June 21, 1949. W. C. BROWN 2,473,567

ELECTRONIC DISCHARGE DEVICE

Filed March 20, 1945 2 Sheets-Sheet 1

FIG. 1.

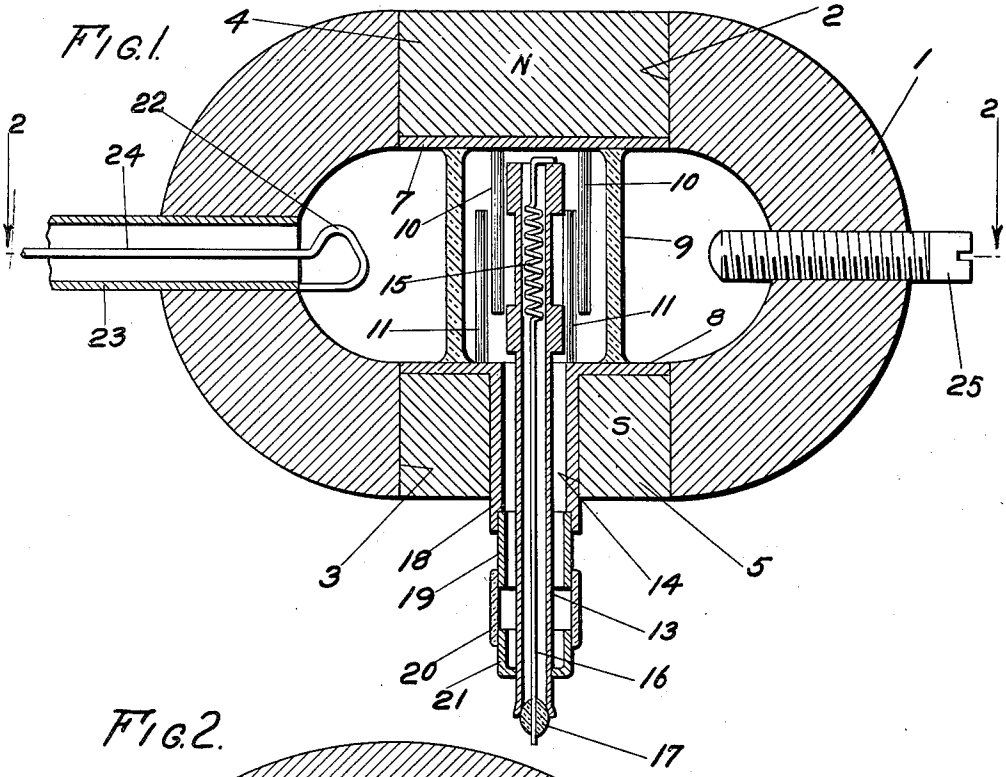
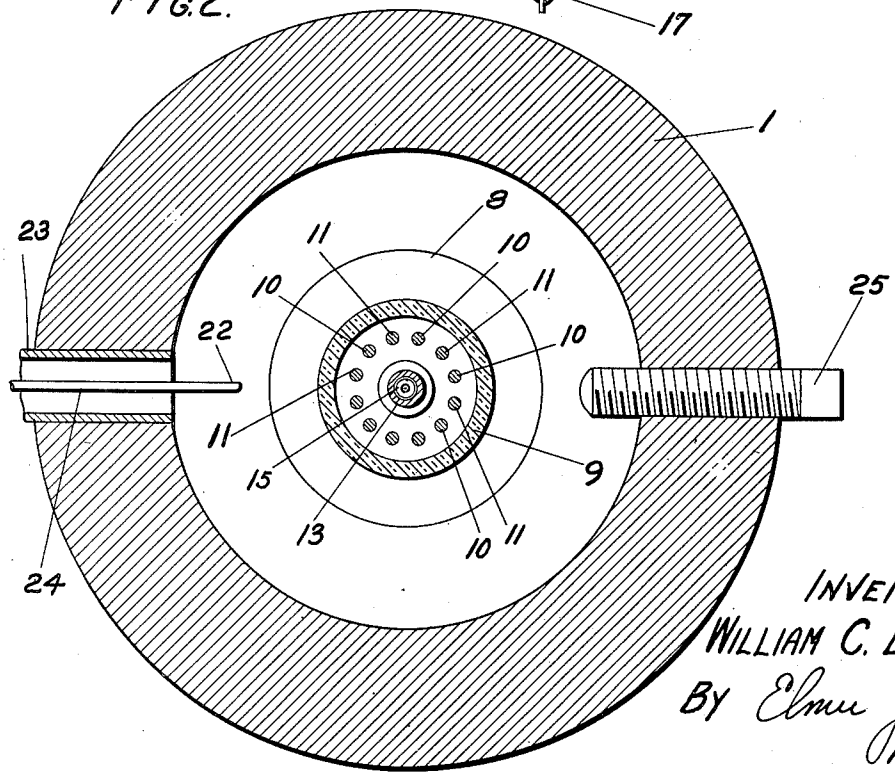


