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P. J. REUTER

2,677,074

ELECTRONIC COUNTING NETWORK

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FIG. 1

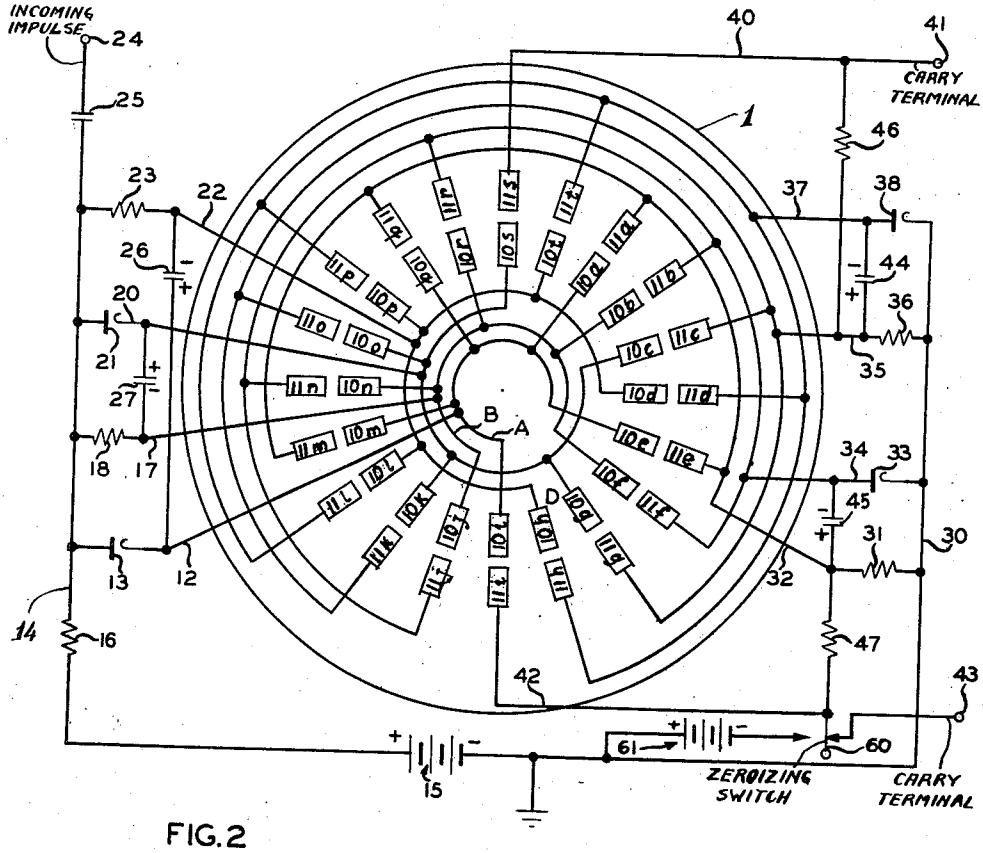


FIG. 2

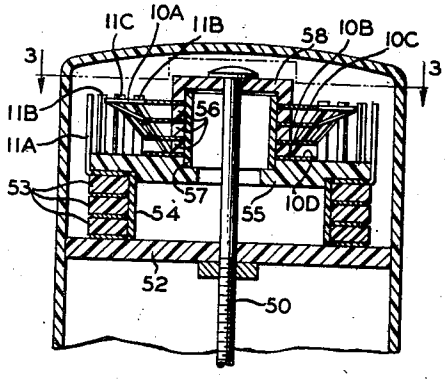
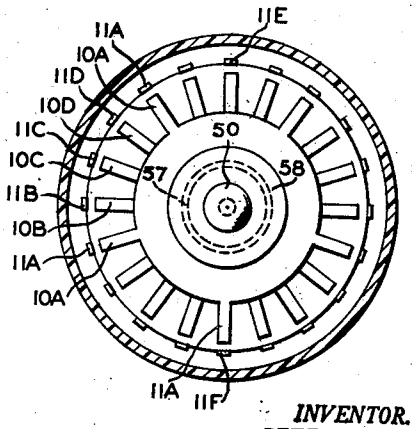


FIG. 3



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ELECTRONIC COUNTING NETWORK

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This invention relates generally to an electronic counting or integrating network provided with a gaseous discharge device having a plurality of discharge paths and more particularly relates to such a network wherein each discharge path may be sequentially energized in response to incoming electrical impulses to count or integrate these pulses.

