Aug. 20, 1957 G. DIEMER 2,803,778

DEVICE FOR GENERATING ELECTRICAL OSCILLATIONS

Filed May 19, 1954 2 Sheets-Sheet 1

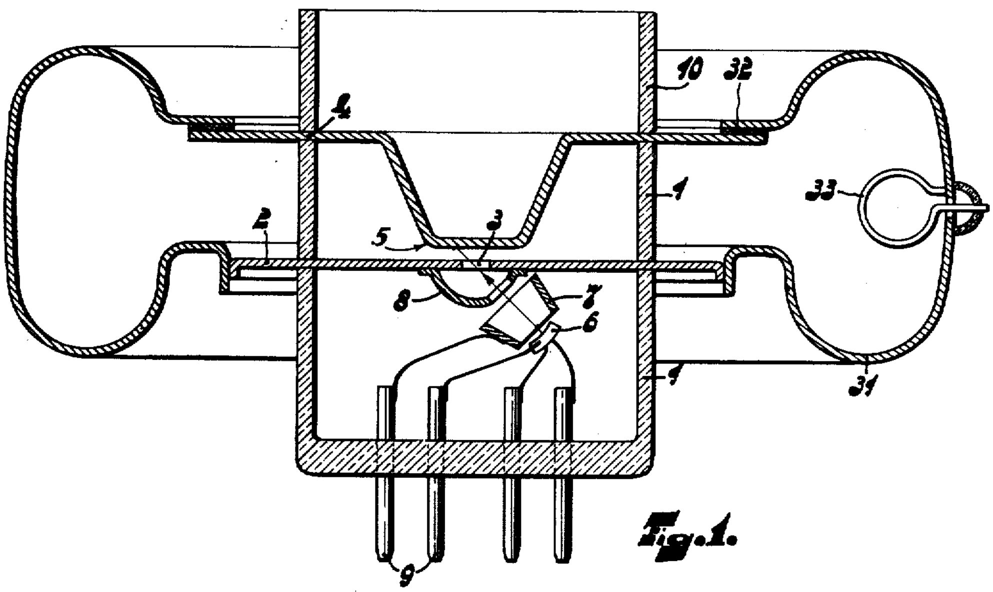

Fig. 1.

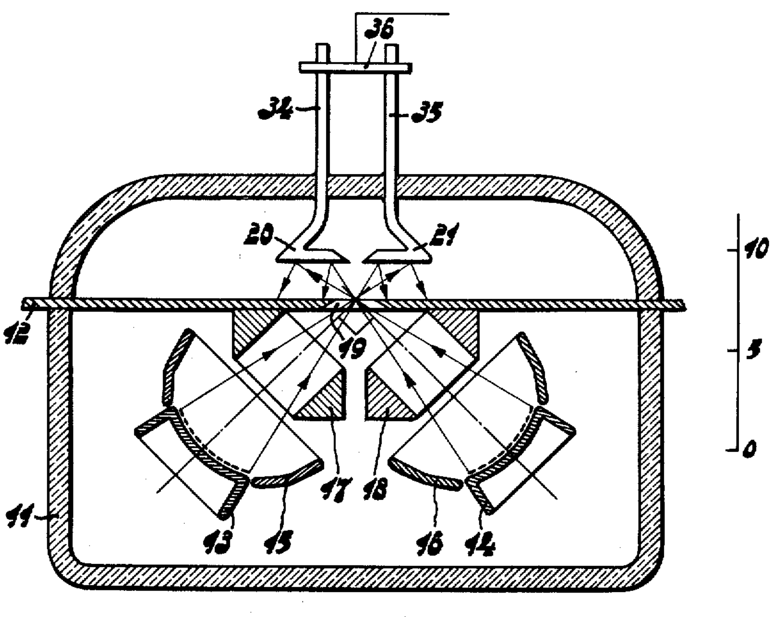

Fig. 2.

