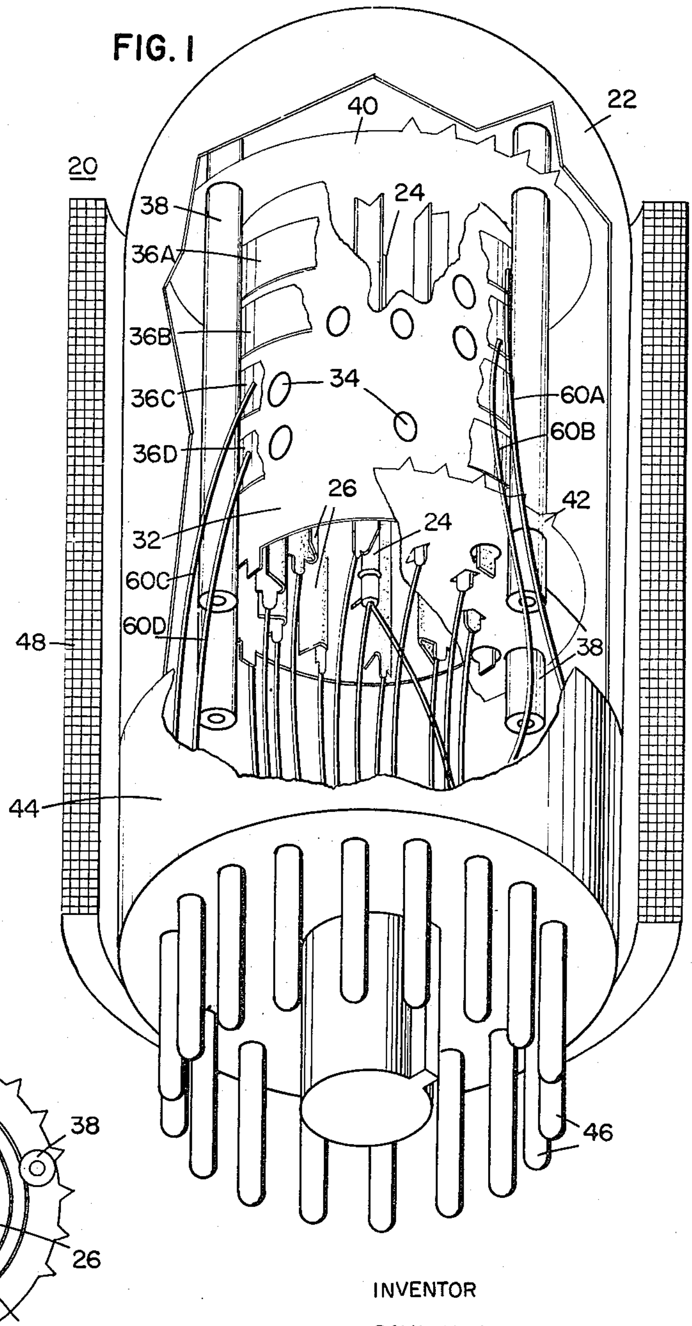
Sept. 25, 1956 S. KUCHINSKY 2,764,711

MULTIPLE POSITION BEAM TUBE

Filed July 24, 1953 4 Sheets-Sheet 1

FIG. 1



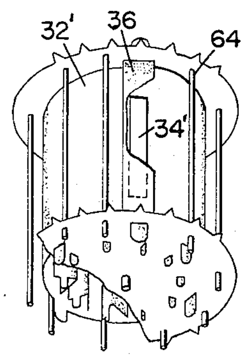
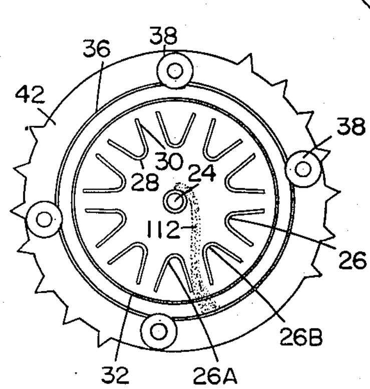


