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NEON TUBE-PHOTOCONDUCTOR MULTIVIBRATOR OR RING COUNTER

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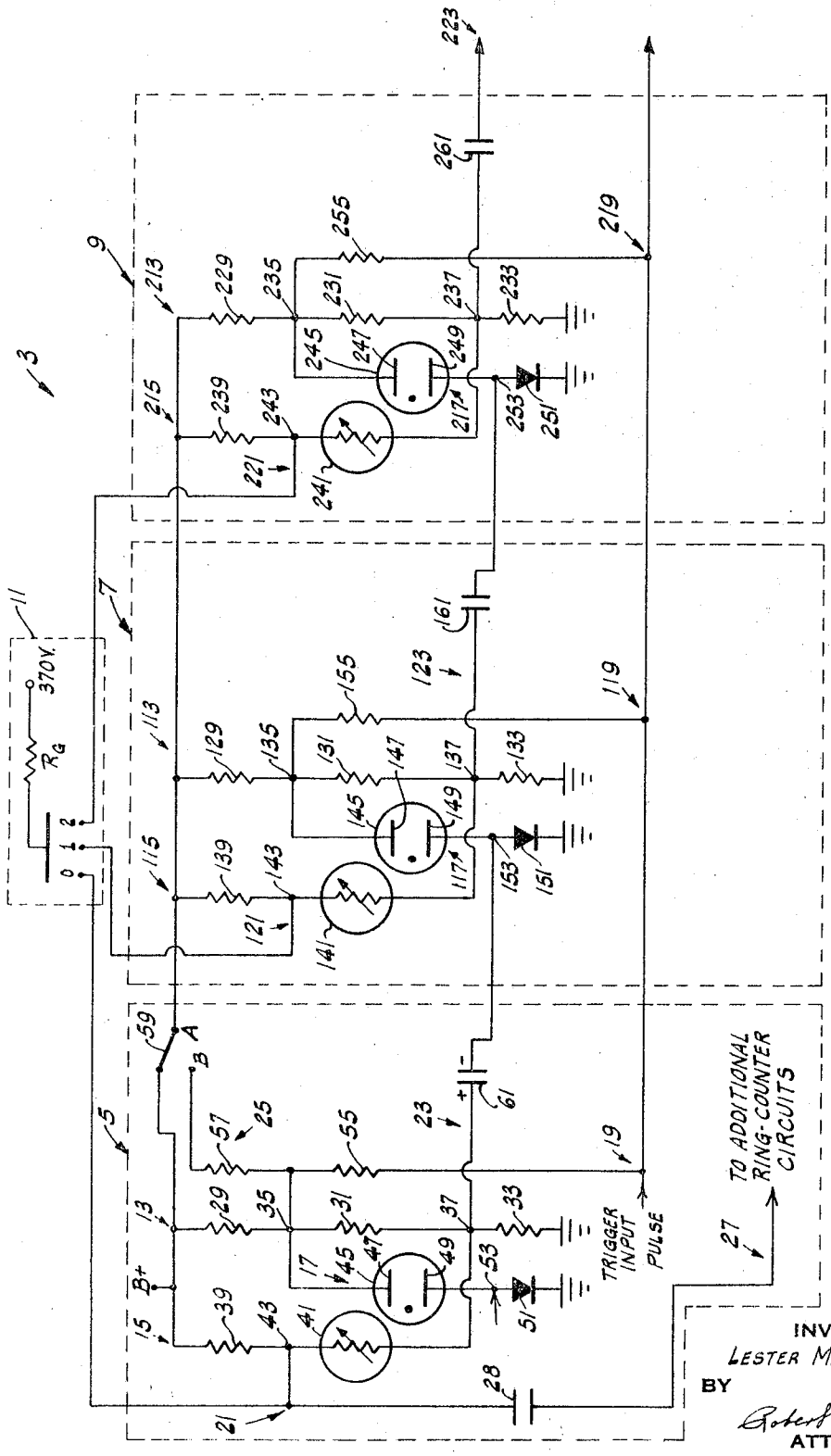


