Feb. 13, 1951 A. E. BOWEN 2,541,195

RESONATOR WITH MULTIPLE ELECTRODES

Filed Sept. 5, 1946

FIG. 1

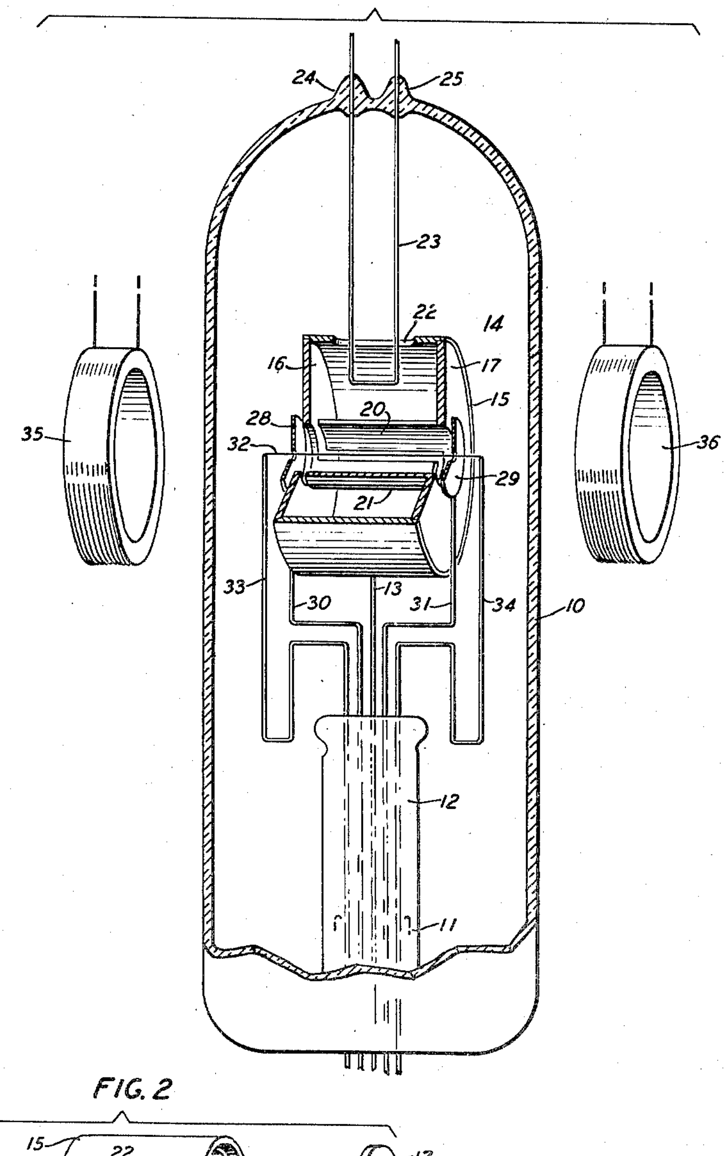
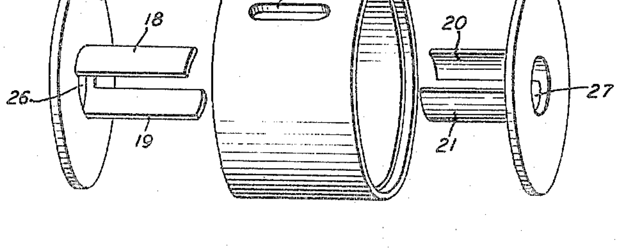


FIG. 2



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Patented Feb. 13, 1951 2,541,195

UNITED STATES PATENT OFFICE

2,541,195

RESONATOR WITH MULTIPLE ELECTRODES

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Continuation of application Serial No. 408,303, August 26, 1941. This application September 5, 1946, Serial No. 695,025

3 Claims. (Cl. 315—40)

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This invention relates to vacuum tubes and more particularly to an anode structure integral with and enclosed by a resonating chamber or substantially non-radiating resonator for electromagnetic waves.

