Nov. 11, 1958 B. H. SMITH 2,860,285

ELECTRON DISCHARGE DEVICES

Filed Dec. 14, 1956 2 Sheets-Sheet 1

FIG. 1

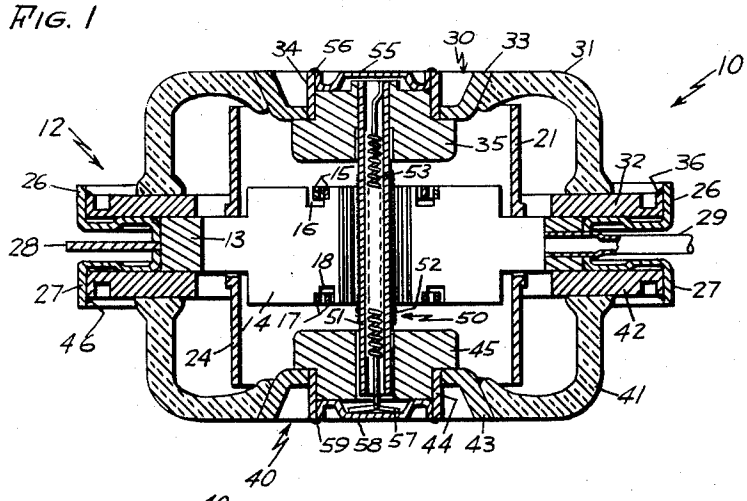



FIG. 2

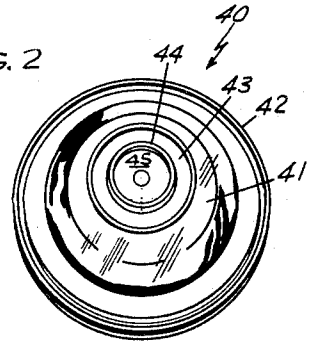



FIG. 3

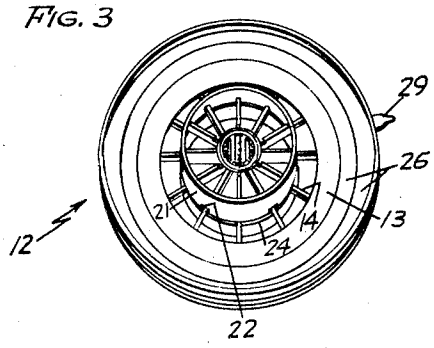
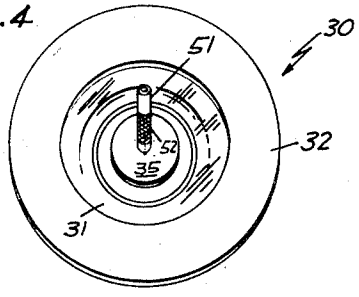



FIG. 4



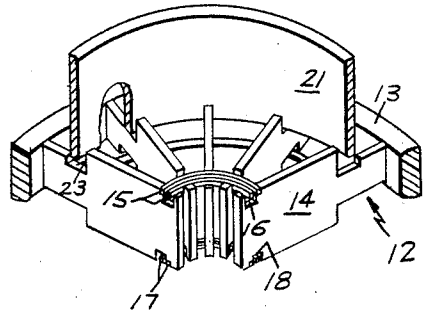




FIG. 5

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ELECTRON DISCHARGE DEVICES

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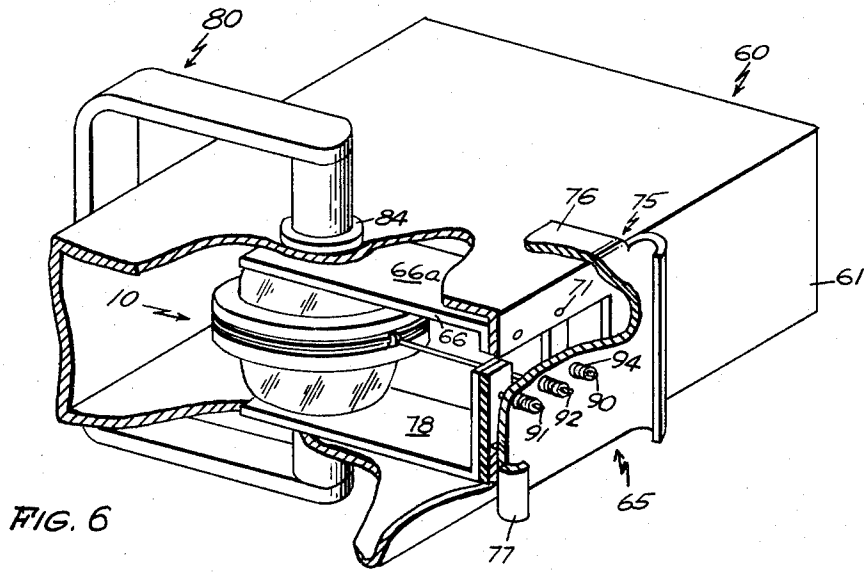



