Aug. 24, 1948. V. L. RONCI 2,447,537

COUPLED CAVITY RESONATOR

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FIG. 1

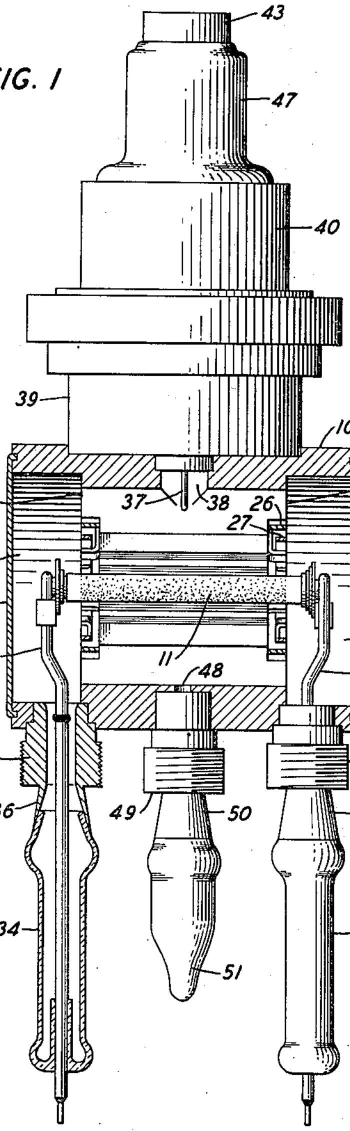

FIG. 2

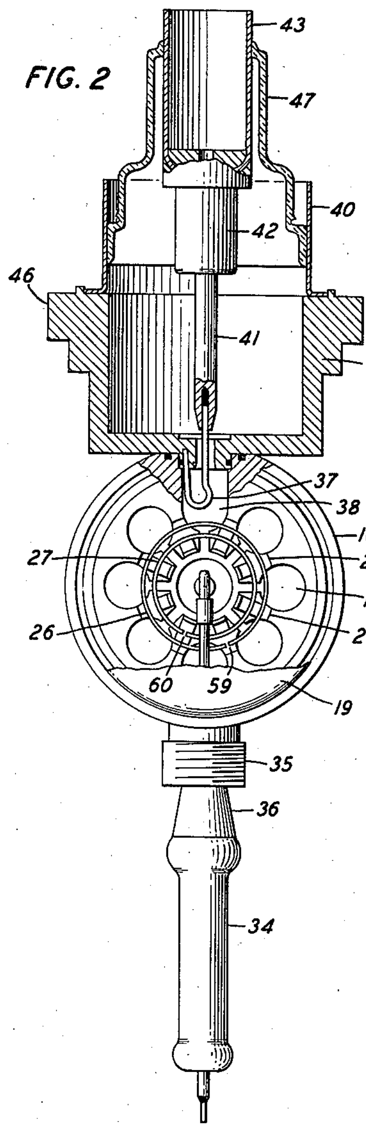

FIG. 5

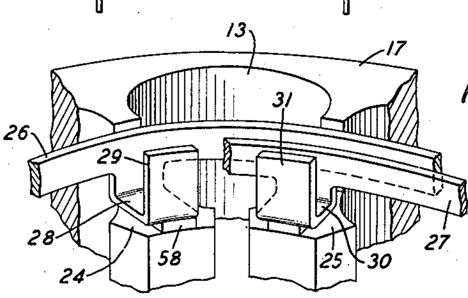

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FIG. 6

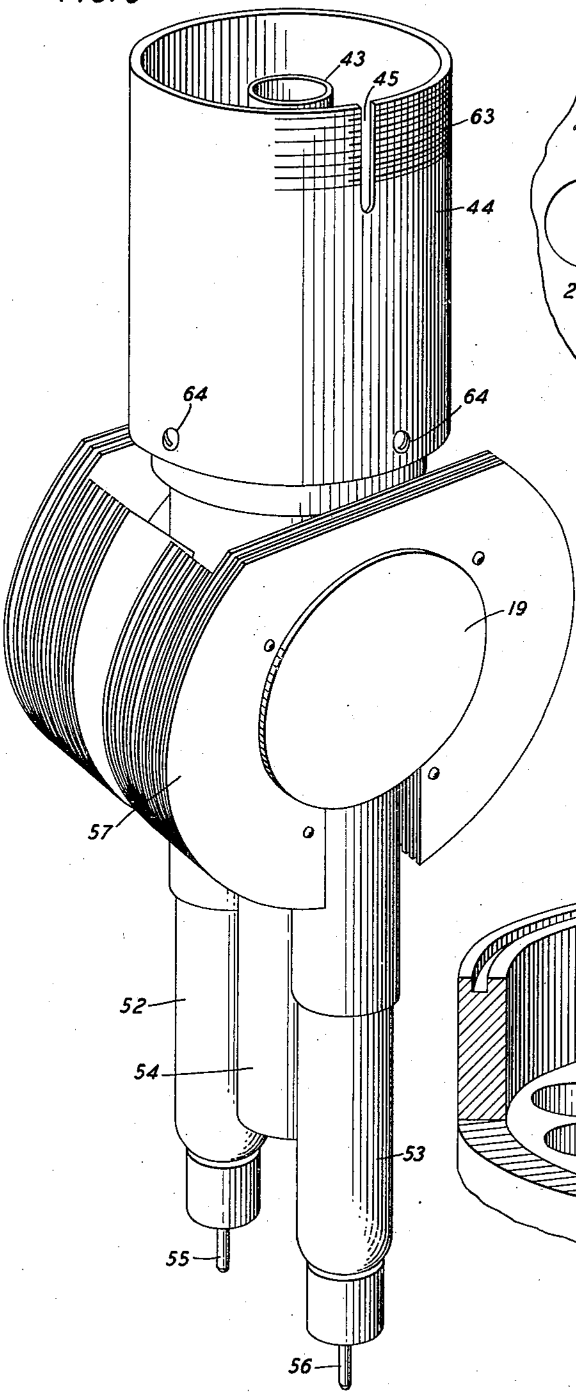


FIG. 3

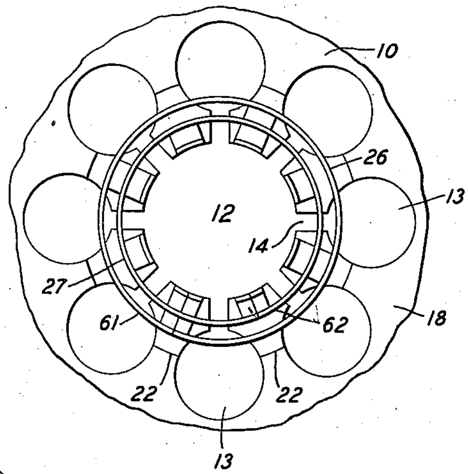
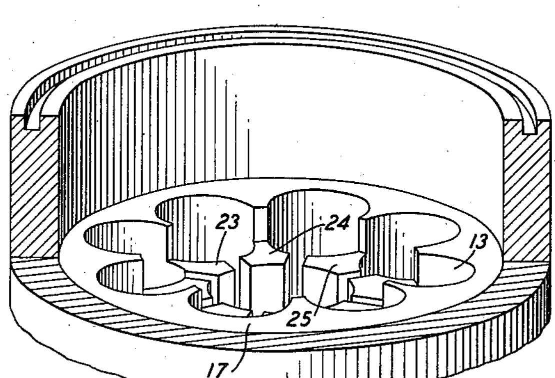


FIG. 4



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COUPLED CAVITY RESONATOR

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9 Claims. (Cl. 315—39)

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This invention relates to coupled systems of cavity resonators, particularly for use in multianode magnetrons, in which interanode straps are employed to influence the separation of the resonant frequencies and in which the straps are shielded to reduce their reaction with the electromagnetic field in the space between the cathode and the anode segments.

The resonating systems commonly employed in multianode magnetrons comprise a plurality of resonating cavities which are coupled, the resonating system as a whole, on account of the coupling, necessarily having a plurality of resonant frequencies at least as numerous as the anode segments. The distribution and separation of the resonant frequencies are dependent upon the nature and degree of the coupling between the cavities, often in a very complicated manner. Upon operation of a given resonant structure in an oscillator, the oscillations are usually found to be restricted to one of the several resonant frequencies, the particular one depending upon various parameters of the excitation system. Some times during operation the operating frequency may change in an erratic and unpredictable manner from one resonant frequency to another. For each resonant frequency the distribution of currents and electric and magnetic fields has a characteristic pattern and the operation of the system with a particular pattern is termed a mode of oscillation. Usually the modes of oscillation are distinguished from each other by different frequencies, although in special cases two modes may have the same frequency but a different pattern of currents and fields.

In practice it is usually desirable to design a magnetron for a particular mode of oscillation and to discourage or prevent oscillation at other modes. It has been found that the particular mode of oscillation which will be set up in a given system may be influenced by the use of conductive straps connecting predetermined selected points of the anode structure. The straps, among other possible effects, introduce more or less concentrated capacitances between surfaces of straps which are opposed and between surfaces of the straps and adjacent portions of the anode. These capacitances have been found to influence the separation of the resonant frequencies. It has also been found that the tendency of the magnetron to confine its oscillations to a particular mode increases with the degree of separation.

