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J. H. BEESLEY

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ELECTRICAL GAS DISCHARGE TUBE CIRCUITS

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2 Sheets-Sheet 1

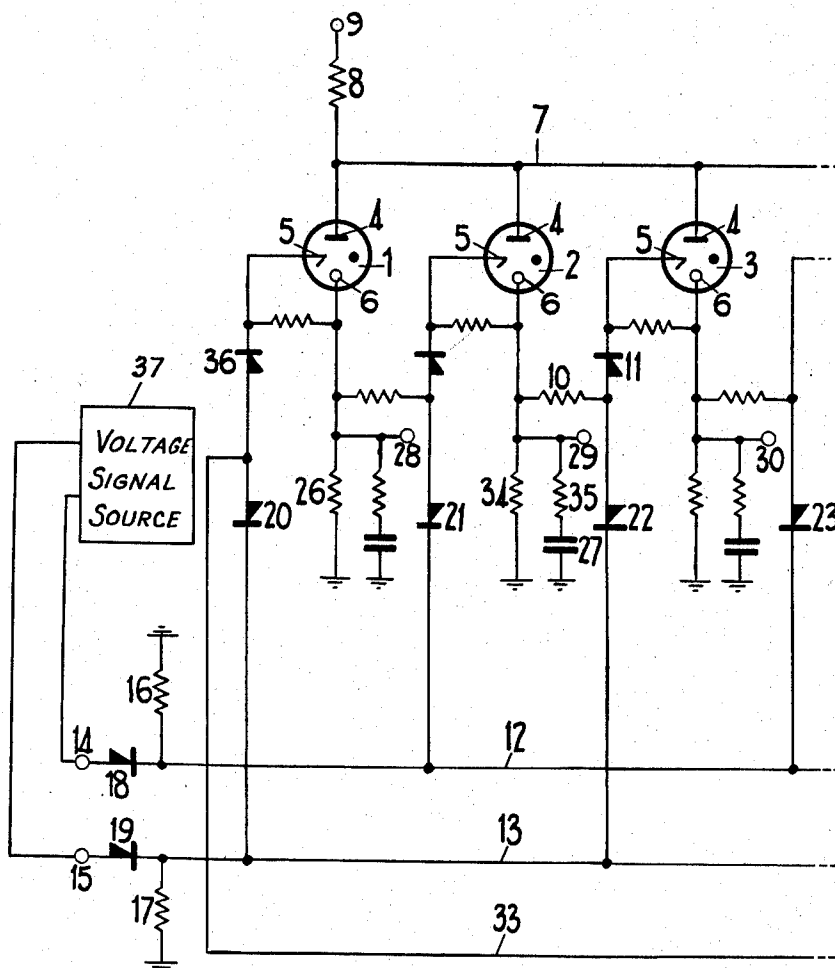


FIG 1

INVENTOR

JOHN HENRY BEESLEY

BY

E. J. Harris & Frankenstein
ATTORNEYS

ATTORNEY

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J. H. BEESLEY

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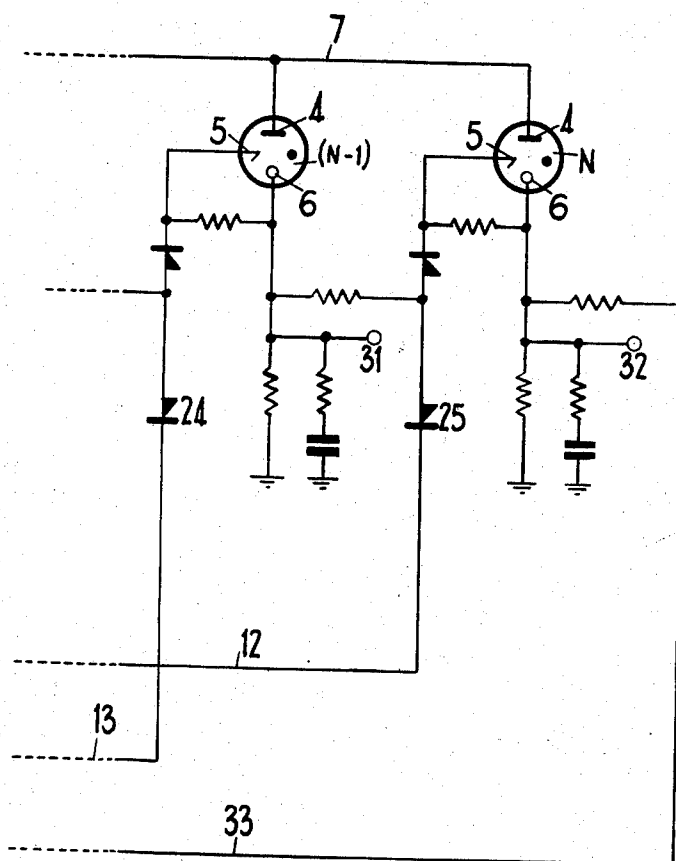


FIG 2

INVENTOR
JOHN HENRY BEESLEY
BY *Wm. H. Beesley*
ATTORNEY

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ELECTRICAL GAS DISCHARGE TUBE CIRCUITS

John Henry Beesley, Coventry, England, assignor to The General Electric Company Limited, London, England

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19 Claims. (Cl. 315—84.5)

This invention relates to electrical gas discharge tube circuits. The invention is particularly concerned with electrical counting or distributing circuits that employ gas discharge tubes of the kind having an anode and a cathode forming a main discharge gap and a striker electrode forming an auxiliary discharge gap with the cathode, such gas discharge tubes being hereinafter referred to as gas tubes.

An object of the present invention is the provision of an improved form of electrical gas tube counting or distributing current.

According to the present invention, a gas tube counting or distributing circuit, comprises a plurality of gas tubes connected in a chain, at least two input leads to which the signals to be counted or distributed are applied, and connections between adjacent gas tubes of the chain and between the said gas tubes and the said input leads so that, when one of the said gas tubes is conducting a striking potential is applied to the striker electrode of the following gas tube in the chain when at least a predetermined voltage is applied to a particular one of the said input leads.

The striking potential may be derived from the main gap discharge current of the said conducting tube.

