April 21, 1936. C. W. HANSELL 2,037,977

HIGH FREQUENCY OSCILLATION SYSTEM

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Fig. 1

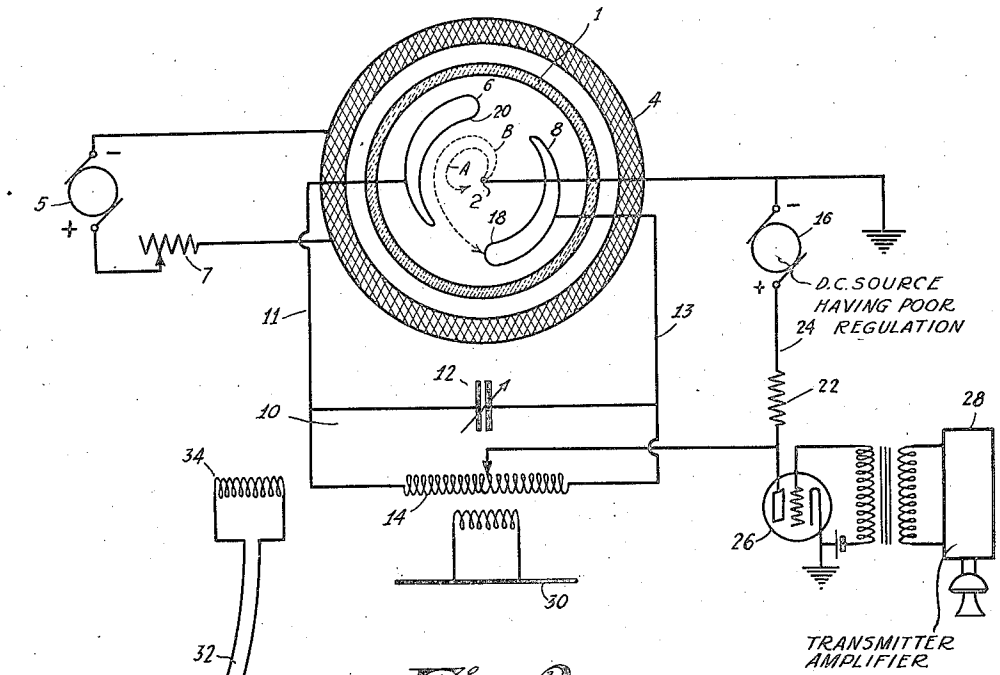


Fig. 2

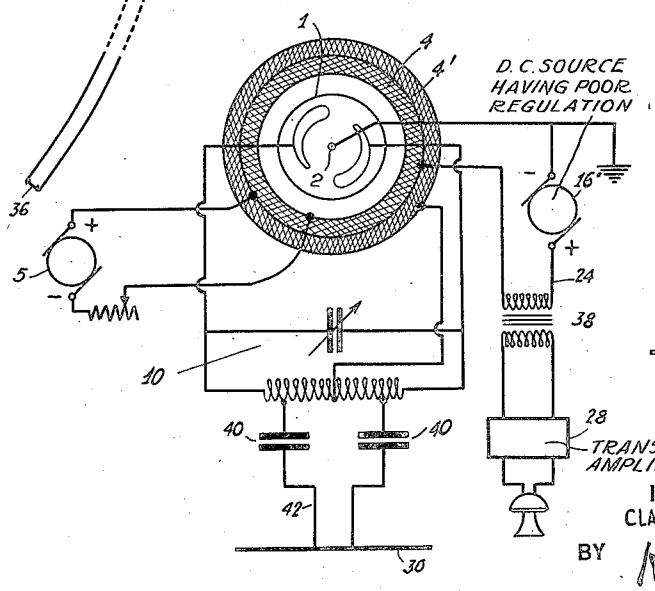
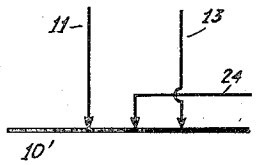


Fig. 3



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HIGH FREQUENCY OSCILLATION SYSTEM

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This invention relates to the generation and modulation of high frequency oscillations and particularly of oscillations of ultra short wave length.

