

April 1, 1952

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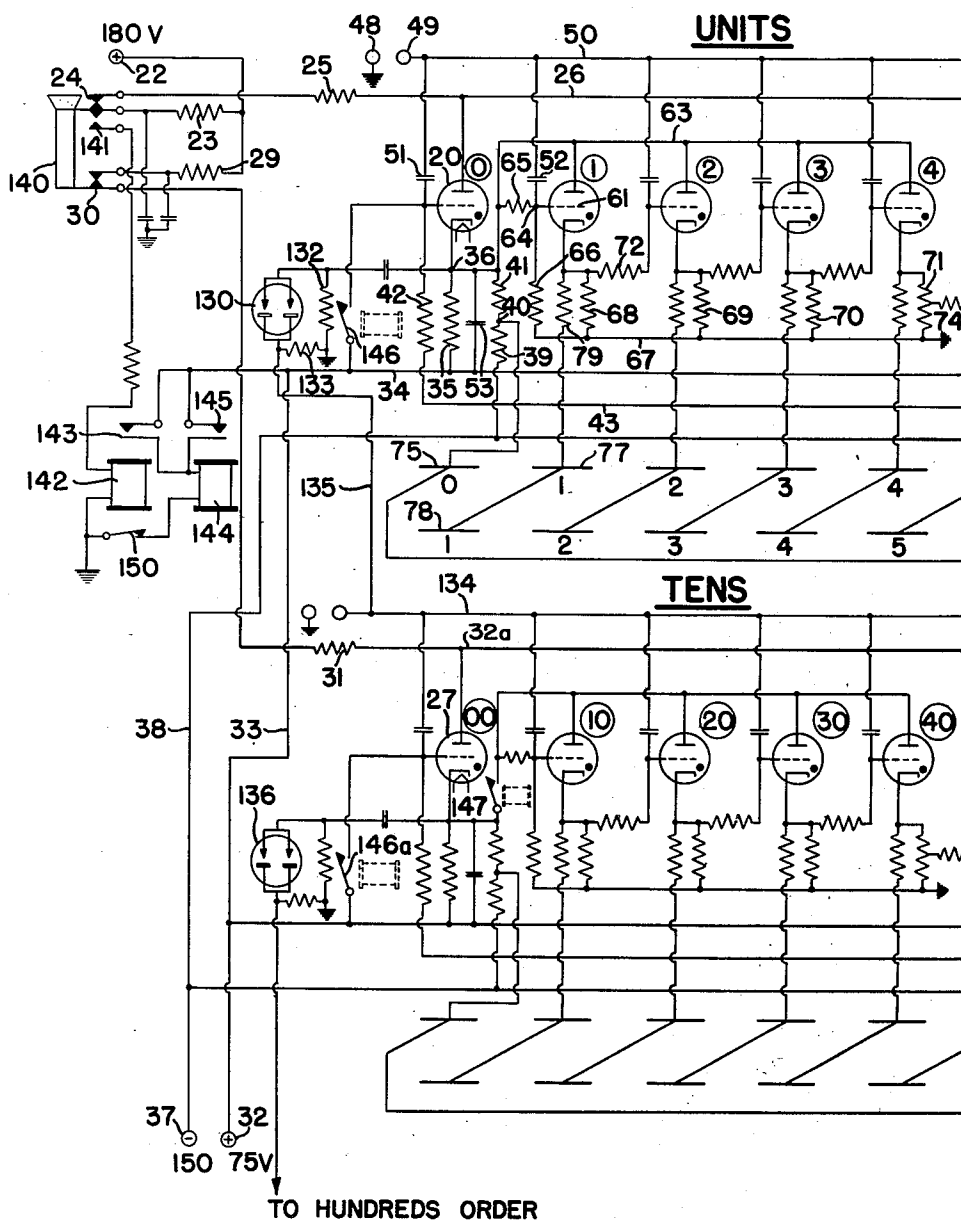
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ELECTRONIC ACCUMULATOR