Preferably, each of the said gas tubes is a cold cathode gas discharge triode.

The operation of a gas tube counting or distributing circuit according to the present invention may be substantially independent of the shape of an input signal pulse. Two or more such counting or distributing circuits may therefore be connected in cascade by means of individual electrical connections from the input leads of one such circuit each to a different output of a similar preceding circuit, there being no pulse shaping between the two circuits.

One arrangement in accordance with the present invention will now be described, by way of example, with reference to the two figures of the accompanying diagrammatic drawings, which are complementary illustrations of the electrical circuit of a counting circuit.

The circuit comprises an even plurality N of gas tube counting stages of which the first three tubes 1, 2 and 3 are shown in Figure 1 and the last two tubes (N-1) and N are shown in Figure 2. The counting stages are arranged in a closed chain. Each of the gas tubes is a cold cathode gas discharge triode, and has an anode 4, a striker electrode 5 and a cathode 6. The anodes 4 are connected to a common lead 7 and thence by way of a resistor 8 to a terminal 9.

The electrical circuit of each counting stage is identical. Thus the gas triode 2 say has its cathode 6 connected to earth by way of a resistance-capacitance network comprising in one of two arms that are connected in parallel a resistor 34 and in the other arm a resistor 35 and a capacitor 27 in series. This cathode 6 is also connected to the striker electrode 5 of the succeeding gas triode 3 of the chain by way of a re-

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sistor 10 and a rectifier element 11. The rectifier element 11, hereinafter referred to as a striker rectifier, is connected so as to afford a low resistance to conventional current flow towards the striker electrode 5 of the triode 3, its function being as described in the specification of co-pending British patent application No. 36,375/53.