This network according to the invention represents an improvement over United States Patents 2,443,407 and 2,524,213 issued to N. B. Wales, Jr.

In practice, it has been found that the network described in these patents is unsuitable in certain respects and particularly fails to respond properly at high counting rates. Furthermore, this network exhibits poor conduction transfer characteristics when the wave shape and duration of these impulses are not uniform.

Through the provision of new principles and techniques, the present invention overcomes these difficulties and extends the utility of this type of network.

It is an object of this invention to provide a network of the type described which has a greatly improved frequency response to incoming electrical impulses.

A further object of this invention is to provide a network of the type described which has a greatly improved stability of operation.

Another object of this invention is to provide a network of the type described which can count negatively or positively i. e., may subtract or add.

Still another object of this invention is to provide a network of the type described which requires a greatly reduced number of circuit components.

Yet another object of this invention is to provide a network of the type described which needs less precise circuit components.

Yet another object of this invention is to provide a network of the type described which uses a novel gaseous discharge device.

Still another object of this invention is to provide a network of the type described which visually indicates the results of the counting process.

These and other objects of the invention will become apparent as reference is made to the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a schematic diagram of an integrating or counting network in accordance with the invention;

Fig. 2 is a cross-section drawing of a gaseous discharge device used in this integrating or counting network;

Fig. 3 is another cross-section drawing of this gaseous discharge device.

In accordance with the invention, the network includes a gas filled counter tube provided with

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an anode electrode system and a cathode electrode system. Each system comprises a predetermined number of discharge elements or fingers, the number of these fingers being the same for both systems. Each anode finger is arranged opposite a corresponding cathode finger, thereby forming an individual conducting or discharge path therewith. In order to energize these paths, it is necessary to apply appropriate operating potentials to the fingers forming these paths through an externally coupled resistance-reactance circuit.

When incoming electrical impulses are supplied to this circuit, these discharge paths are sequentially energized in a selected direction in accordance with these impulses, only one path being energized at a time.

Selected discharge paths may be used as index points. Thus, after a number of impulses sufficient to cause one of these selected paths to be energized in the selected energized sequence, have been applied to the circuit, the change in potential of this energized path provides an index for this number of impulses.

Referring now to Fig. 1, a plurality of equally spaced anode fingers, twenty in number, being specifically shown herein as 10*a* through 10*t*, are mounted within the tube envelope 1. These anode fingers are interconnected to form four anode sections. Thus, anode fingers 10*a*, 10*e*, 10*i*, 10*m* and 10*q* are connected together to form the first anode section; 10*b*, 10*f*, 10*j*, 10*n* and 10*r* form the second section; 10*c*, 10*g*, 10*k*, 10*o* and 10*s* form the third section and 10*d*, 10*h*, 10*l*, 10*p* and 10*t* form the fourth section. These fingers may either be connected together within the tube as herein shown, or they may be connected together externally, for example, through the use of lead-in wires terminating in the tube socket. Moreover, each anode section may be formed from one ring-like structure.

A like plurality of cathode fingers, 11A through 11*t*, are also mounted within the tube envelope in such a manner that each cathode finger is opposite a corresponding anode finger having the same letter designation, thereby forming 20 discharge paths. Each cathode finger is separated from its corresponding anode finger by a small distance to provide a satisfactory spacing for an arc discharge. (When such a discharge takes place, the discharge path within which the arc is produced is said to be energized.)

