

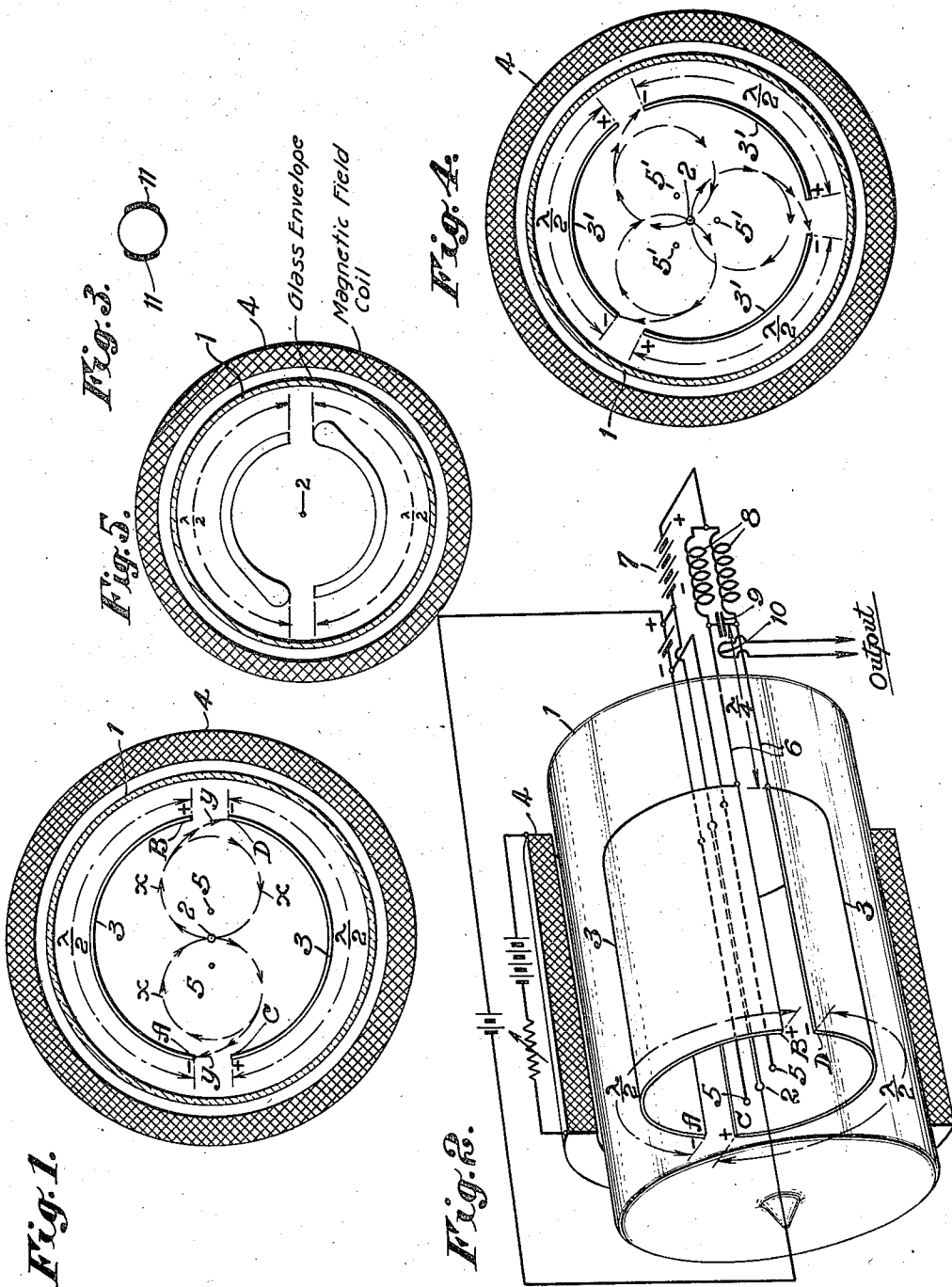
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ULTRA SHORT WAVE OSCILLATOR

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ULTRA SHORT WAVE OSCILLATOR

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10 Claims. (Cl. 250—36)

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This invention relates to electron discharge device apparatus, and more particularly to a magnetron oscillator for the generation of ultra high frequency waves.

An object of the present invention is to provide an electron discharge device oscillator having a completely enclosed anode circuit formed by a plurality of physically spaced anode segments whose circumferential length has a particular relation to the frequency of operation.

Another object of the present invention is to provide a split anode oscillator wherein the width of the gaps between the adjacent anode segments and the natural period of circumferential oscillation of the anode structure, taken together with the magnetic field and potential adjustments, control the frequency of oscillations.