FIG. 3

FIG. 2



INVENTOR

SAUL KUCHINSKY

BY

Earl D. Ayers

AGENT

Sept. 25, 1956 S. KUCHINSKY 2,764,711

MULTIPLE POSITION BEAM TUBE

Filed July 24, 1953 4 Sheets-Sheet 2

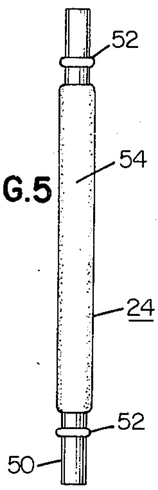


FIG. 5

FIG. 6

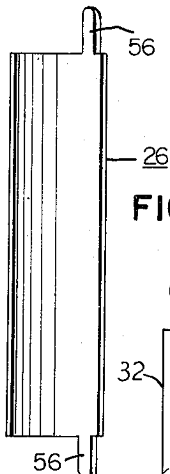


FIG. 7

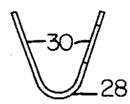


FIG. 8

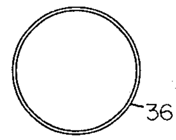


FIG. 9

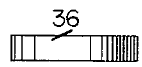


FIG. 10

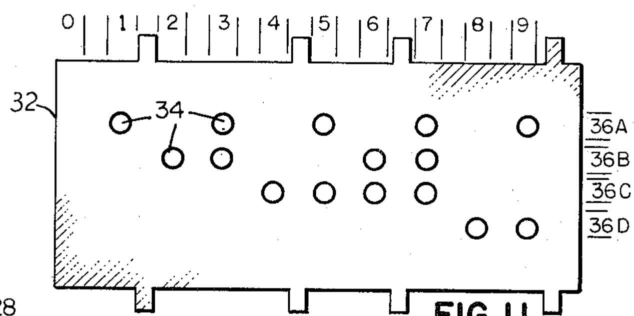


FIG. 11

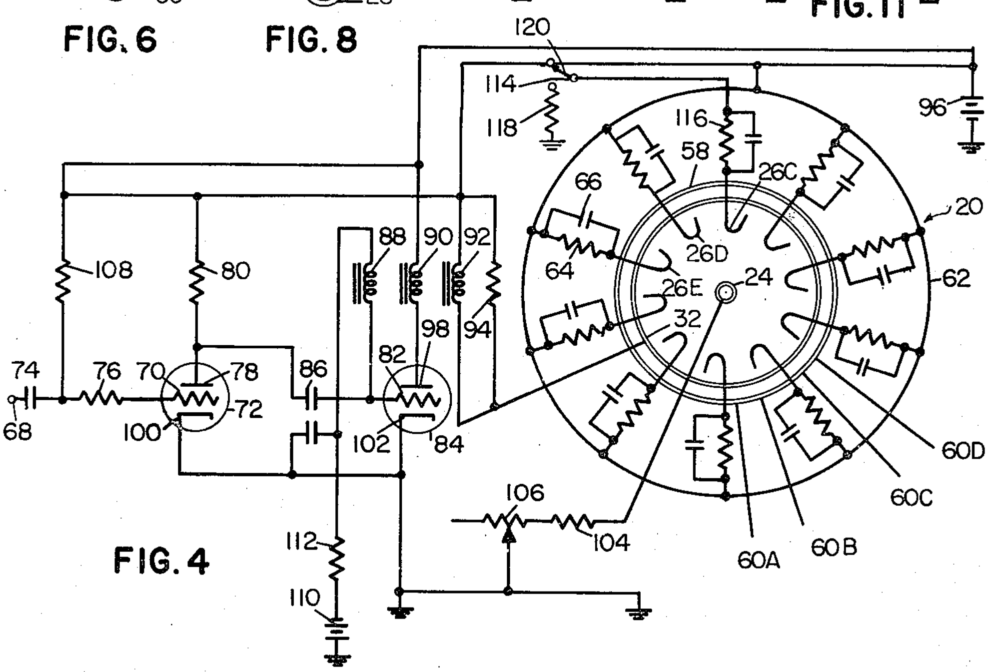


FIG. 4

INVENTOR

SAUL KUCHINSKY

BY

Earl D. Ayers

AGENT

MULTIPLE POSITION BEAM TUBE

Filed July 24, 1953 4 Sheets-Sheet 3

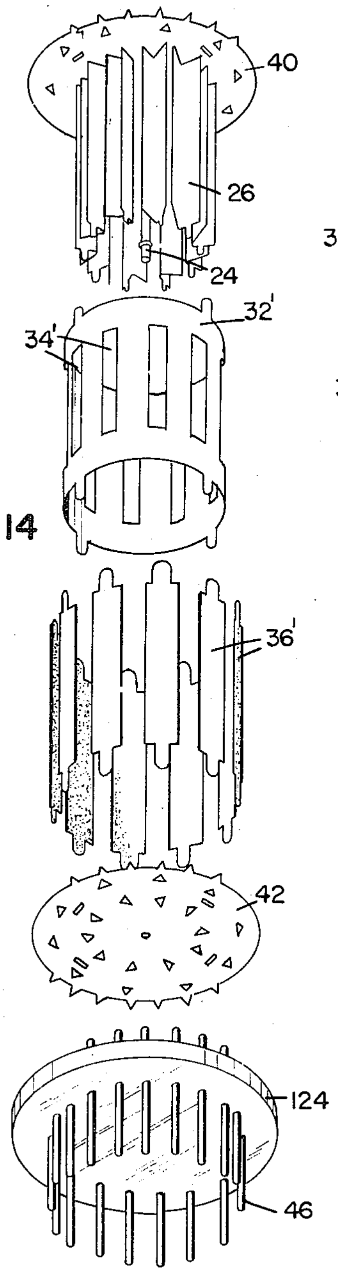


FIG. 14

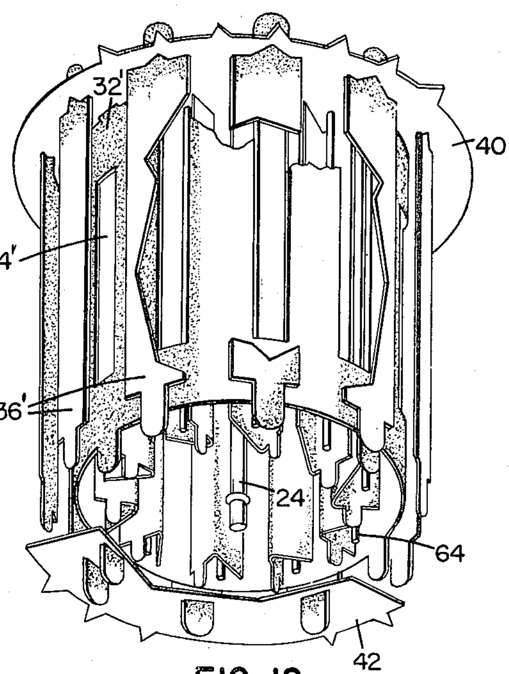
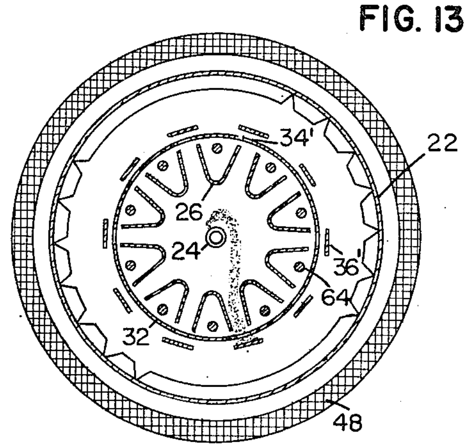


FIG. 12

FIG. 13



INVENTOR

SAUL KUCHINSKY

BY

Earl D. Ayers

AGENT

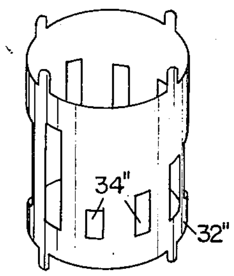


FIG. 15

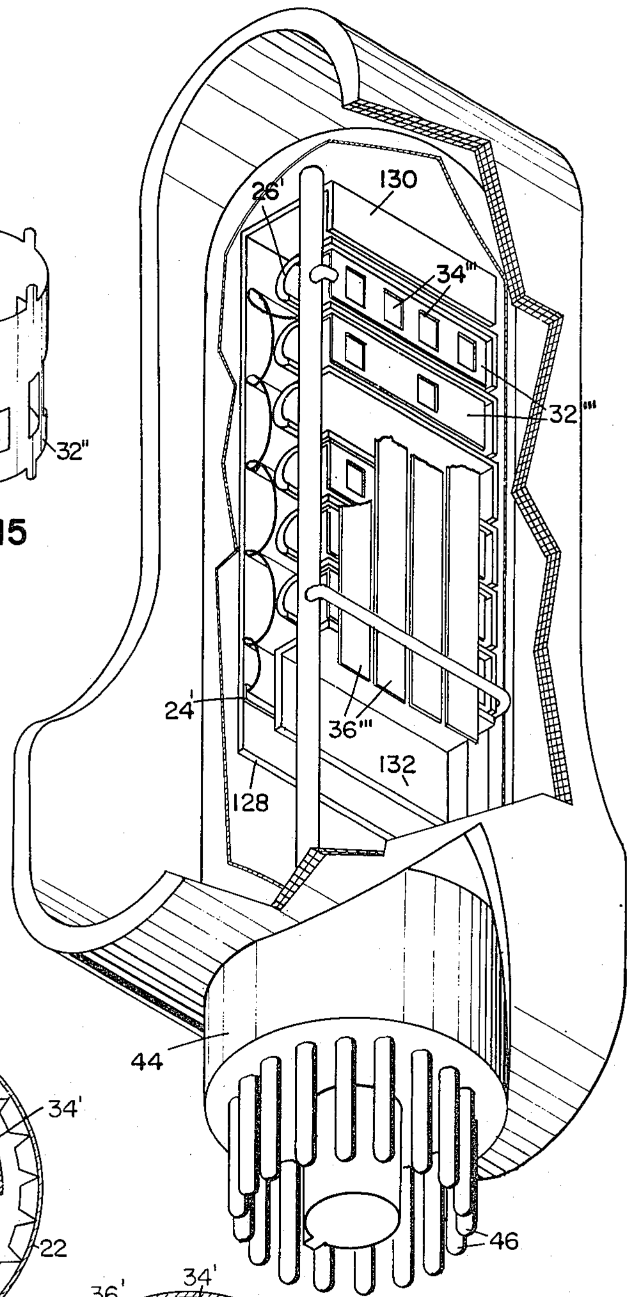
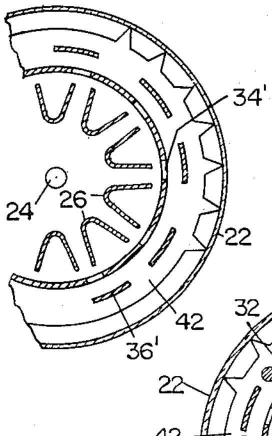


FIG. 18

FIG. 16



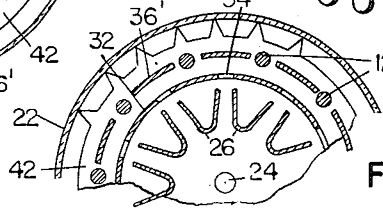


FIG. 17

INVENTOR
SAUL KUCHINSKY
BY
Earl D. Ayers
AGENT

United States Patent Office

2,764,711

Patented Sept. 25, 1956

2,764,711

MULTIPLE POSITION BEAM TUBE

Saul Kuchinsky, Philadelphia, Pa., assignor to Burroughs Corporation, Detroit, Mich., a corporation of Michigan

Application July 24, 1953, Serial No. 370,137

38 Claims. (Cl. 315—21)

This is a continuation-in-part of the present applicant's copending application Serial No. 291,531, filed June 3, 1952, entitled Multiple Position Electron Beam Device.

This invention relates to electron discharge devices and particularly to multiple position beam tubes in which the electron beam is subjected to the influence of a combined magnetic and electrostatic field.

Such tubes are known in the prior art, but have had a restricted field of use for reasons which will be explained below. Structurally, a typical multiple position tube of the prior art type comprises, within an hermetically sealed envelope, a centrally disposed thermionic cathode around which is disposed a coaxial array of generally V shaped elements known as spades, the sides of the V extending in a radial direction. The apex of each spade faces in the direction of the cathode. A magnetic field whose lines of force are substantially parallel to the cathode is provided by an external magnet. Under static conditions each of the spades is maintained at a positive potential, the potential being applied to each spade through an individual resistance or resistance-capacitance spade loading network. Under static conditions, with all the spades at a positive potential and the magnetic field applied, the tube is cut off. That is, the attraction of the electrostatic field, which has substantially circular equipotential lines (as seen along a plane perpendicular to the cathode) due to the physical layout of the spades and because all the spades are at substantially the same potential, and which tends to attract electrons towards the spades, is overcome by the magnetic field which causes the electrons to follow curved paths around the cathode in accordance with well known physical laws.

However, if the potential applied to one of the spades is reduced to, for example, the cathode potential, the rather symmetrical electric field mentioned above is distorted in the area between the cathode and the spade having the lowered potential. Such distortion of the electrostatic field modifies the effect of the magnetic field to the extent that electrons are attracted to the spade having the lowered potential. Further, after the spade circuit voltage is returned to normal, the electron flow through the spade load resistor, previously mentioned, reduces the spade potential to an extent sufficient to hold the electron beam on that spade.

Such a device can be used as a switching tube, but is subject to limitations which limit its usefulness. For instance, the spade impedance (even capacities of the order of a few micro-microfarads) must be held to a value which in itself limits the application of the tube to many devices. Also, the use of a spade as an output electrode is inherently inefficient because the maximum spade current is a small percentage of the total cathode current under normal operating conditions. Further, if the electron stream is modulated, the spade is unsatisfactory as an output electrode.

An alternative form of multiple position beam tube which is known in the prior art is similar to the one described above except that the output of the tube is taken

from target electrodes which are disposed between the spade electrodes, there being one target between each pair of spades. Each target is maintained at a positive potential. Therefore, part of the electron beam is attracted by the electrostatic field of the targets adjacent to the spade having the lowered potential. The direction of rotation of the magnetic field determines the target to which the electrons will be attracted, since there are two targets, one on each side of the spade, to which electrons could be attracted.

