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RANDOM PULSE COUNTER

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FIG. 2.

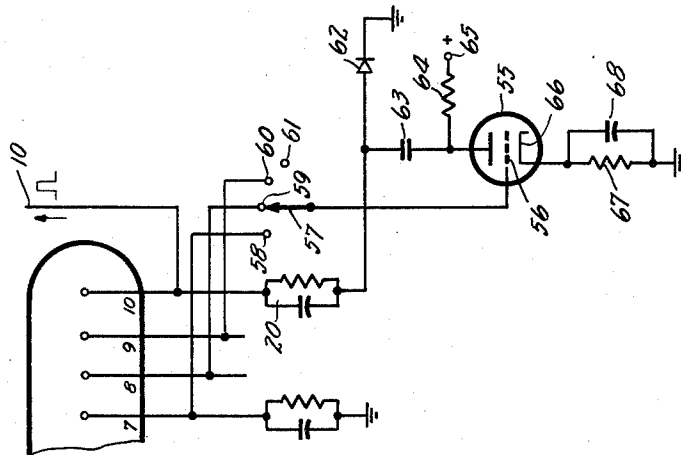
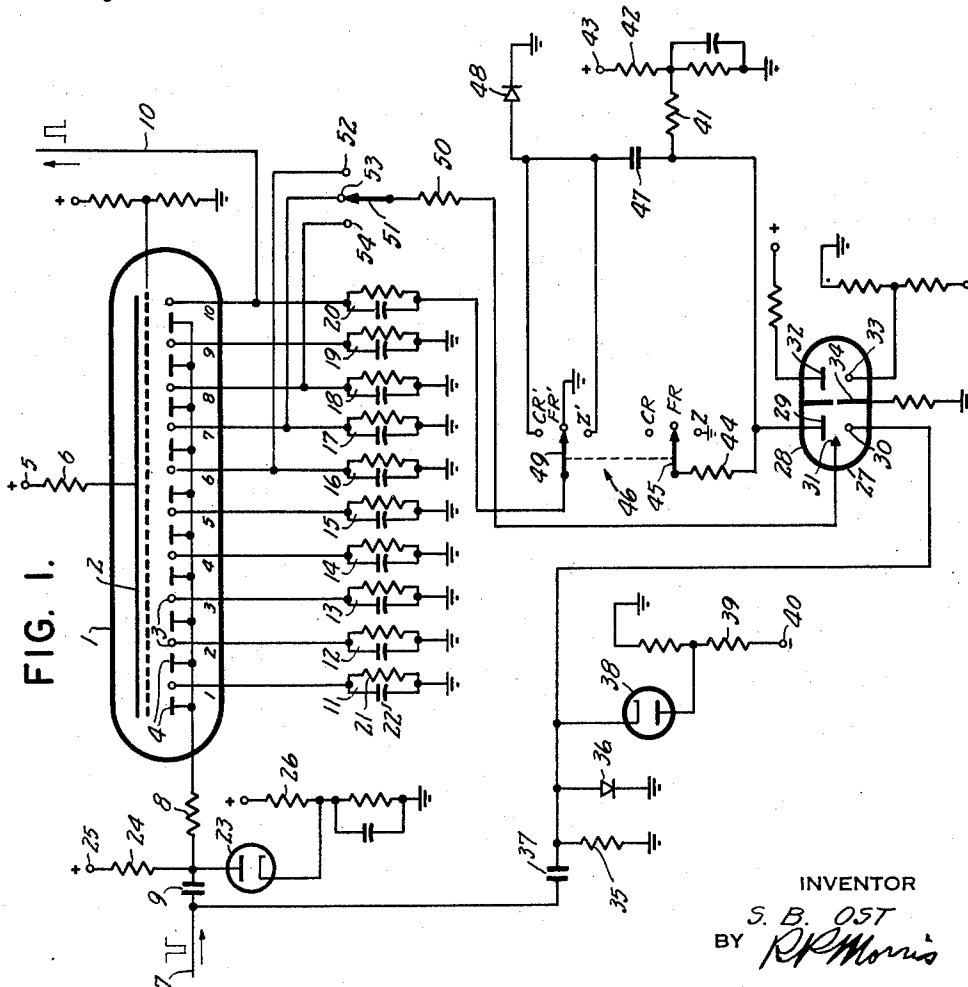


FIG. 1.