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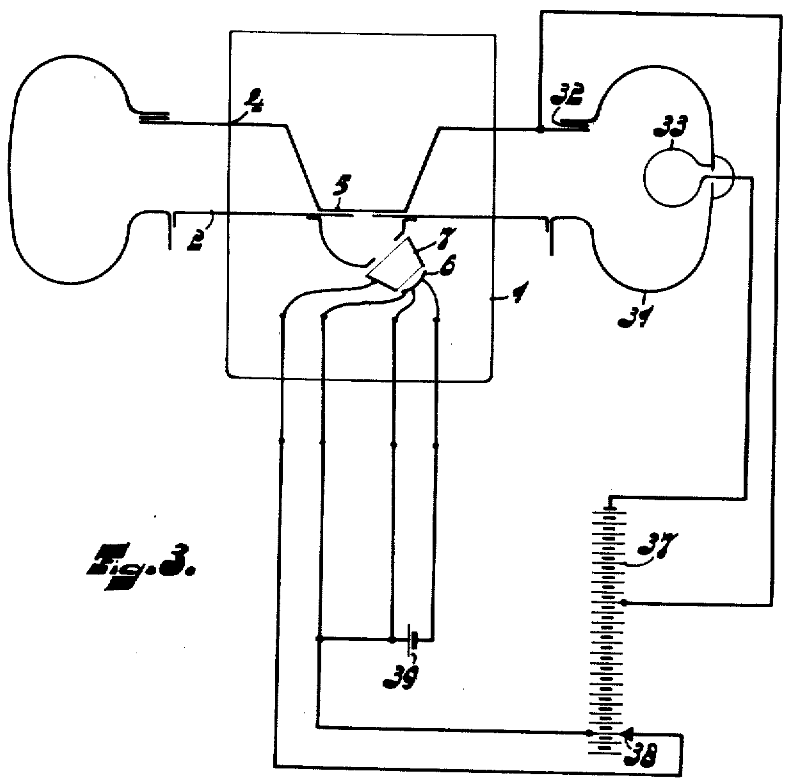

Fig. 3.

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DEVICE FOR GENERATING ELECTRICAL OSCILLATIONS

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Application May 19, 1954, Serial No. 430,964

Claims priority, application Netherlands March 6, 1947

8 Claims. (Cl. 315—5.12)

This application is a continuation in part of my application Serial No. 8,345 filed February 14, 1948 now abandoned.

The invention relates to devices for generating electrical oscillations of a wavelength of a few centimetres by means of an electric discharge tube, wherein the electrons emanating from the cathode are projected through one or more apertures in an anode on a secondary-emission electrode arranged so as to be parallel to the anode and to discharge tubes for use in such devices.

It is already known to generate oscillations of very high frequency by means of a tube as described above. The primary electrons are projected substantially perpendicularly on the secondary emission electrode which constitutes the rear wall of a cavity resonator. The anode forms the front wall of the cavity resonator.

The highest frequency at which such a tube can oscillate as a dynatron, i. e. on the negative internal resistance of the secondary-emission electrode, is determined by the path to be covered by the secondary electrons between the secondary-emission electrode and the anode and by the voltage difference between the two electrodes, it being assumed that the electrons do not oscillate about the parts of the anode but are collected directly. In such a dynatron the transit time of the secondary electrons must be small compared with the period of the alternating voltages to be produced.

It has been found in practice that the frequency cannot exceed approximately 2000 mcs. (wavelength 15 cms.). This occurs with an anode-secondary-emission electrode spacing of 1 mm. and with a voltage difference of 1000 v. between the two electrodes. By raising the voltage and reducing the spacing the wavelength limit may be slightly lowered but in this case the technical difficulties (flash-over) are so great and the efficiency is so low that in the wavelength range below 10 cms. no satisfactory results can be obtained. Furthermore, at these wavelengths at which such a tube still oscillates the efficiency, with normal spacing and field strength, is already comparatively low (by experiments 5% has been attained at 20 cms.) since, in order to obtain a sufficiently negative internal resistance the voltage on the secondary-emission electrode must be chosen to be low whereas, in order to obtain short transit times, the anode voltage must be high. The voltage swing which the secondary-emission electrode may thus obtain, is consequently comparatively small.

With tubes of this kind the negative internal resistance is determined by the variation of the secondary-emission coefficient with the voltage on the secondary-emission electrode. At a voltage of some hundreds of volts at the most this variation is still sufficient for the most usual substances (the variation is greatest at a voltage of 0 v.).

