Dec. 5, 1950 E. EVERHART 2,532,545

MAGNETRON OSCILLATOR

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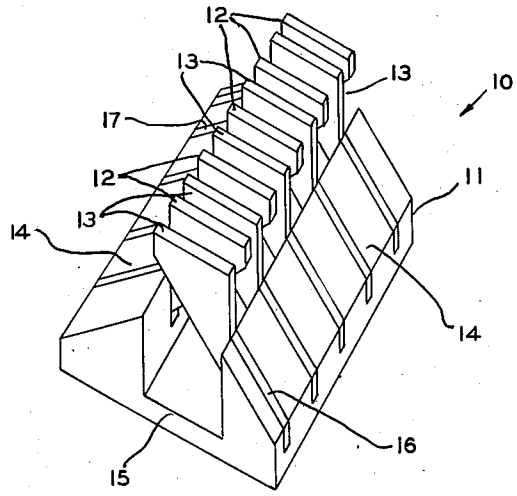


FIG. 1

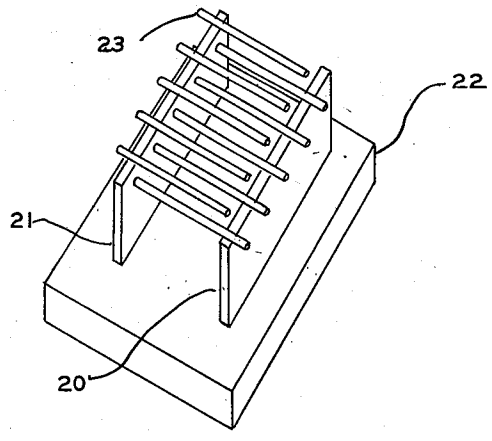


FIG. 2

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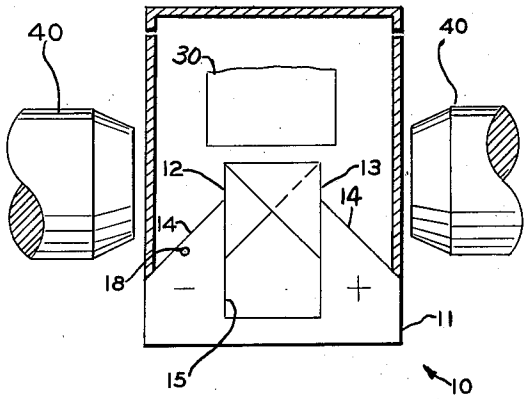


FIG. 3

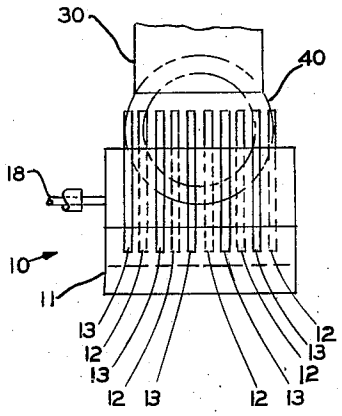


FIG. 4

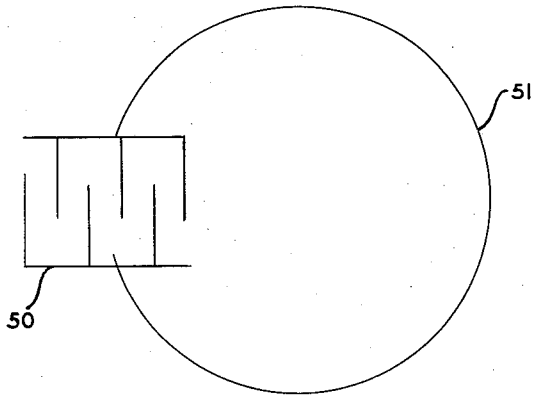


FIG. 5

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FIG. 6

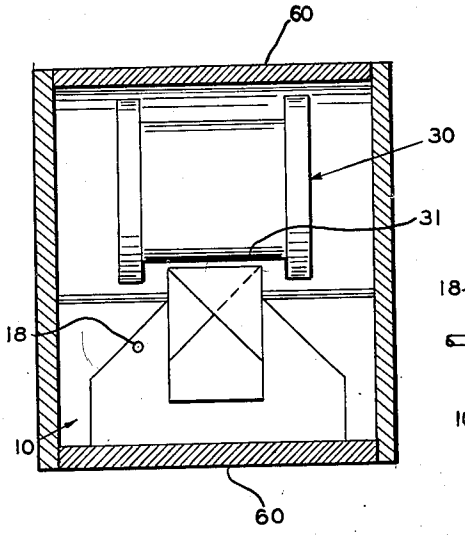
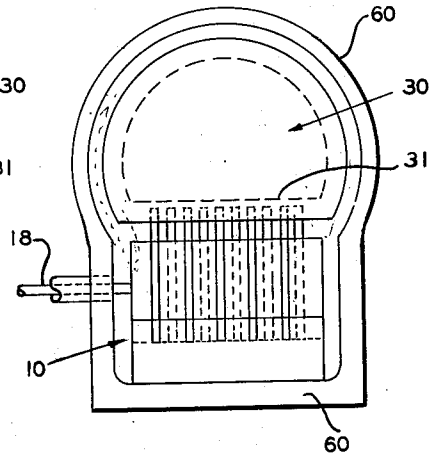


