

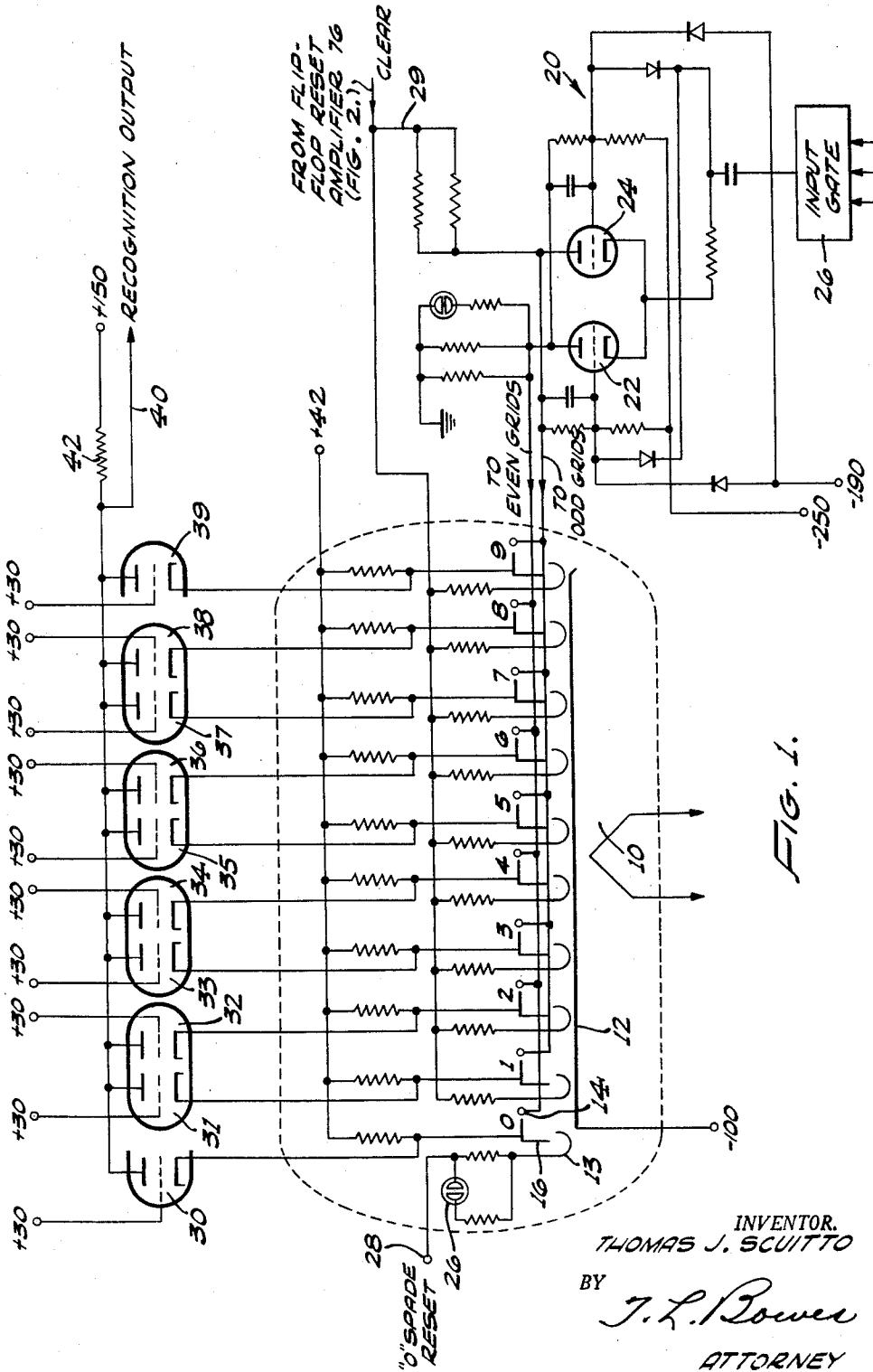
Jan. 27, 1959

T. J. SCUITTO
ELECTRONIC COUNTER

2,871,399

Filed Aug. 22, 1956

4 Sheets-Sheet 1



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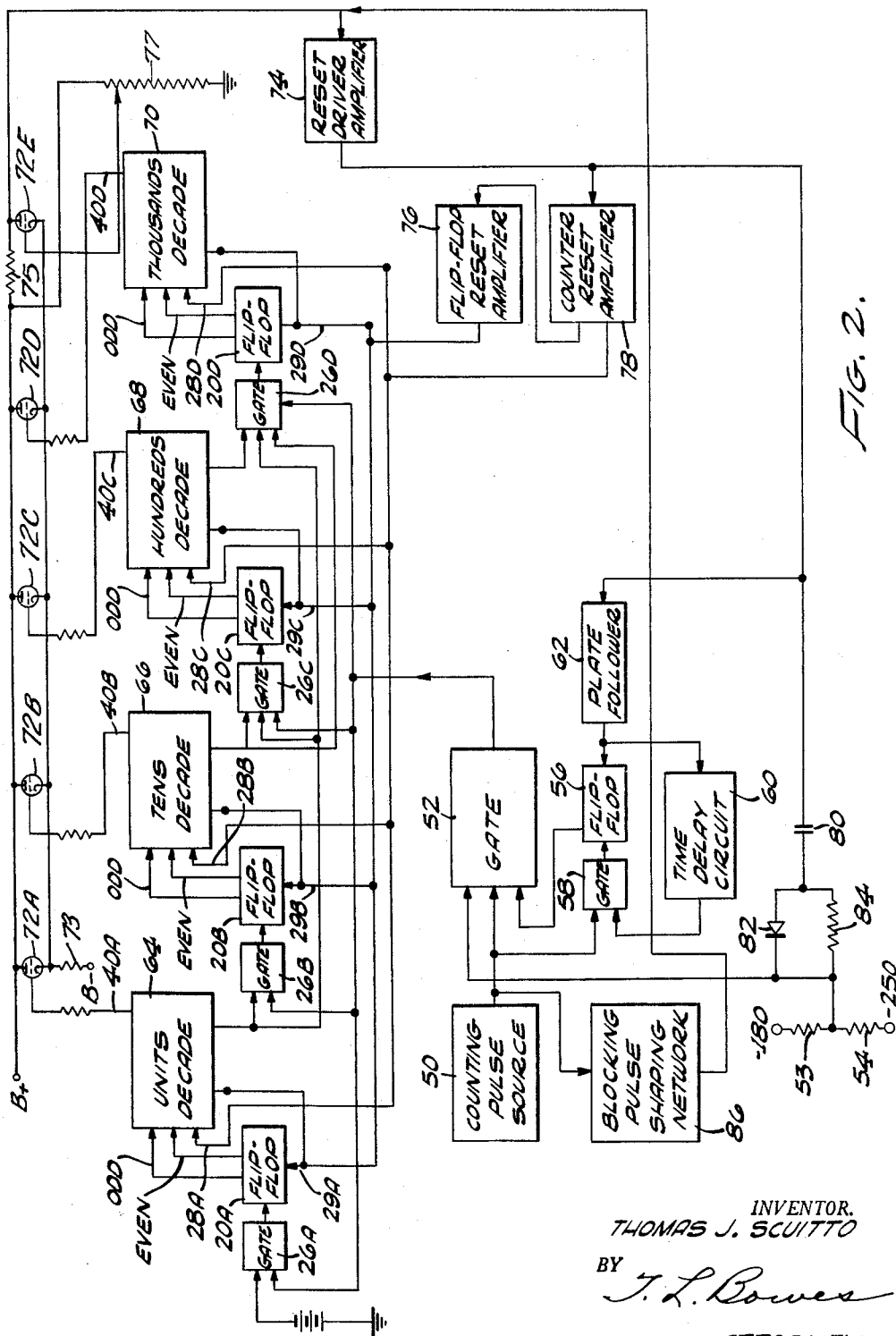
