounted on the same level as openings 10 and 11. The plane of these grids 12 and 13 is perpendicular to the axis of the electron beam. They may be of any appropriate shape but two particular embodiments will be described in relation with Figs. 2 and 3. The electron beam is then reflected, after flowing through grid 13, by the electrical field set up by electrode 14 whose plane is perpendicular to the axis of the electron beam and which is at a negative potential with respect to the cathode. The electron beam again flows through the two windows 11 and 10 and grids 13 and 12. After leaving grid 12 the electron beam is again reflected by electrode 8 brought to a negative potential. The beam flows again through openings 10 and 11, is reflected by electrode 13 and this to and fro movement continues for a number of times through openings **10** and **11** until the electron beam is collected by the wall of the resonating volume **9**.

During all its successive passages between windows **10** and **11** the electron beam retains the shape of a surface of revolution about its control axis. The sections of the beam at the level of grids **12** and **13** are in the shape of rings which increase in diameter at each passage through the grids.

During the successive passages of the electrons through the windows **10** and **11** of the resonating cavity, an interaction takes place between the electromagnetic wave set up inside the volume and the electron beam. The first passages of the electron beam cause modulations which add up to produce a resulting modulation of a sufficient amplitude, while the high frequency potential between grids **12** and **13** remains low because of the large damping factor of the resonating volume **9**.

In the same way, a transfer of energy takes place during the last passages of the electron beam between grids **12** and **13** and it is thus possible to utilise a large part of the energy of the electron beam in spite of the low impedance of cavity **9**, which is a consequence of its high damping.

Fig. 2 shows schematically a grid used at **12** and **13** in the tube shown on Fig. 1. It comprises in particular two concentric rings **15** connected by radial rods **16**.

Fig. 3 shows another grid which may also be used with the tube shown on Fig. 1. This grid comprises a number of concentric rings **17** of increasing diameter connected by rods **18**, three for example. The distance between two successive rings **17** is chosen so as to permit the passage of the electron layer and its return after reflection.

The arrangements shown in Figs. 2 and 3 are given by way of example. It is clear that other arrangements may be used in relation with the tube described.

Fig. 4 is an enlarged scale cross section of an embodiment incorporating features of the invention. The tube shown in this figure comprises an electron gun, with an annular emissive cathode **19**, and a concentrating electrode **20**. Two focussing electrodes **21** and **22** are provided after the electron gun. These various electrodes are held in place inside the tube by supporting members of mica, for instance, such as **23** which is held in place by rods or prongs **24**.

The connections between the prongs **24** and the other electrodes have not been shown for the sake of clarity. The cavity resonator **25** is sealed to the glass envelope **26** which holds the electron gun and focussing electrodes **21** and **22**. The outside glass envelope **27** is sealed to the other wall of resonator **25** and holds the reflecting electrode **29** by means of a rod **28**. Grids **30** and **31** are similar to those shown in Fig. 3.

To make the drawing clearer the high frequency connections between the vacuum tube, and the high frequency circuit have not been shown, since they are well known in the art. Supplementary electrodes may be provided to enable the operation of the tube as an oscillator, amplifier or in any other known manner.

Referring now to Fig. 5, the vacuum tube shown comprises essentially an electron gun **32**, a coaxial resonator **33**, two reflecting electrodes **34**, and **35**. The electron gun **32** comprises for example an emissive cathode **36** whose potential will be considered as a reference potential for the rest of the description, and a concentrating electrode **37** brought to an appropriate potential. The coaxial resonator **33** is constituted by an outside conductor **38** and an inside conductor **39** provided with windows so as to allow the electron beam to flow through. The coaxial resonator is brought to a positive potential with respect to the cathode and the two reflecting electrodes **34** and **35** to negative potentials as shown on the drawing. The electrons from the electron gun flow through the resonator, and are then reflected by the reflecting electrode **34**. These electrons are reflected back into the resonator in which they flow in the reverse direction. The electron gun **32** is slightly aslant in order that the reflected electron beam should not follow the same path as at its first passage, but flows in a direction slightly different from its initial direction.

