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MICROWAVE TUBE WITH INTERDIGITAL ELECTRODE CONSTRUCTION

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Fig. 1.

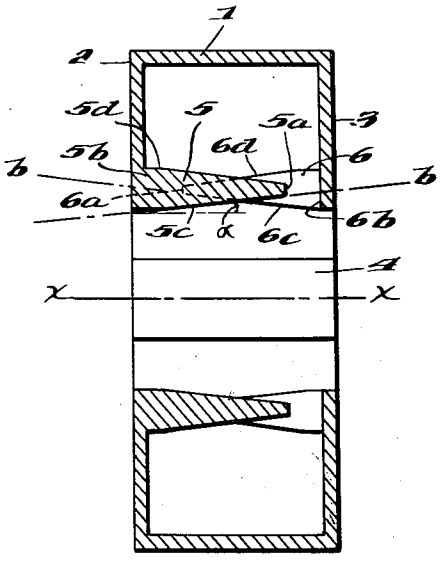
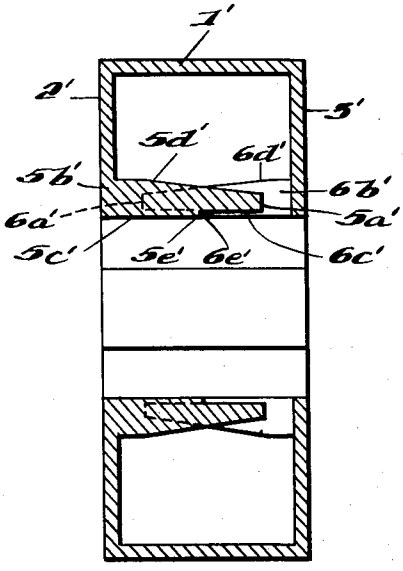


Fig. 2.



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MICROWAVE TUBE WITH INTERDIGITAL ELECTRODE CONSTRUCTION

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The present invention relates to electron tubes of the microwave type and more particularly to microwave tubes which have an interdigital electrode structure. The general object of the invention is to provide an improved interdigital electrode structure which exhibits a greater self-cooling characteristic therefore resulting in a correspondingly greater allowable output for the tube.

In various types of microwave tubes, electrodes with interdigital structure are used, as for example in single-circuit magnetrons and in certain traveling field tubes and revertive wave tubes. Usually said electrodes must receive a considerable portion of the load current of the tube, in single-circuit magnetrons, for example, even the entire current emitted by the cathode. As the electrodes then have positive potential relative to the cathode furnishing the electrons or relative to a guide electrode, a considerable amount of energy may be transformed into heat at the electrodes with interdigital structure by the impingement of the electrons, and this heat must be removed from the electrode. Heat transmission, however, is most difficult in electrodes with interdigital structure because the interleaved finger like segments of such electrodes are usually relatively long and slender. Thus the permissible power loss and hence also the output of such tubes is severely limited by the relatively poor heat transmission in interdigital electrodes, because at higher tube outputs the segments would become too hot.

To make the segments of metals of a high melting point does not furnish a substantial improvement because these metals have at the same time an inferior heat conductivity.

It is known practice in the resonator of a single-circuit magnetron to design the electrode segments in such manner that their radial width increases sharply with increasing distance from the free end of the segment and is of the order of magnitude of the segment length at the segment root. Such an arrangement, while improving the heat transmission, involves disadvantages in high-frequency technique, namely, a higher capacity between the segments and inferior mode separation.

The present invention now develops the idea that, instead of improving the transmission of the heat generated with an approximately uniform segment length, the generation of the waste heat should, on the contrary, be so distributed locally that it can be transmitted by means which are satisfactory in high-frequency technique. Accordingly, it is the object of the invention to form or arrange the segments so that as to the more difficult portions to cool, i.e. those portions near the free end of each segment, a lower density of the impinging electrons prevails than in the portions near the segment root which are easier to cool. In a single-cavity magnetron wherein the interdigital arrangement of the segments is concentric about the axis of the cathode, the cathode has one function of effecting emission of the electrons and also has another function as a guide electrode in forming a radially extending electrostatic field which together with the perpendicular magnetic field serves to guide the electrons in a substantially tangential direction. In a traveling wave type of tube, the interdigital arrangement of the segments takes a rectilinear form as distinguished from the circular form in the single-cavity magnetron, and the cathode is

arranged, for example, at the head of the interdigital structure. In order to obtain an electrostatic guide field perpendicular to the desired movement of the electrons along the rectilinear interdigital segment structure, it is necessary to arrange a counter-electrode parallel to such structure. This counter-electrode is known as a guide electrode because it is used in the establishment of an electrostatic field which together with the perpendicular electromagnetic field serves to guide the electrons along the interdigital structure. A microwave tube according to the invention is thus characterized in that the free ends of the segments are farther removed from the cathode of a single-cavity magnetron or from the guide electrode of a travelling wave tube than are the roots of the segments.

The foregoing objects and advantages of the invention will become more apparent from the following detailed description of two embodiments thereof and the accompanying drawings which illustrate the same.