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FIG. 1A



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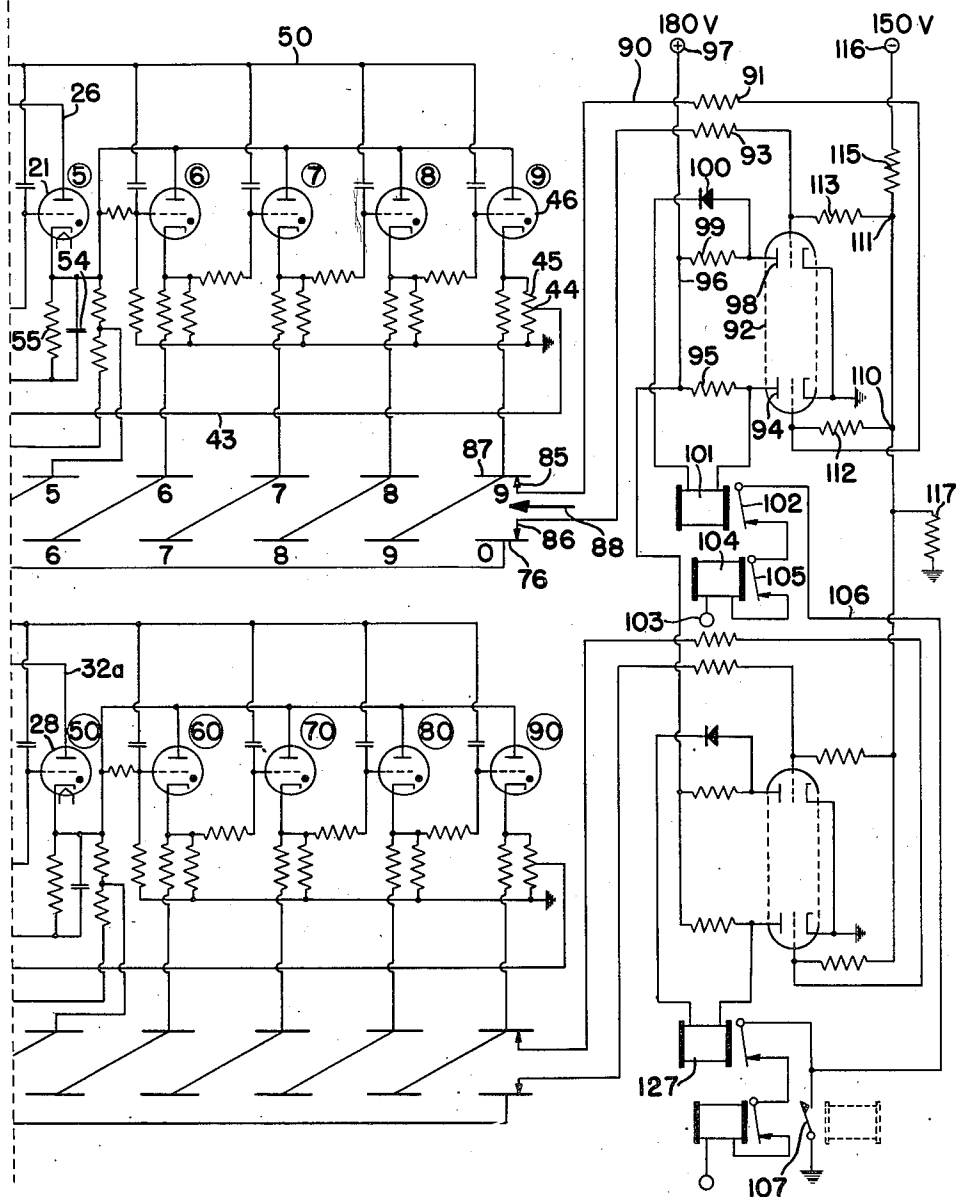
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FIG. 1B



