April 5, 1949. P. L. SPENCER 2,466,060

ELECTRON DISCHARGE DEVICE

Filed March 31, 1945 2 Sheets-Sheet 1

FIG. 1.

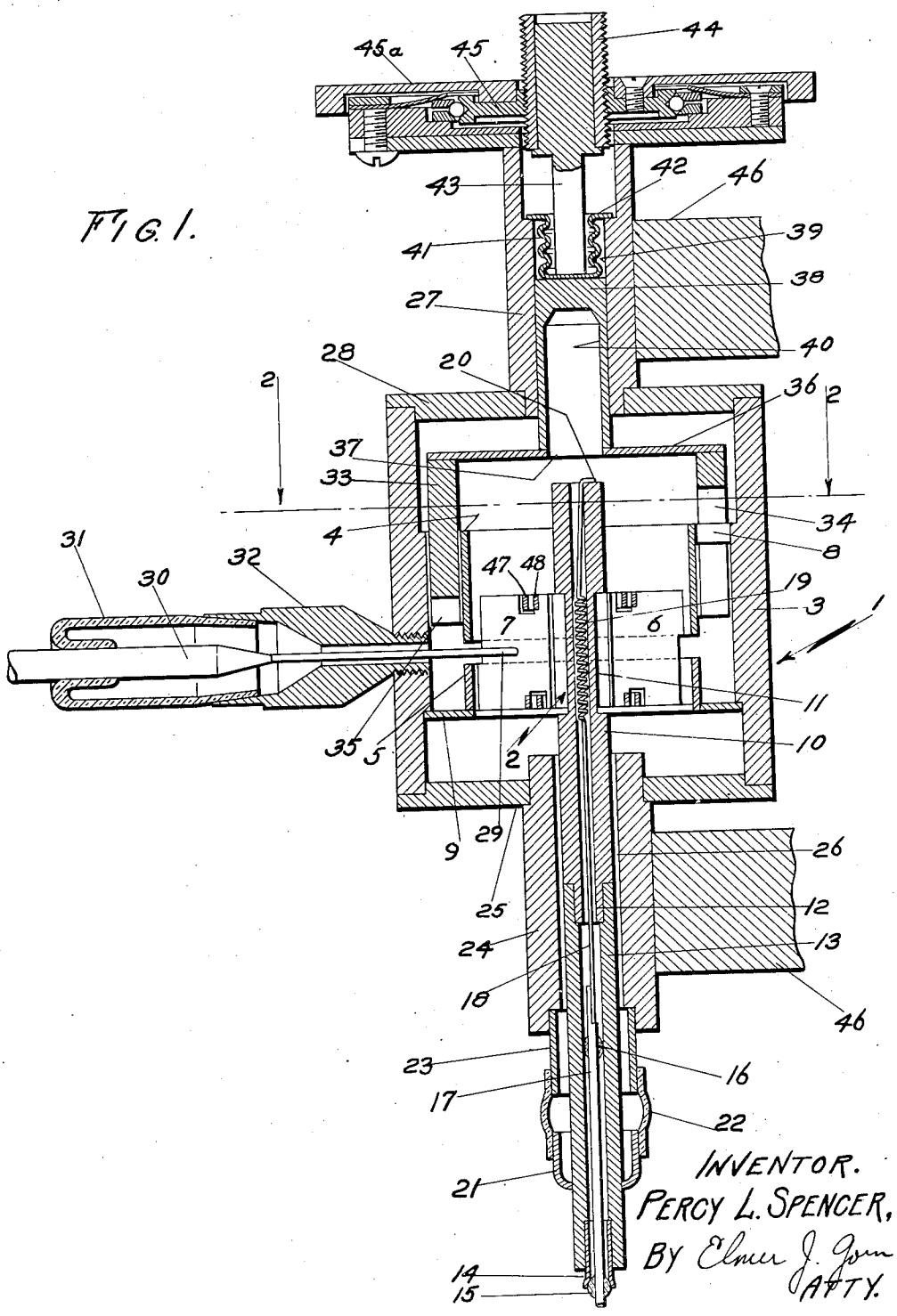

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FIG. 2.