Two input leads 12 and 13 are provided, the voltage signals to be counted being applied to these leads by way of terminals 14 and 15 respectively. Each of the leads 12 and 13 is connected to earth by way of a resistor 16 or 17. Such potentials as are developed across the resistors 16 and 17 during operation are isolated from the terminals 14 and 15 by means of the suitably connected rectifier elements 18 and 19 respectively.

The junction of the resistor 10 and the striker rectifier 11 is connected to the input lead 13 by way of a rectifier element 22, hereinafter referred to as a junction rectifier, so connected as to afford a low resistance to conventional current flow towards the lead 13. The junction rectifiers 20 to 25 are associated each with a different one of the gas triodes and are connected to the leads 12 and 13 in a cyclic order, that is, alternate junction rectifiers along the counting chain are connected to the same lead 12 or 13.

During operation, the terminal 9 is connected to a source of positive potential of insufficient magnitude to initiate a main gap discharge in a gas triode but sufficient to maintain such a discharge once initiated. The positive voltage signals to be counted are applied alternately to the terminals 14 and 15.

Let it be assumed that the gas triode 1 is conducting across its main gap. Its cathode 6 is then at a positive voltage with respect to earth by virtue of the discharge current flowing through the resistor 26. The value of this voltage is sufficient to initiate a striker electrode to cathode discharge in the gas triode 2 when applied across these electrodes. In the absence of a suitable positive voltage signal on the lead 12 the junction rectifier 21 is conductive. The striker electrode 5 of the gas triode 2 is thus maintained below the voltage necessary to cause striking. Application of a suitable positive voltage signal to the terminal 14, and hence to the lead 12, biases the junction rectifier 21 to a non-conductive condition. The voltage at the striker electrode 5 of the gas triode 2 therefore rises and an auxiliary gas discharge is initiated in this tube. The gas triode 2 consequently strikes by transfer of the said discharge to its main discharge gap, such transfer being effected by virtue of the positive voltage on the anode 4 of this gas triode 2. The resulting discharge current flows through the resistor 8 and the voltage on the lead 7 thus falls below the discharge maintaining value for the main gap of the gas triode 1. This discharge in this gas triode 1 is therefore extinguished. The main gap discharge current of the gas triode 2 charges the capacitor 27, the cathode voltage of this gas triode rising from earth to a value sufficient to initiate the striking of the gas triode 3 although that triode does not strike owing to its striker electrode voltage being held down due to the fact that the junction rectifier 22 is conducting.

The next voltage signal is applied to the terminal 15 and acts to bias the junction rectifier 22 to a non-conductive condition. The gas triode 3 therefore strikes, the gas triode 2 being extinguished in the manner previously described. In this way each positive voltage signal applied alternately to the terminals 14 and 15 is registered by the striking of one of the gas triodes, the gas triode previously struck being extinguished. The particular one of the gas triodes conducting at any time during the count is signified by the presence of a positive voltage with re-

spect to earth on the appropriate one of the output terminals, such as the terminals 28 to 32.

The striking of the gas triode N, resulting from both the application of a voltage signal to the terminal 14 and the occurrence of a suitable positive voltage at the cathode 6 of the gas triode (N-1), causes the voltage of the lead 33 to become sufficiently positive to initiate the striking of the gas triode 1 when the next voltage signal is applied to the terminal 15. The counting circuit thus continues to function for as long as suitable voltage signals are applied alternately to the terminals 14 and 15.

When only two input leads, such as the leads 12 and 13, are provided, a false count may result if the input signals overlap in time, that is, if suitable positive voltages exist simultaneously on both leads. This condition may be overcome by providing three or more input leads, the junction rectifiers being connected cyclically to these leads.

