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DEVICE COMPRISING AT LEAST ONE GLOW DISCHARGE TUBE

Filed Aug. 25, 1953

3 Sheets-Sheet 1

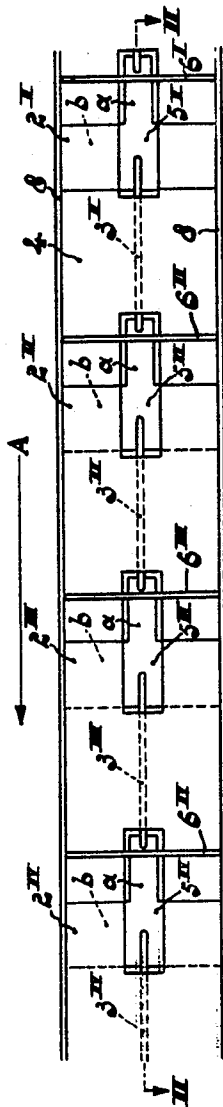


Fig. 1

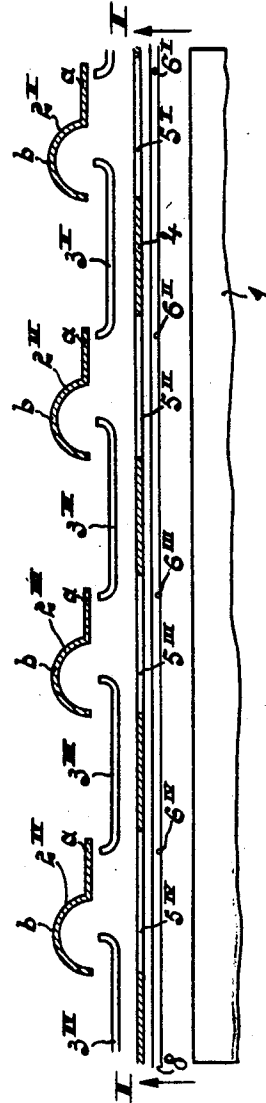


Fig. 2

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3 Sheets-Sheet 2

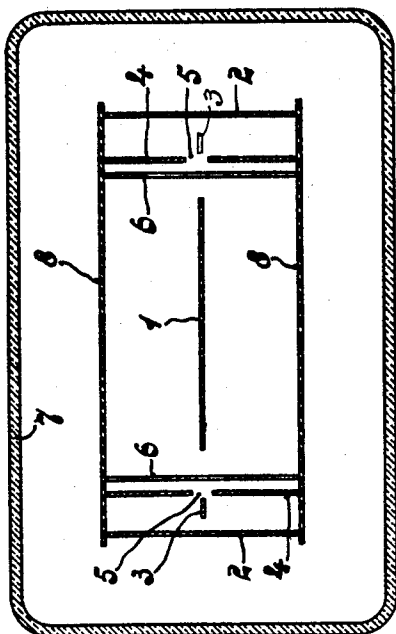


Fig. 3

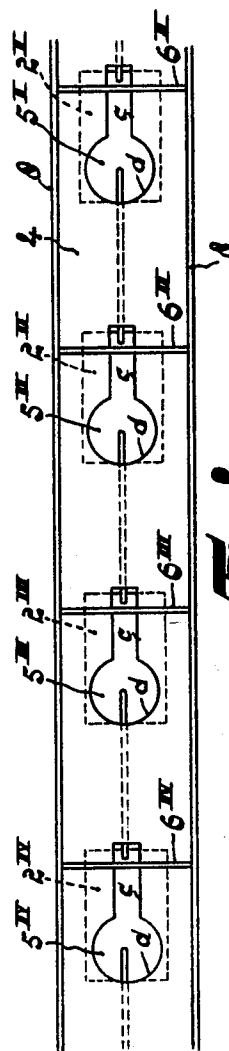


Fig. 4

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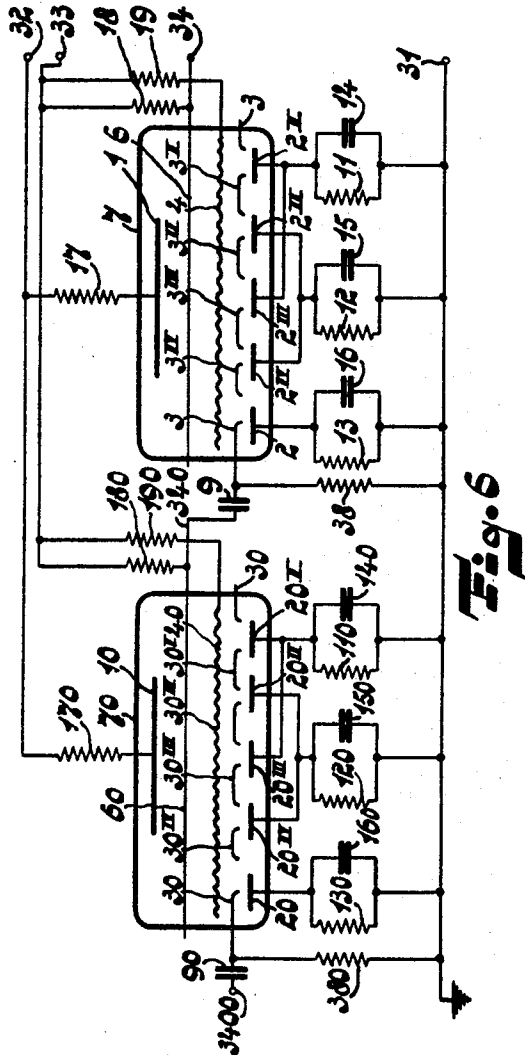
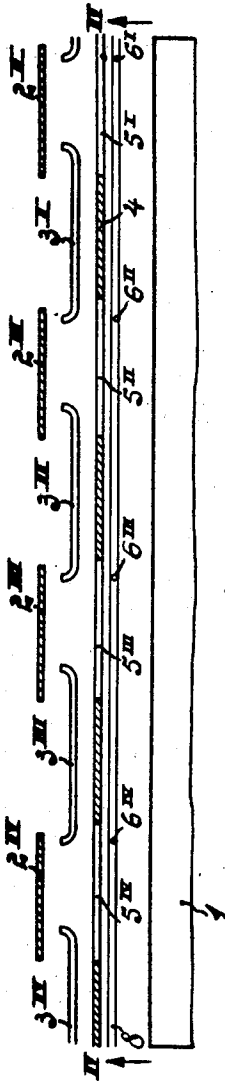
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DEVICE COMPRISING AT LEAST ONE GLOW DISCHARGE TUBE

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3 Sheets-Sheet 3



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DEVICE COMPRISING AT LEAST ONE GLOW DISCHARGE TUBE

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6 Claims. (Cl. 315—84.6)

The invention relates to a device, more particularly for use in counting and similar circuit arrangements comprising at least one glow discharge tube containing inter alia one anode and a plurality of main cathodes to which the discharge may pass at will through apertures in a screen arranged between the cathodes and the anode which correspond with the main cathodes, the cathodes or the apertures in the screen, or both, being shaped in a form such that at the current intensity produced the discharge passes to a definite part of the cathode, while by means of a pulse applied to a plurality of control electrodes the discharge moves up one cathode. In addition the invention relates to a glow discharge tube for use in such a device.

Often the cathodes are arranged so as to form a ring to enable the discharge to move around. The associated tubes are referred to as ring counting tubes. The number of pulses which one tube is able to count is governed by the number of main cathodes. Thus, a tube comprising ten main cathodes is able to count in a decimal system. However, in a decimal system a single tube is able to count only one figure and any successive figure requires an additional tube.

