

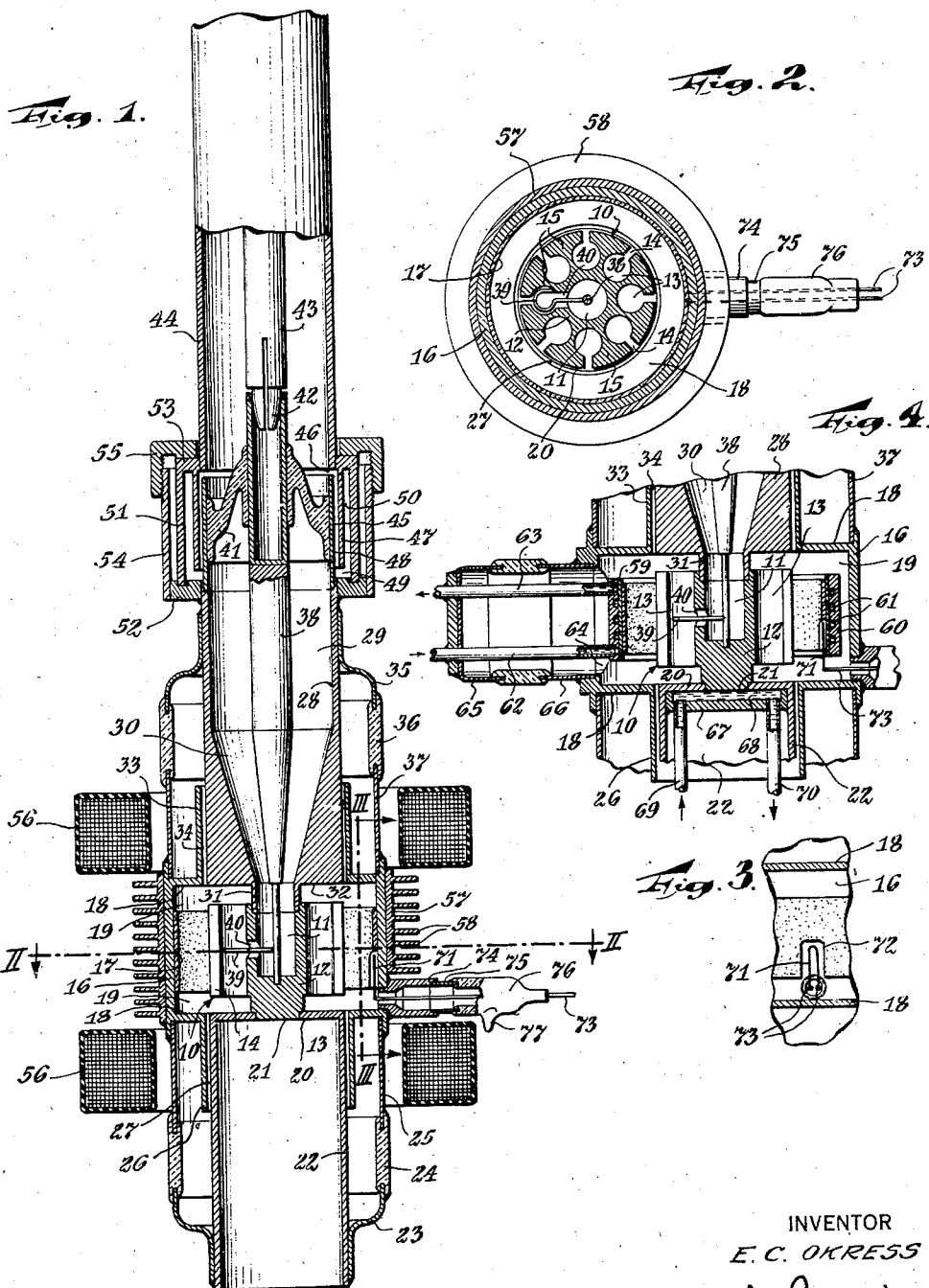
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ELECTRONIC DEVICE

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ELECTRONIC DEVICE

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This invention relates to electronic devices and more particularly to magnetrons.

The magnetron has proved itself to be an exceedingly important instrumentality in the electronic art where used as an alternating current power generator, but has presented increasing difficulties in use as a continuous-wave power source at high power levels. The trouble arises largely from electronic bombardment of the cathode and consequent uncontrolled heating of the cathode. According to the present invention, solution of this problem is attained.

Broadly stated, then, an object of the invention is to provide an operative continuous-wave magnetron having stable characteristics and long life at high power output levels.

More specifically, an object of the invention is to provide a cathode capable of being maintained at a controlled, reasonably constant and desirable temperature during continuous operation.