The use of targets as output electrodes which are separate from the spade loading circuits has the advantage that the tube may be coupled to devices having input impedances other than the spade impedance. However, because the target electrodes are almost as close to the cathode as the controlling portion of the spades are, the electrostatic field of the targets exert a considerable influence over the positioning of the electron stream or beam. Thus, variations in target potential, due to the position of the target between the spades, tends to spread the beam. Spreading or shifting of the beam tends to cause instability of beam holding, for, if any electrons impinge on an adjacent spade, the voltage drop in the load network of that spade and the tendency of the magnetic field to rotate the beam will cause the beam to switch positions. In this tube, as in the one described above, modulation of the electron beam would adversely affect beam holding stability. Further, the position of the targets with respect to adjacent spades provides capacity coupling between input spades and output targets, thus providing cross talk in addition to limiting the upper frequency of operation of the tube.

In addition, because space exists between the target and the spade on each side of the target, electrons not collected either by the spade or target will pass through this space and, under the influence of the magnetic field, may be deflected to other electrodes of the tube, providing undesired cross talk between output channels.

Because of the limited amount of output of prior art multiple beam tubes, some applications of the tube have required that the tube output pass through additional amplifier or buffer stages, or both, before driving a utilization device.

The operational limitations of prior art tubes have restricted their use to relatively few applications. The improved tube of the present invention is designed to provide superior operating characteristics for use in applications where the prior art tubes have proved unsatisfactory and can be used to advantage in code conversion systems, switching and multiplexing applications for either modulated or unmodulated signals, counting and computing devices, and similar applications requiring high speed beam switching and especially in such applications where external circuitry must be simplified or equipment must be compact.

A principal object of the present invention is to provide an improved multiple position beam tube.

A second object of the present invention is to provide an improved multiple position beam tube having useful multiple outputs.

Another object of the present invention is to provide a multiple position beam tube in which variations in output load impedance exert little or no effect on the stability of tube operation.

A further object of the present invention is to provide a multiple position beam tube in which cross talk is minimized.

Still another object of the invention is to provide a multiple position beam tube having increased power output capabilities.

Yet another object of the present invention is to provide an improved coding tube.

A still further object of the present invention is to provide an improved multiple position beam tube which is adapted for use in counting devices with a minimum of external circuitry.

An ancillary object to the present invention is to provide an improved multiple position beam tube which is useful in multiplexing applications involving modulated signals.

A related object of the present invention is to provide an improved multiple position beam tube composed of parts which are capable of being economically fabricated and assembled.

In accordance with the present invention there is provided a multiple position beam tube including, within an hermetically sealed envelope: an elongated thermionic cathode; an array of elongated trough-shaped spade electrodes each having a pair of radially extending sides joined at the inner edges thereof and disposed in side-by-side relation one to another and spaced from and substantially in axial alignment with said cathode, the open parts or side of each of said spades extending generally away from said cathode; at least one apertured or slotted anode disposed adjacent to the open sides of said spades, said apertures or slots being located substantially in line with the space between adjacent spades; and at least one target electrode, said target electrode being disposed adjacent to said anode and on the side opposite said spades, and aligned so that electrons passing through said slots or apertures of said anode will impinge on said target.

Insertion of the slotted or apertured anode between the spades and targets provides an electrostatic shield therebetween, thus isolating the target field, which is subject to change due to output variations, from the area adjacent to the spades. This improves the operating stability of the tube, since the beam holding and directing functions may be practically completely controlled by the spade field independently of the target field.

The anode serves also to minimize cross talk, for most of the electrons which do not impinge on the spade or target associated with the particular beam position are absorbed by the positively charged anode and do not, under the influence of the magnetic field, become attracted to adjacent positively charged target electrodes.

Power output capabilities of tubes made in accordance with the present invention are increased over that of prior art tubes in two ways. First, because the targets are located beyond rather than between the spades, as in prior art tubes, larger area targets may be utilized, with the result that more of the electrons from the beam impinge thereon. Secondly, because the target field exerts very little influence on tube operating stability, larger output voltage variations may be utilized without adversely affecting tube operation.

An improved coding tube is provided, in accordance with the present invention, by providing apertures or slots in the anode at the various beam positions in accordance with a predetermined coding arrangement. A plurality of targets are disposed with respect to the anode in such a manner that a coded output for each beam position is obtained. Such a tube can, for example, be used to provide decimal to binary conversion in a simple manner and with a minimum of external circuitry associated with the tube.

Tubes made in accordance with the present invention are especially useful as counting or switching tubes if, for example, the anode is slotted at each beam position and separate targets, one opposite each slot, are utilized to achieve a separate output for each beam position. A decade counter tube, a specialized counting tube in which an output signal is derived in only one of ten possible beam positions, is provided by slotting the anode at only one of ten beam positions of the tube and having a single target opposite the slot.

Because variations in output voltage have relatively little effect on tube operating stability, tubes made in accordance with the present invention are suitable for use in multiplexing or other switching applications, for example, where modulation of the electron beam takes place.

Further, because multiple position beam tubes made in accordance with the present invention have few critical spacings and are comprised of parts which may be easily and economically fabricated, the tubes may be easily assembled and economically produced.

Referring to the accompanying drawings,

Fig. 1 is an isometric view, partly broken away, of a multiple position beam tube, including a magnet supplying a magnetic field therefor, constructed in accordance with the present invention and which is adaptable for use as a code converter tube;

Fig. 2 is a top plan view of the electrode assembly of the tube of Fig. 1 with the top spacing and supporting member thereof omitted;

Fig. 3 is an isometric view, partly broken away, of a mount assembly constructed in accordance with the present invention and adapted for use in a decade counter tube;

Fig. 4 is a schematic view of the tube shown in Figs. 1 and 2 as incorporated into a binary counting circuit;

Fig. 5 is a side elevation view and Fig. 6 is a plan view of the cathode of the tube illustrated in Fig. 1;

Fig. 7 is a side elevation view and Fig. 8 is a plan view of a spade electrode element of the tube shown in Fig. 1;

Fig. 9 is a top plan view and Fig. 10 is a side elevation view of a collector ring of the tube shown in Fig. 1;

Fig. 11 is a developed view of the anode electrode employed in the tube of Fig. 1 and showing the binary coded arrangement of the apertures therein;

Fig. 12 is a perspective view, partly broken away, of a tube mount assembly embodying the present invention and illustrating a multiple-position beam tube having ten individual output electrodes;

Fig. 13 is a sectional view of a tube employing the mount assembly of Fig. 12;

Fig. 14 is an exploded view of the mount assembly of Fig. 12, also showing the tube base with contact pins therein;

Fig. 15 is a perspective view of a modification of the anode **32′** shown in Fig. 14;

Fig. 16 is a partial sectional view of a tube employing a modification of the tube mount shown in Fig. 12;

Fig. 17 is a partial sectional view of a tube employing another modification of the tube mount of Fig. 12; and

Fig. 18 is an isometric view, partly broken away, of a multiple position beam tube in accordance with the present invention and in which the spades and anodes are arranged in substantially a straight line.

Referring now to Figs. 1 and 2, a multiple position beam tube **20** comprises, within an envelope **22**, a centrally disposed thermionic cathode which is illustrated as an indirectly heated cylindrical oxide coated cathode **24**. A coaxial and concentric array of elongated trough-shaped spade electrodes **26** is radially disposed with respect to the cathode **24**, these spade electrodes also being referred to herein as beam forming or positioning electrodes. Each spade **26**, having the general form of a V or U, has its apex facing the cathode **24** while the two sides **30—30** thereof extend outwardly away from the cathode. Surrounding the array of spades **26** on the side opposite said cathode is a sleeve type anode **32** which is provided with a plurality of apertures or slots **34**. The apertures or slots **34** are aligned with the spaces between adjacent spades. A plurality of ringlike targets or collector electrodes collectively identified by reference character **36** are disposed substantially concentrically about the longitudinal axis of the cathode **24** in axially spaced apart relationship. Each target is aligned with certain ones of the apertures or slots **34** in the anode. The individual target or collector electrodes **36***a*, **36***b*, **36***c* and **36***d*, there being four such targets in this illustrated embodiment of the invention, are secured to and supported by a plurality of insulating support members **38** disposed parallel to the cathode 24 and preferably exteriorly of the target electrodes as shown. Top and bottom mica insulating spacers, 40 and 42 respectively, maintain the cathode 24, spades 26, and anode 32 in proper spaced relationship one to another.

Leads for the cathode heater (not shown), cathode 24, each of the spades 26, anode 32, and each of the target or collector electrodes 36 are brought out through the tube base 44 to the base pins 46. The magnetic field for the tube 20 is provided by the magnet 48 which may be cylindrical in shape and encircle the tube in the manner shown in Fig. 1. The magnet provides a magnetic field whose lines of force in the tube are substantially parallel with the longitudinal axis of the cathode 24. In order to provide uniform dispersion of the flux lines within the tube, the various electrodes, leads and supports are preferably made of materials which are non-magnetic.

As shown in Figs. 5 and 6, the cathode 24 comprises a core 50 having locating beads 52 adjacent to each end in order to axially locate the electron emissive oxide coated portion 54 between the mica spacers 40 and 42.

The spade electrodes 26 each comprise, as shown in Figs. 7 and 8, an elongated trough-shaped conductive member roughly having a V-shaped transverse cross section. A tongue 56 is provided on each end of the spade 26 for locating and, when bent, locking the spade in position between the mica spacers 40 and 42.

Figs. 9 and 10 represent plan and side elevation views, respectively, of one of the ring-like targets or collector electrodes 36.

