Aug. 1, 1967 W. FRUTIGER 3,334,266

COAXIAL OUTPUT LINE FOR A MAGNETRON

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FIG. 1

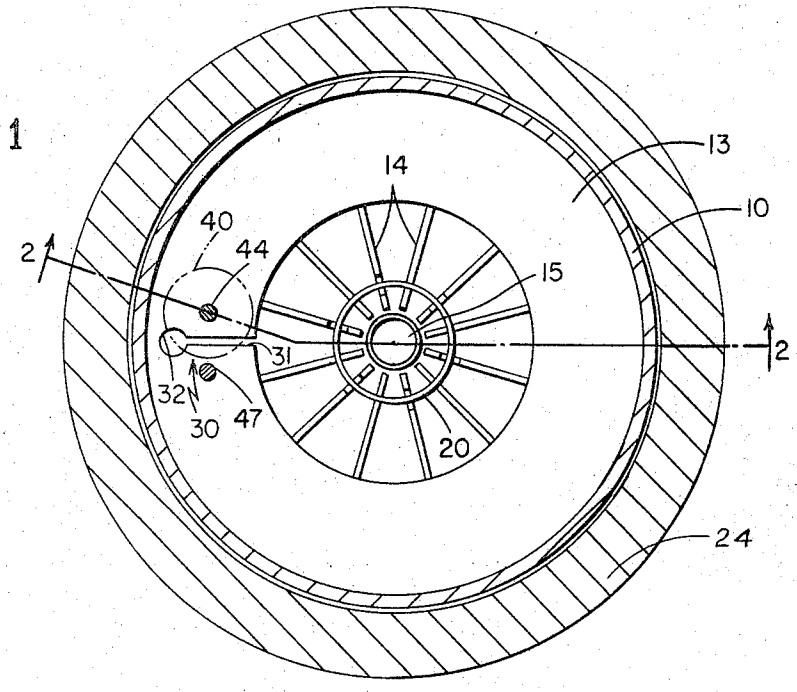
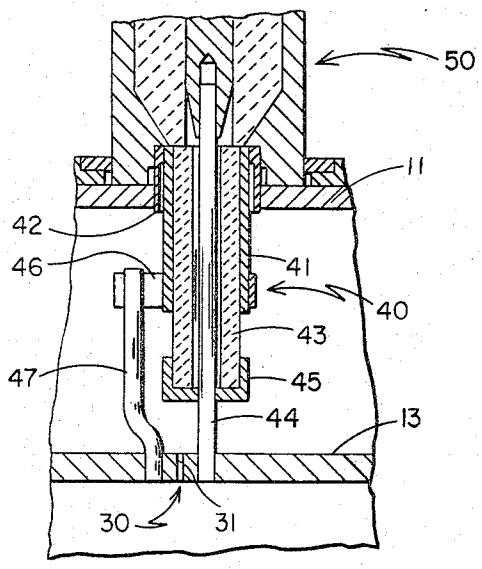


