



1

2,852,719

## TUNABLE MAGNETRON

Paul W. Crapuchettes, Palo Alto, Calif., assignor to  
Litton Industries, Inc.

Application November 29, 1952, Serial No. 323,269

4 Claims. (Cl. 315—39.61)

This invention relates to magnetrons of the multi-cavity resonator type and particularly to magnetrons which are tunable.

Within recent years cavity magnetrons have been developed in which the electrical constants of the cavities could be changed, thereby permitting the tuning of magnetrons over a range of frequencies. The resonant frequency of the magnetron can be changed by varying the resonant circuits of the anode in some manner. Several methods are used, either singly or in combination, to tune magnetrons; one of which consists in employing a "C ring" which adds capacitance between the straps of a ring-strap magnetron to lower the resonant frequency of the mode by an amount, depending upon the position of the C ring. Another method employs a ring termed an "L ring" that is placed over the ends of the cavities and raises the resonant frequency as it is moved closer to the anode block by interfering with the alternating magnetic field that passes through the cavity. A detailed explanation of a combination L-C ring may be found in the U. S. patent entitled "Adjustable Magnetron," No. 2,512,901, filed November 1, 1945, and issued June 27, 1950. Another approach to the tuning problem consists in inserting conducting rods in the cavities parallel to the axis of the cathode. Such rods reduce the effective cross-sectional area of the cavity, thereby reducing magnetic flux and increasing the resonant frequency. Another method for tuning consists of a single pin or plunger which is insertable into one of the cavities to change the characteristics thereof, and since the resonant cavities are closely coupled to each other, it is possible in this way to modify the resonant frequency of the magnetron. A shortcoming of this latter method is that the tuning range is limited because the characteristics of only one cavity is affected.

It is an object of this invention to provide a simple and unique tuning means which permits tuning over a greater range than comparable tuning means heretofore known.

In accordance with an aspect of this invention, there is provided a tunable magnetron comprising a supporting body and a plurality of vanes mounted inside the body integrally therewith; the size and position of the vanes forming together with the body a plurality of resonators determining substantially the mean frequency to which the magnetron may be tuned. The magnetron is tuned by a conductive member having a tuning portion positioned to enter into or egress from two or more resonators.

A highly desirable feature of this invention is the provision of tuning means which simultaneously modifies the electrical characteristics of three resonant cavities, thus greatly improving the tuning range over the pin and plunger type tuners, which can modify the characteristics of only a single cavity.

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 descrip-

2

tion of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a cross-sectional view of a multi-cavity magnetron, the section being taken through what is essentially the axis of symmetry, and showing the tuning element mounted on its guiding structure and the mechanism for adjusting the same to the desired position; and

Fig. 2 is a cross-sectional view looking toward the plane perpendicular to the axis of symmetry of Fig. 1. The figure shows essentially the construction and positioning of the tuning element forming the basis of this invention.

Since the general structure of the magnetron is not part of my present invention, but is described in the aforementioned patent, it will only be briefly described here. Referring to the figures, the reference character 1 represents the body of the magnetron to which other parts are brazed or otherwise suitably fastened to form a structure capable of being evacuated. On a cylindrical section 2 is mounted the cathode support assembly comprising the necessary members to properly support the cathode 3 and to supply the cathode with suitable electrical energy. The cathode may preferably comprise two filament windings of thoriated tungsten so mounted and energized as to constitute a bifilar filament. One end of the filament is shown connected to a power supply lead 4. Pole pieces 5, 6 are provided to supply the necessary magnetic flux parallel to the axis of the cathode in the well known manner.

Oscillator energy from the magnetron is extracted for useful work by coupling a waveguide 7 to one of the cavities through an impedance transformer. The transformer may comprise a pair of ramps 8 positioned within a horn shaped member 9. Adjacent to the cavities, the ramps are close together and, therefore, of low impedance to substantially match the impedance of the cavities. The ramps diverge outwardly and as they approach the waveguide 7 their separation and the internal dimensions of the horn determines their impedance which is designed to substantially match that of the waveguide. The principles underlying this method of coupling energy from the magnetron may be found in the above mentioned patent.

The resonating cavities of the magnetron are formed by brazing a plurality of vanes 10 around the inner diameter of the body 1 as shown. Each cavity may constitute, in effect, a quarter wave line which when resonating has a magnetic flux concentration adjacent its shorted end, the short being the inner wall of the body 1. As is well known, when the magnetron is in operation, the instantaneous operating potentials of the adjacent vanes which form the cavities are equal and opposite. That is, the currents in adjacent cavities are of opposite phase and the currents in alternate cavities are in like phase. To closely couple the alternate cavities together and to cause them to oscillate in effect as a single cavity, the alternate vanes are fastened together in a known manner by conductive straps 11 and 12 as shown in Figures 1 and 2.