It was early noted that in many instances the efficiency of power conversion in strapped magnetrons was markedly less than in otherwise similar magnetrons without straps. A notable exception was found in magnetrons having a particular form of strapping, known as echelon, in which the straps were so arranged that the high potential portion of a given strap was shielded from the cathode-anode space by a low potential portion of another strap situated between the first-mentioned strap and the cathode-anode space. Experiments which have been performed to explain the greater efficiency of the magnetron with echelon strapping indicate that unshielded straps tend to distort or disturb the uniformity of the pattern of the electric and magnetic fields near the ends of the anode structure. It may be assumed that an unstrapped magnetron that is highly efficient has a pattern of fields in the space between the cathode and anode particularly favorable to efficient energy reaction with the electrons in that space. If the same magnetron, when equipped with straps is found to be less efficient than before, the difference is evidently due, at least in part, to disturbance of the field patterns near the ends of the anode structure whereby the favorable field pattern no longer extends over as large a portion of the length of the anode. To restore the former efficiency, shielding may be interposed between the straps and the cathode-anode space.

The purpose of the present invention is to provide a highly efficient arrangement for shielding the high potential strap areas. In accordance with the invention, the straps are mounted upon a ledge depressed in the end of the anode structure and shielding elements are provided in the form of tabs attached to the straps and bent so as to occupy positions between the cathode-anode space and the high potential strap areas. The result is a structure and arrangement of the anode, straps, and shields which has been found to be effective in promoting efficiency in magnetrons as well as in confining the oscillations to a desired particular mode. The structure is at the same time simple and economical to manufacture.

While the strapping and shielding system is applicable to multicavity resonators in general, the arrangement is illustrated herein as embodied in a magnetron.

In the drawings:

Fig. 1 is an elevational view of a magnetron embodying the invention, partly dismantled and partly in section;

Fig. 2 is an elevational view from one end of the anode showing the same structure as in Fig. 1, partly broken away and partly in section;

Fig. 3 is an enlarged detail plan of the end of the anode opposite the end shown in Fig. 2;

Fig. 4 is a fragmentary perspective view of one end of the anode, broken away to show a ledge in the anode structure before the insertion of straps and shields;

Fig. 5 is a fragmentary view of a portion of the anode with straps and shields in place; and

Fig. 6 shows the superficial appearance of the assembled magnetron.

Referring to the drawings, 10 is an anode structure and resonating system comprising a perforated cylindrical block of conductive material and 11 is a cathode of cylindrical form concentrically mounted in a central reaction space in the anode block as shown in Fig. 1. The central reaction space with the cathode removed is shown at 12 in Fig. 3 and preferably comprises a cylindrical bore coaxial with the block 10. A plurality of resonating cavities are formed in the block 10 as by boring a plurality of cylindrical holes 13 having their axes lying on an imaginary cylinder coaxial with the block 10, the holes 13 being connected with the reaction space by individual slots 14, preferably radial.

The anode block is preferably fashioned to provide end spaces 15 and 16 at either end. The block has a plane face 17 intersecting the reaction space 12, the cavities 13 and the slots 14 substantially at right angles to the axis. At the opposite end of the block there is a corresponding plane face 18. The end spaces are preferably closed by end plates 19 and 20 which may be of suitable magnetic material such as iron or steel to facilitate the application of a strong magnetic field to the reaction space 12 by means of an external magnet or magnets in well-known manner. The end face 17 is shown in Fig. 4 in a view with the end plate 19 removed and with part of the outer shell cut away.

The arrangement of the straps and the shielding thereof is shown in detail in Fig. 5. A ledge is first cut in the end of the anode. This may be done conveniently by boring a shallow axial hole concentric with the reaction space 12 and of sufficient diameter to include the slots 14 and a portion of the cavities 13. A portion of the periphery of such a hole appears at 21 in Fig. 2 and a portion of the periphery of a similar hole at the other end of the anode appears at 22 in Fig. 3. The hole is extended to the desired depth to accommodate the straps which are to be employed. The bottom of the hole is preferably defined by a flat surface intersecting the material of the block between the respective slots 14 to form anode segment end faces such as 23, 24 and 25 in Fig. 4. Two of the anode segment end faces 24 and 25 are shown in greater detail on an enlarged scale in Fig. 5, with a fragmentary view of straps in place and means for shielding the straps in accordance with the invention. Plan views of the straps and shields at either end of the anode are shown in Figs. 2 and 3, respectively.

