Dec. 16, 1947. P. L. SPENCER 2,432,827

HIGH EFFICIENCY MAGNETRON

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FIG. 1.

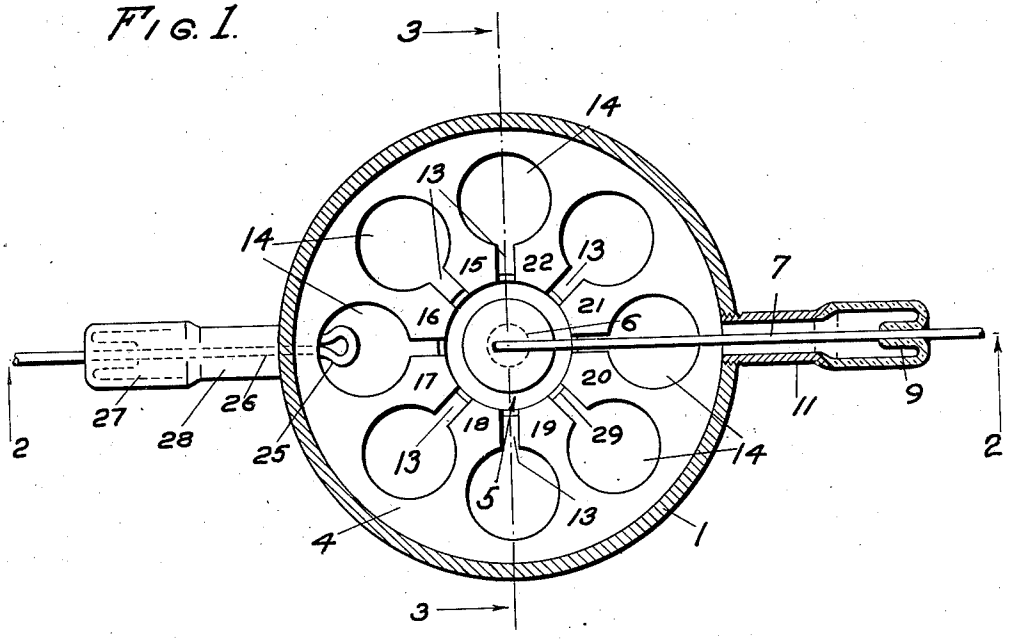
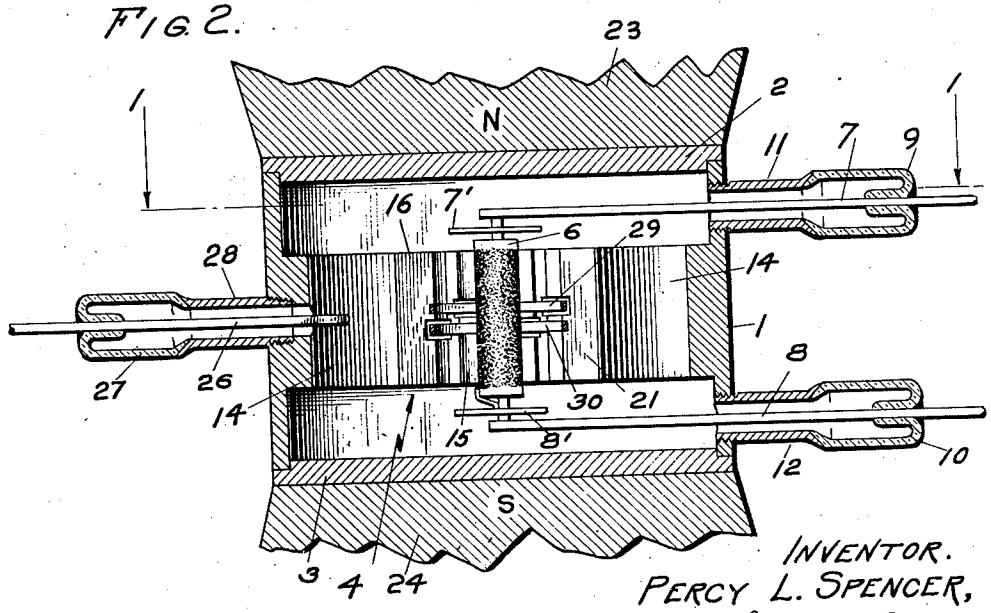


FIG. 2.



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FIG. 3.