However, the known tubes and devices require a gas or vacuum discharge tube as a link between the tubes counting the different figures, which is not conducive to the price and the simplicity of the devices.

The object of the invention is to provide a device of the above-mentioned kind in which coupling between the glow discharge tubes counting the successive figures is effected without requiring gas or vacuum discharge tubes.

The invention relates to a device, more particularly for use in counting and similar circuits, comprising at least one glow discharge tube including one anode and a plurality of main cathodes to which the discharge may pass at will through apertures corresponding with the main cathodes in a screen arranged between the cathodes and the anode, the cathodes or the apertures in the screen or both, being shaped in a form such that at the current intensity produced the discharge is directed to a definite part of the cathode. Part of each cathode which is not used by the discharge adjoins the part of an adjacent cathode which is used by the discharge and vice versa the discharge moving up one cathode due to a pulse applied to a number of control electrodes. According to the invention a number of preferably rod-shaped coupling electrodes is arranged between the cathode and the screen approximately at the positive end of the cathode fall so as to extend substantially parallel to the screen from that part of each cathode which is used by the discharge to the nearest part of a subsequent cathode which is not used by the discharge. The ends of the coupling electrodes are directed to the cathodes and a control electrode is arranged between the screen and the anode in front of each aperture approximately in the shortest line joining the anode and the end of a coupling electrode in front of the non-used part of a cathode. The screen and the control electrodes are maintained at a lower direct voltage than

