Feb. 17, 1959 G. F. McGLUMPHY 2,874,330

ELECTRONIC COUNTER CONTROL

Filed May 21, 1954 3 Sheets-Sheet 1

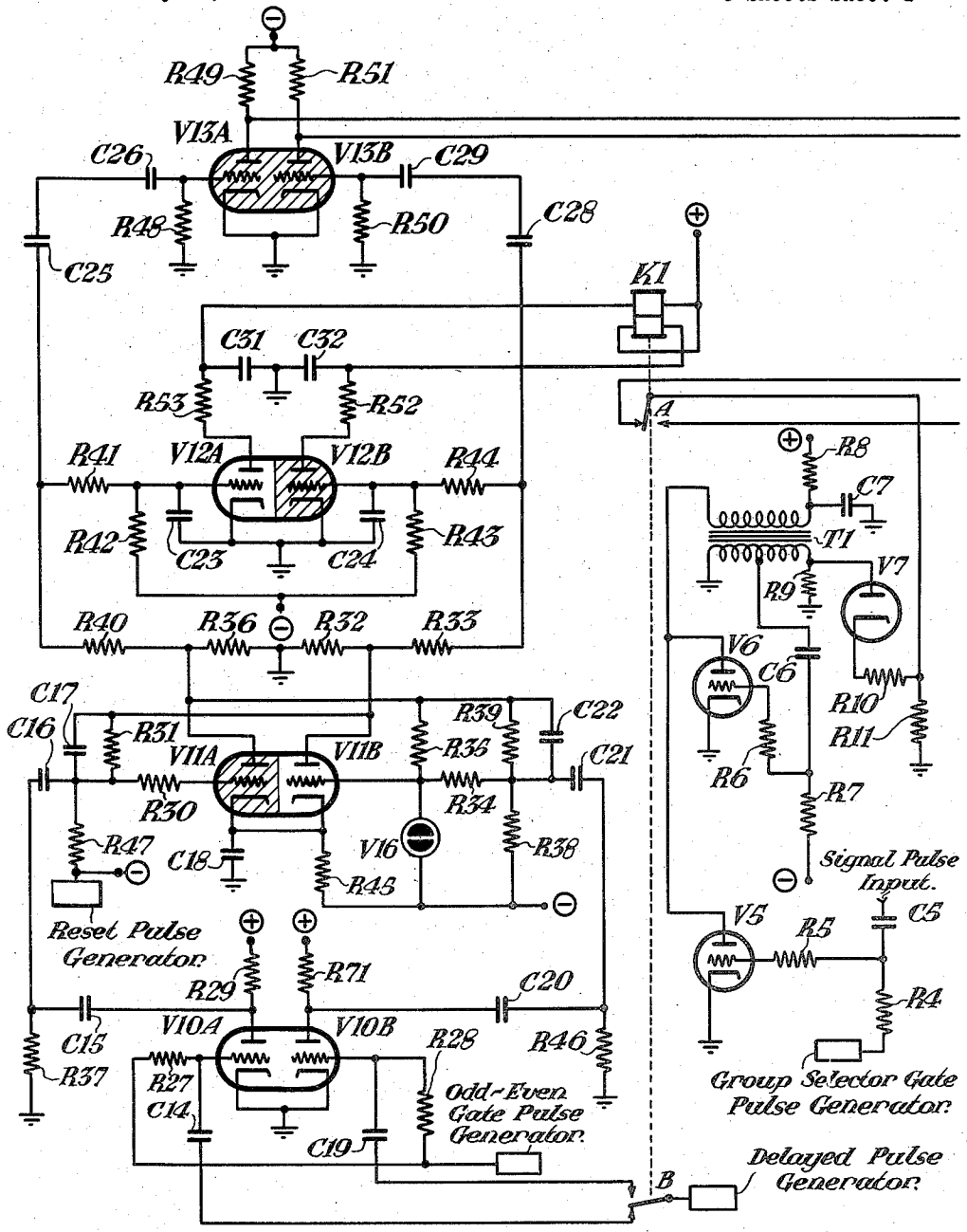


Fig. 1a.

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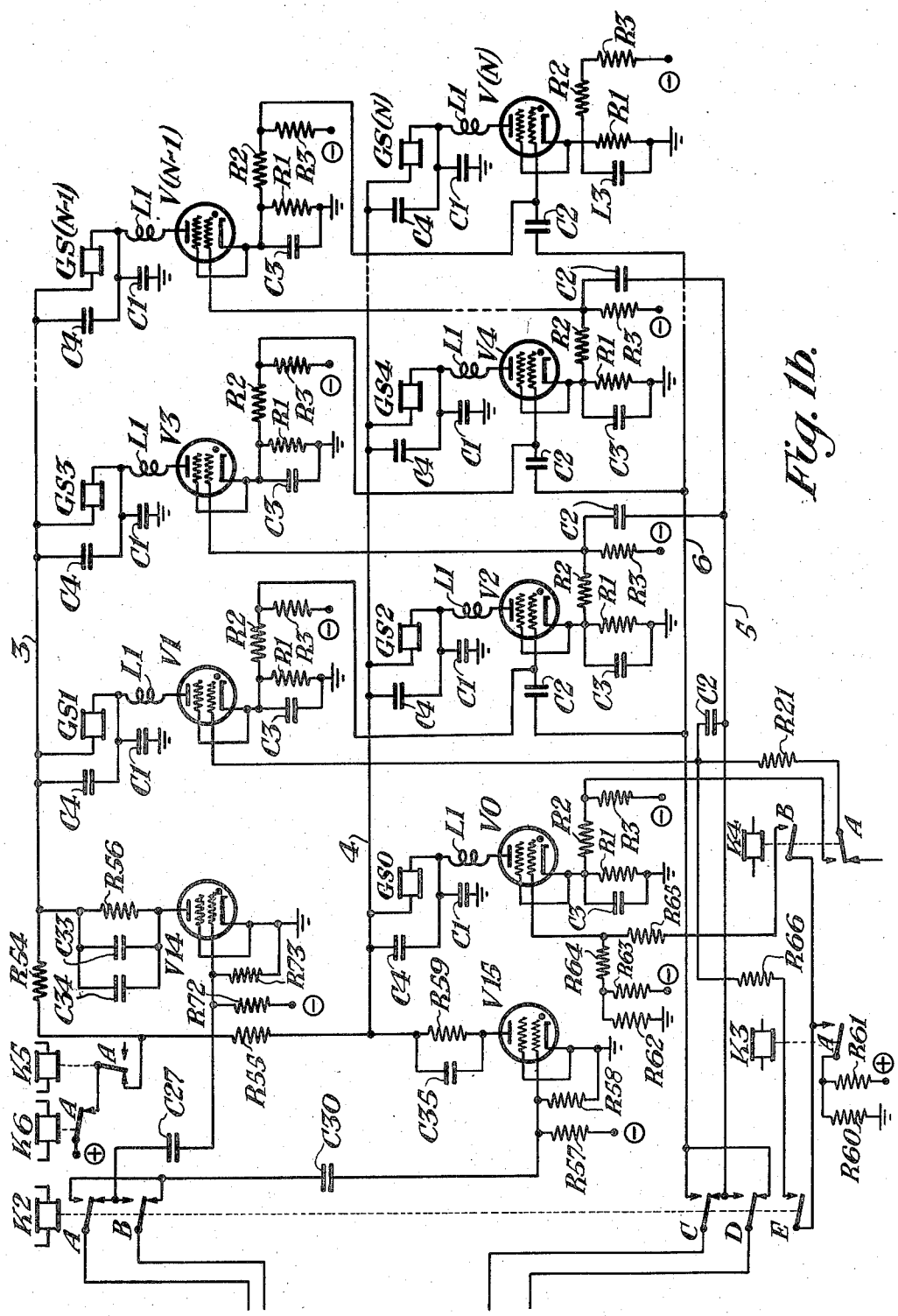


Fig. 1b.

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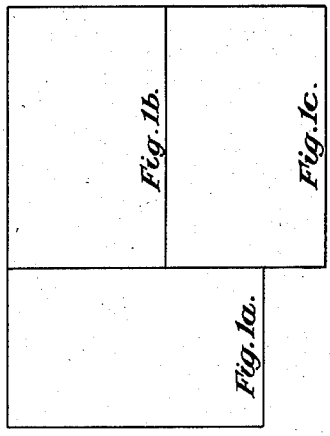


Fig. 2.

