

Feb. 5, 1946.

I. E. MOUROMTSEFF ET AL

2,394,396

COMBINED AIR JACKET AND TUNING MECHANISM FOR RESONATORS

Filed July 18, 1941

3 Sheets-Sheet 1

Fig. 1.

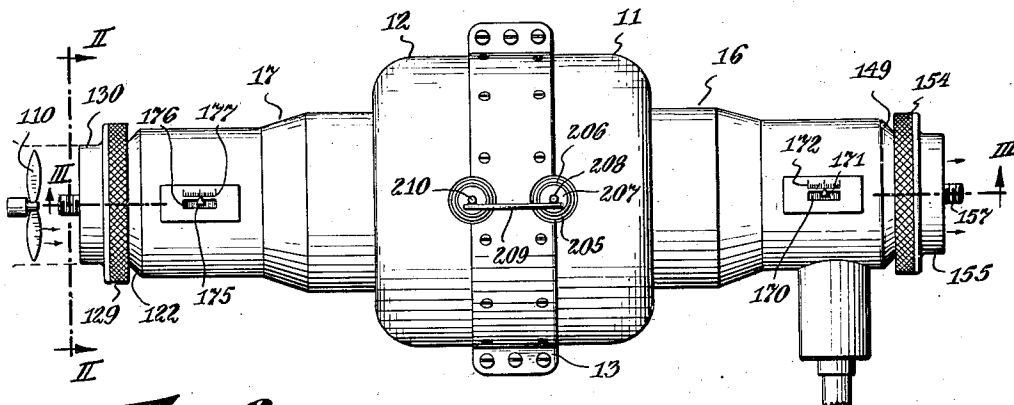


Fig. 2.

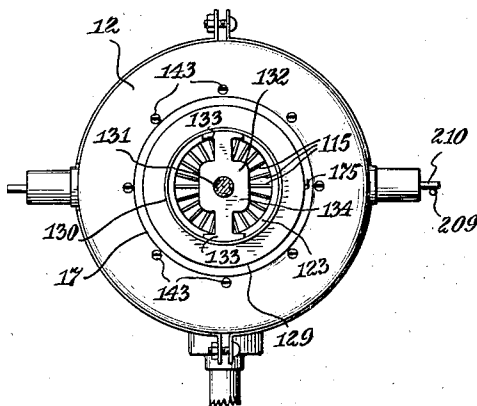


Fig. 3.

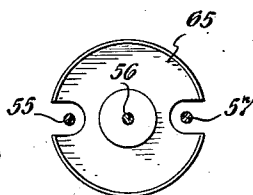


Fig. 4.

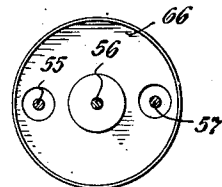


Fig. 5.

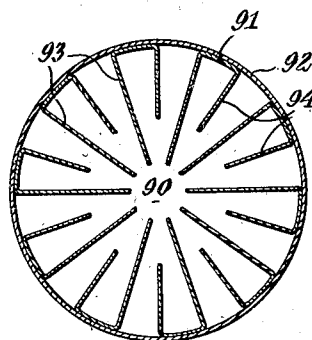
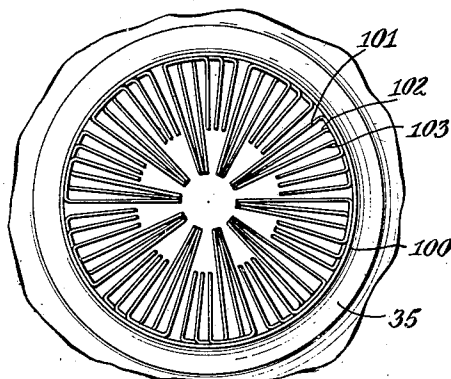


Fig. 6.