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the anode, while the coupling electrodes are not held at a definite voltage or are connected through a heavy resistance to the negative terminal of the voltage source supplying the tube in a manner such that the coupling electrodes assume the potential of the main discharge in which they are situated and lead an auxiliary discharge to that main cathode to the part of which not used by the discharge they correspond.

In the discharge space of a glow discharge between two flat or slightly curved electrodes the field strength in a comparatively small region near the cathode is high and substantially constant, in a comparatively large region in front of the anode it is low and also substantially constant. Between the said two regions there is a small transition region from high to low field strength, which region has hereinbefore been referred to as the positive end of the cathode fall and consequently the coupling electrodes according to the invention are arranged therein.

If more tubes are connected in series one coupling electrode which is connected through a high resistance to the negative terminal of the voltage source is connected through a capacitor to the control electrodes of the subsequent tube.

To ensure the movement of the discharge along the cathodes and to prevent unnecessary pulses from being applied to the coupling electrode provided with an outside extension the main cathodes are alternately interconnected and each of these combinations through a resistance in parallel combination with a capacitor is connected to the negative terminal of the voltage source, the cathode associated with the coupling electrode which is provided with an outside extension being separately connected through a combination of resistor and capacitor to the negative terminal of the voltage source. On transition of the main discharge from one cathode to the next one each subsequent coupling electrode assumes the potential of the discharge path with the result that not only a new auxiliary discharge is initiated but also that a pulse voltage may be derived from this coupling electrode. This pulse voltage is used to control a subsequent tube or to indicate in some manner that the first tube has completed a counting cycle.

The connection of a resistor and a capacitor between the different cathodes and the negative terminal of the voltage source acts to maintain the cathode at a positive potential with respect to the subsequent cathode for some period of time after the discharge has extinguished with the result that the discharge at the subsequent cathode is enabled to develop and does not revert to the first cathode.

The invention will now be described with reference to the accompanying drawing, in which:

Fig. 1 shows a part of the developed electrode system of a decimal ring counting tube viewed from the common anode in the direction of the cathodes;

Fig. 2 is a developed sectional view of this system taken at right angles to its axis;

Fig. 3 is a sectional view through the axis of the system;

Figs. 4 and 5 are only distinguished from Figs. 1 and 2 by the shape of the screen apertures and of the cathodes, and

Fig. 6 shows a circuit comprising tubes according to the invention.

Referring now to the figures, in Figs. 1, 2 and 3 the common anode 1 is shaped in the form of a disc. A number of cathodes which are designated 2^I, 2^{II}, 2^{III}, 2^{IV} in Figures 1 and 2 are arranged so as to form a circle round the anode, the cathodes shown in Fig. 3 being generally designated 2.

The cathodes comprise a narrow straight part *a* and a large curved part *b*. Between the cathodes 2 and the

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anode 1 a number of auxiliary electrodes 3 are arranged which are designated 3^I , 3^{II} , 3^{III} , 3^{IV} in Figs. 1 and 2. These coupling electrodes each extend from the curved part *b* of a cathode to the straight part *a* of the adjacent cathode and have their bent over ends directed to the cathodes.

A cylindrical screen 4 arranged between the coupling electrodes 3 and the anode 1 has rectangular apertures one facing each of the cathodes and designated 5^I , 5^{II} , 5^{III} , 5^{IV} . Between the screen 4 and the anode 1 and radially facing the ends of the coupling electrodes 3 nearer the narrow parts *a* of the cathodes a number of rod-shaped control electrodes 6 are arranged which are designated specifically 6^I , 6^{II} , 6^{III} , 6^{IV} . The electrodes are enclosed in a glass bulb 7 between two mica discs 8. The tube is filled with a rare gas mixture of 50% argon and 50% neon at a pressure of a mercury column of 15 mm. During operation the tube is connected to a 250 volts anode voltage and the screen 4 and the control electrodes 6 are held at a potential of 75 volts positive. The cathodes carrying an even index are connected through the parallel combination of a resistor and a capacitor to the negative terminal of the anode voltage source and the same is the case with the cathodes carrying an odd index, the cathode carrying no index, which is also referred to as zero cathode, being separately connected to the negative terminal through a similar combination.