The cathode fingers are interconnected to form six cathode sections. Thus, cathode fingers 11*a*, 11*e*, 11*m* and 11*q* form the first cathode section; 11*b*, 11*f*, 11*j*, 11*n* and 11*r* form the second section; 11*c*, 11*g*, 11*k* and 11*o* form the third section; 11*d*, 11*h*, 11*l*, 11*p* and 11*t* form the fourth section, 11*i* forms the fifth section and 11*s* forms the sixth section.

These fifth and sixth sections are index or carry electrodes. These carry electrodes with their corresponding anode fingers form the selected discharge paths which constitute index points.

The first anode section is connected through conductor 12, diode 13, common conductor 14 and resistor 16 to the positive terminal of a battery 15. (This battery may, of course, be replaced by any suitable source of direct current.) The second anode section is connected through conductor 17 and resistor 18 to the common conductor 14. In a similar manner, the third anode section is connected through conductor 20 and diode 21 to the common conductor 14, while the fourth anode section is connected through conductor 22 and resistor 23 to the common conductor 14. Capacitor 26 is connected between conductors 22 and 12; capacitor 27 is connected between conductors 20 and 17.

The first cathode section is connected through conductor 32, resistor 31 and common conductor 30 to the negative and grounded terminal of battery 15. The second cathode section is connected through conductor 34 and diode 33 to the common conductor 30. In a similar manner, the third cathode section is connected through conductor 35 and resistor 36 to common conductor 30, while the fourth cathode section is connected through conductor 37 and diode 38 to the common conductor 30.

The two carry electrodes are connected somewhat differently. The fifth cathode section, hereinafter called the first carry electrode, is connected to conductor 35 by way of conductor 40 and resistor 46 and is also connected by way of conductor 40 to carry terminal 41. The sixth cathode section, hereinafter called the second carry electrode, is connected by way of conductor 42 and resistor 47 to conductor 32 and is also connected by way of one terminal of the zeroizing switch 60 to carry electrode 43. The other terminal of switch 60 is connected to the negative terminal of battery 61. The positive end of battery 61 is grounded. (Battery 61, of course, may be replaced by any suitable source of direct current.)

Capacitor 44 is connected between conductors 37 and 35; capacitor 45 is connected between conductors 34 and 32.

Incoming impulses are supplied to the network by way of terminal 24 and blocking capacitor 25.

This network operates as follows. Assuming that the discharge path formed by fingers 10*i* and 11*i* has been energized by some previous operation, a discharge current flows from the positive terminal of battery 15, through resistor 16, diode 13, conductor 12, anode finger 10*i*, cathode finger 11*i*, resistors 47 and 31 and conductor 30 to the negative battery terminal. Capacitor 45 and diode 33 are effectively shunted across resistor 31. Capacitor 45, therefore, is charged by this discharge current to a voltage approximately equal to that produced at the junction of resistors 31 and 47, the forward resistance of diode 33 being so much smaller than that of resistance 31 that the voltage appearing across this diode is relatively insignificant.

Since, for the purposes of this invention, only one discharge path may be energized at any time, the value of the positive voltage delivered by battery 15 has been chosen to exceed the extinguishing voltage (that voltage which is just insufficient to maintain an energized discharge path in an energized condition) and to fall below the ignition voltage (that voltage which is just sufficient to energize an unenergized discharge path). Hence, the voltage of battery 16 is sufficient to maintain, but not initiate, conduction through any discharge path.

It is important to understand, however, that this invention is not so limited that the battery voltage must have this chosen value. For example, the battery voltage may be chosen to exceed the ignition voltage and a source of bias voltage used to reduce the effective voltage produced across any discharge path to a value falling between the value of the ignition voltage and that of the extinguishing voltage.

