Sept. 9, 1958 F. WEST 2,851,635

PULSE INITIATOR

Filed Sept. 16, 1954 2 Sheets-Sheet 1

FIG. 1

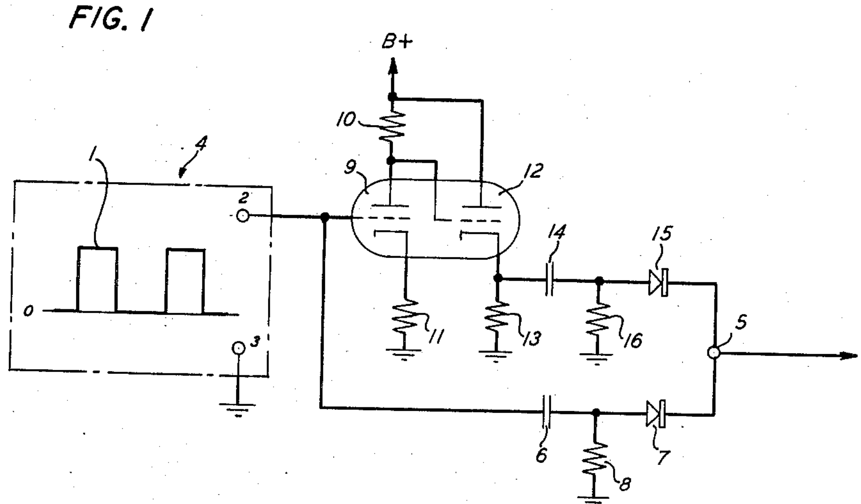
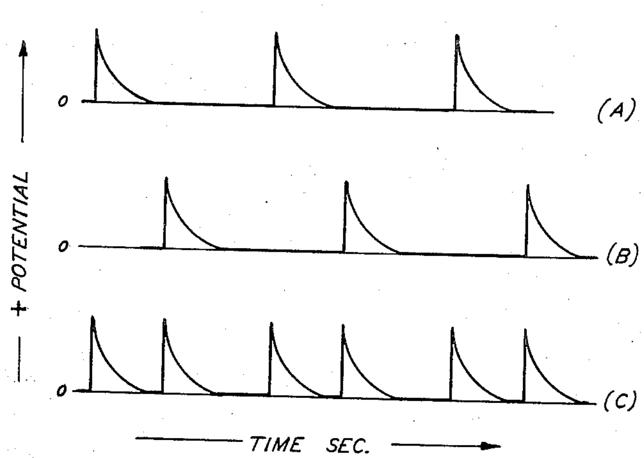