FIG. 3



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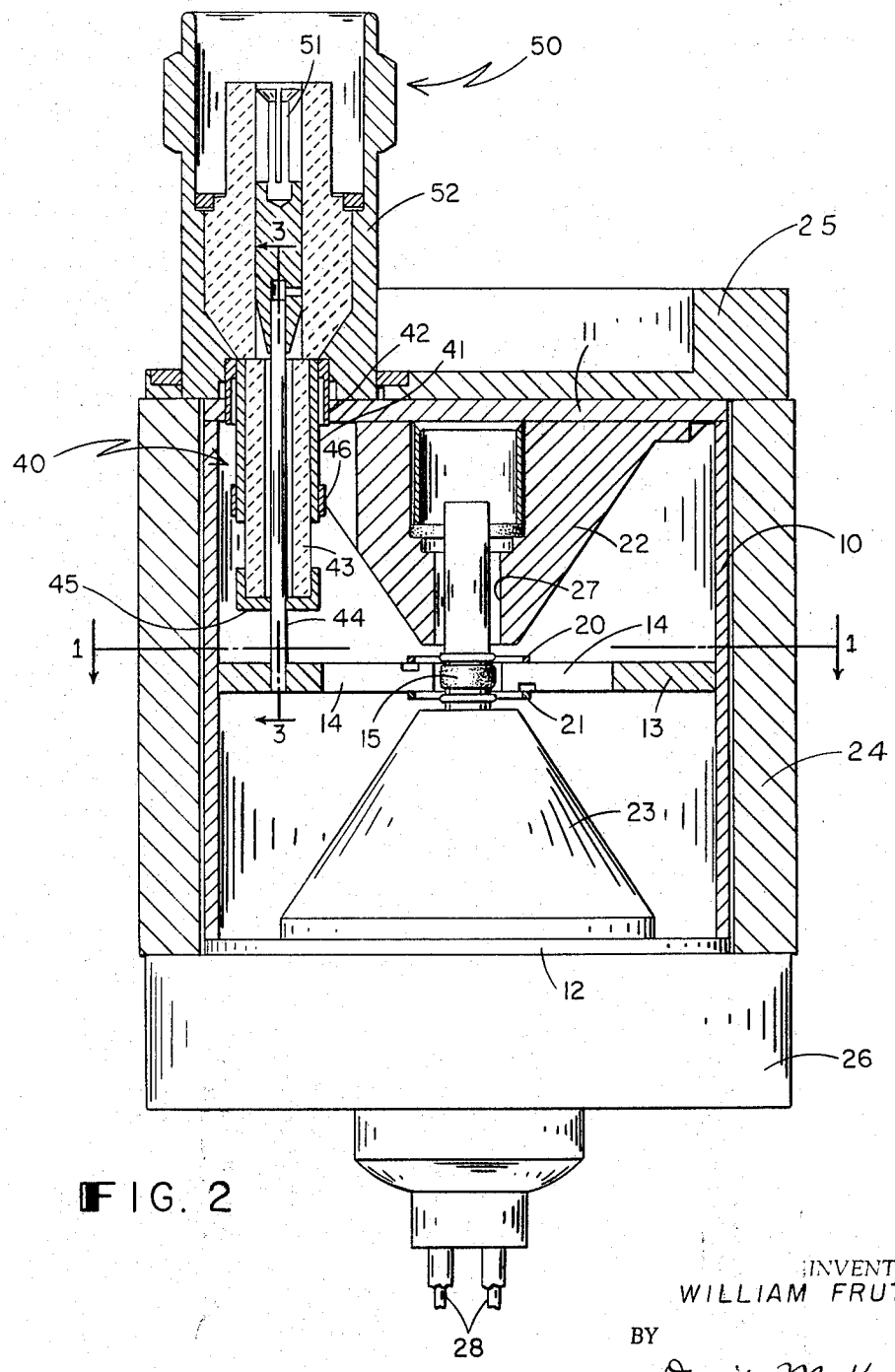


FIG. 2

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COAXIAL OUTPUT LINE FOR A MAGNETRON

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This invention relates to magnetrons. More particularly, it is concerned with coupling arrangements for extracting energy from magnetrons.

Various arrangements have been employed for extracting electrical energy from multi-cavity magnetrons of well-known type. In one form of output an opening in the back wall of one of the resonant cavities of the magnetron anode provides a quarter wave transformer for coupling energy from the cavity into an output waveguide. Another form of output coupling consists of a coaxial arrangement including an inner conductor terminating in a coupling loop within the magnetron enclosure and adapted to extract a portion of the energy stored in the anode. The outer conductor may be connected to the walls forming the magnetron enclosure and the inner conductor may be connected to one of the anode segments which form the resonant cavities of the magnetron anode. The inner conductor passes to the exterior of the magnetron enclosure and may be arranged so as to radiate energy into a waveguide thereby exciting the waveguide. Alternatively, the inner conductor and outer conductor may be adapted to provide a coaxial output connection adapted to be connected to a coaxial transmission line. Although the quarter wave transformer type of output is most widely used in magnetrons for coupling to waveguide, the loop type must generally be employed when it is desired to transmit the output signal along a coaxial transmission line.

It has proven difficult to obtain efficient coupling of electrical energy from the resonant cavities of the anode structure to the coaxial transmission line by way of known forms of output coupling loops. In order to obtain proper coupling from the anode the coupling loop must be precisely located and its terminal connection to an anode segment accurately made. The necessary degree of precision is difficult to obtain in the fabrication of any one device and is exceptionally difficult to obtain consistently from device to device under normal manufacturing conditions. In addition, size and space limitations are imposed on the coupling by the physical configuration of high frequency magnetrons. Compromises are consequently made in the spatial relationships between the coaxial elements and the dielectric materials employed resulting in mismatching of impedances within the coupling. These problems lead to excessive attenuation of power and excessive reflection of energy back into the magnetron cavities as well as lack of uniformity of coupling from device to device.