Assume now that a negative impulse of sufficient amplitude to extinguish the energized discharge path through fingers 10*i* and 11*i* is applied to terminal 24. (The wave shape of this impulse should have a sharp trailing edge and may be, for example, an inverted saw tooth or may have an exponential rise toward the voltage appearing at the positive terminal of battery 15.) This impulse momentarily renders the diode 13 non-conductive, reducing the potential at anode finger 10*i* so that the energized conducting path therethrough is deenergized.

Capacitor 45 then begins to discharge through diode 33. Since the backward resistance of this diode is much larger than its forward resistance, the capacitor discharge time is much longer than its charging time. Consequently, a negative voltage with respect to ground (the magnitude of this negative voltage is of the order of several volts) is applied to the second cathode section, as this section is connected to the junction point between capacitor 45 and diode 33. Since the applied impulse has a sharp trailing edge, the voltage on common conductor 14 rises sharply positive. The voltages on the cathode fingers in the second cathode section are more negative than the voltages on the fingers of any other cathode section so that the largest potential difference across any cathode and anode section is that produced across the second cathode and anode sections. This larger potential difference establishes a preference for ignition of the second section discharge paths.

However, as is known to anyone skilled in this electronic art, when a discharge path is energized, ions are produced in the region surrounding this path, and sufficient ions remain present in the path vicinity immediately after the discharge path is deenergized to set up additional preferential conditions in this region for the re-establishment of a discharge.

The only discharge path through the second cathode and anode sections in which this further preferential condition exists is that through fingers 10*j* and 11*j*. Consequently, this path is energized first, whereupon the voltage on common conductor 14 drops, because of the current flow through this newly energized path to such a value that no other discharge path through the second cathode and anode sections can be energized at this time.

The discharge current through fingers 10*j* and 11*j* charges capacitor 27. When the next successive impulse is applied to the terminal 24, the discharge path through fingers 10*j* and 11*j* is extinguished in the same manner as previously described above for the discharge path through fingers 10*i* and 11*i*; capacitor 27 discharges through diode 20, and the potential on the third anode section is raised relative to the potentials of the other anode sections. The largest potential difference is then across the third anode and

cathode sections. Due to the preferential ionization condition existing about the extinguished discharge path through fingers 10*j* and 11*j*, the discharge path through 10*k* and 11*k* is energized through the same manner as previously discussed.

Thus, in response to incoming impulses, the discharge paths are successively energized in a clockwise direction. On the tenth impulse, the discharge path through fingers 10*s* and 11*s* is energized.

Finger 11*s* is the first carry electrode and is used in this embodiment, as a tens index. When the discharge path through fingers 10*s* and 11*s* is energized (i. e. ten impulses have been supplied to terminal 24), the current passing through this carry electrode traverses resistor 46, thus producing a sudden change in voltage across resistor 46, which change appears at carry terminal 41. This change in voltage represents the arrival of the tenth incoming pulse and may be applied to another counter tube which would represent the next higher denominational order. Additional counter tubes representing still higher denominational orders could be connected in cascade if desired.

On the twentieth pulse, the discharge path formed by the second carry electrode 10*i* and its associated anode finger 11*i* is energized. This second electrode serves two purposes; i. e. that of a twenties index and that of a discharge zeroizer.

As an index, the second electrode passes current through resistor 47, producing a sudden change in voltage thereacross which appears at carry terminal 43. This change in voltage representing the arrival of the twentieth pulse, may be used in the same manner as the change in voltage at carry terminal 41.

Thus, when the discharge paths are successively energized in a clockwise direction, the tube counts forward and indicates at any time the number of impulses which have been previously applied to it. Thus the tube is said to add the number of incoming pulses.

In order to zeroize the discharge after a count has been entered, or to start the tube after it has been placed in the circuit, a start circuit consisting of battery 16 and zeroizing switch 60 is used in conjunction with the second carry electrode. When the tube is to be zeroized or started, the switch on of switch 60 (switch 60 is normally in the position shown in Fig. 1), is momentarily thrown to the left, thus applying a negative potential onto the second electrode. This potential is sufficient, in conjunction with the positive potential applied through battery 15 and resistor 16 to anode finger 10*i*, to energize the discharge path formed by fingers 10*i* and 11*i*. The resulting increased current flow through resistor 16 caused by this energization causes an additional voltage drop across this resistor sufficient to de-energize any other conducting path in the tube which may have been energized previously.

