Oct. 14, 1947. A. E. BOWEN 2,428,779

ULTRA-HIGH-FREQUENCY ELECTRONIC DEVICE

Original Filed July 3, 1942

FIG. 1

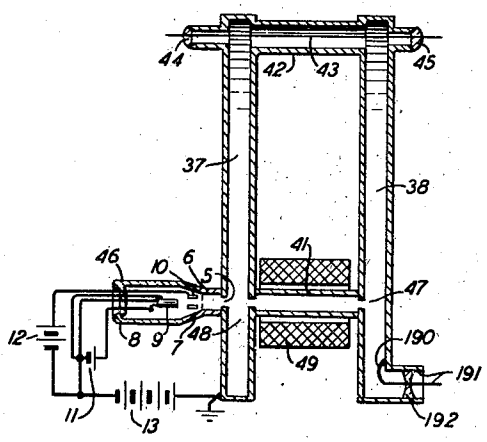
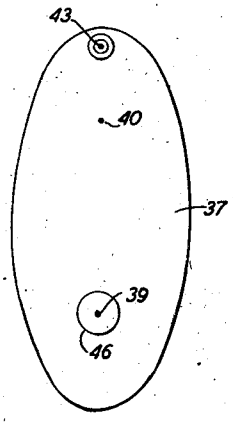


FIG. 2



INVENTOR
A. E. BOWEN
BY Franklin Mohr
ATTORNEY

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ULTRA HIGH FREQUENCY ELECTRONIC DEVICE

Arnold E. Bowen, Red Bank, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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3 Claims. (Cl. 315—39)

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This invention relates to systems employing resonators and resonant cavities so shaped and constructed as to be suitable for reaction with an electron stream to enable an electromagnetic field which may be set up in the resonator or resonant cavity to induce a variation in some characteristic property of the electron stream, or, to permit an interchange of energy between the resonator and the electron stream.

In particular the resonator may be in the shape of a short section of an elliptical cylinder, hollow inside and closed off by parallel plane sheets. A wave guide may be connected to the resonator at a focal point or elsewhere according to the amount of impedance to be provided at the junction point.

The invention is applicable generally to amplifiers, oscillators, modulators, detectors and the like, particularly at ultra-high frequencies, wherever it is desired to effect direct interaction between an electromagnetic field and an electron stream.

This application is a division of my copending application Serial No. 449,581, filed July 3, 1942, which latter application is a continuation in part of my copending application Serial No. 387,432, filed April 8, 1941, Patent No. 2,408,409, issued October 1, 1946.

The present application is specific to a combination of two elliptical cavity resonators with electronic coupling between one pair of respective focal points in the resonators and with a two-directional coupling means connected between another pair of corresponding points in the two resonators, not necessarily focal points.

The invention is described with reference to an illustrative example, while its scope is indicated by the appended claims.

In the drawing:

Figs. 1 and 2 show a sectional view and a plan or elevational view, respectively, of an oscillator employing elliptical resonators and a stream of electrons.

In Figs. 1 and 2 there are shown two substantially elliptical resonators 37 and 38 with focal points indicated at 39 and 40. The resonators may be built with walls of copper or other suitable material, the inner surfaces, at least, being preferably highly conductive. Each resonator may be viewed as comprising a short section of elliptical cylinder closed off by parallel, plane end walls. Apertures are cut through the plane walls of each ellipse at focus 39 and the resonators are joined by a cylindrical conductive tube 41 covering the apertures. Additional apertures are

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cut through the resonator walls preferably near the periphery at a point remote from focus 39 and the resonators are joined at this point by a cylindrical conductive tube 42. Coaxially with the tube 42 is placed a rod of conductive material 43 which is held in place by insulating hermetic seals at 44 and 45. A hollow conductive cylinder 6 is fastened over an aperture 5 in the left-hand end wall of the resonator 37 as viewed in Fig. 1. The tube 6 is joined by means of a suitable hermetic seal 7 to an insulating envelope 8 of glass or other suitable material. Within the envelope 8 are provided the usual elements of an electron gun or beam projector 46 of any suitable type comprising, for example, a cathode 9, and an accelerating electrode 10 cooperating with the cylinder 6 to direct an electron beam through the apertures in the resonators 37 and 38 aligned with the axis of tube 41. A pair of gaps 47 and 48 is constituted, as indicated, in the path of the beam. The gap 48 is defined by the edges of the aperture 5 and the edges of an aperture in the right-hand end wall of the resonator 37 at the entrance to the tube 41. The gap 47 is defined by the edges of an aperture in the left-hand end wall of the resonator 38 and the right-hand end wall of that resonator. Batteries 11, 12 and 13 or other suitable sources may be provided, respectively, for heating the cathode 9, energizing the accelerating electrode 10 and applying an accelerating potential to the conductive system comprising resonators 37 and 38, and the tubes 41, 42 and 6. The tube 41 serves not only as a passage for the electron stream but also as an electromagnetic shield defining a drift space within which the electron bunching action hereinafter described may be effectuated free from fluctuating electromagnetic fields.

