Sept. 29, 1953 L. BATCHELDER 2,654,040

COMMUTATOR TUBE DEVICE

Filed Nov. 21, 1947 2 Sheets-Sheet 1

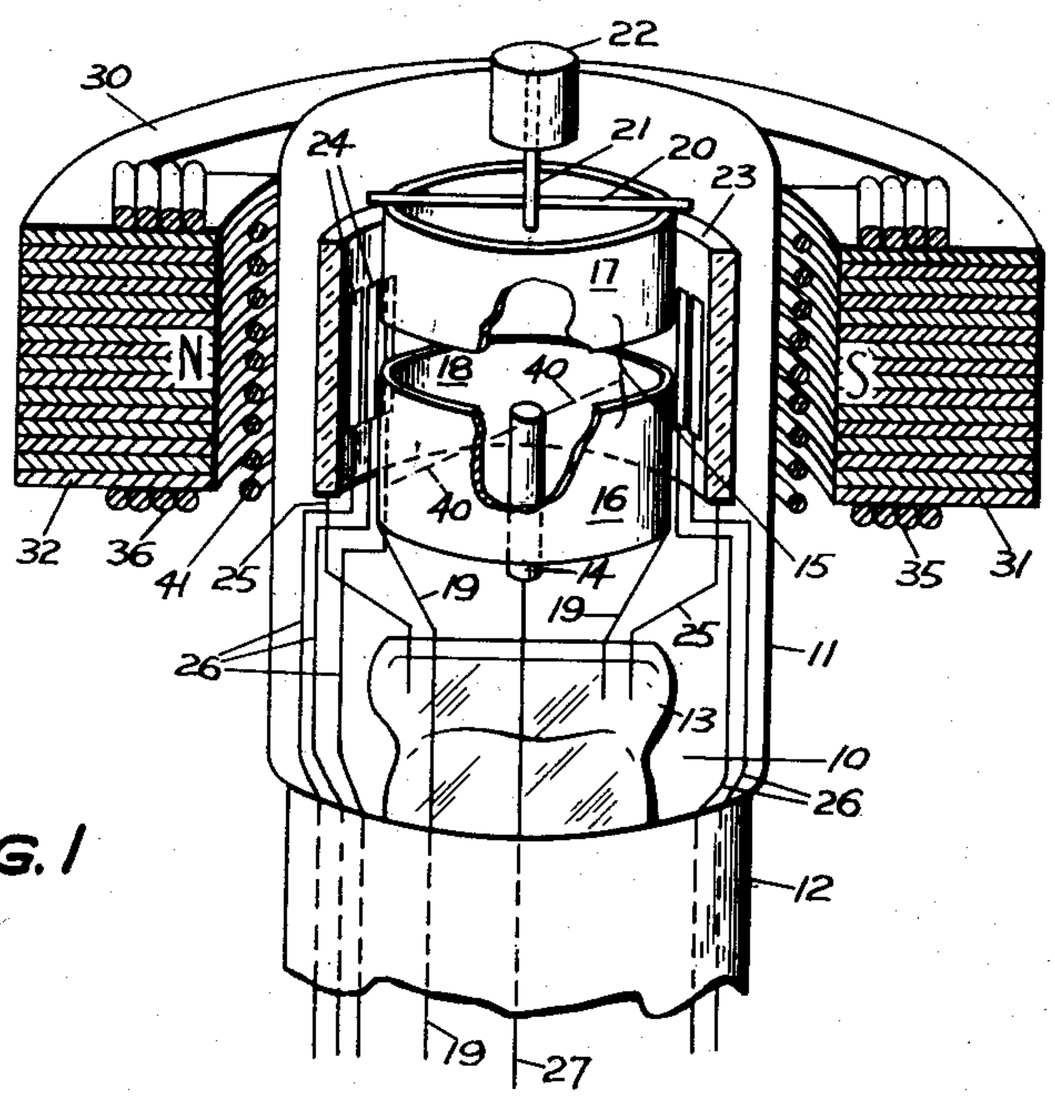

FIG. 1

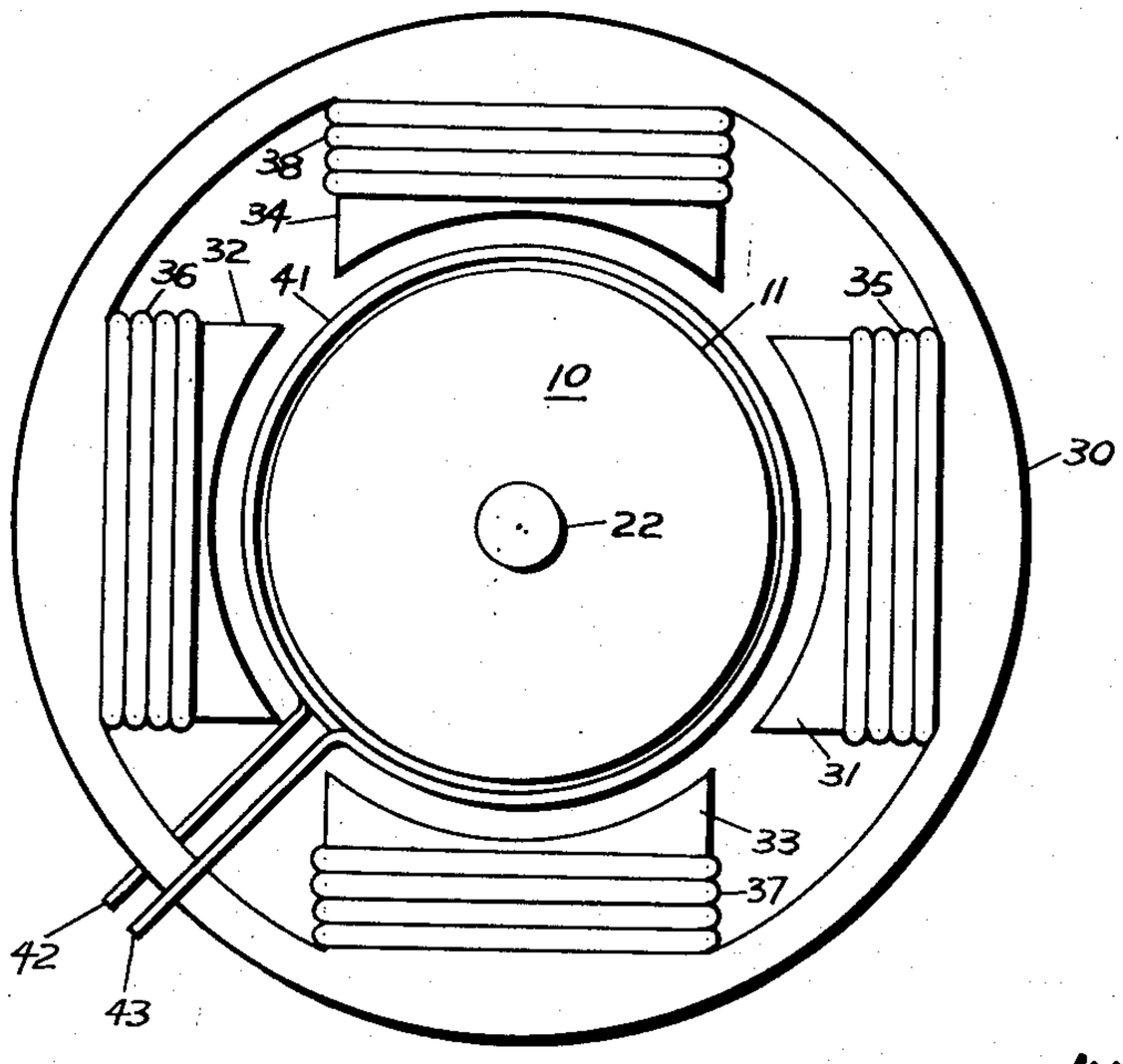

