

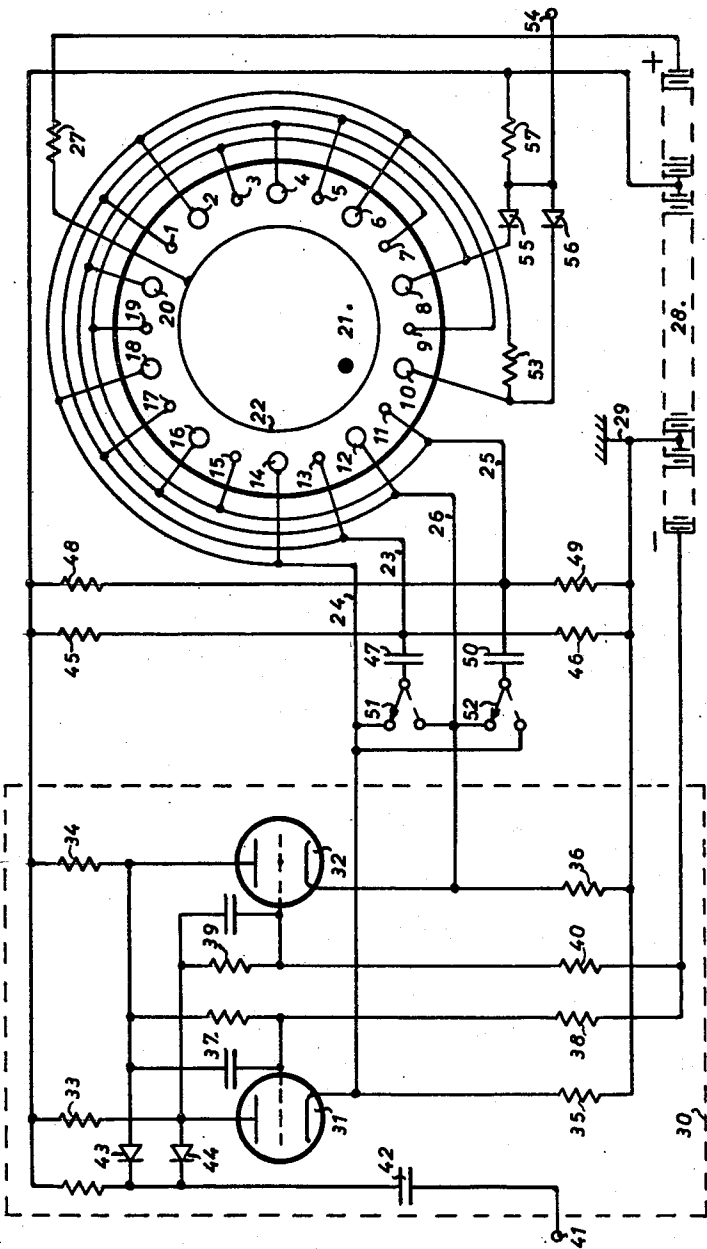
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APPARATUS FOR COUNTING ELECTRIC IMPULSES COMPRISING A
BISTABLE MULTIVIBRATOR AND A GLOW DISCHARGE COUNTING
TUBE HAVING A PLURALITY OF COLD CATHODES

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APPARATUS FOR COUNTING ELECTRIC IMPULSES COMPRISING A BISTABLE MULTIVIBRATOR AND A GLOW DISCHARGE COUNTING TUBE HAVING A PLURALITY OF COLD CATHODES

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This invention relates to an apparatus for counting electric impulses and more particularly to such apparatus including a bistable multivibrator having two output resistances and a glow discharge counter tube having a plurality of cold cathodes and a common anode.

One general object of this invention is to enhance the functional possibilities and to increase the operative safety over long working periods. In accordance with one broad feature of this invention differentiating networks are coupled to each one of the two output resistances of the multivibrator, each one of the two groups of auxiliary cathodes of the glow discharge counting tube is coupled to one of said differentiating networks, and each one of the two groups of main cathodes of the counting tube is coupled to one of said two output resistances of the multivibrator. In accordance with a more specific feature of this invention each of the two main cathode groups of said counting tube is galvanically coupled to one of the two output resistances of said multivibrator and each of said two auxiliary cathode groups is connected through a coupling capacitor to one of the two output resistances of said multivibrator and receives a bias potential through ohmic resistances, said coupling capacitors together with the associated ohmic resistances being dimensioned to form differentiating networks. In accordance with a further specific feature of this invention, a reading resistor is included in the circuit of a main cathode which is to be read, this main cathode is connected through a resistance arrangement having a tap to the main cathode group to which it does not belong, and this resistance arrangement is so dimensioned that a voltage change occurs at said tap only when the main cathode to be read conducts a discharge current.