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2,860,286

RANDOM PULSE COUNTER

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This invention relates to pulse counters and particularly to a circuit arrangement by means of which the counting cycle may be changed at will.

One of the objects of the invention is to provide a circuit arrangement for a counter which will permit the adjustment of the circuit to change the counting cycle of the counter.

Another object of the invention is to provide a circuit arrangement for a pulse counter by means of which the circuit may be adjusted to count through its normal cycle or to count predetermined other cycles having different numbers of steps.

Still another object of the invention is to provide a circuit arrangement for a pulse counter by means of which the counter may be brought to a zero position or "zeroized" by the movement of a key or switch.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood, by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a circuit diagram, of a pulse counter showing the manner of changing the counting cycle; and

Fig. 2 is a circuit diagram of a portion of the circuit of Fig. 1 showing a modified arrangement for the counting cycle control.

Broadly the invention comprises a counting circuit of the gas tube type in which a discharge between an anode and a cathode is caused to step successively from one cathode to another in response to incoming random pulses, an output signal being produced when the discharge reaches a particular one of the cathodes, the circuit further comprising a trigger circuit which may be selectively connected to different ones of the cathodes and which when operated will produce a negative going pulse on a particular cathode to cause the discharge to jump to that cathode from whichever cathode has been selected, thus bypassing the intervening cathode and causing the counter to count a lesser number of pulses than would be true if all of the cathodes were used in succession.

Referring now more specifically to Fig. 1 of the drawing, the invention has been illustrated in connection with a gas counting tube 1 having an anode 2, a plurality of operating cathodes 3, and a plurality of transfer cathodes 4. These electrodes are positioned in an envelope which has a reduced atmosphere of gas and the electrodes are preferably arranged in a ring, so that the discharge may be stepped continuously from cathode to cathode.

The counting tube thus described may be the same as the tube shown in U. S. Patent No. 2,553,585 which is now being manufactured and sold under the tube designation G10/241E.

The anode 2 is connected to a source 5 of positive

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potential through a suitable dropping resistor 6. The transfer electrodes 4 are all connected together and are connected to an input circuit, indicated at 7, through a resistor 8 and coupling condenser 9. The cathodes 3 have been numbered 1 to 10, as indicated, and the number 10 cathode may be considered the output cathode and is connected to an output circuit 10, although of course any one of the cathodes may be used as an output cathode and may be connected to an output circuit. All of the cathodes, except the output cathode, are individually connected to ground through time constant circuits 11 to 20, each of which comprises a resistor 21 and a condenser 22.

In the operation of this counting tube, assuming a discharge to be taking place between one of the cathodes and the anode, a negative pulse from the input circuit 7 will be applied to the transfer cathode 4 adjacent the operating cathode 3 carrying the discharge and will cause the discharge to shift to the next succeeding operating cathode 3. The purpose of the time constant circuit connected to the cathode is to maintain a positive bias for a certain period of time on the cathode from which the discharge has just been shifted, so as to prevent the discharge from reappearing thereon instead of the next adjacent cathode.

The value of the condenser 22 in the time constant circuit of the cathode is important and somewhat critical. The value of the condenser depends on the counting rate. For stable operation below 1000 cycles per second, the condenser 22 is preferably given a value of .01 microfarad; between 1 and 5 kilocycles per second, the condenser is given a value of .005 microfarad; between 5 and 10 kilocycles per second, the condenser is given a value of .003 microfarad; and between 10 and 25 kilocycles per second, the condenser is given a value of .002 microfarad. The resistance has a value of 15,000 ohms.

Because of the fact that the circuit is adapted to count random pulses which may appear at different repetition rates, it is necessary to clamp the potential appearing on the transfer cathodes 4 within a predetermined range. This may be accomplished by means of a clamping diode 23 the anode of which is connected through a resistor 24 to a source of positive potential, indicated at 25, and also to the input connection for the transfer cathodes 4 between the condenser 9 and the resistor 8. The cathode of the diode 23 may be connected to a particular positive potential on a voltage divider circuit 26 connected between the positive source of potential and ground.