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4 Sheets-Sheet 2



INVENTOR.
THOMAS J. SCUITTO
BY
J. L. Bowes
ATTORNEY

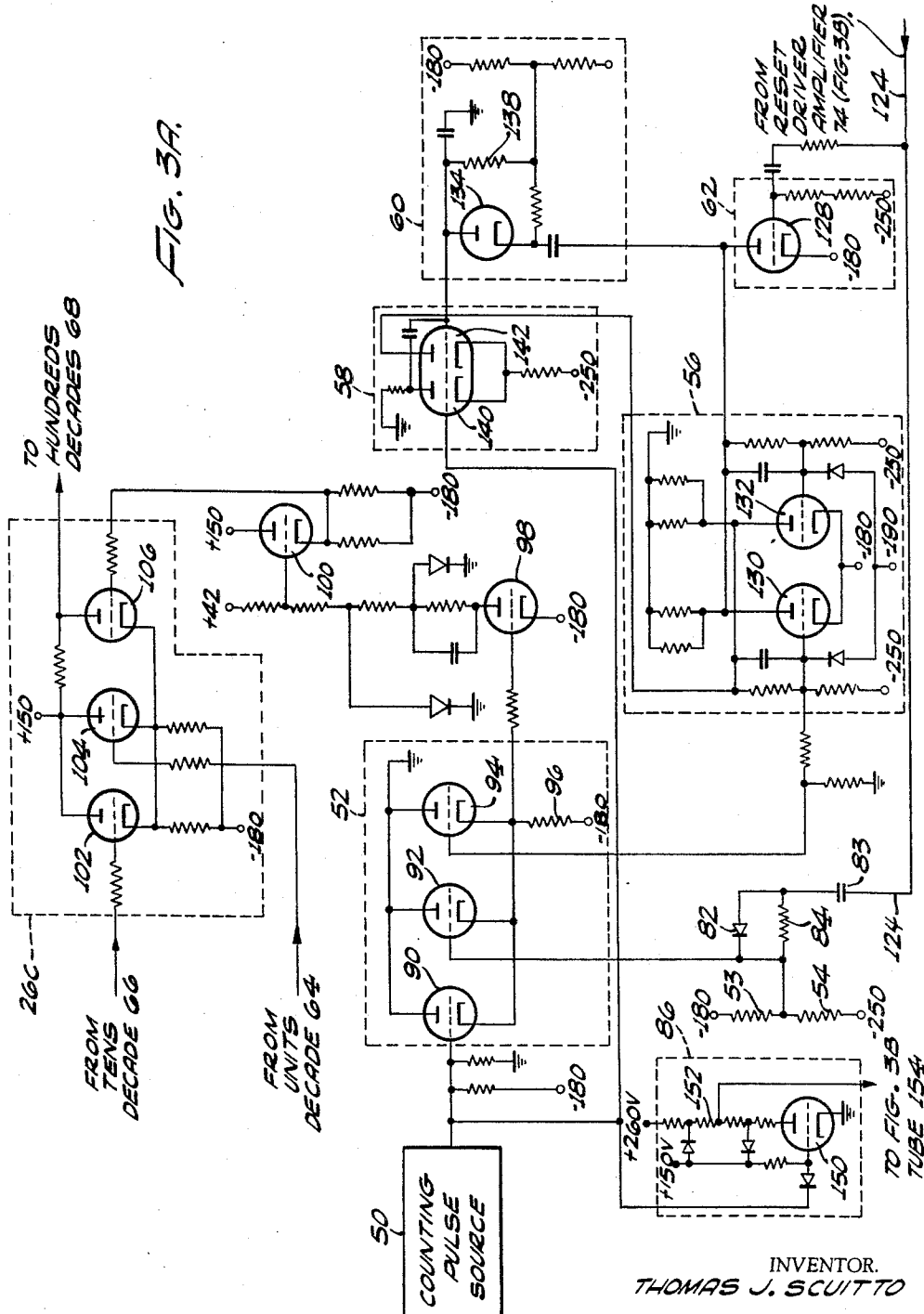
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INVENTOR.
THOMAS J. SCUITTO