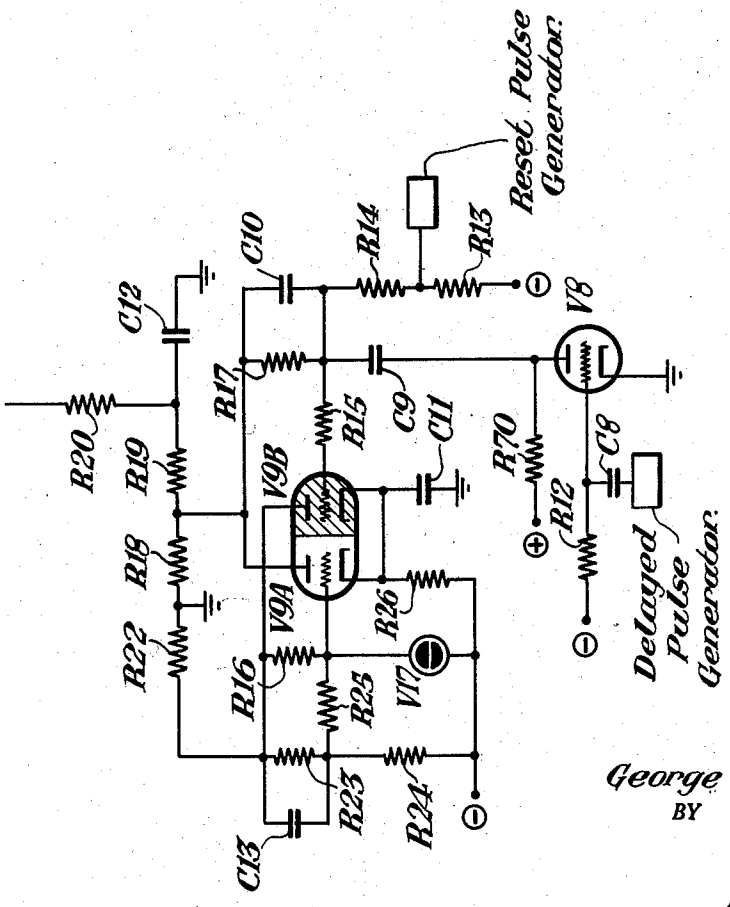


Fig. 1c.

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ELECTRONIC COUNTER CONTROL

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Application May 21, 1954, Serial No. 431,459

22 Claims. (Cl. 315—84.5)

This invention relates to an electronic counter control for a step-by-step electronic counter employing space discharge tubes, and relates specifically to means for determining the time at which the tubes in the counter will begin to conduct and the time at which they will be extinguished.

It is customary with known thyratron counters to pass the current for consecutive tubes in the counter through a common resistor in the plate supply line. The effect of this is that the firing of a tube in the counting series will reduce the plate voltage supplied to the preceding tube to a value which will not support conduction. By this method, each tube is extinguished by the firing of the next succeeding tube in the counting ring or chain.

Where it is desired to employ the space current for some operation which requires a finite period of time for its performance, which time may be greater than the time interval between the firing of consecutive tubes in the counter, the method of extinguishing, outlined above, is unsatisfactory.

Therefore, applicant has devised means for independently controlling the ignition and extinguishment of the tubes in an electronic counter so that any tube in a counting series may conduct for nearly twice the interval between counting pulses. With slight modification, the conducting time may be made three or four or more times the interval between pulses.

As an example, let us assume that the counter is to be used with an information storage system which is capable of storing received bits of information for later use as required.

In order to facilitate an understanding of the operation of the control a short description will be given of equipment with which the control may be used.

For purposes of illustration the information storing device will be considered as consisting of a relay register comprising a battery of storage relays divided into $N+1$ groups numbered consecutively from 0 to N and that the information to be stored in the relays consists of characters or message units each represented by six bits of information and that each group of storage relays has capacity for thirty-six bits of information which we shall call a message group. The equipment includes a message group storage panel consisting of six stages of six read-in relays each, each stage representing a message unit or character. Associated with each read-in relay are a bi-stable multivibrator or flip-flop and a thyratron controlled by the flip-flop. Each character of the message is impressed on the flip-flops of the message group storage panel in the form of a six pulse, broadside code, each character being applied to the first stage and causing the preceding character information to cascade through the panel one stage at a time until all six of the stages contain message information represented by the conditions of the flip-flops. The thirty six bits of information are, in turn, transferred broadside from the message group storage panel to a selected group of the N groups of relays of the relay register. In accordance with the

message code, each flip-flop either will or will not provide a pedestal voltage to its associated thyratron. When the message group storage panel is full, a read-in pulse is applied to all the thyratrons igniting those which have pedestals applied. Current for those thyratrons which have been ignited selectively operates the read-in relays. The read-in relay contacts of the selected relays will complete a circuit from a source of potential through the windings of corresponding relays in the relay register by way of a set of lead-in wires which have been connected to the specific group out of the N groups on which the information from the message group storage panel will be stored. There are two sets of lead-in wires, one for odd-numbered groups of relays and one for even-numbered groups. Selection of the proper group in the relay register is accomplished by group selector relays operated by the tubes of a group selection counting chain for which the control of this invention is intended. As each character of a message enters the message group storage panel, a step-by-step counting ring of six units is advanced one step. Firing of each tube in the six unit counting ring triggers a shift pulse and a delayed pulse which occurs two and one-half milliseconds after each shift pulse. Five milliseconds after every sixth shift pulse a read-in pulse is generated causing operation of the read-in relays as described above. The minimum time lapse between shift pulses is about ten milliseconds. The duration of a shift pulse is approximately one-half microsecond. These shift pulses are the input signal pulses for the counter control.

It is to be clearly understood that the specific nature and function of the information storage equipment are relevant only to the extent of providing a basis for defining the invention without resorting to broad and meaningless generalities. The invention may readily be employed with equipment of different characteristics and to accomplish varying tasks, the equipment with which it is employed determining only what time relations will be maintained and the nature of the signals fed to the invention.

The group selection counting chain includes $N+1$ gas filled tubes V0, V1, V2 and consecutively numbered tubes through V(N) and group selector relays GS0, GS1, GS2, etc. associated with each tube. In the usual operation of the equipment, which will be described, the counting sequence begins with the number one tube V1 of the counting chain. The counting chain is divided into two groups designated as the odd bank and the even bank. The one, three, five, seven and other odd-numbered tubes of the counter compose the odd band and the zero, two, four, six, eight and other even numbered tubes compose the even bank. The tubes of the odd bank have a common plate voltage supply lead 3 which is separate from the plate voltage supply lead 4 for the tubes of the even bank of the counter. Current flowing in the odd bank plate circuit will not affect the plate circuit for the even bank and vice-versa. Input signal pulses are applied to the control grids of the tubes in the odd bank through a conductor 5 and to the control grids of tubes in the even bank through a conductor 6. Firing of a particular tube in the counting series by a signal pulse primes the next succeeding tube for ignition by the next input pulse as is common in counting chains. However, unlike other counting chains, firing of a particular tube in the series will not extinguish the preceding tube since the plate circuits of the tubes in the odd and even groups are isolated from each other. The gas tubes are extinguished by separate extinguishing or blow-down tubes V14 and V15 which are controlled independently of the operation of the counting chain. The counter control which is the topic of this invention accomplishes the igniting and extinguishing of the tubes in the counter, and correlates the

operation of the counter with the functions of the information storage equipment. The invention is by no means limited to a gas tube counter and it is intended that any electric or electron valve device may be employed which is capable of controlling electron flow in an external circuit and which will permit a continuous flow of electrons in response to a triggering pulse.

Since the group selector relays which determine into which of the N groups of relays an incoming message group will be stored are operated by the discharge current of the counting tubes, it is imperative that the time during which a counting tube is conducting is of sufficient duration to insure operation of the relays. Otherwise a message may be lost or scrambled.