FIG. 2

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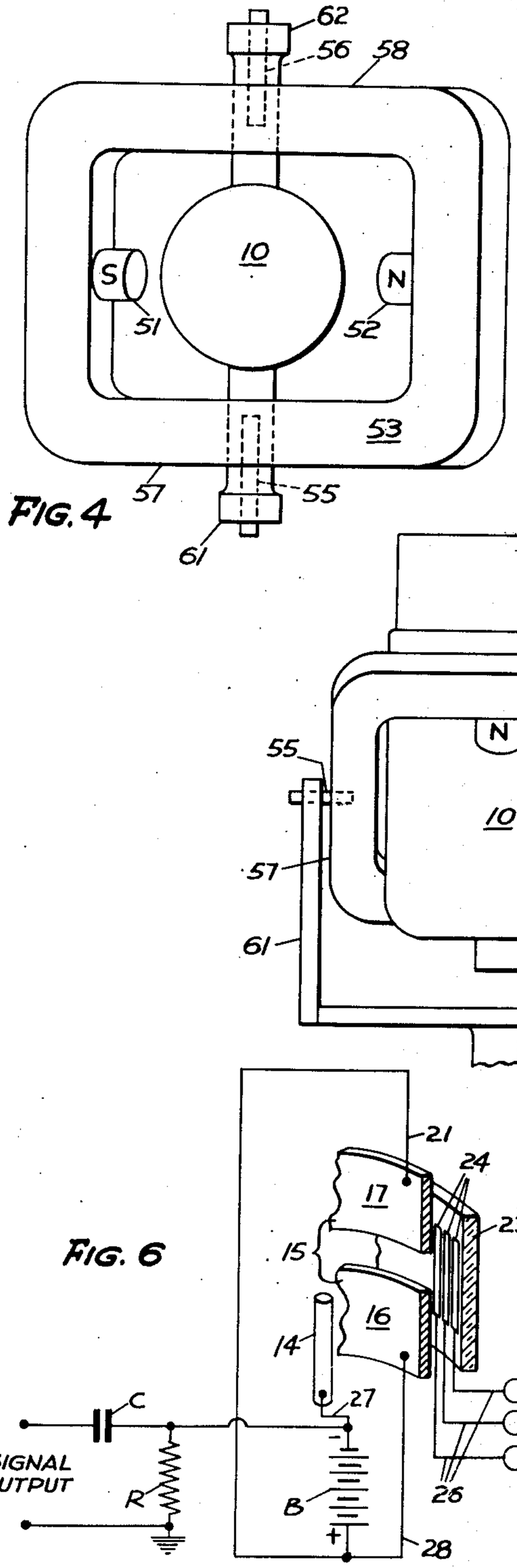

