

April 21, 1953

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2,635,810

MULTICATHODE GASEOUS DISCHARGE DEVICE AND CIRCUITS

Filed Feb. 15, 1952

3 Sheets-Sheet 1

FIG. 1

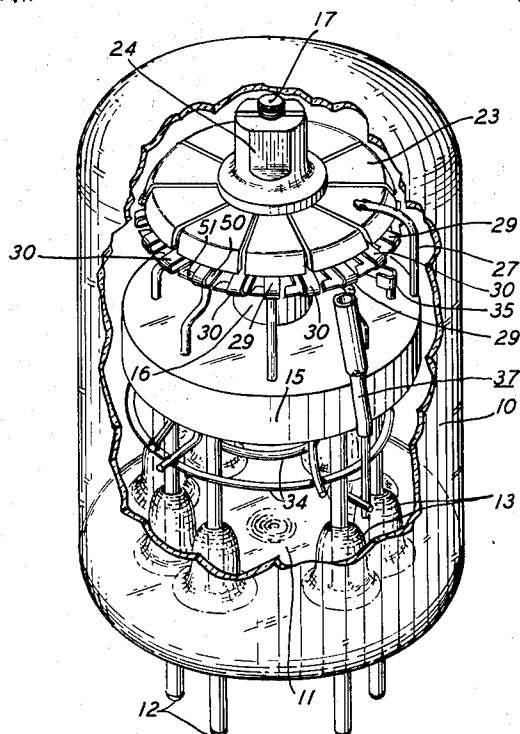
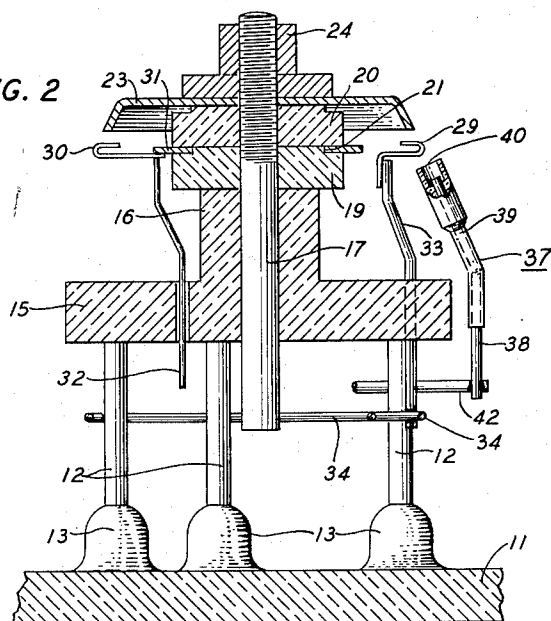