FIG. 6

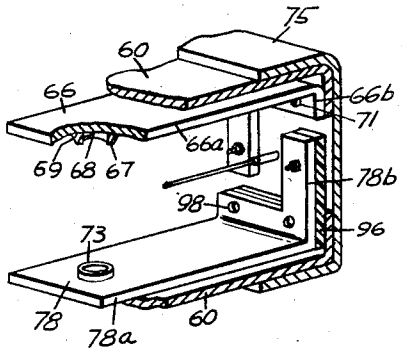



FIG. 7

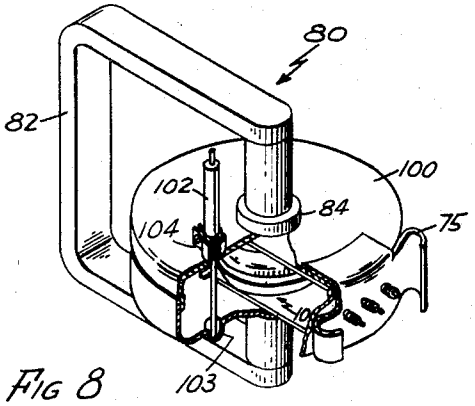



FIG 8

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United States Patent Office 2,860,285 Patented Nov. 11, 1958



2,860,285

# ELECTRON DISCHARGE DEVICES

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Application December 14, 1956, Serial No. 628,303

5 Claims. (Cl. 315—39)

This invention relates to a magnetron of simplified construction which may be manufactured at relatively small cost without sacrificing reliability of operation, and to an output coupling system incorporating said magnetron.

In the magnetron according to this invention, cost is reduced by minimizing the number of tube parts; this is achieved by transferring packaging parts from the tube to a separate unit whose cost is no greater than that of the packaging parts used in comparable tubes. This separate unit provides for supporting the tube, cooling the tube, making electrical connections to the tube, supplying the magnetic field and providing a suitable coupling between the magnetron and the transmission means to the load.

Radio frequency energy may be coupled from the anode resonator system by two electrically conductive cylinders that are connected to the anode so that they act as a dipole. This is achieved by connecting the upper cylinder to one set of alternate anode vanes and the lower cylinder to the other set of alternate anode vanes. Since alternate vanes are at opposite radio frequency potential in the normal mode of operation, the two cylinders are at opposite radio frequency potential at any given instant and act as a dipole. These cylinders radiate energy through glass or ceramic bushings disposed at opposite ends of the magnetron and forming a part of the tube envelope.

The dipole radiator assembly has several advantages, one of which is that the anode is symmetrically loaded and produces a significant increase in the mode boundary over that which can be obtained in prior output systems wherein only one of the cavity resonators is loaded. Another advantage is that the cylindrical shields effectively shield the vitreous bushings from metallic vapors evaporating from the cathode and emanating therefrom in straight lines. These vapors condense on the inside of the electrically-conductive cylindrical shields instead of on the vitreous bushings, where the direct current input to the magnetron, as well as the radio frequency energy radiated through the bushings, would be short-circuited. The vitreous bushings or domes, in addition to providing means for transferring radio frequency energy from within the magnetron, provide heater-to-cathode insulation and insulation of the cathode from high voltage. The coupling can be varied readily by altering the diameter of the dipole cylinder in the region of contact with the magnetron anode. It has been found that a single cylinder, rather than two cylinders, may be used with satisfactory results. This cylinder is attached to alternate anode vanes only at either end of the anode structure.