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FIG. 2

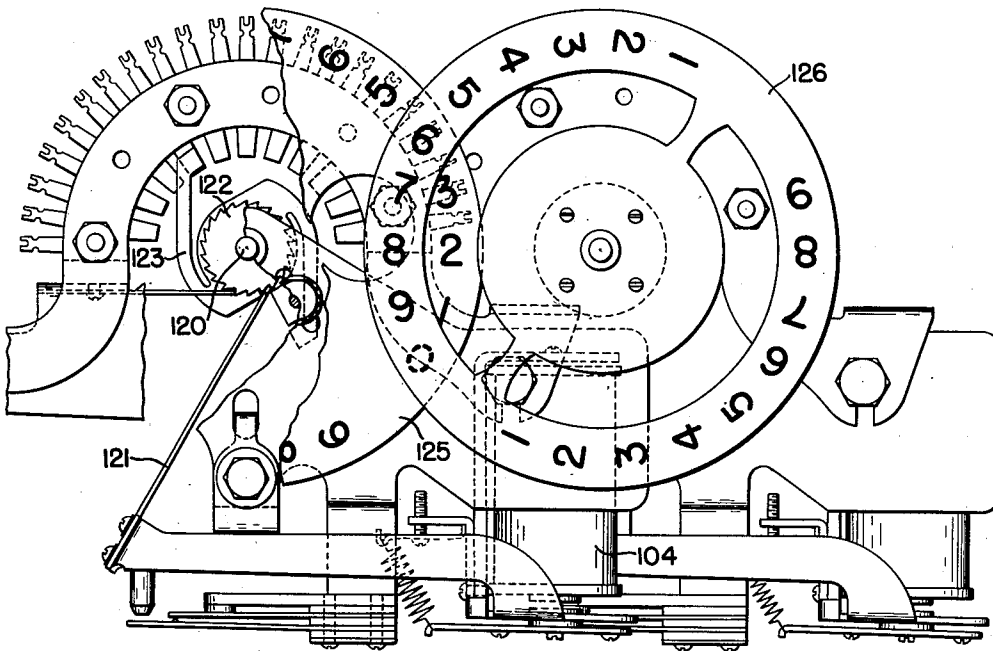
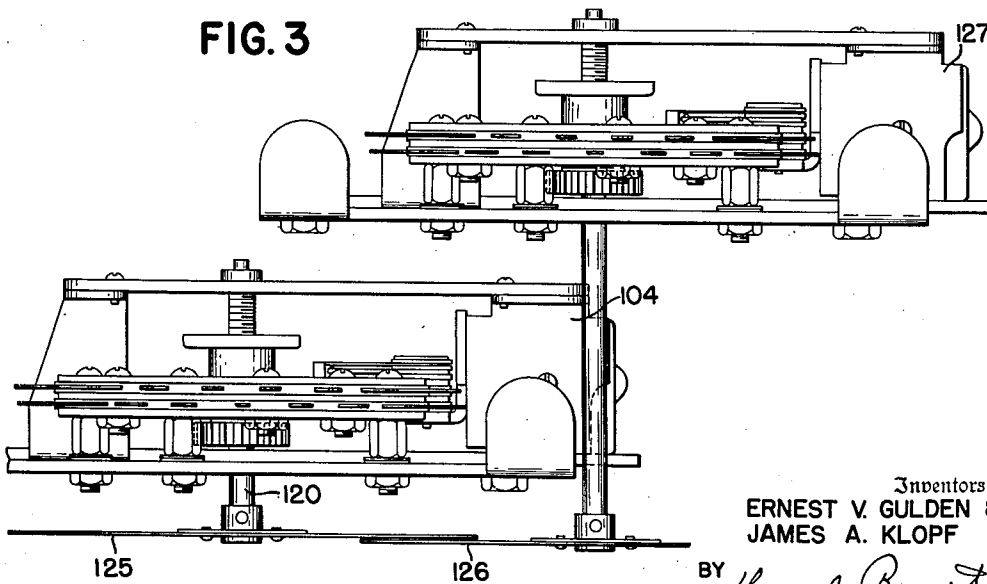


FIG. 3



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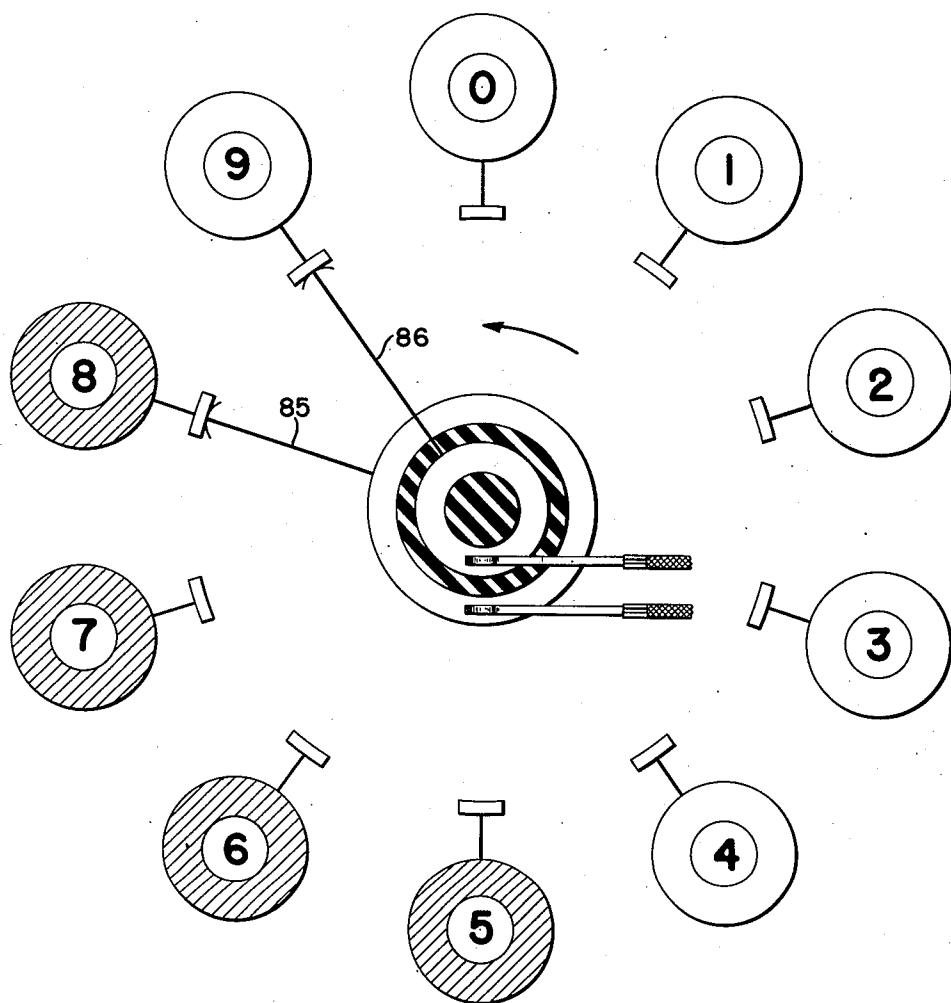
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FIG. 4