In these drawings,

FIG. 1 is a view in axial vertical section of one embodiment of the invention as applied to a single circuit magnetron; and

FIG. 2 is a sectional view similar to FIG. 1 showing a modification of the improved interdigital electrode structure.

With reference now to the drawings and in particular to the embodiment of the invention shown in FIG. 1, the single-circuit magnetron tube is seen to be comprised of a toroidal cavity type resonator which is established by a cylindrical wall **1** and two parallel spaced end walls **2, 3** which meet the ends of the cylindrical **1**. The cylindrical cathode **4** extends along, and is concentric with, the axis *x—x* of the resonator. The resonator is provided with an interdigital electrode structure comprising one cylindrical array of circumferentially spaced electrode segments **5** extending inwardly from the end wall **2** and a like cylindrical array of circumferentially spaced electrode segments **6** extending inwardly from the opposite end wall **3**, the electrode segments **5** and **6** being interdigitated. In FIG. 1, the interdigitated electrode segments **5** and **6** have a generally trapezoidal configuration with the base or root of the trapezoid terminating in the end wall to which the segment is secured. Thus the outer free ends **5***a*, **6***a* of the electrode segments are located farther away from the cylindrical cathode **4** than the root ends **5***b*, **6***b* of these segments. As indicated in the drawing, the sides **5***c*, **6***c* of the electrode segments facing the cathode **4** extend along straight lines *b* which form an angle α with the axis *x—x* preferably not exceeding 10°.

The same electrode segment form can be used, of course, when the interdigitated electrode structure does not have a toroidal self-enclosed form but is, for example, elongated and straight, as in traveling wave tubes. In such tubes, a guide electrode with a flat surface, taking the place of the cathode, usually is opposite and parallel with the side of the electrode provided with segments. In this case, the sides of the electrode segments facing the guide electrode should be inclined by preferably at most 10° relative to the plane of the guide electrode.

In the modified construction shown in FIG. 2, which is also a toroidal cavity type resonator similar to FIG. 1, those structural components corresponding to the FIG. 1 embodiment have been given the same reference numerals but with primes applied thereto for purposes of distinction. Thus the cylindrical outer wall bounding the cavity is designated by **1′** and the end walls by **2′** and **3′** respectively. In this embodiment, the electrode segments **5′** and **6′** do not have the same configuration as in FIG. 1. The upper sides **5***d′* and **6***d′* of the interleaved electrode segments taper inwardly towards the resonator axis in the same manner as the upper sides **5***d* and **6***d* in FIG. 1, but the lower sides **5***c′* and **6***c′* are arranged parallel to the

cavity axis with an offset or step 5e' and 6e in a direction away from the cathode so that the outer free end portions 5a' and 6a' of the electrode segments are thereby also located farther away from the cavity axis than are the root ends 5b' and 6b'. In this embodiment there is but a single step provided along the inner side edges of each of the electrode segments. However, it is to be understood that the inner side edges of the electrode segment can be provided with a plurality of stepped sections.

In conclusion, it will be seen that the improved electrode segment construction as defined hereinafter in the claims provides for a more efficient cooling in that the free end portions of the electrode segments which are more difficult to cool than the root ends secured to the end walls of the cavity are located more remote from the cathode than the root ends and thereby have a lower density of impinging electrons which means a lower heating effect than at the root ends. Experiments have shown that with the improved segmented electrode construction according to the present invention, in an otherwise unchanged single-circuit magnetron, permits a permissible increase in power consumption to about double the former value.

I claim:

1. In a tube of the microwave type comprising a first electrode member which serves in the establishment of an eletrostatic field for guiding electron flow and a plurality of interdigitated electrode segments spaced from said first electrode member and secured in position only at their root portions, the outer end portions of said segments being therefore free, the improvement wherein the free end portion of said electrode segments are located more remotely from said first electrode member than are the root portions of said electrode segments.

2. A tube of the microwave type as defined in claim 1 wherein the sides of said electrode segments facing said first electrode member are inclined relative to said first electrode member at an angle not exceeding 10°.

3. A tube of the microwave type as defined in claim 1 wherein the sides of said electrode segments facing said first eletcrode member are stepped in the direction away from said first electrode member.

4. In a microwave tube of the magnetron type comprising a toroidal resonator cavity established by a cylindrical wall and two parallel spaced end walls joined to said cylindrical wall, a cathode arranged along the axis of said cavity and a plurality of interdigitated electrode segments secured only at their root portions to said end walls and extending inwardly from said end walls and surrounding said cathode, the outer end portions of said segments being therefore free, said cathode also serving as an electrode in the establishment of an electrostatic field for guiding electron flow, the improvement wherein the free end portions of said electrode segments are located more remotely from said cathode than are the root portions thereof located at said end walls.

5. A microwave tube as defined in claim 4 wherein said electrode segments have a trapezoidal configuration.

6. A microwave tube as defined in claim 4 wherein said electrode segments have their sides facing said cathode stepped in a direction away from said cathode to establish the free end portions thereof at a greater distance from said cathode than are the root end portions thereof.

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