The magnetron may be mounted within a waveguide or a cavity resonator, thus providing an output coupling arrangement for transferring energy from the magnetron to a utilization means. If a cavity resonator is employed, energy may be removed from the resonator by means of a coaxial output line. It has been found that by mounting the magnetron within a circular cavity resonator, a



mode boundary superior to that with operation into a section of rectangular waveguide may be obtained.

Other objects and uses of the invention will become evident after reference to the accompanying description and drawings wherein:

Fig. 1 is a central cross-sectional view showing a magnetron in accordance with the invention;

Fig. 2 is a pictorial view of one of the dome assemblies used in the magnetron shown in Fig. 1;

Fig. 3 is a view showing the magnetron anode assembly;

Fig. 4 is a view of the other dome assembly used in the magnetron of Fig. 1;

Fig. 5 is a view showing a portion of the anode assembly using a single strap shield and indicating an alternative method of connecting the cylinder on strap shield to the anode;

Fig. 6 is the pictorial view showing the tube of Fig. 1 mounted within a waveguide and showing the external magnetic field-producing means;

Fig. 7 is a detail view showing a portion of the tube mounting means of Fig. 6; and

Fig. 8 is a pictorial view, partially in section, showing the tube of Fig. 1 mounted within a cavity resonator.

Referring to Figs. 1 to 7 of the drawing, wherein corresponding elements are designated by the same reference numeral, the magnetron **10** consists essentially of a centrally disposed cathode assembly **50**, and a surrounding anode assembly **12** situated between two dome assemblies **30** and **40** which are transparent to radio frequency energy generated by the magnetron, and a transverse magnetic field-producing means **80**, shown in Fig. 6.

The anode assembly **12** includes an anode cylinder **13** from whose inner periphery radially extend several anode vanes **14**, soldered or otherwise secured to the anode cylinder. Alternate anode vanes may be interconnected in the usual manner by pairs of concentric straps **15**, **17**, one pair located at each end of the anode block. The first pair **15** of straps is set in slot **16** in the anode vanes **14** and the second pair **17** of straps is positioned in slots **18** in the anode vanes. The invention, however, is not limited to a strapped magnetron.

A first annular electrically conductive strap shield or cylinder **21** is electrically and mechanically connected to alternate anode vanes **14**; strap shield **21** contains slots **22**, shown in Fig. 3, along one edge at positions adjacent alternate anode vanes whereby the strap shield **21** is connected electrically to alternate vanes only. The vanes not connected to strap shield **21** may be provided with slots **23** in alignment with the strap shield, as indicated in Fig. 5. A second annular strap shield or cylinder **24** is disposed on the opposite side of the anode vanes from strap shield **21**, as shown in Figs. 1 and 3, and is connected to alternate anode vanes lying between the alternate vanes to which a first strap shield **21** is connected. It is possible to connect both strap shields to the same side of the anode block.

A pair of end cooling fins **26** and **27** and a central cooling fin **28** are soldered to the outer periphery of anode cylinder **13**. The central cooling fin **28** is provided with a discontinuity to permit passage of an exhaust stem **29**, one end of which passes through an aperture in anode cylinder **13**.

A dome assembly **30** includes a glass bushing **31**, and an annular bushing disk **32** and a bushing adapter **33**, said bushing disk and bushing adapter being made of a material, such as Kovar, having approximately the same coefficient of thermal expansion as that of glass bushing **31**. Dome assembly **30** further includes a pole sleeve **34** and a pole piece **35** apertured to receive a cathode tube **51** to be referred to subsequently. The glass bushing **31** is hermetically sealed both to the bushing disk **32** and the

bushing adapter 33, as by means of an inductive heating process.

The pole piece 35, pole sleeve 34, and bushing adapter 33 are joined together, as by brazing. The complete dome assembly 30 is hermetically sealed to the anode assembly 12. This may be done, for example, by welding, as at 36, bushing disk 32 to the end cooling fin 26 which forms an extension of anode cylinder 13. The strap shields serve not only as radiating coupling means, but also to shield the glass bushings from the cathode so that metals emitted from the cathode cannot deposit on the glass bushing.