If in the tube shown in Figs. 1 and 2 the discharge initially takes place between the anode 1 and the cathode 2^I , the discharge will be completely directed to the part *b* of the cathode 2^I , if only the current intensity exceeds that at which part *a* of the cathode is completely covered.

Due to the resistor included in the cathode circuit (see Fig. 6) the potential of the cathode 2^I exceeds that of the adjacent cathode by V_1 volts when the discharge takes place. If the cathode fall of the discharge is V_2 volts, the potential assumed by the coupling electrode 3^I with respect to the part *a* of the cathode 2^{II} will be $V_1 + V_2$ volts, as a result of which a weak discharge current will pass between the coupling electrode 3^I and the part *a* of the cathode 2^{II} . Without the provision of the screen 4 the full discharge current would pass between the anode 1 and the cathode 2^{II} and the discharge at the cathode 2^I would extinguish, whereupon the same would be repeated between the coupling electrodes 3^{II} and 2^{III} . The provision of the screen 4, however, prevents the discharge from passing spontaneously from one cathode to the other. The control electrode 6 which normally is at a positive potential of 75 volts has positive control pulses of from 50 to 100 volts of a duration of from 10 to 100 microseconds applied to it. At such a positive control pulse which is able to provide the control electrodes with a potential approximating the anode potential the auxiliary discharge between the part of the coupling electrode which is not in the path of the main discharge and the narrow part of the cathode changes into a main discharge and the main discharge taking place initially extinguishes. Thus, at one pulse applied to the control electrodes the discharge has moved one step and again moves up one step at a subsequent pulse in the direction of the arrow A shown in Fig. 1. The number of the counted pulses may be made apparent from the position of the discharge or, if required, by connecting an outside extension of the coupling electrodes to a suitable device.

In Figures 4 and 5 parts corresponding to Figures 1 and 2 are designated by like reference numerals, the letters *c* and *d*, however, being added to designate the narrow and the round part respectively of the keyhole-shaped apertures in the screen. The cathodes 2 are flat. In this case the current intensity must be such that the discharge moves spontaneously through the round part of the aperture.

The arrangement shown in Fig. 6 has two counting tubes connected in series viz. the tube 7 and the tube 70 permitting counting up to 100, the tube 7 counting the

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units and the tube 70 the tens, if all the tubes comprise ten cathodes of which, however, only the zero cathode and the cathode I to IV are shown in the drawing to save space. The tube 7 comprises an anode 1 and ten cathodes 2, 2^I , 2^{II} , and so forth. A coupling electrode 3 is arranged between two cathodes 2 and 2^I , a coupling electrode 3^I between cathodes 2^I and 2^{II} , and so forth. Between the cathodes 2 and the anode 1 are arranged a screen 4 and the 10 control electrodes indicated by a line and designated 6. In the second tube 70 the electrodes are designated correspondingly, each numeral, however, having a 0 added to it. The anode 1 of the first tube 7 is connected through a resistor 17 of value 50,000 ohms to the positive terminal 32 of a 250 volts voltage source, the negative terminal of which is connected to 31. The control electrodes 6 are connected through a resistor 18 of value 10 megohms to a terminal 33 which is at a positive voltage of 75 volts with respect to the terminal 31. The screen 4 is also connected through a resistor 19 of value 50,000 ohms to the terminal 31. The odd-numbered cathodes are jointly connected through the parallel combination of a resistor 11 of value 50,000 ohms and a capacitor of value 0.002 μ f. to the negative terminal 31. The even-numbered cathodes are connected to the terminal 31 through a combination of a resistor 12 and a capacitor 15 of like values. The zero cathode 2 is connected to the terminal 31 through a parallel combination of a similar resistor 13 and capacitor 16. In the second tube 70 like circuit elements are designated by the same reference numerals as in the tube 7, which have, however, a zero added to them. The input terminal of the tube 7 is designated 34 and the coupling electrode 3 is connected to the terminal 31 through a resistor 38 of value 10 megohms. A capacitor 9 of value 100 μ f. is included between the coupling electrodes 3 and the input terminal 34 of the tube 70. The coupling electrode of the tube 70 is also connected to the terminal 31 through a resistor 38 of value 10 megohms. An output capacitor is designated 90 and an input terminal of a subsequent tube, if any, is designated 3400. When the counting circuit is rendered operative a discharge must take place both to the cathode 2 and to the cathode 20, which may be effected in known manner. At a first pulse applied to the terminal 34 the discharge in tube 7 moves up one cathode from 2 to 2^I . At the tenth impulse the discharge returns to the cathode 2 with a resultant rapid potential increase at the coupling electrode 3 with respect to the terminal 31 due to its assuming the potential of the discharge directed to the cathode 2, whereupon its potential is slowly increased due to the capacitor 16 being charged. The rapid potential increase acts as an impulse applied to the terminal 340 of the tube 70 through the capacitor 9 to the control electrodes 60 with the result that the discharge moves from the cathode 20 to the cathode 20^I. The process taking place at the application of further pulses will from this be obvious. In order to obtain some idea of the dimensions of the various electrode arrangements, it is noted that Figs. 1 to 5 of the drawing are drawn approximately to a 2:1 scale, i.e., the drawing is twice the actual size of a tube built in accordance with the invention.

