Oct. 16, 1956 A. V. BAZARIAN ET AL 2,767,350

GASEOUS COUNTING TUBE

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FIG. 1

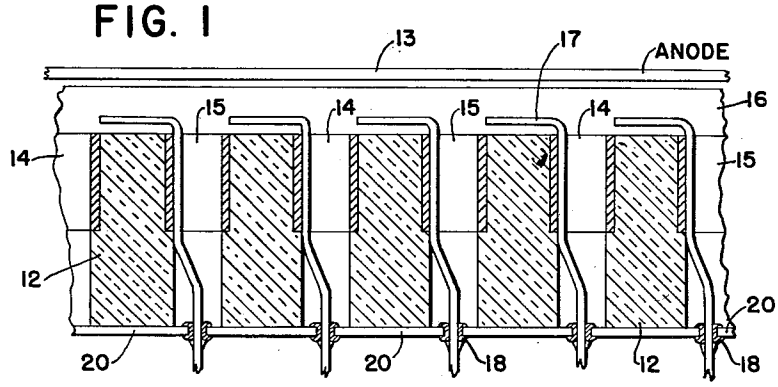


FIG. 2

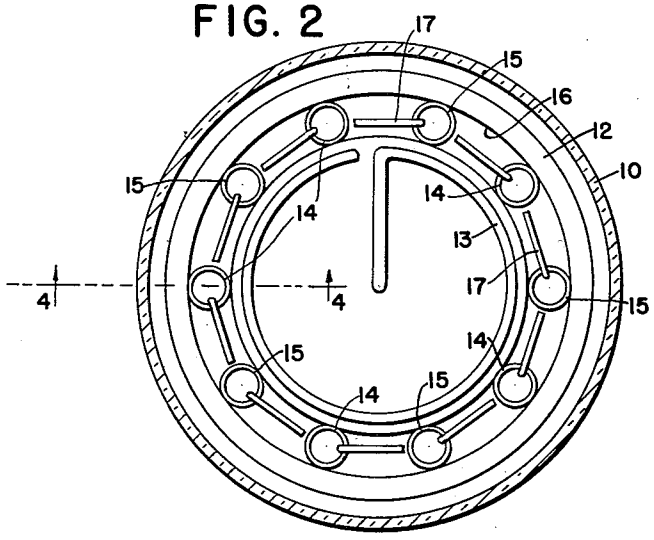


FIG. 3

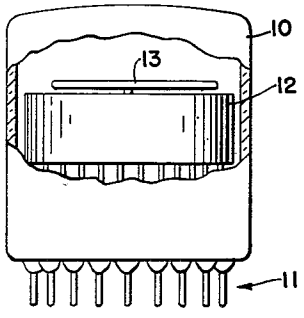
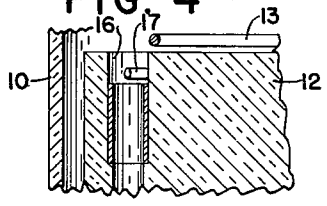