FIG. 2



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FIG. 3

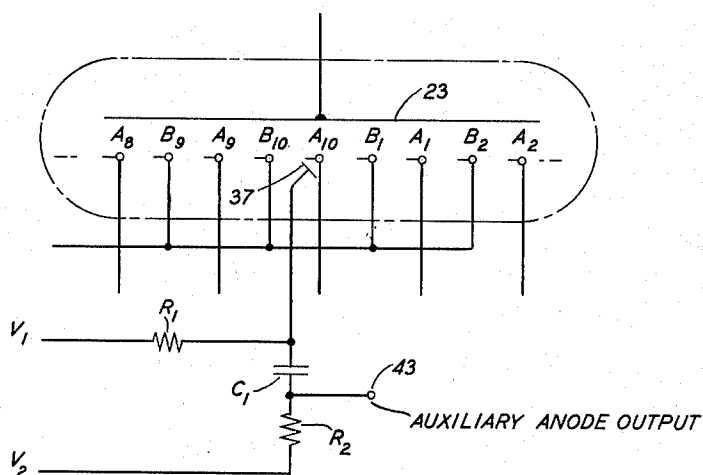


FIG. 4

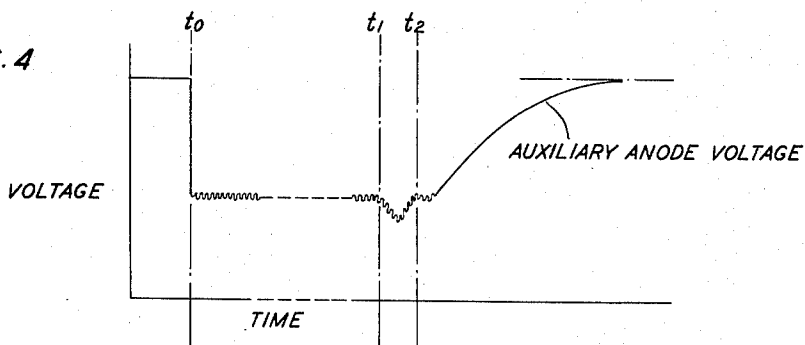
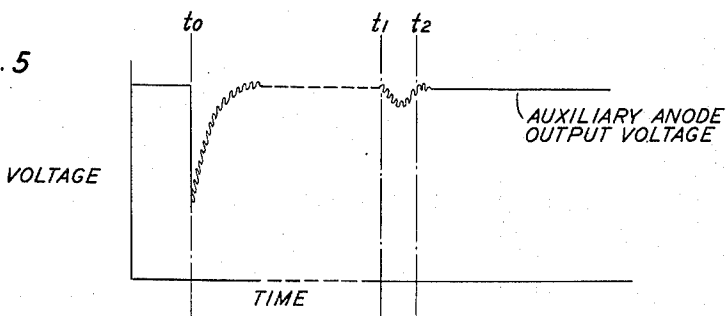


FIG. 5



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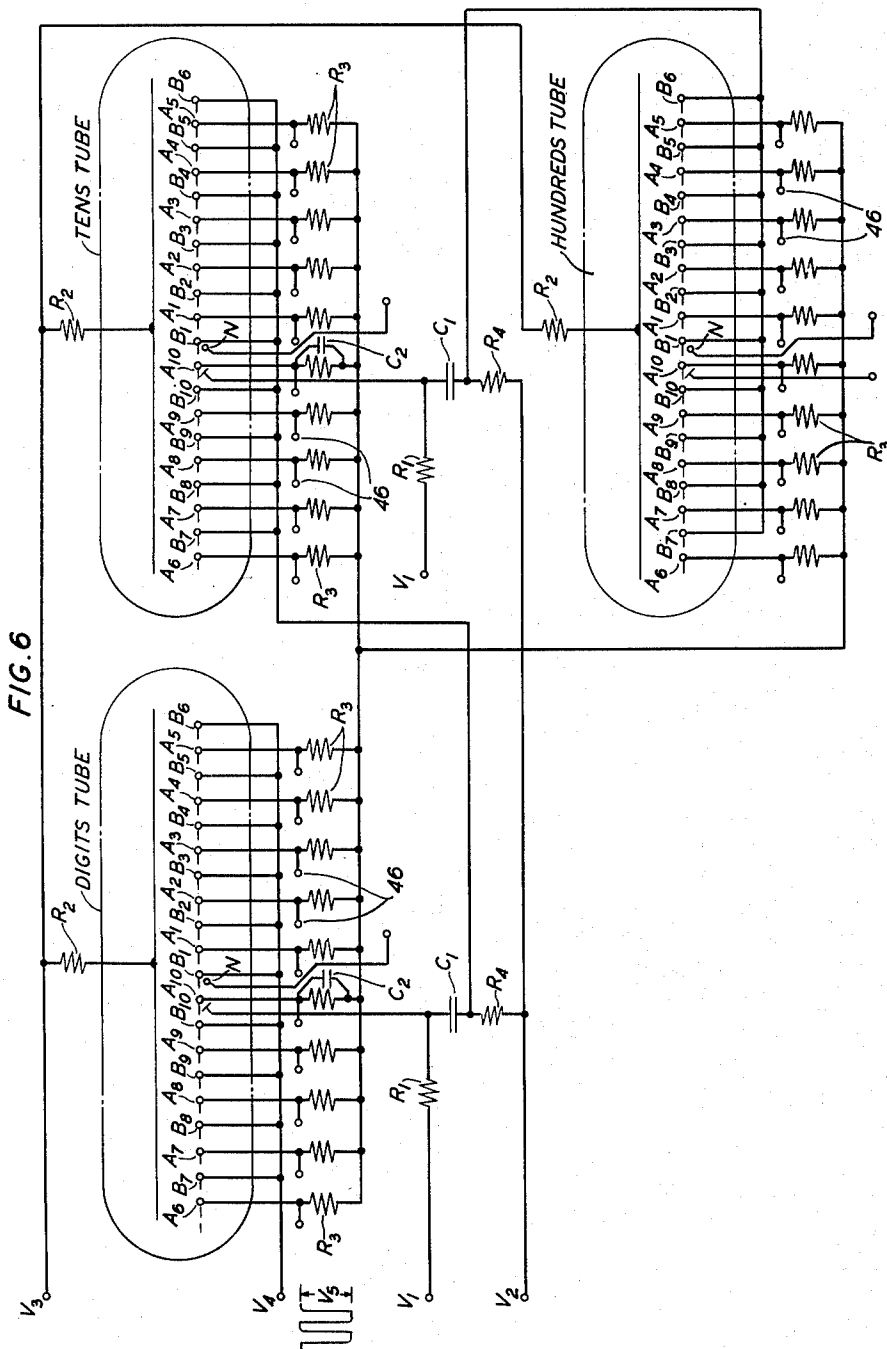
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3 Sheets-Sheet 3