BY
J. L. Bowes
ATTORNEY

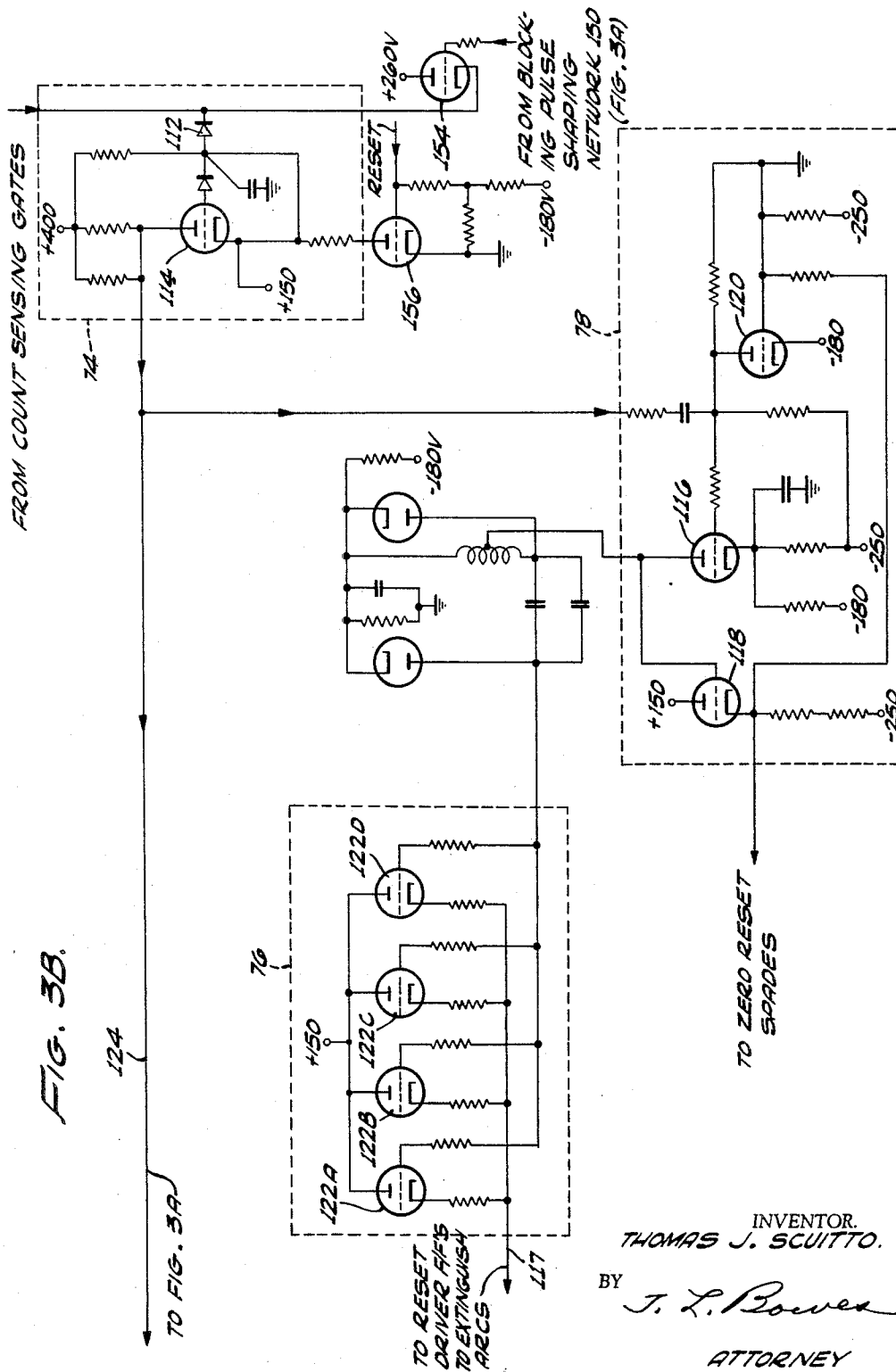
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ELECTRONIC COUNTER

Thomas J. Scuitto, Santa Monica, Calif., assignor to General Dynamics Corporation, Rochester, N. Y., a corporation of Delaware

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9 Claims. (Cl. 315—8.6)

This invention relates to electronic counters and, more particularly, to improvements therein.

There has been recently made commercially available a new type of vacuum device, known as a beam-switching tube. This tube is a small size, high-vacuum device having ten discrete positions established therein. Each position is capable of locking, clearing, or switching an electron beam. Also, there is made possible the obtaining of a pentode-like output from each position. Internally in the tube there is positioned a central cathode which supplies electrons for all of the positions which are mounted radially about the cathode. At each position there are three basic elements; the first is a spade which automatically forms and locks the beam, the second is a grid which is employed to switch the beam, and the third is a target to give a useful output. An axial magnetic field is provided within the tube by mounting small, cylindrical magnets around the glass envelope. Descriptive literature on the tube is available from manufacturers who are known as the "Haydu Brothers," located in Plainfield, New Jersey, who are a subsidiary of the Burroughs Corporation. An article describing the tube and its uses is found in the convention record of the 1953 National I. R. E. Convention, part VI, and is entitled Multi-Output Beam Switching Tubes for Computers and General Purpose Use, by Sol Kuchinsky.

A beam-switching tube of this type obviously lends itself to utilization as a stage of a decade counter. However, when several stages are cascaded in order to extend the range of the counter, especially if it is desirable that the counter operate as a resetting type of counter, problems arise. This is the type of operation where, when a counter reaches a predetermined count, it resets itself to an initial count condition and then starts counting anew. These problems arise since in the operation of the resetting of a stage of the counter, it is first necessary to turn off the arc and then turn the arc on again at the zero position, or starting count, position. Counting pulses which occur during the resetting interval can affect the counter adversely, so that a false starting count position is assumed. Besides the above-noted problem, when the beam-switching tubes are cascaded to provide an operation in which a higher-order stage is driven when all the preceding lower-order stages have been filled, it is necessary to collect outputs from all the lower-order stages and then use this to drive the higher-order stage. Since a two-phase type of drive is required with these beam-switching tubes in order to advance the count, the coupling between stages of the counter and the control thereof for resetting also presents a problem. Besides the above spurious count indications arise, particularly due to different beam-tube-switching times, when it is attempted to sense counts such as 19, 190, 1900, and the like.