FIG. 4

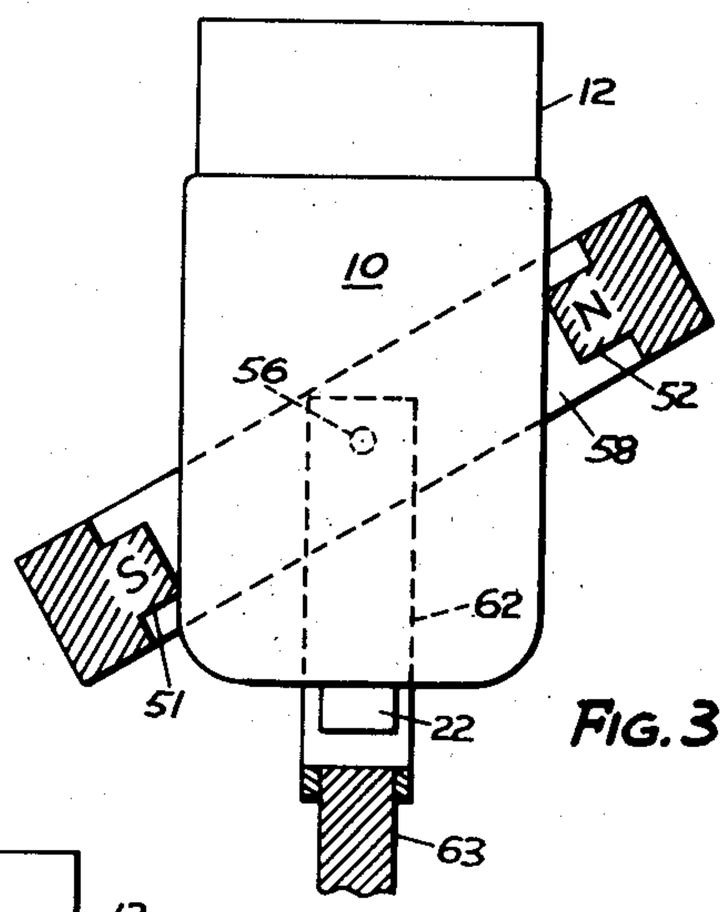

FIG. 3

FIG. 5

FIG. 6

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COMMUTATOR TUBE DEVICE

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16 Claims. (Cl. 313—69)

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The present invention relates to electron tube devices for commutation of electric current in successive different circuits, and in particular to an improved system of electron beam direction control for such tubes.

In copending application Serial No. 655,447, filed March 19, 1946, there is disclosed a commutator tube employing a cathode, an accelerator anode positioned near the cathode, a plurality of commutator electrodes positioned near the anode on the other side from the cathode, means for forming the electrons from the cathode into a beam which has two parts that extend in opposite directions from the cathode, and means for sweeping one end of the beam along the anode to contact successive commutator electrodes. The accelerator anode is provided with an elongated aperture and the beam has one end more or less focussed in the aperture, the other end being intercepted by an unapertured portion of the anode. In a practical embodiment the anode is cylindrical and concentrically surrounds the cathode, and the aperture is a circumferential slot therein, while the commutator electrodes surround the anode adjacent the slot. The beam-forming means comprises at least one pair of dissimilar magnetic poles positioned outside the tube on a line extending diametrically through the tube and passing through the anode and certain of the commutator electrodes. The resultant electron beam is diametrically disposed and has two ends at opposite ends of the diameter. Various means for rotating the effective position of the magnetic poles about the axis of the tube may be employed. The anode in such embodiments is slotted circumferentially for only 180 degrees, for, while one end of the beam is available for current commutation, the other end must be masked or intercepted by unslotted anode material to avoid confusion as to which end is in use. As a consequence, commutator electrodes are useable for only 180 degrees of the available space around the anode in the tube. To provide a tube having commutator electrodes in the entire 360 degrees of available space, an embodiment having in effect two cathodes and an anode with two diametrically opposed 180 degree slots, one for each resultant electron beam, is proposed in said application. This embodiment requires additional grid control means for the beams for best performance.

The present invention has as its major object to improve on the aforementioned and similar devices by providing a commutator tube wherein the accelerating anode has an aperture extending a full 360 degrees about the cathode, and means whereby one end only of a single two-ended electron beam from the cathode is employed to contact commutator electrodes disposed completely about the anode.

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Another object is to provide a commutator tube device of the aforementioned or similar kind wherein the two portions of the beam can be so directed that one end of the beam lies in the plane of the anode aperture and the other end lies in another plane.

Another object is to provide such a commutator tube device having reliable and relatively simple means for directing and rotating the beam.

Still another object is to provide such a device that will take up a minimum of space and be of the lightest possible weight.

Yet another object is to provide a device having the above new features without interfering with the operation with regard to features already in use. Thus, the device of the present invention provides inherently smooth commutation at practically any desirable commutation speed, and is as fully adaptable to use in various circuits as are prior devices, with the additional improvement that more circuits can be handled with a minimum increase in complexity.

