

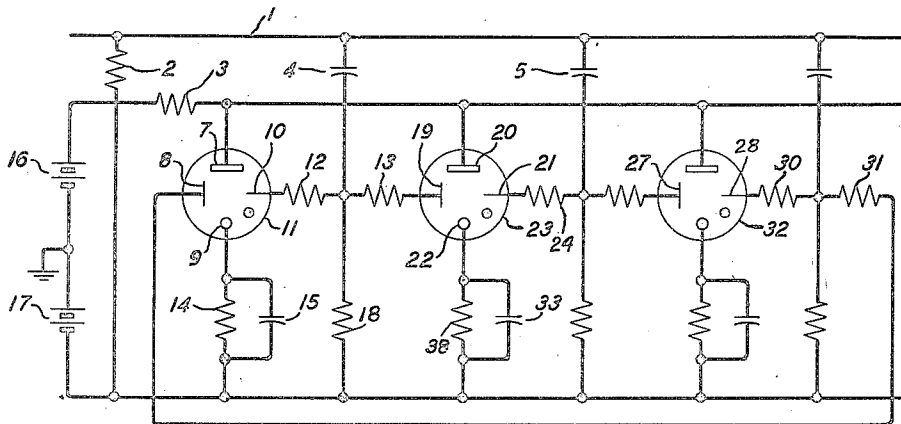
Dec. 19, 1950

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2,534,856

COLD CATHODE GAS TUBE COUNTING CIRCUIT

Filed April 29, 1949



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2,534,856

COLD CATHODE GAS TUBE COUNTING
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Application April 29, 1949, Serial No. 90,502

4 Claims. (Cl. 315-201)

1

This invention relates to electronic counting ring circuits and more specifically it relates to counting ring circuits employing cold cathode gas tubes with probe elements therein to prime an adjacent gas tube.

An object of the invention is a counting ring circuit wherein the priming voltage is greater than that obtained by using a cathode signal bias.

Another object is a counting ring circuit of greater sensitivity than has heretofore been known.

A third object is a counting ring circuit employing cold cathode gas tubes having wider limits of starter gap break-down voltages, thus simplifying the design problems of said cold cathode gas tubes.

A further object of the invention is the improvement of counting rings generally.

A cold cathode gas tube counting chain usually consists of a series of two or more gas tubes and their associated electrical circuits connected in such a way that a first tube which is conducting performs a priming action on a second tube which follows the first in the series or chain. As a result, when the voltage pulse to be counted is admitted to the chain on a busbar connected to all the tubes, only the primed or preferred second gas tube is broken down and said first gas tube, which immediately precedes said primed tube, is extinguished. The circuit is so designed that when the last tube in the chain is ionized, it will prime the first tube in the chain, thus creating what is known in the art as a counting ring.

In this invention the counting ring comprises a series of two or more cold cathode gas tubes arranged in such a manner that when a gas tube is ionized, said gas tube performs a biasing action on the starter anode of the electrically adjacent tube by means of a probe placed in the ionized tube and connected through an impedance to the starter anode of said adjacent gas tube. This positive bias can be adjusted to be sufficient to cause a current to flow in the starter anode-main cathode gap of said adjacent tube, but insufficient to cause a transfer of the discharge to the main anode main cathode gap of said adjacent tube. Alternatively, this positive bias can be adjusted to be insufficient to be the sole cause of ionization of the starter anode-main cathode gap. A direct current impulse then is impressed on the starter anodes of all the gas tubes in the chain but which will ionize only the biased gas tube. This process

2

will reoccur so long as the direct-current pulses are continued.

A salient feature of this invention is the use of a probe in the cold cathode gas tubes as an active element to bias the starter anode of the gas tube to be subsequently ionized.

A further feature is the utilization of a keep-alive current in the starter anode-main cathode gap of the gas tube next to be ionized. This keep-alive current facilitates breakdown of the preferred second gas tube by reducing the input voltage required and also by lessening the amount of time otherwise required.

The above-mentioned features and objects and others will be more fully understood from the drawing and the following detailed description thereof.

