Fig. 1.

Fig. 2.

Fig. 3.

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This invention relates to multiple output electronic counting tubes and to improved circuits for using such tubes.

Electronic counting tubes generally include a plurality of electrodes arranged in groups, and, under the influence of an external driving means, an electron beam switches from group to group during the counting operation. Under some circumstances, it is desirable to be able to stop such a tube at a particular counting position. In the past, this has been accomplished by inactivating the external driving means. However, this type of indirect inactivating of the counting tube does not positively lock or inactivate the counter, since it is possible for stray noise to affect the tube from the portion of the circuitry between the external driving means and the tube itself. Such stray noise may cause undesired, spurious counting.

Accordingly, the principles and objects of the present invention are concerned with an improved circuit for stopping and locking a counting tube in any desired position during a counting operation, with substantially no opportunity for the tube to execute a spurious counting operation.

In brief, the invention relates to a magnetron-type, multi-electrode electron beam tube which operates with crossed electric and magnetic fields and includes a central cathode and a plurality of groups of electrodes, from each of which an output signal is derived. Each group of electrodes includes an output target electrode, a spade electrode adapted to form and hold an electron beam on its associated target electrode, and a switching electrode which serves to switch an electron beam from one group of electrodes to the next. A suitable external driving means is provided for operating the switching electrodes and effecting the counting operation. According to the invention, means are provided for stopping the tube at any particular count. This means operates by biasing the switching electrodes at such a level of potential that they cannot affect the electron beam, regardless of the action of the external driving means.

The means of the invention includes unidirectional current flow means coupled to all of the switching electrodes, this means being capable of operating in two states, one state in which it does not affect the switching electrodes and the tube counts in normal fashion, and one state in which it is activated to disable the switching electrodes and thus prevent the tube from counting.

The invention is described in greater detail by reference to the drawings where:

**FIG. 1** is a perspective view of an electron discharge device utilizing in practicing the invention;

**FIG. 2** is a schematic representation of the device of FIG. 1 and a circuit embodying the invention; and

**FIG. 3** is a schematic representation of a modification of the circuit of FIG. 1.

The circuits and systems described below are particularly suitable for use with a type 6700 multi-position electron beam tube. This type of tube is shown in FIG. 1 as tube 16, and includes, briefly, an envelope 12 which contains a central longitudinally elongated cathode 14 and ten groups of electrodes spaced radially equidistantly from the cathode and surrounding the cathode. Each group of electrodes includes a generally U-shaped elongated spade electrode 16 and a generally L-shaped target electrode 18 positioned so that each target occupies the space between adjacent spade electrodes. Each spade electrode serves to form and hold an electron beam on its corresponding target electrode. A generally rod-like switching electrode 20 is also included in each group of electrodes and is positioned between one edge of each target electrode and the adjacent spade electrode. The switching electrodes are known as switching grids. An open-ended cylindrical permanent magnet 22 is provided surrounding the tube envelope and coaxial therewith. The magnet provides an axial magnetic field which is utilized in conjunction with electric fields within the tube to form and switch an electron beam from the cathode to each of the groups of electrodes. The direction in which the beam switches, that is clockwise or counterclockwise, is always the same and is determined by the orientation of the electric and magnetic fields.

Briefly, in operation of tube 16, electrons emitted by the cathode are retained at the cathode if each of the spades, targets and switching grids carries its normal operating electrical potential. When a spade or switching grid experiences a suitable lowering of its potential, an electron beam is formed and directed to the corresponding target electrode. The electron beam may be switched from one target electrode to the next by thus suitably altering the electrical potentials of a spade or switching grid. Under normal operating conditions, whenever electrode voltages are such that a beam might be supported at several positions, the beam will switch to the most leading position and lock in at this position.

In the circuit of FIG. 2, the output 19 is shown as a schematic, linear form with the positions or groups of electrodes thereof numbered serially from 0 to 9. In the circuit, the cathode 14 is connected through a suitable resistor 24 to ground. Each of the spade electrodes 16 is coupled through a suitable load resistor 26 to a spade bus 28. The spade bus 28 is coupled through a common resistor 30 to a suitable positive D.C. power supply 32. A suitable clear and zero-set circuit 34 for clearing an electron beam in the tube and resetting it at the "0" position is coupled to the spade bus and the spade electrode at the "0" position. A typical zero-set circuit operates by first reducing the potential of the spade bus 28 to a level at which a beam cannot be maintained at any position and then holding the "0" spade at a lower voltage level than the other spades until a beam forms at the "0" position.