High frequency oscillations have been generated with the magnetron type of oscillator which comprises an evacuated container wherein are contained an electron emitting cathode, a plurality of anodes disposed about the cathode, and, means for subjecting electrons traveling from the cathode to the anodes to a magnetic field perpendicular to the path of the electrons. By coupling or connecting a tuned circuit to the anodes, under proper conditions of cathode heating current, anode potential and strength of magnetic field, high frequency oscillations will be set up in the tunable circuit.

It has been noted that when conditions are correct for oscillations at greatest power output and efficiency, the oscillator is not self starting. That is, referring to Figure 1 showing in cross-section a magnetron oscillator in accordance with my invention, electrons emanating from cylindrical cathode **2** when subjected to a magnetic field set up by solenoid **4**, applied in a direction perpendicular to the path of the electrons from cathode **2** to anodes **6**, **8**, and in a direction coaxial with the cathode, will describe an average path indicated by the dotted line A. Under such circumstances there is no flow of anode current.

If now, in tuned circuit **10** connected to the anodes **6**, **8**, an oscillating current could be set up, then there will be times during each cycle of oscillation when anode **6** has its potential increased above the voltage of the anode direct current power source and under such circumstances electrons from cathode **2** will be pulled out away from the cathode by anode **6** along path B striking anode **8** and tending to increase the amplitude of oscillation in the tuned circuit. With a reversal of current in the tuned circuit **10**, anode **8** will become of high potential and tend to attract the electrons as a result of which electrons will strike anode **6**. In other words, each anode will act as a control electrode for the current to the other. But, as the strength of magnetic field for best oscillation efficiency will cause the electrons initially to travel in paths such as A, the oscillator will not be found to be self-starting.

To eliminate this defect is one of the objects of my present invention and in order to do so, I make use of an anode power supply having a relatively large voltage regulation such that voltage applied to the anodes is sufficiently large to cause anode current flow. After oscillations are started, at which time there is an appreciable anode current flow, the voltage of the anode source, of course, drops to a value best suited for high powered oscillation generation.

As an alternative, it is a further object of my present invention to provide an arrangement whereby the magnetic field is set at a value low enough to permit anode current and, after the start of oscillations, is automatically increased to a value giving best efficiency of operation for the magnetron oscillator. To do so, an auxiliary coil is connected in series with the anode potential supply whereby due to the fact that current through this coil increases after oscillations are started, the strength of the magnetic field applied to the electrons emanating from the cathode is increased to more nearly the best operating value.

In the present oscillator certain opposed edges of the anodes or split anode, as it is commonly known in the art, become incandescent due to electronic bombardment as a result of which ordinary anodes heretofore used rapidly deteriorated. It is a further object of my present invention to devise anodes which shall not deteriorate rapidly due to constant bombardment and to do so, according to my present invention, I make the anodes of larger mass and cross-sectional area at the portions thereof subject to greatest bombardment.

Although the tuning circuit associated with the anodes provides some degree of frequency stability, it is a further object of my invention to increase the frequency stability of a magnetron oscillator by coupling to it means other than an ordinary tuned circuit which will serve this purpose. One of the most satisfactory schemes for doing this is to couple to the tunable circuit or to the oscillator a long resonant transmission line such as described in my United States Patent No. 1,945,546, granted February 6, 1934. The long line, with reflection and electrical waves upon it, forms a relatively constant, sharply tuned circuit by which I cause the oscillator to operate at a frequency for which the line is substantially resonant.

Still a further object of my present invention is to provide means for the modulation and transmission of oscillations generated in the manner outlined hereinabove.