Fig. 11 shows the cylindrical anode 32 as it would appear if it were unfolded and flattened onto a plane surface. The apertures 34 in the anode 32 shown in Fig. 11 are arranged to provide an output, in binary form, corresponding to the numerals zero to nine, inclusive, as will be explained later. Thus, with the binary coding arrangement on the anode, a simple convenient tube arrangement is provided for converting from a decimal to a binary number system.

The tube 20 operates generally as follows. Referring to Fig. 1, under static conditions all the spades 26 are at substantially the same potential. The anode 32 is positively charged, and the magnetic field of the magnet 48 permeates the tube 20 in lines extending substantially parallel to the longitudinal axis of the cathode 24. Under the above conditions the magnetic field cuts off the flow of electrons which would normally be attracted to the positively charged spades 26 and anode 32 by causing the electrons to follow curved paths around the cathode 24 in the space between the cathode and the spades.

If, however, the potential of one of the spades, such as that indicated at 26a, is lowered to near the cathode potential, for example, the electrostatic field between the spade 26a and the cathode 24 is altered to the extent that the magnetic field is no longer able to cut off the flow of electrons to the area adjacent spade 26a. Once electrons flow to the spade 26a the voltage drop across the spade impedance is sufficient to hold the beam in that position even though external means for lowering the spade potential be removed. Since only a small proportion of the electrons in the beam is needed for reducing the spade potential to near cathode potential (the spade impedance is high), most of the electrons of the beam or stream are attracted to the anode electrode 32 and to the targets 36. The side of the spade 26a to which the electrons will go depends upon the direction of rotation given them by the magnetic field. As shown in Fig. 2 by way of example, the electron beam 112 is influenced by the polarity of the magnetic field to rotate in a counterclockwise direction. Assuming that the electron beam 112 is impinging on the edge of the spade 26a, most of the beam current (that in excess of the amount needed to keep the potential of the spade at near to cathode potential) will go to the anode 32 and to one or more of the target electrodes 36 if anode 32 has apertures or slots 34 between spades 26a and 26b.

The position of the electron beam may be changed conveniently, by way of example, by applying a negative pulse to the anode 32, thus momentarily lowering the potential of the anode. Lowering the anode potential has the effect of spreading the electron beam, between spades 26a and the next adjacent spade 26b in the present case, causing a small amount of electrons to impinge on spade 26b. The impinging of electrons of spade 26b causes the potential of that spade to drop, altering the electrostatic field in the area adjacent to spade 26b and, because of the tendency of the magnetic field to rotate the beam in the counterclockwise direction, causes the electron beam to switch from spade 26a to spade 26b. Once the electron beam 112 has left spade 26a the potential of that spade rises to its usual positive value. It should be noted that if the negative pulse applied to the anode 32 is of too great a duration, the beam may advance more than one spade or beam position.

Fig. 4 shows a schematic view of a decimal to binary converter tube of the type shown in Figs. 1 and 2 and a circuit suitable for use in operation of the tube. The spades 26 are arranged concentrically around the cathode 24. The anode 32, which has apertures or slots 34 as shown in Fig. 11, for example, surrounds the array of spades 26. The circle 58 adjacent to the anode 32 represents the targets 36 as seen in plan. Four leads, 60a, 60b, 60c, and 60d, shown connected to the circle 58 represent the leads to the targets 36a, 36b, 36c and 36d respectively shown in Figs. 1 and 11. Each of the spades 26 is coupled to a conductor 62 through a separate resistance-capacitance network, as, for example, resistor 64 and capacitor 66. The resistors and capacitors in each of the spade networks are of similar values. For example, resistor 64 may have a value of 200,000 ohms and capacitor 66 may have a value of 30 micro-microfarads.

The operation of the device of Fig. 4 is as follows: stepping pulses are applied to the terminal 68 and are coupled to the control grid 70 of the tube 72 through the condenser 74 and the resistor 76 connected in series between the grid 70 and the terminal 68. The output of the tube 72, taken from the anode 78 and developed across the anode load resistor 80, is applied to the grid or control electrode 82 of the tube 84 through capacitor 86. The tube 84, together with inductances 88 and 90, which are closely coupled, comprises a blocking oscillator which delivers an output pulse through a coupled inductance 92 and shunt resistor 94 to the anode 32. Anode 78 of the tube 72 is connected to a source of positive potential (250 volts, for example) indicated by the battery 96 through its load resistor 80. The anode 98 of the tube 84 is connected to the potential source or battery 96 through the inductance 90. The cathodes 100 and 102 of the tubes 72 and 84, respectively, are maintained at ground potential. The cathode 24 of tube 20 is connected to ground through the fixed current limiting resistor 104 and the variable resistor 106. The grid resistor 108 of tube 72 has a high value, 470,000 ohms, for example, and is connected between the battery 96 and the junction between the condenser 74 and the resistor 76. The control grid 82 of the tube 84 is biased negatively by the potential of the battery 110 applied through the resistor 112 and the inductance 88.

Each time a negative pulse is applied to the terminal 68 the electron beam of the tube 20 is caused to advance one position. When power is applied to the tube 20, a negative potential, relative to the positive potential supplied by battery 96, applied to spade 26c through the lead 114 causes that spade to assume the potential of the negative pulse. The "negative" potential may be provided, for example, by grounding the spade 26c through the resistor 118 by operating the switch 120 which normally connects the spade 26c to the battery 96. If the negative pulse approaches or is below the potential of the cathode 24, an electron beam will flow to the spade 26c because of the change in the electrostatic field between that spade and the cathode **24** as mentioned above. Once the electron beam impinges on the spade **26c** it locks in through its spade impedance **116**. The path of the beam moves in a clockwise or counter-clockwise direction, depending on the polarity of the magnetic field, and only a small portion of the beam continues to impinge on the spade **26c** to maintain the locking effect. The remainder of the electron beam, for example, impinges on that portion of the anode **32** between spade **26c** and spade **26d**. The negative input pulse can be removed and the electron beam will continue to impinge upon the said portion of the anode **32** and the spade **26c** since the current flowing through the resistance **116** maintains the spade **26c** at close to the potential of the cathode **24**. Thus, upon initial operation of the tube, the electron beam can be caused to always flow to the same position. In effect, a negative potential applied to the lead **114**, such as by opening switch **118**, indexes the electron beam or stream on the zero position of the tube, which position is defined as existing when the beam is locked on the spade **26c**.

Pulses which are to be counted are applied to the input terminal **68**. The input pulse, as applied to the circuit illustrated in Fig. 4, must be a negative pulse, and is applied to the control grid **70** of the tube **72** through the capacitor **74** and resistor **76**. When the grid **70** of the tube **72** is caused to become negative the current flow through the tube **72** decreases and the potential on the anode **78** thereof rises positively. The increase of anode potential of the tube **72** results in a positive increase in the potential of the control grid **82** of the tube **84**, since the anode **78** of the tube **72** is capacity coupled to the grid **82** of the tube **84**. Since the tube **84** and the associated inductances **88** and **90** constitute a blocking oscillator, as mentioned previously, the negative pulse generated at the anode **98** of the tube **84** due to the positive potential impressed on the control grid **82** thereof will be of a definite duration determined by the constants of the circuit. In the particular circuit illustrated the duration of the pulse generated at the anode of the tube **84** will be of the order of 0.8 microsecond. This pulse, inductively coupled through the inductances **90** and **92** to the anode **32** of the tube **20**, decreases the potential of the anode **32** to approximately cathode potential, or even below cathode potential. As mentioned previously, the lowering of the anode potential to near the potential of the cathode **24** has the effect of broadening or switching the electron beam. When the beam is switched a few electrons impinge on the next adjacent spade (**26d** in Fig. 4), causing a voltage drop across the spade impedance. Once the potential on the spade **26d** starts to decrease, more electrons are attracted to the spade due to further switching of the beam, and the spade, due to the increased electron flow thereto, is reduced to near or even below the potential of the cathode **24** because of the voltage drop across the spade impedance. Thus, with the electrostatic field being favorable adjacent to spade **26d**, the magnetic field causes the beam to advance to the leading edge of spade **26e**, that is, the beam will impinge on spade **26e**, but the major part of the beam will impinge on that portion of the target which lies between spades **26d** and **26e**. In a similar manner the beam may be advanced from spade to spade each time a pulse is applied to the terminal **68**. In the illustrated embodiment of the invention, there are ten beam positions, as may be seen in Fig. 2 and Fig. 4. These beam positions as used in the coding tube of Figs. 1, 2 and 4, correspond to the numerals 0 to 9 inclusive. The beam, following its advance to the "9" position will advance to the zero or index position where it was positioned when the tube was indexed by applying a pulse to the lead **114**. The tube may, of course, be re-indexed at any time without advancing in a discrete step by step manner, by applying a pulse to the lead **114**. In some cases it may be also desirable to cut off the electron beam.

The explanation of the operation of the device and circuit illustrated in Fig. 4 has thus far been concerned with

one type of movement and control of the electron beam within the tube. Referring now to Figs. 1 and 11, it may be seen that the anode **32** is provided with a series of apertures which are arranged, generally speaking, in nine columns and four levels. The columns of apertures are aligned with respect to the positions of the beam to provide an output to one or more of the targets **36** when the electron beam is in any of the "1" to "9" positions. There are no apertures aligned with the zero position, since no output is to be taken from the target electodes **36** when the beam is in that position. The output of the tube is taken from four target rings **36a**, *b*, *c*, and *d* which are arranged in "levels" around the anode **32** as shown in Fig. 1 and indicated along the right side of the anode in Fig. 11.