Another object of the invention is to provide a cathode of desirable features exterior to the resonant system such that adequate emission may be obtained for high power output levels.

Of like nature, an object of the invention is to provide a structure favorable to use of a cold cathode.

Another object of the invention is to adhere closely to symmetrical arrangement of anode and cathode with efficient electro-magnetic coupling from the generator to the external load.

A further object of the invention is to incorporate a starting cathode substantially the same electron-path distance from the cavity resonators of the anode as the operating cathode.

Yet another object of the invention is to provide a magnetron structure having a direct coaxial line output from the anode, coaxial therewith.

Other objects of the invention are to obtain a structure which is practical from a manufacturing standpoint, which is simple in character, and which is of appropriate dimensions and configuration for efficient and convenient use.

Still further objects of the invention will appear to those skilled in the art to which it appertains, both by direct recitation thereof as the description proceeds and by implication from the context.

Referring to the accompanying drawing in which like numerals of reference indicate similar parts throughout the several views;

Figure 1 is a longitudinal section on a diametric plane of a magnetron embodying the present invention;

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Figure 2 is a cross section on line II—II of Figure 1;

Figure 3 is an elevation of the starting cathode looking at the same from a sectional plane indicated by line III—III of Figure 1; and

Figure 4 is a sectional view similar to Figure 1 wherein liquid cooling is substituted for air cooling.

In the specific embodiment of the invention illustrated in said drawing, the reference numeral 10 designates a generally cylindrical anode with a hollow 11 extending longitudinally and coaxially into one end (for convenience of reference herein designated the upper end) of a hub portion 12. Radially around said hub portion, the anode provides a circular series of resonant cavities 13 here shown as each substantially cylindrical open at both ends, axially parallel to the axis of the hub and having a longitudinal slot 14 at the part thereof radially most distant from the axis of the hub. Segments or partitions 15, constituting parts of the anode, intervene in a circular series one between each pair of cavities and slots. While a cavity resonator type of anode is shown and described, a split plate anode may be substituted.

Girdling and spaced radially from the anode is a cylindrical housing 16 on the inner face of which is an emissive material constituting the cathode emitter 17. Preferably that material is formed as a band of less height than the cylindrical housing wall on which it is applied in radial opposition, so the top and bottom end margins of said wall are free of emissive coating. Said band or emitter 17 and cylindrical wall or housing 16 together constitute the cathode. Said emissive material is preferably of a character which will copiously emit secondary electrons when bombarded by other electrons and is of the type identified in the art as a "cold cathode." It operates at approximately room temperature and with present known materials has the unfortunate characteristic of vaporizing or melting if raised to a high temperature. Various cold cathode materials are available, such as a silver-magnesium mixture, another which is a nickelated compound, "Dow" metal, and others known in the art.

Said cylindrical housing 16 has washer-like end walls 18 substantially at the ends thereof, the distance between said end walls axially of the device being greater than the axial height of the anode, thereby providing end spaces 19 at opposite ends of the anode. The ends of said resonant cavities 13 and slots 14 open into said end spaces 19. The inside diameter of each washer-like end wall 18 is preferably larger than the outside di-

ameter of the anode in order that the anode may be introduced therethrough in course of fabrication. The region bounded by said cylindrical housing and by said end walls is termed the magnetron chamber.

At the bottom of the magnetron chamber as viewed in the arbitrary position of the device as shown in the drawing, within the opening of and coplanar with the washer-like end wall 18, is a disc-like supplemental portion 20 for the end wall 18 which has the anode mounted thereon. As shown, said anode has its hub portion 12 extended downward to said supplemental end wall portion 20 which has a central hole into which a terminating reduced neck 21 of the hub is seated and soldered or otherwise made both rigid and vacuum tight. Said supplemental end wall portion 20 also constitutes the upper end closure for a tube 22 coaxial therewith and with the anode, said tube having an exterior collar 23 thereon at a lower part of itself and of appropriate material for sealing in the lower end of a glass ring 24 the upper margin of which is in turn sealed to a downwardly projecting edge of another collar 25 depending from and soldered or otherwise secured to the anode housing. Supplemental end wall 20 is out of contact from the washer-like end wall and, therefore, as to low potentials the tube and its end wall support the anode insulated from the cathode.