My present invention will be more fully described hereinafter with the aid of the accompanying drawing given solely by way of illustration wherein,

Figure 1 illustrates a preferred form of my invention wherein oscillations are started in a

magnetron oscillator by the use of a source of potential having poor voltage regulation,

Figure 2 illustrates a magnetron oscillating system wherein the strength of magnetic field applied to electrons emanating from the cathode is automatically increased after the start of oscillations, and,

Figure 3 illustrates a substitute for the tunable circuit shown in Figure 1.

Turning to Figure 1, illustrating a cross-sectional view of a magnetron oscillator, within an hermetically sealed evacuated container 1, there is mounted an electron emitting cathode 2 energized in any suitable fashion. About the electron emitting cathode 2 there are placed anodes 6, 8 shaped in a manner to be described more fully hereinafter. For producing a magnetic field in a direction perpendicular to the path of electrons traveling from cathode 2 to the anodes, and in a direction coaxial with the cathode, or in other words, perpendicular to the plane of the drawing, there is provided a solenoid 4 energized from a suitable source of potential 5. The strength of the field produced by solenoid 4 may be varied by adjustment of rheostat 7. Across the anodes 6, 8 there is connected a tunable circuit 10 comprising a variable condenser 12, and inductance coil 14, to a point of substantially zero alternating potential on which there is connected a source of anode potential 16 having a poor voltage regulation characteristic such that in the absence of current flow therethrough there is an appreciable rise in voltage.

By virtue of such a source of potential for the anodes, the effect of the magnetic field applied to the electrons emanating from the cathode 2 will be overcome such that the electrons do not describe the path indicated by the letter A as would be the case with a lower anode potential, but, some electrons are attracted towards at least one of the anodes causing a current flow through coil 14 thereby setting up oscillations in the tunable circuit 10. Now, by virtue of the oscillatory current flow in the tunable circuit 10, the electrodes 6, 8 will alternately be made more positive as a result of which the electrons will travel along paths similar to that indicated at B striking the anodes 6, 8 alternately and predominantly at the portions or edges 18, 20. In order to avoid rapid destruction of the anode structure I make the anodes as shown thicker or of a greater mass at the portions predominantly struck by the electrons.

After oscillation generation is started in circuit 10, continuous anode current flow will, of course, reduce the voltage from source 16 to a suitable value for most efficient oscillation generation. To increase the effect of this regulation, a resistance 22 may be inserted in the anode connection 24 by virtue of which the anode potential is further reduced due to anode current flow therethrough.

This resistance 22 may also be used as part of the modulating scheme; for, by supplying a modulating electron discharge device 26 with modulating potentials from a suitable transmitting device 28, the current flow through tube 26 and consequently resistance 22 may be varied thereby varying the potential on anodes 6, 8, and therefore the amplitude or the frequency of oscillations generated by the oscillator. It will be understood that either amplitude or frequency modulation, or both, may be used for signalling purposes.

By coupling an antenna here shown in the form of a half wave length radiator 30 to the output circuit 10, the modulated energy may be propagated through space. The tunable output circuit 10, may be replaced by a radiator 10' as shown in Figure 3 connected directly to the anode leads 11, 13, the half wave length radiator 10' acting as a tuned circuit to vary the anode potentials.

In order to increase the frequency stability of oscillations generated, means may be provided other than, and in addition to or in place of the tuned circuit 10 which offers, of course, some degree of frequency control. This frequency controlling means takes the form of a resonant transmission line. In the figure the line 32 is shown coupled inductively to the coil 14 of the tunable circuit 10 by means of a coil 34. A suitable slider 36 is provided for adjusting the length of the line 32 so that it and the coupling coil together are the equivalent of a whole multiple of half wave lengths long at the desired frequency of oscillation. Standing waves on the line, when coil 34 is suitably coupled to coil 14, pull the oscillator into step therewith, and, as the input reactance of the line changes rapidly with change of frequency, high frequency stability is insured.