The invention has for its object to obviate the disadvantages of the known devices, among others the high field strength between the anode and the secondary-emission electrode and the low efficiency.

In a device according to the invention for producing electrical oscillations of a wavelength of a few centi-

metres in which the electrons emitted from the cathode are projected through one or more apertures in an anode on a secondary-emission electrode parallel to the anode, these electrons are concentrated into one or more beams which have small aperture angles and the axes of which are at an angle of about 45° with the plane of the anode, the voltages on the anode and the secondary-emission electrode and their relative spacing being so chosen that, in the absence of alternating voltages on the electrodes, the primary electrons still just fall upon the secondary-emission electrode and the transit time of the secondary electrons to the anode is approximately a full period of the oscillations to be produced.

In the device thus obtained the negative internal resistance of the secondary-emission electrode is determined by the variation of the primary current to the secondary-emission electrode with the voltage on the latter, whereas, as long as the primary current does not become excessively high, the variation of the secondary-emission coefficient with voltage hardly has any influence. With the known devices, in which the primary electrons fall almost perpendicularly upon the secondary-emission electrode, the voltage on the latter electrode has practically no influence on the primary current. In a device according to the invention the value of the negative internal resistance is also determined by the aperture angles of the electron beams. With an aperture angle of about 5° (the axis of the beam being at an angle of about 45° with the anode) the voltage path of the secondary-emission electrode in which the whole of the primary current is taken over from the anode is approximately 1/7 of the voltage difference between the anode and the secondary-emission electrode. In order to obtain a great current between the anode and the secondary-emission electrode, the voltage may be chosen to be such that the secondary-emission coefficient has approximately its maximum value. Initially the efficiency increases with the magnitude of the take-over path, and hence with the aperture angle of the beam. With an excessively large aperture angle the negative internal resistance attains a value such that, due to losses of the resistances of the circuit, the efficiency again decreases. The ratio between the voltage on the secondary-emission electrode and that on the anode is chosen to be substantially equal to the square of the sine of the angle which the electron beam makes with the anode plane, whilst the spacing between the two electrodes is determined in this case by the desired transit time.

As stated above the axis of the electron beam is at an angle of 45° with respect to the plane of the anode. However, without any objection this angle may also be comprised between 20 and 70°. The aperture angle of the electron beam is determined by the size of the cathode and the distance from an anode and by the diverging effect of the intervening space between the anode and the secondary-emission electrode. A value of 15 to 20° of the apex of the conical beam directed towards the anode yields excellent results. The transit time of the secondary electrons may, in general, vary between a half and one and a half periods of the oscillations to be produced, with which the tube still continues to oscillate. It is thus possible to tune over a large wavelength range without modifying the voltage.

The simplest construction of a tube for use in a device according to the invention is that in which only one primary electron beam is used. In this case the anode and the secondary-emission electrode may have the form of more or less flat discs, which are directly sealed into a glass wall of the tube and thus incorporated in a cavity resonator.

A favourable form of a tube for use in a device according to the invention is that in which use is made of two cathodes arranged on either side of the axis of the system and the secondary-emission electrode is divided into two halves, each of which co-operates with one of the two electron beams. The two halves of the secondary-emission electrode may, in this case, consist of the bent ends of a Lecher line passing through the wall of the tube in the form of two flat strips. The tube is then adapted to operate in push-pull, so that the efficiency is very high.

The invention is going to be explained more fully with reference to the accompanying drawing, in which Fig. 1 represents a tube with a single electron beam and Fig. 2 a tube having two electron beams and a divided secondary-emission electrode. Fig. 3 represents a tube according to the invention incorporated in an oscillating circuit.