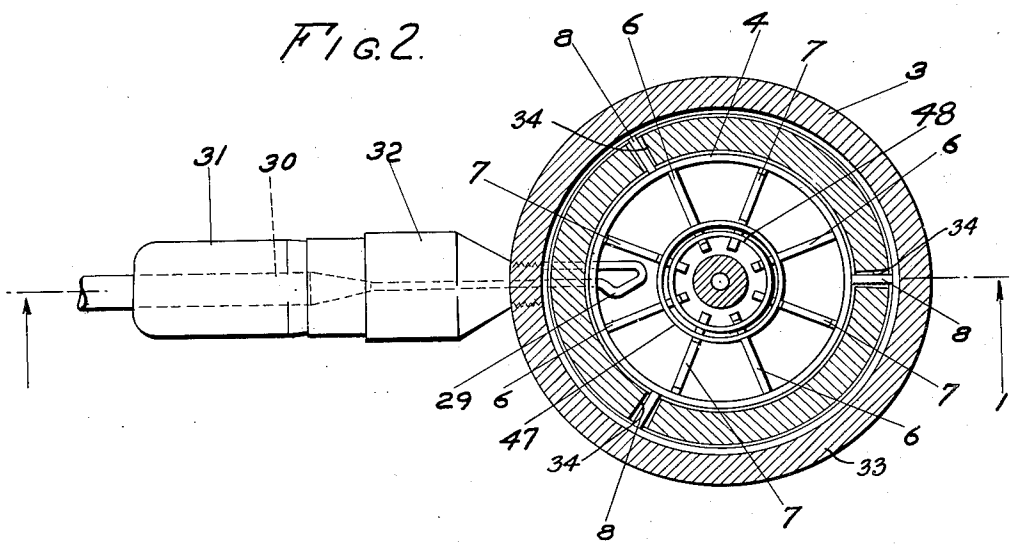
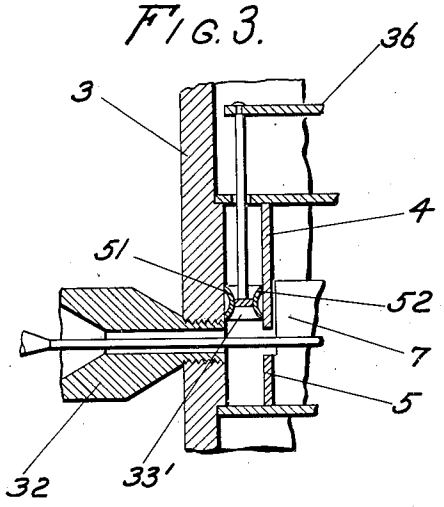


FIG. 3.



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ELECTRON DISCHARGE DEVICE

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10 Claims. (Cl. 250—27.5)

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This invention relates to electron-discharge devices and more particularly to electron-discharge devices of the type intended to amplify or generate ultra-high frequency oscillations.

It is among the objects of the present invention to provide a novel means for tuning such electron-discharge devices through a wide range of frequencies.

It is a further object of the invention to provide an electron-discharge device permitting a wide tuning range and which is, nevertheless, relatively simple in construction, and which may be readily manufactured on a mass production basis.

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 represents a longitudinal section through a magnetron constructed in accordance with the present invention;

Fig. 2 represents a transverse section through the device shown in Fig. 1 and is taken on the line 2—2 thereof; and

Fig. 3 is a fragmentary view of a section similar to Fig. 1 showing a modified form of the tuning means.

Referring to the drawings, reference numeral 1 generally indicates an electron-discharge device of the magnetron type comprising a cathode structure 2 positioned in and coaxial with a tubular body portion 3 of copper or other highly conductive material. A pair of sleeves 4 and 5, also of conducting material, are positioned in alignment in the tubular body 3 with their adjacent ends slightly spaced to prevent direct electrical contact therebetween. The sleeves 4 and 5 are of lesser external diameter than the internal diameter of the body 3 and are concentric therewith providing an annular chamber therebetween. A plurality of anode arms 6, each attached along the upper portion of one edge thereof to the sleeve 4, project inwardly to points adjacent and equally spaced from the cathode 2. The lower ends of the anode arms 6 extend downward into the space enclosed by the lower sleeve 5, that portion of the edges of the arms adjacent said lower sleeve being cut away to leave a small clearance between these arms and the sleeve. Between adjacent arms 6 and equally spaced therefrom are a plurality of anode arms 7. The anode arms 7 are each attached, along the lower portion of one edge thereof, to the sleeve 5 and project inwardly to points spaced from the cathode 2 by a distance

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equal to the distance between the inner edges of the arms 6 and the cathode 2. The upper ends of the arms 7 extend upwardly into the space enclosed by the upper sleeve 4, that portion of the edges of these arms adjacent said upper sleeve being cut away to leave a small clearance between each arm 6 and the sleeve 4. The upper sleeve 4 is supported in concentric relation to the interior wall of the tubular body 3 by means of a plurality of arms 8 soldered to the interior wall of the body 3 and to exterior wall of the sleeve 4 adjacent the upper ends thereof. The lower sleeve 5 is supported by means of a ring 9 soldered to an interior shoulder of the tubular body portion 3.