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ELECTRONIC ACCUMULATOR

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Application January 15, 1949, Serial No. 71,062

12 Claims. (Cl. 235-92)

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This invention relates to an electronic accumulator of the type wherein there is provided an electron tube for each digit of a denominational order, the tubes being rendered conducting serially in response to commonly received electric impulses which are to be counted.

Ordinarily such devices consist of gaseous triode electron tubes joined into a ring, cathode of one tube to control element of the next, for priming. Moreover such devices ordinarily have the control elements of the tubes coupled to a common input conductor which receives electric impulses to be counted, and the tubes are otherwise coupled to potential sources so that the tubes are rendered conducting one at a time, by impulses, the act of a tube becoming conducting extinguishing the previously conducting tube. Any such extinguishing action must persist long enough so the tube to be extinguished becomes deionized to the point where its control element may regain control and keep the tube from reigniting.

The deionization time of a tube is, therefore, a determining factor in the impulse acceptance rate of the accumulator. It has prevented the use of cold cathode types of gaseous triode tubes in such conventional circuits if counts of over 500 per second are to be made.

This invention provides a device differing from the general type outlined above in that a great majority of the tubes are of the cold cathode gaseous triode type yet accepting impulses at the rate of about 4500 to 5000 per second. This novel device has one tube for each digit of a denomination and they are joined in serial fashion, into a ring, by cathode-control element connections between adjacent tubes. The tubes are rendered conducting in succession by commonly received impulses but, contrary to previously known devices, are extinguished in groups.

As will be disclosed, in a decimal denominational order there are ten digit-representing tubes, those representing "0" and "5" being of the hot cathode type and the others being of the cold cathode type. In the zero condition the "0" tube only is conducting. The received impulses successively fire the tubes so that after the receipt of four impulses the tubes representing "0," "1," "2," "3," and "4" will be left conducting. On receipt of the fifth impulse the "5" tube will become conducting and will extinguish the "0" tube which supplies anode potential to the "1," "2," "3" and "4" tubes only when it is conducting and, hence, the "1," "2," "3" and "4" tubes also are extinguished. The act of the "5" tube con-

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ducting supplies anode potential to the "6," "7," "8" and "9" tubes which may then be fired in order as more impulses are received. The tenth impulse fires the "0" tube and it in turn causes extinguishing of the "5" tube and tubes "6," "7," "8" and "9," and also supplies anode potential to the "1," "2," "3" and "4" tubes. Thus the tubes operate in endless chain fashion as a counting ring.

Each group of extinguished tubes has a chance to deionize without interference for five impulse intervals which accounts for the tremendous gain in impulse acceptance rate over the conventional rings employing all cold cathode tubes.

Novel means is shown for visually indicating the amount standing in the accumulator but such indicator is claimed in applicant Klopff's copending application for U. S. Letters Patent Serial No. 95,360, which was filed May 25, 1949.

Therefore, it is the principal object of this invention to provide a counter or accumulator of electrical impulses of high acceptance characteristics which employs, for the majority of its digit-representing electron tubes, cold cathode gaseous triodes.

Another object of the invention is to provide such an accumulator in which the digit-representing tubes of a denominational order are divided by circuits into groups wherein the tubes forming a group are automatically extinguished after sequential conduction begins in the next group.

Another object of the invention is to provide such an accumulator wherein the groups of tubes operate sequentially.

With these and incidental objects in view, the invention includes certain novel features of construction and combinations of parts, a preferred form or embodiment of which is hereinafter described with reference to the drawings which accompany and form a part of this specification.

Of the drawings:

Figs. 1A and 1B, together, show a complete circuit diagram embodying the invention.

Figs. 2 and 3 are, respectively, a broken elevation and a plan view of a mechanism adapted to scan indicator contacts shown in Figs. 1A and 1B.

Fig. 3 is a functional diagram of the working of the indicator contact scanning means.

All electric potentials given will be with respect to ground potential.