It can be seen that when the electron beam of the tube **20** is in the zero or indexing position, no electrons impinge on any of the four target rings. That is, since there are no slots or apertures **34** in the anode **32** in line with the zero beam position of the tube, no electrons pass on to the targets **36**. However, the anode **32** has at least one aperture or slot **34** in each of the beam positions corresponding to the numbers 1 to 9, and consequently when the electron beam is in the position corresponding to one of these numbers, electrons will impinge on one or more of the targets **36a**, *b*, *c*, and *d* and provide an output which is, as will be explained in detail later, indicative of the binary code equivalent of the decimal "number" input to the tube.

By way of background information, in the binary code a number is expressed in terms of exponents of the numeral 2. That is, the number 7 in binary code would be $2^2+2^1+2^0$ expressed in terms of exponents of the numeral 2, or 4+2+1 expressed in the usual decimal notation. Such a system of number representation is well adapted to use in computers, for example, and the general use where electron tubes are employed in number representation as is well known in the art.

The following table illustrates how the four targets **36a**, *b*, *c*, *d* are utilized to provide a binary coded output from decimal input to the tube:

Decimal Input	Output on Target				Binary Code Representation and Arithmetical Equivalent
	36*a*	36*b*	36*c*	36*d*	
1	x				2^0 or 1.
2		x			2^1 or 2.
3	x	x			2^0+2^1 or 1+2.
4			x		2^2 or 4.
5	x		x		2^0+2^2 or 1+4.
6		x	x		2^1+2^2 or 2+4.
7	x	x	x		$2^0+2^1+2^2$ or 1+2+4.
8				x	2^3 or 8.
9	x			x	2^0+2^3 or 1+8.
0					none.

Referring now to Fig. 1, it is seen that the apertures **34** in the anode **32** are so positioned with respect to the targets **36a**, *b*, *c*, *d* that the electron stream passes through the anode **32** to impinge on a different combination of the targets **36a**, *b*, *c*, *d* at different beam positions. Fig. 11 shows more clearly the arrangement of the apertures **34** which provide a binary coded output when the input to the tube causes the beam to lock in at one of the ten beam positions. The anode **32** as shown in Fig. 11, is "unfolded" onto a flat surface. The beam positions with respect to the anode **32** are indicated adjacent to the anode as are the target ring positions. The arrangement of the apertures **34** with respect to the beam positions and to the target rings **36a**, *b*, *c*, *d* may thus be seen to correspond to the binary coding arrangement shown in the table above and the output of the tube, as taken from the target rings **36a**, *b*, *c*, *d* is thus indicative of the binary coded equivalent of the decimal input to the tube. It should be realized that tubes made in accordance with the present invention are adaptable to other output coding arrangements. The target rings **36** are shown in Figs. 1 and 11 as being substantially perpendicular to the columns of apertures or slots 34, but this arrangement is not necessarily so.

The spades 26 have been heretofore described as having a "trough-shaped" transverse cross section, V-shaped cross section, etc., but it should be recognized that solid or tubular spades, or spades having other configurations could be utilized provided the electrostatic field surrounding the spade may be large enough to switch and hold the electron beam. Further, while a spade impedance is described in connection with Fig. 4 as comprising a resistance element shunted by a capacitor, in many applications the capacitor need not be employed.

In the tube structure illustrated in Fig. 12 and shown in more detail in Figs. 13 and 14, an alternative arrangement of anode slots and target electrodes is utilized to provide a multiple position beam tube which is especially useful as a switching or counting tube.

Like the coding tube previously described, the tube shown in Figs. 12, 13, and 14 has an elongated thermionic cathode 24 which is centrally disposed within a hermetically sealed envelope 22 and is surrounded by a substantially cylindrical array of elongated trough-shaped spades. A sleeve type cylindrical anode 32' of larger diameter than the spade array is disposed coaxially and concentrically with respect thereto. The anode has elongated slots 34', equal in number to the number of beam positions of the tube, disposed substantially in parallel alignment with the cathode 24 and so located with respect to the space between adjoining pairs of spades that a substantial part of the electron beam locked in on any spade will pass through one of the slots 34'. In the embodiment shown in Fig. 13 the slots are disposed directly in line with the space between each pair of adjoining spades. However, in view of the fact that the electron beam usually approaches the slots in a slightly curved path, it is possible to pass a larger percentage of the beam through the slots if the latter are offset circumferentially slightly with respect to the spaces between the spades. In such case the direction in which the slots are offset should be opposite to the direction of rotation of the electron beam.

In order to provide a separate output from every beam position, individual target electrodes 36' are disposed opposite each slot 34' in the anode 32 and the side of the anode which is opposite to the spades 26. While the targets 36 are aligned with the space between the adjacent spades as are the slots 34' in the anode 32, the targets 36' like the slots 34' may be circumferentially displaced slightly with respect to the spades and in the same direction as the slots 34 are displaced in order to permit a larger portion of the electron beam to impinge thereon. Fig. 16 shows the offset anode slots and target arrangement.

Leads (not shown) to the individual spades, individual targets, anode, and cathode are brought out through the stem 124 (which may be glass) to the base pins 46. The switching time required to move the beam from one position to another may be made more uniform if the spade resistors 64 are located within the tube envelope. One such arrangement of the spade resistors 64 is shown in Figs. 12 and 13, in which each of the resistors 64 is disposed between the sides of the spade 26 to which the individual resistor is connected. Because the resistors 64 are connected directly to the spades in this arrangement, lead capacitances are minimized and have much less effect on the switching time between individual beam positions than if leads were provided to resistors which were located outside the tube.

Other advantages accrue to the use of resistors which are located inside the tube envelope. All the resistors operate at the same temperature and are unaffected by changes in humidity. Because the resistors operate in a vacuum, they may have a larger wattage rating per unit physical size without burning out and consequently result in a saving in space which is an important advantage where equipment is to be miniaturized. However, the increase in switching speed and the uniformity of wave shape achieved through the use of the internal spade impedance elements 64 is more than sufficient reason to justify their use. In addition to the advantageous increase in switching speed made possible by the use of internal spade resistors, the switching time from one beam position to another is made more uniform. Such uniformity becomes important when it is considered that in many applications a discrete pulse width is required to switch the position of the beam. Variations in spade impedances would result in changes in the pulse widths required to switch the beam from position to position. Thus, the pulse width required to switch the beam to an "average" beam position might, for example, be too short to switch the beam to another position or long enough to advance the beam two positions if only a very short pulse width is required for switching from one position to another.

Further, a reduction in the number of leads which must pass through the tube envelope may be achieved if the switching of the beam is to be accomplished by means other than pulsing the spade electrodes. If the spades are not used to switch the electron beam from one position to another, individual spade leads are unnecessary and the internally mounted spade resistors are connected to a common lead which may be connected to the source of spade operating potential.

A quantized or stepped output from the tube of Figs. 12, 13, or 14 may be obtained if the anode 32'' shown in Fig. 15 is substituted for the slotted anode shown in those figures. The slot length is varied to control the amount of output current available at the target of each beam position. The quantized or stepped output could, of course, be achieved by varying other dimensions of the slots 34''.

Another variation of the tube shown in Fig. 12 is shown in Fig. 3. In that structure the anode 32' is slotted at only one beam position, providing a decade counter tube having an output in only one of the ten beam positions. The spade resistors 64 shown in Fig. 3 are similar to those in Fig. 12.

The anode 32 as shown in various forms in each of the embodiments of the present invention, acts as an electrostatic shield between the targets and spades, thus allowing the target output to vary to a greater extent than was formerly possible without the target field extending inwardly to such an extent that it causes the beam to switch. The positioning of the targets beyond the spades rather than between them also reduces the effect of the target field on beam switching stability. Further, this arrangement isolates the target from adjoining spades both capacitywise and physically. Reduction in spade-to-spade capacitance (through the target) results in improved beam switching characteristics which result in the unmodulated output wave more nearly resembling a square wave. The physical isolation of spades and targets permits targets having larger areas to be used, thus permitting larger power output. "Fringe" electrons near the edge of the electron beam impinge on the anode 32 and thus are not free to escape to adjoining electrodes and cause cross talk. The anode 32 and targets 36 may advantageously be composed of materials which are poor secondary electron emitters or the electrodes may be provided with a coating which reduces the secondary emission capabilities of the material.

Fig. 17 shows an electrode configuration which is similar to that shown in Fig. 13, but has suppressor electrodes 126 disposed between adjacent targets. These suppressor electrodes, which are illustrated as elongated rods, are normally maintained at or near to cathode potential and tend to repel stray electrons which do not impinge on the intended target or any other electrons which might, under the influence of the magnetic field or the positive field, on adjacent targets, tend to impinge on adjacent targets and cause cross talk. The suppressors 126 may be connected to the cathode inside the tube or they may be provided with a common lead through the tube envelope in order that they may be biased in any desired manner.