FIG. 2.



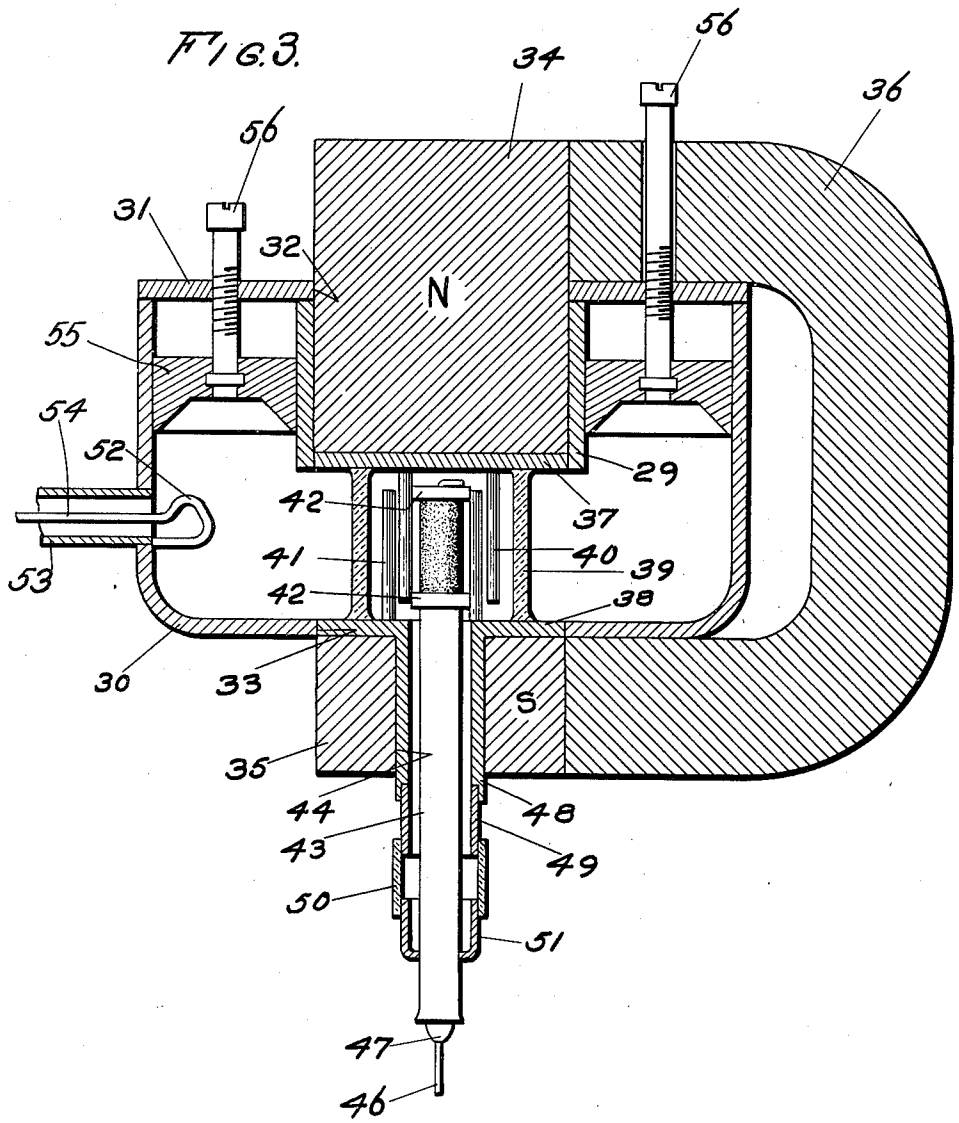
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FIG. 3.