Fig. 1

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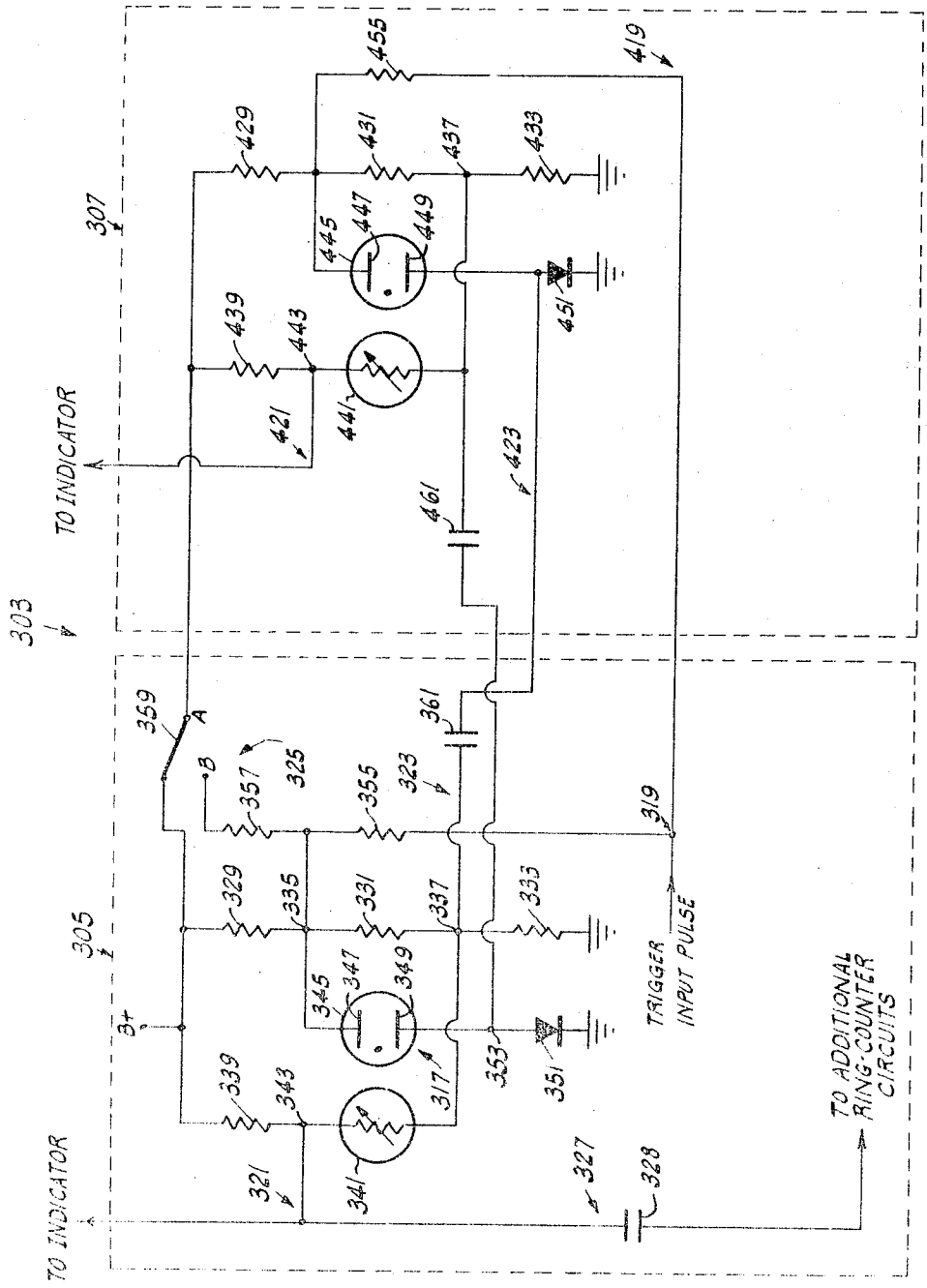


Fig. 2

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NEON TUBE-PHOTOCONDUCTOR MULTIVIBRATOR OR RING COUNTER

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This invention relates to circuits employing light sources and light-responsive variable resistance devices and more particularly to ring counting circuits including a plurality of similar stages wherein glow tubes and photoconductors are activated and deactivated in accordance with an applied signal.

As is well known, a ring counting circuit includes a plurality of substantially symmetrical stages connected in an endless chain. The stages each have an active and an inactive or a conductive and nonconductive state and are sequentially activated in accordance with an applied signal. Also, an indictaor device is usually coupled to the circuit to provide a record, usually visual, of the activating signal applied to the circuit.

