ELECTRIC DISCHARGE DEVICE AND SYSTEM

Filed Dec. 5, 1945 2 Sheets-Sheet 1

Fig. 1.

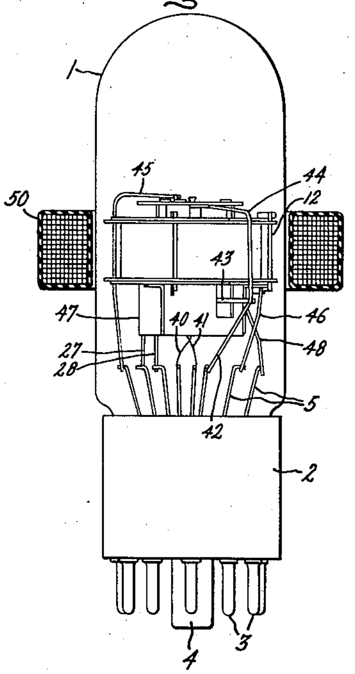


Fig. 2.

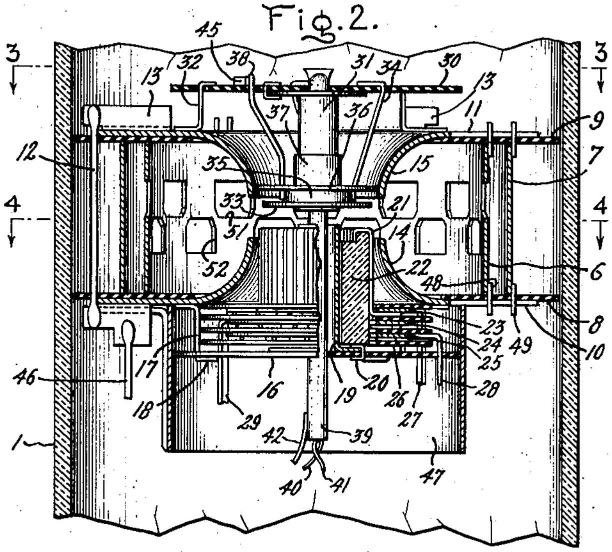


Fig. 3.

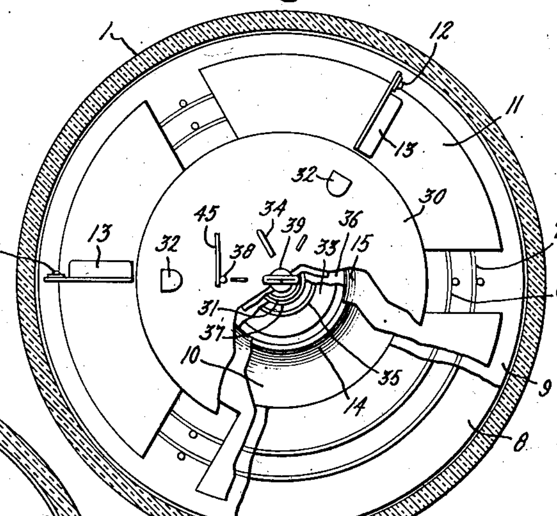
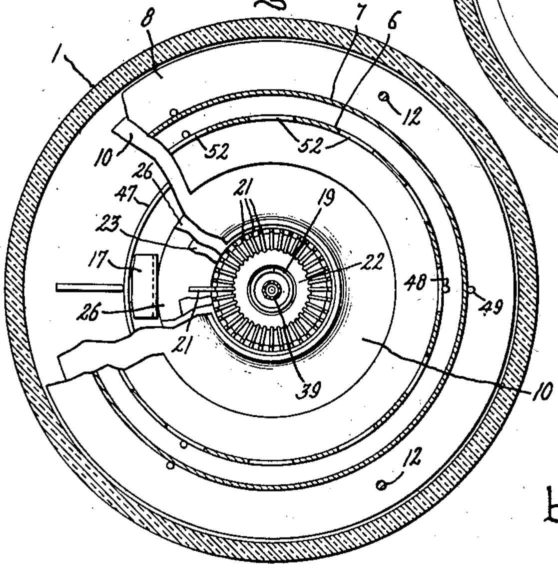


Fig. 4.



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Feb. 8, 1949. F. M. BAILEY 2,461,250

ELECTRIC DISCHARGE DEVICE AND SYSTEM

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Fig. 5.