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ELECTRONIC DISCHARGE DEVICE

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9 Claims. (Cl. 250—27.5)

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This invention relates to magnetrons of the type having a plurality of anode elements providing a plurality of circuits intended to oscillate at the same frequency and thus jointly contribute to the effective output of the magnetron.

Devices of the type to which the invention relates comprise a plurality of anode arms providing capacitances therebetween and connected by an inductance completing the oscillating circuits. The inductance is commonly provided by the metallic walls of the envelope enclosing the evacuated space of the tube. Such devices, as heretofore constructed, involve structural difficulties particularly with respect to the tuning, for since the oscillating circuits are disposed entirely within the evacuated space of the tube, these can be tuned only by resort to flexible walls or to the introduction of additional tuning circuits.

It is an object of the present invention to provide a magnetron which may be tuned externally of the evacuated space, and without the necessity for providing additional tuning circuits.

It is a further object of the invention to simplify the construction of such devices whereby they may be more easily manufactured than has heretofore been possible.

The above and other objects and features of the invention will be made fully apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawing in which:

Fig. 1 is a longitudinal section through one embodiment of the invention;

Fig. 2 is a section taken on the line 2—2 of Fig. 1; and

Fig. 3 represents a longitudinal section, with parts in side elevation, through another embodiment of the invention.

Referring to the drawing and first Figs. 1 and 2 thereof, the magnetron there shown comprises a body portion 1 which in this instance is a hollow spheroid of magnetic material of high coercive force such as Alnico. The body 1 is flattened at the pole thereof and is provided with bores 2 and 3 extending therethrough. The body 1 is so magnetized that these bores constitute the opposite poles of the magnet. Disc-shaped pole pieces 4 and 5 of cold rolled steel or other suitable magnetic material close the bores 2 and 3 making a tight fit therewith. Coextensive with the internal end faces of pole pieces 4 and 5 are a pair of discs 7 and 8 of Kovar or other metallic material which may be readily sealed to glass, and a glass tube 9 is hermetically sealed at each end to one of said discs. A plurality of pins 10 con-

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stituting anode arms arranged in a circle centered at the center of disc 7 project downwardly therefrom and an equal number of pins 11 similarly arranged project upwardly from the disc 8. In the central portion of the tube these pins define a circle in which pins are equally spaced and alternately arranged as may be seen in Fig. 2. A cathode structure comprising a hollow tubular member 13 is positioned in the center of the circle defined by the pins 10 and 11 and spaced therefrom. Said cathode may be coated with a thermionically emissive coating adjacent said pins. A central bore 14 is provided in the pole piece 5 and the hollow tubular member 13 extends therethrough and is spaced therefrom. Within the hollow tubular member 13 is a heating coil 15 connected at its upper end to the tube 13 and at its lower end to a lead 16 which extends through the tubular member 13 and is sealed in a glass seal 17 closing the outer end of the tubular member 13. A metallic tube 18 of the same external diameter as the diameter of bore 14 lines the internal wall of the bore 14 and projects outwardly beyond the external face of pole piece 5. At its inner end the sleeve 18 is hermetically sealed to the disc 8 and at its outer end is brazed or otherwise hermetically sealed to a tubular metal shell 19. The shell 19 is of a material such as Kovar which may be readily fused to glass and at its outer end is sealed to a glass tube 20. The tube 20 is sealed at its opposite end to a cup-shaped member 21, which cup-shaped member 21 has an opening in its outer face through which the tubular member 13 extends and to which it is hermetically sealed. By this arrangement the cathode structure 13 is electrically insulated from the body 1 of the magnetron by means of glass sleeve 20. The externally projecting end of the cathode tube 13 may be connected to one pole of a source of heating current for cathode heating coil 15, the other pole being connected to the lead wire 16.