If the "on" time, the time during which a counting tube is conducting, was made wholly dependent on the time interval between the receipt of consecutive message groups, the receiving speed would have to be held relatively low to make the interval long enough to insure operation of the relays. Applicant remedies this situation by employing a pulse occuring at the beginning of each message group to ignite a counting tube and utilizing a pulse occurring at some time after the beginning of the next message group to extinguish the tube.

In the case of the example, with the counter divided into two banks, it is necessary only that the counting tube be extinguished at a time sufficiently preceding the operation of a group selector relay associated with the next tube in the same bank that at no time will more than one relay associated with the same band have its contacts closed and so that a tube in one bank will be extinguished before the next tube in that bank begins to conduct. This means that the "on" time is limited to just less than the interval from the beginning of one message group to the beginning of the second succeeding message group.

Obviously, by dividing the counter into three, four or more banks, the "on" time may correspondingly be extended to the beginning of the third, fourth or further succeeding message group. The "on" time may also be extended by increasing the capacity of the message group storage panel to extend the length of a message group.

To utilize the time advantage obtainable by permitting a counting tube to conduct beyond the time when the next tube in the counter is ignited, this invention makes use of extinguishing tubes separate from the tubes in the counter.

It is an object of this invention to disclose a novel arrangement for a counting ring or chain of the space discharge type and its associated circuitry to produce more efficient control of the ignition and extinguishment of the discharge elements of the counter.

This invention also has for an object the development of means for controlling in a positive manner the period of time during which space discharge electron tubes of a counting chain or ring will conduct.

Another object of the invention is to provide circuitry associated with a step-by-step counting ring or chain for determining the time at which a conducting tube of the counter will be extinguished independently of the conditions of the other tubes of the counter.

It is another object of this invention to teach a novel method for controlling the ignition and extinguishment of the elements in a counting ring or chain so as to make possible longer periods of useful operation of these elements.

The invention has for a further object the provision of control means for an electronic counter which means will insure against the concurrent discharge of more than one tube of the counting ring or chain through a common anode resistor and which will also protect against triggering of any tube in the chain by a spurious or foreign pulse.

These and other objects of the invention and many of their attendant advantages will be apparent in the following specification and drawings in which:

Fig. 1*a*, Fig. 1*b* and Fig. 1*c* when joined together in accordance with the diagram of Fig. 2 will compose Fig. 1 which is a schematic illustration of an embodiment of the invention.

General operation of the system

The system comprises an electronic counter made up of *N*+1 thyratron tubes numbered consecutively from V0 to V(N) and arranged for step-by-step sequential operation, a counter trigger circuit which includes a group selector trigger pulse gate generator **V5** and a blocking oscillator **V6**, an odd-even selector circuit which includes a polar stick relay **K1** operated to one or the other of its positions by an electron tube driver **V12A**, **V12B** which is controlled through a bi-stable multivibrator or flip-flop which includes electron tubes **V11A** and **V11B** and is in turn controlled by an odd-even trigger generator **V10A** and **V10B**, a blow-down or extinguishing circuit composed of a pair of thyratron tubes **V14** and **V15** controlled by blow-down trigger tubes **V13A** and **V13B** to extinguish any conducting tubes in the odd or even bank, as selected, of the counter and a group selector start network which includes relays **K2**, **K3** and **K4**, voltage divider networks involving resistors **R60**, **R61**, **R62**, **R63** and **R64** and a flip-flop circuit utilizing electron tubes **V8**, **V9A** and **V9B**.

The counter operates once during every six shift pulses which constitute the input signal pulses provided by the information storage equipment to select the specific group of the N groups of relays in the relay register into which the message group which is being received will be stored.

The counter trigger functions to produce a trigger pulse once during every six shift pulses fed in from the message group storage panel referred to previously. This trigger pulse is of longer time duration than the shift pulse, which is on the order of about one-half microsecond, and will insure ignition and step-by-step operation of the counter.

The odd-even selector operates once during every six shift pulses to connect the trigger pulse to the odd or even bank of counting tubes, as is proper, to determine whether the lead-in wires will connect the read-in relays to an odd or even-numbered group of storage relays and to select the correct extinguishing tube in accordance with the condition of the counter.

The blow-down tubes **V14** and **V15** when triggered, provide a pulse of current which passes through a dropping resistor **R54** or **R55** in the plate supply line for the odd or even bank, as determined by the odd-even selector, thereby dropping the voltage supplied to the plates of the odd or even bank of the counter below the potential which will support conduction.

The group selector start network provides a threshold pedestal or a triggering voltage, as preselected, to a selected tube of the counter to initiate step-by-step operation of the counter.

Prior to the receipt of any input signals, the counter and control will be in the reset condition as shown on the accompanying drawings. All of the thyratrons in the counter will be extinguished, the blow-down thyratrons will be extinguished and the cross-hatched tubes in the group selector start network, the extinguishing circuits and the odd-even selector circuits will be conducting. When information signals are fed to the message group storage panel the message group storage system will generate shift pulses in groups of six, one before the receipt of each message unit which is imposed on the message group storage panel. A delayed pulse, occurring two and one-half milliseconds after every shift pulse, will also be generated. An odd-even gate pulse will be provided after every third shift pulse of each group of six and a group selector gate pulse will be generated coinciding with every first shift pulse. Coincident with the occurrence of the first shift pulse, a

group selector gate pulse appears on the grid of the group selector trigger pulse gate generator V5 allowing the first shift pulse to actuate the group selector blocking oscillator V6. The pulse produced by the blocking oscillator is applied to the grids of all the tubes of the odd bank of the counting chain, as determined by the position of the polar contact A of the odd-even relay K1.

In the reset condition, V9A of the group selector flip-flop is cut off and V9B is conducting. In the odd-even flip-flop, V11A is conducting and holds V12A of the odd-even relay driver cut off while V11B is cut off and V12B is conducting. With no plate current flowing in V9A, the voltage at the grid of V1 is such that a trigger pulse produced by the blocking oscillator is capable of igniting V1. The first delayed pulse which is applied to V8 will produce a voltage pulse which will cut off V9B and start V9A conducting. This, in turn, lowers the grid voltage at V1 to a value which will render a trigger pulse ineffective to ignite V1. V1 grid voltage remains at this value until the counter is reset. After the third shift pulse, the odd-even gate pulse, previously mentioned, is applied to the grid of the odd-even trigger tube V10A allowing the third delayed pulse to effect conduction of V10A. A negative pulse is formed at the plate of V10A and appears at the conducting side of the odd-even bi-stable multivibrator reversing the condition of that flip-flop. Reversal of the conditions of the odd-even flip-flop reverses the conducting and non-conducting sides of the odd-even relay driver so that V12A will conduct and V12B will be cut off. This causes the odd-even relay K1 to shift its contact A to its opposite position, that is, contact A will close to the right in the drawing. Reversal of the odd-even flip-flop momentarily drops the voltage at the grid of the blow-down trigger tube V13A reducing its plate current and thereby imposing a positive pulse at the grid of the even blow-down thyratron V15. The even blow-down thyratron fires, reducing the voltage supplied to the anodes of counting tubes in the even bank, but since no tubes in the even bank of the counter are conducting no changes are effected. Current flowing in the plate circuit of V1 in the counting chain causes group selector relay GS1 to pick up, closing its contacts and connecting the thirty-six relays of group one in the relay register to lead-in wires for the odd numbered groups. Five milliseconds after the sixth shift pulse occurs the system generates a read-in pulse igniting the thyratrons in the message group storage panel which are provided with pedestals by their associated flip-flops. The plate current of the conducting thyratrons operates the associated read-in relays to a position which completes an energizing circuit for the corresponding relays in the relay register through the contacts of relay GS1 and the lead-in wires for the odd-numbered groups. This transfers the information stored in the message group storage panel broadside into the relays of group one in the relay register. Each tube of the counting chain except V0 has its control grid connected to the cathode of the preceding tube in the counter, the connection from the cathode of V0 to the grid of V1 being through contact A of relay K4. Then as each tube in the counter begins to conduct, the voltage rise at the cathode of the conducting tube due to current flowing through the cathode resistor R1 will be coupled to the grid of the next succeeding tube to prime it for ignition by the next trigger pulse. Therefore, with V1 conducting, the potential at the control grid of V2 rises to a point at which the next incoming trigger pulse will be capable of firing V2.