It has been customary in the past to employ magnetron oscillators of the split anode type wherein the anode segments operate in push-pull relation to each other. In such known magnetron oscillators, each anode segment has for its entire circumferential length one instantaneous potential, and the normal mode of oscillation is governed by the constants of the external tuned circuits and the adjustments of the magnetic field, as well as by the anode voltage. In these oscillators, the circumferential length of the anode segments bears no especial relation to the wavelength or frequency of operation. The improved magnetron oscillator of the present invention, however, employs a new mode of oscillation which obviates the need for external tuned circuits for the anode structure. By constructing the anode segments of my improved oscillator so that the circumferential length thereof bears a desired relation to the wavelength or frequency of operation, I am able to obtain oscillations in a circumferential direction around the anode structure. In the oscillator of the invention, the circumferential length of each anode segment is electrically one-half wavelength for one mode of oscillation, or multiples of one-half wavelength of other modes of oscillation. The circumferential portions of the anode segments thus define inductances while the gaps between the anode segments form capacitances which together provide a primary influence upon the frequency of oscillations. A secondary influence in determining the frequency of oscillations of my oscillator is the electron velocity in the region of the gaps, which is dependent upon the anode potential relative to the cathode or filament.

By employing circumferential oscillations, the oscillator of the invention provides a very wide

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current path in the anode segments, as a consequence of which there are less losses than would be the case if there were employed the customary externally located tuned circuit with its associated connecting leads. By arranging the anode segments to have instantaneously different potentials at different portions, that is, by producing fluctuations of potential on the anode segments, I am able to obtain higher frequencies of operation than in known types of magnetron oscillators which do not employ circumferential oscillations.

One advantage of the oscillator of the invention lies in the fact that it is possible to obtain oscillations by virtue of electron travel over distances which are quite short compared to the wavelength, so that the electron velocities and anode voltage required for a given wavelength may be very much less than in other types of oscillators.

A feature of the invention resides in the fact that the electrons circle the filament in one direction only, and impinge upon only one end of each anode segment. Another feature lies in the use of means employed for preventing electrons emanating from the filament or cathode from dispersing in wrong directions. In this way I am able to reduce emission of those electrons which do not aid in producing circumferential oscillations.

A more detailed description of the invention follows in conjunction with a drawing, wherein:

Fig. 1 shows in cross section a view of the essential features of a split anode magnetron oscillation generator of the invention, the arrows diagrammatically representing the paths taken by the electrons under different conditions of operation;

Fig. 2 schematically shows the embodiment of Fig. 1 in a complete circuit arrangement;

Fig. 3 is a detail showing an alternative form of filament or cathode for preventing electrons from dispersing in wrong directions;

Fig. 4 is a modification of the oscillator of Fig. 1 showing how more than two anode segments can be employed in an anode structure; and

Fig. 5 is a view in cross section of the oscillator of the invention provided with a preferred form of anode construction.

The oscillation generator shown in Fig. 1 comprises an evacuated envelope 1 made of any suitable material such as glass, containing within it a centrally located linear electron emitting cathode 2, and an anode structure composed of a pair of spaced or split anode segments 3, 3 each

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of which has a circumferential dimension which is electrically one-half wavelength long for the lowest mode of oscillation. These anode segments may be a multiple of a half wavelength long in a circumferential direction for other modes of oscillation. The relation of the circumferential dimension of each anode segment to the wavelength is indicated in the drawing. A field coil 4, which may or may not employ iron to aid its effect, surrounds the envelope and functions to produce an intense but constant magnetic field which has flux lines running through the envelope in a direction parallel to the cathode 2 so as to influence the movement of the electrons emanating therefrom. Grid wires 5, 5 serve to reduce electron emission from the cathode 2 in those directions which do not aid in the production of circumferential oscillations. These grid wires are maintained at near zero or negative potential relative to the cathode 2. Both anode segments 3, 3 are of equal length and are maintained at the same positive direct current potential relative to the cathode.

As is well known, the electrons which ordinarily tend to move in radial lines from the cathode, when subjected to the action of a magnetic field from coil 4 in a direction parallel to the cathode, or at right angles to the electric field between the electrodes and to the paths of the electrons, will tend to move in a spiral line tangentially to the anode as indicated by the arrows of arcuate paths X and Y. As the strength of the magnetic field is increased, these spiral lines contract toward the cathode, and if the field is made strong enough, it will be apparent that substantially none of the electrons will reach the anode segments. If the strength of the magnetic field is decreased, however, substantially all of the electrons can be made to reach the anode. In the present invention, the field strength and the value of the positive direct current potential applied to the anode segments 3, 3 are adjusted to a critical value so that the electrons just skim past the ends of the anode segments and follow either the path X or the path Y, depending upon the instantaneous potential of the ends of the anode segments. The electrons, it should be noted, will strike or come close to a negative anode end A or D when the adjacent ends C or B have a potential momentarily in excess of the positive applied direct current potential; a posteriori, the electrons will not reach or come so close to ends A and D when the adjacent ends C and B are less positive than the applied direct current potential. It will be evident that the potential fluctuations of the anode edges A and C, and B and D control the paths of electron motion. Since points A and C, and B and D have a potential 180° out of phase, and the two anode segments are electrically closely coupled together, we thus have conditions which can maintain oscillation.

