March 4, 1941. R. B. AYER 2,233,763

TUNING STRUCTURE

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Fig. 1

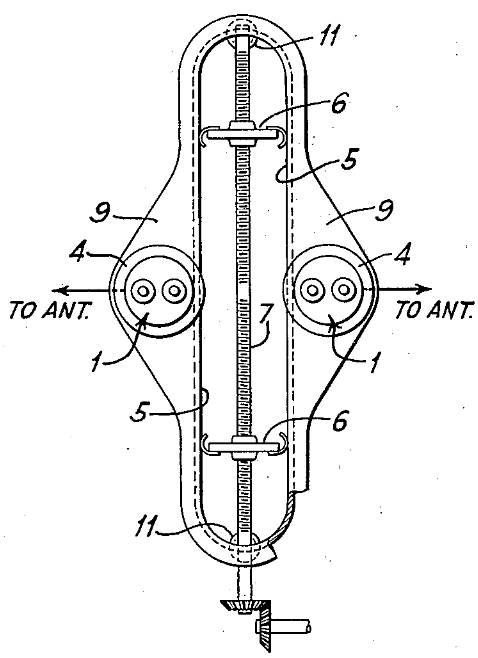


Fig. 4

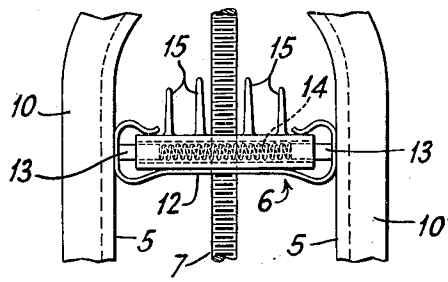


Fig. 5

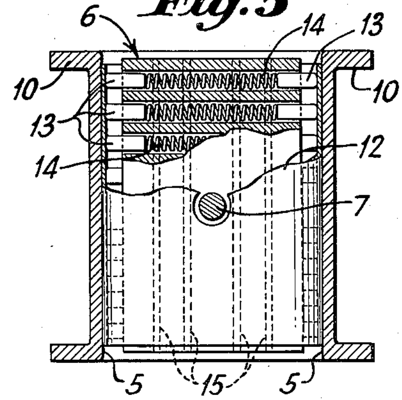


Fig. 2

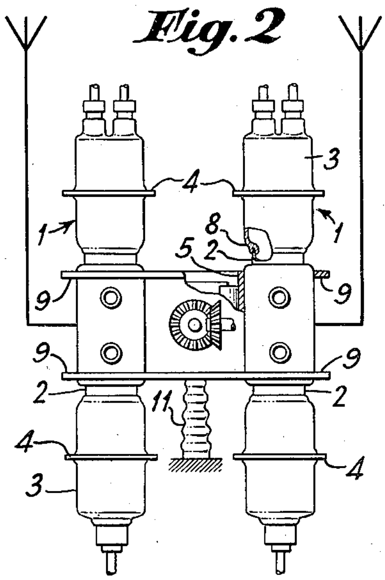
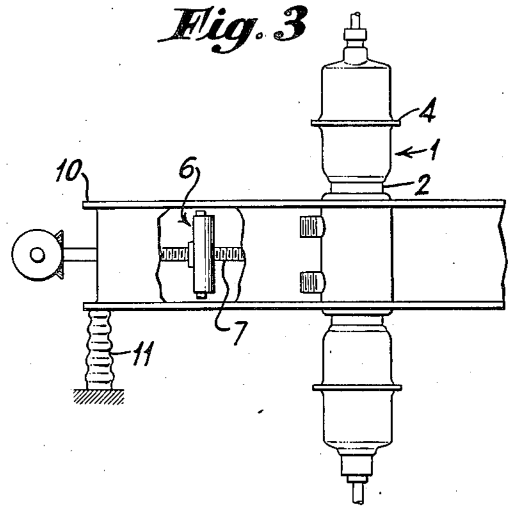


Fig. 3



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TUNING STRUCTURE

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4 Claims. (Cl. 250—27)

My invention relates to high power high frequency radio circuit structures, particularly to apparatus such as shortwave transmitters.