When the counting stages are connected in a closed chain, as in the arrangement illustrated and described above, it is essential that the number of counting stages is a multiple of the number of input leads if all the input signals are to be counted or distributed correctly. Thus with the counting circuit illustrated, had there been an odd number of stages, then both junction rectifiers 20 and 25 would have been connected to the same input lead 13. In this case the application of a voltage signal to the lead 13 to initiate the striking of the gas triode N could also result in the striking of the gas triode 1 if the said voltage signal is maintained for a sufficient period. Alternatively, if only the gas triode N is struck as a result of the said voltage signal, the next voltage signal, which is applied to the lead 12, will be of no effect. In either alternative a false count results.

Although the invention has been described in its application to closed chain circuits, it is not necessarily restricted to such arrangements. Thus, when the number of signals to be counted or distributed at any time lies within predetermined limits it is usually required that a count shall always commence from a predetermined one of the gas tubes, as for example the gas triode 1. In this event the lead 33 can be omitted, as also can the junction rectifier 20. Arrangements are made whereby when the circuit is taken into use the gas triode 1 is struck previous to the application of voltage signals to the leads 12 and 13. This may be effected by applying a suitable positive voltage to the striker rectifier 36. The first voltage signal is then applied to the input lead 12, and is registered by the striking of the gas triode 2, the gas triode 1 being extinguished in the manner previously described.

It will be appreciated from the above description that the junction rectifiers, such as the rectifiers 20 to 25, are substantially non-conductive to the voltage signals on the input leads, so that the input current flow which results from such a voltage signal is substantially independent of the number of counting or distributing stages.

The use of the term junction rectifier for the rectifier elements 20 to 25 should be interpreted as relating to the location of these elements. These rectifier elements, together with all the other rectifier elements employed in the circuit described above, are preferably of the selenium type.

It is sometimes required to connect two or more counting or distributing circuits in cascade and in known arrangements it is usually necessary to employ pulse shaping devices in the inter-connections. Such a necessity does not arise with circuits of the present form since their operation depends upon potential levels and may be substantially independent of the shape of the input signals. Individual connections may thus be made from the input leads of one such gas tube circuit each to a different output of a preceding circuit, there being no pulse shaping between the two. If necessary more than one output may be connected to the same input lead if rectifier elements

are included in the said connections, the said rectifier elements being so connected as to isolate from one another the said outputs without inhibiting the application of signals to the associated input lead.

The voltage signals that are supplied to the input leads 12 and 13 may be derived from any suitable source 37, an example of such a source being a bi-stable trigger circuit.

I claim:

1. An electric circuit comprising a plurality of gas discharge tubes which each has an anode, a cathode and a striker electrode, a small plurality of input leads, means to apply voltage signals, each of a predetermined value, to the input leads in a particular sequence so that such a voltage signal occurs on only one input lead at a time, and a plurality of gating circuits which connect the gas tubes in a chain for sequential striking in response to voltage signals of the predetermined value occurring in the particular sequence on the input leads, each gating circuit coupling a different pair of adjacent gas tubes in a chain and having a first input connected to the first gas tube of its associated pair, a second input connected to one of the input leads and an output connected to the striker electrode of the second gas tube of its associated pair, adjacent gating circuits in the chain having their second input connected to different ones of the said input leads and each gating circuit enabling the second gas tube of its associated pair to be rendered conducting in response to a voltage signal of the predetermined value on the associated input lead only if the first gas tube of the pair is conducting.

2. An electric circuit according to claim 1 in which the said gating circuits connect said gas tubes in a continuous chain.

3. An electric circuit according to claim 1 in which individual resistance means is connected to the cathode of each gas tube to derive a voltage signal of the predetermined value from the discharge current through the gas tube, when conducting, and in which said gating circuit has its first input connected to the cathode of the first gas tube of the associated pair.