The output or target electrodes 18 are each coupled through a suitable load resistor 36 to a target bus 38 which is connected to a suitable positive D.C. power supply 40. Each target electrode is also connected to a suitable utilization circuit which may be, for example, a type 6844A indicator tube or the like. In FIG. 2, each of the targets is shown connected to an element 38 which represents one of the numeral glow cathodes 36 of such an indicator tube. For purposes of simplifying the drawing, only the indicator glow cathodes of the indicator tube are shown.

The switching grid electrodes 20 may be connected in several different ways. In one arrangement, shown in FIG. 2, the grids at the even-numbered position are connected in one set to a common bus 40 and the grids at the odd-numbered positions are connected in another set to a common bus 42. The bus 40 is connected to the output of a cathode follower 44, and the bus 42 is connected to the output of a cathode follower 46. The input of each cathode follower is connected to one of the outputs of a flip-flop circuit 48. As first one and then the other output of the flip-flop operates, pulses applied through the cathode followers to the grid buses...
2,999,183

40 and 42 cause an electron beam in the tube to move from position to position. According to the invention, means are provided for stopping the counting operation of the tube 10 and locking the electron beam at any desired position. This is accomplished by rendering the switching grids 20 inoperative at the desired instant by biasing them all at such a high positive level of potential that they cannot affect the electron beam, regardless of the action of the flip-flop circuit 42. In the embodiment of the invention shown in FIG. 2, this means comprises two diodes 50 and 52 connected between the busses, the cathodes of the diodes being connected to the busses 40 and 42 and their anodes being connected together. The anodes of the diodes are also connected to a two-terminal switch 53 having one terminal 56 coupled to a source of reference potential such as ground and a second terminal 58 coupled to a source of positive voltage $V_o$. The reference potential such as ground serves to reverses the diodes and render them inoperative when the tube is in a normal counting operation. The positive voltage $V_o$ serves to render the diodes conductive, whereby the busses 40 and 42 and the switching grids 20 are raised to the positive potential $V_o$ at which the normal switching function of the tube is interrupted.

Thus, in operation of the circuit of FIG. 2, when it is desired to stop the tube 10 to count in normal fashion, the switch 53 is operated so that the lead 54 is connected to the terminal 56 and to ground and the diodes 50 and 52 are thereby rendered non-conductive and they do not affect the operation of the switching electrodes. When, during the normal counting operation, it is desired to stop the count and to lock an electron beam in a desired position in the tube 10, the switch 53 is operated so that the lead 54 is in contact with the terminal 58 and the positive voltage $V_o$, and the diodes 50 and 52 are thus rendered conductive. When the diodes conduct current, the busses 40 and 42 and the switching grids are raised to the positive potential $V_o$ at which the switching grids are unable to perform a switching function even if switching pulses are applied thereto from the flip-flop circuit 42.

In a typical operative circuit, the target supply voltage $V_T$ may be about 300 volts; the spade supply voltage $V_s$ may be about 200 volts; and the diode positive bias voltage $V_o$ is about 200 volts.

In a modified circuit for operating a beam switching tube shown in FIG. 3, the tube 10 is used and all of the circuit connections may be identical except that the switching electrodes 20 are all connected together to a single bus 60 and to a suitable source 62 of negative switching potential. Such pulses are of controlled time duration to provide the desired one-step switching of an electron beam in the tube 10. In this embodiment of the invention, the count-stopping means comprises a single diode 64 having its anode connected to the bus 60, and its cathode connected to the switch 55 which is energized by a voltage $V_o$ applied to the voltage source 62 as in FIG. 2. The operation of the circuit of FIG. 3 is identical to that of FIG. 2.

It is clear that neither mechanical or electronic switching means may be employed for connecting the anodes of the diodes either to ground or to the positive voltage source $V_o$. Tubes, transistors, or any other suitable means may be employed to provide electronic switching.

