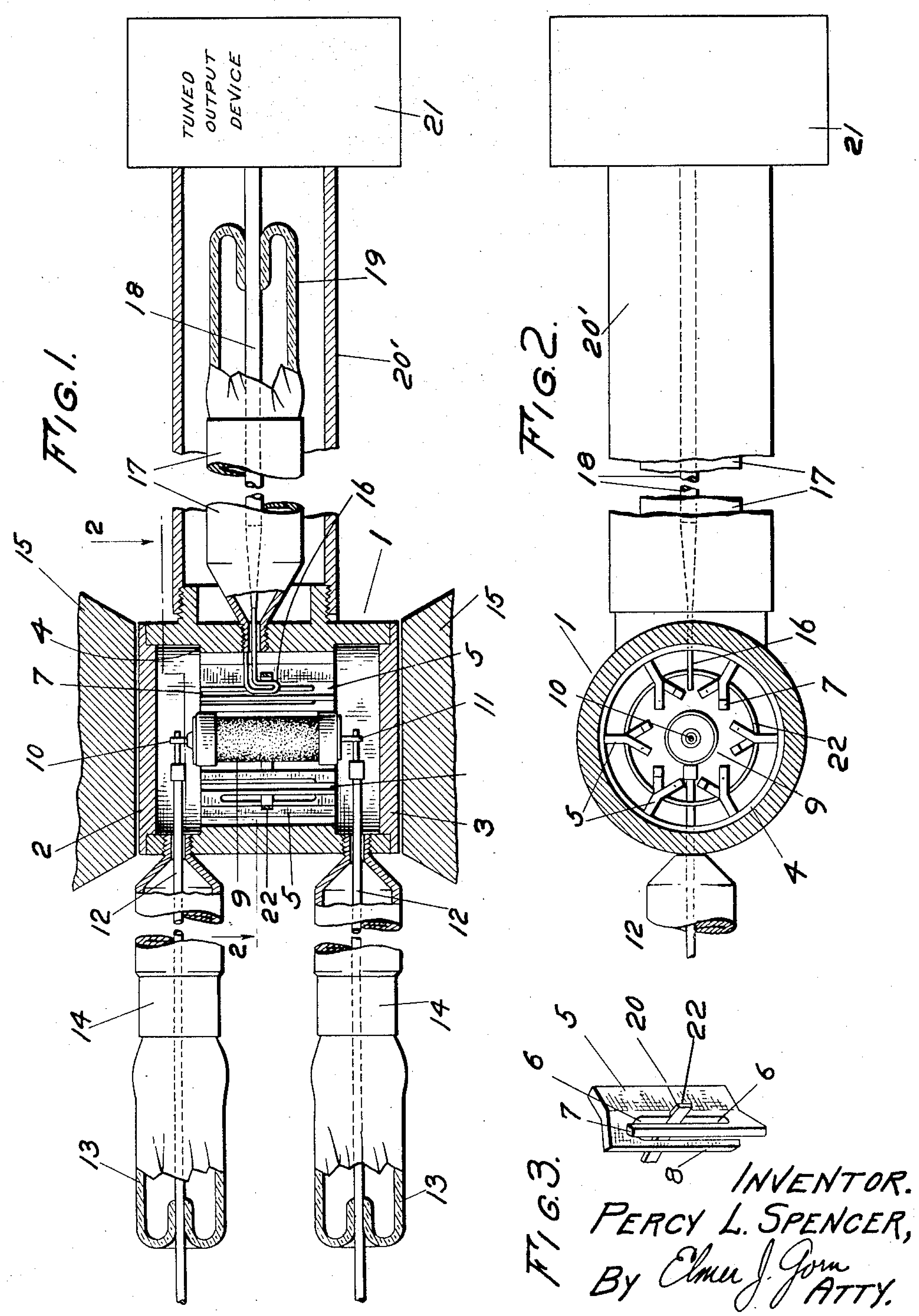
Jan. 23, 1951 P. L. SPENCER 2,539,337

ELECTRON DISCHARGE DEVICE OF THE MAGNETRON TYPE

Filed March 7, 1945



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Patented Jan. 23, 1951

2,539,337

UNITED STATES PATENT OFFICE

2,539,337

ELECTRON DISCHARGE DEVICE OF THE MAGNETRON TYPE

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Application March 7, 1945, Serial No. 581,386