FIG. 2



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2 Sheets-Sheet 2

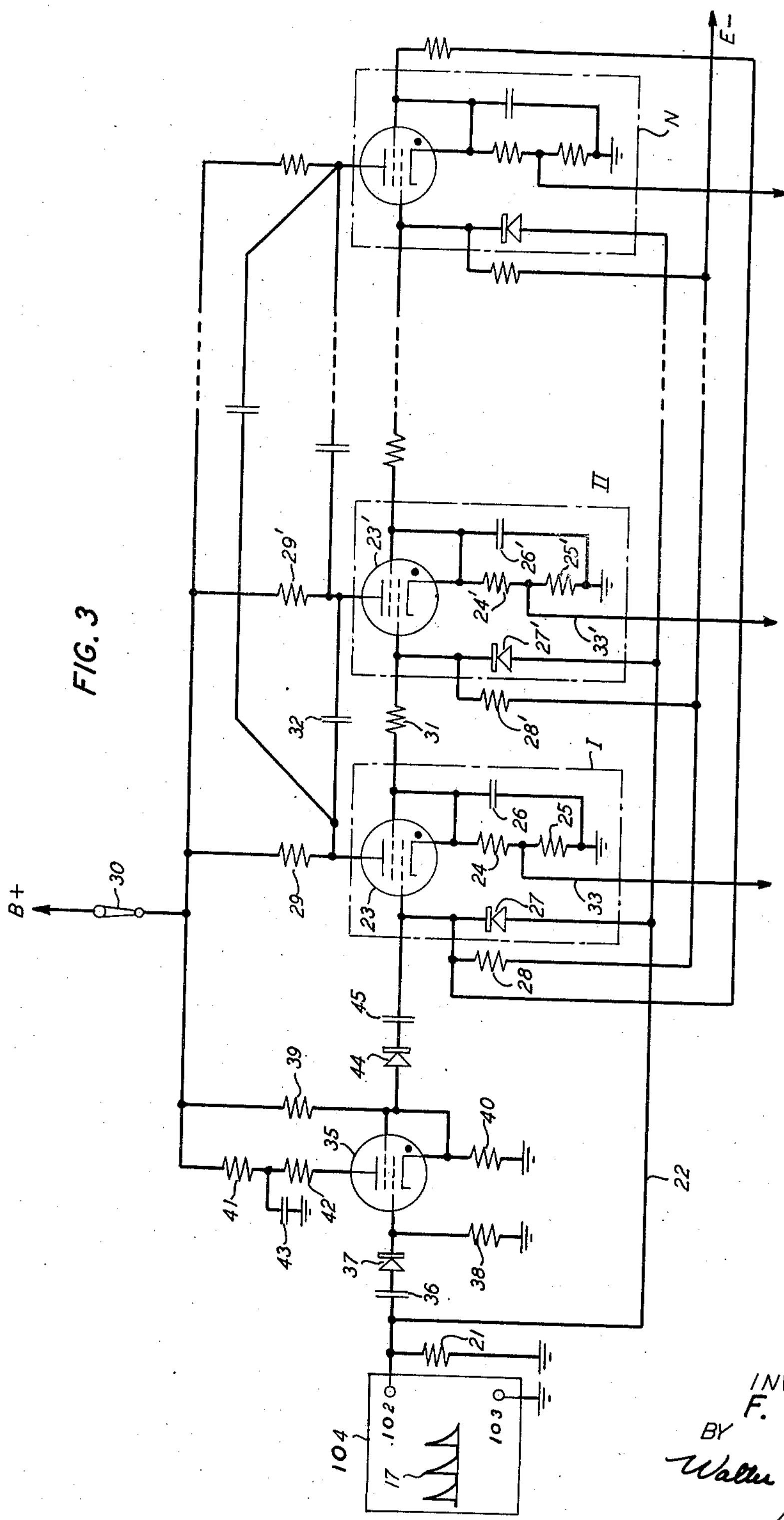

FIG. 3

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PULSE INITIATOR

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6 Claims. (Cl. 315—84.5)

This invention relates to pulse actuated circuits, and particularly to circuits comprising a ring of cascaded bistable devices which are successively responsive to applied control pulses.

Pulse controlled timing and counting circuits usually comprise a cascade of bistable devices which assume one or the other of two possible stable states in response to the application of successive electrical potentials of short duration called control pulses. Very often the first and last device in the cascade are connected in the same manner as successive devices in the cascade, forming a closed ring which will continue operating indefinitely in step with the applied control pulses. In such an arrangement it is generally preferable for all the bistable devices to be identical and to be connected to their associated circuits in an identical manner. This greatly simplifies the problem of achieving continuous operation of the ring. However, it is necessary to make some provision to assure that a single preselected bistable device in the ring is actuated on the occurrence of the first control pulse. This requirement has been recognized, and various special circuits and operating procedures have been devised in the attempt to meet it.

One such technique requires initial application of an unusually large control pulse, capable of actuating one of the bistable devices in the ring even though the ring circuit is designed so any device can normally only be actuated by a control pulse after the preceding device in the ring has already been actuated by the preceding control pulse. This technique has the disadvantage that more than one device may be simultaneously actuated, so that additional means are needed to quickly deactuate all but one device. This complicates the circuit and results in loss of response to the initial control pulse. An alternative initiating system utilizes a manual switch by which an operator can momentarily apply a high potential to a selected bistable device, actuating it before the first control pulse occurs. When the first control pulse occurs, the succeeding device in the cascade circuit is actuated. This procedure requires that the operator know in advance that the first control pulse is soon to occur, and depends on the operator acting beforehand. The advantage of a completely automatic initiating system is evident. Certain types of automatic initiating circuits have been devised which are applicable to circuits comprising cascaded bistable devices wherein the potentials applied to and generated by successive devices in the cascade are all different. While such systems may be suitable where the circuit ceases operation after actuation of the last device in the cascade, they are unadapted to continuous operation of a closed ring.

An object of the instant invention is to provide automatically operative means for initiating operation of a selected one of a cascade of identical bistable pulse actuated devices on the occurrence of the first in a series of control pulses applied simultaneously to all devices in the cascade.