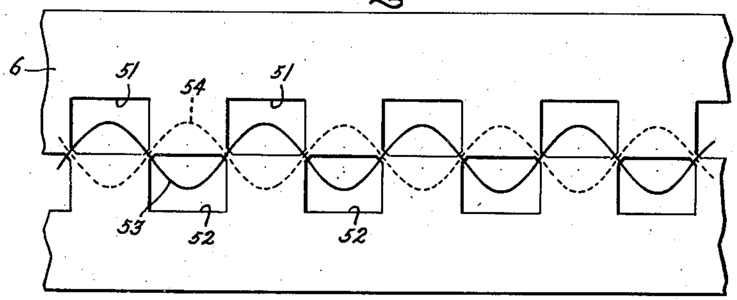


Fig. 6.

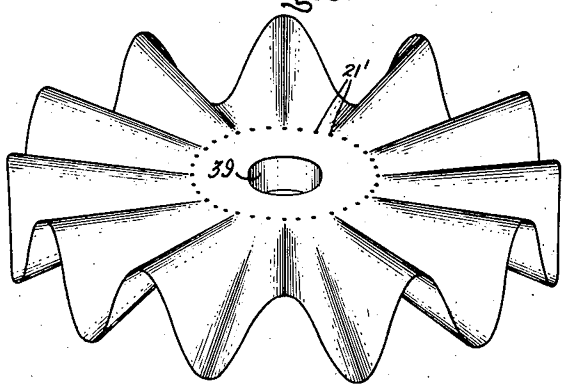


Fig. 7.

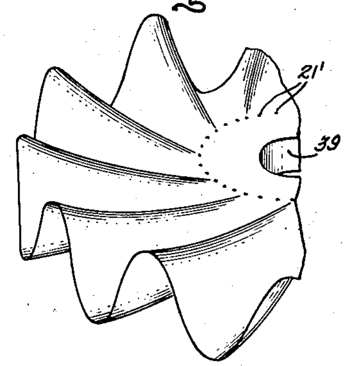


Fig. 8.

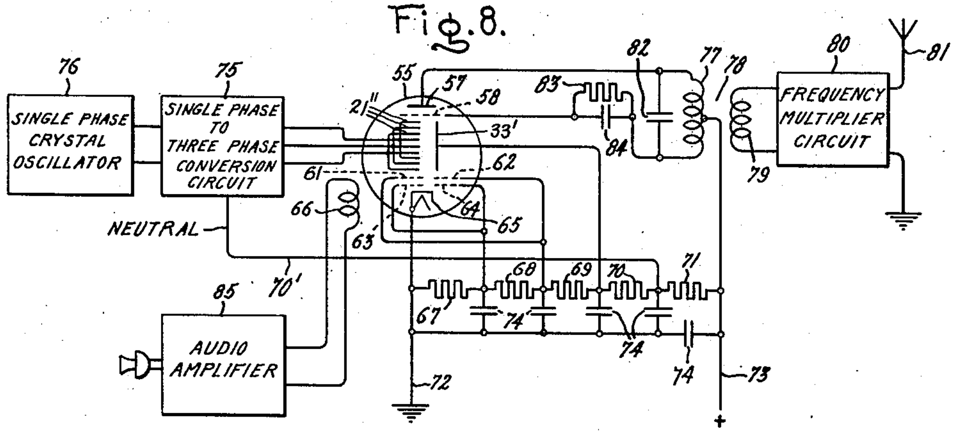
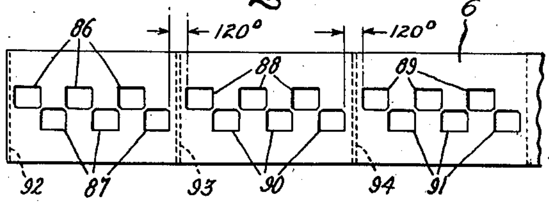


Fig. 9.



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ELECTRIC DISCHARGE DEVICE AND SYSTEM

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Application December 5, 1945, Serial No. 632,977

17 Claims. (Cl. 250—27.5)

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My invention relates to improved electric discharge devices and systems therefor, and particularly to improved phase modulation discharge devices and systems.

In a known system of phase modulation a polyphase carrier wave is employed for energizing two sets of control electrodes which together with suitable focusing electrodes produce a disk of electrons having a ruffled edge. The ruffle or deflection at the edge of the disk is essentially sinusoidal in form. Due to the polyphase energization of the system of electrodes the sinusoidal wave advances around the electron disk at the carrier frequency. An appropriate electron collecting electrode system receives the electrons of the disk selectively in accordance with the progression of the sinusoidal wave at the edge of the disk to produce an output voltage at the carrier frequency. This voltage is modulated by a modulating magnetic field perpendicular to the plane of the disk of electrons to advance or retard the sinusoidal wave at the edge of the disk with respect to its unmodulated position. As will be readily appreciated by those skilled in the art, an alternating modulating signal is effective continually to advance and retard the phase position of the sinusoidal wave at the edge of the electron disk.