FIG. 4



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FIG. 5

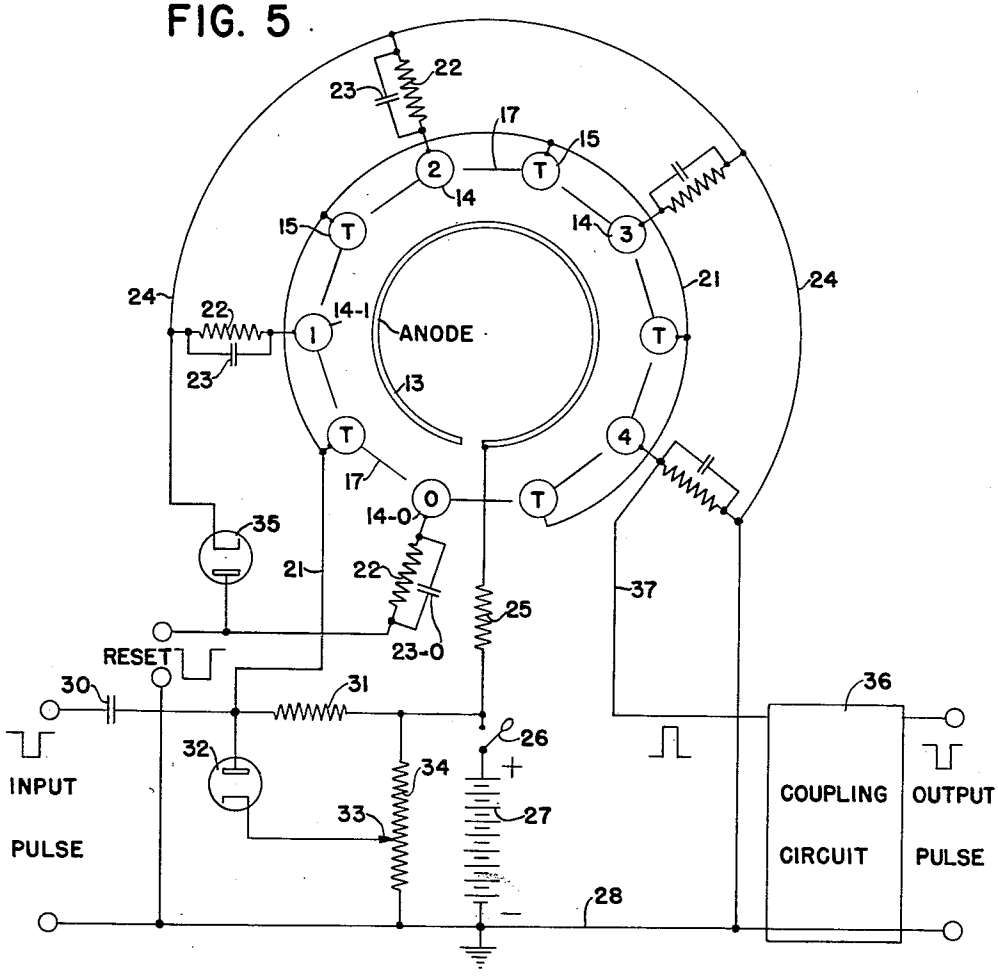


FIG. 6

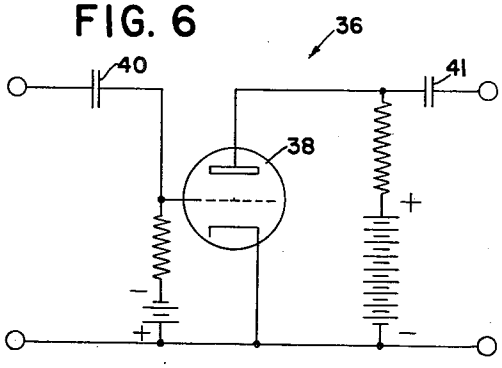
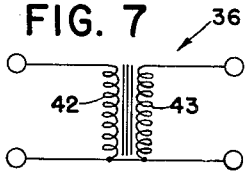


