April 8, 1952 J. M. STINCHFIELD 2,591,976

ELECTRON DISCHARGE DEVICE UTILIZING CAVITY RESONATORS

Filed March 22, 1945

Fig. 3

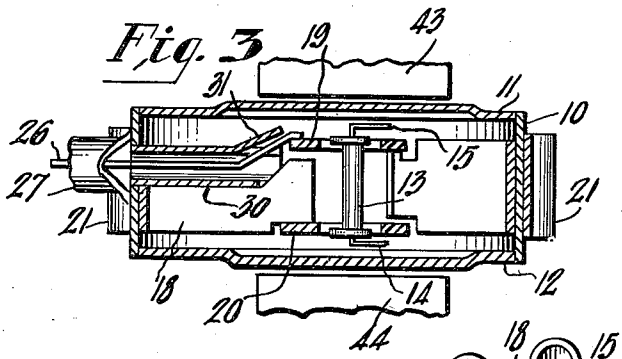


Fig. 1.

Fig. 2.

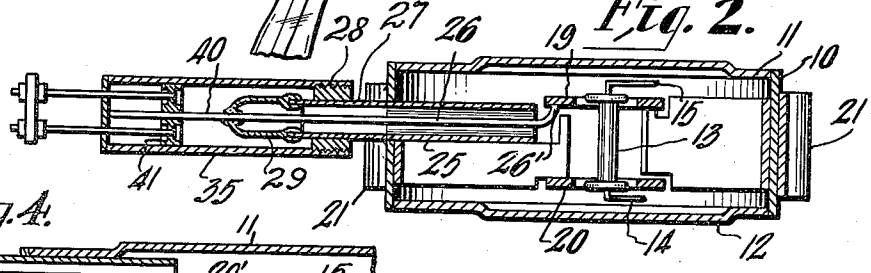
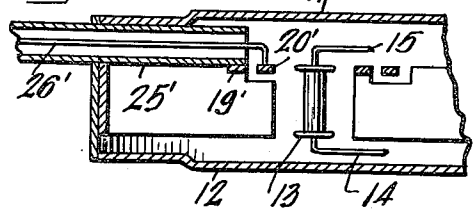


Fig. 4.



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ELECTRON DISCHARGE DEVICE UTILIZING CAVITY RESONATORS

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6 Claims. (Cl. 315—40)

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My invention relates to electron discharge devices, more particularly to magnetrons utilizing cavity resonators and suitable for operation at very high frequencies.

In tubes of this type a cathode is generally surrounded by a plurality of anode segments, the anode segments have connected between adjacent segments the cavity resonators. The anode assembly may be made by broaching a solid block of conducting material, providing a central space in the form of a cylindrical chamber with radially directed slots or radially directed slots communicating with symmetrically-shaped chambers. Another form of anode assembly includes a heavy ring provided with a plurality of radially directed vanes or slats extending toward a central axis, the inner ends serving as the anode segments and defining a cylindrically shaped chamber in which the cathode may be positioned. Alternate anode segments may be strapped together to assure the desired mode of operation. These described types of magnetrons are usually of small size and of limited power dissipation capacity. They are not particularly suitable for construction for larger size high power output tubes and their construction is difficult.

Under some conditions it is desirable to have a magnetron utilizing a cavity resonator which has a large power dissipating capacity, which can be readily tuned and which is easy to assemble. It is also desirable to have such a device in which radio frequency energy is confined within the resonators and is prevented from passing along the leads, such as along the cathode leads. It is also desirable to have means for readily cooling devices of this kind when large amounts of power are handled.

It is, therefore, an object of my invention to provide an improved electron discharge device of the magnetron type utilizing cavity resonators.

Another object of my invention is to provide such a device which is capable of handling large amounts of power.

Another object of my invention is to provide such a device which may be readily tuned.

A still further object of my invention is to provide such a device which is simple in construction and which can be readily assembled.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a perspective view with parts removed of an

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electron discharge device made in accordance with my invention, Figure 2 is a section taken along the line 2—2 of Figure 1, Figure 3 is a section like that of Figure 2 of a modification of an electron discharge device made in accordance with my invention, and Figure 4 is a partial section like that of Figures 2 and 3 and showing a still further modification of a device made according to my invention.

