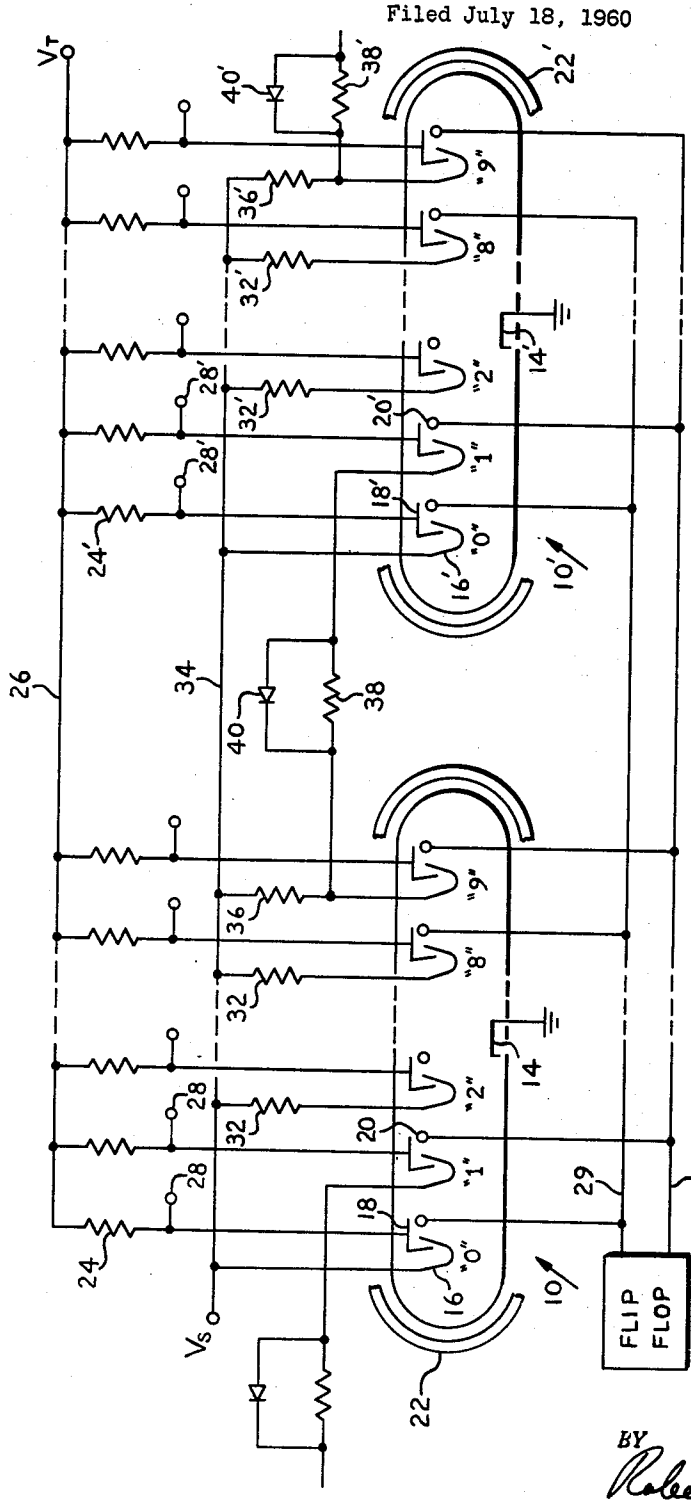
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COUNTER CIRCUIT USING DIODE COUPLED TUBE

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COUNTER CIRCUIT USING DIODE COUPLED TUBE

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This invention relates to electronic counting circuits using multiple position electronic counting devices.

One type of multiple position electronic counting device is known as a magnetron beam switching tube and includes ten counting positions, from each of which an output signal or count may be obtained. In such a device, the counting operation is performed by an electron beam which is generated by a central cathode and is switched from position to position within the tube under the influence of crossed electric and magnetic fields. In many counting circuits, it is desirable to connect such devices in cascade to provide more than ten counting positions. When tubes of this type are connected in series, some consideration must be given to the problem of transmitting a carry pulse from one tube to the next. In addition, under some circumstances, it is desirable to be able to omit one or more positions in a tube while at the same time providing the desired carry pulse.

The purposes and objects of the present invention are directed toward the provision of a counting circuit using series-connected multiple position electronic counting devices in which the transmission of a carry pulse from one tube to the next and the omission of a counting position in a tube are readily achieved.

In brief, a counting circuit, according to the invention, includes a plurality of multiple position electron tubes connected in series. Means are provided for performing the dual functions of transmitting a carry pulse from one tube to the next and at the same time causing at least one counting position in both tubes to be omitted during the counting cycle. The selected last position of one tube which is also a position to be omitted is adapted to be unstable and unable to support an electron beam. This position is coupled to a selected position in the next tube at which a beam is to be formed. When a beam tends to form in the last unstable position of the one tube, a potential is coupled to the selected position of the next tube which causes a beam to form at this selected position. The coupling means and the connection at the unstable last position in the first tube combine to render stable the selected position of the next 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 circuit described below is particularly suited for use with multi-position type 6700 magnetron beam switching tubes shown schematically as tubes **10** and **10'** in the drawing. In actual construction, these tubes are cylindrical in form, but, for convenience, they are shown schematically in linear form. 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 a central longitudinally elongated cathode **14** and ten groups of electrodes in operative relation with the cathode. For simplicity, only five groups of electrodes are shown numbered "0," "1," "2," "8," and "9" in both tubes. 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** is provided surrounding the tube envelope and coaxial therewith. The magnet provides an axial magnetic field which is crossed with respect to electric fields in the tube, and these fields control the formation of an electron beam and its switching from one group of electrodes to the next. The direction in which the beam switches is determined by the orientation of the electric and magnetic fields.