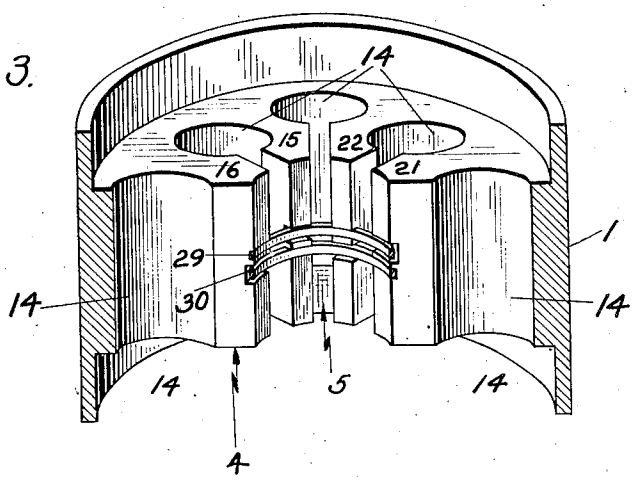


FIG. 4.

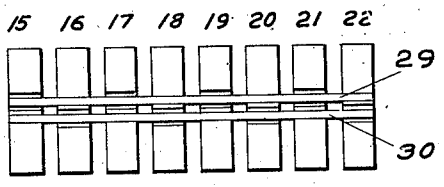
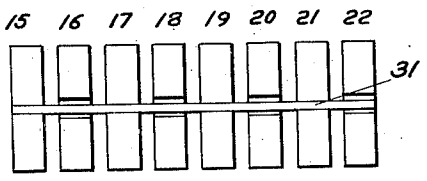


FIG. 5.



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Patented Dec. 16, 1947

2,432,827

UNITED STATES PATENT OFFICE

2,432,827

HIGH EFFICIENCY MAGNETRON

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Application February 11, 1943, Serial No. 475,563

5 Claims. (Cl. 315—39)

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This invention relates to a magnetron, and more particularly to one which has a plurality of possible oscillating modes, each determined primarily by the geometry of the internal structure of the magnetron. A device of this kind is intended to oscillate in a predetermined principal mode so as to generate a predetermined frequency. Heretofore difficulties have been encountered in that additional modes of oscillation have occurred which introduced frequencies differing somewhat from the desired output frequency. These additional modes have caused spurious oscillations to be generated, thus consuming energy and reducing the efficiency and effectiveness of the device.

An object of this invention is to reduce to a minimum the tendency for such spurious oscillations to occur.

Another object is to increase the efficiency and effectiveness of a magnetron of the foregoing type.

A still further object is to devise an internal structure for such a magnetron in which any possible spurious mode of oscillation has associated therewith another possible mode which tends to generate oscillations equal and opposite to those of said possible spurious mode.

The foregoing and other objects of this invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings, wherein:

Fig. 1 is a transverse section of a magnetron embodying my invention, taken along line 1—1 of Fig. 2;

Fig. 2 is a longitudinal cross-section taken along line 2—2 of Fig. 1;

Fig. 3 is a perspective view of one-half of the anode structure of the arrangements shown in Figs. 1 and 2 cut along the line 3—3 of Fig. 1;

Fig. 4 is a developed diagrammatic view of the faces of the anode sections of the arrangements as shown in the foregoing figures; and

Fig. 5 is a diagram similar to Fig. 4, showing an alternate form of anode arm interconnection.

The magnetron illustrated in the drawings comprises an envelope 1 which is preferably made of a block of conducting material, such as copper. This block forms the anode structure of the magnetron, and has hollow end sections which are covered by caps 2 and 3, likewise of conductive material, such as copper. Between the hollow end sections of the block 1 is located a central bridging portion 4. The portion 4 is provided with a central bore 5 within which is supported substantially at the center thereof a cathode 6 which may be of the indirectly-heated oxide-coated thermionic type. The cathode is supported by a pair of cathode lead-in conductors 7 and 8 sealed through glass seals 9 and 10 mounted at the outer end of pipes 11 and 12 hermetically fastened within the walls of the block 1 adjacent the upper and lower hollow end sections. Light conducting shields 7' and 8' may be supported adjacent the upper and lower ends of the cathode 6 so as to prevent electron beams from being projected out toward the end caps 2 and 3. A plurality of slots 13 extend radially from the central bore 5, and each of the slots terminates in a circular opening 14 extending through the bridging portion 4. In this way the anode structure is provided with a plurality of wedge-shaped arms 15—22, the faces of which cooperate as anode sections with the cathode 6.