From a high frequency consideration, it is desirable to have a continuous end wall for the cylindrical housing 16. This desideratum is accomplished in effect by providing a sleeve 26 around tube 22 in closely spaced telescoped coaxial relation thereto, said sleeve depending from the inner periphery of the washer-like end wall 18 the distance of a quarter wave length of the characteristic wave developed by the magnetron. The spacing between the tube and sleeve provides a gap 27 the lower end of which is open at a quarter wave length distance below the plane of the end wall and therefore a high impedance is set up at the bottom or outer gap opening and a low impedance at the upper or inner gap opening. This low impedance at the gap in the end wall of the magnetron chamber is equivalent, for high frequency, to a continuous wall.

A coaxial output coupling is provided from the upper end of the magnetron chamber. This coupling includes as part thereof an outer tubular member 28 extending coaxially upward from the upper washer-like end wall 18 of the magnetron chamber. Said member is hollow, providing a large cylindrical interior passage 29 next the outer end of the member and a passage 30 which tapers from the large passage 29 down to the smaller cylindrical hollow 11 in hub 12 of the anode, connecting thereto with a hollow neck 31. Except for said neck, the bottom of the tube is closed and forms a supplemental end wall portion 32 to the washer-like upper end wall 18 of the magnetron chamber. The bottom of the tube is in the plane of the washer-like upper end wall 18 and is within but spaced from the inner periphery thereof. As with the lower wall and tube construction, the upper wall 18 has a sleeve 33 projecting upwardly from the inner periphery thereof a distance of a quarter wave length of the characteristic wave developed by the magnetron. The spacing between the tube and sleeve provides a gap 34 the upper end of which is open at a quarter wave length distance above the plane of the end wall and therefore a high impedance is set up at the upper gap opening thereof and a low

impedance at the lower or inner gap opening. The low impedance at the gap in the end wall of the magnetron chamber is equivalent, for high frequency, to a continuous wall, and yet an insulative gap is provided against low frequency passage or applied D. C. voltage thereat.

Vacuum seal at the upper end of the magnetron chamber is obtained in similar manner to the seal at the bottom of the chamber. The structure in detail provides an exterior collar 35 at an upper part of said tubular outer member 28 of appropriate material for sealing in the upper margin of a glass ring 36 the lower margin of which is in turn sealed to an upwardly projecting edge of another collar 37 projecting upwardly from and soldered or otherwise secured vacuum tight to the anode housing. By virtue of the glass ring 36 and gap 34, the coaxial outer tube member 28 is out of contact with the anode housing and its upper end wall, and therefore, as to low potentials said member and the anode are insulated from each other.

Within and coaxial to the tube 28 and anode hub 12 is an inner conductor 38 the diameter of which is proportionately larger in the larger part 29 of the tubular outer member, tapering proportionately to smaller diameter in the tapered passage 30, and having proportionately small diameter within the hollow 11 of the hub. A loop 39 is located in one of the resonant cavities 13 and has a stem extending radially inward, through a hole 40 in the hub, and connects with said inner conductor 38. The hollow of the hub and outer coaxial tube 28 is evacuated, there being a glass seal 41 provided across the far end of the tube between the inner surface thereof and the outer surface of inner conductor 38.

Beyond said glass seal 41, the inner conductor is shown hollow and adapted to receive an expanding plug-like end 42 of another coaxial inner conductor 43 representative of one section of an output line for the device. This line also has an outer tubular conductor section 44, and preferably the inner and outer conductors 43 and 44 are of corresponding diameters to the inner and outer conductors respectively of the device so as to form continuations thereof.

The outer tubular conductor 28 of the magnetron and the outer tubular conductor 44 of the output line preferably have their ends substantially abutting and are mechanically coupled together. Such mechanical coupling is accomplished by employment of a releasable or separable structure permitting attachment of the magnetron to any desired output line.

As here shown, tubular conductor 28 includes as part thereof and as the outermost end, a length of material 45 to which the glass seal is particularly capable of attachment and having a coefficient of expansion substantially the same as the glass. In the several instances of glass-to-metal seals shown in the drawing and referred to in the present description, a material and glass are preferred such as described, in the patent to Howard Scott No. 2,062,335, the material being sold in the market under the trade mark "Kovar" and the glass being a suitable borosilicate glass which is available as "704 Corning." The "Kovar" length 45 of the tube is shown substantially a quarter wave length with its outer end beyond the glassing and spaced with a small gap 46 from the end of the wave guide outer member. Depending from said wave guide outer member is a metallic sleeve 47 also of a quarter wave length depth surrounding and