An object of the present invention is the provision of a novel and useful beam-switching tube counter.

Another object of the present invention is the provision

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of a novel beam-switching tube counter wherein difficulties in the presetting thereof are eliminated.

Still another object of the present invention is the provision of a novel beam-switching counter in which false count indications are eliminated.

Yet another object of the present invention is the provision of a novel and useful resetting type of beam-switching tube counter which is not adversely affected during reset by the continued application thereto of pulses.

These and other objects of the present invention are achieved in a beam-switching tube counter which is an embodiment of this invention which has a plurality of stages. Each stage has a separate means to sense when it has a full count. An output indicative thereof is applied to a coincidence gate having a plurality of inputs. A second of these inputs receives pulses to be counted. The remaining ones of the coincidence gate inputs are connected to the means for sensing a full count in all of the preceding counter stages. In effect, when all the preceding counter stages have a full count, the count coincidence gate is primed. Upon the occurrence of the next pulse to be counted, the coincidence gate emits an output which is applied to a flip-flop circuit. This flip-flop circuit is driven from one to the other of its stable conditions in response to successive inputs received from the coincidence gate. Thus, out-of-phase pulses are provided to a counter stage to advance its count. Other sensing means are provided which sense when the counter has attained a predetermined count condition. An output indicative of this is employed to clear the counter stages by quenching the arcs, also to turn the arcs on at the initial count condition position, or zero position, and, further, to reset all the driver flip-flops to an initial condition of stability. The resetting pulse is also used through suitable circuitry to block an input coincidence gate through which pulses to be counted are applied to the counter. The period of time during which this input coincidence gate is blocked is determined by the interval required for resetting the counter. At the end of this time, the input coincidence gate is enabled once again and pulses can then again be applied to the resetting counter for the purpose of being counted.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a circuit diagram of a beam-switching tube and its associated driving and count-sensing circuitry;

Figure 2 is a block diagram of an embodiment of the invention; and

Figures 3A and 3B show circuit details of the embodiment of the invention.

In Figure 1 there is shown a beam-switching tube in circuit diagram form along with associated sensing and driving circuitry. In order to preserve clarity in the drawing, the beam-switching tube is shown laid out in straight-line form, instead of in the circular fashion in which it actually exists. The tube has a heater 10 and a single cathode 12, which services all the ten positions of the tube. At each position (which have been numbered zero through nine), there exists a spade electrode 13, a switching-grid electrode 14, and a target electrode 16. The ten sets of these electrodes are radially positioned about the central cathode and are operated in the presence of an axial magnetic field, which is provided by cylindrical magnets permanently mounted to the glass envelope. The beam is formed in any one of its ten positions by sufficiently lowering the potential of the respective spade with respect to the cathode. The one

spade which forms and locks the beam is near the cathode potential, while the remaining ones are maintained at a high, positive level.

A beam can be advanced from position to position in a number of ways. However, in this embodiment of the invention, the method employed is to lower the switching-grid voltage which is adjacent the spade and target at which the beam is formed, so that the electric field in the outer area between spades is altered. In this manner, enough of the beam is diverted to the following spade to cause that spade to assume the beam. At this time, the potential of the spade from which the beam was removed returns to a high positive potential level, while the spade which has assumed the beam assumes a potential volume which is near cathode potential.

In order to advance the beam from position to position, the odd-numbered grid electrodes are connected together and the even-numbered grid electrodes are connected together. These two common connections are brought external to the tube. The control grids 14 at positions 0, 2, 4, 6, and 8 are considered the even-numbered grids and those at positions 1, 3, 5, 7, and 9 are the odd-numbered grids. These odd and even numbered grids are alternately lowered in potential, whereby the beam is advanced. The out-of-phase voltage required for this progressive switching of the beam is provided by a flip-flop circuit 20.

The operation of a flip-flop circuit is well known. The flip-flop circuit has two stable conditions and may be switched from one to another by an input pulse. In one of the stable conditions, one of the tubes 22 conducts current heavily. The other tube 24 is substantially at cutoff. The tube which is conducting current heavily will have its plate potential at some negative value and the other tube will have its plate potential at some positive value. The plate of tube 22 is connected to all the even grids, and the plate of tube 24 is connected to all the odd grids. The conditions of conduction and nonconduction are interchanged between the tubes by the application of a pulse from an input gate 26. A negative pulse from this input gate is applied to the grids of both flip-flop circuit tubes simultaneously. The tube which is conducting will be cut off by the negative input pulse. Thereafter, when its plate potential rises toward a positive value, it applies this positive pulse to the grid of the other tube, driving it toward conduction. This other tube anode then begins to drop, providing a negative pulse which is applied to the grid of the tube which formerly was conducting, thus driving it further into the non-conducting state. The tube 24 is driven to the nonconducting state by a negative pulse, designated as a "clear" pulse, from the flip-flop reset amplifiers shown in detail in Figure 3. This occurs when the counter is reset and insures that the flip-flop circuit is in the proper condition to advance the position of the beam which is now formed on the "zero" spade to the next, or "one" spade, upon the receipt of the first input pulse. At this time, the even grids are driven negative, whereupon the beam will form on the spade in the position number one.

A neon glow tube 26 is provided which is illuminated when the spade at the zero position has the beam. An input terminal 28 is provided which connects through a resistor to the spade at the zero position. As was previously described, the manner of positioning the beam at a desired location (here zero) is by turning off the beam at whatever location it happens to be, thereafter pulsing the potential of the spade at the desired location to a potential near that of the cathode. The terminal 28 affords access for resetting the beam at the zero-spade position. The pulse that causes reset is designated as the "zero" reset pulse. Each target 16 is connected through a resistor to a common output lead. This output lead is biased at a potential substantially equivalent to 42 volts. Each spade is connected through a resistor to a common output lead. This common output lead is

connected to the same terminal 29 as is the flip-flop tube 24 for the purpose of being reset. This same signal, in conjunction with the zero reset pulse, pulses all the spades negatively to a potential less than that of the cathode, whereby the beam is cut off within the tube. By virtue of the fact that the zero reset pulse reaches a more negative value and is of longer duration than the "clear" pulse, the beam is reformed on the zero spade. It should be noted that the beam-switching tubes are sold with the resistors already mounted within the tube.