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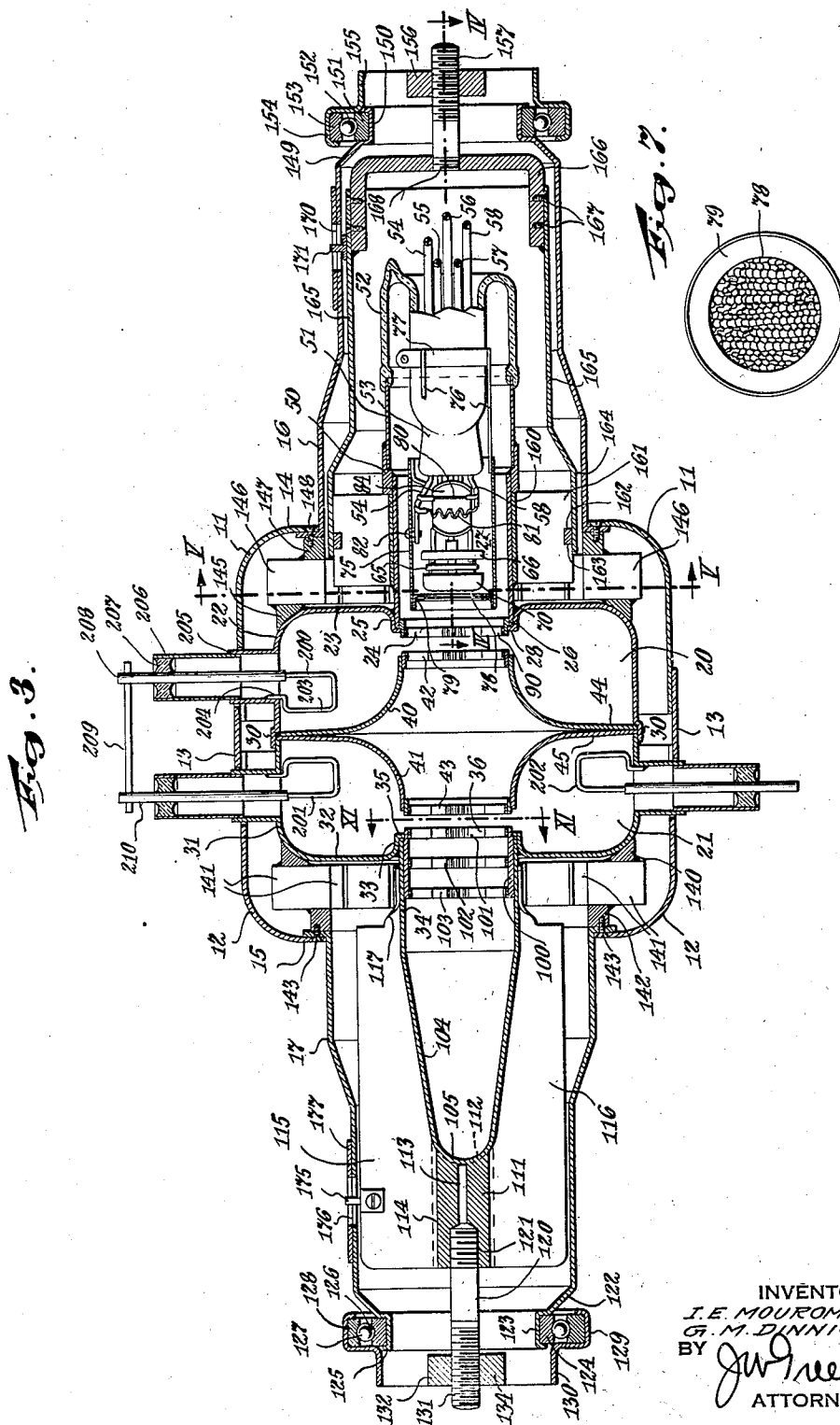
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3 Sheets-Sheet 2