FIG. 7



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UNITED STATES PATENT OFFICE

2,532,545

MAGNETRON OSCILLATOR

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Application March 8, 1945, Serial No. 581,693

3 Claims. (Cl. 250—27.5)

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My invention relates to a magnetron oscillator, and more particularly to a linear transit-time type of magnetron oscillator.

In the development of magnetrons of various types for operation at ultra-high frequencies, certain obstacles and disadvantages have arisen due to the fact that increasingly shorter wave lengths require increasingly smaller physical dimensions within the magnetron. Such a reduction in the physical size of the component parts of previously developed magnetrons has heretofore introduced difficulty in obtaining continuously large amounts of power from magnetron oscillators. The impracticability of high, continuous, power-output heretofore has resulted in the practical use of magnetrons being limited to operation with a pulse-type of modulation, from which the average power output is comparatively low. Accordingly, it is one of the objects of my invention to provide a magnetron type of oscillator which is capable of continuous operation not only at ultra-high frequencies, but with a large power output.

It is also one of the objects of my invention to provide a magnetron with elements, particularly the anode, which are easily constructed and fabricated, and to thus eliminate some of the difficulties previously encountered in the manufacture of magnetrons designed to operate at ultra-high frequencies with wave lengths on the order of centimeters. Furthermore, my invention is particularly adapted to a simple yet effective means of tuning over a considerable frequency-range by changing mechanically the constants of a resonant-cavity structure embodied in the anode design.

In general, my invention embodies a type of anode structure such that a linear array of alternately-charged positive and negative anode segments share a common resonant structure such as a resonant-cavity, the use of which is well known in the art as a resonant means. In conjunction with this anode, there is provided a cathode means for the emission of electrons, and a conventional means such as a permanent magnet for supplying the necessary magnetic flux. When the proper direct current potential is applied between cathode and anode, a transit-time type of oscillations is produced which may be coupled to an output load by a conventional coupling means, such as a coupling loop inserted in the resonant-cavity. Tuning is accomplished by changing the constants of the resonant-cavity, by a means such as a conductor which can be inserted into the resonant-cavity and varied in position.

My invention will best be understood by reference to the appended drawings, in which:

Fig. 1 shows the anode construction;

Fig. 2 shows an alternate type of anode structure;

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Fig. 3 is an end view, showing the placement of elements of the magnetron;

Fig. 4 is a side view, showing the placement of elements of the magnetron;

Fig. 5 shows the equivalent oscillatory circuit; and

Figs. 6 and 7 together show a type of cathode and envelope structure found advantageous in actual practice.

Referring to the drawings, Fig. 1 shows one type of anode structure 10 embodying my invention. This structure consists of a block 11, rectangular in form, with two opposite edges beveled to form the surfaces 14, and with a rectangular slot or groove 15 running symmetrically between the surfaces 14. This slot 15 forms a resonant-cavity. Block 11 is also provided with a number of transverse slots 16 and 17 which are alternately spaced along the axis of the slot 15 and are provided for the retention of segments 12 and 13, all similar segments having like designation in the drawing. These vane-like segments are of sheet metal and so fashioned as to have portions which fill the slots 16 and 17, and are bonded thereto so as to form an integral part of the block 11. The remaining portions of these segments 12 and 13 are so formed as to extend across and above the slot 15, and their respective upper edges are parallel to the bottom of the slot 15. Due to the staggered positioning of the slots 16 and 17, the segments 12 and 13 when placed in these slots form a linear array, with the segments alternately attached to block 11 on the two sides of slot 15, and equally spaced along this slot. The materials used for this anode structure are of substantially non-magnetic material, such as copper.

Represented in Fig. 2 is an alternate form of anode structure, consisting of two conducting plates or posts 20 and 21 which are fastened to and form an integral part of a conducting base plate 22. Alternately fastened to 20 and 21 are rods 23 so arranged as to form a linear array of equally spaced rods. The space between the plates 20 and 21, the base plate 22, and the rods 23, forms the resonant-cavity, the latter being the equivalent of cavity 15 in Fig. 1.