The straps comprise ribbons or rings 26 and 27 of conductive material. Attached to or preferably integral with the ring 26 are a plurality of tabs which are bent into a U-shape. The horizontal portion of the U is secured and electrically connected to one of the anode segment faces in any suitable manner. Such a horizontal portion 28 of a tab is shown attached to the face 24 in Fig. 5 by means of a small amount of solder or brazing material 58. The vertical portion 29 of the tab is preferably mounted flush with the cylindrical surface of the anode segment and serves to shield the reaction space 12 from the electromagnetic influence of the straps 26 and 27. The ring 27 passes over the horizontal portion 28 and behind the vertical portion 29 of the tab attached to the ring 26. The ring 27 has a plurality of tabs also bent into a U-shape. The horizontal 30 portion of a tab is attached and electrically connected with one of the anode segment faces such as 25. The same tab has a vertical portion 31 which rises flush with the cylindrical face of the corresponding anode segment. The ring 26 passes behind the ring 27 in the neighborhood of the tab 30, 31.

In the embodiment illustrated in Fig. 2, the ring 26 is attached to alternate anode segments and the ring 27 is attached to the segments intermediate to those to which the ring 26 is attached. As shown in Fig. 2, the rings may be split to facilitate assembly or to conform with any desired scheme of interconnection of the anode segments. In Fig. 2 the ends of the straps are shown as separated by slight gaps 59 and 60 whereas in Fig. 3 the ends are shown as joining together at the center of a split tab as at 61 and 62. As illustrated by Figs. 2 and 3, the arrangement and connection of the straps may be different at the two ends of the anode.

The cathode 11 preferably has a coating of thermionically highly emissive material and encloses a heating winding. The cathode assembly may be supported by a pair of heater leads 32 and 33. Each heater lead is in turn supported by a tubular glass seal 34 and a bushing 35. The bushing has a tapered flaring edge 36 to the inner surface of which the glass may readily be sealed.

An output coupling arrangement is provided by means of an inductive loop 37 inserted into one of the resonant cavities through a radial bore 38. The two ends of the loop 37 are connected respectively to the inner and outer conductors of a coaxial output fitting. The outer conductor of the coaxial fitting comprises a cup-shaped member 39 sealed into the hole 38 and supporting a cylindrical conductive sleeve 40. The cup 39 and one end of the loop 37 are mechanically and electrically connected to the anode 10 in any suitable manner such as oven brazing or soldering. The inner conductor of the coaxial fitting comprises a succession of cylindrical conductive members 41, 42 and 43, of which the member 41 has a tapered end which is centrally bored to receive one end of the loop 37 as shown in Fig. 2. The member 43 contains a socket to receive the inner conductor of a coaxial transmission line (not shown). The outer conductor of the transmission line is preferably arranged to slide over the member 40 when the inner conductor is inserted into the socket of the element 43. A glass seal 47 is suitably arranged between the inside of the sleeve 40 and the outside of the member 43 as shown in Fig. 2.

The coaxial output fitting may be protected by a sheath 44 (Fig. 6) having a slot 45 to receive a pin projecting from the coaxial line and the open end of the sheath may be threaded as shown at 63 to receive a retaining ring. The sheath 44 may be attached by means of screws 64 to the flange 46 (Fig. 2) of the cup 39.

For convenience in pumping out the structure to the desired degree of vacuum, a small hole 48 (Fig. 1) is drilled into the anode and a bushing 49, similar to the bushings 35, is fitted around the hole 48. The bushing 49 preferably includes a flared and tapered portion 50 to which may be sealed a glass tube for use in pumping. The glass tube may be sealed off after evacuation in the usual manner to form a tip 51 as shown in Fig. 1.

The bushings 35 and 49 may be externally threaded to receive protecting sleeves 52, 53 and 54, of which 52 and 53 terminate in conductive contact tips 55 and 56 for electrical connections and the sleeve 54 is closed off at the bottom to protect the glass tip 51. A plurality of cooling fins 57 (Fig. 6) are preferably arranged on the exterior of the anode block 10.

The magnetron disclosed is adaptable to being built on any suitable scale of magnitude according to the frequency at which it is desired to operate. In an embodiment that has been built for operation in the neighborhood of 3,000 megacycles (10 centimeters wavelength) the cylindrical borings 13 have a diameter of 0.356 inch and are placed with their centers on a circle of 1.17 inches diameter. The reaction space 12 is of 0.567 inch diameter and the slots 14 are 0.072 inch wide. The diameter of the ledge at the periphery 21 or 22 is 1.058 inches and the ledge is cut to a depth of one-eighth inch. The anode block measures 1.576 inches between the faces 17 and 18 and has an over-all length between the end plates 19 and 20 of 2.6 inches. The cathode diameter is three-sixteenths inch. The straps are one-sixteenth inch wide and 0.02 inch thick and the tabs are 0.13 inch wide.