FIG. 7



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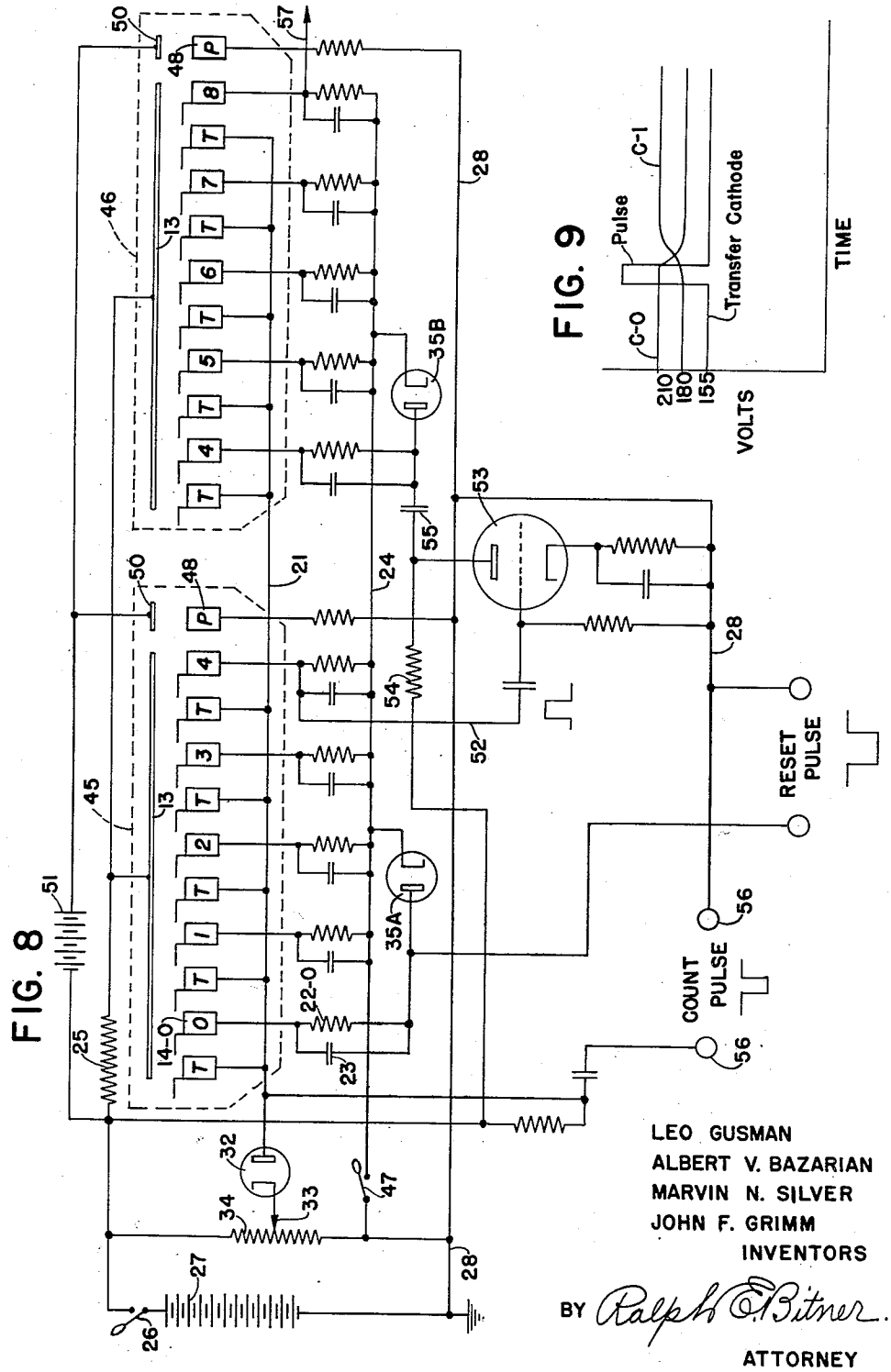


FIG. 8

FIG. 9

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GASEOUS COUNTING TUBE

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Application June 1, 1954, Serial No. 433,754

8 Claims. (Cl. 315—169)

This invention relates to a gaseous counting tube which is operated by electrical pulses. It has particular reference to a gaseous counting tube which employs cylindrical cathodes and a gaseous discharge which is confined to the inside surface of the cylindrical components.

Many types of gaseous counting tubes have been developed, some of which use at least two transfer electrodes between each counting electrode and other types which rely on a specific shape of an electrode structure to transfer an electric discharge in the right direction when a pulse is received. The counting tubes which employ more than one transfer electrode require considerable external circuitry for their successful operation and the tubes which employ shaped electrodes require precise counting pulses which must be adjusted to narrow limits of voltage and time duration in order to count successfully.

The present tube employs a single transfer electrode between each counting electrode and requires no additional vacuum tubes nor amplifying circuits when operated as a decade counter system. A single negative pulse applied to the input terminals produces a count, and an output pulse is available to operate as a carry pulse for application to the counting tube in the next higher denominational order.

One of the objects of this invention is to provide an improved gaseous counting tube which avoids one or more of the disadvantages and limitations of prior art arrangements.

Another object of the invention is to improve the reliability of counting tubes so that a count will be registered when a counting pulse is received even though the supply voltages may vary over a wide range of values.

Another object of the invention is to increase the current carrying capacity of the counting electrodes so that external current indicating devices may be operated directly from the tube without recourse to intermediate circuits.

Another object of the invention is to provide circuit means for connecting two counting tubes in a consecutive counting arrangement.

Another object of the invention is to provide an operating circuit for the counting tube which may be adjusted to suit the requirements of variable characteristics.