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MULTICATHODE GASEOUS DISCHARGE
DEVICE AND CIRCUITS

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9 Claims. (Cl. 235-92)

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This invention relates to cold cathode discharge devices and more particularly to multiple cathode devices and circuits therefor.

Multiple cathode discharge devices of the type disclosed in my Patent 2,575,370 of November 20, 1951, and generally referred to as stepping tubes comprise a row or rows of cathodes along which a discharge is stepped. These cathodes may advantageously be alternating rest or A cathodes and transfer or B cathodes each comprising a preference mechanism, as set forth in the patent noted, whereby the discharge steps in a single direction. Such devices may be employed for counting pulses, as in dial pulse counting or decade counting. Thus three stepping tubes having each ten counting stages may be employed to count from "0" to "999," the first tube being the units tube, the second the tens tube and the third the hundreds tube. In such a counting circuit, the tens tube must be driven on the appearance of a pulse at the last or tenth stage of the units tube and similarly the hundreds tube must be driven by the appearance of a pulse at the last or hundredth stage of the tens tube.

In prior counting circuits employing stepping tubes, the discharge itself between the cathode of the last stage and the anode of the tube has been employed to provide the output pulse to drive the next tube. However, when the pulse is provided by the stepping discharge itself degeneration occurs so that regenerative circuit elements are necessary between the tubes to assure driving pulses of sufficient amplitude. If instead of using the stepping discharge, a probe electrode is positioned in the discharge between the cathode of the last stage of the stepping tube and the anode, the pulse obtained from the probe may be of sufficient voltage but will be of insufficient current to drive the next tube.

It is one object of this invention to provide a stepping tube capable of producing output pulses of sufficient amplitude to drive a similar tube without degeneration, thus obviating the necessity for regenerative circuits between stepping tubes.

The above object of this invention is attained by positioning an auxiliary anode adjacent one cathode in the stepping tube to produce an output signal when the counting discharge reaches that point in the row. The auxiliary anode is shielded so as to be fired only when a discharge is present at that particular cathode. Advantageously the auxiliary anode is biased to a positive voltage so that breakdown does not occur except when the main discharge is stepped to that particular cathode. Then when breakdown occurs to the auxiliary anode the discharge makes available a large negative output signal capable of driving a second stepping tube without requiring an intermediate regenerating circuit, because

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the pulse power is supplied from a source external to the tube under the control of the auxiliary anode discharge.

The auxiliary discharge between the stepping cathode and the auxiliary anode must be extinguished when the main discharge steps to the next stage in the stepping tube. However, if the discharge is made immediately self-extinguishing after providing an output pulse to the next stepping tube, the auxiliary discharge may be extinguished while the main discharge is still present at the stepping cathode which, with the auxiliary anode, forms the auxiliary gap. Thus, the auxiliary gap will break down again causing a second output pulse. If the main discharge is still present on extinguishment of this second auxiliary discharge, another erroneous output pulse will be generated. This can be prevented by positioning the auxiliary anode adjacent the transfer cathode directly before the rest cathode, the main discharge to which it is desired to trigger the next stepping tube. However, if the auxiliary anode is positioned adjacent a transfer cathode, the output pulse provided by the auxiliary anode would occur when the main discharge is at a transfer cathode while the other output signals occur during conduction to a rest cathode.

It is, therefore, a further object of this invention to enable the discharge to remain at a rest cathode for any length of time without generating erroneous pulses to the output circuit connected to the auxiliary anode adjacent that rest cathode and defining an output gap therewith. More particularly, it is an object of this invention to extinguish the auxiliary discharge on transfer of the main discharge from the rest cathode which is adjacent the auxiliary anode and which is cooperating in sustaining discharges in both the main and auxiliary gaps.

A further object of this invention is to provide a counting circuit wherein an output pulse may be taken directly from a prior stepping tube and applied to pulse the subsequent stepping tube without the necessity of an intervening regenerative stage, the output pulse being of sufficient magnitude and in proper phase.

