Aug. 18, 1953 C. V. LITTON 2,649,556

MAGNETRON STRAPPING ARRANGEMENT

Filed May 13, 1950

Fig. 1.

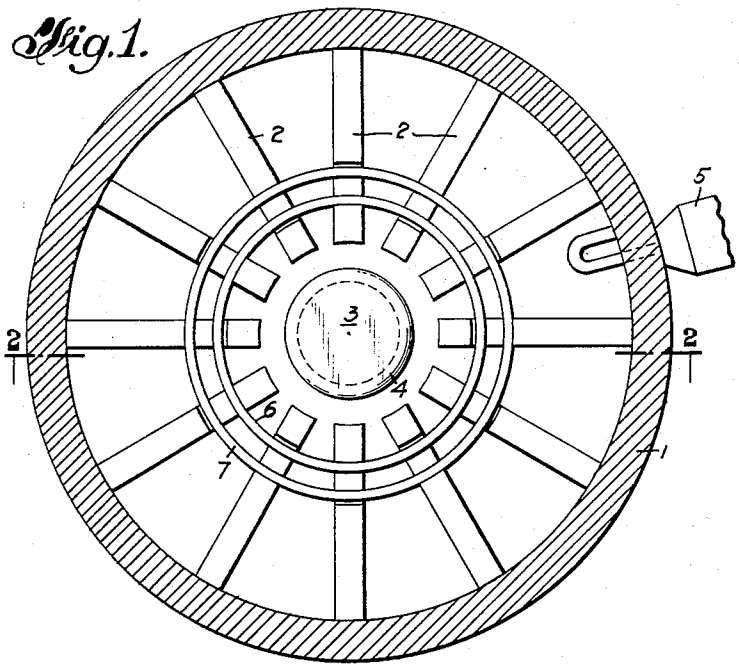


Fig. 3.

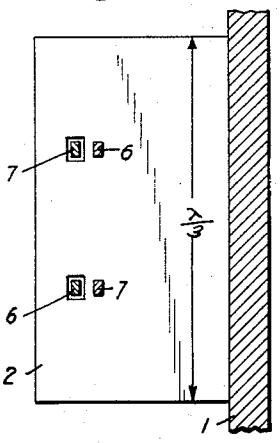


Fig. 4.

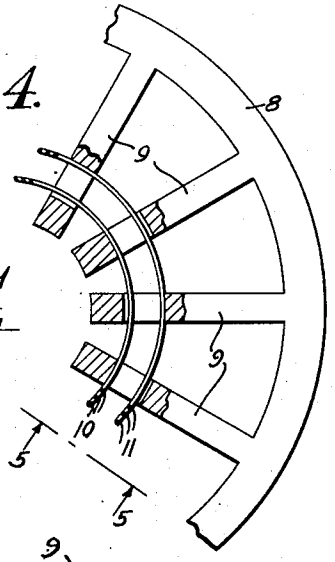
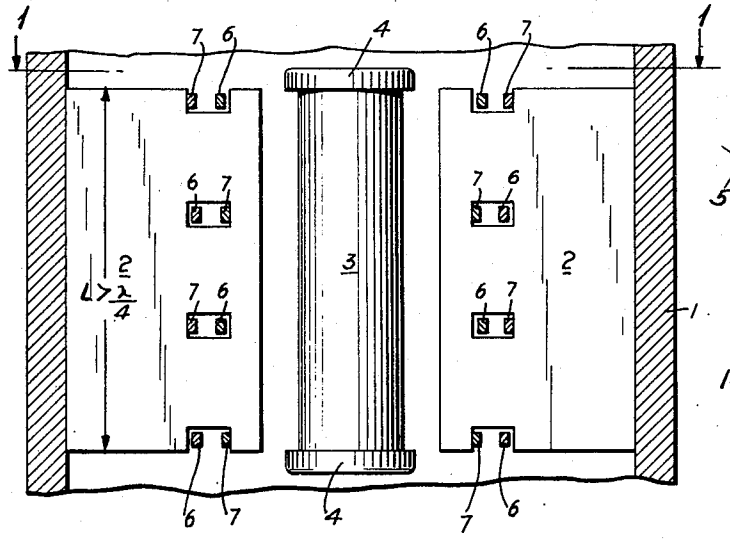


Fig. 2.



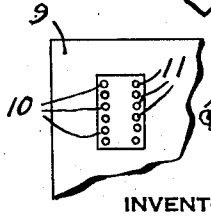


Fig. 5.