It is an object of the present invention, therefore, to provide an improved coupling arrangement for extracting energy from a magnetron.

It is also an object of the invention to provide a multicavity magnetron having an improved coaxial output coupling arrangement.

Briefly, a magnetron in accordance with the foregoing objects of the invention comprises a sealed evacuated enclosure containing a metal anode structure having a central opening within which is supported the cathode of the magnetron. A plurality of cavity resonators are formed in the anode structure surrounding the central cathode opening. An auxiliary resonant cavity in the anode structure is coupled to one of the plurality of resonators surrounding the central opening. A coaxial output coupler having an inner conductor and a concentric outer conductor is sealed through the walls of the enclosure to

provide coaxial connections externally of the enclosure. The inner and outer conductors of the coupler are connected to the anode structure at opposite sides of the auxiliary resonant cavity so as to extract a portion of the energy in the auxiliary cavity.

Additional objects, features, and advantages of magnetrons according to the invention will be apparent from the following detailed discussion and the accompanying drawings wherein:

FIG. 1 is a plan view of a magnetron according to the invention partially in cross-section taken generally along the line 1—1 of FIG. 2,

FIG. 2 is an elevational view in cross-section taken generally along the line 2—2 of FIG. 1, and

FIG. 3 is an elevational view in cross-section of a portion of the magnetron of FIGS. 1 and 2 taken generally along the line 3—3 of FIG. 2.

A magnetron according to the invention as illustrated in the drawings includes a cylindrical body **10** closed by an upper end plate **11** and a lower end plate **12** to form an enclosure. A ring-shaped anode block **13** is mounted to the body within the enclosure. An even numbered plurality of radially extending segments or vanes **14** are fastened at their outer edges to the inner surface of the anode block. The inner edges or tips of the segments terminate in spaced apart relationship adjacent the central region of the anode structure providing space for an electron emissive cathode **15**. The space between each pair of segments constitutes an open ended resonant cavity.

An annular conductive strap **20** coaxial with the anode block and cathode is connected to the upper ends (as viewed in FIG. 2) of alternate segments adjacent their inner edges. The segments between the alternate connected segments are notched so that they are not contacted by the strap. A similar strap **21** is connected to the lower ends of those anode segments not contacted by the upper strap, and the segments contacted by the upper strap are notched at their lower ends so as not to contact the lower strap. As is well known in the magnetron art, the straps connect alternate segments together in order to restrict the magnetron to operation in only the predominant or π mode and suppress other modes of oscillation.

An upper magnet pole piece **22** is mounted on the upper end plate **11** between the upper ends of the anode segments and the upper plate. A lower magnet pole piece **23** is similarly mounted on the lower end plate **12**. A cylindrical magnet **24** encircles the body of the magnetron. The magnet is held in place by retaining members **25** and **26**. Magnetic flux flows from the magnet through the retaining members, end plates, and magnet pole pieces to create a magnetic field in the interaction space centrally of the anode.

The cathode **15** passes through a central bore (not shown) in the lower magnet pole piece **23**, and is positioned centrally of a bore **27** in the upper magnet pole piece **22**. The cathode structure is suitable sealed to the lower end plate in insulating relationship to provide a hermetic seal and permit the cathode leads **28** to be available externally of the magnetron enclosure.

As illustrated in the drawings an auxiliary resonant cavity **30** is provided in the anode block **13**. A slot **31** in the anode block extends radially of the anode structure and opens into one of the resonant cavities defined by the segments centrally of the back wall of the cavity. The end of the slot farthest removed from the center of the anode is terminated in a hole **32**. The hole and slot in the anode block provide a series resonant circuit. The dimensions of the hole and slot are such that the auxiliary cavity is resonant at the same frequency as the resonant cavities.