Briefly, in operation of tube **10**, 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 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.

Referring to the circuit diagram, the cathodes **14** and **14'** are coupled to a source of reference potential such as ground. Each of the target electrodes **18** and **18'** is coupled through a load resistor **24**, **24'** to a common bus **26** which is coupled to a suitable D.C. power supply V_T of about 300 volts. Each target is also provided with an output terminal **28**, **28'** which may be coupled to an indicating device, a printer, or the like. The switching electrodes **20** and **20'** are connected in two sets, with the electrodes at the even-numbered positions in one set, and the electrodes at the odd-numbered positions in the other set. Each set of switching electrodes is connected to one of the outputs **29** and **30** of a flip-flop **31**, whereby beam switching pulses are applied alternately to the sets of switching electrodes. Any suitable circuit means for clearing and resetting an electron beam may be employed. Such circuits are well known and are not shown or described herein.

Assuming that the positions "2" to "8" are to be stable counting positions in both tubes **10** and **10'** and are not to be concerned with carry operations, then the spade electrodes **16** and **16'** at these positions are coupled through spade load resistors **32**, **32'** to a common bus **34** which is coupled to a suitable source of spade bias voltage V_S of about 200 volts. According to the invention, the "9" spades, that is, the spades at the "9" positions in both tubes which are to be unstable positions and are not to be normal counting positions, are coupled through smaller resistors **36**, **36'** to the spade bus. The resistors **36**, **36'** have a sufficiently small resistance value so that the spade electrodes cannot form and hold a stable electron beam at the "9" positions.

Assuming that a carry pulse is to be carried from the "9" position of tube **10** to the "1" position of the next tube **10'**, the "1" spade in the tube **10'** is coupled through a resistor **38** to the "9" spade of tube **10**. A diode **40** is connected in parallel with the resistor **38** with its cathode connected to the "9" spade of tube **10** and its anode connected to the "1" spade of tube **10'**. The diode **40** is not required under all circumstances, but it is effective to insure proper coupling of a pulse from tube **10** to tube **10'** when the tubes are counting at high speed. The resistor **38** has such a value that the combined resistance

of resistors 36 and 38 is large enough so that the "1" spade is able to form and hold a stable electron beam at the "1" position in tube 10'. If there is a counting tube in front of tube 10, then the "1" spade of tube 10 is similarly coupled to the "9" spade of the preceding tube. Similarly, if tube 10' is coupled to a succeeding tube, its "9" spade is coupled thereto, just as the "9" spade of tube 10 is coupled to the "1" spade of tube 10'.

Since the "0" positions are omitted in the arrangement described above, the "0" spades of both tubes are connected directly to the bus 34. If desired, other positions may be omitted and, for example, the "9" spade of one tube may be coupled to the "0" spade of the next tube if the switching electrodes are properly connected to maintain the desired switching sequence. In this way, the "0" position of a tube is included in the counting cycle.

In operation of the circuit of the invention, consider that tube 10 is executing a counting operation and an electron beam is being switched from position to position under the influence of the flip-flop 30. When the beam is switched from the "8" position to the "9" position, current flows through the resistor 36; however, the resistor 36 has such a value that the "9" spade is unstable and is unable to form and hold an electron beam on the "9" target. Thus, the beam is extinguished in tube 10. At the same time, the potential generated across the "9" spade during the short period of time that current flowed therethrough is transmitted through the resistor 38 to the "1" spade of the tube 10'. This current flow reduces the potential of the "1" spade in tube 10' so that a beam forms at the "1" position in the tube 10'. The resulting "1" spade current flows through both resistors 36 and 38, and this combination of resistors has sufficient magnitude to form and hold a beam stably at the "1" position in tube 10'. Normal counting then proceeds in the tube 10' until the beam reaches the "9" position. The same operation occurs now in tube 10' as it did in tube 10. The "9" position in tube 10' is unstable as it is in tube 10, and an electron beam is extinguished. At the same time, a carry pulse is transmitted to the next tube, and an electron beam is set thereby and is held stably due to the combination of "9" spade and "1" spade resistors.

It is clear that any desired position in one tube may be coupled to any desired position in another tube if proper operation of the input switching means is maintained. Thus, substantially any desired number of counting positions may be provided coupled with efficient carry pulse operation.

What is claimed is:

A cascade counter including a pair of series-connected electron beam switching tubes each having a cathode and a plurality of groups of electrodes with each tube being adapted to perform a counting operation in turn,

each group of electrodes including a target electrode which receives an electron beam from its associated cathode 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,

the groups of electrodes in each tube comprising a series of steps in a counting cycle with a first group being arbitrarily designated the first step in the counting cycle and a last group being arbitrarily designated the last step in the counting cycle,

the spade electrode at the arbitrarily desigated last position being coupled to a first smaller-than-normal spade load resistor of such magnitude that an electron beam cannot be stably supported at this position,

all of the other spade electrodes being coupled to normal spade load resistors of such magnitude that an electron beam can be stably supported at their positions,

said spade electrode at the last position being coupled through a second resistor to a selected spade electrode in the next adjacent tube,

said first and second resistors combining to act as the load resistance for said selected spade electrode, the combined resistance of said first and second resistors being of sufficient magnitude to allow said selected spade electrode to support a stable electron beam, and

a diode in parallel with said second resistor to facilitate the coupling of a negative pulse from the spade electrode at the last position in the first tube to the spade electrode at the selected position in the second tube.

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