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MAGNETRON STRAPPING ARRANGEMENT

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11 Claims. (Cl. 315—40)

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This invention relates to magnetron construction and more particularly to magnetron strapping arrangements.

In multi-cavity magnetrons the walls or vanes separating the cavity resonators are generally interconnected by conductors or straps so that the magnetron will operate in a stable mode. These straps are provided to interconnect alternate vanes, one interconnecting the odd numbered vanes and a second interconnecting the even numbered vanes. In the usual construction the straps are arranged at one or both ends of the vanes.

In the construction of higher power magnetrons the length of the vanes is increased to provide greater power output. With such construction a non-uniform heat distribution occurs which tends to cause overheating at points within the magnetron. This presents a troublesome cooling problem and for this reason it has been customary to make the heat conductive path between the magnetron vanes and the anode cooling medium as short as possible.

Applicant has observed that the heating effect is greater in the area of the anode resonator vanes adjacent the points of connection of the strapping conductors. It is considered that this interconnection of the vanes tends to distort the normally even distribution of the charging current in the vanes, causing a concentration at the points of connection of the straps or connecting rings. This tends to cause non-uniform heat distribution and complicates the problem of anode cooling. In the lower power magnetrons the length of the walls or vanes is relatively small with respect to the operating frequency wave length and the problem is therefore not acute. For increased power the length of the cavities is made greater, for example, more than a quarter wave length and thus the problem is greatly aggravated.

It is an object of my invention to improve the operation of magnetrons by providing a plurality of strapping conductors distributed along the length of the anode cavity walls, spaced apart a distance in the order of a sixth wave length or less at the operating frequency.

In accordance with a feature of my invention, in a magnetron having an outer anode wall portion and a plurality of electrode sections forming a plurality of cavity resonators, the length of the sections being greater than a quarter wave length, there is provided two or more sets of anode strapping conductors spaced along the length of the sections at substantially a sixth

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wave length or less. In some forms only two sets of straps are provided the straps being then spaced from the ends of the electrode sections. It is desirable however to use as many sets of straps as practical, bearing in mind that an opening must be preserved for interaction of the electrons from the cathode with the anode resonators.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

Fig. 1 is an illustration of a transverse cross sectional view of a magnetron along the line 1—1 of Fig. 2, illustrating the anode construction incorporating my invention.

Fig. 2 is a cross sectional view of a portion of a magnetron according to Fig. 1 taken along the line 2—2 thereof;

Fig. 3 is a view of a single magnetron vane illustrating a modified form of my invention;

Fig. 4 is a fragmentary vane of a magnetron showing further modification illustrating a different feature of the invention, and

Fig. 5 is a fragmentary view of the modification of Fig. 4 viewed along the line 5—5.

Turning first to the embodiment illustrated in Figs. 1 and 2, a portion of the magnetron anode is shown consisting of an outer wall 1 having a plurality of radially extending walls, electrode sections, or vanes 2 forming extensions of the anode electrode and providing a plurality of cavity resonators. Coaxially mounted with respect to the anode of the tube is provided a cathode 3 which may have the usual heat shield hats 4. It will be understood that in the complete magnetron a magnet will be provided to produce the controlling magnetic field. However, since this may be conventional and is not a part of this invention, illustration thereof has been omitted for clarity. An output coupling for the magnetron has been shown at 5.

As is well known in multi-cavity magnetrons, the magnetron will tend to operate in unstable modes unless certain provisions are made. To avoid this difficulty the various cavities are coupled together by means of conductors or strapping rings as shown at 6 and 7. Strapping ring conductors 6 serve to interconnect alternate ones of vanes 2 which may be designated as the odd numbered vanes and strapping ring 7 couples together the other vanes 2 which may be desig-

nated as the even numbered vanes. In the usual magnetron construction one of such strapping rings may be provided usually connected at one end of the vanes. Such interconnection will serve to prevent mode shifting in the operation of the magnetron. Some types of magnetron have also been produced with straps at both ends of the vanes for the sake of symmetry.

In high powered magnetrons the vanes 2 are made relatively long so that greater energy may be obtained therefrom. In such cases it has been found that the anode did not heat uniformly but that heat spots tend to develop on the inner ends of the resonator vanes. This presents a difficult problem in heat control since it is necessary to provide sufficient cooling to maintain these portions below a dangerous operating temperature. I have found that this heating tends to be localized in the area adjacent the strapping conductors. It is my theory that this heating is caused by a distortion of the normally evenly distributed charging current within the resonators when no strapping is used. The strapping tends to cause these charging currents to be distorted toward the straps resulting in an uneven heat distribution. I have found that this undesirable effect can be largely mitigated by providing a plurality of strapping conductors 6 and 7 distributed along the length of the resonator vanes. When these vanes are an appreciable fraction of a wave length long, for example, longer than a quarter wave length, an undue concentration of currents from the entire surface may take place.