Prior known types of ring counting circuits have employed vacuum tubes, beam switching tubes, cold cathode gas tubes of the triode type, or some form of neon tube-diode combination. While the known circuitry employing such tubes and tube-diode combinations in conjunction with any one of a number of well-known indicating devices have provided reasonably satisfactory results in specific applications, it has been found that each leaves much to be desired for any one of a number of reasons, and especially so when employed with a readout indicating device of the gas-filled type. For example, vacuum tube systems inherently consume power, develop undesirable amounts of heat, and are not particularly adapted to portable equipment. Beam switching tubes are not only expensive in themselves but also require relatively expensive power supplies.

Further, cold cathode gas tubes of the triode type include an electrode having an electron emissive coating thereon, and such devices have an inherently limited period of usefulness because of the deterioration of the coating. Moreover, the voltages available from the known circuits employing such devices are not applicable to the operation of a gas-filled type of indicating device.

Additionally, the known circuitry employing neon tube-diode combinations is especially critical with regard to the voltages applied to the neon tubes as well as the characteristics and electrical parameters of the neon tubes themselves. Thus, such circuitry requires not only expensive components which have a relatively short life expectancy but also additional components for controlling the potentials applied thereto.

Therefore, it is an object of this invention to improve the stability and reduce the parameter criticality of a signal actuable circuit employing light source components.

A further object of the invention is to provide an enhanced signal actuable circuit employing inexpensive components having a comparatively extended period of usefulness.

A still further object of the invention is to provide an improved signal actuable circuit of the ring counter type which includes a light-responsive variable resistance device light-coupled to a light source.

Another object of the invention is to provide an improved signal actuable circuit of the ring counter type which includes a light-coupled photoconductor and gas-filled glow tube and is especially adapted for operation with an indicating device of the gas-filled variety.

Still another object of the invention is to provide an improved signal actuable circuit employing a light-coupled photoconductor and glow tube and including means for applying a signal to actuate the circuit into a conduction state and means for maintaining the circuit in a conducting state upon removal of the actuating signal.

These and other objects are achieved in one aspect of the invention by an electrical circuit having a voltage divider with a first and second voltage tap interconnected by a resistive element and coupled between a voltage source and circuit ground, a light-responsive variable resistance device coupled between a voltage source and the second voltage tap of the divider, a signal actuable light source coupled from the first voltage tap of the divider to circuit ground, and means for applying a signal to the light source in an amount sufficient to cause activation thereof.

For a better understanding of the present invention, together with other and further objects, advantages, and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the accompanying drawings in which:

FIG. 1 is a schematic representation of a preferred embodiment of a signal actuable circuit of the "ring" type; and

FIG. 2 is a schematic representation of a preferred embodiment of a signal actuable circuit useful as a scale-of-two counter.

Referring to FIG. 1 of the drawings, a ring-counter type circuit 3, which may include any number of stages having the output of the last stage coupled to the first stage, is illustrated as having three substantially symmetrical stages 5, 7, and 9, respectively. Also, FIG. 1 includes an indicating device 11 of the gas-filled readout type, although numerous other types of indicating devices are equally applicable and appropriate.

Referring to the first stage 5 of the circuit 3, there is included a voltage source B+, a first voltage divider 13, a second voltage divider 15, a light source means 17, signal applying means 19, signal output means 21, and capacitance coupling means 23. The first stage 5 also includes an initial activation means 25 and an additional circuit triggering means 27.

The first voltage divider 13 is coupled intermediate the voltage source B+ and circuit ground and includes series-connected resistors 29, 31, and 33. A first voltage tap 35 is provided at the junction of resistors 29 and 31 and a second voltage tap 37 at the junction of resistors 31 and 33.

The second voltage divider 15 is coupled intermediate the voltage source B+ and the second voltage tap 37 of the first divider 13 and includes a series-connected resistor 39 and a light-responsive variable resistance device 41 such as a photoconductor for example. A signal output means 21 couples the junction 43 of the resistor 39 and light-responsive device 41 to the previously mentioned indicating device 11, which may be any one of a number of well-known devices utilized for such purposes, and a gas-filled readout type tube will serve as an example. A triggering means 27 also couples the junction 43 to additional circuits (not shown) substantially similar to the present circuit 3 and serves to provide an electrical path for the activation thereof.

The light source means 17 includes a series-connected light source 45, which is preferably a gas-filled glow tube such as an ordinary neon tube having an anode electrode 47 and a cathode electrode 49 and a unidirectional conduction device 51. The light source means 17 is coupled intermediate the first voltage tap 35 of the first divider 11 and circuit ground and includes a junction 53 intermediate the source 45 and conduction device 51 whereto the signal available from the last stage 9 of the circuit 3 is applied.