In the production of oscillations, high frequency fluctuations in potential between adjacent ends of the anodes cause fluctuations in paths taken by the electrons in a manner to increase the potential fluctuations up to a limiting value. Many electrons strike on or near portions A and D but a large number of the electrons fly in the curved path X and return to the cathode. The oscillating currents in the anodes give rise to fluctuating or oscillating magnetic field strengths in the space between cathode and anodes and this also may contribute to the control of electron paths and aid in the production of oscillations.

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It should be noted that the electrons circle the cathode 2 in one direction only and hence there is only one end of each anode segment A or D upon which the electrons impinge. Since anode segments 3, 3 are each a half wavelength long electrically, or a multiple thereof, depending upon the mode of oscillation employed in the operation of the device, there will be a wave propagated around the anode structure whose resonant period is determined in part by the circumferential dimensions of the anode segments and the spacings therebetween, and in part by the electron velocity in the region of the gaps between the anode segments, in turn dependent upon the anode potential relative to the cathode.

Assume, by way of example, that the distance between adjacent edges of the anodes is 0.25 centimeter, then the portion of electron path most active in producing oscillations may be on the order of 1 centimeter. The anode potential, which may be applied in short pulses, may be 25,000 volts, corresponding to electron velocities of 9×10^9 centimeters per second. The time required for each electron to pass through the 1 centimeter active region will then be

$$\frac{1}{9 \times 10^9}$$

second. If this time is allowed to be no greater than say 0.1 of the time of one cycle of oscillation, then the frequency of oscillation will be 900 megacycles. For the case assumed, this would likely be the frequency at which transit time effects begin to reduce the efficiency and strength of oscillation as the frequency is increased but it is not the highest frequency for which oscillations may be produced for this mode of oscillation, when the anodes are properly dimensioned for resonance.

Other higher frequency modes of oscillation are obtainable corresponding to effective time delays of 1, 2, 3, 4, etc., cycles of oscillation for electrons to pass through the active space between ends of the anodes. Thus, there is a series of modes of oscillation obtainable according to physical dimensions and intensity of electric and magnetic fields.

Fig. 2 illustrates how the oscillator of Fig. 1 can be embodied in a complete circuit arrangement. It should be noted that anode segments 3, 3 are of equal length and have equal circumferential dimensions. In order to supply the anode segments with a positive direct current polarizing potential relative to the cathode, there are provided quarter wavelength leads 6, 6 which join the ends of the anode segments to the positive terminal of battery 7 through radio frequency choke coils 8, 8. The lengths of the leads 6 are such that there is provided a high impedance at the points thereof joining the anode segments for energy of the operating frequency. A radio frequency by-pass condenser 9 bridges the ends of leads 6, 6 at the location nearest the choke coils 8, 8. For deriving output energy from the oscillator, there may be provided a loop 10 which can couple inductively with the leads 6, 6 at a suitable point intermediate its ends. Obviously, output energy may be obtained not only by the output coupling loop 10 but also by electromagnetically coupling a loop or open-ended condensers to one or both of the anode segments 3, 3. Further, the nature of the oscillator is such that it can radiate energy directly, for which reason it can, if desired, be mounted in front of a reflector to provide directivity of radiation. It

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also follows that, where radiation directly from the tube is undesirable, the tube should be electromagnetically shielded.

Fig. 3 shows one form of cathode which can replace the cathode 2 and grid wires 5, 5 of Figs. 1 and 2. In the arrangement of Fig. 3, the cathode is coated with electron emissive material at two points 11, 11 in order to prevent electrons from dispersing in the wrong directions. Obviously, if the cathode of Fig. 3 is employed in the oscillator of the invention, there will be no need for employing grid wires 5, 5.

Fig. 4 shows, in cross-section, an oscillation generator which is a modification of the oscillator of Fig. 1, differing therefrom mainly in the use of an additional anode segment. It will thus be evident that the anode segments are not limited to two, as shown in Fig. 1, but may be increased in number to three, as shown in Fig. 4, or any desired number provided the desired relation of circumferential length and resonance frequency to wavelength of operation is followed. It should be noted in Fig. 4 that here again the electrons circle the filament in one direction only. To reduce electron emission from the cathode in undesired directions, there are now employed in Fig. 4 three grid wires 5', 5' which are maintained at zero or negative potential relative to the cathode. If desired, a cathode similar to that shown in Fig. 3 may be employed in Fig. 4 with the modification that the cathode be coated at three equally spaced points circumferentially thereof, in order to furnish electron emission at the desired locations, in which case it will not be necessary to employ the grid wire 5', 5'.