In the operation of the device described in the foregoing, when the cathode heater 15 is energized and a suitable voltage supplied between the cathode and the anode structure, electrons emitted by the cathode into the annular space between the activated portion of the cathode and the anode arms are deflected by the magnetic field, which is directed transversely to the paths of the electrons, as in conventional magnetrons, thereby generating oscillations within the anode structure. In this instance the body 1 provides a common inductive circuit between the anode elements 10 and 11. To facilitate the conduction of the oscillating current over the interior sur-

face of the body 1, this surface may be coated with a highly conductive material such as copper or silver. A portion of the oscillatory energy which is propagated in the interior chamber of the body 1 may be led off to a suitable utilization device by means of a coupling loop 22 which extends into the oscillatory field set up within said chamber. One end of the coupling loop 22 is connected to the inner end of a conducting pipe 23 which extends through an opening in the body 1. The other end of the coupling loop 22 is connected to a conductor 24 which passes through the pipe 23 and constitutes therewith a coaxial line.

When the tube described in the foregoing is oscillating the fingers 10 and 11 are of opposite phase so that oscillating currents tend to flow between alternate fingers 10 and 11. The conducting circuit extends between each pin or finger 10 and its adjacent finger 11 which constitute capacitances. The circuits extend in a circular path through the wall of the body portion 1. It will be seen that a portion of each circuit lies within the evacuated space of the tube 9 and the remaining portion is exterior of this space along the interior walls of the body 1. This circular path constitutes an inductance. Each of these circuits constitutes an oscillatory circuit whose natural frequency is determined by the inductance and capacity thereof. Since the fingers 10 and 11 are of opposite voltage phase so that when the finger 10 is positive the adjacent finger 11 is negative, and on the next half cycle voltage conditions are reversed, oscillatory current will flow between the fingers 10 and 11 through the walls of the annular chamber defined by the body 1 in a direction to create an annular magnetic field in said chamber. All of said currents are in phase with each other, and thus all of said magnetic fields are likewise in phase, producing a strong resultant annular magnetic field. This resultant annular magnetic field couples all of the oscillating circuits, and thus tends to make the inductance of all said oscillating circuits uniform. A part of the inductive portion of the oscillatory circuit is exterior of the evacuated space tube. It is therefore not difficult to construct a means for varying the value of the inductance provided thereby. In the instance shown a tuning rod 25 may be adjusted to project more or less into the annular space within the body 1. In the instance shown the tuning rod 25 is threaded for adjustment longitudinally. However, the screw threads may be omitted and the rod may slide toward or away from the interior chamber of the tube 1. Since the space into which the tuning rod 25 projects is not a portion of the evacuated space of the tube, no provision need be made for hermetically sealing this rod relative to the wall through which it extends. Likewise no provision need be made for hermetically sealing the space between the outer conductor 23 and the coaxial conductor 24 leading from the antenna loop 22.

In the form of the invention disclosed in Fig. 3 the inductive portion of the oscillatory circuit is separate from the magnet 36. Referring to this figure, reference numeral 30 indicates a cup-shaped member of copper or other non-magnetic and highly-conductive material. An end cap 31 closes one end of the cup-shaped member 30 and is provided with a central opening 32. A sleeve 29 surrounding the opening 32 projects into the cup-shaped member 30, concentric with the upper portion of the circumferential wall thereof. The bottom portion of the cup-shaped member 30 is provided with a corresponding opening 33. A pole piece 34 extends through the opening 32 and projects to a point slightly above the lower end of sleeve 29. A pole piece 35 is positioned at the bottom of the cup-shaped member 30 and in alignment with the opening 33. The interior end faces of the two pole pieces 34 and 35 are coextensive respectively with discs 37 and 38 of Kovar or other material readily fusible with glass. A magnet 36 of Alnico or similar magnetic material connects the pole pieces 34 and 35. As in the previously described construction a glass tube 39 is hermetically sealed at each end to the discs 37 and 38. The pins 40 and 41 are arranged in the same manner as pins 10 and 11 in the previously described construction and also the cathode structure 43 is disposed in the same manner and constructed in the same way as the cathode 13 of Fig. 1. In Fig. 3 the cathode is shown in side elevation, and it will be understood that the section therethrough would correspond with the sectional view of the cathode shown in Fig. 1. It will be understood that the portion of cathode 43 lying adjacent to the pins 40 and 41 is activated with an electron emissive material. Enlargements 42 on the tubular member 43 at each end of the activated portion may be provided to confine the electrons to the annular space between the cathode and the juxtaposed portions of the arms 40 and 41. As in the previously described construction the cathode 43 is supported in a bore 44 extending through the pole piece 35 by a tubular member 48 hermetically sealed to the disc 38, the sleeve 49, glass seal 50, and the end cap 51 corresponding respectively to the parts 18, 19, 20, and 21 of the previously described construction.