The invention comprises a single wire anode symmetrically positioned within an envelope which is filled with ionizable gas at a reduced pressure. A plurality of counting electrodes are positioned in closely fitting cavities in an insulating block. A plurality of transfer electrodes are positioned between each counting electrode for transferring the discharge from one count electrode to another when a counting pulse is received. Each counting electrode is connected to lead-in conductors for application of voltages and counting pulses external of the envelope.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

Fig. 1 is a sectional view of a development of the electrodes encased in the insulating block.

Fig. 2 is a cross sectional drawing of a counting tube having five count electrodes and shows a top view of the electrode system.

Fig. 3 is a side view of the counting tube, with some parts in section, and shows the insulator block and the anode.

Fig. 4 is a cross sectional view of a portion of the insulator block and is taken along line 4—4 of Fig. 2.

Fig. 5 is a schematic diagram of connections showing the external circuitry employed with the tube for counting and resetting.

Fig. 6 is a schematic diagram of connections showing one form of coupling circuit which may be used to transfer a carry pulse from one tube to another.

Fig. 7 is a schematic diagram of connections showing an alternate form of coupling circuit.

Fig. 8 is a schematic diagram of connections showing the external circuitry employed when two or more tubes are arranged for consecutive counting.

Fig. 9 is a graph showing the pulse shapes and pulse timing during a counting operation.

Referring now to Figs. 1, 2, 3, and 4, the counting tube comprises an envelope **10** having a plurality of contact pins **11** secured in the base. Within the envelope an insulating block **12**, having a generally cylindrical form, is employed to support the cathodes in cavities within the block and also supports an anode **13** which is adjacent to the top surface of the block and is spaced at equal distances to all the cathodes.

The tube shown in Fig. 2 contains five counting cathodes **14** and five transfer cathodes **15**, there being no difference between the count cathodes and the transfer cathodes except in their external connections. Each cathode is supported within a circular cavity in the block with its top edge flush with the top surface of the insulating block. For convenience in manufacture the cathodes are positioned within an annular groove **16** but this construction is not necessary for counting. On the inside of each cathode a wire probe **17** is conductively secured to the cathode surface, one end of which extends through the bottom of the block **12** where it is secured to eyelet **18** set in a mica insulating sheet **20**. The lower extremities of the probe **17** are used for connection to the lead-in wires and for other connections within the tube when desired. The upper ends of probe **17** are bent over so that they lie horizontally above the insulator block with their ends in close proximity to the next adjoining cathode. When a discharge has been started between the anode **13** and one of the count electrodes **14** a glow appears on the inside of the cathode cylinder but is not visible elsewhere. However, the ionized gas molecules extend between the inside surface of the cylinder and the anode and the ionized region extends sufficiently to one side to include the end of the adjoining probe **17**.

Fig. 5 shows the operating circuit in schematic form, each transfer electrode **15** being connected to a common conductor **21**. The count electrodes **14** are each connected to a resistor **22** which is shunted by a capacitor **23**. The other ends of these circuit units are connected to a common conductor **24**. The anode **13** is connected in series with an anode resistor **25**, an operating switch **26**, and a source of potential **27**. The negative end of battery **27** is connected to a common ground conductor **28** as is also conductor **24**. The input circuit which receives negative input pulses comprises two terminals one of which is connected to the ground conductor **28** and the other of which is connected in series with a blocking capacitor **30** and the transfer conductor **21**. The transfer conductor **21** is also connected through a resistor **31** to switch **26** and the positive end of the source of po-

tential 27 and a diode circuit element 32 is connected between conductor 21 and an adjustable point 33 of a voltage divider 34.

In order to reset a discharge at the zero electrode reset terminals are provided which are connected to the ground conductor 28 and the external end of the zero electrode resistor 22. This point is also connected in series with a diode 35 to the common conductor 24 and ground. In order to carry from one tube to another a coupling circuit 36 is connected between a pair of output terminals and a portion of the circuit which presents a pulse when the count discharge moves from the four terminal to the zero. It will be obvious that in a tube used with the decimal system of counting the carry pulse will be produced when the count moves from nine to zero. The carry pulse may be derived from several parts of the circuit, the simplest being a conductor 37 connected directly to the last count electrode.

The coupling circuit 36 shown in block in Fig. 5 may comprise a number of coupling arrangements, one of which is shown in Fig. 6 and consists of an amplifier tube 38 having blocking capacitors 40, 41 and the usual sources of potential necessary for supplying the tube 38. Fig. 7 shows an alternate form of coupling circuit comprising a primary winding 42 and a secondary winding 43 forming a coupling transformer. Various other coupling circuits may be used.