If the time constant circuit 20, connected to the output cathode number 10, were connected to ground, similarly to all of the other time constant circuits, the counting tube 1 would count 10 pulses and on the tenth pulse a positive output pulse would be produced on the output circuit 10. This is the normal counting cycle of the tube and the manner of connecting the time constant to ground will be described later. The manner in which this counting rate or cycle may be changed will now be described.

A circuit is provided which permits adjustment of the counting cycle, either manually or controlled by some outside circuit, and this circuit comprises a gas-filled trigger tube 27 of the type shown in U. S. Patent No. 2,631,261 and now manufactured and sold under the tube designation G1/370K. This tube comprises an envelope 28 containing a gas at reduced pressure and having an anode 29, a cathode 30, and a control electrode 31. These are the operating electrodes of the tube and when the circuit constants are properly arranged a positive potential on the control electrode 31 will cause a discharge between the anode 29 and cathode 30. The tube has another

anode 32 and cathode 33, separated from the other electrodes by a screen 34 having an aperture therein through which photons from the discharge between the anode 32 and cathode 33 pass to the ionization path between the anode 29 and the cathode 30. This makes the tube much faster in operation and substantially independent of outside light. The cathode 30 is connected to ground through a resistor 35 which is shunted by a rectifier 36 and is also connected to the input circuit 7 through a coupling condenser 37.

In order to maintain a bias on the cathode 30 and hold the potential delivered thereto within predetermined limits a clipping tube 38 is provided with its cathode connected to the cathode 30 and its anode connected to a voltage divider circuit 39 which is connected between ground and a source of negative potential, indicated at 40. The clamping rectifier 36 insures that the cathode 30 of the tube 27 will never get more positive than ground potential. Clipper 38 insures that cathode 30 will never get more negative than the potential supplied by the voltage divider 39, because of the action of the diode tube 38.

The anode 29 of the tube 27 is connected through a dropping resistor 41 to a point on the voltage divider circuit 42 which is connected between a source of positive potential, indicated at 43, and ground. The anode 29 is also connected through a resistor 44 to one arm 45 of a switch 46 which has three selectable contacts labeled "CR," "FR," "Z." The anode 29 is also connected through a coupling condenser 47 and a rectifier 48 to ground, the junction between the condenser 47 and the rectifier 48 being connected to the contacts CR' and Z' which cooperate with a second arm 49 of the switch 46. The contacts CR and FR, cooperating with the switch arm 45, are not connected to anything, but the contact Z, cooperating with the switch arm 45, is connected to ground. The contact FR', which cooperates with the switch arm 49, is connected to ground.

The control electrode 31 of the tube 27 is connected through a resistor 50 to a switch arm 51 which cooperates with a number of contacts, indicated as 52, 53, 54, which are connected, respectively, to operating cathodes number 6, number 7, and number 8 of the counting tube 1.

Assuming that the switch 46 is in the center position with its arms 49 and 45 connected respectively to the contacts FR' and FR, it will be seen that the arm 49 of the switch is connected to ground which connects the time constant circuit 20 of the cathode number 10 of the counting tube to ground. Arm 45 of the switch 46 is not connected to anything. Since all of the time constant circuits 11 to 20 of the counting tube 1 are connected to ground, successive negative pulses received over the input circuit 7 and thus transmitted to the transfer electrodes 4 will cause the discharge to step successively from cathode to cathode until the number 10 cathode is reached, when a positive impulse will be sent over the output circuit 10. Successive negative impulses, received over the input circuit, will then cause the discharge to step to 1 and successively from cathode to cathode until the number 10 cathode is again reached. It will thus be seen that an output pulse is produced at every tenth input pulse received, and the tube will continue thus to count every ten input pulses as long as the switch 46 is on the contact FR'.