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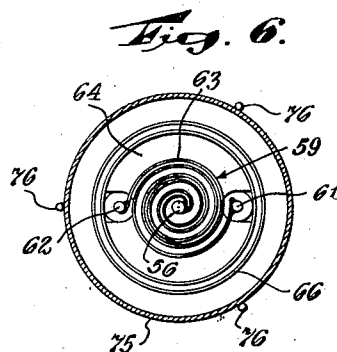
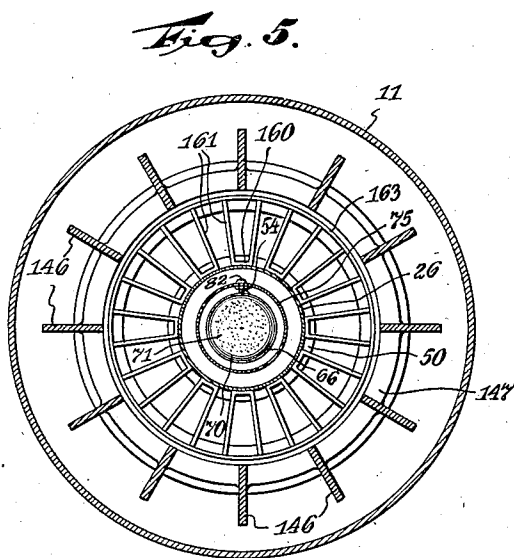
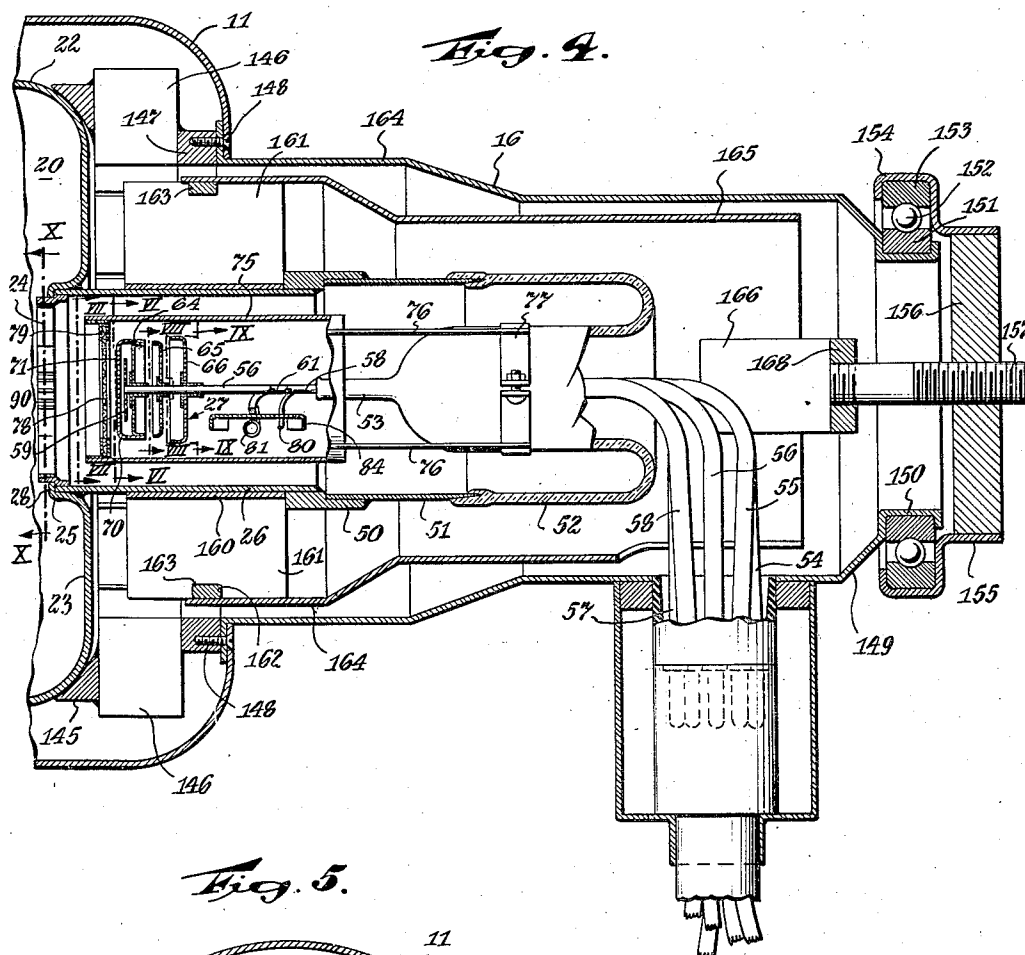
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COMBINED AIR JACKET AND TUNING MECHANISM FOR RESONATORS

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3 Sheets-Sheet 3



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2,394,396

COMBINED AIR JACKET AND TUNING
MECHANISM FOR RESONATORS

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Application July 18, 1941, Serial No. 402,959

10 Claims. (Cl. 250—27.5)

Our invention relates to electronic devices and especially to the type of electronic device known as hollow body resonators or oscillators.