The operation of this form of the invention will be readily understood from the operation of the form previously described, and the output of the tube may be led off by means of an antenna loop 52 connected at one end to a tubular conductor 53 and having the other end connected to a central conductor 54, which tubular member 53 and central conductor 54 comprise a coaxial line. In this instance the tuning of the oscillatory circuit is effected by means of an annular tuning piston 55 which may be moved inwardly or outwardly by means of adjusting screws 56 to vary the inductive portion of the circuit externally of the evacuated space of the tube. In the instance shown the sleeve 29 surrounding the pole piece 34 forms a coaxial line with the circumferential wall of the upper portion of the cup-shaped member 30. The line so formed is terminated at its outer end by the annular tuning piston 55, thus permitting tuning over a wide range of frequencies.

In the manufacture of devices as above described that portion of the device comprising the members defining the evacuated space thereof and the members enclosed therein may be assembled as a separate unit. This assembly unit comprises the discs 7 and 8 of Fig. 1, the glass tube 9 together with the elements enclosed thereby and the sleeve 18 together with the sleeve 19, seal 20, and cup-shaped member 21. This construction complete and evacuated may then be inserted into the body portion 1 through the opening provided for the pole piece 5 being centered by the bores provided for the two pole pieces. Pole piece 5 may then be inserted over the cathode seal and support assembly, the bore 14 being suffi-

ciently large for this purpose. The pole piece 5 may then be secured in position by any desired means, as by brazing or welding. It will be apparent that the device shown in Fig. 3 can be assembled in the same manner.

From the foregoing it will be apparent that both forms of the invention provide a magnetron in which the major portion of inductive part of the oscillatory circuit is exterior of the evacuated space of the tube, and this inductive portion may be tuned within limits without the necessity of providing hermetic seals for the tuning means. Also the output of the tube may be taken from a portion of the enclosed space exterior of the evacuated space without the necessity for hermetic seals closing the output line.

What is claimed is:

1. An electronic discharge device for generating ultra-high frequency oscillations comprising an evacuated envelope, a cathode and a plurality of anode elements enclosed in said envelope, a hollow body of magnetic material defining an enclosed space surrounding said envelope and completing oscillatory circuits between said anode elements, said hollow body imposing a magnetic field extending transversely to the direction of electron flow through the space between said cathode and said anode elements, and means in the space surrounding said envelope for tuning said oscillatory circuits.

2. An electronic discharge device comprising an evacuated envelope having a glass wall, a plurality of anode arms projecting into said envelope, a cathode positioned in said envelope in spaced relation to said anode arms, a hollow metallic body enclosing said envelope and electrically connecting said arms, said hollow metallic body being of magnetic material for imposing a magnetic field extending transversely to the direction of electron flow through the space between said cathode and said anode arms.

3. An electronic discharge device comprising an envelope having a tubular portion of glass, a pair of metallic members hermetically sealing the ends of said tubular portion, a plurality of anode arms projecting into said envelope from each of said metallic members, a cathode projecting into said tubular portion through an opening in one of said metallic members, a cathode sealing and supporting structure hermetically sealing said opening and supporting said cathode in spaced relation to said anode arms, and a hollow metallic body enclosing said envelope, electrically connecting said metallic members to complete oscillatory circuits between said arms, and for imposing a magnetic field transversely to the direction of electron flow between said cathode and said anode arms.