It will be noted that the rings 4 and 5 form a concentric line with the interior wall of the body 3, which line is closed at one end by the ring 9. The concentric line so formed is in communication with the resonant cavities formed by the anode arms 6 and 7 through the slot provided by the short gap between the sleeves 4 and 5.

The cathode structure 2 includes a cathode sleeve 10, preferably of nickel, and is provided with a reduced portion 11 coextensive with the inner edges of the anode arms 6 and 7. The surface of the reduced portion 11 is activated with an electron-emissive substance such, for example, as an alkaline earth metal oxide. In order to support the cathode sleeve 10 in concentric relation to the anode structure and electrically insulated therefrom, one end thereof is provided with a reduced portion 12, adapted to be secured to the inner end of a sleeve 13. The sleeve 13 is of electrically conductive material and has at its outer end a ferrule 14 of Kovar or other metallic material which may be readily fused to glass. The ferrule 14 is closed at its outer end by glass seal 15, which together with a glass bead 16 in the sleeve 13 seals and supports a lead-in conductor 17 which passes through the sleeve 13 and is spaced from the interior wall thereof. The conductor 17 supports at its inner end a lead-in conductor 18 which terminates in a heater filament 19 positioned within the nickel sleeve 10 adjacent the reduced portion 11 thereof. The opposite end of said heater filament 19 is connected by a wire 20 to the free end of the sleeve 10. The conductors 17 and 18 thus provide one lead-in connection for supplying heating current to filament 19 and a biasing potential to the cathode structure, while the conductor 20 and the sleeves 10 and 13 provide the other lead-in connection.

In order to support the cathode structure 2

and to hermetically seal and insulate same from the anode structure, a cup-shaped member 21 of a metallic material which may be sealed to glass is hermetically sealed at one end to the sleeve 13 and at its opposite end to a glass tube 22. The glass tube 22 is sealed at its opposite end to a tubular member 23, which tubular member is sealed at its other end in an enlarged portion of a bore 26 extending through a pole piece 24. The pole piece 24 projects into the tubular member 3 and is sealed through a central opening in an end cap 25 closing the one end of the tubular body 3. At the opposite end of the tubular member 3, a similar pole piece 27 closes a central opening in an end cap 28 which hermetically seals this end of the tubular body 3.

In order to lead off the output of the device, an antenna loop 29 may be provided in one of the cavities formed by the anode arms 6 and 7. The antenna loop 29 projects through the gap provided between the sleeves 4 and 5 and is connected at one end to a central conductor 30 which is hermetically sealed by a glass seal 31 in the outer end of a conductive pipe 32, which pipe is sealed through an opening in the tubular body 3. The other end of the antenna loop 29 may be connected to the inner end of the conductive pipe 32.

In order to tune the construction described in the foregoing, I provide an annular tuning ring 33 having an external diameter slightly less than the internal diameter of the tubular body 3, and an internal diameter slightly greater than the external diameter of the rings 4 and 5, so that the ring may be reciprocated freely in the annular space between the rings 4 and 5 and the interior wall of the tubular member 3. In order to permit the longitudinal movement of the tuning ring 33 in the annular space described, a plurality of slots 34 extend longitudinally of the ring to permit the same to clear the supporting arms 8. A shorter slot 35 is provided in the ring 33 to permit the same to clear the antenna loop 29. In order to move the ring 33 longitudinally of the annular space, the ring is connected at its upper end to the supporting disc 36. The disc 36 is provided with a central opening 37 to permit the same to pass freely over the upper end of the cathode structure 2. A plunger 38 reciprocative in a bore 39 extending through the upper pole piece 27 is provided with a recess 40 extending from its lower end for a substantial portion of the length thereof. The recess 40 is also of sufficient diameter to clear the end of the cathode structure 2, and the open end thereof is connected to the disc 36 at the opening 37. The upper end of the plunger 38 is connected to the lower face of a Sylphon bellows 41, which bellows is provided with an outwardly extending flange 42 at its opposite end adapted to be soldered on a shoulder provided by an enlarged portion of bore 39 and is thus hermetically sealed to the opening provided by this bore. The interior end face of the Sylphon bellows 41 is connected to an adjusting rod 43 which projects outwardly beyond the outer end of the pole piece 27 and is provided at this end with a micrometer screw 44 coacting with a threaded plate 45, which in turn may be driven by a plate 45a provided at its outer edge with means such as knurling so that it may be moved readily. In order to provide a magnetic field extending longitudinally of the annular space between the inner ends of the anode arms 6 and 7 and the activated surface of the cathode 2, the pole pieces 24 and 27 are connected to the opposite ends of a horseshoe magnet 46, the end portions only of which are shown.