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When such a magnetron is placed between suitable magnetic poles 23 and 24 to create a longitudinal magnetic field and the device is energized, oscillations are set up. These oscillations may be led out from the tube by means of a coupling loop 25 extending into one of the cylindrical openings 14, and having one end thereof fastened to the inner wall of said opening. The other end of the coupling loop 25 is connected by a lead wire 26 which passes through a glass seal 27 mounted at the outer end of a pipe 28 likewise hermetically fastened through the wall of the envelope 1. An additional conducting pipe, not shown, may be electrically connected to the pipe 28, and forms with the wire 26 a concentric line through which high frequency oscillations generated by the magnetron may be conducted to a suitable utilization circuit.

Capacitances exist between the side walls of each of the slots 13, the inner walls of the opening 14 constituting inductances. The anode, therefore, is so designed that the inductances and capacitances described constitute circuits which are tuned, and thus are resonant at a predetermined frequency at which the device is to be operated. The device is intended to operate so that each bore 14 and its adjacent arms form a circuit tuned to the frequency at which each of the other bores and its adjacent arms oscillate.

It has been found that in magnetrons of this general type there has been a tendency for oscillations to be produced, not only in accordance with the above desired mode, but also in various undesired spurious modes. One particu-

larly troublesome mode is that in which alternate anode arms form opposite ends of an oscillating circuit extending around the back of a pair of openings 14. As more fully described and claimed in my copending application, Serial No. 421,145, filed December 1, 1941, this spurious oscillating mode can be substantially eliminated by interconnecting the outer ends of alternate anode arms directly by low impedance paths by means of conductors set into the upper and lower tips of the anode arms. Both the principal and the spurious modes described above may be termed "transverse" modes.

Under certain conditions, the interconnections as described above introduce the possibility of a mode of oscillation occurring in a circuit extending from one unconnected end of an anode face down along that anode face through one of the interconnecting conductors to an alternate anode face, and then up along that alternate anode face to its outer unconnected end. Such a mode of oscillation may be termed a "longitudinal" mode. If the dimensions of the longitudinal mode are very carefully chosen so as to make the longitudinal mode of operation exactly equal to the principal mode, the disadvantages of the presence of such an additional mode are considerably decreased. One arrangement whereby this equality may be produced is described and claimed in my copending application, Serial No. 425,071, filed December 31, 1941. However, this and similar arrangements often introduce undue complexities into a tube structure, and therefore it is desirable for many applications to produce a similar arrangement in which the necessity for equalizing the above-described longitudinal mode and the principal transverse mode is substantially eliminated. In accordance with my present invention, I produce this result by interconnecting the anode arms in such a way that with each possible longitudinal mode of oscillation is associated another longitudinal mode which tends to generate oscillations equal and opposite to those of the first-mentioned longitudinal mode.

In the arrangement shown herein, the interconnections are made substantially along the central portions of the anode faces by means of a pair of interconnecting conducting rings 29 and 30. Ring 29 electrically interconnects the anode arms 16, 18, 20 and 22, while the intervening anode arms 15, 17, 19 and 21 have their faces provided with a slot through which the ring 29 passes freely so as to avoid electrical contact with said intervening anode faces. Likewise the conducting ring 30 is electrically connected to the anode arms 15, 17, 19 and 21, while the faces of the anode arms 16, 18, 20 and 22 are provided with slots which permit the ring 30 to pass through without coming into electrical contact with said intervening anode faces. By these interconnections alternate anode arms are directly electrically interconnected, thus substantially eliminating the tendency for transverse spurious modes of oscillation to occur, as more fully described in my copending application, Serial No. 421,145.

Upon referring to Fig. 4, it will be seen that a path exists from the upper end of anode face 16 down to substantially the central point thereof along the conductor 29 to substantially the central point of anode face 18, and thence to the upper end of said anode face 18. This circuit contains an appreciable amount of inductance and some capacitance, and thus constitutes a possible longitudinal oscillating mode. However, it will be also noted that a substantially equal and opposite path exists from the lower end of anode face 16 up to the conductor 29, along the conductor 29 to the anode face 18, and thence to the lower end of said anode face 18. This constitutes a possible longitudinal mode which tends to generate oscillations substantially equal and opposite to those of the previous oscillating mode described above. Thus, during operation, any tendency for either of these longitudinal oscillating modes to produce oscillations of any appreciable magnitude is counteracted and substantially eliminated by the equal and opposite longitudinal mode associated therewith. An investigation of Fig. 4 will show that each possible longitudinal oscillating mode has associated therewith a substantially equal and opposite longitudinal mode in a manner similar to that as described above. Due to the foregoing construction, therefore, my present invention not only substantially eliminates the spurious transverse modes but also substantially eliminates the spurious longitudinal modes.