spaced by a cylindrical gap 48 from the "Kovar" portion of the tube 28. This sleeve 47 provides a gap 49 at its lower end which opens into another cylindrical gap 50 on the outside of said sleeve and within a second sleeve 51 coaxial with and outside of the first said sleeve. Both of these sleeves 47 and 51 are shown depending from a common ring 53 secured at the lower end of the wave guide outer member. The opposite or lower end of the second sleeve seats in another ring 52 secured upon the outer cylindrical face of the magnetron tube 28, said ring being so placed as to provide the aforementioned gap 46 between it and the end of the inner or first mentioned sleeve 47. It will be understood that the tube 28, sleeves 47, 51 and rings 52, 53 are all metallic and conductive. It will be appreciated that as much of the metal surfaces exposed to high frequency are, whenever possible, preferably of as high conductivity material as possible, such as copper or silver. At the outside of the lower ring is secured a cylindrical housing 54, spaced outward from and surrounding the second sleeve, the upper exterior margin of said housing being screw-threaded and receiving thereon the threaded flanged portion of a clamping cap 55 the head portion of which bears upon the outer flat end face of the wave guide ring 53. Cap 55 and housing 54 clamp the second sleeve in a lengthwise direction between the rings and thereby obtain a firm mechanical assembly. The spacing of the inner sleeve by virtue of gaps 48, 49 and 50 presents a half-wave length distance from the upper closed end of gap 50 to the upper end of gap 48 where it opens into the gap 46 between the magnetron tube and the transmission outer member, thus presenting, as to high frequency, a low impedance at gap 46 and effect of electrical continuity from tube 45 to outer member 44 of the transmission line. In order for the magnetron to operate at certain desired region of its impedance plane which it sees at the base of the coupling loop 40, it is necessary that a suitable transformer be inserted on the center conductor 38 or the outer conductor 28 between the glass seal 41 and the loop 39 in vacuum to reduce high voltage break-down troubles.

The magnetron of the present showing is provided with ring-like magnetic coils 56 conveniently situated exterior to the magnetron body just beyond the planes of the end walls 18, and by virtue of the magnetic flux therefrom electrons emitted from cathode 17 tend to spiral. With aid of the uniform actual magnetic field established by the coils 56 over interaction space in which the electrons migrate between the cathode 16 and anode surface 10, plus the applied voltage between the anode and cathode, magnetron oscillations may be generated in the operating region affected by voltage and magnetic field of proper value for the particular mode of operation, which in the present instance is the one known in the art as the π mode.

In practice, many electrons return to or bombard the cathode, and since the cathode readily emits secondary electrons a copious emission of electrons is obtained without necessitating the cathode to be heated. However, the bombardment produces heat, and as explained above, since this heat is injurious to the cathode it must be dissipated.

For purposes of dissipating the undesired heat and keeping the cathode cooled to a normal op-

erating temperature, I have shown in Figs. 1 and 2, an air cooled radiator comprising an inner shell 57 of substantially the length and diameter of the cylindrical wall 16 of the magnetron and shrunk, brazed, soldered or otherwise held thereon in close contact for most effective heat conduction. At the outside of said shell 57 are a plurality of radiating fins 58 integral with the shell and separated from each other and having appropriate surface area for dissipation of the desired amount of heat to the surrounding atmosphere. A fan or other means for circulating air through the radiator may be employed and may be thermostatically controlled by a thermostat either inside or outside of the magnetron. Anode cooling is obtained by conduction to tube 22 which is hollow and open.

For adapting the invention to liquid cooling for even higher power levels than the air cooling, modification of Figure 4 may be employed. The magnetron structure of this liquid-cooled type is closely similar to the air-cooled type and in general the same reference numerals apply. However, in the liquid-cooled type, the cathode emitter 17 is preferably carried by a wall separate or distinct from the cylindrical housing wall of the magnetron. Thus, instead of coating the housing wall 16, I provide inward of and coaxial with said wall 16 another cylinder or cathode wall 59 on the inner face of which is applied secondary electron emissive material consisting emitter 17. On the outer face of said cathode wall 59 away from the anode and toward the housing wall, but still spaced therefrom, is a close fitting jacket 60 having a spiral fluid channel 61. Feed and discharge pipes 62, 63 respectively connect with opposite ends of said channel and extend through a side opening 64 and are rigidly carried by a header 65 sealed by a glass ring to a collar 66 projecting from the opening and vacuum tight with respect to housing cylinder 16. The pipes constitute a supporting means for the cathode.

Water or other liquid cooling of the anode may be effected by provision of a header 67 next the inner end of the hollow anode supporting tube 22 as shown in Fig. 4. A liquid chamber 68 is formed between the header and the end wall 20 of the tube so the fluid is in direct contact with the reduced end 21 of the anode hub. Inlet and outlet pipes 69, 70 for the fluid are secured to the header, opening into said chamber, and having entry into said tube through the open end thereof. Rate of flow of the liquid may be controlled by a thermostat either within the magnetron or in or on the outlet pipe 70.