A further object is to accomplish the foregoing by

means which electrically isolates itself from the cascade after having initiated operation of the selected bistable device.

A more particular object is to provide a ring of cascaded bistable devices each of which contains an electric discharge tube controlled by a train of pulses applied simultaneously to all devices in the ring, whereby each discharge tube is rendered operative after the preceding one and becomes inoperative when the succeeding one is rendered operative, and wherein only a single preselected discharge tube is rendered operative on occurrence of the first control pulse.

The invention attains these objects by utilizing an auxiliary bistable device which is either unbiased or biased to a much lesser degree than the bistable devices in the ring circuit to be controlled. The control pulses are applied to the auxiliary device as well as to all the devices in the ring circuit. The auxiliary device therefore is actuated in response to the first control pulse. Each of the devices in the ring circuit is initially in the deactuated state and is too heavily biased to actuate in response to any control pulse until the preceding device has been actuated. Actuation of the auxiliary device produces an enabling potential which is coupled through a condenser to a selected one of the devices in the ring circuit. This causes immediate actuation of the selected device. The condenser quickly charges and thereafter blocks the enabling potential from the ring circuit. The entire process occurs so quickly that the selected bistable device is actuated at very nearly the instant of occurrence of the first control pulse.

A detailed description of a particular embodiment of the invention is presented in the following specification in conjunction with the appended drawings in which:

Fig. 1 is a drawing of the circuit of one suitable means for converting a train of square pulses to a train of positive control pulses;

Fig. 2 is an illustration of various waveforms involved in the operation of the circuit in Fig. 1; and

Fig. 3 is a drawing of the circuit of an embodiment of the invention.

The embodiment of the invention described hereinafter requires that the control pulses utilized for actuating the ring circuit all be short duration positive potentials. When the pulses to be utilized as control pulses are of another configuration, since the sole function of the pulses is to mark the time intervals with which the ring circuit must be synchronized, it is a relatively simple matter for one skilled in the art to devise a suitable pulse converting circuit to provide a series of pulses of the required type and spaced by the time intervals of interest in the original series of pulses. For example, suppose the original series of pulses are square in shape and of alternately rising and falling potential. Such a pulse train is characteristically produced by telephone dialing circuits. In Fig. 1 is shown one type of circuit which will convert such a pulse train, designated at **1**, to a pulse train of the desired type, indicated in Fig. 2(C). Pulse train **1** is produced across output terminals **2** and **3** of a pulse source designated in block **4**. Terminal **3** is grounded. Terminal **2**, in one path, is connected to output terminal **5** through the series connection of condenser **6** and diode **7**, with diode **7**, poled so as to present low resistance to current flow toward terminal **5**. A grounded resistor **8** is connected to the junction of condenser **6** and diode **7**. Condenser **6** and resistor **8** are chosen to have a small time constant relative to the smallest time interval of interest in pulse train **1**. They therefore serve as a differentiating circuit, the voltage across resistor **8** closely approximating the time derivative of the voltage at terminal **2**. With diode **7** connected as described, only the positively rising portions of this time derivative will be conveyed to terminal 5. The potential at terminal 5 due to the circuit so far described will have a waveshape of the type shown in Fig. 2(A). Each sharp rising portion occurs at the instant of the rising portion of each pulse in waveshape 1.

Terminal 2, in another path, is connected to the grid of a triode 9 serving as a polarity inverter. The plate of triode 9 is connected through a resistor 10 to a source of positive direct-current potential B+. The cathode is grounded through a self-biasing resistor 11. The potential at the plate of triode 9 will be of the same shape as the potential applied to the grid, but of opposite polarity. The plate is connected to the grid of another triode 12 serving as a cathode follower. Triodes 9 and 12 may conveniently be in a single envelope. The plate of triode 12 is connected to source B+. The cathode is connected to ground through a resistor 13. The potential at the cathode will be of the same shape and polarity as the potential applied to the grid, but the low output impedance of a cathode follower is more effective for coupling this potential to a differentiating circuit than direct coupling from the plate impedance of triode 9. The cathode of triode 12 is connected to output terminal 5 through the series connection of condenser 14 and diode 15, the latter poled so as to present low resistance to current flow toward terminal 5. A grounded resistor 16 is connected to the junction of condenser 14 and diode 15. Condenser 14 and resistor 16 serve as a differentiating circuit, and diode 15 only permits the positively rising portions of the time derivative voltage across resistor 16 to be conveyed to terminal 5. The potential at terminal 5 due to this circuit will therefore have a waveshape of the type shown in Fig. 2(B). Due to the polarity inversion produced by triode 9, each sharp rising portion of that waveshape occurs at the instant of the falling portion of each pulse in waveshape 1.