Alternating currents of ultra-high radio frequencies flow on the surface of their conductors, the depth of penetration of the currents into the conductor, or skin effect, being so pronounced at frequencies in the range of 60 megacycles per second that the two sides of a sheet of metal are in effect electrically insulated for such high frequency currents and the current can pass from one side of the sheet to the other only by flowing to and around the edge of the sheet. Because of this phenomenon the high frequency anode current of a conventional cylindrical anode must flow over the rim of the anode, thereby increasing the length and impedance of the anode circuit. These currents, when of high magnitude, heat the metal at the rim of the anode and are particularly troublesome in tubes where glass is sealed to the rim of the anode as in the usual water-cooled types.

The object of my invention is to provide a high frequency circuit structure for radio tubes in which the impedance of the anode circuit and the heating at the rims of connected anodes are minimized.

The characteristic features of my invention are defined in the appended claims and one preferred embodiment is described in the following specification and shown in the accompanying drawing in which Figure 1 shows in plan view two tubes connected in push-pull with the novel circuit structure of my invention, Figures 2 and 3 are, respectively, end and side views of the structure of Figure 1, and Figures 4 and 5 are top and end views of one shorting bar embodying my invention.

For purpose of illustration, two tubes, each of the type shown in the Zottu et al. Patent No. 2,113,671, April 12, 1938, are mounted side-by-side and are connected for push-pull operation. Each tube comprises a cylindrical metal anode **2** sealed at each end, in the particular tubes shown, to a glass bulb **3** through the ends of which are sealed the lead-in conductors for the cathode and grid electrodes. Intermediate the ends of the bulbs are sealed in screen grid lead-in rings **4** and the anodes may, if desired, be enclosed in metal water-cooling jackets. Tuned transmission lines connect the two anodes in push-pull resonant circuits, the lines shown in Figure 1 comprising parallel metal arms **5** extending laterally in both directions from the plane through the centers of the two tubes. The arms are parallel straight flat strips of metal secured to the opposing sides of the anodes.

The arms connecting the two anodes comprise a resonant circuit which may be tuned to any desired frequency by adjusting their electrical length. The circuit of the arms may conveniently be tuned by adjusting the distance of shorting bar **6** from the anodes. The shorting bars, preferably transverse plates, contact the inner faces of the arms with spring wipers, are moved along the arms by a threaded rod **7**, and the two shorting bars may be kept at uniform distances from the anode by right hand and left hand threads on the rod. A load may be coupled to the tubes by direct connections to the anode or by inductive coupling to the tank.

Because ultra high frequency current flows only on the surface of its conductors and flows only along paths of the lowest impedance and shortest distance between points of different potentials, the current flowing between the metal arm and the inside of the anode flows over the rim **8** of the anode adjacent the connection between the arm and anode. The high frequency current concentrated at the anode rim adjacent the arm connection may seriously over-heat the glass seal at the end of the anode and limit the power of the tube. I provide according to my invention means for uniformly distributing the current around the rim of the anode to lessen the local heating and reduce the resistance to the flow of current. According to my invention the current is distributed around the periphery of the anode near the anode rim by a sheet metal flange **9** preferably integral with the edges of the arm and extended outwardly from the arm around the anode and joined to the anode in good electrical contact by clamps or by brazing or soldering. The flange may be tapered from its widest point opposite the anode to a narrow rib or fin **10** at the outer ends of the arms, the contour of the flange being determined by the current distribution between the anode and the shorting bar. The ends of the arms may be made into a one piece structure, and may conveniently be stiffened by the fins extended to the ends of the structure.

The reinforced arms may bear the weight of the tubes, and since no alternating current flows in the arms beyond the shorting bars, the entire tube and tuning structure may be conveniently supported upon insulators **11** at points removed from high frequency potentials.

In operation high frequency current flows along the faces of the flanges and the arms and across the shorting bars. The flanges surrounding the anodes, distribute the current to the rims of the anodes and prevent the concentration of current and heating. My novel anode-to-circuit connection not only decreases the temperature of the anode-to-glass seals, but decreases the mean length of the path for high frequency current, and reduces the impedance of the anode circuit. The symmetrical double circuit of the structure shown with arms extending to both sides of the anodes parallels the circuit inductance and increases the length of the external circuit available for tuning.