Now let us assume that it is desired to cause the tube 1 to count 8 pulses instead of 10. The switch 51 is then set on the contact 53, as shown. Switch 46 is set to CR position. Cathode number 7 of the tube 1 will then be connected to the control electrode 31 of the tube 27. The cathode 30 of this tube is also connected to the input circuit 7 to receive the negative input pulses. The application of a negative pulse on the cathode 30 each time an input pulse is received will permit the tube 27 to operate if at that time a positive pulse is received on its control electrode.

The tube 1 will then continue to count as the input pulses are received, the discharge stepping from cathode to cathode until the discharge reaches cathode number 7. Nothing happens at the tube 27 prior to this, since its control electrode does not receive any positive pulse while the discharge is on the previous cathodes of tube 1. When, however, the discharge reaches cathode number 7, a positive pulse is delivered to the control grid of the tube 27. However, since there is a slight delay between the time an input pulse is received by the tube 1 and the time the next cathode receives the discharge, there will be no negative potential on the cathode 30 of tube 27, and hence this tube cannot operate. The time constant circuit 17 which is connected to the cathode number 7 of tube 1 will maintain a positive potential on this cathode after the discharge has left it. Accordingly this positive potential still remains on the control electrode 31 of tube 27 after the input pulse which has produced the discharge on cathode number 7 of tube 1 has disappeared, and will remain until input pulse number 8 is received. This input pulse will drive the cathode 30 of tube 27 negative and will thus cause the tube to fire. The anode will then be suddenly reduced in potential which sends a negative pulse through coupling condenser 47, contact CR', and switch arm 49, to the time constant circuit 20 of cathode number 10 of the tube 1. This drives the cathode number 10 sufficiently negative and sufficiently so to cause the discharge, which was on cathode number 7, to jump to cathode number 10, thus producing an output positive pulse on the eighth input pulse. It will be noted that since the switch arm 45 is not connected to anything, it has no effect on the circuit. Also rectifier 48 prevents the negative pulse produced by the tube 27 from dissipating to ground, because of its polarity.

It will be evident that the switch 51 may have additional contacts connected to other cathodes of the tube 1. As shown, the other two contacts 52 and 54 of the switch 51 are connected to operating cathodes number 6 and number 8. If the switch 51 is therefore shifted to contact 52, the counting tube 1 will count 7 pulses, because when the discharge reaches cathode number 6, the control electrode 31 of tube 27 will be energized, and when the next or number 7 input pulse is received, the tube 27 will discharge and a negative pulse will be sent to cathode number 10 of the tube 1, thus causing the discharge to jump from cathode number 6 to cathode number 10 and creating an output pulse. Setting the switch 51 on contact 54 will cause the tube 1 to count 9 pulses, as will be clearly understood.

It may be desirable to cause the counting tube 1 to start from a zero position at any particular instant, which action may be referred to as "zeroizing" the tube. Means are therefore provided for causing the discharge to shift the cathode number 10, regardless of where it is situated in the tube. In order to accomplish this purpose the contacts Z and Z' are provided in cooperation with the arms 45 and 49 of the switch 46. If the discharge in tube 1 is on some cathode other than the one which is connected to the control electrode 31 of tube 27, this tube 27 will be rendered ineffective. However, by momentarily shifting the arm 45 of the switch 46 to the Z contact which is connected to ground, current will immediately flow from the voltage divider 42, through resistors 41 and 44, to ground, thus lowering the potential at the junction of coupling condenser 47 and resistor 41. This surge of lower potential produces a negative pulse through the coupling condenser 47 which passes through the contact Z and arm 45 of switch 46 to the time constant circuit 20 connected to the cathode number 10 of tube 1. This impulse will be sufficient to cause the discharge to jump to cathode number 10, regardless of its position in the tube. The next input pulse will then start the counter at 1.

While the "zeroizing" action of the circuit has been shown to return the discharge to cathode number 10

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of tube 1, it will be evident that any operating cathode may be used for this purpose, depending where it is desired to have the tube start counting.