Electrical energy is transmitted from the anode to the

exterior of the magnetron enclosure by a coaxial output coupler 40 (indicated in phantom in FIG. 1). The coupler includes a hollow cylindrical outer conductor 41 which is sealed through an opening in the upper end plate by means of an adapter 42. The outer conductor 41 extends within the enclosure parallel to the central axis of the magnetron toward the anode block 13. A hollow cylinder of insulating material 43, for example a high alumina ceramic, metallized along the upper portion of its outer periphery is sealed to the inner periphery of the outer conductor. The ceramic cylinder extends into the enclosure toward the anode beyond the outer conductor.

The inner conductor 44 of the coupler consisting of a cylindrical rod is located centrally of the hollow ceramic cylinder and is spaced from the inner walls of the cylinder. A conductive end cap or cup 45 is sealed to the inner conductor and to the metallized end of the ceramic cylinder thereby providing a completely sealed enclosure. The end cap 45 and the outer conductor 41 are spaced from each other a sufficient distance so that the impedance characteristics of the coaxial coupler are not affected by that spacing but are primarily determined by the dielectric nature of the ceramic cylinder and air space intervening between the inner and outer conductor. Proper spacing between the end cap and outer conductor provides a slight capacitance which balances the inductance of the lower portion of the inner conductor thus helping to render the coupler non-reactive.

The inner conductor 44 of the coaxial coupler is connected to the anode block adjacent one side of the slot 31 of the auxiliary resonant cavity. A conductive tab 46 is attached to the outer conductor, and a cylindrical lead 47 is connected between the tab and the anode block. The lead is connected to the anode block adjacent the slot and directly opposite the slot from the inner conductor. These connections to the anode block are precisely made at the proper location by virtue of mounting holes in the block adapted to receive the inner conductor and the outer conductor lead.

A coaxial output connector 50 of known type is mounted on the exterior of the enclosure. The inner and outer conductors 51 and 52 of the connector are suitably connected to the inner and outer conductors 44 and 41 of the coupler to provide proper matching of impedances. The connector is adapted to be connected with a mating connector of a coaxial transmission line.

The magnetron according to the invention operates in the usual manner of known open ended multi-cavity magnetrons to produce electrical oscillations. In the magnetron illustrated electrical energy is extracted from the anode structure and transmitted to the exterior of the enclosure by the auxiliary resonant cavity 30 and the coaxial output coupler 40. Energy passes into the auxiliary cavity by way of the opening between the auxiliary cavity and one of the plurality of cavities provided by the anode segments. The auxiliary resonant cavity 30 is constructed so as to resonate at the frequency of oscillations produced in the other cavities of the magnetron. Therefore, the voltages on the regions of the block on opposite sides of the slot are 180° out of phase. The inner conductor 44 and the lead 47 for the outer conductor of the coupler are connected to these regions of opposite potential and serve to extract a portion of the electrical energy circulating in the auxiliary cavity. The amount of energy extracted from the auxiliary cavity is dependent on the position of the connections to the coaxial coupler along the length of the slot. The nearer the connections are to the center of the anode the greater the amount of power intercepted.

In magnetrons according to the invention uniformity of coupling from the anode to the output connector is obtained. Each device is substantially similar to every other device since the assembly of the structural elements is predetermined by the configuration of the elements themselves and the individual elements of structure can be fabricated to close tolerances. Coupling from the anode in the device according to the invention depends primarily on the dimensions of the hold and slot of the auxiliary cavity and the location of the mounting holes for making the coaxial output coupler connections to the anode block. These dimensions can be very precisely controlled in the elements as manufactured and are not subject to alteration during the assembly of the device. Since the assembly of the structural elements can be precisely predetermined, it is possible consistently to obtain the design parameters of the output coupling arrangement.

The coaxial coupler is prefabricated as a subassembly and then accurately connected in position on the anode block by virtue of the mounting holes in the block, thereby providing both ease and precision in assembling to the magnetron. There is no supporting structure of insulating material extending from the inner conductor to the outer conductor along any portion of their length. The structure as shown provides a ceramic cylinder in combination with an air dielectric between the coaxial conductors. This arrangement makes it possible to provide a coaxial coupler which is sufficiently small to be used in high frequency devices, which is of rugged mechanical construction, and which also can be designed to be of proper impedance. These various features make it possible to obtain close matching of impedances between the anode structure, the coaxial coupler, and the output connector with consequent low power attenuation, negligible reflection of electrical energy, and increased transfer of energy to the load.