Referring to the "units" denominational order in Figs. 1A and 1B, two hot cathode gaseous triode electron tubes are shown, tube 20 representing "0" and tube 21 representing "5" of the

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decimal notation, the cathodes of said tubes being heated by conventional means shown only diagrammatically. All of the other tubes of the denomination are cold cathode gaseous triodes. Anode potential is supplied to the hot cathode tubes from positive 180 volt source 22 through resistor 23 of 500 ohms, normally closed contacts 24, resistor 25 of 500 ohms, and conductor 26. The same potential source 22 supplies the hot cathode tubes 27 and 28, respectively, representing the "00" and the "50" in the tens denominational order, through resistor 29 of 500 ohms, normally closed contacts 30, resistor 31 of 500 ohms and conductor 32a. The cathode of the "0" tube 20 is connected on one side to terminal 32, supplied with 75 volts positive potential, through conductors 33 and 34, resistor 35 of 10,000 ohms and point 36, and is connected on the other side to terminal 37, supplied with 150 volts negative potential, through conductor 38, resistor 39 of 1 megohm, point 40, and resistor 41 of 500,000 ohms. The grid of the "0" tube receives its bias potential through resistor 42 of 250,000 ohms and conductor 43 which is connected to a point 44 on resistor 45 such that point 44, which practically will be at ground potential when the "9" cold cathode tube 46 is not conducting, will be at about 65 volts positive when it is conducting, to prime the "0" tube to be responsive to an input impulse.

The hot cathode digit-representing tubes taken as an example have characteristics of the 6D4 type of tube manufactured at present by Sylvania Electric Products Inc. and the cold cathode digit-representing tubes have characteristics of the OA4G tubes manufactured by the Radio Corporation of America.

The input impulses are applied across terminals 48 and 49 for the units order, positive pulses of sharp wave front and of about 50 volts amplitude being sufficient. All of the grids of the units denomination tubes are coupled to input conductor 50 by means of a capacitor. Capacitor 51 is rated at 10 micro-microfarads and is representative of those used in conjunction with the hot cathode digit-representing tubes and capacitor 52 rated at 500 micro-microfarads is representative of those used in conjunction with the cold-cathode digit-representative tubes.

Under the above circumstances the "0" tube will fire on receipt of an impulse if the "9" tube is conducting. As will appear, if the "9" tube is conducting the "5" tube is conducting also, as the "5" tube is of the group including the "9" tube. Upon the "0" tube firing, capacitor 53, of .01 microfarad, in the cathode supply circuit charges through the "0" tube causing a sharp drop in the potential of anode supply conductor 26, due to resistor 25, causing extinguishing of the "5" tube, because as the cathode condenser 54 of the "5" tube was discharging, upon the "5" tube becoming conducting, the resultant potential drop across resistor 55 caused a rise in potential of the cathode which is maintained for a short while by the capacitor 54 when the extinguishing drop in potential of the anode supply conductor occurs. The "5" tube has potential supplies and circuit elements like the "0" tube, so that when the "5" tube is next fired, the "0" tube is extinguished.

As capacitor 53 associated with the "0" tube becomes discharged the resistance in the cathode circuit of that tube will cause a rise in potential of point 36 to about 80 volts positive which primes the starter anode, or control element, 61 of the

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"1" tube 60, whose circuits are next to be described, as well as furnishing anode potential to tubes "1," "2," "3" and "4."

The anodes of all the cold cathode tubes "1," "2," "3," and "4" are directly connected to conductor 63 which receives its potential from point 36. The starter anode 61 of the "1" tube has a potential determined by point 64 connected to ground conductor 67 through 300,000 ohm resistor 66 and connected to point 35 through 300,000 ohm resistor 65.

The cathodes of the tubes "1," "2," "3" and "4" are each connected to ground conductor 67 through a 50,000 ohm resistor, such being numbered 68, 69, 70 and 71 respectively.

The cathode of the "1" tube is connected to the starter anode of the "2" tube through resistor 72 of 250,000 ohms. Similar connections exist between the cathode of tube "2" and the starter anode of tube "3" and between the cathode of tube "3" and the starter anode of tube "4."

As each tube conducts it primes the next tube to become conducting on the next impulse to be counted. After four impulses tubes "0," "1," "2," "3" and "4" will be conducting, indicating a count of four.

The second group of tubes in the units order includes the hot cathode "5" tube and the "6," "7," "8" and "9" tubes which are of the cold cathode type.

Tubes "5," "6," "7," "8" and "9" are connected in the same kind of operative system as just described in connection with tubes "0," "1," "2," "3" and "4," the "5" tube being primed by the cathode rise of the "4" tube as it becomes conducting, through resistor 74 of 250,000 ohms connected to resistor 71 at a point to give the proper bias to the control grid of the "5" tube. As tube "5" becomes conducting the "0" tube and the "1," "2," "3" and "4" tubes become extinguished. Further impulses cause conduction in tube "6," "7," "8" and "9" successively. Conduction in tube "9" primes the "0" tube through conductor 43 as has been explained.

Following is a table representing the condition of the tubes of the units order as the digits of the order are represented.