The invention and the above noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which a schematic circuit diagram is shown illustrating one embodiment of this invention particularly suitable for effecting high counting speed.

The cold cathodes 1 to 20 of the glow discharge counting tube 21 are symmetrically constructed in relation to one another and also in relation to the common anode 22, in such a way that the counting tube in fact has no preferred counting direction. To facilitate understanding of the manner in which the various cathodes are connected into groups, the counting tube has a number of cathodes equal to $2n$ wherein n denotes an even integer. Cathodes Nos. 1, 5, 9, 13, 17 ($2n-3$) are connected to form a first auxiliary cathode group 23, cathodes Nos. 2, 6, 10, 14, 18 ($2n-2$) to form a first main cathode group 24, cathodes Nos. 3, 7, 11, 15, 19 ($2n-1$) to form a second auxiliary cathode group 25, and cathodes Nos. 4, 8, 12, 16, 20 ($2n$) to form a second main cathode group. The anode 22 is connected through a stabilising resistance 27 of about 0.2 megohm to the positive pole of a direct current supply 28, of which a tap is earthed at 29.

A bistable multivibrator 30 of known construction is provided to drive the glow discharge counting tube 21. The multivibrator 30 illustrated uses two high vacuum triodes 31 and 32, the anodes of which are connected,

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through the anode resistances 33 and 34, each of about 20 kilohms, to a further tap at the direct current supply 28. The cathodes of the triodes 31 and 32 are connected through cathode output resistances 35 and 36, each of 4 kilohms, to the earth terminal 29. The circuits of the triodes 31 and 32 are interconnected through the two voltage dividers 37, 38 and 39, 40 to form a galvanically coupled feedback loop having a positive feedback factor in such a manner that always one of the triodes is negatively biased beyond cutoff while the other triode carries an anode current. The resistances 37 to 40 are each about 0.6 megohm. In order to obtain the correct grid biases for the triodes 31 and 32, the resistances 38 and 40 are connected to a potential derived from the source 28 which is sufficiently negative compared to the earth terminal 29, as shown in the drawing. Furthermore, the multivibrator is dimensioned so that the triode 31 or 32 which is at the time conducting an anode current creates a voltage drop of about 40 volts across its associated cathode output resistance 35 or 36. The electrical impulses to be counted are applied between the input terminal 41 and the earth terminal 29. They arrive through the input capacitor 42 and the diodes 43, 44 in the feedback loop of the triodes 31 and 32. If the input terminal 41 receives a negative impulse, this arrives, through the diodes 43, 44 and the voltage divider resistances 37 and 39, at the grid of the triode 31 or 32 which is at the time conducting an anode current. The triode concerned becomes dead and the triode previously blocked will now carry an anode current. Output voltages of different magnitudes therefore arise across the two cathode output resistances 35 and 36 and change with every impulse so long as the input terminal 41 is admitting a series of impulses.

Each of the two main cathode groups 24 and 26 respectively is connected to one or other of the cathode output resistances 35, 36 of the multivibrator 30, so that one main cathode group of the glow discharge counting tube always has a voltage of about 40 volts and the other main cathode group a voltage of virtually 0 volt in relation to the earth terminal 29. Each of the two auxiliary cathode groups 23 and 25 receives, by means of a resistance type voltage divider 45, 46 or 48, 49, a positive bias potential of about 20 volts in relation to the earth terminal 29. The two voltage dividers 45, 46 and 48, 49 are dimensioned accordingly; the resistances 46 and 49 each have about 10 kilohms whilst the resistances 45 and 48 have about 150 kilohms. The two auxiliary cathode groups 23 and 25 are, through the coupling capacitors 47 and 50, coupled to the cathode output resistances 35, 36 of the multivibrator 30. By means of a reversing switch 51, 52 either the auxiliary cathode group 23 can be coupled to the output resistance 35 and the auxiliary cathode group 25 to the other output resistance 36 (full-line position), or the auxiliary cathode group 23 can be coupled to the output resistance 36 and the auxiliary cathode group 25 to the output resistance 35 (broken-line position) of the multivibrator 30. The coupling capacitors 47 and 50 are dimensioned in relation to the resistances 46 and 49 so that differentiating networks are produced and the control voltages arising at the auxiliary cathode groups 23 and 25 are substantially proportional to the changes in the output voltages of the multivibrator 30 arising at its cathode output resistances 35 and 36. Taking into account the above mentioned dimensions for the other parts of the apparatus described, this differentiating effect of the networks 45 to 47 and 48 to 50 is achieved if the capacitors 47 and 50 each have about 100 picofarads.