The structure of the invention is particularly adapted for, but not limited to, use in a multiple anode magnetron oscillator for generating waves a few centimeters or less in length.

This application is a continuation of my copending application, Serial No. 408,303, filed August 26, 1941, and assigned to the same assignee as the present application, and which is now abandoned.

In accordance with the invention, the anode elements are formed in two subassemblies attached respectively to a pair of end members, the latter being fitted into the ends of a tubular casing and arranged so that the respective sets of anode elements are interleaved. Access to the interior of the structure for purposes of coupling may be had through a slot in the casing or in any other suitable manner. The assembled anode structure may be mounted within an evacuated envelope.

Among the objects of the invention are improvement in frequency stability and increase in efficiency of oscillation generators as well as greater facility in their construction. The reduction of radiation losses due to the form of structure employed results in an increased ratio of reactance to resistance, commonly referred to as the "Q" of the system. A high value of "Q" promotes both frequency stability and efficiency.

The type of construction lends itself readily to the use of a large number of anode segments, which is in itself an advantage. It has been found that for a given wave-length and a given diameter of anode structure, the larger the number of anode segments, the lower are the anode voltage and magnetic field intensity required to maintain oscillations. The reason for this result becomes evident from the following qualitative considerations. Electrons in first passing along a path in the vicinity of the gap between two adjacent anode segments are subjected to a sorting action according to the particular phase of the oscillations during which the individual electron passes the gap. Those electrons which make the passage in unfavorable phase so that they take energy from the high frequency field during the passage are likely to be drawn to and intercepted by the next anode segment, while those making the passage in favorable phase give energy to the field, are repelled by the next adja-

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cent segment and continue their travel in a path which takes them near the following gap between segments. In order to deliver energy to the field during its transit of the region near this next gap, and thus help to sustain the high frequency oscillations, one half period of the oscillation must have elapsed between transits. With a given anode diameter, the distance between adjacent gaps is inversely proportional to the number of segments so that a smaller electron velocity and hence a smaller anode voltage is required to get the electrons from one gap to the next in one half period. Instead of using this advantage to secure a smaller anode diameter and a correspondingly lower anode voltage, in many cases it may be preferable to employ a reasonably high anode voltage and increase the diameter of the anode structure accordingly. In this way greater ease in fabricating the parts and in their assembly can be had as well as larger output of oscillations.

Other objects and features of this invention will be evident from the following detailed description while the scope of the invention is indicated by the appended claims.

In the drawings:

Fig. 1 is a view in perspective and partially in section or broken away, showing a vacuum tube assembly embodying the invention, and Fig. 2 is an exploded view of the anode structure of the tube shown in Fig. 1.

In Fig. 1 there is shown a vacuum tube having a suitable insulating envelope 10 which may be evacuated. One end of the tube contains a reentrant stem 11 terminating in a conventional press 12 containing connecting wires and supports associated with the structure within the envelope. Supported by a rod 13 which may also be used as a conductive connection, is an anode structure indicated generally at 14 and shown in exploded view in Fig. 2. The rod 13 is conductively and mechanically attached to a tubular casing 15. The casing is countersunk at each end to receive members 16 and 17, respectively. The member 16 has attached to or integrally formed therewith a plurality of spaced cylindrical segments 18 and 19. Similar segments 20 and 21 are associated with the member 17 and when assembled in the casing 15, the segments 20 and 21 are slightly separated from and interleaved with the segments 18 and 19. A slot 22 is provided in the casing 15 to accommodate a coupling conductor 23 which may be formed to make a loop inside the casing 15. The ends of the conductor 23 may be led out through the envelope 10 in any suitable manner as through beads 24 and 25.

