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2,233,261

MAGNETRON DISCHARGE TUBE AND METHOD OF OPERATING THE SAME

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Fig. 1

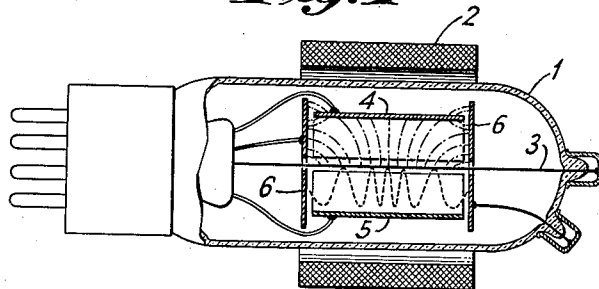


Fig. 2

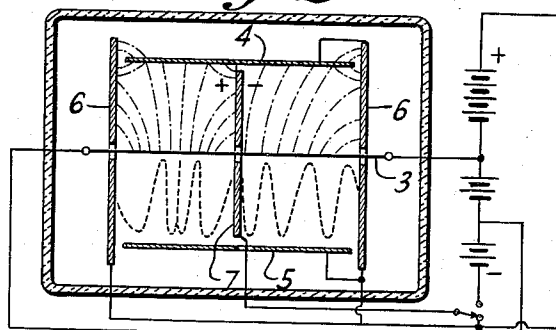


Fig. 3

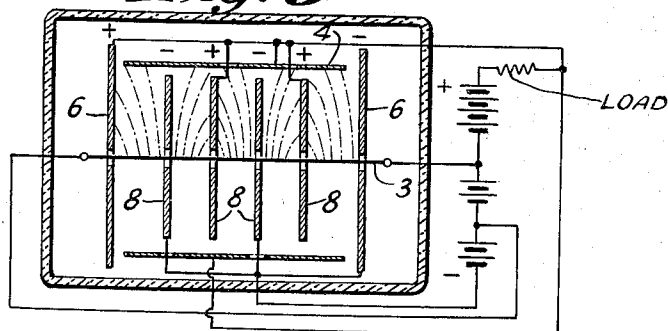
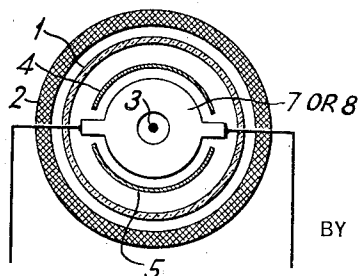


Fig. 4



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METHOD OF OPERATING THE SAME

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8 Claims. (Cl. 250—27)

This invention relates to a tube by means of which electrical oscillations, more especially those of a very high frequency, can be produced and received, respectively, with the aid of a co-axially directed magnetic field.

The invention has for its object to provide a suitable structure in an electron discharge tube for controlling the transit of electrons across the discharge zone between a cathode and an anode system. A further object of the invention is to improve the conditions under which a magnetron discharge tube may be operated particularly by controlling an electrical cross field in the discharge zone. The invention also comprehends a method of operating a magnetron discharge tube which includes the step of modulating the oscillatory energy generated within the tube.

For a better understanding of the physical phenomena underlying the invention, it should be borne in mind that a magnetron transmitter—i. e., a magnetron tube operating in a manner known as such upon a high frequency oscillation system, whereby the anode may be a closed cylinder or divided into two or a greater number of segments or groups of segments,—operates with a higher efficiency if the outer magnetic field is not directed exactly coaxial, but if the symmetry axis of the tube is turned at an angle of a few degrees with respect to the magnetic lines of force. The explanation of this phenomenon will be found if the magnetic field vector is divided into two components at a right angle to each other, the one having an axial and the other one a radial direction. While the axial component acts in the same manner as if the tube were exactly oriented in the direction of the magnetic lines of force, the radial magnetic component causes an axial movement of the electrons so that under the influence of both components the electrons move along helical paths. In order to collect and to lead off the electrons, the plate cylinder is suitably closed up at both ends by means of end plates connected with the cathode. The favorable effect as regards the magnitude of the high frequency energy lies in a spreading out of the negative space charge consequent upon the deflecting action of the end plates. The electrons are thus caused to travel in helical paths.

The accurate orientation of the magnetron in accordance with a predetermined angle relative to the magnetic lines of force, which angle is not constant, but varies greatly in accordance with the operating and tuning conditions, involves an undesirable inconvenience, and thus the idea was

conceived of obtaining the axial component of the electron movement by means of an additional electrical field in place of a magnetic field component. To this end, in the magnetron tubes an auxiliary potential is impressed upon the above-mentioned end plates by which the plate cylinder is closed up. In this manner the electrostatic field lines which otherwise have a radial direction in the anode cylinder are deflected in the manner presently to be described.