In order to explain the mode of operation, let it be assumed that the triode 31 of the multivibrator 30 is conducting an anode current. At the cathode output resistance 35 and thus at the main cathode group 24 there is then a voltage of about 40 volts. Let it further be

assumed that a glow discharge is struck between the main cathode 16 of the other cathode group 26 and the anode 22. The discharge current of this glow discharge causes a slight voltage drop at the output resistance 36 of the non-conducting triode 32, but this is well below 20 volts. The two auxiliary cathodes 15 and 17 adjacent to the main cathode 16 are accordingly positive in relation to the main cathode 16 and the glow discharge is thus stabilised on the main cathode 16. If a negative voltage impulse is now applied to the input terminal 41, then the other triode 32 conducts and the triode 31 is biased beyond cutoff. The voltage at the resistance 36 and therewith the voltage at the main cathode group 26 will thus quickly rise to 40 volts. But this voltage rise also generates a positive control voltage at the resistance 49 due to the differentiating effect of the network 49, 50. This control voltage is superimposed on the constant bias and produces a voltage hump temporarily exceeding 40 volts at the auxiliary cathode group 25, so that the cathode 15 becomes more positive than the main cathode 16. Owing to the functioning of the multivibrator 30, however, the voltage rise at the resistance 36 is associated with a drop in the output voltage at the resistance 35, which was previously 40 volts. This lowering of the voltage across the resistance 35 gives rise to a negative control voltage at the resistance 46, which is superimposed on the bias of 20 volts and produces a negative voltage hump at the auxiliary cathode group 23. This hump results in the springing of the glow discharge from the main cathode 16 to the auxiliary cathode 17, since the latter has become more negative than the main cathode 16. With the lowering of the output voltage at the resistance 35, the voltage at the other main cathode group 24 also drops to well below 20 volts, and by the differentiating effect of the capacitive coupling of the auxiliary cathode group 23 the previously formed negative voltage hump will be built back, so that the control voltage at the auxiliary cathode group 23 again approaches the constant bias of 20 volts. But the voltage at the auxiliary cathode 17 thereby becomes more positive than the voltage at the adjacent cathode 18 and the glow discharge accordingly springs from the auxiliary cathode 17 to the main cathode 18. With the ignition of the glow discharge on the main cathode 18 a small voltage drop will again take place at the resistance 35, this drop being, however, considerably less than 20 volts. The glow discharge is thus transferred from the main cathode 16 to the main cathode 18, while in the multivibrator 30 the triode 32 now conducts and the triode 31 is blocked. In the meantime the two auxiliary cathode groups 23 and 25 have also regained the potential of the constant bias of 20 volts. Similarly, when the next negative impulse is applied to the input terminal 41, the triode 31 once more becomes conductive and the triode 32 is again blocked, so that the glow discharge is transferred from the main cathode 18 by way of the auxiliary cathode 19 to the next main cathode 20.

To reverse the counting direction the switches 51 and 52 have merely to be moved into the position shown in broken lines, the output voltages supplied by the multivibrator 30 and differentiated in the networks 45 to 47 or 48 to 50 being applied only to the auxiliary cathode groups 23 and 25 interchangeably. In the position of the switches 51, 52 shown in broken lines, the counting direction is then counter-clockwise; thus the glow discharge would be transferred for instance from the main cathode 18 through the auxiliary cathode 17 to the main cathode 16.

In order to establish electrically whether the glow discharge is burning on a specific cathode of the counting tube 21, one can arrange in the discharge zone of this cathode a reading electrode which conducts a current only when the glow discharge has ignited on the associated main cathode. Such reading electrodes are, however, not always desirable, as they result in a comparatively complicated construction of the whole counting

tube. A further, equally known method for electrically reading the counting position consists in interpolating a so-called reading resistance in the cathode circuit of the cathode to be read. This reading resistance undergoes a voltage drop only when the cathode in question conducts a discharge current. But this known method cannot be used for the counting apparatus described in its usual embodiment, as all the cathodes of the glow discharge tube receive control voltages and the voltage drop occurring at a reading resistance is superimposed on these control voltages.