Fig. 18 shows a "straight line" version of the coding tube illustrated in Fig. 1. In this tube the spades 26', individual coded anodes 32''' and target or collector electrodes 36''' are disposed in substantially a linear manner. The coding of the anodes 32''' and the arrangement of the targets 36''' with respect to the coding apertures 34''' may be similar to those shown in connection with Fig. 1. The general functioning of the tube is similar to that of the concentric type coding tube shown in Fig. 1 in that a crossed electric and magnetic field are utilized to form and switch the electron beam from one position to another. The cathode 24' lies adjacent to a sheet-like rail electrode 128 which is bent and folded back (at 130) towards the spade 26' which is most remote from the cathode 24'. The rail 128 is electrically connected to the above mentioned remote spade and functions as an equipotential boundary for the electron beam. The generally L shaped electrode 32''' is maintained at a potential such that electrons emitted from the cathode 24' are, under the combined influence of the magnetic and electrostatic fields, caused to travel along a generally trochoidal path.

Electron beam switching from one beam position to another is accomplished in a manner similar to that used to switch the beam in the tube in Fig. 1. Leads, not shown, connect the various electrodes to the base pins 46.

While specific embodiments of the present invention have been described, it will be apparent that this invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of the invention as set forth in the appended claims.

What I claim is:

1. A multiple position beam tube comprising, within a hermetically sealed envelope, an elongated thermionic cathode, an array of elongated trough-shaped spade electrodes disposed in side-by-side relation one to another and spaced from said cathode, the sides of each of said spades extending generally away from said cathode, at least one anode disposed adjacent to the open sides of said spades and remote from said cathode relative thereto, said anode having at least one aperture, said aperture being located substantially in line with the space between a pair of adjacent spades, and at least one target electrode, said target electrode being disposed adjacent to said anode and on the side of said anode which is opposite said spades and aligned with one of said apertures so that electrons passing through the aperture will impinge on the target.

2. A magnetic field tube having positioned in the order named; an electron emissive cathode, a plurality of spades, a shielding electrode remote from said cathode relative to said spades and having an aperture, and a collector electrode, said collector electrode being displaced behind the aperture of said shielding electrode with respect to the cathode to intercept electron beam current passing through the aperture; and means for establishing a magnetic field permeating the area occupied by said elements and having field lines thereof extending substantially perpendicular to the alignment of the elements.

3. An electron discharge device comprising, in combination, an electron emissive cathode element, a plurality of spaced apart electron beam directing spade elements positioned substantially equidistant from the cathode and in insulatingly spaced relationship to one another, a plurality of electron beam collecting elements positioned in spaced relation to said spade elements, said beam collecting elements being more remotely disposed from said cathode than are said spade elements and aligned with the spaces between said spade elements to intercept an electron beam emitted by the cathode element and directed through any of said spaces, means for permeating the area occupied by said elements with a magnetic field having field lines extending substantially perpendicular to a common line extending across said spaces and joining the several spade elements, and beam switching anode means positioned intermediate said spade elements and said beam collecting elements.

4. In an electron discharge device having crossed magnetic and electrical fields, a rod-shaped electron emissive cathode disposed substantially in axial alignment with the lines of force of magnetic field within said device, a sleeve-shaped anode positioned about said cathode with its axis substantially coincident with that of the cathode, a plurality of beam directing spade electrodes symmetrically disposed in spaced apart relation interiorly of the sleeve anode and adjacent to, but spaced from the inner surface thereof, said anode being provided with a plurality of apertures in column arrangement, said columns being aligned substantially between adjacent pairs of said beam directing electrodes, and a plurality of collector electrodes disposed in spaced apart relation exteriorly of the sleeve anode and adjacent to, but spaced from the outer surface thereof, said collector electrodes having portions thereof overlying said apertured columns of the anode.

5. Electron discharge apparatus comprising, in combination, a rod-shaped electron emissive cathode, a sleeve-shaped anode positioned about said cathode with its longitudinal axis substantially coincident with that of the cathode, a plurality of beam directing electrodes disposed in circularly spaced apart relation interiorly of the sleeve anode and adjacent to, but spaced from the inner surface thereof, said anode being provided with a plurality of apertures in column arrangement extending substantially parallel to the axis of the cathode and positioned along radial planes intersecting the axis of the cathode and extending between adjacent pairs of said beam directing electrodes, a plurality of collector electrodes disposed in spaced apart relation exteriorly of the sleeve anode and adjacent to, but spaced from the outer surface thereof, each of said collector electrodes overlying one or more of said apertured columns so as to intercept at least one of said radial planes, magnetic means operable to permeate the discharge space of the apparatus with a substantially uniform magnetic field having field lines extending substantially parallel to the axis of the cathode, means for impressing on the anode and on each of the beam directing electrodes a potential which is positive with respect to the cathode, and means for modifying the impressed positive potential to form a discrete electron beam which is directed along one of said radial planes and extends from the cathode through the space between an adjacent pair of said beam directing electrodes to said sleeve anode, a substantial portion of the electron beam thus formed being passed through the apertured column on the radial plane of the beam for impingement upon a collector electrode overlying the apertured column.

6. Electron discharge apparatus comprising, in combination, a rod-like electron emissive cathode, shielding electrode means concentrically surrounding said cathode, a circular row of spaced apart electron beam positioning electrodes positioned interiorly of said shielding electrode means and adjacent to but spaced from the inner surface thereof, each of said beam positioning electrodes being generally U-shaped in cross section and disposed with the base of the U nearest to the cathode, said shielding electrode means providing a plurality of apertures positioned in line with the spaces between adjacent pairs of the beam positioning electrodes, a plurality of spaced apart collector electrodes positioned outside of said shielding electrode means adjacent to but spaced from the outer surface thereof so as to overlie said apertures, magnetic means arranged for providing a magnetic field

permeating the electron discharge space with field lines extending substantially parallel to the cathode, means for impressing a positive potential with respect to the cathode on said shielding electrode means and on the separate beam positioning electrodes, means for modifying such impressed potential to form a discrete electron beam extending from said cathode through said apertured shielding electrode means for impingement on at least one of said collector electrodes, and output leads separately connected to the collector electrodes, each of the collector electrodes and its respective output lead being electrically isolated from said shielding electrode means except when said electron beam impinges thereon.

7. Electron discharge apparatus comprising a rod-shaped electron emissive cathode, a sleeve-shaped anode arranged concentrically around said cathode, said anode having a plurality of rows of apertures extending substantially parallel to the axis of the cathode and spaced circularly around the anode, a plurality of ring-shaped collector electrodes encircling said anode in radially spaced relation thereto and in axially spaced relation to one another and in such a manner that the collector electrodes overlie the rows of apertures, a plurality of beam forming and positioning electrodes positioned between said cathode and said anode, means to permeate the space encompassed by said collector electrodes with a substantially uniform magnetic field, said magnetic field having the flux lines thereof extending substantially parallel to the axis of the cathode, and D. C. means to impress relative differences in electrical potential on said cathode, said anode and said beam forming and positioning electrodes to cause an electron beam to be formed and directed through any selected one of said rows of apertures for impingement on the collector electrodes overlying the same.

8. Electron discharge apparatus in accordance with claim 7, wherein means is provided for delivering electrical pulses to said apertured anode for beam switching purposes.

9. A multiple position beam tube comprising, within a hermetically sealed envelope, an elongated thermionic cathode, an array of beam directing spades, said array of spades comprising a plurality of similar elongated electrodes symmetrically disposed with respect to said cathode and each presenting a curved surface thereto, an anode exteriorly of said array of spades, said anode having apertures, each of said apertures in said anode being aligned with the space between a pair of adjacent spades, a plurality of target electrodes exteriorly of the anode, said target electrodes being aligned with said apertures in the anode, and suppressor electrodes respectively positioned adjacent said target electrodes.

10. A multiple position beam tube in accordance with claim 9, wherein said suppressor electrodes are conductively connected to said cathode.

11. A multiple position beam tube comprising within a substantially evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being substantially coextensive in length with said emissive portion of said cathode and being arranged to form a circular array centered on said cathode in which said spades are equidistantly and insulatingly spaced one from another, a hollow cylindrical anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of substantially identical slots spaced equidistantly around the circumference thereof, each slot being aligned with the space between a pair of adjacent spades and corresponding in length to substantially that of the electron emissive portion of said cathode, a plurality of conductive planar target electrodes equal in number to the number of slots in said anode and shaped similarly to said slots and each being at least as large in area as said slots, said target electrodes being disposed exteriorly of said anode and adjacent to and aligned with each of said slots whereby electrons passing from said cathode between a pair of spades and through the anode slot aligning with the space between the pair of spades will impinge on the target electrode aligning with the slot.

12. A multiple position beam tube comprising within a substantially evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being substantially coextensive in length with said emissive portion of said cathode and being arranged to form a circular array in which said spades are equidistantly and insulatingly spaced one from another and in which each spade presents a curved surface towards said cathode, a hollow cylindrical anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of substantially identical slots spaced equidistantly around the circumference thereof, each slot being aligned with the space between a pair of adjacent spades and corresponding in length to substantially that of the electron emissive portion of said cathode, a plurality of conductive planar target electrodes equal in number to the number of slots in said anode and shaped similarly to said slots and each being at least as large in area as said slots, said target electrodes being disposed exteriorly of said anode and adjacent to and aligned with each of said slots whereby electrons passing from said cathode between a pair of spades and through the anode slot aligning with the space between the pair of spades will impinge on the target electrode aligning with the slot, and an elongated electron suppressor electrode positioned in side-by-side relation to each of said target electrodes.