The members 16 and 17 may have central apertures 26 and 27, respectively, adjacent to which may be mounted end plates 28 and 29, respectively, mechanically supported and electrically connected by wires 30 and 31, respectively. A filamentary cathode 32 may be passed through central axial apertures in the end plates 28 and 29 and through the apertures 26 and 27, the filament being supported and provided with electrical connections by wires or rods 33 and 34. Magnetizing coils 35 and 36 may be provided to supply an axial magnetomotive force coaxial with the filament 32 and the anode structure 14.

The casing 15 together with the members 16 and 17 and the end plates 28 and 29 comprise a substantially non-radiating resonance chamber which in itself tends to give a high value of "Q." Ohmic losses, further, are reduced by virtue of the large surfaces presented for the flow of high frequency currents, the inner surfaces of the parts being preferably of high electrical conductivity. The casing 15 and the members 16 and 17 are also preferably made to have a large thermal capacity and are placed in good thermal contact with each other to assist in cooling the anode during operation. The reduction of ohmic losses contributes further to a high value of "Q" and the improved cooling facilities permit the handling of large amounts of power. The parts may conveniently be made of metal of good conductivity, such as copper, which is readily machined in a lathe and the conductivity of the inner surfaces may be increased if desired by gold or silver plating or in any other suitable manner.

While four anode segments are represented in the figures, any desired number of segments may be used. It is not necessary that the anode segments be cylindrical, and in the case of a large number of segments, it may be particularly desirable that the segments take the form of wires or rods in which case the anode assembly would be of a squirrel cage type with alternate wires connected to opposite end walls of the cylindrical resonant cavity. The structure of this sort has considerable advantages from the fabrication standpoint.

In a series of anode structures which have been constructed and successfully operated in magnetron generators, an anode diameter of 0.419 centimeter, an anode length of 0.952 centimeter and an inner diameter of resonants chamber of 1.93 centimeters were employed in each of four resonators having 2, 4, 8 and 16 anode segments, respectively. The following operating data were obtained with the resonators:

No. of Segments	Anode Voltage	Magnetic Field Gauss	Wave-length Centimeters	Product of Wave-length and Magnetic Field
2	1,200	1,145	8.97	10,300
4	910	990	9.6	9,500
8	390	660	11.2	7,400
16	170	312	13.8	4,300

In the above series of resonators the wave-length rises only slowly as the number of segments is increased. This is because the increase in the capacitance due to increase in the number of gaps is partially compensated by a decrease in the inductance due to parallelling segments. On the other hand the optimum anode voltage and magnetic field decrease rather rapidly with the increase in the number of segments. The advantage of increasing the number of segments is brought out by a comparison of the values of the product of wave-length and magnetic field intensity, this product falling from a value of 10,300 for a 2-segment anode to a value of 4,300 for a 16-segment anode. With these resonators efficiencies of power conversion as high as 20 per cent have been found as contrasted with values of 10 to 12 per cent for conventional magnetrons operated in the same wave-length range.

What is claimed is:

1. An oscillatory system comprising a hollow continuous length of conductive cylinder having countersunk ends, first and second annular disc end members, each fitted into one of said countersunk ends of said hollow cylinder, a first plurality of spaced cylindrical segments each having one free end and the other end conductively attached to said first annular end member, the free end of each segment of said first plurality extending in the direction toward said second annular end member, a second plurality of cylindrical segments spaced from and interleaved with said first plurality of cylindrical segments, said second plurality of cylindrical segments each having one end free and the other end being conductively attached to said second annular end member, the free end of each of said second plurality of cylindrical segments extending in the direction toward said first annular end member, said first and second pluralities of anode segment all being coaxial with said hollow conductive cylinder and defining therewith and with said first and second annular end members a substantially closed cavity resonator coupled to a central reaction space through the spaces between said interleaved cylindrical segments.

2. An oscillatory system in accordance with claim 1 and having a cathode mounted within the central reaction space.

3. An oscillatory system in accordance with claim 2 together with a pair of centrally apertured shielding discs mounted coaxially with said hollow cylinder and in opposed relation to the said annular end members and substantially closing the central opening of the respective annular end member, and cathode leads extending through the apertures in said shielding discs.

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