According to my invention therefore I provide a distribution of these straps 6 and 7 along the length of the vanes such that the spacing between sets of strapping conductors is in the order of a sixth of the operating wave length or less. This results in considerable reduction of spot heating which I consider to be caused by a more uniform distribution of charging current in the vanes due to the distribution of the strap connections throughout the length thereof.

In Fig. 3 is shown a single magnetron vane 2. This vane, may be, for example, in the order of three tenths of a wave length long. Here I have provided simply two sets of strapping conductors 6 and 7 spaced from the ends of the vane 2 at approximately one quarter of the length of the vane. This construction has been found to provide a very satisfactory operation at high frequency with substantially a 10 kilowatt continuous wave output. The strapping so distributed completely removes any tendency of the magnetron to operate in undesired modes even when the numbers of cavities is quite high as for example 20, and the tendency to improper heating at given spots is substantially overcome.

While I have indicated in the systems shown in Figs. 1, 2 and 3 conventional magnetron strapping conductors it may be realized that the strapping conductors carry no current at the wanted mode but may tend to carry considerable energy in the unwanted modes. In order to attenuate the energy at these unwanted modes a modified type of magnetron strapping may be provided as illustrated in Fig. 4. In this figure is illustrated a conventional vane type magnetron anode having an outer wall 8 and vanes 9 providing the usual resonator cavities. The straps for reducing the unwanted mode operation may comprise a plurality of fine filamentary wires 10 and 11 respectively which serve to interconnect alternate odd and even vanes respectively of the magnetron in the conventional manner. These wires may be made for instance of some metal such as tungsten which changes resistivity considerably upon heating. Thus, when energy of unwanted modes is present in considerable quantities the filamentary wires will be heated to high resistivity possibly even to incandescence serving to greatly reduce the quality of the circuit for the unwanted modes and thus to attenuate this energy.

While in Fig. 4 the strapping conductors 10 and 11 have been indicated as being made of a plurality of fine wires a certain amount of attenuation of the energy at unwanted modes may be achieved by simply making these strapping conductors of materials presenting a relatively high resistance.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

What I claim is:

1. An electrode structure for a multiple resonator magnetron having electrode sections connected to an enclosing wall structure to define a plurality of cavity resonators, said electrode sections being more than a quarter wave length long between the end surfaces thereof at the operating frequency, a first plurality of conductor means, spaced from each other along the length of said sections a distance less than a sixth of a wave length at said operating frequency, interconnecting only the odd numbered electrode sections, and a second plurality of conductor means spaced from each other similarly to said first plurality of conductor means interconnecting only the even numbered electrode sections.

2. An electrode structure according to claim 1, wherein each plurality of conductor means comprises two conductors.

3. An electrode structure according to claim 2, wherein said electrode sections are in the order of three tenths wave lengths long at the operating frequency and said conductive means are spaced substantially a quarter of the distance along the length from each end.

4. An electrode structure according to claim 1, wherein said conductor means are substantially equally spaced along the length of said electrode sections.

5. An electrode structure according to claim 1, wherein said conductor means are of a material which increases in resistivity when conducting heavy current.

6. An electrode structure according to claim 5, wherein said conductor means comprise a plurality of filamentary wires.

7. An electrode structure according to claim 6, wherein said wires are of tungsten.

8. A magnetron anode structure comprising a substantially cylindrical body, an even plurality of electrode sections, each greater than a quarter wave length long at the operating frequency, fastened to said body and spaced apart to provide cavity resonators therebetween, said sections having ends substantially in the opposite faces of said anode, a first plurality of conductor rings spaced from each other not more than a sixth wave length and connected to only all the odd numbered sections and a second plurality of conductor rings similarly spaced from said ends

and from one another, and connected to only the even numbered sections.

9. An anode structure according to claim 8, wherein said pluralities are each greater than two.

10. An anode structure according to claim 9, wherein said rings are substantially uniformly spaced along the lengths of said sections.

11. An anode structure in accordance with claim 8, wherein said pluralities are each two conductors, said length being in the order of three tenths wave lengths, said rings being positioned in apertures in said sections near the edge thereof adjacent the magnetron cathode.

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