These and other objects of this invention are attained in one illustrative embodiment wherein a plurality of alternate A or rest cathodes and B or transfer cathodes are mounted adjacent an anode, each pair of A and B cathodes comprising a stepping stage. External to the stepping row is a normal or N cathode defining a normal stage, a projection from the anode extending adjacent the N cathode. The normal stage is advantageously positioned adjacent the transfer cathode of the first stepping stage, i. e., adjacent the B₁ cathode, to initiate the discharge in the device.

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An auxiliary anode is positioned adjacent one of the rest cathodes to provide an output pulse when the counting discharge reaches a particular point in the stepping row. Advantageously the auxiliary anode is positioned adjacent the rest cathode of a last stepping stage; thus, in the specific embodiment of this invention comprising a ten-stage continuous counter the auxiliary anode is positioned adjacent the A_{10} cathode. The auxiliary anode is shielded so that it has a high breakdown voltage at all times except when the stepping discharge is present on the adjacent rest cathode, at which time the auxiliary gap defined by the auxiliary anode and the adjacent rest cathode will break down and there will then be present at that rest cathode both the main stepping discharge and the auxiliary discharge.

When the main discharge is stepped to the particular rest cathode adjacent the auxiliary anode, the auxiliary gap breaks down. The breakdown of the auxiliary gap causes the discharge of the auxiliary anode capacitor and thereby generates a negative voltage output pulse determined by the values of the resistance and capacitance in the auxiliary anode output circuit. Even though the main discharge remains at the rest cathode adjacent the auxiliary anode, multiple output pulses are avoided by correlating the series capacitance and resistance in the auxiliary anode output circuit so that relaxation oscillation doesn't occur and the auxiliary gap remains conducting all during the time that the main discharge is at the adjacent rest cathode. The auxiliary discharge, in accordance with this aspect of this invention, is then extinguished by means of the stepping signal, both the main and auxiliary discharges being stepped to the next transfer or B cathode. Since the transfer cathode is driven negative by the stepping discharge with respect to the A cathodes, the auxiliary anode capacitor will discharge to a lower value and the auxiliary gap will therefore fail to break down again at the end of the transfer cathode conduction period.

In one specific illustrative circuit in accordance with this invention, three stepping tubes having shielded auxiliary anodes adjacent the last or A_{10} rest cathode are employed for decade counting, the auxiliary anode of one tube being electrically connected to the transfer cathodes of the succeeding tube and the auxiliary anode capacitor and resistance being made such that the auxiliary discharge is present in the auxiliary gap as long as the main discharge is present at the A_{10} rest cathode, both discharges transferring to the next transfer cathode on application of the next stepping pulse.

A feature of this invention is, therefore, the positioning of a shield auxiliary anode adjacent a particular rest cathode in a stepping tube to define an auxiliary gap therewith capable of breaking down only when the main discharge is present at that rest cathode.

It is a further feature of this invention that the circuit constants of the auxiliary anode output circuit be such that the auxiliary discharge will be sustained as long as the main discharge is present at that rest cathode but will be extinguished on application of the next stepping pulse to the tube, both the main and the auxiliary discharge being stepped to the next adjacent transfer cathode.

It is a still further feature of this invention that a plurality of such devices be employed in

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a circuit for decade counting, the auxiliary anode output being applied directly to the transfer cathodes of the next subsequent stepping tube to cause stepping of the discharge in that tube, there being no intervening regenerative circuit between the auxiliary anode and the transfer cathodes of the subsequent device.

A complete understanding of this invention and of the various features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a perspective view of a gaseous discharge device illustrative of one embodiment of this invention, a portion of the envelope being broken away to show the interior elements more clearly;

Fig. 2 is a sectional view of the electrode assembly and mount of the device of Fig. 1;

Fig. 3 is a schematic representation of a portion of the stepping tube of Fig. 1 and the associated auxiliary anode circuit;

Fig. 4 is a graph of auxiliary anode voltage against time, illustrating particularly the variations in auxiliary anode voltage as the main discharge is stepped from rest cathode A_9 to rest cathode A_{10} and thence to rest cathode A_1 ;

Fig. 5 is a graph of the auxiliary anode output voltage for the same period of time as the graph of Fig. 4; and

Fig. 6 is a circuit incorporating a plurality of gaseous discharge devices in accordance with this invention for decade counting.