According to a development of the present invention it is possible to read the counting position electrically in the described apparatus by interpolating a reading resistance 53 of about 10 kilohms in the cathode circuit of a main cathode 10 to be read, connecting the main cathode 10 to the main cathode group 26, to which 10 does not belong, through a resistance arrangement 55 to 57 having a tap 54, and dimensioning this resistance arrangement 55 to 57 so that a voltage change arises at the tap 54 only when the cathode 10 is carrying a discharge current. The resistance arrangement preferably consists of two diodes 55 and 56 connected in the same sense to the tap 54, of which one diode 56 leads to the main cathode 10 to be read and the other diode 55 to the main cathode group 26 not including this main cathode 10. The tap 54 finally receives a further bias through an ohmic resistance 57 of about 1 megohm.

If the main cathode 10 conducts no discharge current, the tap 54 is always on the lower potential possessed by one of the two main cathode groups 24 or 26. If on the other hand a glow discharge burns on the cathode 10, a voltage drop occurs at the resistance 53 and is transferred to the tap 54. In the illustrated embodiment of the invention this electric reading is illustrated only for the main cathode 10. It can be used correspondingly for other cathodes of the two main cathode groups 24 and 26 also. If, as illustrated, only one cathode—the cathode 10—is read, the voltage arising at the tap 54 can be used to control another counting tube, possibly by means of intermediate electronic amplification.

For the rest the apparatus described is capable of many other modifications. In place of the multivibrator 30 equipped with vacuum triodes, for instance, a multivibrator operating with transistors or gas discharge tubes can be used. The differentiating networks 45 to 47 and 48 to 50 can also be built otherwise than shown in the drawing. The switches 51, 52 can finally be replaced by electronic reversing means to enable the counting direction to be changed quickly. These and other modifications which may occur to those familiar with the art fall within the spirit and scope of the invention as set forth in the following claims.

I claim:

1. Apparatus for counting electric impulses comprising a bistable multivibrator having two output resistances, the impulses to be counted actuating said multivibrator in such a manner that output voltages of different value arise in an alternating sequence across each of said output resistances, a differentiating network coupled to one of said output resistances, a second differentiating network coupled to the other of said output resistances, a glow discharge counting tube having $2n$ cold cathodes and a common anode and wherein n denotes an even integer, means for connecting the cathodes Nos. 1, 5, 9, to $2n-3$ of said counting tube to form a first auxiliary cathode group, means for coupling said first auxiliary cathode group to one of said differentiating networks, means for connecting the cathodes Nos. 2, 6, 10 to $2n-2$ of said counting tube to form a first main cathode group, means for coupling said first main cathode group to one of said output resistances of said multivibrator, means for connecting the cathodes Nos. 3, 7, 11, to $2n-1$ of said counting tube to form a second auxiliary cathode group, means for coupling said second auxiliary cathode group to the

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other of said differentiating networks, means for connecting the cathodes Nos. 4, 8, 12, to $2n$ of said counting tube to form a second main cathode group, and means for coupling said second main cathode group to the other of said output resistances of said multivibrator.

2. The invention as recited in claim 1, wherein each of said two main cathode groups is galvanically coupled to one of said output resistances of said multivibrator and in which each of said two auxiliary cathodes groups is connected through a coupling capacitor to one of said output resistances of said multivibrator and receives a bias potential through ohmic resistances, said coupling capacitors together with the associated ohmic resistances being dimensioned to form differentiating networks.

3. The invention as recited in claim 1, wherein a reading resistance is included in the circuit of a cathode of one of said main cathode groups, and in which said cathode is connected to the other of said main cathode

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groups through a resistance arrangement having a tap, this resistance arrangement being dimensioned so that a voltage change occurs at said tap only when said cathode conducts a discharge current.

4. The invention as recited in claim 3, wherein said tap receives a bias potential through an ohmic resistance and in which said resistance arrangement has two diodes connected to said tap in the same sense, one of said diodes leading to said cathode and the other of said diodes leading to said other main cathode group not including said cathode to be read.

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