It will be apparent that the discharge sequence may be reversed (the discharge paths may be succesively energized in a counter-clockwise direction) by changing the conductor connections so that the fourth anode and cathode sections would replace the present first sections, the third sections would replace the present second sections, the second sections would replace the present third sections and the first sections would replace the present fourth sections.

When this counter-clockwise sequence is used, the tube counts backwards and thus is said to subtract.

It is, of course, possible to install a switch in this network so that the tube may be switched in a position to count either forward or backward. In other words, this network may be used either to add or subtract.

Operating speeds up to 25,000 cycles per second have been obtained with this particular embodiment of the invention with optimum circuit stability. Hence, while the invention is subject to a wide range of applications, it is especially suited for use in counter-circuits requiring these operating speeds.

It will furthermore be apparent that the number of cathode and/or anode sections need not be restricted to the number shown in Fig. 1. For example, if the construction of the cathode sections are such as to insure the flow going in one direction only, it is possible to use only two anode sections and two cathode sections. For the discharge sequence within the tube to be reversible (i. e., travel in either a clockwise or counter-clockwise direction) at least three cathode sections are necessary.

Similar principles of producing interacting conduction patterns among a plurality of gaseous discharge devices may also be applied with benefit where the discharge paths are not situated within a common envelope.

Referring now to Figs. 2 and 3, there is illustrated one type of electrode arrangement which can be used to carry out the object of this invention. This arrangement of electrodes is not the only arrangement which could have been used but is one which has been found easy to assemble and easy to mount within a glass envelope. A glass envelope is used so that the various discharge paths become visible as they are energized. Consequently, the tube can give a visual indication of its counting action.

The lead in wires are not shown in either Figs. 2 or 3 and the base of the tube is not indicated. These structures, however, can be easily adapted to one another depending on the type of tube and socket base desired.

As indicated in Fig. 2, the entire assembly is held in position by a bolt 50 and a nut 51. A flat disc washer 52, made of insulating material, is used as a base member and upon this member are assembled the first four cathode sections. These sections are indicated at 11A, 11B, 11C and 11D respectively. These cathodes comprise a flat annular plate surrounded by long discharge fingers which are bent upwardly when assembled and are parallel to the axis symmetry. The cathodes are spaced apart by insulating washers 53 and are held in place by an insulating tube 54 and another disc washer 55. The anodes are assembled on top of disc 55, held apart by spaces 56 and an annular, tubular insulator 57. On top of the anode assembly, a step insulating washer 58 is positioned, being held in place by the head of the bolt 50. This arrangement of cathodes and anodes provides twenty arc positions between the ends of anodes 11 and cathodes 10 and places the arc in position where it may be read through the top of the envelope.

While specific embodiments of the invention have been illustrated and described, it is obvious that the invention is not limited to such disclosures but that additions and modifications may be made therein as required by specific functional and environmental requirements while still retaining the essence of the invention.

What is claimed is:

1. An electronic counting network responsive to applied impulses and comprising a gaseous discharge device provided with a plurality of cathode fingers and a like plurality of anode fingers, each anode finger being arranged with respect to its corresponding cathode finger to form a discharge path therewith, a source of operating potentials for said paths, and a resistance-reactance circuit connected across said paths and coupled to said source, said circuit being responsive to said applied impulses to sequentially energize said discharge paths in accordance with said impulses in a condition in which only one of said paths is rendered conductive at a time.

2. An electronic counting network as set forth in claim 1 wherein said anode fingers are spaced around a first periphery and said cathode fingers are spaced around a second and concentric periphery.