Referring now to the drawing, the specific gaseous discharge device illustrative of this invention depicted in Figs. 1 and 2 comprises a bulb 10 to which is sealed a stem 11 having a plurality of terminals 12 extending therethrough and hermetically sealed, as by seals 13. The bulb and stem may advantageously be of vitreous material, such as glass. Positioned within the bulb is a ceramic insulator block 15 having a central cylindrical raised portion 16. A threaded pin 17 extends axially through the insulator block 15 and portion 16 is secured thereto, as by glazing. A pair of insulator spacers 19 and 20 are positioned on the pin 17, resting on the portion 16 of the insulator block, the spacers defining a groove 21 therebetween. A cup-shaped anode 23, which may be of drawn molybdenum fits onto the pin 17 and is positioned between the spacer 20 and a nut 24 in threaded engagement with the end of the pin 17, the nut holding the assembled pile-up together. The nut 24 may advantageously be split and have its split portions pinched together to prevent loosening of the assembled unit. The insulator block and spacers, center pin 17, anode 23, and nut 24 advantageously have similar expansion properties to prevent loosening of the structure when extreme heating and cooling cycles are encountered during the processing of the device. In one specific illustrative embodiment the insulator members were of a ceramic known as F-66 Steatite, the pin 17 and nut 24 were of Kovar, and the anode 23 of molybdenum.

The anode 23 is advantageously slotted along its periphery to avoid overheating of its outer edge during the outgassing treatment in the processing of the device. A small projection 27 which may advantageously be a wire secured, as by brazing, to the anode 23, provides an anode extension for the normal section, described further below. Mounted and alternately arranged around the periphery of the anode 23 and directly

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adjacent thereto are a plurality of rest cathodes 29 comprising cathodes A₁ through A₁₀ and transfer cathodes 30 comprising cathodes B₁ through B₁₀. Each of the rest and transfer cathodes advantageously includes a preference mechanism, in accordance with my patent referred to above, comprising a hollow portion 50 defining a portion of high discharge efficiency and a flat portion 51 advantageously integral with the hollow portion and defining a portion of low discharge efficiency. The portion of low discharge efficiency is advantageously adjacent the portion of high discharge efficiency of the preceding cathode.

The B cathodes 30 are all mounted by a flat ring 31, as best seen in Fig. 2, and connected by means of a single lead 32 to one of the terminals 12. Advantageously the B cathodes are all stamped out from a single sheet, the high efficiency portions 50 being formed by bending over a part of the cathode so stamped out to provide a hollow portion. The A cathodes 29 are each mounted by a separate lead 33 extending through the insulator block 15 and secured thereto as by a glaze. In the specific illustrative embodiment depicted in Figs. 1 and 2, the leads 33 from the rest cathodes 29 are connected alternately to one of a pair of circular wires 34, in turn each secured to one of the terminals 12. In other embodiments of this invention, however, the leads 33 from each rest cathode may be each connected directly to a terminal 12 so that distinct voltage outputs may be generated to indicate the presence of the main discharge at any single rest cathode, as discussed below with reference to the embodiment of this invention illustrated in Fig. 6.

An N or normal cathode 35 is positioned beneath the row of A and B cathodes and adjacent a transfer cathode. The normal cathode is advantageously mounted by a lead, not shown, extending through the insulator block 15 and glazed thereto. The anode projection 27 defines with the normal cathode 35 a normal gap or section. A preference mechanism may be employed between the normal section and the adjacent transfer cathode to assure the stepping of the main discharge from the normal section into the stepping row following application of the initiating or normalizing pulse to the normal cathode. This preference mechanism may comprise a second portion of low discharge efficiency secured to the transfer cathode and facing the normal cathode.

An auxiliary anode 37 is positioned adjacent one of the rest cathodes and, in this specific embodiment is positioned adjacent the rest cathode immediately preceding the normal section. As this specific embodiment comprises ten stepping sections mounted in a circular array, the normal section will be adjacent cathode B₁, the transfer cathode of the first stepping stage, and the auxiliary anode will be adjacent cathode A₁₀, the rest cathode of the last stepping stage. The auxiliary anode 37 comprises a wire 38 encompassed by an insulating sheath 39 having a cup-shaped end 40 into which the wire 38 projects. The insulating sheath 39 extends beneath the upper surface of the insulating block 15 and, together with its component cup-shaped portion 40, shields the end of the wire 38 and thus shields the auxiliary anode 37 from other cathodes. The wire 38 is supported by a lead 42 attached to one of the terminals 12.