13. A multiple position beam tube comprising within a substantially evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being substantially coextensive in length with said emissive portion of said cathode, and being arranged to form a circular array in which said spades are equidistantly and insulatingly spaced one from another and in which each spade presents a curved surface towards said cathode, a hollow cylindrical anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of substantially identical slots spaced equidistantly around the circumference thereof, each slot being aligned with the space between a pair of adjacent spades and corresponding in length to substantially that of the electron emissive portion of said cathode, a plurality of conductive planar target electrodes equal in number to the number of slots in said anode and shaped similarly to said slots and each being at least as large in area as said slots, said targets being disposed exteriorly of said anode and adjacent to and aligned with each of said slots whereby electrons passing from said cathode between a pair of spades and through the anode slot aligning with the space between the pair of spades will impinge on the target electrode aligning with the slots, and a plurality of elongated electrodes, one of said elongated electrodes being disposed in side-by-side relation to each of said targets and insulated therefrom, each of said elongated electrodes being electrically conductively connected to said cathode within said evacuated envelope.

14. A multiple position beam tube comprising within an evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being coextensive in length with said emissive portion of said cathode and being arranged to form a cylindrical array centered on said cathode in which said spades are equidistantly and

insulatingly spaced one from another and in which each spade presents a curved surface towards said cathode, a hollow cylindrical anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of apertures spaced around the circumference thereof arranged in a coded manner, each aperture being aligned with the space between a pair of adjacent spades, a plurality of conductive ring-like target electrodes, said target electrodes having a larger diameter than and being disposed in stacked relation one with another coaxially with respect to said anode, each of said target electrodes being disposed adjacent to said anode and aligned with at least one of said apertures.

15. A multiple position beam tube comprising within a substantially evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being substantially coextensive in length with said emissive portion of said cathode and being arranged to form a circular array in which said spades are equidistantly and insulatingly spaced one from another, a sleeve-like anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of slots spaced equidistantly around the circumference thereof, each slot being aligned with the space between a pair of adjacent spades, the length of said slots varying in predetermined stepped manner, a plurality of conductive target electrodes equal in number to the number of slots in said anode and disposed exteriorly of the anode with a different one of said target electrodes adjacent to and aligning with each of said slots whereby electrons passing from said cathode through the space between a pair of spades and through the anode slot aligning therewith will impinge on one of said target electrodes.

16. A multiple position beam tube comprising within a substantially evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being substantially coextensive in length with said emissive portion of said cathode and being arranged to form a circular array in which said spades are equidistantly and insulatingly spaced one from another, a sleeve-like anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of slots spaced equidistantly around the circumference thereof, each slot being aligned with the space between a pair of adjacent spades, the areas of said slots differing from one another in accordance with a predetermined pattern, a plurality of conductive target electrodes, said target electrodes being equal in number to the number of slots in said anode and shaped similarly to said slots and each being at least as large in area as said slots, a different one of said target electrodes being disposed adjacent to and aligned with each of said slots exteriorly of said anode whereby electrons passing from said cathode through the space between a pair of spades and through the anode slot associated therewith will impinge on said target electrode.

17. A multiple position beam tube comprising within an evacuated envelope, an elongated cylindrical cathode disposed centrally thereof, said cathode having an electron emissive portion, a plurality of substantially identical spade electrodes, said spade electrodes being coextensive in length with said emissive portion of said cathode and being arranged to form a cylindrical array in which said spades are equidistantly and insulatingly spaced one from another and in which each spade presents a curved surface towards said cathode, a hollow cylindrical anode, said anode being disposed exteriorly of said array of spades and surrounding the same, said anode having a plurality of substantially identical slots spaced equidistantly around the circumference thereof, each slot being aligned with the space between a pair of adjacent spades, and corresponding in length to the electron emissive portion of said cathode, a plurality of conductive planar target electrodes, said target electrodes being equal in number to the number of slots in said anode and shaped similarly to said slots and each being at least as large in area as said slots, a different one of said target electrodes being disposed adjacent to and aligned with each of said slots exteriorly of said anode whereby electrons passing from said cathode through the space between a pair of spades and through the anode slot associated therewith will impinge on said target electrode, said spade electrodes, anode, and target electrodes being composed of conductive substantially non-magnetic materials which have poor secondary electron emission capabilities.

18. An electron discharge device comprising a hermetically sealed envelope, a cathode secured within said envelope, an anode secured within said envelope, a plurality of spade electrodes positioned within said envelope between said cathode and said anode, said spade electrodes being arranged to form an array of electrodes substantially equidistant from said anode, said anode having a plurality of apertures in coded column arrangement with each coded column aligned with the space between an adjacent pair of said spade electrodes, a plurality of collector electrodes positioned behind said anode with respect to said cathode, said collector electrodes being adapted to receive electron beams respectively traversing said apertures aligned therewith, a first means to accelerate an electron beam from said cathode toward said anode, a second means to vary the potential of said anode, and a third means to create a magnetic field substantially parallel with each of said columns of apertures.

19. Electron discharge apparatus comprising a hermetically sealed envelope, a rod shaped cathode in said envelope, a sleeve shaped anode in said envelope and positioned concentrically around said cathode, a plurality of spade electrodes uniformly spaced apart and positioned between said cathode and said anode in a manner concentric with said anode and said cathode, said anode having a plurality of columns of coded apertures and each of said columns being substantially parallel with the axis of said rod shaped cathode, each aperture in each column being intersected by one of a given number of imaginary planes substantially perpendicular to the axis of said rod shaped cathode, a plurality of ring-like collector electrodes in said envelope and positioned concentrically around said anode, each of said collector electrodes being further positioned so as to intercept any straight line drawn perpendicularly from said cathode through any aperture associated with a given one of said imaginary planes, one collector electrode being associated with an individual one of said imaginary planes, a first means to maintain said electrodes positive with respect to said cathode, a second means to apply to said anode a potential which is positive with respect to said cathode, a third means to apply negative pulses upon said anode, and a fourth means to create a magnetic field permeating the envelope and having flux lines thereof extending substantially parallel with the axis of said rod shaped cathode.

20. Electron discharge apparatus in accordance with claim 19 in which said anode and said plurality of spade electrodes are of non-magnetic material.

21. Electron discharges device in accordance with claim 19 in which each of said spade electrodes comprises an elongated strip of non-magnetic metallic composition arranged substantially parallel with the axis of said rod-like cathode, the cross sectional configuration of each of said spade electrodes being substantially U-shaped with the vertex of the U being nearest said cathode.

22. Electron discharge apparatus comprising a hermetically sealed envelope, first means secured within said envelope and adapted to generate a line source electron beam, a plurality of uniformly spaced apart electron beam directing spade electrodes positioned to form a circular row centered on said first means, a sleeve shaped

anode arranged concentrically around said row of spade electrodes, a plurality of ring-shaped collector electrodes in said envelope and arranged concentrically around said anode, said plurality of collector electrodes being axially spaced from one another so as to each be opposite a different portion of the surface of said anode, said anode having a plurality of rows of apertures and each row of apertures being arranged in a coded manner, each of said rows of apertures further being substantially parallel with the axis of said anode and opposite a different space between adjacent pairs of said spade electrodes, and electrode means for displacing said electron beam from one of said rows of apertures to another of said rows of apertures, said plurality of collector electrodes being adapted to intercept and detect the electron beam current flowing through the apertures of any one of said given rows of apertures.

23. Electron discharge apparatus comprising a rod-shaped cathode adapted to emit an electron stream, cylindrically shaped anode means arranged concentrically around said cathode, a plurality of collector rings positioned concentrically around said anode means and spaced axially apart so that each of said collector rings is adjacent to a different portion of said anode means, means to permeate the area between said cathode and said anode means with a substantially uniform magnetic field having flux lines thereof extending substantially parallel with the axis of said rod-shaped cathode, said anode means having a plurality of columns of apertures circularly spaced thereabout and each arranged in a coded manner, electrode means positioned between said cathode and said anode means and operable to cause a portion of said electron stream to selectively and individually impinge upon said columns of apertures, said collector rings being positioned so as to detect the coded arrangement of the apertures in said columns of apertures by individually intercepting portions of the electron stream passing through said apertures.

24. Electron discharge means for producing and displacing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising within a hermetically sealed envelope an elongated cathode, a cylindrical array of circumferentially spaced beam forming and directing electrodes coaxial therewith, target electrodes in a second coaxial cylindrical array remote from said cathode relative to said first array, each target electrode having a portion thereof in radial alignment with a space between adjacent ones of said beam forming electrodes, means for producing a unidirectional magnetic field parallel to the axis of said cathode for action conjointly with an electrostatic field between said cathode and said electrodes to control the formation and the path of an electron beam therebetween, and electrode means intermediate at least one beam forming and directing electrode and an adjacent target electrode constructed and arranged to produce, when suitably excited, a modification of the electrostatic field in which said beam is formed and directed for causing the switching of the beam from one target electrode to another.

25. Electron discharge means as defined in claim 24 wherein said electrode means comprises circumferentially alternating conductive portions and apertures devoid of conductors, at least a portion of each of said apertures being in radial alignment with a space between adjacent beam forming electrodes and with a portion of a target electrode.