4. An electric circuit according to claim 3 in which individual capacitance means is provided for each gas tube, each said capacitance means being connected in shunt with the individual resistance means of the associated gas tube to provide an exponential rise and fall to the voltages developed across said individual resistance means in which there are provided resistance connected in common to the anodes of the gas tubes and mutual extinguishing means including the common resistance and the individual capacitance means whereby the conduction of any one of said gas tubes causes any previously conducting gas tube to be extinguished.

5. An electric circuit according to claim 1 in which said gas tubes are cold cathode gas discharge triodes.

6. An electric circuit comprising a plurality of gas discharge tubes which each has an anode, a cathode and a striker electrode, a small plurality of input leads, means to apply voltage signals, each of a predetermined value, to the input leads in a particular sequence so that such voltage signal occurs on only one input lead at a time, resistance connected in common to the anodes of the gas tubes, a plurality of capacitance means each connected to the cathode of a different one of the gas tubes, mutual extinguishing means including said resistance and said capacitance means whereby the conduction of any one of the gas tubes causes any previously conducting gas tube to be extinguished and a plurality of gating circuits which connect the gas tubes in a chain for sequential striking, one at a time, in response to voltage signals of the predetermined value occurring in the particular sequence on the input leads, each gating circuit coupling a different pair of adjacent gas tubes in the chain and having a first input connected to the cathode of the first gas tube of the associated pair, a second input connected to one of the

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input leads and an output connected to the striker electrode of the second gas tube of the associated pair, adjacent gating circuits in the chain having their second inputs connected to different ones of the said input leads and each gating circuit enabling the second gas tube of its associated pair to be rendered conducting upon the occurrence of a voltage signal of the predetermined value on the associated input lead only if the first gas tube of the pair is conducting.

7. An electric circuit according to claim 6 in which the said gating circuits connect said gas tubes in a continuous chain.

8. An electric circuit according to claim 6 in which said gas tubes are cold cathode gas discharge triodes.

9. An electric circuit comprising a plurality of gas discharge tubes which are each of the kind having an anode, a cathode and a striker electrode and which are connected in cascade to form a chain, individual resistance means connected to the cathode of each gas discharge tube to derive a voltage signal of predetermined value from the discharge current through the gas tube when conducting, a small plurality of input leads, means to apply voltage signals, each of at least the said predetermined value, to the input leads in a particular sequence so that such a voltage signal occurs on only one input lead at a time, a plurality of signal coincidence circuits which each has a first input, a second input and an output and which are each arranged to act upon the coincidence of voltage signals of the said predetermined value on the first and second inputs to gate a voltage signal of the same value to the associated output, connections between the first inputs of the said coincidence circuits and the said resistance means to apply to the first inputs the said voltage signals derived, during operation, at the said resistance means, connections between the second inputs of the said coincidence circuits and the said input leads to apply to the second inputs the said voltage signals occurring, during operation, on the said input leads and connections between the outputs of the said coincidence circuits and the striker electrodes to apply to the said striker electrodes the voltage signals of the said predetermined value which, during operation, are gated to the outputs of the said coincidence circuits and which render the said gas tubes conducting, each said coincidence circuit being thus associated with a different pair of the said gas tubes which occupy adjacent positions in the chain and the said coincidence circuits which have their outputs connected to adjacent gas tubes in the chain having their second inputs connected to different ones of the said input leads.

10. An electric circuit according to claim 9 in which each said coincidence circuit comprises a common point, resistance connected between the first input and the common point, and a rectifier element which is connected between the common point and the output and which is conductive towards the output and a second rectifier element which is connected between the common point and the second input and which is conductive towards the second input.

11. An electric circuit according to claim 9 in which the said coincidence circuits connect said gas tubes in a continuous chain.

12. An electric circuit according to claim 9 in which individual capacitance means is provided for each gas tube, each said capacitance means being connected in shunt with the individual resistance means of the associated gas tube to provide an exponential rise and fall to the voltages developed across said individual resistance means and in which there are provided resistance connected in common to the anodes of the gas tubes and mutual extinguishing means including the common resistance and said capacitance means whereby the conduction of any one of said gas tubes causes any previously conducting gas tube to be extinguished.