The operation of the auxiliary anode in supplying an output pulse can best be understood with reference to Figs. 3, 4, and 5. Fig. 3 illus-

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trates schematically a portion of the stepping tube of Fig. 1, illustrating particularly the rest and transfer cathodes adjacent the auxiliary anode, and also the auxiliary anode output circuit. The auxiliary anode bias and output circuit connections, as shown in Fig. 3, comprise a bias voltage V₁ applied to the auxiliary anode 37 through a resistance R₁, a bias voltage V₂ connected to the auxiliary anode through a resistance R₂ and a condenser C₁, and an output terminal 43 connected between the condenser C₁ and the resistance R₂. Figs. 4 and 5 are graphs of voltage wave forms at two different points in this auxiliary anode output circuit.

At the time the main discharge steps from rest cathode A₉ through transfer cathode B₁₀ to rest cathode A₁₀, the auxiliary gap defined by the auxiliary anode 37 and the rest cathode A₁₀ breaks down; this occurs at time t₀ in Figs. 4 and 5. Prior to this time the auxiliary anode voltage bias, which is the voltage on one side of condenser C₁, and is shown in Fig. 4, had been a certain value V₁ and the voltage at the auxiliary anode output terminal, which is the voltage on the other side of C₁ and is shown in Fig. 5, had been a certain value V₂. When the auxiliary gap breaks down, however, both these voltages drop, and, as they are separated merely by the condenser C₁ which cannot follow the sudden voltage drop, the two voltages will drop an equal amount. Condenser C₁ discharges on breakdown of the auxiliary gap and, together with the impedance R₁ in series therewith, provides a large negative output signal. Because R₁, R₂ and C₁ have been properly chosen, conduction will remain indefinitely in the auxiliary gap until some time t₁ when an additional pulse, from whatever source, is applied to the transfer cathode B₁. This causes both the main discharge and the auxiliary discharge to transfer from cathode A₁₀ to cathode B₁ and at time t₂ the main discharge transfers to cathode A₁, as described in my patent. However, during the time from t₁ to t₂ the condenser C₁ is discharged to such a value that the auxiliary gap can no longer sustain a discharge. Then when the main discharge is stepped to cathode A₁ no conduction occurs between the auxiliary anode and cathode A₁ and the auxiliary discharge is extinguished.

The voltage wave forms will have slight variations in them due to anode oscillations and also due to certain inductive effects. The curves of Figs. 4 and 5 have been slightly simplified for the purposes of this explanation. However the voltage curves will have the general forms shown. As can be seen the voltage across the resistance R₂, which is the auxiliary anode output voltage, will have an initial negative output pulse. This initial output pulse can be of sufficient magnitude to perform a variety of functions, including firing other gaseous tubes or stepping a discharge along a similar stepping tube without requiring an intervening regenerative stage. A circuit for decade counting of pulses from 000 to 999 wherein the auxiliary anode output is employed to step the discharge in the next succeeding tube is shown in Fig. 6, similar elements being identified with the reference characters previously referred to. As there seen the anodes 23 of each of the tubes are connected to a voltage V₃ through an anode resistance R₂. In this embodiment the rest cathodes are not connected to a common terminal but each of the rest cathodes is singularly connected through an output resistance R₃ to ground, an output being taken across each rest

cathode from the terminals 46. The resistances R_3 are advantageously of identical resistance so that the same output pulse will be derived from each of the rest cathodes. However if the resistance R_3 in series with the rest cathode A_{10} is of the same size as the other resistances R_3 then an excessive output signal will be derived when the auxiliary gap also fires into rest cathode A_{10} . This can be avoided either by employing a smaller resistance or by putting a capacitance C_2 across the resistance in series with rest cathode A_{10} , the capacitance C_2 being large with respect to capacitance C_1 .

Each of the transfer cathodes of the first or digit tube is connected to a voltage V_4 to which a negative pulse V_5 is applied to step the discharge in the units tube. The transfer cathodes of the second or tens tube and of the third or hundreds tube are connected to the output terminal of the auxiliary anode output circuit of the preceding tube. In the operation of this circuit for decade counting the operation of the auxiliary anode is as described above. Thus when the number 200 has been reached in the counting the main discharges will be at rest cathode A_{10} in each of the units and tens tubes and at rest cathode A_2 in the hundreds tube. Despite the fact that the main discharge will remain at rest cathode A_{10} in the tens tube until ten pulses have been counted by the units tube, only a single pulse will be supplied to the hundreds tube, R_1 , C_1 , and R_2 having been chosen so that the auxiliary discharge remaining conducting during the entire time that the main discharge is present at rest cathode A_{10} . Erroneous generation of pulses will therefore not occur.