The first shift pulse of the next group of six shift pulses will be gated through the group selector trigger pulse gate generator V5 to activate the blocking oscillator V6. The blocking oscillator pulse will be conducted through the polar contact A of the odd-even relay K1 which is now in the position where the pulses will be applied to the input line 6 for the grids of all the tubes in the even bank of the counter. However, the pulse is of insufficient amplitude to fire any of the tubes in the counter except V2, which has imposed on its grid the priming voltage derived from the cathode of V1. Tube V2 will discharge and its plate current will pick up group selector relay GS2 and extinguish the even blow-down tube V15. This connects the thirty-six relays in group number two to the lead-in wires for the even numbered groups.

The third delayed pulse of the group of six is gated through the odd-even trigger tube V10B by the odd-even gate pulse and produces a pulse at the grid of V11B in the odd-even bi-stable multivibrator which will cut off V11B and again reverse the condition of the flip-flop. The multivibrator plate voltage levels change causing V12B in the odd-even relay driver to conduct and V12A to be cut off. This again reverses the odd-even relay polar contact. A pulse from V11A is applied to the grid of V13A to generate a trigger pulse at the plate of V13A which ignites the odd blow-down tube V14. The firing of the odd blow-down tube cuts off the number one tube of the counter. After the number six shift pulse occurs, indicating that the message group storage panel has now stored a complete message group, a read-in pulse occurs which ignites the message group storage thyratrons having a pedestal voltage applied by their associated flip-flops, causing operation of the selected read-in relays, thus completing energizing circuits for the corresponding relays in the relay register through the even lead-in wires. Thus, the second message group is stored in the relays of the second group of the N groups in the relay register since they were previously connected by relay GS2 to the lead-in wires for the even numbered groups of relays.

This action continues until an end of message symbol is received in the information which is being stored. The message storage equipment generates an end of message pulse in response to the received symbol. The end of message pulse is employed to cause a reset relay K5 to operate removing plate voltage from all the tubes in the counter and to trigger a reset pulse generator causing the application of reset pulses to the group selector start flip-flop and to the odd-even flip-flop to restore them to their reset conditions as they are shown on the drawings. In practice, the end of message symbol may consist of signal information representing any unique character or combination of characters.

Circuit details and operation

Each of the counting tubes V0 through V(N) in the counting chain has identical circuit components which are designated by like numerals in the drawings. In the tube circuits, R1, R2 and R3 form a voltage divider network from ground to a negative supply voltage. The cathode of the counting tube is connected to the junction between resistors R1 and R2. R1 forms a cathode resistor and is by-passed by a capacitor C3. The plates for the tubes are connected through an inductance L1 and the winding of the corresponding group selector relay GS1, GS2, etc., in series, to a plate supply line 3 or 4 for the corresponding odd or even bank. The relay winding is by-passed by a capacitor C4 and a capacitor C1 is connected from the junction between L1 and the relay winding to ground. L1 and C1 form a filter which prevents thyratron noise from reaching and affecting other circuits in the storage equipment. The control grid of each of the counting tubes except V0 is coupled through a capacitor C2 to the appropriate odd or even signal input line 5 or 6. The control grid is also directly connected to the junction point between resistors R2 and R3 in the cathode circuit of the preceding tube in the chain.

By way of example, with a negative supply voltage of minus 150 volts, components of the following values may be selected. R1—750 ohms, R2—0.47 megohm, R3—

0.82 megohm, L1—1 millihenry and relay winding resistance 550 ohms. The counting tube may be a four element gas filled tube type 5727. With the gas tube not conducting, the voltage at the junction between R2 and R3 and at the grid of the succeeding tube is approximately minus 40 volts and the triggering pulse supplied by the counter trigger circuit will be of insufficient amplitude to raise the grid voltage of the succeeding tube to the ionization point. With the counting tube conducting, voltage at the junction of R2 and R3 rises to a value of approximately minus 10 volts and with a plate supply voltage of approximately 275 volts, an incoming trigger pulse is capable of igniting the succeeding tube.

Thus, it will be seen that the tubes in the counting chain cannot be fired by a trigger pulse unless the immediately preceding tube in the chain is in a conducting condition or unless a pedestal or igniting voltage is supplied by the group selector start network. In the case of V1 the control grid is connected through resistor R21 to the heel of contact A of relay K4. When relay K4 is in its picked up condition, the grid of V1 will be connected to the junction between R2 and R3 in the cathode circuit of V0. When relay K4 is down, the grid of V1 is connected through a back contact of relay K4 to ground through resistors R20, R19 and R18. In the reset condition of the counter, as shown, with the equipment in the condition to begin the storage of incoming messages, group selector start flip-flop composed of tubes V9A and V9B provides a threshold voltage to V1 in the following manner. The plate of V9A is connected to the junction point between R18 and R19. The grid of V9A is coupled to the plate of V9B by capacitor C13 and is connected via resistor R25 to the junction between resistors R23 and R24 of a series divider network composed of resistors R22, R23 and R24 connected from ground to a negative supply voltage. The plate of V9B is tied to the junction of R22 and R23 and the grid of V9B is connected through R15 to the junction of resistors R17 and R14, to one side of capacitor C9 and to one side of capacitor C10. In the reset condition, V9B is conducting and the current drawn by V9B flowing through the cathode resistor R26 keeps the cathode of V9A at a relatively high potential with respect to its grid. R26 is by-passed by capacitor C11. The grid voltage of V9A is suppressed by plate current for V9B flowing through R22 to ground. V9A therefore is held cut off, and the voltage at the junction of R18 and R19 and at the grid of V1 is determined by the voltage divider network comprising R13, R14, R17 and R18 extending from ground to negative supply voltage. The resistors are proportioned so that in the reset condition the voltage coupled to the grid of V1 through resistors R19, R20 and R21 is such that V1 is primed for ionization by a trigger pulse supplied by the blocking oscillator. The grid of V3 is connected through R12 to a negative biasing potential. The first delayed pulse which occurs after message reception begins will be coupled via capacitor C8 to the grid of group selector start flip-flop trigger V8. The delayed pulse will be amplified and the voltage change at R70 imposed on the grid of V9B through coupling capacitor C9 and resistor R15. This produces a voltage pulse in the negative direction at the grid of V9B, which is in a conducting condition when message reception begins. When the pulse is applied to V9B, plate current flowing through R22 to ground is reduced producing a rising voltage pulse at the plate. The rising voltage is coupled through C13 to the grid of V9A, which is in non-conducting condition. V9A is held at cut off until its grid voltage rises above the cut off point. As V9A starts to conduct, its plate voltage will start to decrease. The decreasing volage at the plate of V9A will be applied through C10 and R15 to the grid of V9B accelerating the cut off of that tube and the conditions of V9A and V9B will be reversed with V9A conducting and V9B cut off. When V9A is fully conducting the voltage at the junction between resistors R18 and R19 will be reduced due to the voltage drop produced by V9A plate current flowing through R18. Threshold voltage at the V1 control grid will therefore be removed and further signal pulses cannot fire V1 until the counter has been reset. Neon indicator V17 connected in series with resistor R16 will light when V9B is cut off. C12 is a by-pass capacitor.

V10A and V10B are the odd-even trigger tubes. The grids of V10A and V10B are connected through resistors R27 and R28, respectively, to a source for an odd-even gate pulse and through capacitors C14 and C19 to the back and front points respectively of contact B of relay K1. The plate of V10A is connected to a positive source of potential through resistor R29 and by capacitors C15 and C16 to the grid circuit for V11A. The plate of V10B receives positive plate voltage through resistor R17 and is joined to the grid circuit of V11B through capacitors C20 and C21. The junction between C15 and C16 is tied to ground through resistor R37, and resistor R46 provides a path to ground from the junction of C20 and C21.