Digit	Tubes Conducting									
	0	1	2	3	4	5	6	7	8	9
0	X									
1	X	X								
2	X	X	X							
3	X	X	X	X						
4	X	X	X	X	X					
5						X				
6						X	X			
7						X	X	X		
8						X	X	X	X	
9						X	X	X	X	X

X = Tube conducting.

Contacts are provided to represent each digit-representing tube of a ring, the potential on contacts representing a tube being more positive when the associated tube is non-conducting. Thus, the "0" tube is represented by contacts 75 and 76 connected to point 40 between resistors 41 and 39. The "1" tube is represented by contacts 77 and 78 connected through resistor 79 of 500,000 ohms to the cathode of the "1" tube. The contacts for all conducting tubes have the same potential and the contacts for all non-conducting tubes have the same potential. It is for this reason that the resistance connections of the contacts to the cathode of the hot-cathode

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"0" tube are different from the connections of the contacts to the cathode of the cold cathode "1" tube. The "5" tube contacts are connected in a manner similar to those of the "0" tube, and the "2," "3," "4," "6," "7," "8" and "9" tube contacts are connected in a similar manner to those of the "1" tube. The tubes cannot be scanned through their contacts one at a time to determine the digit count as reference to the above table will show that conduction in a single tube is no evidence that that tube represents the count. Provision is made for scanning the contacts of two adjacent tubes at the same time, such scanning proceeding from the higher to the lower digit values. Such a scanning is shown diagrammatically in Figs. 1A and 1B wherein brushes 85 and 86 are shown at a position where brush 85 is standing on a "9" contact 87 and brush 86 is standing on a "0" contact 76. The scanning proceeds in the direction of the arrow 88, cyclically traversing all the contacts and commencing over, as may be accomplished by multiple level rotary scanning switches such as shown in Figs. 2 and 3.

Fig. 4 is a diagrammatic representation of the scanning system and the method of interpreting the sensed data. The numbered circles arranged in a ring represent the digit-representing tubes of a denomination, here the units denomination, and the shaded circles represent conducting tubes. As is evident from the table, the diagram represents an accumulation of eight, inasmuch as the "5," "6," "7" and "8" tubes are conducting. Scanning brushes, insulated from one another, but rotating without angular change with respect to one another, in the direction of the arrow, have come to a point where brush 85 is at a high potential with respect to brush 86 as tube "8" is conducting and tube "9" is non-conducting. Under such circumstances, as will be shown, the scanning will stop and a mechanical indicator rotating with the brushes will indicate nine at a viewing position.

Returning to Fig. 1B, it is seen that brush 85 is connected by conductor 90 through a 500,000 ohm resistor 91 to one of the grids of a duodiode amplifier 92 which may be of the 6J6 type. The other grid of the amplifier 92 is connected through a 500,000 ohm resistor 93 to the brush 86. The common cathode of the amplifier is grounded. Anode 94 is connected through resistor 95 of 15,000 ohms to conductor connected to terminal 97 supplied with 180 volts positive potential. Anode 98 is also connected to conductor 96 through a resistor 99 of 15,000 ohms. Anode 98 is connecting to anode 94 through a rectifier 100 and solenoid 101. Current passing through the solenoid 101 opens normally closed switch 102 breaking a stepping switch motor circuit traced from potential supply terminal 103 through solenoid 104, make and break stepping switch 105, normally closed switch 102, conductor 106 and normally open switch 107, when closed, to ground. The rectifier is so oriented that current only passes through solenoid 102 when the electron flow is from the cathode of the amplifier tube to anode 94 controlled by the grid connected to brush 85 and at the same time there is no electron flow from the cathode to anode 98 controlled by the grid connected to brush 86. Brush 86 is always scanning a contact of a tube lower in value than brush 85. Both grids are given the same bias through being respectively connected to points 110 and 111 through 500,000 ohm resistors 112 and 113.

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Points 110 and 111 normally have a potential of 12 volts negative being connected through 50,000 ohm resistor 115 to 150 volt negative terminal 116, and through 3,900 ohm resistor 117 to ground. As the brushes pass over the contacts, any contact associated with a conducting tube will convey sufficient potential to the associated grid to permit electron flow to the associated anode.

Under any circumstances, wherein the denominational order represents a digit, there is but one scanning position wherein the leading brush 85 senses a contact of a conducting tube and the trailing brush 86 does not. Therefore, the scanning will stop at the registered number.

Referring to Figs. 2 and 3, the stepping motor solenoid 104 (see also Fig. 1B), of the self-actuating type, turns shaft 120 through the reciprocating action of member 121 on ratchet wheel 122, in a manner well known in the art. Two wiper arms, like arm 123 are attached to shaft 120 and each scans a set of contacts which are wired in staggered relationship as shown for the pairs of contacts representing the digit tubes of Figs. 1A and 1B. The wiper arms are the brushes 85 and 86 as described. When a situation arises in the scanning operation which opens the switch 102 the scanning will stop and a dial indicator 125, having digit indicia arranged thereon, will indicate the number registered in the denominational order. A similar indicating means is provided for the tens denominational order to be described, the tens dial 126 and driving motor solenoid 127 being shown in Figs. 2 and 3.