The electron beam thus flows to and fro a number of times between reflectors **34** and **35**. At each of these successive passages through the windows of the coaxial structure **38** and **39**, an interaction takes place between the electron beam and the electromagnetic wave set up inside the coaxial structure. During the successive passages of the electron beam concurrent modulation effects take place which produce a high resultant modulation. The windows provided on the outside of conductor **38** may be provided with grids **40** and **41**. The high frequency potential between grids **40** and **41** may be kept low, and this makes it possible to adequately damp the coaxial resonator.

In the same way, it is possible to obtain cumulative catcher effects in the last passages of the electron beam between grids **40** and **41** as this makes it possible to utilise a large amount of the energy of the electron beam in spite of the low impedance of the coaxial resonator due to its large damping.

Fig. 6 is an enlarged longitudinal cross-section of an oscillator incorporating the features shown in Fig. 5, and Fig. 7 is a cross section along line **7—7** of Fig. 6.

According to known processes, the electron beam is generated by a cathode **42** whose emissive surface is slightly aslant with respect to the vertical axis of the tube. A concentrating electrode **44** is provided opposite the cathode **42** so as to produce a narrow electron beam. Other electrodes may be associated with electrodes **42** and **44** as known in the art, but have not been shown for the sake of clarity. Other members already shown in Fig. 5 have been designated by the same reference numerals. The electrode structure comprises a glass envelope **45** and an appropriate flare provided with prongs **46** connecting the various electrodes to the outside circuit. An annular metal disc **47** is welded to the envelope **45** and to a glass cover **48** surrounding the coaxial conductor **49**. The coaxial conductor **38** is fixed to the said annular disc **47** which is also used for the mounting of the different members of the tube. The other electrodes are connected to prong **46** by wires **50**. Grids **40** and **41** may be provided in the windows of the outside coaxial conductor **38** and have been shown schematically on Figs. 6 and 7 by dotted lines. These grids may be constituted by a metal wire mesh or by small sized wires appropriately arranged. In some cases these grids may be disposed with. When they are used they may be brought to the same potential as the coaxial resonator.

While we have described two particular embodiments of our invention for purposes of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

We claim:

1. A velocity modulation tube comprising a conductive housing defining a cavity resonator, said housing having aligned apertures in opposite walls thereof, means including an electron gun mounted outside said cavity resonator at an angle to the alignment axis of the apertures, for projecting a beam through said apertures, the beam being angularly disposed with respect to their alignment axis, and means for reflecting the beam back and forth through said cavity including a pair of reflector electrodes mounted outside said housing and respectively overlying said apertures, whereby the beam after projection through said apertures is reflected by and between said reflector electrodes to flow back and forth through said cavity in displaced paths.

2. A velocity modulation tube comprising a conductive housing defining a cavity resonator, said housing having aligned apertures in opposite walls thereof, means including an electron gun mounted outside said cavity resonator, for projecting a beam through said apertures angularly disposed with respect to their alignment axis, said electron gun including a cathode electrode having an emitting surface of substantially annular configuration and a pair of reflector electrodes mounted outside said housing and respectively overlying said apertures, whereby the beam after projection through said apertures is reflected by and between said reflector electrodes to flow back and forth through said cavity in displaced paths.

3. A velocity modulation tube comprising a conductive housing defining a cavity resonator, said housing having aligned apertures in opposite walls thereof, grid electrodes disposed substantially within the confines of each of the apertures contained in said housing, means including an electron gun mounted outside said cavity resonator, for projecting a beam through said apertures angularly disposed with respect to their alignment axis, and a pair of reflector electrodes mounted outside said housing and respectively overlying said apertures, whereby the beam after projection through said apertures is reflected by and between said reflector electrodes to flow back and forth through said cavity in displaced paths.

4. A velocity modulation tube comprising a conductive housing defining a cavity resonator, said housing having aligned apertures in opposite walls thereof, means including an electron gun mounted outside said cavity resonator and positioned adjacent one edge of one of said apertures, for projecting a beam through said apertures angularly disposed with respect to their alignment axis, and a pair of reflector electrodes mounted outside said housing and respectively overlying said apertures, whereby the beam after projection through said apertures is reflected by and between said reflector electrodes to flow back and forth through said cavity in displaced paths.

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