A second dome assembly 40, similar to that previously described, is mounted on the other side of the anode assembly 12 and includes a glass bushing 41, bushing disk 42, bushing adapter 43, pole sleeve 44 and pole piece 45. The glass bushing 41 is sealed to bushing disk 42 which, in turn, is in contact with one flat surface of anode cylinder 30 opposite that to which the bushing disk 32 of dome assembly 30 is attached. Dome assembly 40 is hermetically sealed to the anode assembly 12 by welding, as at 46, the edge of bushing disk 42 to the end cooling fin 27, which forms an extension of the anode cylinder.

The cathode assembly 50 comprises a cathode tube 51 surrounded at the central portion thereof by a wire mesh 52 containing an electron-emissive material; wire mesh, for example, may have metal powder brushed into the mesh and may be sintered to the cathode tube. A heater wire 53 is contained within cathode tube 51; one end of heater wire 53 is attached, as by a spot welding, to the inner periphery of cathode tube 51 at one end, as shown in Fig. 1. The cathode tube 51 also is secured to the pole piece 35 of dome assembly 30, as by welding. An end cap 55 is hermetically sealed to the pole sleeve 34 as by weld 56. The other end of the heater wire 53 is fastened to a connector wire 57 which, in turn, is secured at more than one point to an end cap 58. This mode of attachment is superior mechanically to the direct attachment of the heater wire to end cap 58, although either type of connection is within the scope of this invention. End cap 58 is sealed hermetically to the pole sleeve 44, as by the weld 59. It should be noted that the cathode tube 51 is electrically isolated from pole piece 45.

The magnetron 10, which includes anode assembly 12, dome assemblies 30 and 40, and cathode assembly 50, is mounted within a waveguide generally designated by reference numeral 60. The mounting means 65 for magnetron 10, which includes a cathode connector 66, consists of a flat portion 66*a* terminating at one end in a flanged portion 66*b*, and a tubular member 67 projecting from the flat portion 66*a*, as shown in Fig. 7. The inner periphery 68 of the member 67 is adapted to surround the pole sleeve 34 of dome assembly 30 of Fig. 1, while the tapered outer periphery 69 engages the tapered outer surface of the bushing adapter 33, shown in Fig. 1. The flanged portion 66*b* is attached to the wave guide by appropriate fastening devices 71.

The tube mounting means 65 further includes a heater connector 78 having a flat portion 78*a* and a flanged portion 78*b*, similar to the cathode connector 66, except that the projecting member 73 is cylindrical and is adapted to fit against the outer periphery of the pole sleeve 44 of dome assembly 40, shown in Fig. 1.

A connecting clip 75 fits over an opening in the narrow wall 61 of waveguide 60 through which external circuit leads may pass. Clip 75 includes portions 76 which fit against the broad walls of the waveguide and bent portions 77, which assist in maintaining the clip in position against the waveguide. A ground (cathode) terminal 90, heater terminal 91 and high voltage (anode) terminal 92 provide electrical connections to the cathode 50, heater 53, and anode 12, respectively; these terminals are insulated from the waveguide 60 or other tube elements, as the case may be, by means of electrically insulated bushings 94. The cathode connector 66 may be connected directly to the waveguide wall by means of the fastening devices 71 in applications where the cathode is maintained at ground potential. If the cathode is to be held at a potential other than ground, the cathode member 66, of course, would be insulated from the waveguide wall, in a manner to be shown in connection with the heater connector 78, and the terminal 91 would be connected to an appropriate negative terminal of a heater supply.

The heater connector 78, whose flat portion 78*a* is spaced from the broad wall of the waveguide, is electrically insulated from the narrow wall of waveguide 60 and from clip 75 by shim 96 inserted between the flanged portion 78*b* of the heater connector and the narrow wall of the waveguide, as shown in Figs. 6 and 7. The heater connector 78 may be attached to the waveguide 60 and to the clip 75 by means of electrically insulating screws 98.

A magnetic field-producing means 80 transverse to the electrical field between anode and cathode of magnetron 10 includes a C-shaped magnet having a yoke 82 and including adapters 84 for facilitating mounting of the magnet to the waveguide transition unit 60. The pole pieces of the magnet 80 are axially aligned with the interaction space between the cathode 50 and the tips of anode vanes 14. As previously stated, the pole piece 35, to which cathode 50 is connected, may be operated at ground potential, in which event the ground terminal of the heater voltage source (not shown) is connected by way of the cathode terminal 90 to the pole piece 35. The other heater supply terminal is then connected by way of the heater terminal 91 to the other pole piece 45 of magnetron 10. The high voltage source is connected between the anode and ground. Radio frequency energy may be extracted from the open end of the waveguide which is adapted to be connected to any desired load, in a well-known manner.