An object of my invention is to provide such a phase modulating electron discharge device having certain operating advantages and which, in addition, is less difficult to manufacture.

In accordance with an important aspect of my invention, the polyphase carrier voltage supply is provided with a neutral terminal and the discharge device is provided with one set of control electrodes for energization from the polyphase carrier voltage supply, and with a relatively simple control electrode structure for energization in accordance with the voltage of the neutral terminal of the carrier voltage supply.

It is an object of my invention to provide a new and improved electric discharge device and system.

It is another object of my invention to provide a new and improved electric discharge device for producing phase modulation of a carrier wave.

It is a still further object of my invention to provide a new and simple electrode structure for discharge devices of the type described above.

Further objects and advantages of my invention will become apparent from the following description when taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

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In the drawings, Fig. 1 is an elevational view of an electric discharge device embodying my invention; Fig. 2 is an enlarged view, in section, of a portion of the electric discharge device shown in Fig. 1 showing in detail the electrode assembly; Fig. 3 is a sectional view taken along the line 3—3 of Fig. 2; Fig. 4 is a sectional view taken along the line 4—4 of Fig. 2; Fig. 5 is a development of one of the electrodes of the devices shown in Figs. 1 to 4; Figs. 6 and 7 illustrate schematically the electron pattern under certain operating characteristics of the device; Fig. 8 illustrates diagrammatically a frequency modulating system embodying my invention; and Fig. 9 is a development of a three-phase collecting electrode system.

Referring now to Figs. 1 to 4 of the drawings, I have shown my invention embodied in an electric discharge device including an evacuated envelope 1 to the lower end of which is secured a conventional base 2 including a plurality of contact prongs 3 and an orientation protuberance 4. The electrode assembly of the discharge device which is supported from the stem press (not visible in the drawing) by lead-in conductors 5 will now be described with particular reference to the enlarged views of Figs. 2 to 4. The assembly includes a pair of concentrically arranged anode or collecting electrode members 6 and 7 which are clamped between a pair of mica washers 8 and 9 by the planar marginal portions of a pair of focusing and modulating electrode elements 10 and 11. The electrodes 10 and 11 and washers 8 and 9 are clamped together at spaced points by suitable connecting links 12, which are secured at opposite ends to angle members 13 which are, in turn, secured to the marginal portions of the electrode members 10 and 11. The members 10 and 11 are formed of a material of reasonably high permeability such as steel, and comprise planar marginal portions and centrally located circular flange portions 14 and 15 defining central openings of gradually decreasing diameter. The members 10 and 11 are assembled with the flange portions 14 and 15 directed inwardly to provide a control gap between the inner ends thereof.

A polyphase control electrode assembly is positioned in the opening defined by the flange portion 14 of electrode 10 by means of a mica washer 16 supported from the lower side of the electrode 10 by three supporting members 17, which are welded or otherwise secured to the flange portion 14 and which are provided with projections 18 bent over against the outer surface of the washer 16. The electrode assembly includes a hollow cylindrical focusing electrode 19 having a flanged lower end portion 20 clamped to the inner surface of the washer 16. Surrounding the focusing electrode is an assembly of control electrodes, which, in the specific embodiment illustrated, includes thirty-six wire-like elements 21 supported in a circular array about the focusing electrode and supported by an insulating cylinder 22. Each of the wire-like electrodes includes a radially extending control portion, which is positioned on the upper end of the insulating cylinder 22. An end portion of each of the conductors 21 is bent downwardly over the inner edge of the insulating cylinder to position the electrodes, while the other end of each conductor extends downwardly along the outer surface of the cylinder 22.

The particular tube illustrated is designed for energization from a three-phase carrier voltage supply and the electrode members 21 are, therefore, arranged in three sets, with the individual conductors each conductively connected together and mutually insulated with respect to the conductors of the other sets. In order to accomplish this electrical connection, each of the conductors 21 is provided with a radially extending portion for connection with a conducting disk. As illustrated in the drawing, every third conductor is connected with a conducting apertured disk 23. The conductors adjacent these conductors on one side are connected with a second conducting disk 24 and the remaining conductors are connected with a third disk 25. These disks are insulated from one another and from the electrode 11 by suitable insulating disks 26. The disks 23, 24 and 25, each provides a common terminal for the respective set of conductors, there being three sets. These disks and the respective sets of conductors, which are mutually insulated, are connected with different ones of the lead-in conductors 5 by conductors 27, 28 and 29, respectively. The radially extending portions of electrodes 21 connected with the different treminal disks 23, 24 and 25 are located at different levels so that the stacked arrangement of terminals illustrated is provided.