9 Claims. (Cl. 315—40)

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This invention relates to a magnetron and more particularly to one of the multiple anode type in which the internal structure provides a plurality of oscillating circuits or cavity resonators. The frequency at which such a magnetron oscillator operates is dependent upon the geometrical size of the tube elements constituting such a cavity resonator. Particularly in the very short wave length magnetrons it has been difficult to build the device sufficiently large to generate substantial amounts of power and yet limit the cavity resonators to the requisite small size so as to generate the proper frequency.

An object of this invention is to devise a magnetron of the multiple anode type which can be built in substantial sizes capable of being fabricated readily and yet being adapted to generate extremely short wave length at substantial power levels.

In accordance with my invention I have found that if a magnetron of the above type is built with cavity resonators which are adapted to oscillate with substantially equal intensity in a plurality of different modes, each having a different frequency, the output frequency of the magnetron can be made to be the average of the frequencies of said plurality of modes.

In accordance with the foregoing, therefore, another object of this invention is to devise a magnetron incorporating the above-mentioned principles.

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

Fig. 1 is a longitudinal sectional view taken substantially through the center of a magnetron made in accordance with the principles of the present invention;

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

Fig. 3 is a perspective view of one of the anode arm members of the arrangement shown in Figs. 1 and 2.

The magnetron illustrated comprises a tubular envelope 1 made of a cylinder of conducting material, such as copper. The ends of the envelope are covered by caps 2 and 3 likewise formed of conducting material, such as copper and hermetically soldered in place on the ends of envelope 1. The envelope 1 is formed with a central annular projection 4. A plurality of anode arm members 5 are secured to the inner face of the projection 4, as by soldering, and disposed substantially radially within the envelope 1. The anode arm members 5 may be formed by being stamped from a sheet of highly conductive copper. Each of said anode arm members is formed with a central opening 6 and is provided along one side with upper and lower anode arms 7 and 8 extending substantially the full length of the anode arm member 5. Each anode arm member 5 is bent so as to displace the arms 7 and 8 relatively to each other. A convenient way of forming such an anode arm member is to make it in two halves, each stamped out of a sheet of copper, and after bending each half in the desired direction said halves may be joined by soldering along a joint indicated at 20. The anode arm members 5 are so arranged within the envelope 1 that the upper and lower anode arms 7 and 8 are alternately disposed around the central region within the envelope 1. The outer edges of the arms 7 and 8 form electron receiving anode faces which cooperate with a cathode 9 supported substantially centrally of said anode faces. The cathode 9 is preferably of the indirectly-heated oxide-coated thermionic type having an outer conducting cylinder coated with electron emissive oxides and having an internal heater. The end conductors 10 and 11 of the heater project from the opposite ends of the cathode structure 9. One of the conductors 10 may be electrically connected to the external cathode sleeve, while another conductor 11 is insulated from said sleeve. The cathode 9 is supported by a pair of lead-in conductors 12 welded respectively to the end conductors 10 and 11. The lead-in conductors 12 pass through glass seals 13 mounted at the outer ends of conducting pipes 14 hermetically sealed through the wall of the envelope 1 adjacent the upper and lower ends thereof.

When such a magnetron is placed between suitable magnetic poles 15 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 16 substantially aligned with the openings 6 in the anode arm members 5. One end of the coupling loop 16 is connected to the inner end of a conducting pipe 17 hermetically sealed through the wall of the envelope 1 substantially midway between the ends thereof. The other end of the coupling loop 16 is connected to a conductor 18 which passes through said pipe 17 and is sealed through a glass seal 19 mounted at the outer end of said pipe. An additional conducting pipe 20′ may be electrically connected to the envelopes and form with the conductor 18 a concentric transmission line through which the high frequency oscillations generated by the magnetron may be led to a suitable utilization device 21.