The tens denominational order of the accumulator, shown in Figs. 1A and 1B, is the same in every respect to the units denominational order except provision is made for the entry of carry-over data transferred to it from the units order as the units order passes from nine to zero.

A carry-over device or transfer tube 130, which may be a duodiode of the 6AL5 type with the two anodes connected and the two cathodes connected, has its anodes coupled to the cathode point 36 of the "0" tube through capacitor 131 of .01 microfarad, and is connected to ground through resistor 132 of 500,000 ohms. The cathodes are connected to ground through resistor 133 of 100,000 ohms, and are connected to the input conductor 134 of the tens order by means of conductor 135. Upon the "0" tube 20 becoming conducting the sudden rise in potential of point 36 is transmitted through diode 130, as an impulse, to step the tens order along by one count. A similar diode 136 is provided to be operated by operation of the "00" tube 27, when it becomes conducting, to transfer a unit to a hundreds order.

Provision is made for resetting the device to a "cleared" or "zero" condition through the operation of a reset key 140 (Fig. 1A) which opens contacts 24 and 30, depriving the anodes of the hot cathode digit tubes of potential, thus extinguishing all the digit representing tubes. At the same time contact 141 is connected to terminal 22, operating solenoid 142 which closes contacts 143 which operates solenoid 144 to close contacts 145, forming a holding circuit. Solenoid 144 when operated closes normally open switch 107 (Fig. 1B) to energize the indicator. Solenoid 142 in addition to operating solenoid 144 closes normally open switches 146 and 146a (Fig. 1A) connecting the grids of the zero tubes to the 75 volt positive conductor 33, and opens normally closed switch 147. If, now, reset key

140 is returned to normal position shown in Fig. 1A, the zero tubes will become conducting as the time lag of solenoid 142 holds switches 145, 146a and 147 in the moved position for an instant after anode potential is restored through contacts 24. Switch 150 may be temporarily opened to release solenoid 144 and open switch 167 any time it is desired to disable the indicator.

It will be apparent that the circuits are so constituted that the hot cathode gaseous triode tubes may be substituted for any of the cold cathode tubes specified and that the groupings of the tubes may be of a size other than five to a group.

What is claimed is:

1. An electric impulse counter including, in combination, a plurality of digit-representing tubes, each having at least an anode, a cathode, and a control element; means connecting the cathode of each tube to the control element of another tube to form an operative chain and including a resistance for each cathode for controlling the control element potentials to the tubes; means coupling each control element to a common input conductor to enable input impulses to be applied to all the tubes; and means supplying anode potential to the tubes by groups, each group of which includes a plurality of adjacent tubes in the chain with the last tube of a group chain-coupled to the first tube of the next group, said anode potential supply means including the first tube in each group which, when operated, supplies operating potential to the remaining tubes of the group and including extinguishing means between the first tubes in each of the several groups to enable conduction beginning in a group to extinguish the first tube and thereby conducting tubes in a previous group in the chain, whereby on receipt of electric impulses on the input conductor the tubes in the chain will become conducting one at a time in sequence and as the action of becoming conducting leaves a preceding group and commences in the next group, the tubes in the said preceding group become extinguished.

2. The device of claim 1 in which the first tube of a group in the act of conducting causes the other tubes of the group to become operable in sequence in response to said input impulses.

3. The device of claim 2 in which the anodes of all but the first tube of a group are connected together and to the cathode of the said first tube of the group.

4. The device of claim 3 in which the first tube of the group is of the hot cathode type and the rest of the tubes of the group are of the cold cathode type.

5. The device of claim 1 in which there are two groups of five tubes each.

6. The device of claim 1 in which the first tube of each group is of the hot cathode type and the rest of the tubes of each group are of the cold cathode type.

7. The device of claim 1 in which the extinguishing means includes a common anode potential supply for the first tubes of the groups and a resistance in the supply common to said first tubes; a capacitor in the cathode potential supply of each of said first tubes; and a connection between the cathode of each of said first tubes and the anodes of the tubes of its associated group.

8. The device of claim 1 in which there are two groups of five tubes each to represent the

digits of the decimal notation, the first tube of a first group representing zero.

9. The device of claim 1 in which all tubes but the first tube in each group are of the cold cathode type and said first tubes are of the hot cathode type.