The odd-even flip-flop is composed of V11A and V11B which have a common cathode resistor R45 leading to a source of negative potential. C18 is a cathode by-pass capacitor. The grid of V11A is connected through resistor R30 to the junction between C16, capacitor C17, resistor R31 and resistor R47. R47 and R31 together with resistor R32 form a voltage divider network from a negative source of potential to ground. C17 couples the grid of V11A to the plate of V11B. The grid of V11B is connected through resistor R34 to the junction between resistors R38 and R39, and capacitors C21 and C22 provides coupling from the grid of V11B to the plate of V11A. R38 and R39 are part of a voltage divider which also includes resistors R34, R35 and R36 and extends from a negative potential to ground. The plate of V11B is tied to the junction of R31 and R32 and the plate of V11A is connected to the junction of R35 and R36. R32 is also part of a voltage divider beginning at ground and going to a source of positive potential through resistors R32, R33, R44 and R43 in parallel with resistors R36, R40, R41 and R42.

An odd-even gate pulse is applied through resistors R27 and R28 to the grids of V10A and V10B, the odd-even trigger tubes at a time overlapping the occurrence of the third delayed pulse. The delayed pulse is selectively applied to the grid of V10A through coupling capacitor C14 or to the grid of V10B through coupling capacitor C19 depending upon the position of contact B of relay K1. In the reset condition of the system, as shown, the delayed pulse will be connected through a back contact of relay K1 to the grid of V10A and will cause a rise in plate current producing a falling voltage pulse at resistor R29. This pulse is coupled through capacitor C15, capacitor C16 and resistor R30 to the grid of section V11A of the odd-even flip-flop. In the reset condition V11A is conducting while V11B is cut off. With the application of the negative going pulse, the current through V11A will begin to decrease. As the plate current for V11A decreases, the plate voltage rises and is coupled to the grid of V11B through C22 and R35 causing V11B to begin to conduct. The plate voltage at V11B decreases and is coupled to the grid of V11A through C17 and R31 further suppressing the grid voltage until V11A is cut off.

V12A and V12B make up the odd-even relay driver. In the reset condition V12B is conducting and V12A is cut off. The cathodes of V12A and V12B are connected directly to ground while the grid of V12A is connected to the junction of R41 and R42 and the grid of V12B is tied into the junction between R43 and R44. Capacitors C23 and C24 are connected from the grids of V12A and V12B respectively to ground. The plate of V12A is connected through resistor R53 and the reverse winding of relay K1 to a source of positive potential. The plate of V12B is connected through resistor R52 and the nor-

mal winding of relay K1 to the source of positive potential. Shunting capacitors C31 and C32 are connected from the relay windings to ground. As V11A starts to cut off and V11B begins conducting, the grid voltage of V12A will rise while the grid voltage of V12 decreases. V12A will then conduct and V12B will be cut off. Plate current for V12B will cause polar contact A of relay K1 to move to the reverse position and contact B will be picked up. This conditions the system so that the next odd-even gate pulse will gate the number three delay pulse to V10B of the odd-even trigger circuit and so that the next trigger pulse furnished by the blocking oscillator will be applied to the even bank of counter tubes.

The group selector trigger pulse gate generator V5 has its cathode grounded and its grid connected by a resistor R5 to the junction between a resistor R4 and a capacitor C5. R4 couples a group selector gate pulse to the grid of V5 once during every six shift pulses. C5 is the signal pulse input capacitor. The signal pulses in this case are the shift pulses which were previously referred to. The plate of V5 is connected through the primary winding of a blocking oscillator transformer T1 and a series resistor R8 to a source of positive potential. Capacitor C7 is connected from ground to the end of R8 which is adjacent T1.

A group selector gate pulse is applied through resistors R4 and R5 to the grid of the group selector gate pulse generator V5 at a time coincident with the occurrence of the first shift pulse of each group of six. The shift pulse which is of approximately one-half microsecond duration is coupled to the grid through capacitor C5. This causes a rise in plate current for V5 and its plate voltage begins to fall. Blocking oscillator V6 has its cathode connected to ground and its grid connected through resistors R6 and R7 to a source of negative bias voltage which normally holds the tube below cut off. The plate of V6 is connected to the same terminal of the blocking oscillator transformer as the plate of V5.

One end of the secondary winding of transformer T1 is grounded and its other end is connected to ground through a resistor R9. A capacitor C6 couples the junction of R6 and R7 to a centertap on the secondary winding of T1. The plate of a feedback limiting diode V7 is tied to the junction of R9 and the end of the transformer winding. The cathode of V7 goes to ground through resistors R10 and R11. The heel of polar contact A of the odd-even relay K1 is electrically connected to the junction of R10 and R11. In its position, as it is shown on the drawings, which will be called the normal position, contact A of relay K1 will make circuit with conductor 5 leading to the grids of the odd-numbered tubes in the counter and in the opposite position, which will be called the reverse position, contact A will make circuit with conductor 6 which is coupled to the grids of the even-numbered tubes in the counter.

The falling plate voltage of V5 induces a rising voltage on the secondary of T1 which is coupled through capacitor C6 to the grid of V6 causing V6 to begin to conduct. Plate current for V6 flowing through the primary of T1 further raises the voltage applied to the grid of V6. This action continues until the grid of V6 begins to draw current charging capacitor C6. V6 plate current will then begin to fall producing a decreasing voltage in the secondary of T1 which is impressed on the grid of V6 further reducing the plate current. This action continues until V6 is cut off. V6 will remain cut off until the next rising voltage pulse is applied to its grid. The action of the blocking oscillator produces a group selector pulse of a width substantially greater than the one-half microsecond shift pulse and which will therefore be more positive in its action in triggering the counter. The group selector pulse is applied to the plate of the feed-back limiting diode V7 whose cathode is connected to the appropriate odd or even input lead of the counter through resistor R10 and the polar contact A of relay K1. In the reset condition as shown, the pulse is applied to the odd bank of counter tubes and the count will start with V1.

The purpose of the feed-back limiting diode V7 is to prevent spurious triggering of the blocking oscillator by the discharge current of capacitors C2 after a group selector pulse has been applied to the counter. The discharge current for capacitors C2 causes a rising voltage pulse to appear at the junction between resistors R10 and R11 in the cathode circuit of the V7 diode. If it were not for the presence of the diode, this voltage would also appear across the resistor R9 and the secondary winding of transformer T1 and would be applied to the grid of V6. This voltage would then begin the blocking oscillator cycle previously described and cause spurious triggering in the counter.

With the group selector flip-flop in its reset condition, the group selector pulse is of sufficient magnitude to cause ionization of V1 and that tube will discharge. Firing of V1 will operate group selector relay GS1 and place a priming pulse at the grid of V2, as hereinbefore described, so that the next group selector pulse will effect the firing of V2.

With the odd-even relay K1 in its reverse position the circuits are now arranged so that the next group selector pulse will be applied to the even bank of counting tubes.

The blow-down trigger tubes V13A and V13B are in normally conducting condition. The cathodes of V13A and V13B are connected directly to ground. The grid of V13A is connected to ground through resistor R48 and is coupled to the junction between resistors R40 and R41 through capacitors C25 and C26. The plate of V13A is connected to a source of positive potential through plate resistor R49. Similarly, the grid of V13B is connected to ground through resistor R50 and to the junction between resistors R33 and R44 by capacitors C28 and C29. When the odd-even flip-flop V11A and V11B reverses conditions as described above and V11B begins to conduct, the negative pulse produced at the plate of V11B will be applied through resistor R33 and capacitors C28 and C29 to the grid of V13B, the even blow-down trigger tube. This pulse will be amplified by V13B and applied as a positive pulse through capacitor C30 to the grid of the even blow-down tube V15. The even blow-down tube V15 is a thyratron type tube with its cathode connected to ground and its grid connected to the junction between resistors R57 and R58 which form a voltage divider network extending from ground to a source of negative potential. The plate of V15 is connected through resistor R59, which is by-passed by capacitor C35, to the plate supply line for the even bank of counter tubes. The plate current for V15 flows through resistor R55 which is a common load resistor for the even blow-down tube and all of the tubes of the even bank of the counter. Similarly, the odd blow-down tube V14 has its cathode grounded and its grid connected to a junction between resistors R72 and R73 which form a voltage divider extending from ground to a source of negative potential. The plate of V14 is connected through resistor R56 shunted by capacitors C34 and C33 to the plate supply line for the tubes in the odd bank of counting tubes. R54 is the common load resistor for the odd blow-down tube and for the tubes in the odd bank of the counting tubes. As shown, the grid of V14 is coupled through capacitor C27 and a contact A of relay K2 to the plate of the odd blow-down trigger tube V13A and the grid of V15 is coupled through capacitor C30 and contact B of K2 to the plate of the even blow-down trigger tube V13B. V14 and V15 are held cut off by grid bias until a positive trigger pulse is supplied to the grid by the corresponding blow-down trigger tube. Plate current for the blow-down tubes flowing through the common load resistor R54 or R55 reduces the plate voltage supplied to the plates of the associated counter tubes to a level insufficient to sustain conduction. Any

counting tube in the associated bank which might be conducting will therefore be extinguished. The blow-down tubes are extinguished by the plate current pulse of the next counting tube which fires in the bank with which the blow-down tube is associated. Alternately, the blow-down tubes could be made self-extinguishing by a proper choice of circuit components.