Also, the light source 45 is light-coupled to the light-responsive device 41.

A signal applying means 19 includes a resistor 55 and serves to couple an activating signal to the first voltage tap 35 of the first divider 13. Also, an initial activation means 25 includes a fixed resistor 57 and a double pole switch 59 having alterable positions A and B, respectively. When the switch 59 is in the A position, the voltage source B+ is coupled to the remaining stages 7 and 9. However, altering the switch 59 from the A to B position removes the voltage source B+ from the following stages 7 and 9, respectively, and shunts resistor 29 of the first divider 13 of the first stage 5 with the resistor 57.

Additionally, the first stage 5 is coupled to the next stage 7 by a capacitance coupling means 23, which is preferably in the form of a capacitor 61. The coupling means 23 is connected intermediate the second voltage tap 37 of the first divider 13 and the next stage 7 as will be explained hereinafter.

Since the stages 5, 7, and 9 are substantially symmetrical and the components of the second stage 7 are substantially the same as the components of the first stage 5, a 100 series of numbers has been used for the components of the second stage 7. In a similar manner, a 200 series of numbers has been used to identify the components of the third stage 9.

It should be noted that the above-described circuit 3, as well as all of the known circuitry employing gas-filled glow tubes and light-responsive variable resistance devices, is preferably operated in a low ambient light enviroment rather than complete darkness in order to prevent the well-known problem of "dark storage" wherein the device fails to respond to initial signal activation after a period of inactivation in complete darkness. Alternately, a relatively low level of light may be provided for all of the glow tubes and light responsive devices when a dark environment is utilized. Moreover, provisions may be made for supplying a low light level to all of the glow tubes and light-responsive devices upon activation of the first stage 5 in the above-discussed circuit 3. In any event, any one or all of the established and well-known techniques for preventing "dark storage" problems in circuitry, which includes glow tubes and light-responsive devices, are applicable and appropriate to the above circuitry.

As to the operation, activation of the circuit 3 is initiated in the first stage 5 by locating the switch 59 at position B which shunts resistor 57 across resistor 29 of the first divider 13 to produce a reduced ohmic value intermediate the voltage source B+ and the anode electrode 47 of the light source 45. Thus, the effective ohmic reduction raises the potential applied to the light source 45 in an amount sufficient to initiate current conduction therethrough. At the same time, the positioning of the switch 59 at the B position removes the voltage source B+ from the remaining stages 7 and 9, respectively, which prohibits activation thereof. After condition of the first stage 5 has been initiated, the switch 59 is returned to the original position A which provides a path from the voltage source B+ to the remaining stages 7 and 9, respectively, of the circuit 3.

Once activation of the light source 45 in the first stage 5 has been initiated, the resistance of the light-responsive device 41, which is light coupled thereto, is greatly reduced. The reduced ohmic value of the device 41 results in an increased current flow from the voltage source B+ through the fixed resistor 39, the light-responsive device 41, and the resistor 33 of the first voltage divider 13 to circuit ground. This increased current flow through the resistor 33 increases the voltage drop thereacross whereby the potential is raised at the second voltage tap 37 and, by way of the resistor 31, at the first voltage tap 35 which is directly connected to the anode electrode 47 of the light source 45. Thus, once conduction of the stage 5 is initiated, it is maintained by a "bootstrap" feedback loop as will be explained hereinafter.

Also, the reduction in the resistive value of the light-responsive device 41 and the resultant increased current flow through the resistor 39 of the second voltage divider 15, upon initiation of conduction in the first stage 5, lowers the potential at the junction 43 which is applied to the indicating means 11 by way of the output means 21. Thus, an increased potential difference across the indicating device 11 serves to provide an initial recording thereon. Obviously, this same potential change at the junction 43 may be applied to a second similar circuit (not shown) by way of the circuit triggering means 27, including a capacitor 28, to provide a similar result.

During conduction of the first stage 5, the capacitor 61 is charged to the above-mentioned increased potential at the voltage tap 37 by way of a path which includes the unidirectional conduction device 151 of the second stage 7, circuit ground, and the resistor 33. Moreover, the charge on the capacitance 61 has a positive polarity on the side connected to the voltage tap 37 with respect to the polarity of the side connected to the junction 153 of the light source 145 and the unidirectional conduction device 151 of the second stage 7.