The count-sensing circuitry comprises ten tubes 30 through 39, each of which is associated with a different one of the beam-switching positions. These tubes have their respective cathodes connected to the respective targets. The anodes of all these tubes are connected together and brought out to an output terminal 40. Plate voltage is supplied to all the tubes through a common resistor 42. The manner of obtaining the count recognition, as desired, is performed by applying substantially zero voltage to the grids of all the tubes except the one which is associated with the desired count position. A voltage of 30 volts is applied to the grid of this tube. Since all the targets at the positions at which the beam does not exist are essentially at a potential of +42 volts, effectively, the tubes which are connected to these targets are cut off. The tube which has the +30 volts applied to its grid is also cut off. The reason is that the cathode is still at a higher positive potential for this tube than the control grid until such time as the beam forms at this position.

When the beam forms at the desired location, current is drawn through the target load resistor at this position, whereby the cathode potential drops sufficiently below the control-grid potential to enable the sensing tube at this position to become conducting. Accordingly, at this time a negative pulse is seen at the recognition output terminals 40. This signifies that the beam has attained the position of a desired count. Otherwise, the potential at the terminals 40 is positive. When the beam forms at a position other than the desired count position, the cathode potential of the sensing tube connected thereto does become lower than 42 volts. However, it does not become lower than the zero volts applied to the control grid of the tube, and, accordingly, the tube will still remain cut off.

From the above description, it should be seen how counts within a beam tube stage are advanced by successively applying negative pulses to the odd and even groups of grids. Furthermore, the count for which an output indication is desired may be sensed by applying a positive potential to the control grid of a sensing tube which has its cathode connected to the target at the count position. To reset a beam tube, the "clear" signal is applied to both the flip-flop, which drives the counter stage, and to all the spades to pulse them to a potential less than the cathode of the beam tube, thus extinguishing the arc. Simultaneously, the spade at the zero position of the tube is pulsed more negative and for a longer duration by the zero reset signal at this position, causing the beam to reform. The counting stage is then ready for the next count. Any pulses which are applied to be counted during the interval of reset can serve to cause a beam to be formed at a position other than the one desired. In situations where it is desired that the counter operate repetitively to count to a desired condition and then reset itself and count again, either to the same or a different count condition, a failure in the zero reset renders the system valueless. Such a failure is prevented by this embodiment of the invention.

Reference is now made to Figure 2, which shows a block diagram of an embodiment of the invention. A counting pulse source 50 provides as its output pulses which are properly shaped and which are to be counted. The counting pulse source may be any well-known sine wave oscillator which feeds its output to a shaping cir-

cuit. These circuits are well-known in the art and need not be described here. The counting-pulse source output is applied to a coincidence gate 52. This gate requires the presence of three inputs simultaneously or coincidentally, in order to provide an output. One of these inputs is provided by the counting pulse source. A second one of these inputs is provided by a bias source, which is represented by the two resistors 53, 54, connected to sources of negative potential. The junction of these two resistors is connected to the gate 52 as the second required input. A third required input is provided by the output from a flip-flop 56 when in one of its two stable conditions. This flip-flop is driven to that one of its two stable conditions by the output of a gate 58. This gate 58 has one input derived from the counting-pulse source. The second input to the gate 58 is an inhibiting input which is provided by a time-delay circuit 60. This inhibiting input occurs over an interval required for the counter to be reset. The time-delay circuit is energized to provide this inhibiting input by a plate-follower circuit 62, which also drives the flip-flop 56 to its second stable condition, at which time the enabling input to the gate 52 is removed. The output of the gate 52, which consists of pulses to be counted, is simultaneously applied to input gates 26A, 26B, 26C, 26D. These gates are also coincidence gates, requiring the simultaneous presence of all their inputs before emitting an output.

The counter which is shown in this embodiment of the invention has four decade stages 64, 66, 68, 70. Each one of these decade stages consists of a beam-switching tube, such as the one described in Figure 1. As a matter of fact, each one of these decade stages has associated therewith the circuitry shown in Figure 1, consisting of the input gate 26, the flip-flop circuit 20 (here designated by 20A through 20D), the count-sensing tubes having an output terminal 40 (represented by 40A through 40D).

The gate 26A has as a second required input a potential derived from a bias battery. Its output is applied to the flip-flop 20A, the output from which drives the units decade. When the units decade has advanced until the beam is positioned at the location of the ninth spade, or the nine-count position, output is derived from the target there and applied to the gate 26B. The second required input to the gate 26B is provided by the output of gate 52. The output of gate 26B will not be obtained, however, until both pulses appear coincidentally at its input. Thus, it is the pulse to be counted which appears after the pulse that has driven the units decade to its nine-count condition which provides the output to the succeeding flip-flop 24B to drive the tens decade.

The pulse which drives the units decade to its nine-count condition is made short enough so that it is not present by the time the units decade has switched from the eight to the nine count. This insures that the next decade is driven only by the tenth counting pulse.

Reference is now made to gate 26C. It has as its required coincident inputs first the output from the number nine target of the tens decade 66, second the output of the number nine target of the units decade 64, and third the presence of a counting pulse which will be the one-hundredth counting pulse. Thus, the hundreds decade is not driven from its zero to its one position until the occurrence of the one-hundredth counting pulse. Referring now to the gate 26D, it will be seen that besides all the inputs required for gate 26C, there is also required an input from the ninth target of the hundredths decade. Thus, gate 26D does not provide an output until the occurrence of the one-thousandth pulse to be counted.