An electrode assembly is supported from the upper electrode 11 in a manner similar to that just described in connection with the lower electrode 10. The upper assembly includes a supporting mica washer 30 to which is secured a cylindrical focusing electrode 31, which is identical with the focusing electrode 19 of the lower assembly. The washer 30 is supported from the disk 11 by suitable members 32, which may be of the same construction as the members 17. In the upper assembly a single planar electrode 33 of annular form and having a surface substantially co-extensive with that occupied by the radial portions of the wire-like electrodes 21 is provided. This electrode is supported concentrically, and in insulated relation, with respect to the focusing electrode 31 by means of a plurality of supporting wires 34 (three in the illustrated embodiment), which are secured to an upwardly extending collar 35 on the electrode 33, and which are bent over at their upper ends to engage the upper surface of the mica washer 30. The wires 34 clamp the electrode 33 against the lower surface of an insulating washer 36, which is held in position on the focusing electrode 31 by collar 37 secured to the outside of the focusing electrode 31. The washer 36 centers the focusing electrode 31 and the control electrode 33 with respect to the electrode 10. A supply connection for the control electrode 33 is provided by a conductor 38 which extends through the upper washer 30.

A source of electrons is provided in the region between the inner ends of the focusing electrodes 19 and 31 to radiate electrons outwardly radially between the upper ends of the control electrodes 21 and the planar electrode 33 to form a disk of electrons. This source is provided by an indirectly heated cathode sleeve 39, which is supported concentrically within the focusing electrodes 19 and 31 by means of the insulating washers 16 and 30.

The cathode may be provided with an oxide coating and heated by an insulated heater element received within the sleeve 39 and provided with terminal conductors 40 and 41, which extend from the lower end thereof. The terminal conductors 40 and 41 are connected with separate ones of the lead-in wires 5 and the cathode sleeve is connected by conductors 42 to one of these lead-ins.

Upper focusing electrode 31 is connected with lower focusing electrode 19 and to a lead-in conductor 5 by conductors 43 and 44 shown in Fig. 1. The upper planar control electrode 33, which in operation is connected with the neutral of the polyphase carrier supply voltage, is connected to a lead-in conductor 5 by a conductor 45, shown in Fig. 1, which connects with conductor 38.

The upper and lower focusing and modulating electrodes 10 and 11 are electrically connected together by the links 12 and to a lead-in conductor 5 by a conductor 46 secured to one of the angle members 13.

A cylindrical shield 47 of substantially the diameter of the lower supporting washer 16 is secured to the lower electrode 11 and electrically connected thereto. The member 47 shields the conductors 27, 28 and 29 which are adapted to be energized from the polyphase carrier supply voltage from the output connection which are connected respectively with the anodes or collecting electrode members 6 and 7.

In Fig. 1 only the supply conductors 27 and 28 connected with the polyphase electrode system are visible, and only conductor 48, which is connected with the collecting electrode 6, is shown on the exterior of the shield member. It will be understood that the conductor 49 of Fig. 2 connects the collecting electrode 7 with a separate lead-in conductor 5 and that the conductor 29 is connected with a lead-in conductor.

The modulation of the output voltage appearing across the collecting electrodes 6 and 7 is effected by a magnetic field produced between the opposed end portions of the flanges 14 and 15 of the modulating and focusing electrodes 10 and 11. As indicated earlier in the specification, these members are formed of a material of high permeability and provide a magnetic circuit for a modulating coil 50 which surrounds the envelope of the device in the region of the outer edges of the electrodes 10 and 11. They serve to carry the magnetic flux of coil 50 inward and to concentrate it at right angles to the electron disc in a circular region just outside of and between the peripheries of planar electrode 33 and the electrode assembly 21, 22.

In order that the electrons may be collected selectively by the electrodes 6 and 7 in accordance with the deflections produced by the various electrodes of the control system, the inner collecting electrode 6 is provided with two sets 51 and 52 of substantially rectangular openings. As indicated in the drawing, the openings of both sets are of equal size and are staggered with respect to each other on opposite sides of a median line. The spacing between adjacent openings in each set is equal to the width of the openings so that each opening of one set is opposite a space between adjacent openings of the other set.