Having once initiated activation or conduction of the first stage 5 by the activation means 25, the first stage 5 is shifted from a conducting state to a nonconducting state and the following stage 7 shifted from a nonconducting state to a conducting state by way of a signal provided at the signal applying means 19. Preferably, a negative-going signal in trigger pulse form is applied to the first voltage tap 35 and the anode electrode 47 of the light source 45. The negative-going signal reduces the potential difference between the electrodes 47 and 49 of the light source 45 whereupon the light source 45 is extinguished and current conduction therethrough interrupted. The negative-going signal is also applied to stages 7 and 9 by way of the signal applying means 119 and 219, respectively. However, the application of a negative-going signal to the already nonconducting light sources 145 and 245 of the stages 7 and 9, respectively, has no aparent effect thereon because the stages 7 and 9 are in a nonconducting state.

Upon extinguishing the light source 45, the resistance value of the light-responsive device 41 greatly increases thereby reducing the current flow through the resistor 39 and the resistor 33. The reduced current flow causes a reduction in the voltage drop across the resistor 39 and an increase in the voltage applied to the output means 21. This increased voltage at the output means 21 is applied to the indicating device 11, reducing the potential difference thereacross which rapidly removes the recorded indication.

At the same time, the decreased current flow through the resistor 33 decreases the voltage drop thereacross and the voltage at the voltage tap 37 is reduced. Thereupon, the capacitance 61, which had been previously charged to the relatively high potential of tap 37, discharges by way of a path which includes the resistor 33, circuit ground, and the relatively high "back resistance" of the substantially unidirectional conduction device 151. Thus, a relatively large negative potential is applied to the cathode electrode 149 of the light source 145 of the second stage 7. This relatively large negative-going signal applied to the cathode electrode 149 shifts the stage 7 from a nonconducting state to a conducting state. Also, as previously described, the potential applied to the indicating device 11 by way of the output circuit means 121 again causes activation thereof.

It is to be noted that the light-coupled source 45 and light-responsive device 41, in combination with the electrical series coupling of the light-responsive device 41, resistor 31, and source 45, provide a "bootstrap" feedback loop. Specifically, the light source 45 is activated or fired by an initial signal applied to the anode electrode 47.

This activation of the source 45 is light coupled to the responsive device 41 which drastically changes in resistance value resulting in an increased steady-state or maintaining potential being applied to the anode electrode 47 by way of the resistive element 31. Further, utilization of the "bootstrap" loop negates the necessity of critically maintaining the voltage applied to the light source within an extremely narrow range limited by the voltage required to activate or fire the device and the voltage required to maintain conduction thereof. Thus, the stability and reliability of the circuitry is enhanced. Also, the increase in value of the steady-state potential applied to the light source 45, due to the "bootsrap" loop, permits the utilization of a potential difference thereacross during the nonconducting state which is not only below the firing potential but also below the maintaining potential thereof. This increased stability and reduced voltage criticality provided by the "bootstrap loop" permits the use of an inexpensive light source 45 having a wide parameter tolerance and a greatly increased life expectancy.

It should also be noted that the greatly increased value of signal commutation provided by the above-described circuit is unobtainable in any other known counting circuit. More specifically, the utilization of a signal having a relatively small amplitude to provide a triggering signal of greatly increased amplitude to the following stage due to the inherent wide variation in resistance of and voltage drop across the light-responsive variable resistance device 41, is believed to be unique and has been found to be not only desirable but advantageous as well.

Further, the circuit not only provides potentials in an amount sufficient to activate an indicating device but also provides potentials in an amount sufficient to inactivate the indicating device in a positive and reliable manner without fear of residual glow or partial conduction thereof. Moreover, the circuit provides potentials in an amount sufficient to activate other similar circuits by way of a passive component without need of additional expensive and inherently less reliable amplifying means.

The principles and operation of the above-described ring-counter type of circuit illustrated in FIG. 1 are also applicable to the multivibrator or scale-of-two type circuit schematically illustrated in FIG. 2. Herein, the components are the same as the components of FIG. 1 and for purposes of identification a 300 and 400 series of numerals have been used.