13. An electric circuit according to claim 9 in which said gas tubes are cold cathode gas discharge triodes.

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14. An electric circuit comprising a plurality of gas discharge tubes which each has an anode, a cathode and a striker electrode, a direct current power source for energizing said gas tubes, a small plurality of input leads, means to apply voltage signals, each of a predetermined value, to said input leads in a particular sequence so that such a voltage signal occurs on only one input lead at a time, individual resistance means connected between the cathode of each gas tube and the negative side of said power source to derive a voltage signal of said predetermined value from the discharge current through the gas tube, when conducting, individual capacitance means connected between the cathode of each gas tube and the negative side of said power source to provide an exponential rise and fall to the voltages occurring at the cathode, resistance connected in common to the anodes of said gas tubes, a connection from the positive side of said power source to said common resistance, the said power source, the common resistance and the said capacitance means acting to cause a mutual extinguishing action between the gas tubes whereby the conduction of any one of the said gas tubes causes any previously conducting gas tube to be extinguished, and a plurality of gating circuits which connect said gas tubes in a chain for sequential striking, one at a time, in response to said voltage signals occurring on the input leads in the particular sequence, each gating circuit coupling a different pair of adjacent gas tubes in the chain and having a first input connected to the cathode of the first gas tube of the associated pair, a second input connected to one of the input leads and an output connected to the striker electrode of the second gas tube of the associated pair, adjacent gating circuits in the chain having their second inputs connected to different ones of the said input leads and each gating circuit being adapted to gate a striking voltage to the striker electrode of the second gas tube of the associated pair to render said second gas tube conducting upon the coincidence of voltage signals of said predetermined value on the first and second inputs of the gating circuit.

15. An electric circuit according to claim 14 in which the said gating circuits connect said gas tubes in a continuous chain.

16. An electric circuit according to claim 14 in which each said gating circuit comprises a common point, resistance connected between the first input and the common point, a first rectifier element which is connected between the common point and the output and which is conductive towards the output and a second rectifier element which is connected between the common point and the second input and which is conductive towards the second input.

17. An electric circuit according to claim 14 in which said gas tubes are cold cathode discharge triodes.

18. An arrangement comprising at least two electric circuits which are each in accordance with claim 14, there being provided connections from the input leads of one of said circuits each to the cathode of a different gas tube in the other one of said circuits.

19. An electrical circuit comprising a plurality of gas discharge tubes which each has an anode, a cathode and a striker electrode, a positive supply conductor which is for connection to the positive side of a direct current power source for energizing the gas tubes and to which said anodes are connected, a negative supply conductor for connection to the negative side of said power source, a plurality of resistance means which are each connected between a different one of said cathodes and the negative supply conductor, and which are each to derive a voltage of a predetermined value from the discharge current that flows through the associated gas tube when conducting, at least two input leads and a plurality of signal gating circuits which connect the gas tubes in a chain for sequential striking in response to voltage signals of the predetermined value occurring in a particular sequence between the input leads and the negative supply conductor, each

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gating circuit coupling a different pair of adjacent gas tubes in the chain and comprising a resistance-rectifier network which interconnects the cathode of the first gas tube of the associated pair, the striker electrode of the second gas tube of that pair and one of the input leads so that the flow of electric current is permitted from the associated cathode to both the associated striker electrode and input lead, adjacent gating circuits in the chain being connected to different ones of the input leads and each gating circuit being arranged to apply a striking voltage of the predetermined value between the striker electrode and cathode of the second gas tube of its associated pair to render that gas tube conducting only upon the occur-

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rence of the predetermined voltage between the cathode of the first gas tube of that pair and the negative supply conductor and also between the associated input lead and the negative supply conductor.

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