3. An electronic counting network as set forth in claim 2 wherein said anode and cathode fingers are easily spaced around their respective peripheries.

4. An electronic counting network responsive to applied impulses and comprising a gaseous discharge device provided with a plurality of cathode fingers and a like plurality of anode fingers, said anode and cathode fingers being spaced along respective concentric peripheries, each anode finger being arranged adjacent to its corresponding cathode finger to form a discharge path therewith, a source of operating potentials for said paths, and a resistance-capacitance circuit connected across said paths and coupled to said source, said circuit being responsive to said applied impulses to sequentially energize said discharge paths in a selected direction in accordance with said impulses in a condition in which only one of said paths is rendered conductive at a time.

5. An electronic counting network as set forth in claim 4 wherein said discharge paths are sequentially energized in a selected one of two given directions, said network further including switching means coupled between said circuit and said discharge paths to select said selected one direction.

6. An electronic counting network as set forth in claim 4 wherein said paths are sequentially energized in a clockwise direction.

7. An electronic counting network as set forth in claim 4 wherein said paths are sequentially energized in a counter-clockwise direction.

8. An electronic counting network responsive to applied impulses and comprising a gaseous discharge device provided with a plurality of cathode fingers and a like plurality of anode fingers, each anode finger being arranged with respect to its corresponding cathode finger to form a discharge path therewith, means connecting each of said anode fingers to selected other anode fingers to form a plurality of anode sections and means connecting selected ones of said cathode fingers to selected other cathode fingers to form a first plurality of cathode sections, said unselected cathode fingers constituting a second plurality of cathode sections; a source of operating potentials for said device, a resistance-capacitance circuit coupled between said source and said cathode and anode sections and responsive to applied impulses to sequentially energize said discharge paths in accordance with said impulses in a condition in which only one of said paths is rendered conductive at a time.

9. An electronic counting network as set forth in claim 8 wherein each of said second plurality of cathode sections constitutes a carry electrode.

10. An electronic counting network as set forth in claim 9 wherein each discharge path which is formed in conjunction with one of said second plurality of cathode sections is designated as an index point.

11. A discharge device comprising a gas-filled envelope, an anode system mounted within said envelope and constituted by a plurality of discharge fingers, and a cathode system mounted within said envelope and constituted by a like plurality of discharge fingers, each anode finger being arranged with respect to its corresponding cathode finger to form a discharge path therewith.

12. A discharge device comprising a gas-filled envelope, an anode system mounted within said envelope and constituted by a plurality of discharge fingers spaced along a first periphery, and a cathode system mounted within said envelope and constituted by a like plurality of discharge fingers spaced along a second and concentric periphery, each anode finger being arranged adjacent to its corresponding cathode finger to form a discharge path therewith.

13. A discharge device as set forth in claim 12 wherein the cathode and anode fingers are equally spaced around their respective peripheries.

14. In apparatus adapted for operation with a source of operating potential and responsive to incoming impulses, a first series circuit including in the order named a first resistance, a first set of electric valve elements and a first unidirectional conductor, a second series circuit connected across said first circuit and including in the order named a second unidirectional conductor, a second set of electric valve elements and a second resistance, said first and second sets being contained within a common envelope, and first and second capacitive members, said first member coupled between the junction of said first resistance and said first set and the junction of said second conductor and said second set, said second member coupled between the junction of said first set and said first conductor and the junction of said second set and said second resistance.

15. In apparatus adapted for operation with a source of operating potential and responsive to incoming impulses, a first series circuit including in the order named a first resistance, a first set of electric valve elements and a first unidirectional conductor, a second series circuit connected across said first circuit and including in the order named a second unidirectional conductor, a second set of electric valve elements and a second resistance, said first and second sets being immersed in a common atmosphere, and first and second capacitive members, said first member coupled between the junction of said first resistance and said first set and the junction of said second conductor and said second set, said second member coupled between the junction of said first set and said first conductor and the junction of said second set and said second resistance.

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