An object of our invention is to provide a hollow body oscillator or resonator that is easily ad-
5 justed.

Another object of our invention is to provide combined adjusting and cooling means for a hollow body oscillator or resonator.

Another object of our invention is to provide
10 an inner metal casing and an outer metal casing that will not substantially change their relative positions while heated in operation.

Other objects and advantages of the invention will be apparent from the following description
15 and drawings in which:

Fig. 1 is a view in elevation of a preferred embodiment of our device.

Figs. 2 and 3 are views on lines II—II and
III—III of Fig. 1.

Figs. 4, 5 and 11 are views on lines IV—IV,
V—V and XI—XI of Fig. 3.

Figs. 6, 7, 8, 9 and 10 are views on lines VI—VI,
VII—VII, VIII—VIII, IX—IX and X—X of Fig. 4.

While it has other applications, our invention has special application to hollow body oscillators and particularly to those operating with micro-
20 waves with frequencies of the order of 10^8 . The prior art devices have, at the most, very clumsy and awkward adjusting means and very little or inefficient cooling means applied thereto. Our invention provides a very efficient cooling and adjusting means in which accurate adjustment may be accomplished with the pressure of finger
25 tips.

As disclosed in elevation in Fig. 1 and in cross section in Fig. 3, the device in its specific form comprises an outer casing enclosing two hollow
30 body oscillators with an air space therebetween. The outer casing in our preferred form has a central cylindrical portion preferably comprising two shells 11 and 12 bound together by a supporting band 13.

These shells are preferably of light but strong material, such as aluminum, although copper-nickel sold under the trade name of "Monel" might also be utilized. These two shells 11 and
35 12 have curved ends 14 and 15 with a large central opening from which project two elongated cylinders 16 and 17 preferably of the same casing material. The use of the aluminum has a special advantage in combination with the copper reso-
40 nators as pointed out below.

Inside of the space enclosed by the shells 11
45 and 12 are two hollow body oscillators 20 and 21.

These hollow body oscillators may have various shapes, but essentially they must be vacuum-tight and are preferably of copper in order to be highly electrically and thermally conductive. The copper used in these oscillators has a lower
5 coefficient of expansion than the aluminum in the outer casing but the higher temperature of the copper in operation makes the copper expand practically the same amount as the outer aluminum casing. There is accordingly no relative change in dimensions of the two casings during operations. The hollow body oscillator 20 is preferably constructed of a cup-shaped copper piece
10 22 having a bottom flexible wall 23 with a central opening 24 therein. The cup-shaped copper bottom 23 preferably has an in-turned rim 25 about the opening 24 and to the inner edge of this rim is welded a cathode sleeve 26 extending into the space enclosed by the outer cylinder 16. This
15 sleeve is preferably of aluminum. Within this sleeve is the cathode structure 27 which will be hereafter described.

The in-turned rim 25 is preferably turned over at 28 over the edge of this cathode sleeve 26. The
20 cup-shaped copper shell 22 preferably has an edge flange 30 fitting over a somewhat similar cup-shaped shell 31 of the hollow body oscillator 21. The cup-shaped shell 31 has a flexible bottom portion 32 parallel with the bottom wall 23 of the other hollow body oscillator. This cup-shaped
25 shell has a similar inturned rim 33 about the opening 36 and an anode sleeve 34 is welded to the interior of this rim 33, and this sleeve extends outwardly into the extension of the cylinder 17.
30 The edge of the rim 33 is flanged over the edge of the anode sleeve 34 providing an inturned lip 35 thereat. The two other boundaries of the hollow body oscillators preferably comprise two frusto-conical members 40 and 41 with their central
35 openings 42 and 43 spaced slightly from the openings 24 and 36 of the cup-shaped bodies 22 and 31. The frusto-conical shape of these two bodies curves outwardly into two gradually flattening areas 44 and 45 that have their edges
40 bound under the exterior flange 30 between the edges of the cup-shaped portions.