In operation, when such a magnetic field is supplied and when a suitable potential difference is applied between the cathode and the anode, the device can be made to generate electrical oscillations of a wave length determined by the effective capacitance and inductance of the resonant cavities defined by the anode arms 6 and 7. It will be understood that the resonant frequency of any one of the resonant cavities defined by a pair of adjacent arms 6 and 7 is substantially the same as that of any other resonant cavity defined by other arms. This is true since the geometry of any given cavity defined by a pair of adjacent arms 6 and 7 is the same as that of the geometry of any other cavity as defined by another pair of adjacent arms. Accordingly the capacitance and inductance of the cavities are substantially the same determining the resonant frequency thereof and thus the fundamental frequency at which the tube is adapted to oscillate. However, as is well known, other oscillatory circuits exist within the tube apart from the circuits defined by the resonant cavities and these may oscillate at frequencies which are different from the fundamental frequencies of the cavities resulting in spurious oscillations. In order to limit the spurious oscillations, the alternate arms may be connected in a known manner. In the instance shown, at one end of the anode arms a strap 47 interconnects each of the arms 6 and a second strap 48 interconnects each of the arms 7. A similar strap arrangement is also used at the other end of the anode arms.

The effect of the coaxial line provided by the annular chamber between the sleeves 4 and 5 and the interior wall of the tubular body 3 is to add an impedance coupled in parallel to each of the resonant circuits provided by the resonant cavities described. The parameters of the circuit provided by the coaxial line may be varied over wide limits by moving the ring 33 into or out of the annular chamber between the two conductors of the coaxial line.

In the form of the device described in the foregoing, the tuning sleeve 33 does not contact either the inner conductor or the outer conductor of the coaxial line, defined by the sleeves 4 and 5 constituting the inner conductor, and the tubular member 3 constituting the outer conductor. In this case, movement of the annular ring 33 alters the condenser effect between the inner conductors and the outer conductor, and hence alters the capacity component of the impedance added by the coaxial line, and thus alters the resonant frequency of the system. However, the tuning ring 33 may be constructed in such a manner as to contact the walls of the annular chamber so that this member terminates the coaxial line. In the embodiment shown in Fig. 3, the tuning ring 33' is provided with annular bands of spring metal 51 and 52 adapted to resiliently engage the walls of the annular chamber between sleeves 4 and 5 and tubular envelope 3. In this case, movements of the tuning ring vary the effective length of the coaxial line. When adjusted to a position which is equal to one-quarter of the length of the waves corresponding to the natural frequency of the resonant cavities, the added impedance becomes infinite. When adjusted to position corresponding to less than one-quarter wave length, the impedance supplied by the line becomes inductive. When adjusted to a position greater than one-

quarter wave length, the added impedance of the line becomes capacitive.

While there have been herein described preferred embodiments of the invention, other embodiments within the scope of the appended claims will be apparent to those skilled in the art from a consideration of the embodiments shown.

What is claimed is:

1. An electron-discharge device comprising an envelope of conductive material enclosing a cathode, a plurality of cavity resonators enclosed by said envelope providing a plurality of anode faces coacting with said cathode, means surrounding said cavity resonators and providing with said envelope a concentric line, said cavity resonators being in open communication with said concentric line, and adjustable means for varying the effective impedance of said concentric line coupled to said cavity resonators to vary the resonant frequency of said cavity resonators.

2. An electron-discharge device comprising an envelope of conductive material enclosing a cathode, a plurality of cavity resonators enclosed by said envelope and spaced from the internal wall thereof, said cavity resonators providing a plurality of anode faces coacting with said cathode, the exterior walls of said cavity resonators forming with said envelope a concentric line, said cavity resonators being in open communication with said concentric line, and adjustable means for varying the effective impedance of said concentric line coupled to said cavity resonators to vary the resonant frequency of said cavity resonators.