Shown in Fig. 3 is an end view of the assembled magnetron, showing the relative placement of elements. The cathode 30 is a conventional means for electronic emission, comprising an emitting surface and a means (not shown) for heating this surface to the necessary temperature for proper electronic emission. This cathode 30 is spaced opposite to, and faces the anode segments 12 and 13 of anode structure 10. Anode structure 10 is provided with a conventional output-coupling means 18. The pole pieces 40 are part of a conventional means such as a permanent magnet, for producing the desired mag-

netic flux. The cathode and anode structures are enclosed by a conventional means, such as a metal envelope, in order that the interelectrode space may be evacuated to produce the necessary conditions for vacuum-operation. A source of direct current potential is applied between cathode 30 and anode 10.

Fig. 4 is a side view of the magnetron elements, to further clarify the relative placement of the individual elements. The spacing of the anode segments 12 and 13, as well as the linear arrangement of these segments with respect to the cathode 30, is clearly seen in this view. The position of the pole pieces is represented by the dashed line 40.

Fig. 5 represents the equivalent oscillatory circuit presented by the anode structure. The equivalent capacitance 50 represents the capacitance of the anode segments 12 and 13. The equivalent inductance 51 represents the inductance of the resonant-cavity embodied in the anode structure. The operation of the magnetron oscillator is similar to that of other transit-time magnetron oscillations in that the emitted electrons follow cycloidal paths through the interelectrode space, due to the combined action of the electric and magnetic fields. In pursuing these cycloidal paths, the electrons receive kinetic energy from the direct current electric field, and this kinetic energy in turn is converted into electromagnetic energy as the electrons pass through the oscillatory electric field near the anode segments. This electromagnetic energy is oscillatory at the frequency of magnetron-oscillation, and reenforces the oscillations of the resonant circuit comprised of the anode segments and resonant-cavity over and above the inherent circuit losses, so that a useable output energy at the desired frequency is produced. Because of the large cathode-emitting area which is possible with this design without sacrificing or limiting the available anode region for energy conversion, the power output of this magnetron is large. Since only one resonant-cavity is embodied in the anode structure, tuning can be accomplished by sliding a single conductor in or out of the cavity structure.

Shown in Figs. 6 and 7 are two related views of a magnetron showing greater detail of cathode 30 and envelope or shell structure 60. Such detail was omitted in Figs. 3 and 4 for the sake of simplicity. It was found in practice that a large percentage of the emitted electrons drifted out of the energy-conversion region between cathode and anode, thus causing excessive magnetron current, and also definitely affecting the output. Furthermore, raising of operating voltages enhanced the danger of injuring the tube with the electron flow involved. This difficulty was successfully surmounted with the type of cathode structure 30 and shell structure 60 shown in Figs. 6 and 7, wherein the free electrons, after passing from the energy-conversion region under the influence of the combined electric and magnetic fields, are provided a free-space path around the cathode 30 and back again into the energy-conversion region.

To accomplish this, the cathode 30 is made in the form of a cylindrical section so turned down that a slot runs symmetrically around the circumference, a part of the circumference being machined to a plane surface to form the emitting area 31. The anode 10 is fastened mechanically and conductively to the shell 60, which is essentially tube-shaped, with a larger diameter than the cathode 30, and is so placed that, along with the slot in the anode, it confines the free-space path of the electrons after they leave the energy-conversion region until they again reach that region under the influence of the static electric and magnetic fields.

It will be apparent to those skilled in the art that changes and adaptations can be made in the specific design herein described without departing from the spirit or idea of my invention, and I claim all such modifications as fall fairly within the spirit and scope of the hereinafter appended claims.

What I claim is:

1. In a magnetron oscillator, a substantially rectangular block having two opposite edges thereof beveled and provided with a substantially rectangular slot running substantially symmetrically between the respective surfaces of the beveled edges of said block and forming a resonant-cavity, said block being provided with slots in each of the beveled edges thereof, the slots in each of said edges being substantially equally spaced with respect to the adjacent slots and alternately spaced with respect to the other and oppositely disposed slots in the direction along the axis of said first-named slot, and segments of substantially non-magnetic material disposed and fixed in said alternately-spaced slots and extending across and above said first-named slot with their upper edges substantially parallel to the bottom of the latter.

2. A magnetron oscillator comprising a conducting base plate and two conducting plates fixed with respect to said base plate and spaced with respect to each other, and rods fixed to said two plates and arranged with those fixed to one of said two plates alternately disposed with respect to those fixed to the other of said two plates, said base plate and said two plates and said rods forming a resonant-cavity.

3. A magnetron oscillator comprising a base member of conducting material having two portions thereof spaced in substantially parallel relation with respect to each other, and two sets of elements fixed respectively to said portions and extending across the space therebetween, said elements being substantially equally spaced with respect to the ones adjacent thereto, the elements of one set being alternately disposed with respect to those of the other set and forming therewith and with said base member and with said two portions of the latter a resonant-cavity.

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