The cathode sleeve 26 has a ring 50 secured to its exterior edge and this ring has secured thereto
45 a cylinder 51 of a nickel-cobalt-iron alloy sold under the trade name of "Kovar" which is especially adapted for sealing vacuum-tight into glass. To this cylinder is sealed a reentrant glass seal
50 52 of borosilicate glass having a press 53 through which are sealed the five leads 54, 55, 56, 57, and
55 58. Two of these leads extend to a heater 59

disclosed in Fig. 6. This heater has, for example, the two standards 61 and 62 to which is connected a bifilar heater wire 63. This bifilar winding is preferably of the flat pancake spiral form disclosed in this figure although other forms may be used. A plurality of cup-shaped heat shields 64, 65, and 66 are preferably placed just in back of this cathode heater 63. Heat shields 65 and 66 are disclosed in Figs. 8 and 9, respectively. The cathode itself preferably comprises a cup-shaped member 70 coated on its flat surface with an electron-emissive coating 71, such as the standard barium, strontium and calcium oxide coating. The cup-shaped member 70 and the first heat shield 64 preferably interfit to enclose the heater 63. Surrounding the cathode just described and within the cathode sleeve 26 is a second cylinder 75 as a grid support. This cylinder 75 is supported by standards 76 from a band 77 on the reentrant glass seal 52. The grid proper 78 is supported at the inner portion of the grid cylinder 75 and is closely parallel to the electron-emitting material 71 on the cup-shaped cathode 70. This grid 78 is preferably of a very light, fine woven mesh wire, such as that disclosed in Fig. 7. This wire is of approximately 1 or 2 mils and from its similar form is called frequently a stocking mesh or grid. This stocking grid 78 has a binding ring 79 securing it in the grid cylinder 75. In order to insure a vacuum inside our device, we preferably include a getter arrangement for absorbing the last traces of gas which may be evolved from the walls or other elements of the device after the device has been sealed off. We utilize a connection such as the extension of the wire 58 through the press 53 and attach to it at spaced points two getter wires 80 and 81 of different resistances. The resistance of one of these may be four times the other. The other end of these getter wires may be attached to one of the other leads such as the wire 54, making a connection to the grid cylinder 75, as illustrated at 82 in Fig. 3. The wire of low resistance such as 80 may be flashed first and the other getter 81 is preferably left intact as our experience has shown that the device may be overloaded at times and some gas releases from the metal walls or seeps therethrough during this overloading. The second getter can be flashed in the field to clean up this gas. Of course, more than two of these getters may be utilized if desired. We also preferably place these getters in the rear of the heat shields 65 and 66 for the cathode and also preferably provide a shield 84 to prevent the getter material from flashing on the conductors or cathode structure.

In the opening 24 we preferably insert a grid such as that disclosed in Fig. 10. This grid 90 comprises a series of flat ribbons with a bottom portion 91 secured to the inner periphery of a ring 92 attached in turn to the inner edge of the cathode sleeve 26 and peened-over or silver soldered to the edge 28 of the cup-shaped shell 22 of the first hollow body resonator. This ribbon may be of copper, molybdenum or tantalum. This ribbon has one leg 93 extending almost to the center of the ring 92, and the other leg 94 projects towards the center a shorter distance, as disclosed in Fig. 10. A plurality of these grids extends from the periphery of the ring 92 as disclosed in Fig. 10 to provide control of the space with a minimum of interference with the passage of the electrons therethrough. A similar grid ring and grid structure is inserted in the openings 42, 43, and 36 of the frusto-conical members

40, 41 and the cup-shaped shell 31. The ring 100 supporting the grid structure 101 in the opening of the shell 31 of the resonator 21 preferably extends for a distance in the collector shell 34 and has two additional grid structures 102 and 103 therein with their legs or spokes spaced around the axis, as disclosed in Fig. 11. This plural grid structure prevents the effect of any secondary emission from the collector from affecting the hollow body resonators. The collector sleeve 34 preferably terminates in a tapered portion 104 terminating in turn into a curved end portion 105. The tapered portion 104 and curved end 105 form the collector for the electrons and the shape is especially designed to prevent the concentration of an electron stream upon any particular area and resulting over-heating of this particular area.