The manner in which the electric discharge device of the illustrated embodiment of my invention operates to phase modulate a carrier voltage wave will now be briefly described. The electrons emitted from the central portion of the cathode sleeve 39 pass radially outwardly between the opposed ends of the cylindrical focusing members 19 and 31 and through the region bounded on one side by the annular planar electrode 33 and on the opposite side by the polyphase system of control electrodes including the wire-like control members 21. The electrons next pass between the opposed ends of the focusing and modulating electrodes 10 and 11 and continue to the collecting electrodes 6 and 7. The first focusing electrodes 19 and 31 assist in neutralizing the space charge around the cathode and also tend to confine the electrons to a relatively narrow region in an axial direction. With the control electrodes 21 connected to provide a three-phase system, a rotating electrostatic field is produced in the region between the radial portions of these electrodes and the face of the annular electrode 33, which latter electrode is adapted to be connected to the neutral of the carrier voltage supply and which may therefore be termed a neutral plane electrode. This field is effective to produce a deflection of the electrons in an axial direction and provide a sinusoidal ruffle at the edge of the electron disc having a space distribution determined by the space distribution of the control electrodes 21. With the thirty-six electrodes provided in the illustrated embodiment, the edge of the disc takes the form of a sinusoidal ruffle made up of twelve complete cycles. A diagrammatic representation of the electron disc is shown in Fig. 6 in which the wall bounding the opening in the center represents the surface of the cathode 39 and the control electrodes 21 are indicated diagrammatically by a circumferential array of equally spaced dots 21'. The ruffled disc is brought to a relatively thin edge by the electrostatic focusing action of the electrodes 10 and 11.

The manner in which the electrons are selectively received by the collecting electrodes 6 and 7 will be readily understood from a consideration of Fig. 5 in which a portion of the electrode 6 has been developed.

Referring to Fig. 5, two sinusoidal waves 53 and 54 having the spacial distribution of the wave at the edge of the electron disc have been represented with respect to the developed portion of the electrode 6. The wave 53 represents the edge of the electron disc at an instant when essentially all of the electrons pass through the openings 51 and 52. Under these conditions the voltage of the collecting electrode 7 is a maximum and the voltage of the electrode 6 a minimum. The dotted curve 54 represents the edge of the disc displaced 180 degrees with respect to the edge of the disc represented by the curve 53. It will be noted that with this displacement essentially all the electrons are collected by the electrode 6 and that none of the electrons passes through the openings 51 and 52 to be collected by the electrode 7. Under these conditions, the voltage of electrode 6 is a maximum and the voltage of electrode 7 a minimum. From this description it will be apparent that the number and size of the openings 51 and 52 are correlated directly with the number of control electrodes of the polyphase electrode system and the number of phase groups in which they are arranged. The dotted curve 54 represents the edge of the disk at an interval of time later than the curve 53 corresponding to a half cycle at the carrier frequency. In other words, the voltage of each of the control electrodes 21' positioned opposite the crests of the waves as illustrated in Fig. 6 have changed from a positive maximum to a negative maximum during the interval of time during which the edge of the disc has changed from the configuration represented by curve 53 to that represented by curve 54.

In addition to the change in shape of the electrons at the edge of the disc due to the rotating field produced by the polyphase system of electrodes and the neutral plane electrode 33, the wave at the edge of the disc may be advanced or retarded by the application of voltage to the modulating coil 50 which produces a magnetic field between the opposed ring-like edges of the focusing and modulating electrodes 10 and 11. As will be understood by those skilled in the art, an axial magnetic field will deflect the electrons tangentially. A diagrammatic representation of the effect on the electron disc of a unidirectional magnetic field of predetermined magnitude is illustrated in Fig. 7 where the edge portion has been rotated in a clockwise direction with respect to the electrons making up the inner portion of the disc. It is apparent, therefore, that the distribution of the electrons collected by plates 6 and 7 in this instance is dependent not only upon the electrostatic field produced by the polyphase system of control electrodes 21 and the planar electrode 33 but also on the modulating electromagnetic field produced between the opposed edges of the focusing and modulating electrodes 10 and 11. It will be understood by those skilled in the art that an alternating modulating voltage applied to the coil 50 will cause a continual advance and retard of the wave at the edge of the electron disc with respect to that which it would occupy in the absence of a magnetic field, with the overall result that both phase and frequency modulation of the voltage appearing between electrodes 6 and 7 are produced. However, since a unidirectional voltage of constant magnitude applied to modulating coil 50 produces pure phase modulation of the output voltage between electrodes 6 and 7, the tube is essentially a phase modulation tube.