26. Electron discharge means for producing and directing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising an elongated cathode, beam forming electrodes equidistant from the cathode in spaced cylindrical array and each having a radially extending portion, target electrodes in spaced cylindrical array coaxial with said cathode and remote therefrom relative to said first array of beam forming electrodes, each of said target electrodes having a portion thereof intercepted by radial lines from said cathode extending through the space between adjacent ones of said beam forming electrodes and further having another portion thereof in substantial radial alignment with said radial portion of one of the adjacent beam forming electrodes, means for producing a unidirectional magnetic field parallel to the axis of said cathode to control the formation and path of a beam of electrons originating at the cathode for action conjointly with an electrostatic field between the cathode and said other electrodes, and further electrode means positioned within the space between the radially aligned portions of the beam forming electrodes and the adjacent target electrode for creating, when suitably excited, an electrostatic field for beam switching purposes.

27. Electron discharge means for producing and directing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising an elongated cathode, beam forming electrodes equidistant from the cathode in spaced array and each having a radially extending portion, target electrodes in spaced cylindrical array coaxial with said cathode and remote therefrom relative to said first array of beam forming electrodes, each of said target electrodes having a portion thereof intercepted by lines from said cathode extending through a space between adjacent ones of said beam forming electrodes and another portion thereof in substantial radial alignment with said radial portion of one of said beam forming electrodes, means for producing a unidirectional magnetic field parallel to the axis of said cathode to control the formation and path of a beam of electrons originating at the cathode conjointly with an electrostatic field between the cathode and said other electrodes, and further electrode means positioned within the space between the radially aligned portions of the beam forming electrodes and the adjacent target electrode for modifying the electrostatic field in said space for switching the beam from one target electrode to another target electrode.

28. Electron discharge means as defined in claim 26 wherein circuit means are provided for supplying an electric impulse of short duration to said further electrode means for the excitation thereof to switch the beam from one target electrode to another.

29. Electron discharge means for producing and directing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising an elongated cathode, beam forming electrodes equidistant from the cathode in spaced array, target electrodes equidistanct from the cathode in spaced array and remote therefrom relative to said beam forming electrodes, each target electrode having a portion thereof intercepting straight lines from said cathode extending through the space between adjacent ones of said beam forming electrodes, means for producing a unidirectional magnetic field parallel to the axis of said cathode for cooperation with an electrostatic field between the cathode and said other electrodes for controlling the formation and the path of a beam of electrons originating at said cathode, beam switching electrode means in the space intermediate each of said beam forming electrodes and the adjacent target electrode, an evacuated envelope enclosing all said electrodes, a base therefor, and contact pins mounted on said base providing external connections to said several electrodes and said beam switching electrode means, the latter being electrically isolated within said envelope from said other electrodes.

30. Electron discharge means for producing and displacing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising within a hermetically sealed envelope an elongated cathode, beam forming and directing electrodes in circumferentially spaced apart cylindrical

array and coaxial with the cathode, target electrodes in a second coaxial cylindrical array remote from said cathode relative to said first array, means for producing a unidirectional magnetic field parallel to the axis of said cathode for action conjointly with an electrostatic field between said cathode and said electrodes, other electrode means intermediate at least one beam forming and directing electrode and an adjacent target electrode for beam switching purposes, contact means passing through said envelope for making external connection to said several electrodes, and circuit means connecting a contact of said last means with one of said several electrodes, said circuit means including a resistor mounted within said envelope.

31. Electron discharge means for producing and displacing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising within a hermetically sealed envelope an elongated cathode, spade electrodes in circumferentially spaced apart cylindrical array and coaxial with the cathode, target electrodes in a second coaxial cylindrical array remote from said cathode relative to said first array, means for producing a unidirectional magnetic field parallel to the axis of said cathode in crossed relation to an electrostatic field between said cathode and said electrodes, other electrode means intermediate at least one spade electrode and an adjacent target electrode for beam switching purposes, contact means passing through said envelope for making external connection to said several electrodes, and circuit means connecting a contact of said last means with one of said spade electrodes, said circuit means including a resistor mounted within said envelope.

32. Electron discharge means for producing and displacing an electron beam to cause selective impingement thereof for controllable periods on a plurality of target electrodes comprising within a hermetically sealed envelope an elongated cathode, spade electrodes in circumferentially spaced apart cylindrical array and coaxial with the cathode, each spade electrode having the general form of a U with its apex facing the cathode, target electrodes in a second coaxial cylindrical array remote from the cathode relative to said first array, means for producing a unidirectional magnetic field parallel to the axis of said cathode in crossed relation to an electrostatic field between said cathode and said electrodes, other electrode means intermediate at least one spade electrode and an adjacent target electrode for beam switching purposes, contact means passing through said envelope for making external connection to said several electrodes, and circuit means connecting a contact of said last means with one of said spade electrodes, said circuit means including a resistor mounted within said envelope within the area generally bounded by the spade electrode to which it is connected, whereby said resistor is shielded from the electron beam.

33. Electron discharge apparatus comprising a hermetically sealed envelope, a rod shaped cathode in said envelope, a sleeve shaped anode in said envelope and positioned concentrically around said cathode, a plurality of spade electrodes uniformly spaced apart and positioned between said cathode and said anode in a manner concentric with said anode and said cathode, said anode having a plurality of columns of coded apertures and each of said columns being substantially parallel with the axis of said rod shaped cathodes, each aperture in each column being intersected by one of a given number of imaginary planes substantially perpendicular to the axis of said rod shaped cathode, a plurality of ring-like collector electrodes in said envelope and positioned concentrically around the outside of said anode, each of said collector electrodes being further positioned so as to intercept any straight line drawn perpendicularly from said cathode through any aperture associated with a given one of said imaginary planes, one collector electrode being associated with an individual one of said imaginary planes, a first means to maintain said electrodes positive with respect to said cathode, a second means to apply a positive potential with respect to said cathode upon said anode, a third means to apply negative pulses upon said anode, and a fourth means to create a magnetic field permeating the envelope and having the field lines thereof extending substantially parallel with the axis of said rod shaped cathode.

34. Electron discharge apparatus comprising within a hermetically sealed envelope, an elongated thermionic cathode, a plurality of uniformly spaced apart spade electrodes concentrically disposed with respect to said cathode, a sleeve shaped anode arranged concentrically around said spade electrodes, a plurality of ring-shaped collector electrodes arranged concentrically around the outside of said anode, said plurality of collector electrodes being axially spaced from one another so as to each be opposite a different portion of the surface of said anode, said anode having a plurality of rows of apertures and each row of apertures being arranged in a coded manner, each of said rows of apertures further being substantially parallel with the longitudinal axis of said anode and opposite the space between adjacent pairs of said spade electrodes, and electron-deflecting means for causing stepping of an electron beam current from one pocket between spade electrodes to another, said plurality of collector electrodes being adapted to intercept in a detectable manner the electron beam current flowing through the apertures of any one of said given rows of apertures.

35. In an electron discharge device having crossed magnetic and electrical fields, a rod shaped cathode in the magnetic field and arranged with its axis substantially paralleling the lines of force of the magnetic field, a sleeve shaped anode positioned about said cathode with its axis substantially coincident with that of the cathode, a plurality of beam control electrodes disposed in circularly spaced apart relation inside the sleeve anode and adjacent to but spaced from the inner surface thereof, said anode being provided with a plurality of apertured columns, each of said columns extending substantially parallel to the axis of the cathode and on radial planes paralleling and intersecting the axis of the cathode and extending substantially between adjacent pairs of said control electrodes, and a plurality of collector electrodes disposed in spaced apart relation on the outside of the sleeve anode and adjacent to but spaced from the outer surface thereof, each of said collector electrodes being arranged to intercept at least one of said radial planes to receive an electron beam directed through the apertured column coextensive with the plane.

36. In electron discharge apparatus for forming and directing an electron beam in which the electrons thereof follow trochoidal paths responsive to the joint action of crossed electrostatic and magnetic fields to cause selective impingement of the beam on a plurality of collector electrodes, the combination of a hermetically sealed envelope, a source of electrons therewithin adapted to emit a beam of electrons, a first electrode structure spaced from said electron source and constituted by a plurality of beam forming and controlling spade electrodes spaced from each other to define passageways therebetween into which the electron beam may be directed and locked, a second electrode structure spaced from said first electrode structure and disposed on the side thereof remote from said electron source constituted by a plurality of collector electrodes arranged with respect to the electrodes of said first structure so that each collector electrode has an area overlying the passageway between two adjacent spade electrodes and disposed to receive an electron beam directed through said passageway, and a beam switching structure situated intermediate said spade electrode structure and said collector electrode structure and spaced from each constructed and arranged to permit electron

flow to the beam receiving areas of the collector electrodes and including distinct conductive portions thereof respectively associated with juxtaposed spade and collector electrodes serving to effect, when suitably excited, the switching of beam from one passageway to another.

37. The combination defined in claim 36 wherein said beam switching structure is constructed and arranged to provide openings therein intermediate adjacent ones of said conductive portions thereof, said openings being respectively aligned with said beam receiving areas of the collector electrodes to permit passage of electrons of the beam to said areas.

38. The combination defined in claim 36 wherein said conductive portions of the beam switching structure are electrically interconnected for common excitation thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,591,997 Backmark ---------- Apr. 8, 1952
2,616,061 Charton ---------- Oct. 28, 1952
2,616,062 Charton ---------- Oct. 28, 1952
2,620,454 Skellett ---------- Dec. 2, 1952