10. An electric impulse counter including, in combination, a plurality of digit-representing tubes, each tube having at least an anode, a cathode, and a control electrode; means supplying anode potential to the tubes by groups, each group including a plurality of adjacent digit-representing tubes, said means including a circuit to supply anode potential to the first tube in each group, which circuit includes extinguishing means whereby conduction in the first tube of a group extinguishes the first tube of another group, and said means including a connection from the cathode of the first tube of a group to the anodes of the other tubes of the group to supply anode potential thereto when the first tube conducts; means to connect the cathode of each tube to the control electrode of another tube to form an operative chain, the connections between tubes in a group enabling the tubes to be operated one after another after the first tube has operated, and the connection between the last tube of a group and the first tube of the following group enabling the sequential operation of the groups to take place; a cathode circuit for each tube, each of said cathode circuits including a resistor whereby conduction in a tube can prime the next tube in the sequence to respond to input impulses and conduction in the first tube can also cause operating potential to be supplied to the other tubes of the group; and means coupled to the control electrodes to apply input impulses to the tubes to cause any primed tube to conduct; said anode potential supply circuits and cathode-to-control-electrode circuits cooperating to cause counting to take place sequentially in a group and in the groups in sequence, the act of conduction beginning in the first tube of a group causing the tubes of the preceding group to be extinguished, whereby the counting operation can continue in a succeeding group while the preceding group is recovering from an extinguishing action.

11. An electric impulse counter including, in combination, a plurality of digit-representing tubes, certain of said tubes being of the hot cathode type and others of said tubes being of the cold cathode type and each tube having at least an anode, a cathode, and a control electrode; means supplying anode potential to the tubes by groups, each group including a plurality of adjacent digit-representing tubes of which the first tube is a hot cathode tube and the remaining tubes are cold cathode tubes, said means including a circuit to supply anode potential to the hot cathode tube in each group, which circuit includes extinguishing means whereby conduction in the hot cathode tube of a group extinguishes the hot cathode tube of another group, and said means including a connection from the cathode of the hot cathode tube of a group to the anodes of the cold cathode tubes of the group to supply anode potential thereto when the hot cathode tube conducts; means to connect the cathode of each tube to the control electrode of another tube to form an operative chain, the connections between tubes in a group sequentially priming the tubes to enable the tubes in a group to be operated one after another after the hot cathode tube has operated, and the connection

between the last cold cathode tube of a group and the hot cathode tube of the following group enabling the sequential operation of the groups to take place; a cathode circuit for each tube, each of said cathode circuits including a resistor whereby conduction in a tube can prime the next tube in the sequence to respond to input impulses and conduction in the hot cathode tube of a group can also cause operating potential to be supplied to the cold cathode tubes of the group; and means coupled to the control electrodes to apply input impulses to the tubes to cause any primed tube to conduct; said anode potential supply circuits and cathode-to-control-electrode circuits cooperating to cause counting to take place sequentially in a group and in the groups in sequence, the act of conduction beginning in the hot cathode tube of a group causing the tubes of the preceding group to be deionized, whereby the counting operation can continue in a succeeding group while the tubes of the preceding group are being deionized and made ready for a further counting operation.

12. An electric impulse counter operable to count in the decimal notation including, in combination, a plurality of digit-representing tubes, one for each of the digits "0" and "1" through "9," each tube having at least an anode, a cathode, and a control electrode; means supplying anode potential to the tubes in two groups of five, one group including the digit-representing tubes "0" to "4" and the other including the digit-representing tubes "5" to "9," said means including a circuit to supply anode potential to the first tube in each group, the "0" and "5" tubes, which circuit includes extinguishing means whereby conduction in either the "0" tube or the "5" tube extinguishes the other, and said means including a connection from the cathode of the "0" tube to the anodes of the "1," "2," "3," and "4" tubes of one group and a connection from the cathode of the "5" tube of the other group to the anodes of the "6," "7," "8," and "9" tubes of that group, said "0" and "5" tubes, when conducting, supplying anode potential to the other tubes of their groups; means to connect the cathode of each tube to the control electrode of another tube to form an operative chain, the connections be-

tween tubes in a group enabling the tubes to be operated one after another after the first tube has operated, and the connection between the "4" and "5" tubes and the "9" and "0" tubes enabling the sequential operation of the groups to take place; a cathode circuit for each tube, each of said cathode circuits including a resistor whereby conduction in a tube can prime the next tube in the sequence to respond to input impulses, and conduction in the "0" and "5" tubes can also cause operating potential to be supplied to the other tubes of their related groups; and means coupled to the control electrodes to apply input impulses to the tubes to cause any primed tube to conduct; said anode potential supply circuits and cathode-to-control-electrode circuits cooperating to cause counting operation of the tubes to take place sequentially in a group and in the groups in sequence, the act of conduction beginning in the "0" tube or the "5" tube causing the tubes of the other group to be extinguished, whereby the counting operation can continue in one group while the other group is recovering from an extinguishing action.

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