All the output-sensing terminals 40A through 40D are connected to a count-sensing gate 72. This gate requires that all its inputs be present simultaneously before providing an output. The count-sensing gate 72 includes five tubes 72A, 72B, 72C, 72D, 72E, the first four of which are respectively associated with the respective units,

tens, hundreds, and thousands decades. These four tubes have their cathodes connected together and to a common load resistor 73. Four of the tubes 72A, 72B, 72C, 72D have their anodes connected directly to B+. The fifth tube 72E has its anode connected to B+ through a plate load resistor 75. The anode of tube 72E is connected to the reset driver amplifier 74. The respective inputs to the grids of the tubes 72A, 72B, 72C, 72D are from the output sensing terminals 40A, 40B, 40C, 40D. The input to tube 72E is a fixed positive signal derived from the potentiometer 77, which is connected across the operating potential supply. Tube 72E is, however, prevented from conducting by the common cathode coupling to the other tubes until all the other tubes are cut off when they receive negative signals from the respective decades. When tube 72E conducts, an output signal is derived from its anode. Thus, any predetermined count which has been established for the entire counter is detected by the count-sensing gate 72. At the time the counter attains this predetermined count, the count-sensing gate provides an output to a reset driver amplifier 74. This reset-driver amplifier drives a flip-flop reset amplifier 76 and a counter reset amplifier 78. The flip-flop reset amplifier 76 supplies the "clear" pulse which, as shown in Figure 1, is applied to terminal 29. Here the reset terminals are identified by reference numerals 29A through 29D. This clear pulse serves the purpose of resetting the flip-flops and also extinguishing the beam of the various beam-switching tubes. The counter reset amplifier applies its zero reset signal output to all the zero spade reset terminals 28A through 28D. These zero-spade reset terminals are connected to the spades at the zero positions and, as shown in Figure 1, enable the potential of these spades to be lowered until the beam is reformed at the zero position within each stage of the counter.

The output of the reset driver amplifier is also applied to the plate follower 62 and through a condenser 80 and a diode 82 in parallel with a resistor 84 to one of the inputs to the gate 52. The condenser 80 and the network 82, 84 permit the output of the reset driver amplifier to negate, or render ineffective, the input provided by the bias source. This instantly cuts off any counting pulses from the source 50 from being applied to the counter. The plate follower 62 meanwhile drives flip-flop 56 to its second stable condition, whereby it also removes its enabling input to the gate 52. Counting pulses will still occur from the source 50. However, the gate 52 will not be able to pass these pulses, since it is now blocked.

The gate 58 also is closed to the passage of counting pulses by reason of the operation of the time delay circuit 60. This circuit is energized by the output of the plate follower and inhibits gate 58. The time of this inhibition is determined by the time required for the entire counter to be reset. Once this has occurred and stability of the circuits has been established, the time-delay circuit removes its inhibiting input from the gate 58, whereby the next counting pulse to occur from the counting-pulse is applied to flip-flop 56 to reset it to its first condition of stability.

The pulse which is applied to inhibit the input gate via the diode 82 and resistor 84 is a short one and subsides before the gate 58 is enabled again. The reason that it is applied through the resistor-diode network is to block the gate 52 as soon as the reset pulse is generated, since the plate follower and flip-flop circuitry do require time to function. Therefore, the counter can now be reset without a false initial count condition being injected therein by reason of counting pulses occurring during the resetting interval. By reason of the circuits used in this invention for coupling between these stages, the higher-order stages are positively driven by the carry-over pulse from the lower-order stages. Heretofore, the drive made by a carry-over pulse was derived by sensing

the transition within a decade of a beam from the nine position back to the zero position. This involved expensive and complex circuitry.

Another circuit to which output from the counting-pulse source is applied is designated as the blocking-pulse shaping network 86. This circuit stretches the pulse from the counting-pulse source and applies it to the input to the reset driver amplifier 74 to oppose or block any input thereto from the count-sensing gate 72 for the duration of the stretched clock pulse. Since a true output from the count-sensing gate lasts longer than the stretched clock pulse, a response to spurious sensing of counts is prevented. Spurious count sensing particularly arises when it is desired to sense counts such as 19, 190, and the like, where the switching times of the beam-switching tubes differ. For example, it is desired to sense a count of 19. The units decade counts nine pulses. The next pulse to be counted should cause the tens decade to show a count of one and the units decade to show a count of zero. However, due to the slowness of the switching operation of the units-decade tube, or the rapidity of operation of the tens-decade tube, for a time the counter actually represents a count of nineteen. This will be sensed by the sensing gates and cause a false pulse count-indication, as well as resetting of the counter. The false count indication is cleared by the end of the interval of the counting pulse and thus, if the reset amplifier is blocked for this interval, the spurious count indication is prevented.

Figures 3A and 3B show the circuit details of the arrangement for resetting the counter, preventing false count indications, and blocking counting pulses during an interval of reset. This circuitry is employed in the embodiment of the invention. The gate 52 consists of three triode tubes 90, 92, 94. These triode tubes have their anodes connected together and to a source of reference potential, or to ground. These triodes have their cathodes connected together and to a common cathode load resistor 96. The presence of a positive signal on any one of the control grids of these three tubes causes that tube to draw current. As is well known, current drawn through the cathode load resistor raises the potential of the cathode. Thus, the output of the three tubes which is derived from across the cathode load resistor is positive as long as a positive signal is applied to any one of the control grids. When all of the control grids are negative, all of the tubes are cut off and the potential at the common cathode output point across the load resistor 96 is negative. Signals from the counting-pulse source are negative, signals from the negative source of bias obviously are negative, and the flip-flop 56 provides a negative output when in its first stable condition. Thus, the occurrence of each counting pulse will provide a negative pulse at the output of the gate.

The output of the gate is applied to a tube 98, which is cut off by the negative pulse, whereby a positive pulse can be applied to the tube 100. The purpose of the diodes and resistors associated therewith is to maintain the proper shape for this pulse. The output of the tube 100 is derived from its cathode and is applied to the various input gates 26A through 26D for the stages of the counter.