In Fig. 8 I have illustrated a frequency modulating system embodying my invention. In the system shown in Fig. 8 the discharge device 55 is a diagrammatic representation of the device described previously in connection with Figs. 1 to 7. Electrode 57 corresponds to the outer collecting electrode 7; electrode 58 corresponds to the inner collecting electrode 6; the three sets of electrodes 21'' correspond to the three-phase system of control electrodes provided by the wire-like control members 21, every third one of which is connected to the same phase conductor; electrode 33' corresponds to the neutral plane electrode 33; electrodes 61 and 62 represent the focusing and modulating electrodes 10 and 11, while the electrodes 63 and 64 correspond to the inner focusing electrodes 19 and 31. A cathode 65 corresponds to the cathode 39. A coil 66, which cooperates with the electrodes 61 and 62, corresponds to the modulating coil 50 shown in Fig. 1.

The discharge device as described above is connected in a frequency modulation system in the following manner. A voltage supply for maintaining the various electrodes at appropriate direct current voltages is provided by voltage dividing resistors 67, 68, 69, 70 and 71 connected in series between a ground connection 72 and the positive conductor 73 of a source of direct current voltage. High frequency by-pass capacitors 74 are connected between one terminal of each of the voltage dividing resistors and ground. As illustrated in the drawing, the cathode 65 is connected to the direct current ground. The inside focus electrodes 63 and 64 are connected to the positive terminal of resistor 67 which may be at a positive voltage of the order of 10 volts, and the outside focusing and modulating electrodes 61 and 62 are connected to the positive terminal of resistor 68 and may be maintained at a voltage of 50 volts. The neutral plane electrode 33' is connected to the positive terminal of voltage dividing resistor 69 which may be 70 volts positive, for example. The positive terminal of voltage dividing resistor 70 is connected to the neutral terminal of the polyphase carrier supply voltage by conductor 70' to provide a direct current voltage differential between the neutral plane electrode 31' and the polyphase system of electrodes 21'', which are energized by the three-phase carrier voltage supplied by a single-phase to three-phase conversion circuit 75. The conversion circuit 75 as illustrated is energized by the output of a single-phase crystal oscillator illustrated diagrammatically at 76.

The collecting electrodes 57 and 58 are connected together by a center-tapped output coil 77, which forms the primary winding of an output transformer 78 having a secondary winding 79 connected to a frequency multiplier and amplifier circuit, illustrated diagrammatically at 80, which supplies the modulated carrier to an antenna 81. The primary winding 77 is shunted by a capacitor 82 to provide an oscillatory circuit resonant at the carrier frequency. The mid-point of the transformer 77 is connected to the positive terminal of the voltage dividing resistor 71, which may be at a suitable voltage, such as 250 volts.

In order to suppress secondary emission of electrons by the electrode 57, a self-biasing circuit including a parallel resistor 83 and a capacitor 84 is connected in the circuit with the inner collecting electrode 58 to maintain it at a substantial negative direct current voltage with respect to the outer collector electrode 57. The modulating coil 66 is energized from a suitable source of signal voltage, such as the output of an audio amplifier indicated diagrammatically by the numeral 85.

The operation of the system illustrated in Fig. 8 is believed to follow directly from the detailed description of the operation of the discharge device of Figs. 1 to 4. The utilization of a carrier supply having a neutral terminal and a discharge device employing a neutral plane electrode renders it possible to interpose a direct current voltage between these two electrode systems so that the undeflected edge of the electron disc may be lined up with the line separating the two groups of openings 51 and 52 of the inner collecting electrode, thus producing symmetrical alternating voltage between the output electrodes 57 and 58.

It will be apparent that the present invention, in addition to affording the advantages just described in connection with the system of Fig. 8, provides a tube with many advantages over the prior art, particularly from the standpoint of simplicity of construction. Some of the important features contributing to the simplicity are the use of the neutral plane electrode and the compact assembly in accordance with which the inner focusing and control electrodes are supported from the outer focusing and modulating electrodes 10 and 11 as shown in Fig. 2. The assembly of the polyphase electrodes and associated terminal discs provided is also a feature of the invention.