Referring to Fig. 1, **1** designates the glass wall or envelope of the tube, **2** the anode constituted by a copper disc, **4** the secondary-emission electrode, the bent part **5** of which is in the shape of a truncated cone and is located at a distance of 1.5 mms. from the anode **2** and opposite the aperture **3** provided in the latter. The hollow cathode **6** is arranged in such manner that a beam emanating therefrom and projected, through the aperture in the anode, on the part **5** of the secondary-emission electrode is at an angle of about 45° with the anode plane. In front of the anode and the cathode are provided concentrating members **7** and **8** respectively, to the first of which a separate voltage may be applied. Into the bottom of the tube are sealed a plurality of supply wires **9**, whilst on top of the secondary-emission electrode another glass wall **10** is sealed to permit the secondary-emission electrode to be cooled in a simple manner by means of a liquid. A further advantage of the obliquely incident primary beam is that the secondary electrons have to travel in a space comprised between two flat plates, so that the transit time dispersion is very small. Associated with the tube is a toroidal cavity resonator **31** coupled galvanically with the anode **2** and capacitively through a mica ring **32** with the secondary emissive electrode **5** a coupling loop **33** serves the purpose of guiding out the energy generated.

Referring to Fig. 2, **11** designates the glass wall of the tube in which an anode **12** having an aperture **19** is provided. Two cathodes **13** and **14** are arranged on either side of the axis of the anode in such manner that the junction lines between the centre of the aperture **19** and the centres of the cathodes are at an angle of 45° with the plane of the anode. In front of the two cathodes are arranged concentrating members **15** and **16** whilst in front of the aperture in the anode two concentrating members **17** and **18** are arranged which are formed as solid bodies of revolution. The members **17** and **18** each have the form of two superimposed frustums of cones and are each revolved about an axis, perpendicular to the surface of the respective cathodes, and passing through the centre thereof. Into the wall of the tube are sealed two Lecher wire strips **34** and **35** which terminate in sections **20** and **21** parallel to the anode. The latter sections are coated with caesium oxide to serve as secondary-emission electrodes. The electrons emanating from the cathode **13** are projected on the part **21** of the secondary-emission electrode and those emanating from the cathode **14** on the secondary-emission electrode **20**. If the voltage on the anode is 1400 v. and that on the secondary-emission electrode 800 v., oscillations may be produced in a wavelength range of from 3 to 5 cms. with an efficiency of approximately 20% at a wavelength of 5 cms. The dimensions of the tube may be computed from a scale shown at the side of the latter, said scale being calibrated in mms. The two electrodes **20** and **21** are connected to a Lecher wire system consisting of the strips **34** and **35**, which are tuned with the aid of a tuning bridge **36**.

Fig. 3 shows a tube according to Fig. 1 with associated resonator in a generating circuit. The anode voltage is derived from a battery **37** and the secondary emissive electrode is tapped about midway between the cathode and anode. The concentrating electrode **7** is tapped at **38** at a slightly positive or negative voltage with respect to cathode **6**. The heater battery is indicated at **39**.

What is claimed is:

1. An electric discharge device for generating short wavelength electrical oscillations comprising an electron discharge tube, said tube including an anode electrode having a planar surface and provided with an aperture, a secondary-emissive electrode mounted on one side of said anode and spaced therefrom a given distance, means mounted on the other side of said anode to generate a small aperture-angle electron beam forming an angle between 20° to 70° with the surface of said anode and directed towards said aperture, means for applying potentials to said anode and secondary-emissive electrode at which the transit time of secondary electrons liberated by the electron beam and travelling from the secondary-emissive electrode to the anode is about one full period of the electrical oscillations and at which the electrons produced by the generating means just strike the secondary-emissive electrode in the absence of signal potentials on the electrodes, and a resonant circuit associated with the space between the anode and the secondary-emissive electrode and adapted to be excited into oscillation by the electron flow.

2. An electric discharge device for generating short wavelength electrical oscillations comprising an electron discharge tube, said tube including an anode electrode having a planar surface and provided with an aperture, a secondary-emissive electrode mounted on one side of said anode and having a planar surface portion which is parallel to the anode planar surface and spaced therefrom a given distance, means mounted on the other side of said anode to generate a small aperture-angle electron beam forming an angle of about 45° with the surface of said anode and directed towards said aperture, means for applying potentials to said anode and secondary-emissive electrode at which the transit time of secondary electrons liberated by the electron beam and travelling from the secondary-emissive electrode to the anode is about one full period of the electrical oscillations and at which the electrons produced by the generating means just strike the secondary-emissive electrode in the absence of signal potentials on the electrodes, and a resonant circuit associated with the space between the anode and the secondary-emissive electrode and adapted to be excited into oscillation by the electron flow.