One of these gates 26C is shown in detail by way of illustration. It is substantially similar to the gate described, consisting of three triodes 102, 104, 106. Each of them has its cathode connected to a common cathode load resistor which is connected to a source of negative potential. The anodes of two of them are connected together and to a source of operating potential. The anode of the third of them 106 is connected through a load resistor to the same source of operating potential. Output, however, is derived from the anode of the third tube 106. Input to the first of the three tubes 102 is derived from the nines target in the decade stage 66. Input to the second of the three tubes 104 is derived from

the nines target of the units decade stage 64. The control grid of the third of the three tubes 106 receives the pulses to be counted. Tube 106 is biased off if either tube 102 or 104 is conducting. When both of these tubes receive a negative pulse, then tube 106 can be rendered conductive by receiving a positive pulse from the cathode of tube 100. When tube 106 is rendered conductive, it provides a negative pulse at its output, which can then drive the flip-flop 20C. It should be noted that the gate 26A will have two triode tubes also, the gate 26C will have three triode tubes, and the gate 26D will have four triode tubes. All of these tubes will have their cathodes connected together and to a common cathode load. Only the last of these tubes, that is, the one to which the pulses to be counted are applied, will have the plate load resistor and an output derived from its anode. The others of the tubes will have their anodes connected in common and then to a source of operating potential. These, it will be recognized, follow the pattern shown in the circuit for the gate 26C.

The count-sensing gate is of the same type as those described. Its output will be a negative pulse which is applied through a diode 112 to the reset driver amplifier 114. The circuitry described represents that of the rectangle labeled "reset driver amplifier 74" in Figure 2. The output of the tube 114 will be a positive pulse. This positive pulse is applied to a regenerative amplifier which represents the circuitry labeled in Figure 2 as the "counter reset amplifier 78." The regenerative amplifier includes a tube 116, whose output is applied to a cathode-follower tube 118. The output of the cathode-follower tube, in turn, is fed back to the control grid of a tube 120. The output of tube 120 is then coupled to the grid of the tube 116.

The operation of this regenerative amplifier is as follows. The positive pulse applied to the grid of the tube 116 is amplified and is applied to the grid of the tube 118 as a negative pulse. The cathode of this tube is driven negative and applies the negative pulse to the control grid of the tube 120. This inverts the pulse phase to positive and thus increases the amplitude of the positive pulse applied to the grid of the tube 116. This operation continues until tube 116 is driven to saturation conduction.

The output from the cathode of tube 118, which is negative, is applied to the spades at the zero positions in the counter through terminals 28A through 28D. The negative output of tube 116 is applied to the flip-flop reset amplifier 76. It will be seen that this comprises cathode-follower tubes 122A through 122D. These tubes are connected in parallel and their output is applied to the flip-flops and to the spades of the various counter stages for the purpose of resetting the flip-flop tubes and for the purpose of extinguishing the beam in each one of the counter stages. The reason for employing four cathode-follower tube stages is because a large amplitude driving current is required, too large to be supplied by a lesser number of tubes. The positive output pulse from the tube 114 is applied by lead 124 to the diode and resistor network 82, 84. The diode 82 then begins to conduct and, as a result, applies a positive pulse to the grid of the tube 92. This closes the gate 52 to the passage of counting pulses. The condenser 83 insures that the only signal that will pass to affect the gate will be an alternating-current signal.

The plate-follower stage 62 includes a tube 128. This tube has its anode connected to the anode of one of the two tubes in the flip-flop stage 56. Thus, if the tube 128 is rendered conductive, then it draws current through the anode load of the tube 130, to which it is coupled. This is the same as applying a positive signal to the grid of the tube 130 or a negative signal to the grid of the tube 132. Thus, conduction of the two tubes is interchanged if tube 130 was nonconductive. The first condition of stability at which a negative signal is applied from the flip-flop 56

to the grid of the tube 94 is the one in which conduction is in tube 132 and tube 130 is not conducting. Accordingly, when plate-follower tube 128 receives a positive signal, it causes tube 130 to become conductive, whereby tube 132 is made nonconductive and the gate 52 is blocked.

The output of tube 128 is also applied to a time-delay network 60. This includes a diode 134 and a condenser 136. The condenser is charged up through the diode by the output from tube 128. The charge on the condenser 136 then, after a period of time, leaks off across the resistor 138. The time required for the condenser to lose its charge across resistor 138 is determined by the time required for the counter to be completely reset. The gate 58 includes two tubes 140, 142. One of these two tubes has its grid connected to receive counting pulses. The other of these two tubes has its grid connected to the condenser 136. The cathodes of the two tubes 140, 142 are connected together and to a common cathode load resistor. This resistor is connected to a negative bias source. The anode of the tube 142 is connected to the anode of the tube 132 in the fashion of a plate follower. Thus, in the absence of an inhibiting voltage being applied to the control grid of tube 142, when a negative pulse is applied to the control grid of tube 140 from the counting-pulse source, tube 140 is cut off. This enables tube 142 to become conductive, whereby it operates in the manner of the plate follower previously described, only this time to cause tube 132 to be rendered conductive and tube 130 to be rendered nonconductive. This enables gate 52 to be opened upon the appearance of the next counting pulse. When condenser 136 charges up, however, it applies an inhibiting bias to the control grid of tube 142, and thus the flip-flop 56 cannot be set into its first stable condition, despite the application of counting pulses to the tube 140.

The output of the counting-pulse source 50 is also applied to the blocking-pulse shaping network 86. This includes an amplifier tube 150, having its control grid connected to receive the counting pulses. A voltage-divider resistor 152 serves as the anode load for the tube. Diodes coupled between points on the divider resistor and the control grid serve to shape the counting pulse so that the output of the tube 150 which is applied to the control grid of a cathode-follower tube 154 is substantially rectangular. This tube has its cathode coupled to the diode 112 at the same position as the one to which the count-sensing gates are applied.