4. An electronic discharge device comprising an envelope having a tubular portion of glass, a pair of metallic members hermetically sealing the ends of said tubular portion, a plurality of anode arms projecting into said envelope from each of said metallic members, a cathode projecting into said tubular portion through an opening in one of said metallic members, a cathode sealing and supporting structure hermetically sealing said opening and supporting said cathode in spaced relation to said anode arms, a hollow body of magnetic material enclosing said envelope and connecting said metallic members to complete oscillatory circuits between said arms, said hollow body imposing a magnetic field extending transversely to the direction of electron flow between said cathode and said anode arms, and means projecting into said hollow metallic body for tuning said oscillatory circuits.

5. An electronic discharge device comprising an envelope having a tubular portion of glass, a pair of metallic members hermetically sealing the ends of said tubular portion, a plurality of anode arms circularly mounted and projecting into said envelope from each of said metallic members, alternate of said arms being connected to one of said members and the intervening arms being connected to the other of said members, a cathode projecting into said tubular portion through an opening in one of said metallic members, a cathode sealing and supporting structure hermetically sealing said opening and supporting said cathode in spaced relation to said anode arms, a hollow metallic body enclosing and defining an annular space around said envelope, electrically connecting said metallic members to complete oscillatory circuits between said arms, and imposing a magnetic field between said cathode and anode arms in a direction transverse to the electron flow therebetween, and an annular tuning piston adjustable in said annular space for tuning said oscillatory circuits.

6. An electronic discharge device comprising an envelope having a tubular portion of glass, a pair of metallic members hermetically sealing the ends of said tubular portion, a plurality of anode arms projecting into said envelope from each of said metallic members, a cathode projecting into said tubular portion through an opening in one of said metallic members, a cathode sealing and supporting structure hermetically sealing said opening and supporting said cathode in spaced relation to said anode arms, a hollow metallic body enclosing and defining an annular space around said envelope, electrically connecting said metallic members to complete oscillatory circuits between said arms, and imposing a magnetic field transversely of the direction of the electron flow between said cathode and anode arms, and an annular tuning piston adjustable in said annular space for tuning said oscillatory circuits.

7. An electronic discharge device for generating ultra-high frequency oscillations comprising an evacuated envelope, said envelope having a tubular portion of glass, upper and lower metallic members, one at each end of said tubular portion and hermetically sealed thereto, a cathode and a plurality of overlapping electron-receiving anode portions enclosed in said envelope, and means defining an enclosed space surrounding said envelope and completing oscillatory circuits between said anode portions, said anode portions projecting alternately from said upper and lower metallic members and being spaced from and concentrically disposed about said cathode, and said last-named means additionally imposing a magnetic field between said cathode and anode directed transversely to the direction of electron flow between said cathode and said anode portions.

8. An electronic discharge device for generating ultra-high frequency oscillations comprising an evacuated envelope, said envelope having a tubular portion of glass, upper and lower metallic members, one at each end of said tubular portion and hermetically sealed thereto, said metallic members each having a portion projecting exteriorly of said tubular portion, a cathode and a plurality of overlapping electron-receiving anode portions enclosed in said envelope, and means contacting said metallic members defining an enclosed space surrounding said envelope

and completing oscillatory circuits between said anode portions, said anode portions projecting alternately from said upper and lower metallic members and being spaced from and concentrically disposed about said cathode, and said last-named means additionally imposing a magnetic field between said cathode and anode directed transversely to the direction of electron flow between said cathode and said anode portions.

9. An electric discharge device comprising a hollow cylindrical insulator, a closure member having a marginal portion sealed to one end of said insulator and a flange defining a centrally located opening, a second closure member sealed to the opposite end of said insulator, a plurality of elongated anode elements mounted in a circular array with the individual elements extending in parallel mutually spaced relation, alternate ones of said anode elements being joined respectively to the closure members sealed to opposite ends of said insulator, an annular pole piece supported adjacent said flange, and a cathode supported from said pole piece.

WILLIAM C. BROWN.

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