The circuit 303 includes but two stages 305 and 307 which are alternately shifted from an operational or conducting state to a nonoperational or nonconducting state by a negative-going applied signal such as described and detailed with regard to FIG. 1. This circuit 303, like the circuit 3 of FIG. 3, possesses all of the unique advantages previously discussed. For example, the "bootstrap" feedback loop, the inherent gain or amplification of the signal commutation due to the capacitance coupling and the light-coupled source and variable resistance device, the provision of a signal sufficient to properly operate an indicator device, and the provision of a signal sufficient to activate another similar circuit are all common to the circuits of both FIGS. 1 and 2.

As an illustrative example of a specific embodiment of substantially symmetrical stages, but not to be construed as limiting in any manner, the following component values are appropriate:

Light-responsive variable resistance device 41: Photoconductor-activated—
- 15 foot-candles
- 15,000 Ω resistance

Light source 45:
- Neon gas-filled glow tube—NE2
- Firing voltage about 85 v.
- Maintaining voltage about 65 v.

Source voltage B+: 250 v. to 275 v.

Switch 59: Single throw double pole

Indicator device 11: Gas-filled readout tube

Diode 51: 1N463A silicon diode

Resistors:

57	150,000
29	390,000
31	100,000
33	15,000
39	56,000
55	27,000

Capacitors:

61 μf.	.047
28 μf.	.01

Referring specifically to the utilization of the above-listed components in the illustrated embodiment, it was found that a negative-going applied signal having an amplitude of about ten (10) volts shifted the stages from a conducting to a nonconducting state. Further, the commutation system and inherent gain or amplification, due primarily to the light-responsive variable resistance device, provided an activating signal of about 60 volts for the following stage.

Also, it was found that the "bootstrap" feedback loop permitted the use of a steady-state potential of about 50 volts across the light source during the nonconducting period which is well below either the firing or maintaining potential of the device. Moreover the shifting of a stage from the conducting to nonconducting state provided a variation in the potential applied to the indicating device in the neighborhood of about 130 v., which is more than enough to provide the optimum operation thereof.

Additionally, it was found that an applied signal, in the form of a negative-going pulse having a width in the range of about 0.002 to 0.020 second, provided stable and reliable operation of the circuitry. Also, the circuitry was found capable of counting at a speed in the range of about 4000 to 5000 counts/min.

Thus, there has been provided a circuit which not only provides the signal potentials necessary to activate an indicating device without need of additional amplification but also provides signal potentials in an amount sufficient to activate other similar circuits by way of a passive, reliable, and inexpensive component. Further, the method of signal commutation and the inherent signal gain obtainable thereby, as well as the utilization of a "bootstrap" loop arrangement whereby inexpensive components having greatly increased parameter tolerances and life expectancies are utilized at reduced and far less critical potentials, are believed to be unique and advantageous results unobtainable in any known circuit. Moreover, the accomplishment of all of these functions simultaneously is not only novel and inexpensive in comparison with known circuitry capable of performing the above-discussed functions but also provides numerous other unanticipated advantages over any known circuit.

While there have been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention as defined by the appended claims.

What is claimed is:

1. A signal actuable counter circuits comprising a pair of substantially symmetrical stages with each stage including:

voltage source means including a first and second voltage tap;

voltage divider means coupled intermediate the positive terminal of a voltage source and said second voltage tap of said voltage source means, said divider means including a light-responsive variable resistance means;

light source means including a series-connected light source and unidirectional conduction device coupled intermediate said first voltage tap of said source

means and circuit ground, said light source means being light coupled to said light-responsive means;

means for applying a signal to said light source means to decrease the voltage thereacross and shift said light source from a conducting to a nonconducting state; and

circuit means capacity coupling said second tap of said voltage source means of one stage to said junction of said light source and unidirectional conduction device of a second stage whereby the shift of said light source from a conducting to a nonconducting state cause a change in the voltage applied to a second nonconducting light source in an amount sufficient to shift said second light source from a nonconductive to a conductive state.