In one specific illustrative embodiment of this invention, the voltage bias V_1 applied to the auxiliary anode was +200 volts, the voltage bias V_2 was +17 volts, the voltage V_3 applied to the main anode 23 was +270 volts, the voltage V_4 applied to the transfer cathodes was +17 volts, and the amplitude of the stepping pulse V_5 was 45 volts. Resistance R_1 was 200,000 ohms, R_2 was 75,000 ohms, R_3 was 10,000 ohms, and R_4 was 36,000 ohms. Capacitance C_1 was .005 microfarad and capacitance C_2 was .1 microfarad. The envelope 10 was filled with neon at a pressure of 135 millimeters of mercury, the spacing between the rest cathode A_{10} and the auxiliary anode 37 was .030 inch, and the operating current in the main discharge was 2 milliamperes. It has been found advantageous to use a driving pulse having somewhat slowly rising and falling wavefronts as indicated by the shape of the signal applied to the B cathode of Fig. 6.

The auxiliary anode 37 has a high breakdown voltage at all times except when the stepping discharge is present at the adjacent rest cathode, which enables a negative output pulse of considerable amplitude to be obtained when the auxiliary gap is triggered by the main discharge being stepped to the auxiliary anode, the auxiliary anode being connected to a positive voltage, as set forth above. The upper limit of this bias voltage is set by the requirement that the auxiliary gap shall not break down when the main discharge is present on cathodes other than the adjacent rest cathode. The lower limit is determined by the requirement that the auxiliary gap break down, or be triggered, by the presence of the main discharge at that adjacent rest cathode. These limits are dependent on gap spacing, the gaseous filling, and the operating current in the main anode circuit. The auxiliary anode bias

voltage also determines the output pulse. When the auxiliary gap breaks down the auxiliary anode potential falls to the sustaining voltage of the auxiliary gap, which may advantageously be of the order of 115 volts. The available output signal is therefore the difference between the bias voltage and the auxiliary gap sustaining voltage, the current of the output signal and its duration being determined by the circuit elements in the auxiliary anode discharge circuit, and particularly the condenser which discharges on breakdown of the auxiliary gap.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention and that numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A multicathode gaseous discharge device comprising a plurality of rest and transfer cathodes alternately arranged, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes, and means for applying a bias to said auxiliary anode to cause breakdown of the gap between said auxiliary anode and said adjacent rest cathode only when the main discharge is present at said adjacent rest cathode.

2. A multicathode gaseous discharge device comprising a plurality of rest and transfer cathodes alternately arranged in a circular array, each of said cathodes comprising a portion of greater and a portion of lesser discharge efficiency and the portion of lesser efficiency being adjacent the portion of greater efficiency of the preceding cathode, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes, circuit means for applying a potential to said auxiliary anode to cause breakdown of the gap between said auxiliary anode and said adjacent rest cathode only upon breakdown of the gap between said adjacent rest cathode and said main anode, and output means connected to said auxiliary anode providing an indication of said breakdown to said auxiliary anode.

3. A multicathode gaseous discharge device comprising a plurality of rest and transfer cathodes alternately arranged, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes and defining an auxiliary gap therewith, said auxiliary anode being substantially shielded from the remainder of said rest cathodes, circuit means for applying a potential to said auxiliary anode to cause breakdown of said auxiliary gap when the main discharge is present at said adjacent anode, and output means connected to said auxiliary anode to provide a single output pulse on breakdown of said auxiliary gap.

4. A stepping tube comprising a plurality of rest and transfer cathodes alternately arranged in a circular array, each of said cathodes including a preference mechanism to assure stepping of the discharge along said array, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes and shielded from the other of said cathodes, circuit means for applying a potential to said auxiliary anode to cause breakdown of the auxiliary gap between said auxiliary anode and said adjacent rest cathode only when the main discharge is stepped to

said adjacent rest cathode, and output means connected to said auxiliary anode to provide a single output pulse on breakdown of said auxiliary gap.

5. In combination, a stepping tube comprising a plurality of rest and transfer cathodes alternately arranged in an array, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes and defining an auxiliary gap therewith, said auxiliary anode being substantially shielded from the remainder of said rest cathodes, circuit means for applying a potential bias to said auxiliary anode to cause breakdown of said auxiliary gap only when the main discharge is stepped to said adjacent rest cathode, output means connected to said auxiliary anode to provide a single output pulse on breakdown of said auxiliary gap, and circuit means for extinguishing the discharge in said auxiliary gap only on the stepping of the main discharge from said adjacent rest cathode to the next succeeding rest cathode in said array.