Two of the main problems of our device are the adjustment of the spacing between the grid openings 24 and 42 of the hollow body resonator 20 and the grid openings at 43 and 36 of the hollow body resonator 21, and also the adequate cooling of the interior hollow body resonators. We have combined the solution of these two problems by providing a structure intermediate the vacuum-tight enclosed structure and the outer casing whereby both easy adjustment and adequate cooling are obtained. We prefer to have the device air-cooled such as by air blasts provided by a fan 110 located at the collector end of the device.

In order to effectively cool the collector 104, we provide the fin arrangement disclosed in Figure 3. A core 111 of copper is soldered with a curved end 112, exactly fitting the curved end 105 of the collector. The core may be slightly hollowed at 113. The cylindrical surface of the core is longitudinally slotted, as indicated at 114, and a plurality of thin copper fins 115 are fitted into these slots and soldered to the core. The plurality of fins 115 about the core and collector, are indicated in Figure 2. These fins 115 have longitudinally-extending legs 116, that are cut away to fit exactly the gently tapered slope of the collector 104. These fins terminate at a position adjacent the collector sleeve 34 into a finger 117 which is twisted to fit on the cylindrical surface of the anode sleeve 34 and to be soldered thereto.

A stud 120 is screw-threaded into a screw-threaded exterior hole 121 of the fin core 111 and preferably soldered therein. The extension 17 of the exterior casing is sloped inwardly at 122 to form a reduced diameter annular portion 123 about the extension of the stud 120.

A seamless ring 124, preferably of cold rolled steel, is placed about this annular extension 123 of the exterior casing, and the casing is peened over this ring at 125. The outer surface of the ring has a groove 126 therein for ball bearings 127, that are enclosed by a second ring 128, and an enclosing casing or cap 129, which is spun over this ring 128.

The case or cap 129 has an outer extension 130 surrounding the exterior portion 131 of the stud 120, which extends outwardly. An arm 132, disclosed more fully in Figure 2, extends across the diameter of this outer extension 130 and has enlarged curved ends 133 which are screw-threaded to the interior surface of this extension 130 of the adjusting cap 129. This arm 132 has an enlarged central portion 134, which is screw-threaded to the stud 120. The adjusting cap 129 can be turned in either direction and this turning

action will exert through the screw-threaded connection of the arm 132, a push or pull on the stud 120 to adjust through the plug 111 and the collector 104, the position of the grid 101, in respect to the grid 43 adjacent the free field space between the two hollow body resonators.

In order to form a fulcrum on the hollow body resonator 21, a ring 140 is curved to bear against the outer curved surface of the resonator cap 31. This ring has a substantially triangular cross-section except for the slightly curved side bearing on the cap 31. To one side of this ring are welded a plurality of flat plates 141, and the outer surface of these plates are supported in turn by a ring 142, having a diameter equal to the diameter of the casing portion 17. Screws 143 can conveniently bind the extension 17 and cap 15, and the ring 142 together.

The radial positions of the fins 141, permit the circulation of air around the outer surface of the two hollow body resonators after this air has passed through the fins 115. A similar arrangement of ring 145, fins 146 and ring 147 extends between the curved edge of the resonator cap 22 and the casing. The extension 16 and cap 11 of the outer casing are bound together and to the ring 147 by screws 148.

The extension 16 of the casing slopes at 149 to an annular portion 150, that has an adjusting arrangement similar to the anode or collector end of the casing and composed of ring 151, ball bearings 152, ring 153 and adjusting cap 154, with its extension 155 having the cross arm 156 in screw-threaded adjustment with a stud 157 similar to the corresponding parts just described in connection with the other end of the casing.

The structure for both adjusting the openings of the hollow body resonator 20 and for cooling the cathode casing, are disclosed in Figures 3, 4 and 5. We have previously described the sleeve 26 enclosing the cathode and terminating in the grid 90 of the hollow body resonator 20.

To the outer surface of this cathode-enclosing sleeve 26, are welded the bottom portion 160 of a plurality of narrow U-shaped fins 161. The outer edges of these fins are slotted at 162 in order to have a binding ring 163, surrounding and securing them rigidly in radial position, about the sleeve 26. To this ring 163 is secured a casing 164 having extension 165 slightly reduced in diameter and extending near to the termination of the outer casing 16. A U-shaped support 166 is rigidly attached to this casing, such as by screws 167 illustrated in Figure 3. The stud 157 is securely attached to the central portion 168 of this U-shaped support 166.