In the following part of the specification reference is made to the accompanying drawing in which:

Figure 1 illustrates in longitudinal cross section a magnetron discharge tube inclusive of end plates,

Figs. 2 and 3 show in longitudinal cross section the electrode structures of two preferred embodiments; and

Fig. 4 shows a transverse cross section through the tube.

Referring to Fig. 1, a magnetron discharge tube is shown having an envelope 1 surrounded by a magnetic field coil 2, and having a cathode 3 coaxially disposed within a cylindrical anode system composed of two anode segments 4 and 5. In addition to these usual electrodes I provide two end plates 6 upon which it is best to impress a potential which is positive relative to that of the cathode but is less positive than that of the anodes. The application of these relative potentials produces lines of electric force substantially as shown in the upper part of the figure. These lines of force can be defined by their two components, one being radial and the other axial. A similarity exists between this arrangement and the magnetic field produced by an exactly coaxially directed magnetic field from an external influence such as the field coil 2 acting alone and in the absence of the end plates. In both cases there is an axial acceleration force applied to the electrons, but in the present embodiment an additional acceleration is obtained, the same as when the axis of the external magnetic field is inclined with respect to the electrode axis. The end plates have an electrostatic influence which proves to be of decided advantage because of the ease with which the conditions for optimum behavior of the tube can be adjusted by a suitable choice of potentials applied to the end plates.

A more accurate investigation of the field distribution, shown in the upper half of Fig. 1, indicates, however, a marked difference as compared with the two magnetic field line com-

ponents. While in the obliquely disposed magnetic field the radial and axial components are constant throughout the anode cylinder, they no longer have the same values everywhere if subjected to the influence of the electrostatic field caused by the end plates, but they depend on the disposition of each element in respect to the others. It can be immediately seen that the disturbance of the original radial field within the anode cylinder is greatest in the vicinity of the end plates, and that a neutral zone is obtained in the center plane of the tube. The influences of the two end plates are cancelled out in the said neutral zone so that at this place only the original purely radial field remains. Therefore, the pitch of the screw shaped path of all electrons will be greater the more the electrons approach the end plates. This characteristic is indicated by the dotted lines in the lower half of Fig. 1, the lines being projections of the spiral paths upon the plane of the drawing. Therefore, a dispersion of the space charge does not occur at all in the center space of the anode cylinder, and it is not possible to obtain an optimum operating state throughout the length of the electrodes.

This disadvantage will now be eliminated by the invention in that in the interior of the plate cylinder one or several radial auxiliary plates 7 are disposed. The inner and outer radii of these plates are such as to provide minimum clearances away from the cathode and anode. If these plates have suitable auxiliary potentials the result will be that the axial electrostatic field components practically extend uniformly between these auxiliary electrodes over the total axial length of the electrode system.

In Fig. 2 there is shown a tube in cross section in which the idea of the invention is embodied, said tube being obtained by inserting a single radial auxiliary electrode 7 in the center plane of the tube according to Fig. 1. Now, if this auxiliary electrode 7 has the same positive potential as the two end plates 6, then the action as regards the shape of the field is in principle the same as if the tube of Fig. 1 were reduced to one-half its original length since the two tube halves separated by the center plate 7 can be considered individually. Consequently the field distortions are much greater, but the pattern remains principally the same as before as seen from the left part of the field lines and electron paths of Fig. 2. A neutral center zone remains, however, between the center plate 7 and each end plate 6.

As a modification of the above described arrangement the auxiliary plate 7 may have impressed thereon a negative potential relative to the cathode. All electrical potential lines are thereby deflected away from the auxiliary plate and towards the positive end plates 6, as shown in the upper right hand part of Fig. 2. The neutral zone now disappears. By a proper choice of the voltage conditions the electrical field between the center plate 7 and each end plate 6 can be made almost homogeneous so that the electron paths have a constant pitch. At any rate through this measure the space charge can be uniformly dispersed in the entire anode space in the same manner as is the case when the tube is inclined relative to the magnetic field.

