TRANSMISSION OF CARRY SIGNALS BETWEEN ELECTRONIC COUNTER TUBES
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This invention relates to electronic counters or distributors and particularly to such circuits which use multiple position electron discharge devices.

One type of electron discharge device which may be used for counting or distributing is known as a magnetron beam switching tube and is described in U.S. Patent No. 2,721,955. This type of tube includes a central cathode and a plurality of groups of electrodes surrounding the cathode, from each of which an electrical output current may be obtained. Each group of electrodes includes a target electrode to which an electron beam flows and from which an output signal is obtained, a spade electrode which forms and holds an electron beam on its associated target electrode, and a switching electrode which is used to switch an electron beam from one position to the next. The tube is enclosed in a cylindrical magnetic field which provides a longitudinal magnetic field in the tube. In its commercial form, the magnetron beam switching tube includes ten positions or groups of electrodes, and when it is desired to provide counters or distributors which have more than ten operative positions, two or more beam switching tubes are connected together in cascade. However, in the past, it has not been convenient to obtain an output signal or count from each position in each tube in a cascade arrangement while, at the same time, providing both means for transmitting an output pulse from one tube to the next and means for clearing and resetting the electron beam in each tube.

Accordingly, the principles and objects of the present invention are directed toward the provision of an improved electronic counter or distributor employing multiple position magnetron beam switching tubes and providing an output signal from each position of each tube while, at the same time, including both means for clearing and resetting each tube and means for transmitting carry signals from tube to tube.

Briefly, the principles and objects of the invention are accomplished in a counter or distributor which includes, for illustrative purposes, two 10-position magnetron switching tubes connected to provide a 20-position counter or distributor. In each tube, one of the positions is selected as the first position, and one is selected as the last. According to the invention, an auxiliary external electron discharge device is coupled between the last position of the first beam tube and the first position of the second beam tube. The auxiliary device is so coupled that, without interfering with the provisions of an output signal from the last position of the first tube, it clears the first tube and sets the electron beam at the first position in the second tube to initiate the counting cycle thereof. A similar external device is coupled between the last position of the second tube and the first position of the first tube to perform the functions of clearing the second tube and setting an electron beam in the first tube.

The invention is described in greater detail by reference to the single figure of the drawing which is a schematic representation of a circuit embodying the invention. The drawing described below is particularly suitable for use with magnetron beam switching tubes, such as Type 6700 tubes, shown schematically as tubes 10 and 10' in the drawing. In actual construction, such tubes have a circular arrangement of parts, but, for convenience, they are shown schematically in linear form. The tubes 10 and 10' are identical and corresponding parts carry the same reference numerals, the numerals being primed in tube 10'. The tube 10 includes an envelope 12 which contains a central cathode 14 and ten groups of electrodes in operative relation with the cathode. Each group of electrodes comprises a position to which an electron beam may flow and from which an output signal may be obtained.

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 represented schematically at 22 surrounds the tube envelope and provides an axial magnetic field in the tube. The tube utilizes crossed electric and magnetic fields to form and switch an electron beam from the cathode to each of the groups of electrodes in turn. 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 both tube 10 and 19', 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 the potential of a spade is suitably lowered, 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 shown, the cathodes 14 and 14' are connected together by lead 24 and to a source of reference potential such as ground. All of the spade electrodes 16 in the tube 10 are connected to spade load resistors 26, with the load resistance at the "9" position provided in two separate equal parts 27. This facilitates coupling external circuitry to the "9" spade, that is the spade at the "9" position. The "0" spade in tube 10, that is the spade at the "0" position, is connected through its spade load resistor to a buss 28 which is connected in turn through a common spade resistor 30 to a second buss 32. The buss 32 is coupled to a suitable power supply 38 of about 300 volts. The spade electrode at the "9" or last position is coupled through its load resistors 27 to a buss 34 which leads to a suitable power source 39 of about 90 volts. The other spade electrodes at positions "1" to "8" are connected through load resistors 26 to a buss 36 which is connected in turn through a resistor 38 to the buss 32 and power supply 39. The buss 36 is also connected through a push-button switch 39 to the lead 24 between the cathodes 14 and 14'. A clamping diode 40 is connected between buss 28 and the cathode. A clamping diode 42 is connected between buss 34 and buss 36.