In accordance with my invention I provide an envelope comprising the ring shaped member 10 closed by means of the discs 11 and 12. Mounted within this envelope at the axis thereof is an indirectly heated cathode 13 having the heater and the cathode leads 14 and 15 extending through the wall of the envelope and through the tubular member 16, the leads being sealed through the cup-shaped member 17. These leads also support the cathode within the envelope.

In accordance with my invention the anode assembly comprises a plurality of preformed U-shaped members or parts 18, the open ends of which surround and define a central space in which the cathode 13 is positioned and the inner ends of the legs of which provide anode segments. The pairs of contacting legs of the U-shaped members constitute flat elongated vanes converging toward the cathode 13. A plurality of these U-shaped members 18 which may be made of flat strips of sheet copper are bent around a wedge-shaped forming block. These are annealed and assembled into a jig which determines their final shape and holds these parts together for silver soldering into a single assembly. Strapping rings 19 and 20 are mounted at the top and bottom of the U-shaped members and are connected to different alternate vanes to which the strapping rings may be silver soldered. The U-shaped members 18 are assembled within the tubular casing 10 and silver soldered intermediate the cover members 11 and 12 nesting and in contact with the member 10. The U-shaped members 18 provide cavity resonators coupled between adjacent anode segments. The strapping rings help to insure π mode oscillation in which alternate vanes are 180° apart during operation of the tube. The cathode 13 is mounted within the cathode space after the vanes are mounted in place.

The exterior of the envelope has secured thereto for heat radiating purposes a radiator element such as 21 of corrugated shape. By this arrangement the radiating area is greatly increased and a cooling medium can be directed between the casing and the open corrugations of the radiator.

Output energy is taken from the interior of the resonators by means of the coupling loop 22 which is extended into the internal conductor 22' of a coaxial line cable having the outer tubular conductor 23. The internal conductor is sealed by the cup-shaped member 24.

In order to be able to tune the magnetron over a range of frequencies, a coaxial line tuning arrangement is coupled to the strapping rings in accordance with my invention described and claimed in my copending application, Serial No. 584,136 filed March 22, 1945, and assigned to the same assignee as the present application. This tuning circuit includes the internal conductor 26 electrically connected at 26' to the strapping ring 19 as shown in Figure 2. The outer conductor 25 which lies along and contacts one of the legs of the U-shaped members communicates with the external tubular member 27 having the thread 28 to which may be attached an external outer conductor of a coaxial line cavity resonator, having outer conductor 35, inner conductor 40 and tuning ring 41. Thus the inner conductor is electrically connected to one strapping ring and the outer conductor to the other strapping ring through the vane which supports it. If both rings were mounted at one end of the tube, the rings could both be directly connected to the coaxial line. The internal conductor 26 is sealed by means of the elongated cup-shaped member 29 and is connected to the internal conductor 40 of the coaxial line cavity resonator. The coaxial line resonator may be made tuneable by sliding tuning ring 41 as described in my copending application above referred to.

The conductor 26 should be shielded by the outer conductor 25 close to the conductor ring near the center of the tube so that the outer conductor surrounds and shields the internal conductor as completely as possible. This shielding may be improved as shown in Figure 3 by having an outer conductor 30 provided with a shield extension 31. The tuning frequency range for a tube constructed as in Figure 3 is greater than that shown in Figure 2.

The rings 19 and 20 have sufficient conducting surface to permit the flow of large circulating currents between the tuning line and the internal cavity structure. These rings serve as a part of the cavity structure and help to function as straps in separating the modes of oscillation. These rings also support mechanically the ends of the vane sections, thus maintaining good alignment of these parts. It is obvious that straps connecting alternate vanes could replace the rings.

The tuning line 25—26 may be made an integral part of one of the vane sections between the cavities. It should be located with respect to the load loop 22 in such a position that the desired mode of oscillation, usually the so-called π mode is obtained without distortion of the symmetry of the intensities of the fields of the standing-wave pattern for the desired mode. This mode is favored by having the line positioned at some angle other than 90, 180 or 270° from load line 22, 23.