If the first pulse in waveshape 1 is a rising portion, the first pulse at terminal 5 will be the first pulse in the waveshape in Fig. 2(A). The succeeding pulse in waveshape 1 will be a falling portion, so that the next pulse at terminal 5 will be the first pulse in the waveshape in Fig. 2(B). This process cyclically continues in response to successive pulses in waveshape 1, and the resultant time variation of the potential at terminal 5 will be the sum of the pulses in Figs. 2(A) and 2(B), and is shown in Fig. 2(C). Since this is a train of positive pulses, with the intervals between pulses marking the time intervals of interest in waveshape 1, it is the desired result.

Referring now to Fig. 3, there is illustrated the circuit of a preferred embodiment of the invention. In block 104 is designated a source of positive polarity control pulses 17 of the same general type as those illustrated in Fig. 2(C). Pulse source 104 has output terminals 102 and 103, of which terminal 103 is grounded. A ground return resistor 21 is connected between terminal 102 and ground. Terminal 102 is also connected to a control pulse conductor 22 which conveys the control pulses to each of a plurality of electrical bistable devices I, II, . . . N. These devices are connected in cascade, with the first coupled back to the last to form a continuous ring. There may be any number of such devices, and since they are identical and are connected identically a detailed description of device I will serve for all.

Device I includes a gaseous electric discharge tube 23 having an anode, a cathode and a control electrode. Tube 23 is of the type in which conduction, or "discharge," from anode to cathode starts and continues after a suitable voltage is applied to the control electrode, and ceases when the anode potential is sufficiently reduced. The starting of conduction is called "firing." Preferably, but not necessarily, the control electrode is a grid structure, and a shield grid is included in the tube to reduce the current flow to the control grid when the tube fires. Such tubes are well known and are commercially available. The shield grid is connected to the cathode, which is connected to ground through the series connection of resistors 24 and 25. A condenser 26 shunts these resistors. The control grid is connected to pulse conductor 22 through a diode 27 poled to present low resistance to current flow from conductor 22 toward the control grid. The control grid is also connected to a source of negative direct-current potential E− through a resistor 28. The anode of tube 23 is connected through a resistor 29 to a source of positive potential B+. Source B+ may be disconnected from all bistable devices I, II, and N by opening a switch 30, thereby restoring all tubes, including tube 35, to their nonconducting state. The coupling of device I to device II consists of a resistor 31 connecting the cathode of tube 23 to the control grid of another discharge tube 23′ in device II, and a condenser 32 connecting the anodes of both tubes. The output potential of device I appears at the cathode of tube 23, and the portion of it existing across resistor 25 is made available by output conductor 33 connected to that resistor.

To explain the operation of the ring circuit reference will be made to two adjacent devices I and II. All elements of device II serving the same function and connected in the same way as corresponding elements of device I have been designated with the same identifying numeral but with a prime superscript. Until tube 23 is conducting, the bias applied by source E− to the control grid of the succeeding tube 23′ is sufficient so that the latter tube cannot fire even though control pulses are applied to its control grid from pulse conductor 22. Suppose tube 23 has been rendered conductive by means hereinafter described. The resultant current flow through resistors 24 and 25 produces a positive potential at the cathode. A fraction of this potential determined by the voltage divider comprising resistors 31 and 28′ is applied to the control grid of tube 23′. This reduces the effective bias of the control grid so that, on occurrence of the next control pulse, tube 23′ fires. Diode 27′ serves to prevent the positive cathode potential of tube 23 from reaching pulse conductor 22, which might result in out-of-turn actuation of another bistable device in the ring circuit. The firing of tube 23′ causes a sharp drop in its plate potential due to current flow through resistor 29′, and this potential drop is conveyed as a large negative pulse to the plate of tube 23 by condenser 32. The net plate potential of tube 23 drops below the level required to sustain conduction, and the tube extinguishes. This process occurs very rapidly, tube 23 being extinguished practically at the instant that tube 23′ fires. The portion of the cathode potential of tube 23′ appearing across resistor 25′ is made available by output conductor 33′, and constitutes the output of tube 23′. This potential appears when the tube fires, remains substantially constant, and ends when the tube is extinguished at the occurrence of the succeeding control pulse. Condenser 26′ serves to slow down the rate of rise of potential of the cathode of tube 23′, since too sharp a voltage pulse at the cathode would result in transient voltages that could trigger the tube in the succeeding bistable device in the ring circuit in a random manner.