Other and further objects and features of the invention will become apparent from the description of certain embodiments thereof that follows, reference being made to the accompanying drawings, wherein:

Fig. 1 shows a side elevation partially in section of a device in accordance with the invention;

Fig. 2 shows a top view of the embodiment of Fig. 1;

Fig. 3 shows a side elevation partially in section of another embodiment of the invention;

Fig. 4 shows a top view of the embodiment of Fig. 3;

Fig. 5 shows an end view of the same embodiment; and

Fig. 6 shows a typical circuit connection for the commutator tube shown in the other figures.

In Figs. 1 and 2, there is shown an electron tube 10 having an envelope 11 which is preferably evacuated or contains a small amount of an inert gas. The envelope is mounted on a base 12 to which there is sealed a press 13 of well-known form through which certain wires communicate with the interior of the envelope and on which certain of the tube elements are mounted. The tube elements comprise in part a thermionic cathode 14 and a cylindrical anode 15, made in two parts 16 and 17 which are coaxially disposed endwise with a slot-shaped aperture 18 between them extending a full 360 degrees about the anode. The cathode 14 is disposed within the lower anode portion 16 only, being supported on a conductor 27, which is sealed through the base 12 and press 13. It may be indirectly heated by any well-known heating means, not shown. The lower anode portion 16 is supported in the press 13 by means of sup-

ports 19, of which one extends through the base 12 for the purpose of making an electrical connection, while the upper portion 17 is supported by a conductive rod 21 sealed through the top of the envelope 11 and provided exteriorly thereof with an electrical connector 22 of the form commonly known as a "grid cap." The rod 21 may be attached to the upper anode portion 17 by means of a conductive cross-arm 20. Other means of supporting the anode sections may be employed if desired, it being necessary for smooth commutation, however, that the slot 18 be uninterrupted for its entire circumferential length.

Surrounding the anode 15 is a non-conductive cylinder 23, which may be made of glass, to the interior side of which are attached conductive strips 24 which have the function of commutator electrodes. These strips may be made of silver sputtered onto the glass and separated by scratching away or otherwise removing hair-thin portions of the silver at desired intervals to space the strips closely apart. The non-conductive cylinder is supported in the press by supports 25 sealed to the cylinder and into the press, and a conductor 26 is attached to each commutator strip 24 and brought out of the tube through the base 12.

The electron stream from the cathode 14 to the anode 15 is formed into a pair of oppositely-directed narrow radial beams, not shown, by means of a four-pole electromagnetic resolver of a well-known form having uniformly distributed pole pieces 31, 32, 33 and 34, each of which is provided with an individual energizing coil 35, 36, 37 and 38, respectively. The core structure of the resolver is preferably laminated as shown in Fig. 1. The coils 35 to 38, inclusive, may be energized in a well-known manner from any known kind of source of alternating current which provides voltages at the same frequency in phase quadrature to the respective coils. The pole pieces 31 to 35, inclusive, are thereby energized so that diametrically opposed faces, for example N and S, have dissimilar magnetic polarities. As is well known, the resolver 30 will, when energized in this manner, rotate the electron beams about the axis of the cathode 14 to sweep the beam ends circumferentially around the interior of the anode 15. The beams will then lie at any time along a diameter of the cylindrical anode within the lower portion 16, with both ends in the same transverse plane.

In the present embodiment of the invention, the beams are tilted with respect to a plane transverse to the anode 15, the direction of tilt being toward parallelism with the axis of the anode, so that the beams are directed as shown by the dot-dashed line 40, and one end of the beams lies in the slot 18 while the other end is totally intercepted by anode material, here by the lower portion 16. The tilting is accomplished by applying an additional component of magnetic flux parallel to the axis of the tube 10, with an additional coil 41 which is disposed about the tube as a solenoid wound about the axis of the tube. This coil 41 may be energized from any suitable source of unidirectional current by connection to the ends 42 and 43. The magnitude of the direct current potential applied to the beam tilting coil 41 determines the amount by which the beams are tilted, and hence the disposition of the direction line 40.