The operation of this circuit may be described by reference to Fig. 5. When a circuit is not counting switch 26 is open. When the circuit is started switch 26 is closed supplying positive voltage to the anode 13 and starting a discharge somewhere in the tube between a count electrode and the anode. The position of this first discharge may occur between the anode and any of the cathodes in the tube. In order to reset the tube discharge to the zero cathode a negative pulse is applied to the reset electrodes. This negative pulse is confined only to the zero electrode 14–0 because diode 35 will not transmit a negative pulse to any other count electrode. The negative pulse produces a voltage between the zero electrode and the anode 13 which is considerably greater than any other discharge voltage, therefore the gaseous discharge is transferred at once to the zero position. At this starting condition no current flows through diode 35.

When it is desired to count, a single negative pulse is applied to the input terminals and this pulse, travelling over conductor 21, makes all the transfer electrodes 15 more negative than their normal condition and provides a voltage drop between each transfer electrode and the anode. This voltage drop is greater than the normal voltage difference between the anode and a lighted count electrode and the electric discharge from any count electrode is transferred to the transfer electrode whose probe 17 lies adjacent to the discharge. The presence of ionized gas between the anode 13 and a count electrode 14 (Fig. 1) produces an ionized gas path between the anode 13 and the adjacent probe of the next transfer cathode 15 and the discharge transfers to the transfer cathode as soon at the voltage drop between the transfer cathode and the anode is greater than the voltage drop between the count cathode and the anode. The discharge between the anode and the transfer cathode lasts only as long as the input pulse. When the input terminals and conductor 21 (Fig. 5) return to normal, the transfer cathodes are all returned to their normal voltage which is less than the maintaining voltage for a discharge and the discharge then transfers to the next higher count cathode because its probe wire extends into the ionized region of the transfer eleetrode.

The voltage variations caused by the negative input pulse can be explained in detail as follows: when the glow discharge is between the zero count cathode and the anode, the voltage furnished by the source of potential 27 (Fig. 5) is divided between resistor 25, the arc drop, resistor 22, and the diode 35. The voltage drop across resistor 22 keeps the zero cathode at some positive potential above ground. When the negative count pulse is received and applied to all the transfer electrodes they are all lowered in potential making the voltage drop between the transfer electrodes and the anode greater than the breakdown voltage. The input pulse being negative cannot pass through the diode 32 and the lower part of resistor 34, therefore very little current must be supplied.

Since the transfer electrodes are arranged so that only one has its probe wire 17 in the region of the discharge, only that one will be lighted and take the discharge. As the count pulse is applied the additional current causes the voltage drop across resistor 25 to increase and the anode potential is lowered until the discharge between the count cathode 14–0 is reduced to zero. However, the zero count cathode is still biased at some potential above ground due to the charge on capacitor 23–0. This capacitor discharges through its parallel resistor 22 at a rate governed by the time constant of the circuit and the component values are adjusted so that this time constant is several times the duration of the count pulse.

When the count pulse ends the current through the resistor 25 decreases and the anode voltage again rises so that the potential difference between the all count cathodes 14 is greater than the breakdown voltage. Cathode 14–1 takes the discharge because it is primed by having its probe in the ionized region of the previously lighted transfer electrode. The zero count cathode 14–0 does not take the discharge because its capacitor 23–0 maintains a potential above ground of sufficient value so that the primed cathode 14–1 breaks down first. The graph shown in Fig. 9 illustrates the change of voltage values during the application of the count pulse and the change of the discharge from one count cathode to another.

After a counting sequence or operation the value of the count may be determined visually by noting the position of the lighted cathodes. If it is desired to produce a more permanent record of the count recording means such as printers, relays, and graphical indicators can be used. These recording devices may be placed in the tube circuit in place of the resistors 22 (Fig. 5) or they may be connected between the count cathodes and ground in parallel with the resistors 22.