Referring to tube 10', the spade electrodes 16' are connected to spade load resistors 26', with the "9" spade resistance being in two parts 27'. The "0" spade is coupled through its load resistor to the buss 36. The "9" spade in the tube 10' is connected through its load resistors 27' to the buss 34. The spade electrodes at positions "1" to "8" are connected through their load resistors to the buss 28.
All of the target electrodes 18 and 19' are coupled through load resistors 44 and 44', respectively, to the common target bus 32 which is coupled to the power supply through V, 50. If desired, an auxiliary output tap 45 and 45' may be provided for each target for connection to a suitable utilization device or circuit, such as a cathode glow indicator tube, a printing mechanism, relays, or the like.

The switching grid electrodes 20 and 20' are connected as follows. For convenience, the connections are not shown in the drawing as being made directly to the electrodes in the tubes 10 and 19', but are shown outside the tubes. The switching electrodes at the even-numbered positions in both tubes 10 and 19' are connected together in one set, and the switching electrodes at the odd-numbered positions in both tubes are connected together in another set. One set of grids is then connected to a capacitor 56 and a lead 58 to one of the outputs of a suitable flip-flop circuit 50, and the other set of grids is connected through a capacitor 52 and a lead 54 to the other output of the flip-flop 50. As one and then the other output of the flip-flop is applied to a switching grid, a beam is moved from position 0 to position 1 in one of the tubes. Resistors 56 and 58 are coupled between leads 54 and 52, and the junction point thereof is connected to a power source Vo of about 5 volts.

According to the invention, a pair of electron discharge devices are provided for promoting the transfer of a count or signal from one counting tube to the other and at the same time clearing the beam from the tube from which the count is transferred. These devices are connected and operate in such a way that, when, for example, tube 10 reaches the last count in a cycle, the tube 10' is then set into operation, and at the same time, the electron beam in the tube 10 is cleared or cut off. The circuitry includes a first external electron discharge device 56, for example a triode tube, which has a cathode 62, a control grid 64, and an anode 66. The cathode 62 is connected to a source of potential Vo of about 5 volts, and the control grid 64 is connected through a resistor 68 and through a coupling capacitor 70 to the junction 72 of the spade resistors 27 of the "9" spade of tube 10. The anode 65 of the tube 60 is connected to the bus 35 and to the free end of the resistor 26' coupled to the "0" spade of the second tube 10'.

According to the invention, a second similar external electron tube 60' is provided having a cathode 62', a control grid 64', and an anode 66'. The cathode 62' is connected to ground, and the control grid 64' is connected to ground through a resistor 68' and through a coupling capacitor 70' to the junction 72' of the spade resistors 27' of the "9" spade of tube 10'. The anode 65' of the tube 60' is connected to the bus 35 and to the free end of the lead resistor 26' coupled to the "0" spade of the second tube 10'.

In operation of the system of the invention, assume that tube 10 is executing a counting operation and a beam is moving from position to position as a result of pulses applied to the switching electrodes 28 from the flip-flop 50. At this time, tubes 60 and 60' are cut off. An output pulse is obtained from each target 18 as the beam flows to each position. When the beam reaches the "9" position, which is assumed to be the last position in a counting cycle, an output pulse is obtained from the "9" target as from the others. In addition, electron flow through the resistors 27 lowers the potential of grid 64 and drives tube 60 farther into its cutoff region. The next switching pulse applied to the switching grids 28 by the flip-flop 50 moves the electron beam from the "9" position to the "0" position in tube 10. This action causes the potential of the grid 64 of tube 60 to become positive enough so that tube 60 conducts. The potential of the anode 66 is lowered, and, since the anode is connected to the "0" spade of tube 10', the "0" spade is lowered in potential sufficiently to cause an electron beam to form at the "0" position. At the same time, spades "1" to "8" of tube 10, through their connection to anode 66, are reduced in potential to such a level that the beam which tended to form at the "0" position is immediately cleared. When the beam leaves the "9" position in tube 10, triode 60 is once again cut off. Thus, a new beam is cleared in tube 10 and is formed at the "0" position in tube 10'.