With the arrangement just described, one end of the electron beams is at all times interrupted by anode material, and only one end of the beams

is in the slot 18 as the beams are swept around by the resolver, so that commutator electrodes 24 may be employed throughout the full 360 degrees through which the beams are swept. The anode slot 18 is to this end continuous throughout 360 degrees. If desired, the cathode 14 may be disposed within the upper anode section 17 instead of the lower anode section 16. Or, if a reduction in sharpness of commutation can be tolerated, one anode portion may be eliminated, and the cathode can be disposed within the remaining portion. One of the electron beams would still be interrupted by anode material, while the other beam would be passed over the upper edge thereof.

In the embodiment of the invention shown in Figs. 3, 4 and 5 the tube 10 is disposed between two dissimilar magnet poles 51 and 52, which are part of a permanent magnet yoke 53. The yoke may be likened in effect to a pair of horseshoe magnets disposed with like poles confronting each other to form the loop, with the resulting dissimilar poles diametrically opposed on the loop. There results a magnetic flux along the line between the poles 51 and 52. If desired, this flux may be provided by a single U-shaped permanent magnet. The yoke is tiltably supported in a U-shaped frame 54, being mounted therein by means of bearings 55 and 56. The bearings hold the yoke at the non-pole-bearing arms 57 and 58 at points which are intermediate between the poles 51 and 52, on a line that is disposed at right angles to a line drawn between the poles. The bearings 55 and 56 are in turn supported in the ends of the upstanding arms 61 and 62, respectively, of the frame 54. The tube 10 is so disposed within the yoke 53 and frame 54 that the line on which the bearing points lies is perpendicular also to the axis of the tube and of the elements therein. The U-shaped frame 54 is mounted on a shaft 63 at its lower mid-point for rotation about an axis coincident with the tube axis. The shaft 63 may be rotated by any desirable means, either manually or through a motor system.

The latter embodiment of the invention is operated by tilting the yoke 53 by the amount necessary to place one of the electron beams in the anode aperture or slot 18, shown in Fig. 1, and rotating the shaft 63 at a desired speed to rotate the poles 51 and 52 about the tube 10 and thereby sweep the beam along the slot to make contact with successive commutator electrodes 24.

The elements of the tube 10 may be connected in a utilization circuit as shown in Fig. 6. A battery B provides a uniform electron accelerating potential between the anode 15 and the cathode 14. The two anode portions 16 and 17 are connected together to the positive terminal of the battery, while the cathode is connected to the negative terminal. Signal generators G1, G2, G3, the signal currents from which are to be commutated, are connected at one side to individual commutator electrodes 24 via the connecting wires 26, and at the other side to the cathode 14 via a common load resistor R. The common connection may be completed through the ground, as shown, or otherwise if desired. The cathode 14 and the commutator electrodes 24 are thus all at the same potential in the absence of signals from the signal generators, but, when the electron beam establishes a connection between the cathode and a particular commutator electrode, the signal from the thereto connected generator

produces a voltage in the load resistor R. This voltage is furnished to succeeding circuits as the signal output through a capacitor C or any other desired means.

While the invention has been illustrated as applied to an electron tube which functions as a diode as far as the input signals, from the generators G1, G2, G3, are concerned, it is to be understood that the particular number of electrodes employed in the electron tube is not a material part thereof. For the purposes of the present invention it does not matter whether the collector electrodes 24 are diode anodes, or triode grids for controlling signal flow to additional elements which may be added for the purposes of providing amplification, or for any other known desired function of a multielectrode tube.

Many other arrangements and modifications within the scope of the invention will occur to those skilled in the art, and no attempt has been made here to exhaust all the possibilities that come to mind. It is therefore intended that the claims that follow shall be given the broadest possible interpretation consistent with the state of the prior art, and shall not be limited to the particular embodiments of the invention herein illustrated.