At one portion of the outer casing 16, there is an opening 170 and a marker 171 is attached to the inner casing 165 to indicate the position thereof, in respect to the outer casing.

For further convenience a scale 172 may be attached to the outer casing with respect to the indicator 171. A similar indicator 175 is attached to one of the fins 115 about the anode collector and projects through an opening 176 to indicate on a similar scale 177, the position of the collector in respect to the outer casing.

For the adjustment of the openings of 24 and 42 of the hollow body resonator, the adjusting cap 154 and its associated parts are revolved in one direction or the other.

The fulcrum is made through the outer casing extension 16, ring 147, fins or vanes 146, and ring 145, upon the curved outer edge of the flexible copper shell 123. The pushing or pulling force

of the adjusting cap is exerted through the arm 156, stud 157, U-shaped arm 166, casing 165, vanes 161 and sleeve 26, to move the grid opening 24 nearer to or spaced further from the grid 42.

A similar adjusting action of the openings 36 and 43 of the hollow body resonator 21 by the adjusting cap 129 and its associated elements are accompanied by using a fulcrum composed of the outer casing 17, ring 142, vanes 141 and ring 140, bearing on the outer curved edge of the flexible cap 31 of the resonator 21. The pulling or pushing force is exerted through the arm 132, stud 120, core 111, collector 104, sleeve 34 to the grid 101, to push it closer to the grid opening 43 or to pull it further therefrom. These elements not only adjust the positions of the openings in the hollow body resonator, but also cooperate to provide a very efficient cooling operation for the device. The air from the fan 110 passes through the fins 115 to the adjacent end of the hollow body resonator 21 and then through the vanes 141 about the outer cylindrical edge of the resonator 21 and 20, then through the vanes 146 to the vanes 161 and then passes through the space between the cathode sleeves 50, 51 and on the enclosing casing 165 to the exit provided by the extension 155 of the adjusting cap 154.

Various loops 200, 201, 202 and more, if desired, may be placed in the resonators for the purpose of feeding ultra high wave frequency from an outside source into the resonators or of taking it from the resonators. We generally use two of these loops such as 200, 201 to feed back oscillations from one resonator to the other by any desired transmission line. The type and adjustments of the transmission lines will govern the phase and amplitude of the oscillations. The loops preferably comprise a conductor 203 forming the loop and passing through an opening 204 in the copper casing. A sleeve 205 of metal alloy, preferably that sold under the trade name "Monel" is silver soldered to the copper. A sleeve 206 of nickel-cobalt-iron alloy sold under the trade name of "Kovar" is welded to the first sleeve and a plug 207 of borosilicate glass seals vacuum tight the space between the sleeve 206 and the conductor 203 which has an exterior portion 208. A metal bar 209 may be placed on this portion 208 to make contact with the exterior portion 210 of loop 201 and the bar 209 shifted along 208 and 210 to the most desired position. In place of this construction the portions 208 and 210 may be made into loops similar to 200 and 201 and coupled to similar loops connected to a concentric transmission line. The length of this transmission line and the angles between the loops will regulate the amplitude and phase of the oscillations.

Because of the higher temperature of operation of the copper resonators there is no relative change in position with respect to the aluminum outer casing with its higher coefficient of expansion but lower temperature. The fine adjustments of the positions of the grids 90 and 101 can be made with delicate fingertip pressure on the adjusting collars 154 and 129. Various elements do double duty of both aiding the cooling of the resonators and regulating the position of their grids. No such ease of adjustment and efficiency of cooling is present in the prior art.

We claim:

1. An electronic device comprising two joined hollow body resonators, one of said resonators having a flexible wall having an opening for the entrance of electrons therein, the other resonator

having a flexible wall with an opening therein for the emergence of the electrons, a casing enclosing said resonators and spaced therefrom for circulation of a cooling medium about said resonators, adjusting means between said resonators and said casing for positioning the openings in said flexible walls and a completely circular fulcrum between the outer portion of said flexible walls and the casing.