For instigating operation of the magnetron, a starting cathode 71 is provided, this starting cathode being shown in Figures 1, 3 and 4 as a hair-pin type of thermal electron emissive filament situated as nearly as practical the same distance from the anode as the operating cathode emitter 17 above described. The angular position of the filament with respect to the gaps 14, especially in the case of the simple split-plate anode, must be such that a minimum back electronic bombardment is encountered. As shown, a conforming area 72 of the main cathode material or emitter 17 has been omitted and the starting cathode situated thereat but out of contact from the surface of the main cathode support. Lead-in wires 73 for the starting cathode 71 enter through a nipple 74 at the side of the cylindrical housing, the nipple having a collar 75 secured thereto and

capable of sealing to a glass stem 76 through which said lead-in wires are sealed. A lateral tubulation 77 is shown from the glass stem and by it the interior of the magnetron is evacuated and the tubulation pinched to a sealed condition for maintaining the vacuum.

I claim:

1. A magnetron device comprising a cylindrical housing having end walls, a sleeve of quarter wave length depth projecting outwardly from one of said end walls, anode supporting means extending coaxially of said sleeve and out of contact therefrom and having an end wall in the plane of said end wall of the housing having the sleeve, an anode mounted on said supporting means coaxially within the housing, and a cathode coaxially around said anode and within the housing.

2. A magnetron device comprising a cylindrical housing having end walls, sleeves of quarter wave length depth projecting outwardly from said end walls, anode supporting means extending coaxially of one of said sleeves and out of contact therefrom and having an end wall in the plane of one of said end walls of the housing, an anode mounted on said end wall of the anode supporting means, a cathode coaxially around said anode and within the housing, and a coaxial output line having a tubular outer member extending coaxially through another of said sleeves, the said tubular member having an end wall in the plane of the end of the housing from which the second mentioned sleeve extends.

3. A magnetron device comprising a cylindrical housing having end walls, sleeves of quarter wave length depth projecting outwardly from said end walls, anode supporting means extending coaxially of one of said sleeves and out of contact therefrom and having an end wall in the plane of one of said end walls of the housing having said one of said sleeves, an anode mounted on said end wall of the anode supporting means, a cathode coaxially around said anode and within the housing, and a coaxial output line having a tubular outer member extending coaxially through another of said sleeves, the said tubular member having an end wall in the plane of the end of the housing from which the second mentioned sleeve extends and means sealing the said tubular member to the housing outside the sleeve thereat and sealing the said anode supporting means to the housing outside the sleeve at that end of the housing.

4. A magnetron device comprising an anode, a secondary electron emissive cold cathode of greater diameter than and girdling the anode, means in heat conductive contact with the cathode at the side thereof away from the anode for dissipating heat from the cathode, and a starting cathode spaced from both the anode and the cold cathode, and said starting electrode in its entirety being substantially the same distance from said anode as said cold cathode.

5. A magnetron device comprising an anode, a secondary electron emissive cold cathode of greater diameter than and girdling the anode, means in heat conductive contact with the cathode at the side thereof away from the anode for

dissipating heat from the cathode, and a thermionic starting cathode spaced from both the anode and the cold cathode, and said starting electrode in its entirety being substantially the same distance from said anode as said cold cathode.

6. A magnetron device comprising an anode, a secondary electron emissive cathode of greater diameter than and girdling the anode, said cathode providing a cold emitter as part thereof and providing means in heat conductive contact with the cold emitter at the side thereof away from the anode, means exterior to the first said means for transmitting and dissipating heat of conduction from the first said means by which said emitter is kept at less than ruinous temperature, and a starting cathode spaced from both the anode and the cold emitter, and said starting electrode in its entirety being substantially the same distance from said anode as said cold cathode.

7. A magnetron device comprising an anode, a secondary electron emissive cathode of greater diameter than and girdling the anode, said cathode providing a cold emitter as part thereof and providing means in heat conductive contact with the cold emitter at the side thereof away from the anode, means exterior to the first said means for transmitting and dissipating heat of conduction from the cold emitter by which said emitter is kept at less than ruinous temperature, and a thermionic starting cathode spaced from both the anode and the cold emitter, and said starting electrode in its entirety being substantially the same distance from said anode as said cold cathode.

8. A magnetron device having an electron emitter and an anode with the emitter coaxial with and girdling the anode, a housing having a cylindrical wall around said emitter and anode, said housing having end walls at the ends of said cylindrical wall, means supporting the anode through one end wall physically out of contact from the same, and a coaxial output tube extending through the other end wall physically out of contact therefrom.

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