The cathode leads 14 and 15 extend through the enclosing case which may be of stainless steel, "Monel" metal or other non-magnetic material, and are positioned in a plane bisecting the cavity resonator so that a negligible amount of high frequency power passes out through these leads.

The usual magnets 43 and 44 may be utilized to provide the magnetic field in alignment with the axis of the cathode and in the cathode-anode space.

In Figure 4 there is shown a modification of the arrangement shown in Figures 1 to 3, inclusive, in which the magnetron is provided with a pair of strapping rings 19' and 20' both at the same end of the cathode. The rings are connected to alternate anode segments in the manner shown in Figures 1 and 2. As shown the outer conductor 25' of the coaxial line resonator is electrically connected to the outer ring 19', which is connected to alternate anode segments, and the inner conductor 26' is connected to the inner ring 20' connected to the other alternate anode segments.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having an anode assembly including a plurality of adjacent and contacting U-shaped parts, the open ends of said U-shaped parts surrounding a central space, the legs of said U-shaped parts converging radially toward said central space, the ends of the legs of the U-shaped parts providing anodes adjacent said space, a cathode adjacent said anode assembly for supplying electrons within said space, a tubular casing surrounding and in contact with said U-shaped parts and means closing said tubular casing and providing therewith an envelope for said U-shaped parts and said cathode.

2. An electron discharge device having an anode assembly including a plurality of adjacent and contacting U-shaped elements, the open ends of said U-shaped elements surrounding a central space, the legs of said U-shaped elements converging toward said central space, the ends of the legs of said U-shaped elements providing anodes adjacent said space, a cathode adjacent said anode assembly for supplying electrons within said space, a casing receiving said U-shaped elements, means closing said casing and providing an envelope for said cathode and anodes, said U-shaped elements being nested in said casing, and means for radiating heat from said anode assembly including a corrugated radiating element secured to the periphery of said casing.

3. An electron discharge device having an anode assembly including a plurality of adjacent and contacting U-shaped members, the open ends of said U-shaped members surrounding a central space, the legs of said U-shaped members lying in radial planes and converging toward said central space, the ends of the legs of the U-shaped members providing anode elements adjacent said space, a cathode adjacent said anode assembly for supplying electrons within said space, a casing for said cathode and U-shaped members providing an envelope, said U-shaped members being nested in said casing, means for tuning said electron discharge device including a coaxial line extending from the outside of said envelope along a pair of adjacent contacting legs of said U-shaped

members to a point adjacent the inner ends thereof and a conductor connecting alternate anode elements, the internal conductor of said coaxial line being electrically connected to said conductor connecting alternate anode elements.

4. An electron discharge device including a drum-shaped envelope of conducting material, a cathode positioned at the axis of said drum-shaped envelope, a plurality of adjacent U-shaped sheet metal elements, the closed ends of which contact the inner wall of the said drum-shaped envelope and the legs of which extend radially toward said cathode, the inner ends of said legs defining a chamber of cylindrical shape and providing anode elements, the legs of adjacent U-shaped elements being in contact along their length from the inner surface of said drum-shaped envelope to the ends of said legs.

5. An electron discharge device including a drum-shaped envelope of conducting material, a cathode positioned at the axis of said drum-shaped envelope, a plurality of adjacent U-shaped elements, the closed ends of which contact the inner wall of the said drum-shaped envelope and the legs of which extend radially toward said cathode, the inner ends of which provide anodes defining a chamber of cylindrical shape, legs of adjacent U-shaped elements being in contact along their length from the inner wall of said drum-shaped envelope to the ends of said legs, a conducting ring-shaped member connecting alternate anodes together, a coaxial line tuning device extending through and in contact with the envelope and extending closely adjacent said ring-shaped member, the inner conductor of said coaxial line being electrically connected to said ring-shaped member.

6. An electrode for a magnetron discharge device comprising a cylindrical retaining ring and a multi-cavity resonator structure arranged symmetrically around the inner surface of the ring; said multi-cavity resonator structure comprising a plurality of adjacent and contacting U-shaped sheet metal parts forming a plurality of U-shaped cavities; said parts being arranged in a circle, with the open ends of the U's projecting inwardly toward a common axis, and set as a unit within and contacting said retaining ring.

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