With V2 supplied with the priming voltage from the cathode of V1 and the odd-even relay operated to impose the next group selector pulse on the grids of the tubes in the even bank of the counter, the first shift pulse of the next group of six will effect the initiation of a group selector pulse which will fire V2. Firing of V2 will pick up relay GS2 and will also supply a threshold voltage to the grid of V3. The odd-even gate pulse will gate the third delay pulse of this group through tube V10B of the odd-even trigger. This will cause V10B to conduct producing a voltage drop at R71. The odd-even trigger pulse thus generated will be applied through C20, C21 and R34 to the grid of V11B and will cut off V11B, raising the grid voltage at V12B. V11A will again conduct and a pulse of voltage in the negative direction will appear at the grid of V12A and cut off V12A. Relay K1 will be operated to the normal position by V12B plate current and will stick up in its normal position. Reversal of the conditions of the odd-even flip-flop will also produce a pulse in the negative direction at the grid of V13. The pulse is amplified and appears at the plate of V13B as a pulse in the positive direction which is coupled to the grid of V14 through contact A of relay K2 and capacitor C27. V14 will fire and the plate current for V14 flowing through common resistor R54 will extinguish V1.

Step-by-step operation of the tubes in the counter will take place until all of an incoming message has been stored in the relays composing the relay register and a reset pulse is received. The reset pulse will be applied to the grid of V9B of the group selector start flip-flop and to the grid of V11A in the odd-even flip-flop. Neon lamps V16 and V17 will be extinguished to indicate that the flip-flops have been properly reset. The reset pulse also causes energization of the reset relay K5, momentarily removing plate voltage from the blow-down tubes and all the tubes in the counting chain. A reset pulse may be introduced by an operator at any point during the counting cycle.

Relays K2, K3 and K4 are employed to enlarge the function and scope of the counter. An explanation of their use will illustrate how the utility of the counter control may be enlarged.

Relay K2 is the synchronizing and start relay which permits starting the counting chain at a preselected point and correlates the signal input lines and blow-down trigger pulse input lines. As shown, relay K2, when energized, will function as follows: Through one of its contacts, not shown, it completes a pick-up circuit for relay K3. Through its contact E and contact A of relay K3 it applies a positive potential from the junction of R60 and R61 to the grid of V1 through resistor R66, thereby causing V1 to fire. Contacts A and B of K2 reverse the input leads to the blow-down tubes so that the first blow-down trigger pulse is applied to the odd blow-down thyratron rather than the even blow-down thyratron. The contacts C and D of K2 reverse the signal input lines to the odd and even banks of counting tubes so that the first counter trigger pulse will be applied through contact A of the odd-even relay to the grids of the tubes in the even bank. Obviously, a contact such as contact E of K2 may be employed to place a starting voltage at the grid of any selected tube in the counting chain, so the count may be started at any point in the chain.

Relay K3 is energized when either relay K2 or K4 is picked up and in its energized condition provides a path through its contact A to the junction of R60 and R61 of a voltage divider extending from ground to a source of positive potential.

Relay K4, when energized, causes relay K3 to be energized, removes threshold voltage from the grid of V1 and applies an ignition potential to the grid of V0. When K4 is picked up, its contact A connects the grid of V1 through R21 to the junction between R2 and R3 in the cathode circuit of V0 and breaks the circuit through R19 and R20 to the plate of V9A. The grid of V0, which is normally held cut off by a negative potential applied through resistor R64 from the junction between resistors R62 and R63 in a voltage divider extending from ground to a negative voltage, is connected by a circuit including resistor R65, contact B of K4 and contact A of K3 to the positive voltage at the junction of R60 and R61. This places an ignition potential at the grid of V0 so that V0 conducts and the resulting current flow through the cathode resistors of V0 raises the voltage at the grid of V1 conditioning it for firing by the next trigger pulse applied to the signal input lines for the odd bank of counting tubes.

It is to be noted that the counting chain with its associated elements acts as a link between the message group storage panel and the relay register. Obviously, the link, when completed, may be used either to transfer to the relay register information received from an external source and temporarily stored in the message group storage panel or to transfer information from the relay register to the message group storage panel for transmittal to an external point.

In some forms of transmitting, it is required to transmit certain specific information in advance of a message. This information may be stored in the relay register in the relays of group 0 and operation of relay K4, as above described, would place the information on the message group storage panel ready for transmission externally.

It is also obvious that a simple change in the voltage divider, whereby a threshold voltage instead of an ignition voltage would be applied to the grid of V0, would result in extending the usable counting chain ahead of its normal starting end.

With relay K4 deenergized, the grid of V1 has applied thereto, through contact A of K4, the voltage at the plate of V9A in the group selector flip-flop as has been described. Obviously, contacts of K4 may be arranged to apply a firing voltage or a threshold voltage to any tube in the counting chain.

As was previously suggested, a greater time advantage may be gained by dividing the counter into more than two banks. To accomplish this, the signal supplying equipment must be capable of supplying information over a correspondingly greater number of paths. For example, in the case herein related, the read-in relays would be provided with a correspondingly greater number of sets of contacts, one for each bank, and the number of thyratrons increased to at least one for every two sets of read-in relay contacts or both thyratrons and read-in relays may be increased in number to at least one for every two banks of the counter. In the counter control, the odd-even relay K1 and the synchronizing relay K2 would be provided with a plurality of contact positions equal to the number of banks of counting tubes or several relays could be connected in cascade to effect selection of the proper bank in sequence. Additional blow-down tubes would be required, one for each bank of counting tubes. A counting ring or chain may be employed instead of relays to effect sequential selection of the proper bank of tubes.

As was previously related, the reset relay K5 is operated at the end of each count to extinguish all the tubes in the counter and to place the counter control in condition to begin a new counting cycle. This relay may be operated at any time during the counting cycle, upon the occurrence of an end of message pulse, to stop the counter at any point in the chain and to reset the con-

trol for a new count. Emergency release relay K6 is manually controlled by an operator. When its contact A is picked up, it removes plate voltage from all the tubes in the counting chain and from the blow-down tubes.

Although I have herein shown and described only one form of an electronic counter control embodying my invention, it is to be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. A counter control for an electronic counter made up of separate odd and even banks of electric discharge devices with separate signal input lines and separate power supply lines for the odd and even banks, the control comprising means for priming a selected one of the discharge devices for firing by a signal pulse to initiate a step-by-step counting operation in synchronism with applied signal pulses, and means for extinguishing a discharge device in one bank at a predetermined time after it has fired independently of the time at which a discharge device in the other bank may be fired.

2. A counter control for an electronic counter composed of separate odd and even banks of electric discharge devices, devices in the odd bank having common signal input lines and common discharge lines, devices in the even bank having common signal input lines and common discharge lines separate from the signal input lines and discharge lines for the odd bank, said control comprising means for priming a selected one of the discharge devices for firing by a triggering pulse, means for generating counter triggering pulses in synchronism with input signals supplied by an external source and applying said pulses alternately to the signal input lines for the odd and even banks to cause a step-by-step counting operation, and means for extinguishing a discharge device in one bank at a predetermined time after it has fired independently of the time at which a discharge device in the other bank may be fired.