The collecting electrodes of the discharge device may be constructed to provide a three-phase output. In Fig. 9 cylindrical electrodes of this type have been developed into a planar view. The inner electrode, designated by the numeral 6', is in general similar to the inner collecting electrode 6 as shown in Fig. 2. However, instead of twelve openings in each set, the structure includes three sets of three each electrically displaced from the preceding set by a distance corresponding to 120 electrical degrees or two-thirds of the width of one of the openings. Since the displacement precludes the possibility of using twelve openings, the total number of openings is reduced to nine, and a portion of the cylinder is accordingly unused. As shown in Fig. 9, the collecting electrode includes in the first phase group three openings 86 above the center of the electrode and three openings 87 below the center of the electrode and staggered with respect to the openings 86. As in the case of electrode 6, the width of the openings is equal to the space between them. The second set of openings, corresponding to the second phase of the output, are displaced 120 electrical degrees with respect to the openings 86 and 87. As indicated, the first opening of the upper set 88 of the second group is displaced from the last opening 87 of the preceding phase group. In a similar manner, the first opening of the upper set of openings 89 of the third phase group is displaced 120 degrees with respect to the last opening of the lower set 90 of the second phase group. The lower openings of the third group are designated by the numeral 91. In order that the displaced voltages may be collected and supplied to separate output terminals, the collecting electrode corresponding to the outer electrode 7 of Fig. 2, for example, is formed in three sections located respectively behind the three groups of displaced openings. These sections, designated by the numerals 92, 93 and 94, are indicated by dotted lines in Fig. 9. It will be understood that three output circuits will be provided for the electrode system of Fig. 9 with one terminal of each circuit connected to the common electrode 61, and the other terminal of each of the circuits connected to the three electrode sections 92, 93 and 94.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electric discharge device comprising a source of electrons including means for confining said electrons in a generally planar region, said means including electrode means positioned on opposite sides of said region, a plurality of control electrodes supported in mutually spaced and insulated relation in a plane on one side of said

region and parallel thereto, a substantially planar control electrode lying in a plane on the opposite side of said region and in opposed relation to said plurality of control electrodes, and a pair of collecting electrodes for selectively collecting electrons emitted by said source in accordance with the energization of said control electrodes.

2. An electric discharge device comprising a source of electrons including means for confining said electrons in a generally planar region, said means including electrode means positioned on opposite sides of said region, a plurality of control electrodes supported in mutually spaced and insulated relation in a plane bounding one side of said region, a substantially planar electrode lying in a plane bounding the opposite side of said region and in opposed relation to said plurality of control electrodes, and collector electrode means, said control electrodes being supported between said source and said collector electrode means.

3. An electric discharge device comprising a source of electrons including means for confining said electrons in a generally planar region, said means including electrode means positioned on opposite sides of said region, a plurality of control electrodes supported in mutually spaced and insulated relation on one side of said region, a substantially planar control electrode supported on the opposite side of said region abutting said plurality of control electrodes, a pair of collecting electrodes for selectively collecting electrons emitted by said cathode in accordance with the energization of said control electrodes.

4. An electric discharge device comprising an elongated cathode, a plurality of electrodes supported in mutually spaced and insulated relation in a circular array concentric with said cathode and lying in a plane substantially perpendicular to the axis of said cathode, a substantially circular electrode supported concentrically with said cathode and spaced longitudinally of said cathode with respect to said plurality of electrodes, and collector electrode means surrounding said cathode and said control electrodes.

5. An electric discharge device comprising an elongated cathode, a plurality of control electrodes supported in mutually spaced and insulated relation in a circular array concentric with said cathode, a substantially circular electrode supported concentrically with said cathode and spaced longitudinally of said cathode with respect to said plurality of electrodes, and collector electrode means surrounding said cathode and said control electrodes.

6. An electric discharge device comprising an elongated cathode, a plurality of radially extending control electrodes supported in mutually spaced and insulated relation in a circular array concentric with said cathode and lying in a plane substantially perpendicular to the axis of said cathode and providing a polyphase electrode system, a substantially annular electrode supported concentrically with said cathode and spaced longitudinally of said cathode with respect to said plurality of electrodes, and collector electrode means surrounding said cathode and said control electrodes.

7. An electric discharge device comprising a substantially cylindrical collector electrode, a pair of members of magnetic material each including a marginal planar portion and a central flange portion defining an opening of gradually decreasing diameter, said members being supported at opposite ends of said electrode with said flanges directed inwardly and terminating in spaced relation, a cathode supported centrally in the openings defined by said flanges, and a coil surrounding said members for producing a flux in the gap between said flanges to control the electrons emitted by said cathode.

8. An electric discharge device comprising a substantially cylindrical collector electrode, a pair of members of magnetic material each including a marginal planar portion and a central flange portion defining an opening of gradually decreasing cross section, said members being supported at opposite ends of said electrode with said flanges directed inwardly and terminating in spaced relation, a cathode supported centrally in the openings defined by said flanges, and a pair of control electrode assemblies supported respectively in the openings defined by said members and between said cathode and said collector electrode.