In the above construction a capacitance exists between adjacent anode arms. Likewise a conducting path exists between each pair of alternate anode arms, extending, for example, from an upper anode arm 7, through its anode arm member 5, around the opening 6 to the lower anode arm 8. It will also be noted that a possible conducting path exists, for example, from one upper anode arm 7, through its anode arm member 5, and thence through the adjacent anode arm member 5 to the lower anode arm 8 of the latter. Each of the above disposed paths contains a substantial amount of inductance. The above capacitances and inductances constitute a plurality of tuned circuits or cavity resonators, as they are commonly known. It is desired that all of these circuits shall be resonant at a definite predetermined frequency at which the device is to be operated. When the magnetron is in its oscillating condition the anode arms 7 and 8 will be of opposite voltage phase, and thus oscillating currents will flow through each of the conducting paths above described. These oscillating currents will flow in a generally circular direction around each opening 6 and thus tend to create a magnetic field extending axially through each of said openings. It will be noted that the openings 6 collectively form a closed annular space within the envelope 1. Since the anode arms 7 and 8 are of opposite voltage phase, all of the oscillating currents will be in phase so as to tend to create an annular magnetic field extending in one direction through said annular space during one half cycle and in the other direction through said annular space during the other half cycle. Thus all of the oscillating currents will contribute to the production of a strong resultant annular magnetic field in said annular space.

Many features of the above structure are described and claimed in my copending application, Serial No. 508,709, filed November 2, 1943, now Patent No. 2,437,280, issued March 9, 1948.

The predetermined frequency which that portion of the structure as described above generates is so selected as to be substantially below the frequency which the tube is intended to generate. For example, in a tube which is intended to generate a 3 cm. wave, the above predetermined frequency may represent a 4 cm. wave. In order to derive a 3 cm. wave from the magnetron, a ring 22 of highly conductive material, such as copper, is inserted at the back of each opening 6 and directly interconnects the anode arm members 5. It will be noted that a new oscillatory circuit or cavity resonator exists through the conducting path extending, for example, from an upper anode arm 7, through the anode arm member 5, through a portion of the ring 22, to an adjacent arm member 5, and thence to the lower anode arm 8 of the latter. This new oscillating circuit or cavity resonator will oscillate at a frequency substantially higher than that due to the previously described cavity resonator. This new frequency is selected so as to be substantially higher than the frequency which the tube is designed to deliver. For example, if the new frequency represents a wave length of 2 cm., these new oscillations when combined with the 4 cm. oscillations already described will cause the tube to deliver a strong 3 cm. wave to its output device. In other words the tube is constructed so that both of the above modes of oscillation are excited to substantially the same degree. Thus when the output device 21 is tuned to the 3 cm. wave, or intermediate frequency, a considerable amount of energy at this intermediate frequency will be delivered to said output device.

The magnetic field of the last described cavity resonator is also in line with the previously described resultant magnetic field. The coupling loop 16 is interposed so that said resultant magnetic field passes through said coupling loop whereby said loop is closely coupled to all of the oscillating circuits. In this way the energy of each of said oscillating circuits is propagated through a simple annular path of shortened length directly to said coupling loop 16, which thus leads said oscillatory energy from the tube with a substantial maximum of efficiency.

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 forms of cavity resonators than those illustrated herein may be used provided that said cavity resonators contain at least two modes of operation both capable of being strongly excited and each of a frequency lying substantially equidistant on either side of the desired resultant frequency.

What is claimed is:

1. A magnetron comprising a cathode, an anode structure spaced from said cathode, said anode structure comprising a plurality of anode arm members each having a pair of electron receiving faces adjacent said cathode, each pair of said faces being interconnected through a path of conducting material in the arm member, said path surrounding an opening in said arm member, and a conductor connected to each of said anode arms at the back of said opening whereby said anode arms are directly interconnected through said conductor.

2. A magnetron comprising a cathode, an anode structure spaced from said cathode, said anode structure comprising a plurality of anode arm members each having a pair of electron receiving faces adjacent said cathode, each pair of said faces being interconnected through a path of conducting material in the arm member, said path surrounding an opening in said arm member, said arm members being disposed with said openings substantially in register with each other, said registered openings forming a resultant path in which a resultant magnetic field is adapted to be set up, a coupling loop interposed in said resultant path, and a conductor connected to each of said anode arms at the back of said opening whereby said anode arms are directly interconnected through said conductor.