6. In combination, a stepping tube comprising a plurality of rest and transfer cathodes alternately arranged in an array, each of said cathodes including a preference mechanism to assure stepping of the discharge along said array, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes and defining an auxiliary gap therewith, means for applying stepping pulses to said transfer cathodes to cause said discharge to step along said array, means for applying a potential to said auxiliary anode to cause breakdown of said auxiliary gap only when said discharge is stepped to said adjacent rest cathode, output means connected to said auxiliary anode to provide a single output pulse on breakdown of said auxiliary gap, and circuit means for extinguishing the discharge in said auxiliary gap only on stepping of said main discharge from said adjacent rest cathode to the next succeeding rest cathode in said array.

7. In combination, a stepping tube comprising a plurality of rest and transfer cathodes alternately arranged in an array, each of said cathodes including portions of greater and lesser discharge efficiency, the portion of lesser efficiency being adjacent the portion of greater efficiency of the preceding cathode, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes and defining a gap therewith, said auxiliary anode being shielded from the remainder of said rest cathodes, means for initiating a main discharge between said main anode and one of said rest cathodes, means for stepping said main discharge along said array comprising means for applying stepping pulses to said transfer cathodes, means for applying a potential to said auxiliary anode to cause breakdown of said auxiliary gap only when said main discharge is stepped to said adjacent rest cathode, output means connected to said auxiliary anode to provide a single output pulse on breakdown of said auxiliary gap, and means for extinguishing the discharge in said auxiliary gap only on the stepping of said main and auxiliary discharges from said adjacent rest cathode to the next succeeding transfer cathode in said array, said last-mentioned means comprising a capacitance and a resistance in series in said auxiliary discharge circuit and of such value as to enable said auxiliary discharge to be sustained until said auxiliary

discharge is stepped from said adjacent rest cathode.

8. In combination, a stepping tube comprising a plurality of rest and transfer cathodes alternately arranged in a circular array, each of said cathodes including portions of greater and lesser discharge efficiency, the portion of lesser discharge efficiency being adjacent the portion of greater efficiency of the preceding cathode, a main anode opposite said cathodes and in cooperative relationship therewith, an auxiliary anode adjacent one of said rest cathodes and defining an auxiliary gap therewith, said auxiliary anode being shielded from the remainder of said rest cathodes, means for initiating a main discharge between said main anode and one of said rest cathodes, means for applying stepping pulses to said transfer cathodes to cause said discharge to step along said array, a source of potential connected to said auxiliary anode through a first resistance of about 100,000 ohms, said potential being sufficient to cause breakdown of said auxiliary gap only when said main discharge is present at said adjacent rest cathode, a condenser of about .005 microfarads connected to said auxiliary anode, and an output terminal and a second resistance of about 36,000 ohms connected to the other side of said condenser, said second resistance and said condenser being in series in said auxiliary discharge circuit whereby said auxiliary discharge supplies a single output pulse to said output terminal and is sustained until said main discharge is stepped to the next succeeding rest cathode in said array, said auxiliary discharge being also stepped away from said adjacent rest cathode and being extinguished.

9. A counting circuit comprising a digits stepping tube, a tens stepping tube, a hundreds stepping tube, each of said tubes comprising ten rest and ten transfer cathodes alternately arranged in a circular array, said cathodes including a preference mechanism to assure stepping of the discharge along said array, a main anode opposite said cathodes and in cooperative relationship therewith, and means for initiating a main discharge between said main anode and one of said transfer cathodes, and said digits and tens tubes also comprising an auxiliary anode adjacent the rest cathode immediately preceding said one transfer cathode and defining a gap therewith, said auxiliary anode being shielded from the remainder of said cathodes, means for applying a potential to said auxiliary anode to cause breakdown of said auxiliary gap only when the main discharge is stepped to said adjacent rest cathode, means for applying stepping pulses to the transfer cathodes of said digits tube to step the discharge along said digit tube array, circuit means connected between said auxiliary anodes and the transfer cathodes of the next succeeding stepping tube to provide a single pulse to said transfer cathodes on breakdown of said auxiliary gap, and means for extinguishing the discharge in said auxiliary gap only on the stepping of said main and auxiliary discharges from said adjacent rest cathode to the next succeeding transfer cathode in said array, said last-mentioned means comprising a capacitance and a resistance in series in the auxiliary discharge circuit of each of said auxiliary anodes and of such value as to enable said auxiliary discharge to be sustained until said auxiliary discharge is stepped from said adjacent rest cathode.

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No references cited.