2. A signal actuable counter circuit comprising a pair of substantially symmetrical stages with each stage including:

a first resistive voltage divider coupled intermediate the positive terminal of a voltage source and circuit ground, said divider having a first and second voltage tap interconnected by a resistive element;

a second voltage divider coupled intermediate said voltage source and said second voltage tap of said first divider, said second voltage divider including a series-connected fixed resistor, a light-responsive variable resistive means, and output circuit means coupling the junction of said fixed resistor and light-responsive means to an indicating means;

a series-connected glow tube and a substantially unidirectional conduction device coupled intermediate said first voltage tap of said first divider and circuit ground, said glow tube having an anode and a cathode electrode and being light coupled to said light-responsive device;

means for increasing the voltage difference between the anode and cathode electrodes of one of said stages to shift said stage from a nonconducting state to a conducting state;

first voltage tap of said first divider and circuit signal means for decreasing the voltage difference between the anode and cathode electrodes of a conducting stage to shift said stage from a conducting state to a nonconducting state; and

capacity means coupling the second voltage tap of said first voltage divider to the junction of the glow tube and unidirectional conduction device of the other stage whereby the shift of one stage from a conducting to a nonconducting state causes a shift of the other stage from a nonconducting state to a conducting state.

3. A signal actuable counter circuit comprising a plurality of substantially symmetrical stages in a ring arrangement with each stage including:

a first resistive voltage divider coupled intermediate the positive terminal of a voltage source and circuit ground, said divider including a first and second voltage tap interconnected by a resistive element;

a second resistive voltage divider coupled intermediate a voltage source and said second voltage tap of said first divider, said second divider including a series-connected resistor and photoconductor;

counter indicating means coupled to the junction of said resistor and photoconductor;

a series connected glow tube and unidirectional conduction device coupled intermediate said first voltage tap of said first divider and circuit ground, said glow tube including an anode and a cathode electrode and being light coupled to said photoconductor;

means for applying a signal to the anode of said glow tube to lower the potential difference between the anode and cathode electrodes and shift the tube from a conducting state to a nonconducting state; and

circuit means capacity coupling said second voltage

tap of said first voltage divider of one stage to the junction of said glow tube and said unidirectional conduction device of a following stage whereby the applied signal causes the shift of one stage from a conducting to a nonconducting state and the voltage change due to the shift from a conducting to a nonconducting state is transmitted to and causes the following stage to shift from a nonconducting to a conducting state.

4. A signal actuable counter circuit comprising a plurality of substantially symmetrical stages in a ring arrangement with each of said stages including:

a first resistive voltage divider coupled intermediate the positive terminal of a voltage source and circuit ground, said divider including a first and second voltage tap interconnected by a resistive element;

a second resistive voltage divider coupled intermediate a voltage source and said second voltage tap of said first divider, said second divider including a series-connected resistor and photoconductor;

counter indicating means coupled to the junction of said resistor and photoconductor;

a series-connected glow tube and unidirectional conduction device coupled intermediate said first voltage tap of said first divider and circuit ground, said glow tube including an anode and a cathode electrode and being light coupled to said photoconductor;

means for applying a signal to said glow tube to lower the potential difference between said anode and cathode electrodes and shift said tube from a conducting state to a nonconducting state;

circuit means capacity coupling the second voltage tap of said first voltage divider of one stage to the junction of the glow tube and unidirectional conduction device of a following stage whereby the voltage change caused by the shift of one stage from a conducting to a nonconducting state causes an increased potential difference between the electrodes of the glow tube of a following stage which shifts the following stage from a nonconducting state to a conducting state;

switching means for increasing the potential difference between the electrodes of the glow tube of one of said stages to cause conduction thereof; and

circuit means including a capacitance coupling the junction of said series-connected resistor and photoconductor of one of said stages to a second actuable counter circuit.

5. A bootstrap circuit comprising in combination:

a voltage source having a positive potential terminal;

a voltage divider coupling said terminal to a circuit ground and including an impedance interconnecting a first and second voltage tap;

a light source coupling said first voltage tap to circuit ground;

potential altering means coupled to said positive potential terminal and said first voltage tap to provide alterations in potential at said first voltage tap; and

bootstrap circuit means coupling said first voltage tap to said positive potential terminal, said means including said impedance connected in series with a light-responsive variable resistive device light-coupled to said light source whereby increasing the potential at said first voltage tap by said potential altering means causes activation of said light source which reduces the ohmic resistance of said resistive device increasing the potential at said first voltage tap in an amount sufficient to maintain said light source operational.

6. The bootstrap circuit of claim 5 wherein said light source is in the form of a neon glow tube and said light-responsive variable resistive device is in the form of a photoconductor.

7. The bootstrap circuit of claim 5 wherein said potential altering means is in the form of a means for applying a signal potential to said first voltage tap.

8. The bootstrap circuit of claim 5 wherein a unidirectional conduction device is connected in series with said light source coupled intermediate said first voltage tap and circuit ground.

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