The homogeneity of the electrical field is from the outset best assured if the distance between auxiliary electrode 7 and end plate 6 is small compared with the distance between cathode

and anode. In order to fulfill this requirement in case of a longer electrode system, I have found it expedient to adopt the arrangement shown in Fig. 3, wherein several radial plate electrodes 8 are inserted. These auxiliary plates 8 may again have either identical positive bias potentials impressed upon them or they may be alternately biased positively and negatively. The potential conditions in the last mentioned case are indicated in Fig. 3. It is seen that the electrons emitted from all points of the filament must describe screw lines having the same pitch, whereby it is immaterial as regards the functioning of the entire tube if the axial direction of the electron movement is opposite in the individual interspaces between the plates. The mechanical mounting of several such plates inside the plate cylinder is particularly simple when the anode is slotted, since then the supporting wires can be introduced through the slots between the anode halves and connected with the auxiliary plates 8 as shown in Fig. 4.

Finally, it should be remarked that the idea known as such of modulating a magnetron transmitter by controlling the potential of the end plates can also be applied to the present magnetron tube having several auxiliary electrodes, and the modulation of all auxiliary plates including the end plates may be carried out either in equal phase such as is suitable when all plates have the same bias potential, or the two groups of the auxiliary electrodes differing from each other in view of their negative and positive bias potentials are modulated in opposite phase.

The insertion into the interior of the plate cylinder of the auxiliary electrodes claimed in the present invention does not depend on the particular structure of the magnetron transmitter herein shown, but can be applied to any magnetron tube. Furthermore, it is not necessary that the anode have a cylindrical shape nor that the anode segments be arranged about a cylindrical surface. In fact, any anodes confining a space forming a parallelepiped, may be employed. In the latter case, the auxiliary plates should have suitably a rectangular or polygonal shape so as to conform with the available space within the anode walls.

Having thus described my invention, what I claim is:

1. A circuit arrangement comprising a magnetron discharge tube having a cathode, an anode, end plates and at least one intermediate plate disposed parallel to the end plates and perpendicular to the cathode, means for causing electrons to describe helical paths between the cathode and anode, said means being operative to apply a potential to the end plates which is intermediate between the respective potentials of the cathode and anode, and means for constantly biasing the intermediate plate either positively or negatively with respect to the end plates.

2. A magnetron discharge tube having a linear cathode, a cylindrical anode system surrounding said cathode, means for producing a magnetic field in the discharge zone of said tube, end plates substantially enclosing the zone of electronic discharge from the cathode to the anode system, and a plurality of intermediate plates extending radially about the axis of the cathode, direct current biasing means for producing differences of potential on each end plate with respect to an intermediate plate adjacent thereto, and means for applying modulating potentials of a refer-

ence phase to alternate ones of said end and intermediate plates while applying said modulating potentials of a phase opposite to said reference phase to the remaining ones of said end and intermediate plates.

3. A magnetron discharge tube having a centrally disposed linear cathode, a cylindrical anode system coaxially surrounding said cathode, an end plate disposed at each end of the anode system, an intermediate plate within the anode system and disposed parallel to the end plates, means for applying a magnetic field to the discharge zone of said tube, and terminals for applying different direct current operating potentials to said electrodes and to said end plates and intermediate plate, said end plates and intermediate plate being co-operable with said field producing means and being suitably biased with respect to the potentials applied to the cathode and anode system whereby the electrons emitted by the cathode are caused to describe helical paths.

4. A device in accordance with claim 3 and having a plurality of intermediate plates disposed perpendicular to the axis of the cathode-anode system, and means for impressing upon said intermediate plates potentials which are alternately positive and negative with respect to the cathode and always less positive than the potential applied to the anodes.

5. A device in accordance with claim 3 and

having supports for said intermediate plate extending through slots intervening between different portions of said anode system.

6. A magnetron discharge tube having the usual cathode and anode electrodes, and means for producing a magnetic field within the discharge zone thereof, means for applying operating potentials to said cathode and anode electrodes, a plurality of plates disposed in planes perpendicular to the electrode axis and means for impressing different direct current biasing potentials and modulating potentials upon said plates.

7. A device in accordance with claim 6 and having means for applying modulating potentials of a reference phase to alternate ones of said plates and of a phase in opposition to said reference phase to adjacent ones of said plates.

8. A magnetron discharge tube comprising a linear cathode, an anode, end plates and a plurality of intermediate plates disposed parallel to the end plates and perpendicular to the cathode, and means for causing electrons to describe helical paths between the cathode and anode, said means being operative to apply constant potentials to said end plates and to said intermediate plates, alternate ones of said plates being rendered positive with respect to the cathode and the remaining plates being rendered negative with respect thereto.

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