3. A counter control for an electronic counter made up of separate odd and even banks of electric discharge devices, the devices in the odd bank having common signal input lines and common discharge lines and the devices in the even bank having common signal input lines and common discharge lines separate from the signal input lines and discharge lines for the odd bank, said control comprising means for priming a selected one of the discharge devices for firing by a triggering pulse to initiate a step-by-step counting operation in synchronism with applied triggering pulses, means for generating counter triggering pulses in synchronism with input signals supplied by an external source and applying said pulses alternately to the signal input lines for the odd and even banks, means for rendering inactive said means for priming a selected one of the discharge devices after said selected device has been fired, and means for extinguishing a discharge device in one bank at a predetermined time after it has fired independently of the time at which a discharge device in the other bank may be fired.

4. In a counter control for an electronic counter composed of separate odd and even banks of electric discharge devices, the odd bank of discharge devices having common signal input lines and a common discharge line and the even bank of discharge devices having a common signal input line and a common discharge line, the signal input line and the discharge line for the odd bank being separate from the signal input line and discharge line for the even bank, the control comprising means for priming a selected one of the discharge devices for firing by a triggering pulse to initiate a step-by-step counting operation in synchronism with applied triggering pulses, means for generating counter triggering pulses in synchronism with input signals applied by an external source and applying said pulses alternately to the signal input lines for the odd and even banks, first means for extinguishing a discharge device in the even bank at a predetermined time after it has fired independently of the time at which a discharge device in the odd bank may be fired, second means for extinguishing a discharge device in the odd bank at a predetermined time after it has fired independently at the time at which a discharge device in the even bank may be fired, and means for producing triggering pulses to control the operation of said first and second means.

5. In a counter control for a step-by-step electronic counter comprising a series of electric discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device and an odd bank including the second discharge device and each succeeding alternate discharge device, the discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path, the control comprising means for conditioning a selected one of said discharge devices for firing by an input signal to initiate a step-by-step sequential counting operation in synchronism with applied input signals, and means for extinguishing a discharge device in one bank after a selected interval after it has fired independently of the time at which a discharge device in the other bank may be fired but before another discharge device in said one bank is fired.

6. In a counter control for a step-by-step electronic counter comprising a series of electron discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device and an odd bank including the second discharge device and each succeeding alternate discharge device, the discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path, the control comprising means for conditioning a selected one of said discharge devices for firing by a triggering pulse to initiate a step-by-step sequential counting operation in synchronism with applied trigger pulses, means for generating a counter triggering pulse in synchronism with input signals supplied from an external source, and means for extinguishing a discharge device in one bank at a selected interval after it has fired independently of the time at which a discharge device in the other bank may be fired but before a succeeding discharge device in said one bank is fired.

7. In a device of the class described for use with a step-by-step electronic counter comprising a series of electric discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device in the series and an odd bank including the second discharge device and each succeeding alternate discharge device in the series, the discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path, the device comprising means for conditioning a selected one of said discharge devices for firing by an input signal to initiate a step-by-step sequential counting operation in synchronism with applied input signals, means for rendering inactive said means for priming a selected one of the discharge devices after said selected device has been fired, and means for extinguishing a discharge device in one bank at a selected interval after it has fired independently of the time in which a discharge device in the other bank may be fired.

8. In a device of the class described for use with a step-by-step electronic counter comprising a series of electric discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device and an odd bank including the sec-

ond discharge device and each succeeding alternate discharge device, discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path, the control comprising means for conditioning a selected one of said discharge devices for firing by an input signal to initiate a step-by-step sequential counting operation in synchronism with applied input signals, first means for extinguishing a discharge device in said even bank at a selected interval after it has fired independently of the time at which a discharge device in the odd bank may be fired, second means for extinguishing a discharge device in said odd bank at a selected interval after it has fired independently of the time at which a discharge device in the even bank may be fired, and means for producing triggering pulses to control the operation of said first and second means.

9. A counter control for a step-by-step electronic counter comprising a series of electric discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device and an odd bank including the second discharge device and each succeeding alternate discharge device, the discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path, the control comprising means for conditioning a selected one of said discharge devices for firing by a trigger pulse to initiate a step-by-step sequential counting operation in synchronism with applied trigger pulses, means for generating a counter trigger pulse in synchronism with input signals supplied from an external source, means for applying consecutive trigger pulses alternately to the odd bank and to the even bank and means for extinguishing a discharge device in one bank at a selected interval after it has fired independently of the time at which a discharge device in the other bank may be fired.

10. A counter control for a step-by-step electronic counter comprising a series of electric discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device and an odd bank including the second discharge device and each succeeding alternate discharge device, the discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path, the control comprising means for conditioning a selected one of said discharge devices for firing by a trigger pulse to initiate a step-by-step sequential counting operation in synchronism with applied trigger pulses, means for rendering inactive said means for conditioning a selected one of the discharge devices after said selected device has been fired, means for generating a counter trigger pulse in synchronism with input signals supplied from an external source, means for applying consecutive trigger pulses alternately to the odd bank and to the even bank and means for extinguishing a discharge device in one bank at a selected interval after it has fired independently of the time at which a discharge device in the other bank may be fired.

11. In a counter control for a step-by-step electronic counter comprising a series of electric discharge devices arranged in an even bank including the first discharge device and each succeeding alternate discharge device and an odd bank including the second discharge device and each succeeding alternate discharge device, the discharge devices in said even bank having a common input signal path and a common discharge path and the discharge devices in said odd bank having a common input signal path and a common discharge path separate from the input signal path and the discharge path for said even bank, the control comprising means for conditioning a selected one of said discharge devices for firing by a triggering pulse to initiate a step-by-step sequential counting operation in synchronism with applied triggering pulses, means for generating a counter triggering pulse in synchronism with input signals supplied from an external source, means for applying said pulses alternately to the signal input lines for the odd and even banks, means for rendering inactive said means for conditioning a selected one of the discharge devices after said selected device has been fired, first means for extinguishing a discharge device in the even bank at a selected interval after it has fired independently of the time at which a discharge device in the odd bank may be fired, second means for extinguishing a discharge device in the odd bank at a selected interval after it has been fired independently of the time at which a discharge device in the even bank may be fired, and means for producing triggering pulses to control the operation of said first and second means.

12. In a counter control for a step-by-step electronic counter comprising a consecutive series of electron tubes each including a cathode, an anode and a control grid, said series of tubes being divided into an even bank including the first tube and each succeeding alternate tube and an odd bank including the second tube and each succeeding alternate tube, the control grids of the tubes in the even bank being connected to a common input signal path and the anodes of the tubes in the even bank being connected through a common discharge path to a source of voltage and the tubes in the odd bank having their grids connected to a common signal input path and their anodes connected through a common discharge path to a source of voltage, the common paths for the odd bank being separate from the common paths for the even bank, the control comprising means for conditioning a selected one of said electron tubes by applying a threshold voltage to the control grid thereof and means for extinguishing a conducting tube in one bank by reducing the anode voltage supplied through the common discharge path for that bank below the voltage which will support conduction, said means for extinguishing the conducting tube being operable at a selected interval after a tube in said one bank begins conducting independently of the time at which a discharge tube in the other bank begins to conduct.

13. In an electronic counter composed of a consecutive series of electron tubes each having a cathode, an anode and a control grid, said series of tubes being separated into an even bank including the first tube and each succeeding alternate tube and an odd bank including the second tube and each succeeding alternate tube, the anodes of tubes in the even bank being connected to a source of voltage through a common discharge path and the control grid of tubes in the even bank being connected to a common signal input path and the anodes of tubes in the odd bank being connected to a source of voltage through a common discharge path and the control grids of tubes in the odd bank being connected to a common signal input path, the common paths for the odd bank being separate from the common paths for the even bank, means for conditioning a selected one of the tubes in the series for firing by a trigger pulse by applying a threshold voltage to the control grid thereof to initiate a step-by-step sequential counting operation in synchronism with trigger pulses applied alternately to the signal input path for the odd bank and to the signal input path for the even bank, a blocking oscillator for generating trigger pulses in synchronism with received external signal pulses, and means for extinguishing a conducting tube in either bank at a time independent of the time at which a tube in the other bank begins to conduct.