What is claimed is:

1. A counting circuit comprising a multi-position electron beam tube adapted to operate with crossed electric and magnetic fields including a cathode, a plurality of groups of electrodes surrounding said cathode, each of said groups of electrodes including a target output electrode and a spade electrode adapted to hold an electron beam on its corresponding target electrode and a switching electrode for switching an electron beam from one group of electrodes to the next, a source of switching signals coupled to each of said switching electrodes, and circuit means coupled to all of said switching electrodes and adapted to operate in two states in one of which it applies an operating potential to said switching electrodes which allows them to perform their normal switching function in response to signals from said source of switching signals and in the other of which it applies a different potential to said switching electrodes so that said switching electrodes are disabled and do not perform their normal switching function when switching signals are applied thereto from said source of switching signals.

2. A counting circuit comprising a multi-position electron beam tube adapted to operate with crossed electric and magnetic fields including a cathode, a plurality of groups of electrodes surrounding said cathode, each of said groups of electrodes including a target output electrode and a spade electrode adapted to hold an electron beam on its corresponding target electrode and a switching electrode for switching an electron beam from one group of electrodes to the next, a source of switching signals coupled to each of said switching electrodes, and circuit means coupled to all of said switching electrodes and directed current flows means coupled to all of said switching electrodes and directed current flows to operate in two states in one of which it applies a bias potential to said switching electrodes so that said switching electrodes perform their normal switching function in response to signals from said source of switching signals and in the other of which it applies a lower bias potential to said switching electrodes so that said switching electrodes are unable to perform their normal switching function in response to switching signals from said source of switching signals.

3. A counting circuit comprising a multi-position electron beam tube adapted to operate with crossed electric and magnetic fields including a cathode, a plurality of groups of electrodes surrounding said cathode, each of said groups of electrodes including a target output electrode and a spade electrode adapted to hold an electron beam on its corresponding target electrode and a switching electrode for switching an electron beam from one group of electrodes to the next, driving means coupled to said switching electrodes for switching an electron beam from position to position in said tube, diode means coupled to all of said switching electrodes, circuit means coupled to said diode means for applying a different potential to said diode means in two states in one of which the diode means applies a positive bias voltage to said switching electrodes so that said switching electrodes perform their normal switching function in response to said driving means and in the other state said diode means applies a voltage to said switching electrodes which disable said switching electrodes and prevents them from performing their normal switching function in response to said driving means.

4. A counting circuit comprising a multi-position electron beam tube adapted to operate with crossed electric and magnetic fields including a cathode, a plurality of groups of electrodes surrounding said cathode, each of said groups of electrodes including a target output electrode and a spade electrode adapted to hold an electron beam on its corresponding target electrode and a switching electrode for switching an electron beam from one group of electrodes to the next, driving means coupled to said switching electrodes for switching an electron beam from position to position in said tube, and circuit means coupled to all of said switching electrodes and directed current flows means adapted to operate in two states in one of which it applies an operating potential to said switching electrodes which allows them to perform their normal switching function in response to switching signals from said source of switching signals and in the other of which it applies a different potential to said switching electrodes so that said switching electrodes are disabled and do not perform their normal switching function when switching signals are applied thereto from said source of switching signals.
trod<et>es are disabled and do not perform their normal switching function when switching signals are applied thereto from said driving means.

5. A counting circuit comprising a multi-position electron beam tube adapted to operate with crossed electric and magnetic fields including a cathode, a plurality of groups of electrodes surrounding said cathode, each of said groups of electrodes including a target output electrode and a spade electrode adapted to hold an electron beam on its corresponding target electrode and a switching electrode for switching an electron beam from one group of electrodes to the next, all of said switching electrodes being connected together, a source of switching signals coupled to said switching electrodes, and circuit means coupled to all of said switching electrodes adapted to operate in two states in one of which it applies an operating potential to said switching electrodes which allows them to perform their normal switching function in response to signals from said source of switching signals and in the other of which it applies a different potential to said switching electrodes so that said switching electrodes are disabled and do not perform their normal switching function when switching signals are applied thereto from said source of switching signals.

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