The output of the tube 150 is a positive pulse. This is applied by the cathode-follower tube 154 to the diode 112, thus blocking its conduction and preventing any signal from the count-sensing gates from affecting the reset driver amplifier tube 114 until after the blocking pulse subsides. Then, if the counter still manifests the count for which sensing is desired, the reset amplifier input is enabled to respond to the output from the count-sensing gates. Tube 156 serves the function of resetting the beam-switching tube counter at any time in response to any externally provided pulse applied to its grid. It has its anode coupled to the grid of tube 114 through a resistor and to B+ through a second resistor in series therewith.

It should become apparent from the above description that there has been described a novel, useful, and stable beam-switching tube counter of the reset counter variety. The arrangement described also provides interstage coupling, which enables accurate drive of succeeding counter stages from the lower-order stages. The counter also is one wherein reset to the initial count condition is positively made, without interference from the source of pulses to be counted or without being affected by temporary false count indications. It should be noted that although only four decade stages have been shown by way of example, by the application of the principles taught by this invention, the counter may be extended to have as many decade counter stages as are required.

I claim:

1. In a beam-switching tube counter for counting pulses, means to sense when said counter attains a desired predetermined count condition and to provide an output indicative thereof, means responsive to output from said means to sense to reset said counter to an initial count condition, means to block said means to reset for an interval substantially equal to a counting-pulse interval, and means for applying pulses to said counter to be counted including an input gate for said counter to which pulses to be counted are applied, means to close said gate responsive to an output from said means to sense, and means to maintain said gate closed for the interval required to reset said counter by said means to reset.

2. In a beam-switching tube counter for counting pulses means to sense when said counter attains a desired predetermined count condition and to provide an output indicative thereof, means responsive to output from said means to sense to reset said counter to an initial count condition, and a pulse-input circuit for said counter including an input gate for said counter having a first enabling input and second and third inhibiting inputs, means for applying pulses to be counted to said enabling input, means to apply an output from said means to sense to said second inhibiting input, and means to apply a signal to said third inhibiting input for the interval required to reset said counter including a flip-flop circuit having a first and second stable condition, means to apply output from said flip-flop when in its second stable condition to said third inhibiting input, means for driving said flip-flop to its second stable condition responsive to output from said means to reset, and a time-delay means to drive said flip-flop to its first stable state responsive to a pulse applied to said input gate enabling input.

3. In a beam-switching tube counter for counting pulses means to sense when said counter attains a desired predetermined count condition and to provide an output indicative thereof, means responsive to output from said means to sense to reset said counter to an initial count condition, and means to prevent the application of pulses to said counter for the interval required for reset including a three-input coincidence gate, means for applying pulses to be counted to a first of said inputs, means for applying an enabling bias to a second of said inputs, means for blocking said enabling bias responsive to an output from said means to sense, a flip-flop circuit having a first and second stable condition, means for applying enabling output from said flip-flop when in its first stable condition to the third of said inputs, first means for driving said flip-flop to its second stable condition responsive to an output from said means to sense, second means for driving said flip-flop to its first stable condition responsive to the application of a pulse to be counted to said input coincidence gate, and means for inhibiting said second means for driving for an interval required for the reset of said counter responsive to an output from said means to sense.

4. In a beam-switching tube as recited in claim 3 wherein said second means for driving said flip-flop to its first stable condition includes a two-input coincidence gate, means for applying pulses to be counted to a first of said two inputs, and means for applying an enabling bias to the second of said two inputs; said means for inhibiting said second means includes a time-delay network coupled to the second of said two inputs, and means to activate said time-delay network responsive to output from said means to sense.

5. A beam-switching tube counter for counting pulses comprising a plurality of decade count stages of successively higher order, each stage including a beam-switching tube, first means for each stage to sense when the decade count stage has reached a full count and to provide an output indicative thereof, a separate means for driving each stage except the first each including a flip-

flop circuit having its outputs coupled to drive a stage, a coincidence gate circuit having a plurality of inputs and having its output coupled to drive a flip-flop circuit, means to apply pulses to be counted to a first of said plurality of inputs, means to apply to others of said plurality of inputs outputs from each first means to sense associated with each lower-order stage, second means to sense when each count stage has attained a predetermined count condition and to provide an output indicative thereof, means responsive to output from all said means to sense to reset all said counter stages and said flip-flop circuits to an initial condition, and means responsive to said means to reset to prevent further counting pulses from being counted for the interval required to accomplish reset.

6. A beam-switching tube counter as recited in claim 5 wherein said means responsive to said means to reset to prevent further counting pulses from being counted for the interval required to accomplish reset includes a three-input coincidence gate, means for applying pulses to be counted to a first of said inputs, means for applying an enabling bias to a second of said inputs, means for blocking said enabling bias responsive to an output from said means to sense, a flip-flop circuit having a first and second stable condition, means for applying enabling output from said flip-flop when in its first stable condition to the third of said inputs, first means for driving said flip-flop to its second stable condition responsive to an output from said means to reset said counter, second means for driving said flip-flop to its first stable condition responsive to the application of a pulse to be counted to said input coincidence gate, and means for inhibiting said second means for driving for an interval required for the reset of said counter responsive to an output from said means to reset.

7. In a beam-switching tube counter for counting

pulses, means to apply pulses to said counter to be counted, means to sense when said counter attains a desired predetermined count condition and to provide an output indicative thereof, means responsive to output from said means to sense to reset said counter to an initial count condition, and means to block said means to reset for an interval substantially equal to a counting-pulse interval.

8. A beam-switching tube counter as recited in claim 7 wherein said means to block includes means for deriving pulses from said means for applying pulses to said counter, and means for applying said derived pulses to block said means to reset for the duration of said pulse.

9. A beam-switching tube counter for counting pulses comprising a plurality of beam-switching-tube stages of successively higher order, means to apply pulses to said stages to be counted, means to sense when all said stages represent a desired predetermined count condition and to provide an output indicative thereof, means responsive to output from said means to sense to reset said counter to an initial count condition, means to block operation of said means to reset during the interval of the application of pulses by said means to apply pulses, and means responsive to said means to reset to prevent application of pulses by said means to apply pulses during the interval required for resetting said counter.

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