Having now described my invention, I claim:

1. An electronic commutator tube device comprising a source of electrons, an accelerating anode surrounding said source and having one endless edge defining a plane to one side of which said source is wholly disposed, means positioned near said source for forming the electrons from said source into a pair of oppositely directed beams substantially normal to said anode, means positioned near the path of said beams for directing one beam over an edge of the anode and the other beam to the anode, and means positioned near said source and including said beam-forming means for sweeping said one beam along said edge.

2. An electronic commutator tube device comprising a source of electrons, an accelerating anode surrounding said source and having one endless edge defining a plane to one side of which said source is wholly disposed, means positioned near said source for forming the electrons from said source into a pair of oppositely directed beams which are normally interrupted by said anode, means positioned near the path of said beams for directing one beam over an edge of the anode, and means positioned near said source and including said beam-forming means for sweeping said one beam along said edge.

3. An electronic commutator tube device comprising a cathode, an accelerating anode surrounding the cathode and being circumferentially apertured to provide a slot lying in a plane which does not include said cathode, means positioned near said cathode for forming the electrons from the cathode into a pair of oppositely directed beams normally directed to unslotted anode material, means positioned near the path of said beams for directing said beams to place the end of one in the slot and to interrupt the other with anode material, and means positioned near said cathode and including said beam-forming means for sweeping said end along said slot.

4. An electronic commutator tube device comprising a cathode, an accelerating anode surrounding the cathode and being circumferentially apertured to provide a slot lying in a plane which does not include said cathode, means positioned near said cathode for forming the electrons from the cathode into a pair of oppositely directed beams normally directed to unslotted anode material, means positioned near the path of said beams for directing said beams to place the end of one in the slot and to interrupt the other with anode material, means positioned near said cathode and including said beam-forming means for sweeping said end along said slot, and means positioned exteriorly of said anode in the vicinity of said slot to intercept electrons therefrom.

5. An electronic commutator tube device comprising a cathode, an accelerating anode surrounding the cathode and being circumferentially apertured to provide a slot lying in a plane which does not include said cathode, a plurality of electrodes surrounding the anode positioned near said slot, means positioned near said cathode for forming the electrons from the cathode into a pair of oppositely directed beams normally directed to unslotted anode material, means positioned near the path of said beam for directing said beams to place the end of one in the slot and to interrupt the other with anode material, and means positioned near said cathode and including said beam-forming means for sweeping the said one beam along the slot to contact successive ones of said electrodes.

6. An electronic commutator tube device comprising a cathode, a cylindrical accelerator anode concentrically surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the outside of the anode positioned near the slot, means positioned near said cathode for forming the electrons from the cathode into a beam extending generally diametrically across the anode and hence directed to unslotted anode material, means positioned near the path of said beam for directing the beam in a tilted path and thereby maintain only one end thereof in the slot while maintaining the other end directed to unslotted anode material, and means positioned near said cathode and including said beam-forming means for sweeping said one end along the slot to contact successive ones of said electrodes.

7. An electronic commutator tube device comprising a cathode, a cylindrical accelerator anode concentrically surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the outside of the anode positioned near the slot, means positioned near said cathode for forming the electrons from the cathode into a beam extending generally diametrically across the anode and hence directed to unslotted anode material, means positioned near the path of said beam for directing the beam in a tilted path and thereby maintain only one end thereof in the slot while maintaining the other end directed to unslotted anode material, and means positioned near said cathode to rotate the beam about the axis of the tube to sweep said one end along the slot.

8. An electronic commutator device comprising an electron tube having a cathode, an accelerating anode surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the anode

positioned near the slot, and an envelope surrounding the electrodes, electromagnetic means positioned outside the envelope for forming the electrons from the cathode into a beam extending across the anode and hence directed to unslotted anode material, means positioned near the path of said beam for directing the beam in a tilted path and thereby maintain only one end thereof in the slot, and means positioned outside the envelope and employing said electromagnetic means for sweeping said end along the slot.