In the preferred embodiment of the invention shown in the drawing battery source 16 is +130 volts with respect to ground; the battery source 17 is -48 volts. Resistance 2 is a tie-down resistance of a relatively small value in the neighborhood of from 300 to 500 ohms. Resistance 3 is also a small resistance of about 300 ohms; its purpose being to limit the main anode-main cathode current in a tube when that tube ionizes. Elements 7, 8, 9 and 10 are the main anode, starter anode, the main cathode and probe, respectively, of tube 11. Cathode resistance 14 and capacitance 15 have values of 4,000 ohms and 2 microfarads. Their function is to provide a load for their associated gas tube when ionized and also to extinguish any other gas tube that might be ionized when tube 11 becomes ionized. Resistances 12, 13 and 18 have values of 2 megohms and 5 megohms, respectively, and capacitance 4 has a value sufficiently large to allow the direct-current voltage pulses to be applied over line 1 and through capacitance 4 to starter anode 19 of tube 23. It is to be noted that each of the three tubes has similar elements and external circuits, the value of the constants of said external circuits being the same for tubes 23 and 32 as has been given above for tube 11. It should further be noted that the relationship of tube 22 to tube 11 is the same as the relationship of tube 11 to tube 23 and of tube 23 to tube 32. The three tubes thus constitute a continuous ring, every element of said ring being identical with every other element of said ring.

The hereinbefore list of component values were selected for circuit operation which includes a keep alive current feature. However, non-keep alive current operation of the circuit of this

invention is easily attained by increasing the value of resistances 12, 24 and 30 to approximately 10 megohms each.

The operation of the circuit shown in the drawing will now be described in detail in conjunction with keep alive current tube operation. Assume that tube 11 is in an ionized condition and conducting a current from main anode 7 to main cathode 9 through resistance 14, battery 17, battery 16, resistance 3 and back to main anode 7. Probe 10 adopts a potential of about 10 volts below that of main anode 7. Since resistance 18 has a value of 5 megohms as compared to the 2-megohm value assigned to resistance 12, approximately five-sevenths of the potential developed across resistance 14 and main cathode-probe gap 9-10 appears across the starter anode-main cathode gap 19-22 of tube 23. This probe voltage is positive enough with respect to -48 volts with respect to ground impressed on main cathode 22 to break down the starter anode-main cathode gap of tube 23 and to establish a small current in the starter anode-main cathode gap designated herein as the "keep alive" current. The keep alive current which flows is sufficient to ionize starter anode-main cathode gap 19-22. However, it is not great enough to permit ionization transfer to main anode-main cathode gap 20-22. Resistances 12, 13 and 38 limit the "keep alive" current to such a value that it is not sufficient to break down the main gap of tube 23. When a pulse of direct-current voltage is transmitted over lead 1 through capacitance 4 the potential of starter anode 19 is raised sufficiently to increase the density of said "keep alive" current to a point where transfer of said current will occur to the main anode-main cathode gap thus completely ionizing tube 23. When this current is first established in the main anode-main cathode gap the potential of main cathode 22 for a very short period of time will remain at -48 volts due to the presence of condenser 33 in the cathode circuit which, of course, does not charge instantaneously. Furthermore, since the sustaining voltage of tube 22 is approximately 60 volts the potential of main anode 20 will be about +12 volts. It should be noted here that tube 11 at the time of ionization of tube 22 had been operated in a steady-state condition so that there was a large voltage drop of over 100 volts across resistance 14 thus placing main cathode 9 of tube 11 at a potential of over +50 and main anode 7 of said tube at a potential of over +110. Now since main anode 20 of tube 23 has suddenly been forced to assume a value of +12 the potential of main anode 7 of tube 11 must therefore assume the same value, which will be negative with respect to the potential of main cathode of tube 11, thus extinguishing tube 11. Thereafter condenser 15 will discharge through resistance 14 and condenser 33 and the cathode circuit of tube 23 will charge to a value determined by the current through tube 23 and resistance 38, thus preparing tube 23 for probe action on tube 32 and also for extinguishment when tube 32 ionizes. The probe action mentioned immediately above will raise the potential of starter anode 27 to a point where breakdown will occur in the starter anode-main cathode gap of tube 32 and a "keep alive" current will be established in said gap.

It is to be noted that the probe 28 of tube 32 is connected through resistances 30 and 31 to the starter anode 8 of tube 11 and a similar

action will occur between those two tubes as occurs between tube 23 and tube 32.

The operation of the circuit wherein keep alive current is not required is as follows: Assuming tube 11 to be operating in a steady-state condition the potential of main cathode 9 is more than +60 volts and the potential of main anode 7 is more than +120 volts. Probe 12 has a potential about 10 volts less than that of main anode 7. Since resistance 12 is very large in comparison with resistance 18 the potential of starter anode 19 is several volts below the potential of probe 10 and is not great enough with respect to the potential of main cathode 22 of tube 23 to establish a keep-alive current in the starter anode-main cathode gap of tube 23. It is to be noted that the potential of main cathode 22 is -48 volts since there is no current flowing in that part of the circuit.