In the circuit of Fig. 1 the zeroize or reset portion of the trigger circuit of tube 27 requires an additional input pulse to operate it, and therefore it is connected to, for example, the number 7 cathode of the tube 1 when it is desired to have the tube count eight pulses. A modified circuit arrangement is shown in Fig. 2 in which the trigger circuit is connected to the operating cathode having the same number as the number which it is desired to have the tube count. In this arrangement a 3 element electron discharge tube 55 is used instead of the gas tube 27 of Fig. 1. The control electrode 56 of this tube is then connected to a switch 57 having contacts 58, 59, 60 and 61, the contacts 58, 59 and 60 being connected respectively to operating cathodes number 7, 8 and 9 of the counting tube 1. The time constant circuit 20 of the cathode number 10 of tube 1 is connected to ground through a rectifier 62, and the junction of the time constant circuit 20 and rectifier 62 is connected through coupling condenser 63 to the anode of tube 55, the anode being also connected through a dropping resistor 64 to a source of positive potential, indicated at 65. The cathode 66 of tube 55 is connected to ground through a resistor 67 which is by-passed by a condenser 68.

In this arrangement, if it is desired to have the tube 1 count eight pulses, the switch 57 is placed on contact 59 which is connected to cathode number 8. When the discharge reaches cathode number 8 of tube 1, a positive potential appears on the control electrode 56 of tube 55 and the tube operates, thus causing a negative pulse to pass through the coupling condenser 63 to the cathode number 10 of tube 1 and thus shift the discharge to that cathode which sends a positive output pulse over the output circuit. The rectifier 62 is poled so that the negative pulse cannot dissipate to ground, while the discharge current of cathode number 10 can pass to ground.

If the switch 57 is placed on contact 58 which is connected to the number 7 cathode, the trigger circuit of the tube 55 will operate when the seventh pulse is received and the negative pulse will be sent to the cathode number 10 of tube 1 to shift the discharge to that cathode and deliver an output pulse. Placing the switch on contact 60 will cause the tube 1 to count nine pulses.

If it is desired to permit the counting tube 1 to run freely and count its normal ten pulses, the switch 57 may be moved to contact 61 which is not connected to anything, and the tube 55 will therefore be ineffective.

While a particular type of counting tube has been shown and described, it will be evident that other counting devices may be used with the invention. Instead of a single tube, for example, each discharge circuit may be in a separate tube with suitable circuit arrangements for causing the discharges to occur in succession in response to the input pulses. Also it will be evident that additional counting devices may be used in conjunction with the single one shown and the output of tube 1 of the figures may lead to an additional counting device for counting tens and the additional counting device may lead to still another counting device for counting hundreds and so on. The trigger circuit may be used with any one or all of these counters to obtain different counting effects. Also while a particular type of trigger tube has been shown in Fig. 1, it will be understood that other trigger circuits may be used to obtain the same results.

While I have described above the principles and other features of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention, as set forth in the objects thereof and in the accompanying claims.

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What is claimed is:

1. A circuit arrangement for repeatedly counting selected numbers of pulses comprising electron discharge counting tube means having first electrode means, a plurality of operating electrodes spaced from said first electrode means, one of said operating electrodes being an output electrode, circuit means including a resistor connected to each said operating electrode, an input circuit, means for causing an electron discharge to step from one operating electrode to a next succeeding operating electrode when a voltage pulse of a predetermined polarity and voltage is applied to said input circuit, means for feeding pulses of said predetermined polarity and voltage to said input circuit to cause an electron discharge to step from one operating electrode to the next, whereby the potential of the operating electrode receiving said discharge is altered because of the drop of potential across the associated resistor, a trigger circuit having a trigger input responsive to said altered potential and an output, means for selectively connecting one of said operating electrodes, other than said output electrode, to said trigger input, whereby the arrival of the discharge on the selected operating electrode initiates the operation of said trigger circuit, means activated by the operation of said trigger circuit for producing a pulse of sufficient voltage to cause the discharge to shift to a particular operating electrode when said pulse is applied thereto, and means connected to said output electrode for applying said pulse to said output electrode to cause the discharge in said counting tube means to jump to said output electrode, whereby the counting cycle of said tube means is changed dependent on which of said operating electrodes has been selected.