Since, for the type of operation described, electrons impinge principally on or near one edge of each anode segment, this edge will have greatest heating. As an aid to disposing of this heat, and to lengthen the anode life when very high potentials are used, I contemplate increasing the thickness of metal at and near this edge after the manner described in my United States Patent No. 2,037,977. Fig. 5 shows a fragmentary view of an oscillator of the invention with the anode segments of greater mass at the portions predominantly struck by the electrons.

What is claimed is:

1. Electron discharge apparatus comprising a linear cathode, a self-contained oscillatory circuit comprising a plurality of spaced anode segments surrounding said cathode, the circumferential length of each of said anode segments being electrically one-half wavelength for the lowest mode of oscillation and said circumferential portions defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances.

2. An electron discharge device oscillator comprising a linear cathode, a self-contained oscillatory circuit comprising a plurality of spaced anode segments of equal circumferential length surrounding said cathode, the circumferential length of each of said anode segments being electrically a multiple, including unity, of one-half wavelength for a mode of oscillation and said circumferential portions defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances, whereby there are obtained oscillations in a circumferential direction around said anode segments.

3. An electron discharge device oscillator comprising a linear cathode, a plurality of spaced anode segments surrounding said cathode, the

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circumferential lengths of said anode segments being a multiple, including unity, of a half wavelength long for a desired mode of oscillation, means for producing a constant magnetic field having flux lines in a direction parallel to said cathode, the circumferential portions of said anode segments defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances.

4. An electron discharge device oscillator comprising a linear cathode, a plurality of spaced anode segments surrounding said cathode, the circumferential lengths of said anode segments being a multiple, including unity, of a half wavelength long for a desired mode of oscillation, means for producing a constant magnetic field having flux lines in a direction parallel to said cathode, the circumferential portions of said anode segments defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances, and grid wires parallel and symmetrically arranged relative to said cathode for controlling the electron emission distribution in said oscillator.

5. An electron discharge device oscillator comprising a linear cathode, a plurality of spaced anode segments surrounding said cathode, the circumferential lengths of said anode segments being a multiple, including unity, of a half wavelength long for a desired mode of oscillation, means for producing a constant magnetic field having flux lines in a direction parallel to said cathode, whereby the electrons emitted from said cathode circle the cathode in one direction, the circumferential portions of said anode segments defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances in virtue of which electrons impinge substantially solely on one edge of each anode segment to produce oscillations in a circumferential direction around the anode segments, said one edge of each anode segment being thicker than the other portions thereof to hasten heat dissipation.

6. An electron discharge device oscillator comprising linear electron emitting means, a self-contained oscillatory circuit comprising a plurality of spaced arcuate anode segments surrounding said electron emitting means, said means comprising a plurality of coats of electron emission material of the same number as the number of anode segments, said coats being parallel and symmetrically arranged relative to one another in such manner as to prevent electron dispersion in undesired directions, the circumferential length of each of said anode segments being electrically a multiple, including unity, of one-half wavelength for a mode of oscillation, said circumferential portions defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances.

7. An electron discharge device magnetron oscillator comprising a linear cathode, a self-contained oscillatory circuit comprising a plurality of spaced anode segments surrounding said cathode, means for producing a constant magnetic field having flux lines in a direction parallel to said cathode, whereby the electrons emitted from said cathode circle the cathode in one direction, the circumferential lengths of said anode segments being a multiple, including unity, of a half wavelength long for a desired mode of oscillation, and grid wires of the same number as the number of said anode segments arranged parallel and symmetrically around said cathode for

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controlling the electron emission distribution in said oscillator, each grid wire being positioned substantially in a straight line extending from said cathode to one of the gaps formed by the spaced edges of adjacent anode segments.

8. An electron discharge device oscillator comprising linear electron emitting means, a plurality of spaced anode segments surrounding said electron emitting means, the circumferential lengths of said anode segments being a multiple, including unity, of a half wavelength long for a desired mode of oscillation, means for producing a constant magnetic field having flux lines in a direction parallel to said electron emitting means, the circumferential portions of said anode segments defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances, and means for con-

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trolling the electron emitting distribution in said oscillator to prevent dispersion of electrons in undesired directions.

9. An oscillator in accordance with claim 7, including means for maintaining said anode segments at a positive potential and said grid wires at a negative potential relative to said cathode.

10. Electron discharge apparatus comprising a linear cathode, a self-contained oscillatory circuit comprising a plurality of spaced anode segments surrounding said cathode, the circumferential lengths of said anode segments being a multiple, including unity, of a half wave-length long for a desired mode of oscillation and said circumferential portions defining inductances, the spaced portions of said anode segments forming capacitances in circuit with said inductances.

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