What is claimed is:

1. A circuit arrangement comprising a glow discharge tube comprising an envelope containing a glow-discharge-sustaining atmosphere and having one anode and a plurality of main cathodes associated therewith, a screen arranged between the cathodes and anode and having a plurality of apertures each associated with one of said cathodes, each of said cathodes having means associated therewith of two discharge efficiencies whereby a discharge tends to concentrate at one portion of the cathode even though originating on another portion, said cathode and means being arranged such that said one portion of one of said cathodes is adjacent said other portion of another of said cathodes, a plurality of coupling electrodes being

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disposed between the cathodes and screen approximately at the area of the positive end of the cathode fall of potential of a discharge path, each of said coupling electrodes extending substantially parallel to said screen from said one portion of a cathode to said other portion of an adjacent cathode and having its ends extending toward the cathodes, and a plurality of control electrodes each being arranged between the screen and the anode and facing an aperture in the screen, each of said control electrodes being located approximately along the shortest line joining the anode and the end of the coupling electrode arranged in front of said other portion of said cathode; means for maintaining a high positive potential between the anode and said cathodes, means for maintaining the screen and control electrodes at positive potentials relative to the cathode but below that of the anode, said coupling electrodes being adapted to assume the potential of a discharge between the cathodes and anode, and means for applying control voltages to the control electrodes to transfer the main discharge via the coupling electrodes through the tube.

2. A circuit arrangement as set forth in claim 1 wherein the coupling electrodes are rod-shaped and some are free of external circuit connections.

3. A circuit arrangement as set forth in claim 1 wherein the coupling electrodes are rod-shaped, and a high resistor is connected between one coupling electrode and ground potential.

4. A circuit arrangement as set forth in claim 1 employing two of said glow discharge tubes, a high resistor connecting a coupling electrode of one tube to ground potential, and a capacitor coupling said coupling electrode of said one tube to the control electrode of the other tube.

5. A circuit arrangement as set forth in claim 1 wherein the odd-numbered cathodes are connected together and the even-numbered cathodes are connected together, a first parallel combination of a resistor and capacitor is connected between the odd-numbered cathodes and ground potential, a second parallel combination of capacitor and resistor is connected between the even-numbered

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cathodes and ground potential, and a third parallel combination of capacitor and resistor is connected between the zero-numbered cathode and ground potential.

6. A glow discharge tube comprising an envelope containing a glow-discharge-sustaining atmosphere and having one anode and a plurality of main cathodes associated therewith, a screen arranged between the cathodes and anode and having a plurality of apertures each associated with one of said cathodes, each of said cathodes having means associated therewith of two discharge efficiencies whereby a discharge tends to concentrate at one portion of the cathode even though originating on another portion, said cathode and means being arranged such that one portion of one of said cathodes is adjacent said other portion of another of said cathodes, a plurality of coupling electrodes disposed between the cathodes and screen approximately at the area of the positive end of the cathode fall of potential of a discharge path, each of said coupling electrodes extending substantially parallel to said screen from said one portion of a cathode to said other portion of an adjacent cathode and having its ends extending toward the cathodes, and a plurality of control electrodes each being arranged between the screen and the anode and facing an aperture in the screen, each of said control electrodes being located approximately along the shortest line joining the anode and the end of the coupling electrode arranged in front of said other portion of said cathode.

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