What is claimed is:

1. A magnetron comprising
a sealed evacuated enclosure containing a metal anode structure having a central opening within which is supported the cathode of the magnetron,
a plurality of cavity resonators in said anode structure surrounding the central opening,
an auxiliary resonant cavity in said anode structure coupled to one of said plurality of cavity resonators, and
a coaxial output coupler having an inner conductor and a concentric outer conductor,
said conductors of the coaxial output coupler being connected to said anode structure at opposite sides of said auxiliary resonant cavity to extract a portion of the energy in said auxiliary resonant cavity.

2. A magnetron comprising
a cylindrical anode block,
a plurality of segments extending radially inwardly from said block and providing a resonant cavity between each pair thereof,
the inner tips of said segments being spaced apart and providing a circular cathode space centrally of the anode block,
an auxiliary resonant cavity in said anode block coupled to one of said resonant cavities, and
a coaxial output coupler having an inner conductor and a concentric outer conductor,
said conductors of the coaxial output coupler being connected to said anode block on opposite sides of said auxiliary resonant cavity to extract a portion of the energy in said auxiliary resonant cavity.

3. A magnetron comprising
a sealed evacuated enclosure containing a metal anode structure having a central opening within which is supported the cathode of the magnetron,
a plurality of cavity resonators in said anode structure surrounding and opening into the central opening,
an auxiliary resonant cavity in said anode structure opening into one of said plurality of cavity resonators, and
a coaxial output coupler having an inner conductor and a concentric outer conductor,
means connecting the inner and outer conductors of

the coaxial output coupler to the anode structure at opposite sides of said auxiliary resonant cavity to extract a portion of the energy in said auxiliary resonant cavity.

4. A magnetron comprising

a sealed evacuated enclosure containing a cylindrical metal anode block,

a plurality of segments extending radially inwardly from said block and providing a resonant cavity between each pair thereof,

the inner tips of said segments being spaced apart and providing a circiut cathode space centrally of the anode block,

an auxiliary cavity in said anode block extending radially outwardly from one of said resonant cavities and opening into said one cavity to extract energy therefrom,

a coaxial coupler including an outer cylindrical conductor passing through and sealed to the walls of said enclosure and a concentric inner conductor sealed to the other conductor in insulating relationship,

means connecting the outer conductor to the anode block adjacent one side of said auxiliary resonant cavity, and

means connecting the inner conductor to the anode block adjacent the opposite side of said auxiliary resonant cavity whereby energy is extracted from said auxiliary resonant cavity.

5. A magnetron comprising

a sealed evacuated enclosure containing a cylindrical metal anode block,

a plurality of segments extending radially inwardly from said block and providing a resonant cavity between each pair thereof,

the inner tips of said segments being spaced apart and providing a circular cathode space centrally of the anode block,

a slot in said anode structure extending radially outwardly from one of said plurality of cavity resonators,

a hole in said anode structure at the end of said slot removed from said one cavity resonator,

said hole and slot providing an auxiliary cavity resonant at the frequency of resonance of said cavity resonators,

a coaxial output coupler sealed to a wall of said enclosure and extending to the interior and exterior of the enclosure having an inner conductor and a concentric outer conductor,

means connecting the inner conductor to the anode structure adjacent one side of the slot, and

means connecting the outer conductor to the anode structure adjacent the opposite side of the slot.

6. A magnetron comprising in combination

a sealed evacuated enclosure containing a metal anode structure,

a plurality of cavity resonators in said anode structure,

a coaxial output coupler for extracting energy from one of said cavity resonators and transmitting the energy to the exterior of said enclosure,

said output coupler comprising

a conductive hollow cylindrical outer conductor sealed to a wall of said enclosure and extending to the interior and exterior of the enclosure,

a hollow cylinder of insulating material sealed within said outer conductor and having a portion extending beyond the outer conductor into the interior of said enclosure toward the anode structure,

an inner conductor connected to the anode structure adjacent one side of said one cavity resonator and extending to the exterior of said enclosure concentric with and spaced from the outer conductor and cylinder of insulating material,

a sealing member sealing the inner conductor to the cylinder of insulating material in said portion of the cylinder extending beyond the outer conductor, and

a conductive member connected between the outer conductor and the anode structure adjacent the side of the cavity opposite the inner conductor whereby the outer conductive member and the inner conductor extract a portion of the energy in said one cavity resonator.

No references cited.

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