The counting operation is now performed by tube 10' under control of the flip-flop 50. When an electron beam in tube 10' reaches the "9" position, tube 60' is cut off, as described above with respect to tube 60. The next switching pulse tends to switch a beam gain position "9" to the "0" position in tube 10', and, in the manner described above, this causes an electron beam to form at the "0" position in tube 10 while the beam in tube 10' is cleared.

The push-button switch 39 may be used to manually clear an electron beam in tube 10 and set it at the "0" position in tube 10'.

What is claimed is:

1. A counter circuit including two electron beam switching tubes each having a cathode and a plurality of groups of electrodes; each group of electrodes including a target electrode which receives an electron beam and produces an output signal therefrom, a spade electrode which holds 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; said groups of electrodes comprising positions to which an electron beam from one group of electrodes to the next; said groups of electrodes comprising positions to which an electron beam may move with one position in each tube being designated a first position and one being designated a last position; an electron discharge device directly coupled between the last position of one tube and the first position of the next tube and coupled to electrodes in both tubes, a signal from said last position being adapted to energize said electron discharge device to apply a signal to said first position of the next tube whereby an electron beam forms at said first position in the next tube, said device also being coupled to other groups of electrodes in said one tube to prevent the formation of an electron beam therein.

2. A counter circuit including two electron beam switching tubes each having a cathode and a plurality of groups of electrodes; each group of electrodes including a target electrode which receives an electron beam and produces an output signal therefrom, a spade electrode which holds 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; said groups of electrodes comprising positions to which an electron beam may move with one position in each tube being designated a first position and one being designated a last position; an electron discharge device coupled directly between the spade electrode at the last position of one tube and the spade electrode at the first position of the other tube, said discharge device also being coupled to all of the spade electrodes in said one tube except the spade electrode at said last position of the one tube being adapted to energize said electron discharge device which thereby applies a signal to the spade electrode at said first position of the other tube whereby an electron beam forms at said first position of the other tube, said last-mentioned signal being applied to all of the spade electrodes in said one tube except the spade electrode at the first position in the one tube and thereby preventing the formation of an electron beam in said one tube.

3. The circuit defined in claim 2 wherein said electron discharge device comprises an electron tube including a cathode, a control grid, and an anode, the anode being coupled to the spade electrode at the first position of one tube and to all of the spade electrodes in the other tube, except the spade electrodes at the first and last positions, the control grid being coupled to the spade electrode at the last position of said other tube, the aforementioned...
couplings being such that when an electron beam leaves the last position of the one tube, a positive signal is applied from the spade electrode to said control grid and said electron discharge device is turned on whereby a negative pulse is applied to the spade electrode at the first position of the next tube, said negative pulse lowering the potential of said first spade electrode of the next tube sufficiently to cause an electron beam to form thereat, said negative pulse also being applied to all of the spade electrodes in the one tube except the spade electrodes at the first and last positions whereby an electron beam is prevented from forming in said one tube.

4. A counter circuit including an electron beam switching tube operable as a counting tube and having a cathode and a plurality of groups of electrodes; each group of electrodes including a target electrode which receives an electron beam and produces an output signal therefrom, a spade electrode which holds 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; said groups of electrodes comprising positions to which an electron beam may flow with one position being selected to transmit a carry pulse to another counting device; electrical pulse producing means having an input and an output and having its input coupled to the spade electrode at said one position so that it can be energized thereby and caused to generate a carry pulse at its output,

the output of said pulse producing means being coupled to the spade electrodes in a plurality of groups of electrodes in said tube;

the couplings being such that when said pulse producing means transmits a carry pulse from its output to another counting device, it also applies said carry pulse to the spade electrodes in said plurality of groups of electrodes in said tube and thereby prevents an electron beam from forming at any position in said tube.

5. The counter circuit defined in claim 4 wherein said electrical pulse producing means comprises an electron discharge device.

6. The counter circuit defined in claim 4 wherein said electrical pulse producing means comprises an electron discharge device having an input electrode and an output electrode, the input electrode being coupled to the spade electrode at said one position in said tube selected for the transmission of a carry pulse, the output electrode of said electron discharge device being adapted for coupling to another counting tube and being coupled to spade electrodes in said plurality of groups of electrodes in said tube.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,168,677

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, lines 30 and 31, for "from one group of electrodes to the next; said groups nated" read -- may flow with one position in each tube being designated --.

Signed and sealed this 6th day of July 1965.

(SEAL)
Attest:

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