9. An electrode assembly comprising a disk-like member of magnetic material having a centrally located aperture defined by a flange of gradually decreasing diameter, an electrode assembly supported from said member and extending within said opening including a cylindrical electrode, an insulating spacer member surrounding said cylindrical electrode and engaging the inner wall of said flange, and a disk-like electrode secured in engagement with said insulating spacer and in concentric relation with said cylindrical electrode.

10. A polyphase electrode assembly comprising an insulating cylinder, a plurality of wire-like electrode elements each element including a radial portion extending across a portion of one end of said cylinder and an axial portion lying along the outer surface of said cylinder, said elements being supported in uniformly spaced relation with the longitudinal portions of adjacent elements extending along the surface of the cylinder at different distances, said conductors being arranged in symmetrical groups having longitudinal portions of equal lengths, a plurality of conductive washers surrounding said cylinder and supported in spaced insulated relation, the conductors of each group being connected with a different one of the washers.

11. An electric discharge device system comprising cylindrical collector electrode means including mutually insulated complementary collecting surfaces, a source of electrons including means for confining said electrons in a relatively narrow region in the direction of the axis of said cylinder, a polyphase deflecting electrode system supported on one side of said region from said source and said collector electrode means, an electrode supported on the opposite side of said region, a polyphase supply of carrier voltage including a neutral connection, and means energizing said polyphase electrode system with the phase voltage of said supply and said electrode with the voltage of said neutral connection.

12. An electric discharge device system comprising cylindrical collector electrode means including mutually insulated complementary collecting surfaces, a source of electrons including means for confining said electrons in a relatively narrow region in the direction of the axis of said cylinder, a polyphase deflecting electrode system supported on one side of said region and between said source and said collector electrode means, an electrode supported on the opposite side of said region, a polyphase supply of car-

rier voltage including a neutral connection, means energizing said polyphase electrode system with the phase voltages of said supply and said electrode with the voltage of said neutral connection, and means comprising a unidirectional bias voltage between said neutral connection and said electrode.

13. In combination, cylindrical collector electrode means including mutually insulated complementary collecting surfaces, a source of electrons including means for confining said electrons in a relatively narrow region in the direction of the axis of said cylinder, a polyphase deflecting electrode system supported between said source and said collector electrode means for producing a repetitive deflection of electrons provided by said source from one of said surfaces to the other, and a self-biasing circuit connected with one of said surfaces to maintain it at a substantial negative voltage with respect to the other of said surfaces.

14. An electric discharge device comprising a pair of concentrically arranged cylindrical collecting electrodes, a pair of apertured disks of insulating material positioned respectively on opposite ends of said electrodes, a pair of members of magnetic material, each of said members comprising a marginal planar portion and a central flange portion defining a central opening, said members being assembled on said disks with said flanges extending inwardly through the apertures of said disks and terminating in spaced relation to provide a central gap, and a cathode supported within the opening defined by said flanges.

15. An electric discharge device comprising a pair of concentrically arranged cylindrical collecting electrodes, a pair of apertured disks of insulating material positioned respectively on opposite ends of said electrodes, a pair of members of magnetic material, each of said members comprising a marginal planar portion and a central flange extending substantially perpendicular to said marginal portion and defining a central opening, said members being assembled respectively on said disks with said marginal portions in parallel relation and said flanges extending inwardly through the apertures in said disks and terminating in spaced relation, a cathode supported centrally within the opening defined by said flanges, control electrode means positioned between said cathode and said flanges for producing a deflection of the electrons emitted by said cathode and in an axial direction with respect to said cylindrical electrodes, and means cooperating with said members of magnetic material for producing a magnetic field between the ends of said flanges.

16. An electric discharge device comprising a pair of concentrically arranged cylindrical collecting electrodes, a pair of members of magnetic material, each of said members comprising a marginal planar portion and a central flange extending generally perpendicular to said marginal portion and defining a central opening, said members being assembled respectively on opposite ends of said cylindrical collecting electrodes with said marginal portions in parallel relation and with said flanges extending inwardly and terminating in spaced relation to provide a control gap, a cathode supported within the opening defined by said flanges, and control electrode means positioned between said cathode and said flanges for producing a deflection of the electrons emitted by said cathode and in an axial direction with respect to said cylindrical electrodes.

17. A three-phase cylindrical electrode system for collecting electrons selectively in accordance with a repetitive displacement of the electrons in an axial direction comprising a cylindrical electrode having three sets of openings with each opening having a width corresponding to 180° at a predetermined frequency and with the first opening of the second and third groups displaced a distance corresponding to 120 electrical degrees at said frequency with respect to the last opening of the preceding group, and three mutually insulated electrode means supported outside of said cylindrical electrode.

FRANCIS M. BAILEY.

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