3. An electron-discharge device comprising an envelope of conductive material enclosing a cathode, a plurality of cavity resonators enclosed by said envelope providing a plurality of anode faces coacting with said cathode, means surrounding said cavity resonators and providing with said envelope a concentric line, said cavity resonators being coupled with said concentric line, and adjustable means for varying the length of said concentric line coupled to said cavity resonators to vary the resonant frequency of said cavity resonators.

4. An electron-discharge device comprising an envelope of conductive material enclosing a cathode, a plurality of cavity resonators enclosed by said envelope providing a plurality of anode faces coacting with said cathode, means surrounding said cavity resonators and providing with said envelope a concentric line, said cavity resonators being in open communication with said concentric line, and an annular tuning ring adjustable longitudinally of said line for varying the effective impedance of said concentric line coupled to said cavity resonators to vary the resonant frequency of said cavity resonators.

5. An electron-discharge device comprising a tubular envelope of conductive material enclosing a cathode, a tubular member concentric with said tubular envelope and spaced from the internal wall of said tubular envelope providing an annular chamber therebetween, a plurality of anode arms projecting from the interior wall of said tubular member and having end faces equally spaced from and coacting with said cathode, said arms providing a plurality of cavity resonators therebetween, each of said resonators being in open communication with said annular chamber, and means adjustably mounted within said annular chamber for varying the effective impedance thereof to vary the resonant frequency of said resonators.

6. An electron-discharge device comprising a tubular envelope of conductive material enclosing a cathode, a tubular member concentric with said tubular envelope and spaced from the internal wall of said tubular envelope providing an annular chamber therebetween, a plurality of anode arms projecting from the interior wall of said tubular member and having end faces equally spaced from and coacting with said cathode, said arms providing a plurality of cavity resonators therebetween, each of said resonators being in open communication with said annular chamber, and means adjustably mounted within said annular chamber and spaced therefrom for varying the capacitance thereof to vary the resonant frequency of said resonators.

7. An electron-discharge device comprising a tubular envelope of conductive material enclosing a cathode, a tubular member concentric with said tubular envelope and spaced from the internal wall of said tubular envelope providing an annular chamber therebetween, a plurality of anode arms projecting from the interior wall of said tubular member and having end faces equally spaced from and coacting with said cathode, said arms providing a plurality of cavity resonators therebetween, each of said resonators being in open communication with said annular chamber, and means adjustably mounted within said annular chamber, and contacting the internal wall of said envelope and the external wall of said tubular member for varying the effective impedance thereof to vary the resonant frequency of said resonators.

8. An electron-discharge device comprising a tubular envelope of conductive material enclosing a cathode, a pair of aligned tubular members concentric with said tubular envelope and spaced from the internal wall of said tubular envelope providing an annular chamber therebetween, a plurality of anode arms projecting from the interior wall of each of said tubular members and having end faces equally spaced from and coacting with said cathode, said arms providing a plurality of cavity resonators therebetween, each of said resonators being in open communication with said annular chamber, and means adjustably mounted within said annular chamber for varying the effective impedance thereof to vary the resonant frequency of said resonators.

9. An electron-discharge device comprising a tubular envelope of conductive material enclosing a cathode, a pair of aligned tubular members concentric with said tubular envelope and spaced from the internal wall of said tubular envelope providing an annular chamber therebetween, a plurality of anode arms projecting from the interior walls of said tubular members and having end faces equally spaced from and coacting with said cathode, said arms providing a plurality of cavity resonators therebetweeen, said tubular members being spaced at the adjacent ends thereof providing an opening between each of said resonators and said annular chamber, and means adjustably mounted within said annular chamber for varying the effective impedance thereof to vary the resonant frequency of said resonators.

10. An electron-discharge device comprising a tubular envelope of conductive material enclosing a cathode, a pair of aligned tubular members concentric with said tubular envelope and spaced from the internal wall of said tubular envelope

providing an annular chamber therebetween, a plurality of anode arms projecting from the interior walls of said tubular members and having end faces equally spaced from and coacting with said cathode, said arms providing a plurality of cavity resonators therebetween, alternate of said arms projecting from one of said tubular members and having portions extending into the space enclosed by the other of said tubular members and the intervening arms projecting from said other of said tubular members and having portions extending into the space enclosed by said one of said tubular members, said tubular members being spaced at the adjacent ends thereof providing an opening between each of said resonators and said annular chamber, and means

adjustably mounted within said annular chamber for varying the effective impedance thereof to vary the resonant frequency of said resonators.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,144,222	Hollmann	Jan. 17, 1939
2,411,151	Fisk	Nov. 19, 1946
2,414,085	Hartman	Jan. 14, 1947