In the operation of the arrangement of Figs. 1 and 2, the electrons comprising the electron stream from the gun 46 are subjected to the gap 48 to interaction with any electromagnetic field which may exist in the resonator 37 and at the gap 47 with any such field that may exist in the resonator 38. An accidental irregularity in the charge density of the electron stream will suffice to set up an electromagnetic wave in the resonator 38 as the irregularity passes across the gap 47. The wave thus set up spreads through the cavity of the resonator 38 and converges again at the focus 40, inducing current in the conductor 43 where the latter crosses the resonator. An induced wave travels over the coaxial transmission line comprising the tube 42 and the conductor 43 into the resonator 37. A wave is induced in

the latter resonator which wave in the course of propagation converges upon the gap **48**. Each electron in its passage across the gap **48** either takes energy from or gives energy to the electromagnetic field in the resonator **37**, depending upon the phase of the field during its transit of the gap. The velocities of the electrons are varied in accordance with this energy interchange.

After leaving the gap **48**, the velocity-varied electrons pass through the tube **41** where a grouping or bunching effect takes place, these electrons which have lost energy and have, as a consequence, been slowed down being overtaken by other electrons which entering later, have gained energy and have speeded up. Consequently, at a point some distance to the right of the gap **48**, the electrons are traveling in more or less well-defined groups. Upon reaching the gap **47** the bunches of electrons may, if the length of the tube **41** and the initial speed of the electrons have been adjusted correctly, cross the gap **47** in opposition to the high frequency electromagnetic field, thus contributing energy to the field, and in greater amounts than are absorbed by the thinly distributed electrons which may cross the gap **47** during the unfavorable phase of the high frequency field. The net energy contributed by the electron stream to the field tends to sustain and build up the original wave and thus to maintain the system in oscillation.

It may be further noted that the wave above described, upon first arriving at the gap **48** and there initiating an electron group in the electron stream, is, in effect, reflected back through the resonator **37** and coaxial line **42**, **43** into the resonator **38** and to gap **47**. If the velocity of the electrons in the beam is adjusted so that the electron bunch reaches the gap **47** at the same time the reflected wave arrives there, or an integral number of cycles later, a fresh supply of energy is given to the wave and the oscillation is maintained. The adjustment in this case will also satisfy the condition for oscillation specified in the preceding paragraph.

The type of construction shown in Figs. 1 and 2 accommodates a magnetizing coil **49** which may be wound around the cylinder **41** and used to improve the collimation and focusing of the electron stream. Energy may be extracted from the system by any suitable means, such as a coupling loop **190** connected across a coaxial transmission line **191**. The vacuum chamber will include the envelope **8**, the resonators **37**, **38** and the tubes **6**, **41**, **42** and the closure may be completed with an insulating seal **192**. The spent electrons are collected at the right-hand end wall of the resonator **38** and returned to the battery **13**.

The construction shown in Fig. 1 will be observed to require a minimum of insulating material and practically none in the space containing the high frequency field.

What is claimed is:

1. An electronic oscillator comprising a pair of spaced elliptical cylindrical resonators, means in a path interlinking said resonators for producing an electron stream, said path forming a substantially unidirectional coupling between said resonators and passing substantially through a pair of focal points of said respective resonators, and a coaxial transmission line forming a feedback path between another pair of points in said respective resonators.

2. An electronic oscillator comprising a pair of spaced elliptical cylindrical resonators, means in a path interlinking said resonators for producing an electron stream, said path forming a substantially unidirectional coupling between said resonators and passing substantially through a pair of focal points of said respective resonators, and coupling means forming a feedback path between another pair of points in said respective resonators.

3. An oscillator comprising two flat, hollow elliptical resonators in each of which the foci are substantially the same distance apart, said resonators being placed with their flat faces substantially parallel, first and second tubular members separating said resonators and interconnecting the interior spaces thereof, the first of said tubular members connecting a pair of respective foci and the second of said tubular members having a conductive inner surface, a central conductor within said second tubular member forming with said member a concentric conductor transmission line and means in a path interlinking said resonators and the first of said tubular members to project an electron beam through one of said resonators and through the first of said tubular members into the other of said resonators.

ARNOLD E. BOWEN.

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