As a result of this construction and mode of operation of the ring circuit, device I will produce an output potential during the interval that tube 23 is conductive, device II will produce an output potential during the interval that tube 23′ is conductive, and similarly for all other devices in the ring circuit. These output potentials appear at output conductors 33, 33′, etc. in succession. They may be utilized for many well-known applications, including, for example, use in gate generators, distributors, and time division multiplex transmission systems. Patent 2,485,886, issued October 25, 1949, to C. W. Johnstone et al. illustrates a system of the latter type wherein the function of the "Gating switch" could obviously be performed by connecting output leads 33, 33', etc. to the respective "transmitters."

The above description of the circuit in Fig. 3 proceeded on the assumption that one device in the ring circuit had already been actuated. The manner in which a selected device, device I, is actuated on occurrence of the first control pulse will now be explained. An auxiliary tube 35, which may be of the same type as tube 23, has its control grid connected to output terminal 102 of pulse source 104 through the series combination of a condenser 36 and a diode 37. Diode 37 is poled to present low resistance to current flow toward the control grid. Diode 37 has a reverse resistance of a few megohms, and may conveniently be a crystal rectifier. A grounded resistor 38 connected to the control grid provides a ground return path. A small positive bias is applied to the cathode of tube 35 by source B+ connected to a voltage divider comprising resistors 39 and 40 in series, the latter resistor being grounded and the junction of the two being connected to the cathode. The anode of tube 35 is connected to source B+ through series connected resistors 41 and 42. A condenser 43 is connected between ground and the junction of those resistors. The cathode of tube 35 is connected to the control grid of tube 23 in device I through the series connection of a diode 44 and a condenser 45, diode 44 poled to present low resistance to current flowing toward the control grid of tube 23. Diode 44 has a reverse resistance of a few megohms, and may conveniently be a crystal rectifier.

Before any control pulses have occurred, all tubes in the circuit are made nonconductive by momentarily opening switch 30. At the instant the first control pulse occurs, it will be conveyed through condenser 36 and diode 37 and will return to ground through resistor 38. The resultant positive potential across resistor 38 is enough to fire tube 35 since it has a relatively small applied cathode bias. Diode 37 limits the transient voltage fed back to pulse source 104 when positive ion grid current starts as a result of firing tube 35. Condenser 36 prevents the steady state grid current flowing after the firing of tube 35 from introducing an unwanted bias voltage in pulse source 104. Condenser 43 is provided because when switch 30 is first closed, before the first control pulse, a transient surge voltage is initiated from source B+. This transient may appear at the grid of tube 35 with sufficient magnitude to inadvertently fire it because of its relatively low bias. Condenser 43 delays the rise of B+ potential at the anode of tube 35 for a sufficient time for the transient voltage to die out. It thereafter remains charged and has no further effect on the circuit.

The firing of tube 35 suddenly raises the potential of its cathode, and this sharp positive surge voltage is conveyed through diode 44 and condenser 45 to the control grid of tube 23. Tube 23 therefore fires. The cathode potential of tube 35 thus serves as an enabling potential for tube 23. The entire process occurs very rapidly, tubes 35 and 23 firing almost together at the instant of occurrence of the first control pulse. Condenser 45 is charged rapidly by the cathode potential of tube 35 through a path from the cathode, through diode 44, condenser 45, resistor 28, source E— and cathode resistor 40. Hence, the cathode potential of tube 35 is thereafter blocked and has no further effect on the operation of tube 23. Diode 44 prevents control pulses conveyed to the control grid of tube 23 from being dissipated in the circuitry of tube 35. Diode 44 and condenser 45 thus serve as means for blocking the enabling potential from reaching device I after that device has responded to the first control pulse.

When it is desired to reset the complete circuit to starting conditions, switch 30 may be momentarily opened. This removes the plate potential from all of the tubes, causing all of them to extinguish.