While the arms are preferably flat rectangular metal pieces with flanges and fins for strength and are secured tangentially against the opposed sides of the anodes for closer spacing and higher capacity, the arms may if desired be pipes, rods or bars extending tangentially or radially from the sides of the anodes. By adjusting the shorting bar to a distance from the anodes equal to an odd multiple of a quarter-wavelength of the operating frequency, standing waves are produced on the arms with a current maximum and a voltage node at the shorting bar. My improved tank circuit can, of course, be used with single-ended tubes where only one end of the anode is sealed to a glass bulb.

While the circuit structure shown in Figures 1, 2 and 3 is symmetrical with respect to the plane through the centers of the two tubes, it will be obvious to those skilled in the art that the tank circuit may be extended in one direction only from said plane. In such an arrangement flanges 9 would extend from the tuning arms 5 and encircle the anodes at least one-half way around the adjacent side of the anode.

In transmitters designed for radiating considerable amounts of high frequency power, the problem of making good electrical contact between the shorting bar 6 and the tuning arm 5 may conveniently be solved as shown in Figure 4 where the body of the bar carries a rectangular piece of thin sheet metal 12, such as copper, curled into a loop along its edges and held in firm contact with the inner face of the arms 5 by spring pressed blocks 13. The pressure applied by the blocks 13 may be made as high as practical by springs 14 consistent with easy sliding of the bar along the faces of the tuning arms 5. Since most of the resistance of the tuning circuit is lumped at the contacting area between the arms and the shorting bar, the principal heating caused by the current is at the bar. This heat may be conveniently dissipated by vertical cooling fins 15, preferably integral with the shorting bar and extending outwardly from its rear face. To obtain a good heat transfer from sheet 12 to the radiating fins the sheet is preferably soldered or brazed to the inner face of the shorting bar. Naturally or artificially circulated air through the fins may serve to keep the shorting bar at reasonable temperatures.

A high frequency circuit structure according to my invention decreases anode circuit inductance, increases the length of the external circuit and decreases heating at the rim of the anode.

I claim:

1. An electron discharge device with a tubular anode, a tuning element for said device comprising a straight, flat strip of metal secured tangentially to and extending in opposite directions from one side of said anode, a flange along the edge of said strip, said flange at least partly surrounding said anode and in good electrical contact with the outer wall of the anode, the sole support for said electron discharge device being supporting insulators at the outer ends of said strip.

2. Two electron discharge devices with cylindrical anodes, a structure for operating said devices at frequencies at which the current of the operating frequency does not penetrate the wall of said anode, comprising two parallel straight, flat strips of metal secured to opposing sides of each of said anodes and extending laterally from the plane through the centers of the anodes, said strips being electrically coupled, means for uniformly distributing said current along the rim of each anode as it flows between the anode and its strip and for stiffening the strip comprising a laterally extending flange on each of said strips surrounding and in good contact with the anodes, adjacent outer ends of said strips being joined and supported on an insulator.

3. A circuit structure for electron discharge devices comprising an electron discharge device with a cylindrical anode, a tuning element for said device comprising two rigid arms extending laterally in opposite directions from the anode, each of said arms being longer than one-quarter of a wavelength at the operating frequency and being secured to said anode in a unitary mechanical structure, the sole support for said tuning element and its attached electron discharge device comprising an electrical insulator joined to each arm at its outer end.

4. A circuit structure for electron discharge devices comprising two parallel straight flat strips of metal, an adjustable shorting bar between said strips comprising a rectangular block between and transverse to the planes of said strips, a rectangular piece of thin sheet metal attached, in good heat transfer relation, to one side of said block, said piece of sheet metal being approximately coextensive with the width of said strips, the edges of said sheet metal being curled into loops and slidably engaging said strips throughout the width of said strip, means for holding the loops in contact with said strips comprising a plurality of side-by-side spring pressed plungers in the edges of said block bearing against the inner surfaces of said loops.

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