14. In an electronic counter composed of a consecutive series of electron tubes each having a cathode, an anode and a control grid, said series of tubes being sepa-

rated into an even bank including the first tube and each succeeding alternate tube and an odd bank including the second tube and each succeeding alternate tube, the anodes of tubes in the even bank being connected to a source of voltage through a common discharge path and the control grid of tubes in the even bank being connected to a common signal input path and the anodes of tubes in the odd bank being connected to a source of voltage through a common discharge path and the control grids of tubes in the odd bank being connected to a common signal input path, the common paths for the odd bank being separate from the common paths for the even bank, means for conditioning a selected one of the tubes in the series for firing by a trigger pulse by applying a threshold voltage to the control grid thereof to initiate a step-by-step sequential counting operation in synchronism with applied trigger pulses, a blocking oscillator for generating trigger pulses in synchronism with received external signal pulses, relay means for alternately applying trigger pulses to the signal input paths for the odd and even banks, the first trigger pulse being applied to the signal input path for the bank of tubes of which said selected one is a constituent, and means for extinguishing a conducting tube in either bank at a time independent of the time at which a tube in the other bank begins to conduct.

15. In an electronic counter composed of a consecutive series of electron tubes each having a cathode, an anode and a control grid, said series of tubes being separated into an even bank including the first tube and each succeeding alternate tube and an odd bank including the second tube and each succeeding alternate tube, the anodes of tubes in the even bank being connected to a source of voltage through a common discharge path and the control grid of tubes in the even bank being connected to a common signal input path and the anodes of tubes in the odd bank being connected to a source of voltage through a common discharge path and the control grids of tubes in the odd bank being connected to a common signal input path, the common paths for the odd bank being separate from the common paths for the even bank, means for conditioning a selected one of the tubes in the series for firing by a trigger pulse by applying a threshold voltage to the control grid thereof to initiate a step-by-step sequential counting operation in synchronism with trigger pulses applied alternately to the signal input path for the odd bank and to the signal input path for the even bank, a blocking oscillator for generating trigger pulses in synchronism with received external signal pulses, first means for extinguishing a tube in the even bank at a time appreciably delayed from the time at which a tube in the odd bank is fired, second means for extinguishing a conducting tube in the odd bank at a time appreciably delayed from the time at which a tube in the even bank is fired, and means for controlling the times at which said first and second extinguishing means are operable.

16. In an electronic counter composed of a consecutive series of electron tubes each having a cathode, an anode and a control grid, said series of tubes being separated into an even bank including the first tube and each succeeding alternate tube and an odd bank including the second tube and each succeeding alternate tube, the anodes of tubes in the even bank being connected to a source of voltage through a common discharge path and the control grid of tubes in the even bank being connected to a common signal input path and the anodes of tubes in the odd bank being connected to a source of voltage through a common discharge path and the control grids of tubes in the odd bank being connected to a common signal input path, the common paths for the odd bank being separate from the common paths for the even bank, means for conditioning a selected one of the tubes in the series for firing by a trigger pulse by applying a threshold voltage to the control grid thereof to initiate a step-by-step sequential counting operation in synchronism with trigger pulses applied alternately to the signal input path for the odd bank and to the signal input path for the even bank, a blocking oscillator for generating trigger pulses in synchronism with received external signal pulses, relay means for applying successive trigger pulses alternately to the signal input paths for the odd and even banks of the tubes, electron tube means for controlling said relay means, and means for extinguishing a conducting tube in either bank at a time independent of the time at which a tube in the other bank begins to conduct.

17. The combination of a consecutive series of electron tubes forming a step-by-step electronic counter, each of said tubes having a control grid for controlling the start of electron discharge through its associated tube, a source of signal pulses, electron tube means maintained alternately in one or the other of two conditions, in one condition said means providing a threshold voltage to the control grid of a selected one of said series of electron tubes priming it for firing by an incoming signal pulse to begin a counting operation and in the other condition being ineffective to provide a threshold voltage, means for selectively controlling the condition of said electron tube means, and means independent of said electron tube means for cutting off the electron discharge through the tubes of the counter.

18. In combination, a consecutive series of electron tubes forming a step-by-step electronic counter, each of said tubes having a control grid for controlling the start of electron discharge through its associated tube, a source of signal pulses, electron tube means maintained alternately in one or the other of two conditions, in one condition said means providing a threshold voltage to the control grid of a selected one of said series of electron tubes priming it for firing by a trigger pulse and in the other condition being ineffective to provide a threshold voltage, means for controlling the time at which said electron tube means are in said one condition, blocking oscillator means for generating trigger pulses in synchronism with incoming signal pulses, and further electron tube means connected in common with said series of electron tubes and effective to cause the extinguishment of a conducting tube in said series at a time independent of the time at which a trigger pulse occurs.

19. In combination, a consecutive series of electron tubes forming a step-by-step electronic counter, the tubes of the counter being divided into one bank and another bank such that consecutive tubes belong to different banks, each of the tubes of the counter having a cathode, an anode and a control grid, a source of positive potential, the anodes of the tubes in said one bank being connected together and joined in series with a common resistor to said source of positive potential and the anodes of the tubes in said other bank being connected together and connected through a common resistor to said source of potential, the control grids of the tubes in said one bank being joined to a common input wire and the control grids of the tubes in said other bank also being joined to a common input wire, a source of signal pulses, electron tube means maintained alternately in one or the other of two conditions, in one condition said means providing a threshold voltage to the control grid of a selected one of said series of electron tubes priming it for firing by a trigger pulse, blocking oscillator means for generating trigger pulses in synchronism with incoming signal pulses, means for controlling the condition of said electron tube means, relay means maintained alternately in one or the other of two conditions, said relay means when in the one condition providing a path for applying said trigger pulses to the control grids of counter tubes in said one bank and when in the other condition providing a path for applying trigger pulses to the control grids of counter tubes in the other bank, electron tube means for controlling the condition of said relay means, first electron

discharge means having a discharge path including said common resistor for the one bank of counter tubes, second electron discharge means having a discharge path including the common resistor for said other bank of counter tubes, and means for selectively initiating a discharge of said first or second electron discharge means through the common anode resistors to reduce the potential supplied to the anodes of said one bank or of said other bank to a value insufficient to support conduction.

20. In combination, a consecutive series of electron tubes forming a step-by-step electronic counter, each of said tubes having an anode and a control grid, the tubes of the counter being divided into a plurality of banks such that any given tube and every tube of the consecutive series which is separated from the given tube by a number of tubes equal to one less than the number of banks will belong to the same bank and consecutive tubes will always be in different banks, the tubes which compose any given banks having their control grids coupled to a common input signal path for that bank and having their anodes supplied with operating potential through a common resistor, a source of trigger pulses of the same relative polarity, means for conditioning a selected one of said discharge devices for ignition by a trigger pulse to thereby initiate a step-by-step sequential counting operation in synchronism with applied trigger pulses, means for applying consecutive trigger pulses to consecutive tubes in the series, and means for extinguishing a tube in one bank at a selected interval after it has fired independently of the time at which a tube in another bank may be ignited

21. A counter control for a step-by-step counter composed of separate odd and even banks of electron flow control devices, devices in the odd bank having a signal input line in common with the other devices in said odd bank and controlling electron flow through a common circuit, devices in the even bank having a signal input line in common with the other devices in said even bank and controlling electron flow through a common circuit, the signal input line and circuit associated with said odd bank being separate from the signal input line and circuit associated with said even bank, said control comprising means for priming a selected one of the control devices for conditioning by a triggering pulse to permit an electron discharge in its associated circuit, means for generating triggering pulses in synchronism with signals supplied from an external source and for applying said pulses alternately to the signal input lines for the odd and even banks to produce a step-by-step counting operation, and means for conditioning a control device in one bank to interrupt the electron flow which it has initiated at a time independent of the time at which a control device in the other bank may initiate an electron discharge.

22. In combination, a consecutive series of electron flow control devices capable of initiating an electron discharge through an associated circuit in response to triggering pulses applied to said devices, said devices being connected to form a step-by-step counter, a source of triggering pulses, means for conditioning a selected one of said devices and each consecutive control device in sequence to respond to a triggering pulse to initiate an electron discharge thereby producing a step-by-step counting operation in synchronism with said triggering pulses, and means operative at a time independent of the time at which an electron discharge is initiated by one of the control devices to condition a control device to interrupt the electron flow which it has initiated.

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