Rather than start oscillations by an increase in anode potential, oscillations may, of course, be started by a reduction in magnetic field strength whereby some electrons are allowed to reach the anodes to cause oscillations in the tuned anode circuit. An arrangement for automatically increasing the strength of the magnetic field applied after oscillations are started is illustrated in Figure 2. Here, an auxiliary coil 4' is provided connected in series with the source of anode potential 16'. Consequently, the strength of the magnetic field applied to the electrons flowing from the cathode within the container 1, is not increased to best oscillation operating value until after oscillations have started or, in other words, until after there is anode current flow.

Also, as indicated in Figure 2 modulating potentials may be applied through transformer action, transformer 38 introducing, algebraically, modulating potentials from source 28 into the anode lead 24.

The modulated energy may be radiated from a suitable radiator 30 by coupling it through blocking condensers 40 and transmission lines 42 to the output circuit 10.

It is to be clearly understood, of course, that in combination with the system shown in Figure 2, the source 16' may be made to have poor regulation such that starting action is insured both by the virtue of the decreased magnetic field and increased anode potential both of which will tend to cause an initial flow of anode current and hence initial starting of oscillations.

Having thus described my invention, what I claim is:

1. A high frequency oscillation generator comprising an hermetically sealed container having therein a cathode, and a plurality of anodes substantially symmetrically disposed about said cathode, means for applying a magnetic field to the electrons leaving said cathode for said anodes whereby said electrons describe curved paths and strike predominantly only portions of said anodes, said anodes being made of larger mass and cross-sectional area at said electron struck portions.

2. An oscillation generator comprising an hermetically sealed container wherein are contained an electron emitting cathode and a plurality of anodes disposed substantially symmetrically with

reference thereto, a tuned circuit connected across said anodes, and means for subjecting the electrons flowing from said cathode to said anodes to a magnetic field whereby said electrons strike predominantly along opposite edges of said anodes, said anodes at said edges being made substantially heavier than the remaining portions of said anodes.

3. In an oscillation generator, an electron discharge device having an evacuated container wherein are contained an electron emitting cathode, a plurality of anodes disposed thereabout, a tuned circuit coupled to said anodes, a coil for subjecting electrons from said cathode to a magnetic field, and means including another coil in circuit with both said anodes and said tuned circuit for automatically increasing the strength of said field after the starting of oscillations in said tuned circuit.

4. An oscillation generating system comprising an evacuated container wherein are contained an electron emitting cathode and a plurality of anodes disposed thereabout, a tunable circuit connected to said anodes, means for subjecting electrons traveling from said cathode to said anodes to a magnetic field, and means, other than said tunable circuit, for increasing the frequency stability of oscillations generated in said tunable circuit.

5. An oscillation generator comprising an hermetically sealed container wherein are contained an electron emitting cathode and a plurality of anodes disposed thereabout, means for subjecting electrons traveling from said cathode to said anodes to a magnetic field, a tunable circuit coupled to said anodes, and a resonant transmission line coupled to said tunable circuit for frequency stabilizing the frequency of oscillations set up in said tunable circuit.

6. A high frequency oscillation generator comprising a hermetically sealed container having therein a cathode and a plurality of comma-shaped anodes substantially symmetrically disposed about said cathode, each anode having a portion of large mass at one end which tapers down to a much thinner mass at the other end, means for applying a magnetic field to the electrons leaving said cathode for said anodes whereby said electrons describe curved paths and strike predominantly only those portions of said anodes which are of largest mass.

7. In an oscillation generator, an electron discharge device having an evacuated container wherein are contained an electron emitting cathode and a plurality of anodes disposed thereabout, a tuned circuit coupled to said anodes, a source of potential for said anodes, two superimposed coils surrounding said container, and means for applying a constant unidirectional potential to one of said coils for subjecting the electrons emanating from said cathode to a magnetic field, said other coil being in series with said source of anode potential, whereby the strength of magnetic field is automatically increased after the commencement of oscillations.

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