When two conducting rings 29 and 30 are utilized so as to interconnect each alternate anode arm, said interconnections can be made only approximately along the center of the anode faces, since space must be provided for both of these conductors. If it is desired to interconnect the anode faces exactly at the central portions thereof, a single interconnecting ring 31 may be used in the arrangement as shown diagrammatically in Fig. 5. In this arrangement the ring 31 is electrically connected to the alternate anode arms 15, 17, 19 and 21, while the faces 16, 18, 20 and 22 are cut away along their central points so as to avoid electrical contact with the ring 31. In this arrangement a more exact equality between the upper and lower longitudinal oscillating modes may be obtained. It will be noted, however, that such an arrangement does not provide for an interconnection between the alternating anode arms 16, 18, 20 and 22, so that it might be considered possible for transverse oscillating modes to exist in connection with these non-interconnected anode arms. However, the ability of the transverse spurious mode to introduce deleterious effects into the device is dependent somewhat upon the ease with which the oscillations produced by such a transverse mode may be propagated around the tube. By eliminating such a spurious transverse mode in connection with the anode arms 15, 17, 19 and 21, in effect a barrier is set up to the propagation of any oscillations generated by a spurious transverse mode associated with the arms 16, 18, 20 and 22, so that for many applications the connection as represented by Fig. 5 may be satisfactory.

Of course it is to be understood that this invention is not limited to the particular details as described above as many equivalents will suggest themselves to those skilled in the art. For example, other anode configurations could be used in which a plurality of oscillating modes might be possible, and in which interconnections might introduce the possibility of spurious longitudinal modes. In each instance, by utilizing the principles of my invention as enunciated herein, the entire arrangement may be made substantially free of such spurious modes of oscillation, and thus the device may be caused to operate with high efficiency.

What is claimed is:

1. An electron discharge device comprising an electrode structure including a cathode and an

anode, said anode having a plurality of anode faces of substantial length, a loop portion of said anode interconnecting each pair of adjacent anode faces, each of said loop portions forming a capacitance and an inductance constituting a tuned circuit which is adapted to have oscillations set up therein, and relatively low impedance means electrically interconnecting substantially the mid-points of alternate anode faces.

2. An electron discharge device comprising an electrode structure including a cathode and an anode, said anode having a plurality of anode faces of substantial length, a loop portion of said anode interconnecting each pair of adjacent anode faces, each of said loop portions forming a capacitance and an inductance constituting a tuned circuit which is adapted to have oscillations set up therein, and relatively low impedance means electrically interconnecting alternate anode faces, said means being connected to said alternate anode faces at points, each of which divides each connected anode face symmetrically.

3. An electron discharge device comprising an electrode structure including a cathode and an anode, said anode having a plurality of anode faces of substantial length, a loop portion of said anode interconnecting each pair of adjacent anode faces, each of said loop portions forming a capacitance and an inductance constituting a tuned circuit which is adapted to have oscillations set up therein, a conductor interconnecting substantially the mid-points of alternate anode faces, and another conductor interconnecting substantially the mid-points of the intermediate anode faces.

4. A magnetron comprising an electrode structure including a cathode and an anode spaced to provide an electron discharge path therebetween, said anode having a plurality of anode

faces of substantial length, a loop portion of said anode interconnecting each pair of adjacent anode faces, each of said loop portions forming a capacitance and an inductance constituting a tuned circuit which is adapted to have oscillations set up therein, relatively low impedance means electrically interconnecting substantially the mid-points of alternate anode faces, and means adjacent said electrode structure for producing a magnetic field about said cathode.

5. An electron-discharge device comprising a cathode, an anode structure spaced from and surrounding said cathode, a plurality of radially-disposed anode arms extending inwardly from said anode structure, each pair of adjacent anode arms, together with that portion of said anode structure lying therebetween defining an open-ended cavity resonator communicating at the open ends thereof with end spaces formed in said anode structure, and a pair of closely adjacent conducting rings electrically connected, respectively, to alternate and intermediate anode arms.

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

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Certificate of Correction

Patent No. 2,432,827. December 16, 1947.

PERCY L. SPENCER

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 5, line 23, claim 2, before the word "symmetrically" insert *substantially*; column 6, line 10, claim 4, after "cathode" and before the period insert *in said electron discharge path and transverse thereto*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of February, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.