When a pulse is transmitted along lead 1 through condenser 4 the potential of starter anode 9 is increased to a point where a current is established in the starter anode-main cathode gap of tube 23. This current immediately transfers to main anode 20 thus completely ionizing tube 23. Since it takes a certain interval of time for condenser 33 to charge, the potential of main cathode 22 remains at -48 volts, and because the sustaining voltage of tube 23 is approximately 60 volts, the potential of main anode 20 is about +12 volts. As main anode 7 of tube 11 is directly connected to main anode 20 of tube 23 through a shorted circuit the potential of main anode 7 necessarily assumes a value equal to that of main anode 20 and inasmuch as that value of potential is below the potential of main cathode 9 tube 11 is extinguished. Subsequently, condenser 15 discharges, placing main cathode 9 at a potential of -48 volts and condenser 33 of tube 23 which is now completely ionized gradually charges thus raising the potentials of main cathode 22 and main anode 20 accordingly. Probe 21 follows the potential of main anode 20 and when condenser 33 becomes fully charged the starter anode 27 of tube 32 is fully positively biased by probe 21 so that a current will be established in the starter anode-main cathode gap of tube 32 when the next direct-current pulse is transmitted over lead 1 and through condenser 5. It is here again to be noted that the probe of tube 32 is connected to the starter anode 8 of tube 11 through resistances 30 and 31 so that the next pulse will cause tube 11 to ionize as a result of the probe action of tube 32 upon the starter anode of tube 11.

It is to be understood that the form of this invention, herewith shown and described, is to be taken as a preferred embodiment of the same, and that various changes and arrangements of the circuit may be resorted to without departing from the spirit or scope of the invention.

What is claimed is:

1. A plurality of space discharge devices each comprising a starter anode, a main anode, a main cathode, and a probe electrode, said main anodes being connected in multiple, a first resistance common to said main anodes, a plurality of resistance-capacitance parallel combinations, one individual to each of said main cathodes, a direct current voltage source applied across said first resistance and said resistance-capacitance parallel combinations, a third resistance connecting the probe of one space discharge device to the starter anode of the adjacent space discharge device, a fourth resistance connecting

5

said third resistance to said direct current voltage source, and a condenser to transmit pulses to be counted connected to said third resistance.

2. A plurality of space discharge devices each comprising a starter anode, a main anode, a main cathode, and a probe electrode, said main anodes being connected in multiple, a first resistance and a capacitance in parallel in the cathode circuit of each space discharge device, a direct current voltage source applied across the main anode and resistance-capacitance parallel combination of each space discharge device, current limiting resistors connecting the probe of a given space discharge device to the starter anode of the adjacent space discharge device, each probe being connected through a large resistance to the terminal of the direct current voltage source that is applied to the said resistance-capacitance parallel combinations in the cathode circuits of the said plurality of space discharge devices.

3. A plurality of space discharge devices each comprising a starter anode, a main anode, a main cathode, and a probe electrode, said main anodes being connected in multiple, a first resistance common to all of said main anodes, a second resistance in the main cathode circuit of each of said space discharge device, a capacitance in parallel with said second resistance, a direct current voltage source applied to the main anode and said second resistance, current limiting resistors connecting the probe of each space discharge device to the starter anode of the adjacent space discharge device to positively bias the starter anode of said adjacent gas discharge device sufficiently to cause a current to flow in the

6

starter anode-main cathode gap therein but insufficient to cause a current flow in the main anode-main cathode gap, and other resistors connecting said probes to the terminal of said direct current voltage source that is connected to said second resistances.

4. A plurality of space discharge devices each comprising a plurality of electrodes including a starter anode, a probe electrode and a main cathode, a direct current voltage supply common to all said space discharge devices, first resistances connecting the said probe electrode of one space discharge device to the starter anode of the adjacent space discharge device, a second resistance and a capacitance in parallel in the cathode circuit of each space discharge device, and an impedance connecting each of said probes to said direct current voltage supply, the potential of the starting anode of any space discharge device which is adjacent to and has its starting anode connected to any ionized space discharge device being sufficient to cause a current flow in the starter anode-main cathode gap of said adjacent space discharge device, but being insufficient to cause total ionization of said adjacent space discharge device.

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