2. A circuit arrangement, as defined in claim 1, further comprising switch means for rendering the trigger circuit ineffective and for simultaneously delivering a pulse of a predetermined polarity to a particular electrode of the counting tube means regardless of the position of the discharge in said tube means, for zeroizing said tube means.

3. A circuit arrangement, as defined in claim 2, in which the switch means includes means for selectively rendering the trigger circuit ineffective and simultaneously connecting the output electrode similarly to all the other operating electrodes, whereby the counting tube means will operate according to its normal cycle of operation.

4. A circuit arrangement, as defined in claim 1, further comprising switch means for rendering the trigger circuit ineffective and for simultaneously connecting the output electrode similarly to all the other operating electrodes, whereby the counting tube means will operate according to its normal cycle of operation.

5. A circuit arrangement, as defined in claim 4, in which the trigger circuit comprises a discharge tube having an anode, a cathode, and a control electrode, with the trigger input connected to said control electrode and the means for applying a pulse of a predetermined polarity connected to the output electrode of the counting tube means connected to said discharge tube anode.

6. A circuit arrangement, as defined in claim 1, in which the trigger circuit comprises a discharge tube having an anode, a cathode, and a control electrode, with the trigger input connected to said control electrode and the means for applying a pulse of a predetermined polarity connected to the output electrode of the counting tube means connected to said discharge tube anode.

7. A circuit arrangement for counting random pulses comprising gas counting tube means having anode means, a plurality of operating cathodes spaced from said anode means, one of said operating cathodes being an output cathode, circuit means including a resistor connected to each operating cathode, an input circuit, means for causing an electron discharge to step from one operating cathode to a next succeeding operating cathode when

a voltage pulse of a predetermined polarity and voltage is applied to said input circuit, means for feeding random pulses of said predetermined polarity and voltage to said input circuit to cause said discharge to shift from one operating cathode to the next, whereby the potential of the operating cathode receiving said discharge is altered because of the drop of potential across the associated resistor, a trigger circuit having a trigger input responsive to said altered potential and an output, means connected to said pulse-feeding means for rendering said trigger circuit effective each time a pulse is received from said pulse feeding means, means for selectively connecting one of said operating cathodes, other than said output cathode, to said trigger input, whereby said trigger input is energized when the discharge arrives on the selected operating cathode, means forming part of said stepping means for maintaining the energization of said trigger input until the next pulse arrives from said pulse feeding means, whereby said trigger circuit is operated by the arrival of said next pulse, means activated by the operation of said trigger circuit for producing a negative-going pulse of sufficient voltage to cause the discharge to shift to a particular operating cathode when said pulse is applied thereto, and means connected to said output cathode for applying said negative-going pulse to said output cathode to cause the discharge in said counting tube means to jump to said output cathode, whereby the counting cycle of said tube means is changed dependent on which of said operating cathodes has been selected.

8. A circuit arrangement, as defined in claim 7, further comprising switch means for rendering the trigger circuit ineffective and for simultaneously delivering a negative-going pulse to a particular cathode of the counting tube means regardless of the position of the discharge in said tube means, for zeroizing said tube means.

9. A circuit arrangement, as defined in claim 8, in which the switch means includes means for selectively rendering the trigger circuit ineffective and simultaneously connecting the output cathode similarly to all the other operating cathodes, whereby the counting tube means will operate according to its normal cycle of operation.

10. A circuit arrangement, as defined in claim 7, further comprising switch means for rendering the trigger circuit ineffective and for simultaneously connecting the output cathode similarly to all the other operating cathodes, whereby the counting tube means will operate according to its normal cycle of operation.

11. A circuit arrangement, as defined in claim 10, in which the trigger circuit comprises a discharge tube having an anode, a cathode, and a trigger electrode, with the means for rendering the trigger circuit effective connected to said discharge tube cathode, the trigger input connected to said trigger electrode, and the means for applying a negative-going pulse to the output cathode of the counting tube means connected to said discharge tube anode.