The circuit shown in Fig. 5 is designed to produce a carry pulse each time the count has reached a total of the number of count electrodes in the tube. An example of such a system is a number of counting tubes, each having ten count cathodes, and each tube representing a denominational order in the decimal system. Such a counting array has a single input circuit at the lowest denominational order tube and all count pulses are applied there. However, there have been applications where it is desired to count sequentially through several tubes; that is, count around the electrodes in the first tube and then count in sequence around the electrodes in the second tube. Such a circuit arrangement is shown in Fig. 8 where the electrodes of two envelopes 45 and 46 are indicated in schematic form.

The electrodes inside the envelope are the same as those shown in Fig. 5 except that an additional priming electrode 48 has been added to each tube. These electrodes have their own anode 50 adjacent to their upper edge and an additional source of potential 51 is supplied so that, in conjunction with the main source of potential, the priming electrodes are always lighted, furnishing a supply of ions and electrons in the tubes at all times. While these tubes, as shown in Fig. 8, have a transfer cathode to the left of the zero count electrode, this component is not necessary for sequential counting and is not used in the in-line operation.

It should be noted that a single anode resistor 25 is employed for both tubes. This means that only one count or transfer cathode can be lighted at any instant in both tubes. A single limiter diode 32 is connected to all count-

ing tubes since the transfer electrodes in each tube require the same operating voltage. The count pulse terminals are connected in the same manner as the tube shown in Fig. 5 and the reset circuit which includes diode 35A is the same as that previously described.

The output of the first tube is connected by conductor 52 through a blocking capacitor to a vacuum tube amplifier 53, having the usual connections for pulse amplification including an anode resistor 54 and an output coupling capacitor 55. The amplified, and inverted, pulse from the amplifier stage is applied to the first count cathode 14–4 in the second tube, isolated from the other count electrodes by a diode 35B connected in a manner similar to diode 35A in the first tube.

When this circuit is operated to count, the switches 26 and 47 are both closed and both priming electrodes 48 will light at once and then a count cathode somewhere in the array will be lighted. The position of this cathode is indeterminate and to return the discharge to the zero cathode a negative pulse is applied to the reset terminals, causing an increase of potential drop between the anode 13 in the first tube and the zero count electrode 14–0, and transferring the discharge to that electrode.

If, now, counting pulses are applied to the input terminals 56 the same transfer action takes place as previously described and the discharge is stepped along until it is transferred to the count cathode 4 in the first tube. When this happens a positive pulse is sent over conductor 52 to amplifier tube 53 and a strong negative pulse is thereby applied through capacitor 55 to cathode 4 in the second tube. This negative pulse is applied only to the 4 cathode because of diode 35B and the discharge on the 4 cathode in the first tube is transferred to the 4 cathode in the second tube. This latter transfer occurs immediately following the application of the count pulse which caused the transfer from the 3 cathode to the four cathode.

Subsequent pulses applied to terminals 56 cause the discharge to be moved from one count cathode to another as previously described. When the discharge is moved to the 8 cathode a carry operation may be effected over conductor 57 as described in connection with Fig. 5, or the same kind of transfer may be effected as described between tubes 45 and 46.

The voltage values indicated in Fig. 9 are by way of example only and represent the values used in a test made with tubes having a gas pressure of 30 cm. of mercury.

While there have been described and illustrated specific embodiments of the invention, it will be obvious that various changes and modifications may be made therein without departing from the field of the invention which should be limited only by the scope of the appended claims.

We claim:

1. A gaseous discharge device for sequentially transferring a glow discharge from one electrode to another in response to a single applied electrical pulse comprising; a plurality of count electrodes, each of which may comprise a terminal for a glow discharge; a plurality of transfer electrodes, each of which is positioned intermediate a pair of count electrodes; each of said count and transfer electrodes comprising a hollow cylinder which is partially enclosed in a block of insulating material; and a transfer probe for each of said electrodes, said probes comprising an elongated conductor with one end affixed to said electrodes and the other end extending therefrom to an open end of one other preselected electrode to establish a preferential path for transferring the discharge.