3. A magnetron comprising a cathode, an anode structure spaced from said cathode, said anode structure comprising a plurality of anode arm members each having a pair of electron receiving faces adjacent said cathode, each pair of said faces being interconnected through a path of conducting material in the arm member, said path surrounding an opening in said arm member, said anode structure thereby providing a first path extending from each of said faces through said arm members to an adjacent electron receiving face, the material of said first path constituting a cavity resonator tuned to oscillate at a first predetermined frequency, and a conductor connected to each of said anode arms at the back of said opening whereby said anode arms are

directly interconnected through said conductor, said anode structure thereby providing a second path extending from each of said faces through said conductor to an adjacent electron receiving face, the material of said second path constituting a cavity resonator tuned to oscillate at a second predetermined frequency differing substantially from said first frequency.

4. A magnetron comprising a cathode, an anode structure spaced from said cathode, said anode structure comprising a plurality of anode arm members each having a pair of electron receiving faces adjacent said cathode, each pair of said faces being interconnected through a path of conducting material in the arm member, said path surrounding an opening in said arm member, said arm members being disposed with said openings substantially in register with each other, said registered openings forming a resultant path in which a resultant magnetic field is adapted to be set up, said anode structure thereby providing a first path extending from each of said faces through said arm members to an adjacent electron receiving face, the material of said first path constituting a cavity resonator tuned to oscillate at a first predetermined frequency, a coupling loop interposed in said resultant path, and a conductor connected to each of said anode arms at the back of said opening whereby said anode arms are directly interconnected through said conductor, said anode structure thereby provided a second path extending from each of said faces through said conductor to an adjacent electron receiving face, the material of said second path constituting a cavity resonator tuned to oscillate at a second predetermined frequency differing substantially from said first frequency.

5. A magnetron comprising a cathode, an anode structure spaced from said cathode, said anode structure comprising a plurality of anode arm members each having a pair of electron receiving faces adjacent said cathode, each pair of said faces being interconnected through a path of conducting material in the arm member, said path surrounding an opening in said arm member, said anode structure thereby providing a first path extending from each of said faces through said arm members to an adjacent electron receiving face, the material of said first path constituting a cavity resonator tuned to oscillate at a first predetermined frequency, a conductor connected to each of said anode arms at the back of said opening whereby said anode arms are directly interconnected through said conductor, said anode structure thereby providing a second path extending from each of said faces through said conductor to an adjacent electron-receiving face, the material of said second path constituting a cavity resonator tuned to oscillate at a second predetermined frequency differing substantially from said first frequency, and an output device connected to said magnetron, said output device being tuned to a frequency intermediate said predetermined frequencies.

6. An electron-discharge device comprising a cathode, an anode structure spaced from said cathode and incorporating two cavity resonators having different electrical dimensions, and a common output means magnetically coupled to both said cavity resonators and tuned to a frequency intermediate the frequencies corresponding, respectively, to the different electrical dimensions of said cavity resonators.

7. An electron-discharge device comprising a cathode, an anode structure spaced from said cathode and incorporating two cavity resonators having different electrical dimensions, and a common output means magnetically coupled to both said cavity resonators and tuned to a frequency which is the average of the frequencies corresponding, respectively, to the different electrical dimensions of said cavity resonators.

8. An electron-discharge device comprising a cathode, an anode structure spaced from said cathode and incorporating two cavity resonators having different electrical dimensions, one of said cavity resonators having electrical dimensions corresponding to a frequency which is higher than that desired of the output of said device and the other of said cavity resonators having electrical dimensions corresponding to a frequency which is lower than that desired of the output of said device, and a common output means magnetically coupled to both said cavity resonators and tuned to a frequency intermediate the frequencies corresponding, respectively, to the different electrical dimensions of said cavity resonators.

9. An electron-discharge device comprising a cathode, an anode structure spaced from said cathode and incorporating two cavity resonators having different electrical dimensions, one of said cavity resonators having electrical dimensions corresponding to a frequency which is higher than that desired of the output of said device and the other of said cavity resonators having electrical dimensions corresponding to a frequency which is lower than that desired of the output of said device, and a common output means magnetically coupled to both said cavity resonators and tuned to a frequency which is the average of the frequencies corresponding, respectively, to the different electrical dimensions of said cavity resonators.

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