12. A circuit arrangement, as defined in claim 7, in which the trigger circuit comprises a discharge tube having an anode, a cathode, and a trigger electrode, with the means for rendering the trigger circuit effective connected to said discharge tube cathode, the trigger input connected to said trigger electrode, and the means for applying a negative-going pulse to the output cathode of the counting tube means connected to said discharge tube anode.

13. A circuit arrangement for counting random pulses comprising a gas counting tube having an anode, a plurality of operating cathodes equally spaced from each other and from said anode, one of said operating cathodes being an output cathode, a like number of transfer cathodes, there being one positioned between every two operating cathodes, spaced therefrom and from said anode, an input circuit connected to all of said transfer cathodes, an output circuit connected to one of said output cathodes, a time constant circuit for each of said

operating cathodes connected individually thereto, whereby the potential of a cathode receiving said discharge will be altered, all of said time constant circuits except that connected to said output cathode being connected together, means for feeding random negative-going pulses to said input circuit to cause a discharge to shift from one operating cathode to the next, a trigger circuit having a trigger input responsive to said altered potential and an output, means connected to said pulse-feeding means for rendering said trigger circuit effective each time a pulse is received from said pulse feeding means, means for selectively connecting one of said operating cathodes, other than said output cathode, to said trigger input, whereby said trigger input is energized when the discharge arrives on the selected operating cathode, the time constant circuit of said selected cathode acting to maintain the energization of said trigger input until the next pulse arrives from said pulse feeding means, whereby said trigger circuit is operated by the arrival of said next pulse, means activated by the operation of said trigger circuit for producing a negative-going pulse of sufficient voltage to cause the discharge to shift to a particular operating cathode when said pulse is applied thereto, and means connected to the time constant circuit of said output cathode for applying said negative-going pulse to said output cathode to cause the discharge in said counting tube to jump to said output cathode, whereby the counting cycle of said tube is changed dependent on which of said operating cathodes has been selected.

14. A circuit arrangement, as defined in claim 13, further comprising switch means for rendering the trigger circuit ineffective and for simultaneously delivering a negative-going pulse to the time constant circuit of the output cathode of the counting tube, regardless of the position of the discharge in said tube, for zeroizing said tube.

15. A circuit arrangement, as defined in claim 14, in which the switch means includes means for selectively rendering the trigger circuit ineffective and simultaneously connecting the time constant circuit of the output cathode to ground, whereby the counting tube will operate according to its normal cycle of operation.

16. A circuit arrangement, as defined in claim 13, further comprising switch means for selectively rendering the trigger circuit ineffective and for simultaneously connecting the time constant circuit of the output cathode to ground, whereby the counting tube will operate according to its normal cycle of operation.

17. A circuit arrangement for counting random pulses comprising gas counting tube means having anode means, a plurality of operating cathodes spaced from said anode means, one of said operating cathodes being an output cathode, circuit means including a resistor connected to each said operating cathode, an input circuit, means for causing a discharge to step from one operating cathode to a next succeeding operating cathode when a voltage pulse of a predetermined sense and value is applied to said input circuit, means for feeding random pulses of said predetermined sense and value to said input circuit to cause a discharge to step from one operating cathode to the next, whereby the potential of the cathode receiving said discharge is altered because of the drop in potential across the associated resistor, a trigger circuit having a trigger input and an output, means connected to said pulse-feeding means for rendering said trigger circuit effective each time a pulse is received from said pulse feeding means, means for selectively connecting one of said operating cathodes, other than said output cathode, to said trigger input, whereby said trigger input is energized when the discharge arrives on the selected operating cathode, means forming part of said stepping means for maintaining the energization of said trigger input until the next pulse arrives from said pulse feeding means, whereby said trigger circuit is operated by the arrival of said next pulse, means activated by the

operation of said trigger circuit for producing a negative-going pulse of sufficient voltage to cause the discharge to shift to a particular operating cathode when said pulse is applied thereto, and means connected to said output cathode for applying said negative-going pulse to said output cathode to cause the discharge in said counting tube means to jump to said output cathode, whereby the counting cycle of said tube means is changed dependent on which of said operating cathodes has been selected.

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