2. A gaseous discharge device for sequentially transferring a glow discharge from one electrode to another in response to a single applied electrical pulse comprising; a plurality of count electrodes, each of which may comprise a terminal for a glow discharge; a plurality of

transfer electrodes, each of which is positioned intermediate a pair of count electrodes; each of said count and transfer electrodes comprising a hollow cylinder which is partially enclosed in a block of insulating material; a transfer probe for each of said electrodes, said probes comprising an elongated conductor with one end affixed to the inside of said electrodes and the other end extending therefrom to an open end of one other preselected electrode to establish a preferential path for transferring the discharge; and a common electrode which is equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

3. A gaseous discharge device for sequentially transferring a glow discharge from one count electrode to another count electrode in response to a single applied electrical pulse comprising; a plurality of count electrodes, each of which may comprise a stable terminal for a glow discharge to designate a count value; a plurality of transfer electrodes, each of which is positioned intermediate a pair of count electrodes; each of said count and transfer electrodes comprising a hollow cylinder which is enclosed in a common block of insulating material with the cylinder ends mounted flush with a surface of the block; a transfer probe for each of said electrodes, said probes comprising an elongated conductor with one end affixed to the inside of the electrodes and the other end extending therefrom to an open end of one other preselected electrode to establish a preferential path for transferring the discharge; and a common electrode which is equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

4. A gaseous discharge device for sequentially transferring a glow discharge from one count electrode to another count electrode in response to a single applied electrical pulse comprising; a plurality of count electrodes positioned in alternate array with a plurality of transfer electrodes; each of said count and transfer electrodes comprising a hollow cylinder open at one end and set flush in an insulating block; a transfer probe for each of said electrodes, said probes each comprising an elongated conductor having one end affixed to the inside of the electrode and the other end extending therefrom to the open end of the adjacent electrode; and a common electrode connected through a common impedance to a source of potential, said common electrode equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

5. A gaseous discharge device for sequentially transferring a glow discharge from one count electrode to another count electrode in response to a single applied electrical pulse comprising; a plurality of count electrodes positioned in alternate array with the same number of transfer electrodes; means for electrically connecting all the transfer electrodes to a common conductor which is connected to a circuit which receives an electrical counting pulse, each of said count and transfer electrodes comprising a hollow cylinder open at one end and set flush in an insulating block; a transfer probe for each of said electrodes, said probes each comprising an elongated conductor having one end affixed to the electrode and the other end extending therefrom to the open end of the adjacent electrode; and a common electrode connected through a common impedance to a source of potential, said common electrode equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

6. A gaseous discharge device for sequentially transferring a glow discharge from one count electrode to another count electrode in response to a single applied electrical pulse comprising; a plurality of count electrodes positioned in alternate array with the same number of transfer electrodes, said electrodes arranged in a row equally spaced from an adjacent electrode; means for connecting all the transfer electrodes to a common conductor, each of said count and transfer electrodes com-

prising a hollow cylinder open at one end and set flush in a channel in an insulating block; a transfer probe for each of said electrodes, said probes each comprising an elongated conductor having one end connected to a portion of the electrode and the other end extending therefrom to the open end of the next adjacent electrode; and a common electrode connected through a common impedance to a source of potential, said common electrode equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

7. A gaseous discharge device for sequentially transferring a glow discharge from one count electrode to another count electrode in response to a single applied electrical pulse comprising; an envelope filled with gas at a reduced pressure; a plurality of count electrodes and transfer electrodes mounted within the envelope in alternate array; means for connecting all the transfer electrodes to a common lead-in conductor for external connection to a source of potential; each of said count and transfer electrodes comprising a hollow cylinder open at one end and set flush in a channel in an insulating block; a transfer probe for each of said electrodes, said probes each comprising an elongated conductor having one end connected to a portion of the electrode and the other end extending therefrom to the open end of the next adjacent electrode; and a common electrode connected through a common impedance to a source of potential, said common electrode equally spaced from the other electrodes to comprise a common terminal for the glow discharge.

8. A gaseous discharge device for sequentially transferring a glow discharge from one count electrode to another count electrode when a single electrical pulse is applied to the device comprising; an envelope filled with gas at a reduced pressure; a plurality of count electrodes and transfer electrodes mounted within the envelope in alternate array; means for connecting all the transfer electrodes to a common lead-in conductor for external connection to a source of potential; means for connecting each of the count electrodes to a lead-in conductor for external connection to a source of potential in series with an impedance; each of said count and transfer electrodes comprising a hollow cylinder which is partially enclosed in a block of insulating material; and a transfer probe for each of said electrodes, said probes comprising an elongated conductor with one end connected to the electrode and the other end extending therefrom to an open end of one other preselected electrode to establish a preferential path for transferring the discharge.

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