9. An electronic commutator device comprising: an electron tube having a cathode, an accelerating anode surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the outside of the anode adjacent the slot, and an envelope surrounding the electrodes; a pair of dissimilar magnetic poles positioned one on each side of the tube for forming the electrons from the cathode into a beam extending across the anode, means mounting said poles tiltably about an axis disposed perpendicularly to both the axis of the tube and the line between the poles, and means for effecting relative rotation between the poles and the tube about the tube axis.

10. An electronic commutator device comprising: an electron tube having a cathode, an accelerating anode surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the anode adjacent the slot, and an envelope surrounding the electrodes; a magnetic core having two opposed confronting dissimilar poles, disposed about the tube with one pole on each side thereof, a bifurcated frame tiltably mounting the core at two diametrically opposed points intermediate the poles and lying on a line perpendicular to both the tube axis and the line between the poles, and means for rotating the frame on the tube axis.

11. An electronic commutator device comprising: an electron tube having a cathode, an accelerating anode concentrically surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the outside of the anode adjacent the slot, and an envelope surrounding the electrodes; a multipolar electromagnetic resolver surrounding the tube for forming the electron stream from the cathode into a beam extending across the anode directed to unslotted anode material, and adapted for energization from a multiphase source of alternating current for rotating the beam about the axis of the tube to sweep the ends thereof circumferentially about the interior of the anode; and a solenoidal coil surrounding the tube and adapted to be energized to provide a steady magnetic flux in the tube parallel to the axis thereof, whereby the beam may be directed toward parallelism with said axis to maintain only one end thereof in the slot while maintaining the other end directed to unslotted anode material.

12. An electronic commutator device comprising: an electron tube having a cathode, an accelerating anode surrounding the cathode, said anode being circumferentially apertured to provide a circumferential slot extending completely around the anode defining a plane to one side of which the cathode is wholly positioned, a plurality of electrodes arrayed side by side about the outside of the anode adjacent the slot, and an envelope surrounding the electrodes; electromagnetic means positioned outside the envelope for forming the electrons from the cathode into a beam extending across the anode and hence directed to unslotted anode material, means positioned near the path of said beam for directing the beam in a tilted path and thereby maintain only one end thereof in the slot, and means positioned outside the envelope and employing said electromagnetic means for sweeping said end along the slot; and a four pole electromagnet adapted for energization with alternating current in phase quadrature, surrounding the tube at the sides.

13. An electron tube having, in order, a cathode, an electron accelerator electrode, and a collector electrode, spaced apart generally in a first direction; said accelerator electrode having a passage therethrough for the passage of electrons; said cathode being of restricted size and disposed wholly to one side of said passage with respect to said first direction; whereby only those electrons which travel substantially in a second direction angularly disposed with respect to said first direction can reach said collector electrode.

14. An electronic commutator tube device comprising a source of electrons, a cylindrical accelerating anode surrounding said source and having one endless edge defining a plane to one side of which said source is wholly disposed, means adjacent said source for forming the electrons from said source into a pair of oppositely directed beams normal to said anode, and means adjacent the path of said beams for tilting the direction of said beams to direct one beam over said edge while maintaining the other beam directed to said anode.

15. An electronic commutator tube device comprising a source of electrons, an accelerating anode surrounding said source and having one endless edge defining a plane to one side of which said source is wholly disposed, means adjacent said source for forming the electrons from said source into a pair of oppositely directed beams normally impinging entirely upon said anode, and means adjacent the path of said beams for tilting said beams into a new direction in which one beam is directed over said edge and the other beam continues to be directed to said anode.

16. An electronic commutator tube device comprising a source of electrons, a cylindrical accelerating anode surrounding said source and having one endless edge defining a plane to one side of which said source is wholly disposed, means adjacent said source for forming the electrons from said source into a pair of oppositely directed beams normal to said anode, and means adjacent the path of said beams for directing one of said beams over said edge while maintaining the other beam directed to said anode.

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