3. An electron discharge tube as claimed in claim 6 in which said secondary-emissive electrode has a body portion in the form of a truncated cone.

4. An electron discharge tube as claimed in claim 7 in which said secondary-emissive electrode has a body portion in the form of a truncated cone mounted on one side of said anode in spaced relationship to said anode with the apex directed towards the anode.

5. An electron discharge tube comprising an anode electrode having a planar surface and provided with an aperture, a first secondary-emissive electrode arranged on one side of said anode a first cathode source mounted on the other side of said anode diametrically opposite said first secondary-emissive electrode for generating a beam of electrons directed towards said aperture and said first emissive electrode, a second secondary-emissive electrode located on the same side of said anode as the first secondary emissive electrode, a second cathode source arranged on the same side of the anode as the first cathode source and diametrically opposed to said second secondary-emissive electrode for generating a beam of electrons directed towards said aperture and said second secondary-emissive electrode, each of said electron beams forming an angle of approximately 45° with said anode and also forming an angle of approximately 90° therebetween, each of said first and second cathode sources subtending an angle of approximately 15° with said aperture.

6. An electron discharge tube as claimed in claim 7 in which said secondary-emissive electrode has a body portion in the form of a truncated cone mounted on one

side of said anode in spaced relationship to said anode with the apex directed towards the anode, and said means to generate a small aperture-angle electron beam comprises a cathode source mounted on the other side of said anode, said cathode source subtending an angle of approximately 15° with said aperture, a first concentrating electrode in the form of a frustum of a cone with its apex in the direction of said cathode source and having a voltage applied thereto and in aligned spaced relation with said cathode for concentrating said electron beam, and a second concentrating electrode positioned between said first concentrating electrode and said anode and aligned with said aperture in said anode and having an offset aperture aligned with said first concentrating electrode, said second concentrating electrode having a voltage applied thereto for concentrating said electron beam.

7. An electron discharge tube comprising an anode electrode having a planar surface and provided with an aperture, a first secondary-emissive electrode arranged on one side of said anode, a first cathode source arranged on the other side of said anode diametrically opposite said first secondary-emissive electrode for generating a beam of electrons as directed towards said aperture and said first secondary-emissive electrode, a second secondary-emissive electrode located on the same side of said anode as the first secondary-emissive electrode, a second cathode source arranged on the same side of the anode as the first cathode and diametrically opposed to said second secondary-emissive electrode for generating a beam of electrons directed towards said aperture and said second secondary-emissive electrode, each of said electron beams forming an angle of 45° with said anode and also forming an angle of approximately 90° therebetween, each of said first and second cathode sources also subtending an angle of approximately 15° with said aperture, a first concentrating electrode having the form of a truncated cone and in spaced relation with said first cathode, a second concentrating electrode positioned between said first concentrating electrode and said anode, a third concentrating electrode also having the form of a truncated cone and in spaced relation with said second cathode, and a fourth concentrating electrode positioned between said third concentrating electrode and said anode.

8. An electric discharge device for generating short wavelength electrical oscillations comprising an electron discharge tube, said tube including an anode electrode having a planar surface and provided with an aperture, a Lecher line mounted on one side of said anode, said line being constituted by a pair of flat strips each having bent ends facing said anode and spaced therefrom a given distance, a secondary-electron-emissive material on said bent ends, first electron-beam generating means mounted on the other side of said anode diametrically opposite one of said bent ends for generating an electron beam directed towards said aperture and said one bent end, second electron-beam generating means mounted on the same side of the anode on the first generating means and diametrically opposite the other of said bent ends for generating an electron beam directed towards said aperture and said other bent end, each of said electron beams forming an angle of approximately 45° with said anode, each of said generating means subtending a small angle with said aperture, and means for applying potentials to said Lecher line and said anode at which the transit time of secondary electrons liberated by the electron beams and travelling from the bent ends to the anode is about one full period of the electrical oscillations and at which the electrons produced by the generating means just strike their associated bent ends in the absence of signal potentials on the Lecher line or electrode.

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