What is claimed is:

1. A cavity resonator comprising a block of conductive material having a bore therein, said bore having an enlarged portion providing a ledge, and a plurality of conductive straps mounted upon said ledge, each said strap having a plurality of conductive tabs extending radially inward toward the center of said bore, each said tab having a portion extending axially along said bore, and positioned between said straps and the inner edge of said ledge.

2. A cavity resonator comprising a block having a bore therein having a portion of uniform diameter and an enlarged portion with a greater diameter, a plurality of shields in the enlarged portion and flush with the inner surface of the bore portion of uniform diameter to simulate an extension of the uniform diameter into the enlarged portion, a strap within said enlarged portion in a position behind said shields between said shields and the body of the block, and a plurality of metallic tabs connecting said strap and said shields.

3. A cavity resonator comprising a block having a bore therein having a portion of uniform normal diameter, said bore also having an enlarged portion of a diameter greater than the said normal diameter, a strap positioned within the said enlarged portion of the bore and beyond the said normal diameter, and a plurality of tabs attached to said strap, each of said tabs comprising a radially extended portion conductively attached to said block and an axially extended portion substantially flush with the surface of the portion of the bore of normal diameter.

4. A cavity resonator comprising a block having a bore therein including a portion of uniform diameter and having a plurality of axially extended slots radiating outward from said bore, said bore also having a portion of enlarged diameter, a plurality of shields positioned in said enlarged portion between adjacent slots and flush with the surface of said bore portion of uniform diameter, a strap positioned behind said shields and within the limits of said portion of enlarged diameter, and a tab connecting said strap with one of said shields.

5. A resonator comprising a block of conductive material including a plurality of cavity resonators and having a perforation opening into said cavity resonators, said block having at least one face intersecting said cavity resonators and said perforation and having a ledge surrounding said perforation and depressed with respect to said face, a plurality of conductive straps mounted on said ledge and each connected to said block at a plurality of points on said ledge, and a plurality of conductive tabs attached to said straps extending toward said perforation and providing an array of shielding elements between said straps and the said perforation.

6. A resonator comprising a block of conductive material having a central perforation and a plurality of slots and including a plurality of cavity resonators each opening into said central perforation through a different one of said slots, said central perforation being enlarged at one end to provide a ledge, said ledge being divided into a plurality of discrete portions by said slots, a plurality of conductive straps mounted on said ledge and bridged between discrete portions thereof, and a plurality of conductive tabs attached to said straps extending inwardly toward the axis of said central perforation and providing an array of shielding elements between said straps and the central space within said central perforation, whereby the said central space is substantially shielded from the electromagnetic influence of the straps.

7. A cavity resonator comprising a block of conductive material having a central perforation and a plurality of peripheral perforations angularly disposed around said central perforation and opening thereinto through a plurality of individual slots, said central perforation having an enlarged region providing a ledge, a plurality of conductive straps mounted upon said ledge and contained within the enlarged portion of the said central perforation, each said strap being conductively connected to said block at a pair of points upon said ledge, said points being separated by one of said slots, and a plurality of conductive tabs attached to said straps and extending radially toward the axis of said central perforation and having axially extending inner end portions, whereby the space within the central perforation is substantially shielded from the electromagnetic influence of the straps by means of said inner end portions.

8. A cavity resonator comprising a block of conductive material having a central perforation defining a reaction space therewithin and having a plurality of outer perforations around said central perforation and having a plurality of slots each opening into an outer perforation and into the said central perforation, said block also having a ledge surrounding said central perforation at one end of said block, a plurality of conductive straps mounted upon said ledge, each said strap being conductively connected to said block at a plurality of points, any two adjacent points of connection having a slot therebetween and a plurality of conductive tabs attached to said straps and extending radially toward the axis of the block, and having axially extending portions interposed between the straps and the central perforation, whereby the said reaction space is substantially shielded from the electromagnetic influence of the straps.

9. A cavity resonator comprising a block hav-

ing a bore therein including a portion of uniform diameter and having a plurality of axially extended slots radiating outward from said bore, said bore also having a portion of enlarged diameter, a shield having an axially extended surface, said shield being mounted upon said block between adjacent slots and having its axially extended surface flush with the surface of said bore portion of uniform diameter, a strap positioned behind said shield and within the limits of said porton of enlarged diameter, and a tab connecting said strap with said shield.

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