The magnetron structure as described above constitutes a known structure, the details of which may be found in the above-mentioned patent. In accordance with the present invention there is provided, in addition to the above defined structure, a novel tuning means which modifies the electrical characteristics of a plurality of cavity resonators to permit tuning thereof. The tuning means is housed in an assembly generally indicated at 13 (Fig. 1) which is fastened to one side of the body 1. The housing 13 is preferably made of a heat conducting material such as copper. A conductive member in the form of a paddle 14 is attached to a supporting member 15, which in turn is brazed to a cup-shaped member 16. The paddle member 14 is preferably a flat rectangularly

3

shaped member. However, the tuning portion of the paddle member has a curved forward wall corresponding to the curvature of the magnetron wall and the end walls of the paddle member are angularly disposed parallel with respect to the adjacent complete vanes. Thus, it is seen that the geometrical discontinuity is maintained at a minimum during the tuning operation and practically non-existent when the paddle member is withdrawn so that the wall thereof is aligned with the wall of the magnetron.

A platform 17 is sealed to the body portion 1 and has a receptacle 18 for accommodating the supporting member 15. The movement of the paddle tuning member 14 within the cavity does not affect the evacuated condition of the resonator cavities by virtue of a Sylphon bellows 19 being hermetically sealed at one end 20 to the platform 17, and at the other end 21 to the cup-shaped member 16. A rod 22, which is movable rotatably but not longitudinally, threadedly engages the interior of the inner portion 23 of the cup member 16. Thus, when the rod 22 is rotated, the cup member 16, supporting member 15 and paddle tuning member 14 move unitarily in the longitudinal direction. That is, into or out of the cavity. The upper portion of the rod 22 threadedly engages a shoulder member 24 against which a plurality of washers 25 act to seal tightly the hollow portion 26 of the cylindrical housing 13. An end member 27 closes the housing 13 and is positioned by a thread engagement with the tubular portion of the housing 13. A set screw 28 may be used to prevent the rod 22 from rotation.

A plurality of the vanes 10, defining the cavity resonator of the magnetron, have a cut out portion 29 (Fig. 2), whereby the tuner paddle 14 may enter into or egress from without contacting the sides of the vanes. By way of illustration, two vanes are provided with cut out portions, thereby permitting tuning of three cavities simultaneously. It is important to recognize that the clearance between the paddle member and the cut out in the vanes is critical. If this clearance is made very small, then the tuner can be made to tune more than 500 mc. at 9000 mc. As the paddle tuner is moved into the cavity, it blocks off the normal path of flux, thus reducing the inductance of the cavity and, raising the frequency. Therefore, if leakage between the paddle member and cut out is great, a greatly lessened tuning range will result. For best operation the clearance should be as small as

4

possible, while maintaining separation between the paddle tuner and resonator vanes.

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 is claimed:

1. A tunable magnetron comprising a supporting body, a plurality of vanes mounted inside said body integrally therewith forming a plurality of resonators, the size and position of said vanes determining substantially a normal frequency at which the magnetron may operate, and means mounted on said body for tuning said magnetron over a given frequency range, said means characterized by a single conductive member having a tuning portion of a width greater than one resonator cavity width, means for mounting said member for linear radial movement to enter into and egress from at least two adjacent resonators at an intermediate point on a longitudinal wall of said resonator body, and means for moving said member to tune said magnetron.

2. A magnetron according to claim 1, wherein said plurality of vanes constituting the tuning resonators have a cut out portion along one longitudinal edge thereof, and said tuning portion being adapted to enter into and egress from the cut out portions of said vanes.

3. A magnetron according to claim 1, wherein said tuning portion of the conductive member comprises a forward wall having a curvature corresponding to the radius of curvature of said body and angularly disposed end walls parallel to adjacent vanes, whereby the geometrical discontinuity is maintained at a minimum during the movement of said tuning member.

4. The magnetron according to claim 2, wherein the thickness of the tuning portion is only slightly less than the cut out portion of said vanes.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

|           |              |               |
|-----------|--------------|---------------|
| 2,418,469 | Hagstrum     | Apr. 8, 1947  |
| 2,419,572 | Laico et al. | Apr. 29, 1947 |
| 2,559,506 | Kursham      | July 3, 1951  |
| 2,615,156 | Smith        | Oct. 21, 1952 |