While the particular embodiment of the invention described above utilizes a gaseous discharge tube circuit as each of the bistable elements in the ring circuit, it is evident that any device capable of being switched from a nonconductive to a conductive condition and back again to the nonconductive condition by properly applied voltage pulses would be suitable. For example, a bistable multivibrator using high vacuum tubes, wherein only one tube is utilized as a source of output pulses, would provide such a characteristic. In addition, the only basic requisite of the auxiliary tube is that it act as a switch which is open until a control pulse causes it to close and stay closed. This behavior could be attained by a lock-down type of relay circuit, which therefore could readily be adapted to serve as a substitute for the tube shown. The discharge tube is preferred, however, because of its greater speed of response to applied pulses, its high sensitivity, and general superior compatibility with the circuitry involved.

What is claimed is:

1. In combination, a ring circuit of identically interconnected discharge tubes each of which has a control electrode, a cathode, and an anode, each of said discharge tubes having extinguished and conductive stable states, a common pulse conductor connected to said control electrodes of said tubes to convey successively applied control voltage pulses of the same polarity, a resistor connecting the cathode of each tube to the control electrode of the succeeding one of said tubes in said ring circuit, a bias source connected through impedance means to each control electrode, said source having a voltage sufficient to permit conduction by a tube upon receipt of said control pulses only when its preceding tube in said ring is conducting, a capacitive connection between said anodes of successive ones of said tubes adapted to cause the preceding one of said tubes to extinguish substantially at the instant that the succeeding one of said tubes becomes conductive, an auxiliary discharge tube having a cathode and a control electrode, means connecting said auxiliary tube control electrode to said common pulse conductor, said auxiliary tube having an extinguished and a conductive stable state, and a capacitive connection between the control electrode of a selected one of said tubes in said ring circuit and said cathode of said auxiliary tube.

2. The combination described in claim 1, wherein said means connecting said control electrode of said auxiliary tube to said pulse conductor comprises a capacitor and a device presenting low resistance to current flow in a direction toward said control electrode and high resistance to current flow in the reverse direction.

3. In combination with a ring circuit of the type comprising a plurality of pulse responsive bistable devices so interconnected as to be individually actuated in succession in response to occurrence of successive pulses in a series of pulses applied to said ring circuit, biasing means adapted to apply a biasing potential to all of said devices whereby all are initially deactuated and insensitive to said pulses, initiating means comprising an initially nonconductive electric discharge tube, an input circuit and an output circuit therefor, means for applying said series of pulses to said input circuit whereby said tube becomes and remains conductive in response to the first of said pulses to generate an enabling potential in said output circuit, means including a capacitor in series with an asymmetric conductive device connecting said output circuit to a selected one of said devices whereby said enabling potential overcomes said biasing potential and actuates said selected device substantially at the time of occurrence of said first pulse.

4. In combination, a chain of bistable devices adapted to be connected to a source of pulses of like polarity, each of said devices constructed and arranged to change from a first to a second stable state in response to a pulse occurring after the preceding device in said chain has so changed in response to the preceding pulse, each of said

devices further constructed and arranged to change from said second to said first stable state in response to the changing of the succeeding device in said chain from said first to said second stable state, a bias means for said devices to render all of them initially unresponsive to said pulses, an auxiliary bistable device comprising an electron discharge device having a normally nonconductive state and a conductive state, a cathode and a control electrode in said device, means for coupling said control electrode to said source of pulses whereby said auxiliary device changes to its conductive state upon receipt of the first pulse, a connection comprising impedance means between said cathode and a selected one of the bistable devices in said chain whereby said selected device changes state in response to a pulse from said cathode.

5. Means for initiating operation of only a selected one of a ring circuit of bistable electron discharge devices of the type wherein each device is caused to operate in sequence in response to a series of control pulses, said means comprising means for initially setting all of said devices to the same one of their two stable states, means for simultaneously supplying control pulses to each of said devices, biasing means connected to each

device rendering them unresponsive to said pulses while all are set to said one stable state, an auxiliary bistable device including an input electrode and an output electrode, means for connecting the input electrode to said means for supplying control pulses whereby said auxiliary device is caused to change state upon receipt of the first control pulse, and a connnection from said output electrode to the selected bistable device in said ring circuit whereby the operation of said ring circuit is initiated by the operation of the selected device in response to the first control pulse.

6. The combination of claim 5 wherein the connection from said output electrode comprises a capacitor and an asymmetric conductor connected in series.

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