A modification of the invention as shown in Fig. 6 is shown in Fig. 8 in which the transition unit comprises a cyclindrical cavity resonator 100 and a coaxial line 102, rather than the waveguide 60 of Fig. 6. In this embodiment, the tube radiates radio frequency energy into the cavity resonator 100 and the energy within the latter is supplied to an external load by means of a coaxial line 102 coupled to the resonator. A stub 103 is provided for coupling adjustments and may be preset for a given tube. The coaxial line 102 may be supported from the outer surface of the resonator 100 by the bracket 104. The remainder of the assembly of Fig. 8 is similar to that shown in Fig. 6, except, of course, for the shape of the mounting brackets 75.

This invention is not limited to the particular details or construction materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. In combination, an electron discharge device comprising an evacuated envelope having a portion thereof transparent to electromagnetic energy and containing therein an anode assembly including a plurality of spaced members, a cathode arranged adjacent said anode members, means for producing a magnetic field transverse to the region between the cathode and the anode assembly, means for radiating energy generated within said electron discharge device through said portion of said envelope, said means for radiating including a cylindrical electrically-conductive member connected to a set of alternate anode members, an energy containing means, means for mounting said discharge device within said energy containing means, a pair of magnetic pole pieces each fixedly attached to said portion of the envelope at a corresponding end of said electron discharge device, said mounting means including a pair of elements each contacting a corresponding pole piece and including means secured to and conforming to a wall of said energy containing means.

2. In combination, an electron discharge device comprising an evacuated envelope having a portion thereof transparent to electromagnetic energy and containing therein an electrode capable of propagating high frequency energy, a cathode, a heater, a magnetic field-producing means having oppositely disposed pole pieces, means including said magnetic field-producing means for directing said electrons in paths adjacent said electrode, means for radiating energy generated within said electron discharge device through said portion of said envelope, said means for radiating including a cylindrical electrical conductive member connected to spaced portions of said electrode, said cathode being connected to one pole piece of said magnetic field-producing means, said heater being connected to the other pole piece of said magnetic field-producing means.

3. In combination, an electron discharge device comprising an evacuated envelope containing therein an anode assembly including a plurality of spaced members, said anode assembly being connected to a first portion of said envelope, a cathode arranged adjacent said anode members, means including a pair of oppositely disposed magnetic pole piece assemblies for producing a magnetic field transverse to the region between said cathode and said anode assembly, said envelope having electrically insulating portions intermediate said first portion and a corresponding one of said pole piece assemblies which is transparent to electromagnetic wave energy, and means for radiating energy generated within said electron discharge device through said electrically insulating portions of said envelope, said means for radiating including a first cylindrical electrically-conductive member connected to one set of alternate anode members, and a second cylindrical electrically-conductive member connected to the other set of alternate anode members.

4. In combination, an electron discharge device comprising an evacuated envelope having a portion thereof transparent to electromagnetic energy and containing therein an anode assembly including a plurality of spaced members, a cathode arranged adjacent said anode members, means for producing a magnetic field transverse to the region between the cathode and the anode assembly, means for radiating energy generated within said electron discharge device through said portion of said envelope, said means for radiating including a cylindrical electrically-conductive member connected to a set of alternate anode members, a pair of magnetic pole pieces each attached to said portion of said envelope at a corresponding end of said device, a waveguide, and means for mounting said device within said waveguide, said mounting means including means connected to a corresponding pole piece and supported from said waveguide.



5. In combination, an electron discharge device comprising an evacuated envelope having a portion thereof transparent to electromagnetic energy and containing therein an anode assembly including a plurality of spaced members, a cathode arranged adjacent said anode members, means for producing a magnetic field transverse to the region between the cathode and the anode assembly, means for radiating energy generated within said electron discharge device through said portion of said envelope, said means for radiating including a cylindrical electrically-conductive member connected to a set of alternate anode members, a pair of magnetic pole pieces each attached to said portion of said envelope at a corresponding end of said device, a cavity resonator of cylindrical configuration, and means for mounting said device within said cavity resonator, said mounting means including means connected to a corresponding pole piece and supported from said cavity resonator.

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