2. An electronic device comprising two joined hollow body resonators, one of said resonators having a flexible wall having an opening for the entrance of electrons therein, the other resonator having a flexible wall with an opening therein for the emergence of the electrons, a casing enclosing said resonators and spaced therefrom for circulation of a cooling medium about said resonators, adjusting means between said resonators and said casing for each said resonator, said adjusting means having a rotatable cap, one at each end of the casing, and having indicators showing sleeve position as adjustment is made by rotating said caps.

3. An electronic device comprising two joined hollow body resonators each having an outer flexible wall, and each said flexible wall having an opening, a sleeve in each opening, a cathode in one sleeve, insulation sealing said cathode in said sleeve, said other sleeve terminating in a collector enclosing its respective resonator opening, fins on each of said sleeves, a bearing ring around the outer portion of each outer flexible wall, fins connected to said bearing rings, a casing enclosing said resonators, sleeves and fins, means attaching said casing to the bearing ring fins, and anti-friction adjusting means on said casing for operating on said sleeves to position the openings in said outer walls.

4. An electronic device comprising a hollow body resonator having a flexible wall, said wall having a part thereof depressed and said depressed part of the wall having its end flanged inward and providing a lip thereat and said lip providing an opening therethrough into the interior of said resonator, a sleeve exterior to the resonator and secured in said depressed part of the wall against said lip, and adjusting means having connection with said sleeve for thereby applying flexing pressure to said wall to regulate the position of said opening.

5. An electronic device comprising a hollow body resonator having a flexible wall, said wall having a part thereof depressed and said depressed part of the wall having an opening into the interior of said resonator, a sleeve exterior to the resonator and secured in said depressed part of the wall about said opening, a fixed ring having a bearing surface against said flexible wall at a distance from said sleeve, and adjusting means for flexing the part of said wall between said ring and sleeve and having connection with said sleeve determining the position of said opening.

6. An electronic device comprising a hollow body resonator having a flexible wall, said wall having a circular depression and having an open-

ing into the interior of said resonator, a sleeve construction exterior to the resonator and secured in said depression about said opening, a ring having a bearing surface against said flexible wall, a casing enclosing said resonator and sleeve, means anchoring said ring to said casing, and adjusting means having connection with said sleeve and casing to regulate the position of said opening.

7. An electronic device comprising a hollow body resonator having a flexible wall, said wall having a circular depression and having an opening into said hollow body resonator, a sleeve construction exterior to the resonator and secured in said depression about said opening, a ring having a bearing surface against said flexible wall, a casing enclosing said resonator and sleeve, means anchoring said ring to said casing, and adjusting means having threaded connection with said sleeve and exerting a thrust longitudinally of said casing to regulate the position of said opening, said adjusting means including an anti-friction bearing between said casing and adjusting means.

8. An electronic device comprising a hollow body resonator having a flexible wall, said wall having a circular depression in said flexible wall having an opening into the hollow body of said resonator, a sleeve construction exterior to the resonator and secured in said depression about said opening, a ring bearing against said flexible wall, a casing enclosing said resonator and sleeve, means anchoring said ring to said casing, adjusting means connected with said sleeve and casing to regulate the position of said opening, said adjusting means including an anti-friction bearing on said casing, a screw-threaded shaft attached to said sleeve, and an arm having a screw-threaded engagement with said shaft, said arm attached to said anti-friction bearing on said casing.

9. An electronic device comprising a hollow body resonator providing a flexible wall having a depression therein, said depression having an opening into said resonator, a sleeve exterior to said resonator and secured in said depression about said opening, a collector electrode attached to said sleeve, a ring having a bearing surface against said flexible wall, and adjusting means having connection with said collector electrode and ring to position said opening.

10. A hollow body resonator providing a flexible wall having a depression therein and said depression having an opening into said resonator, a sleeve secured to said wall in said depression about said opening, a fixed ring bearing against said flexible wall next the circumference thereof entirely around the same and radially spaced from the sleeve, said sleeve terminating in a collector for electrons passing through said opening and adjusting means at the end of said sleeve for operating on said sleeve and flexible wall to adjust the position of said opening.

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