July 30, 1946. W. P. OVERBECK 2,404,920

ELECTRONIC DISCHARGE APPARATUS

Filed Sept. 27, 1940 2 Sheets-Sheet 1

Fig. 1

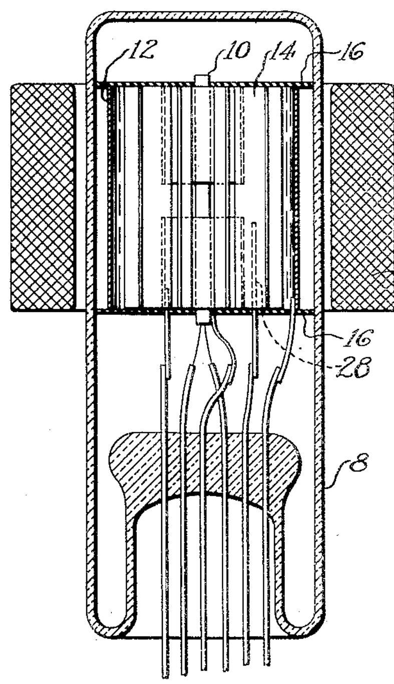


Fig. 2

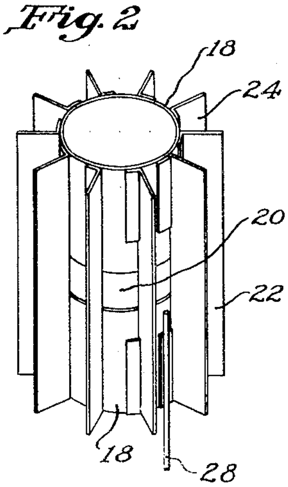


Fig. 3

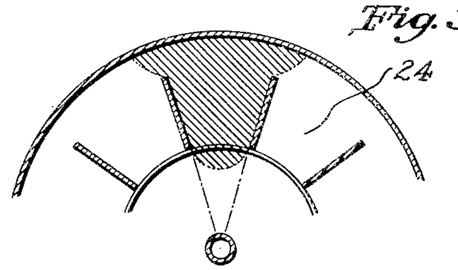
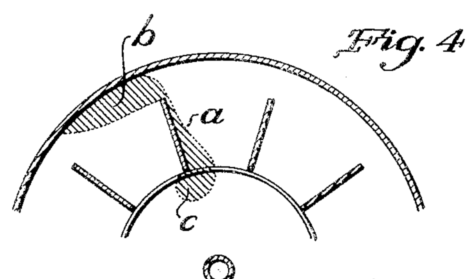


Fig. 4



Witness

Paul F. Bryant

Inventor

Wilcox P. Overbeck

by his attorneys

Fish Hildreth Cary Jenney

July 30, 1946. W. P. OVERBECK 2,404,920

ELECTRONIC DISCHARGE APPARATUS

Filed Sept. 27, 1940 2 Sheets-Sheet 2

Fig. 5

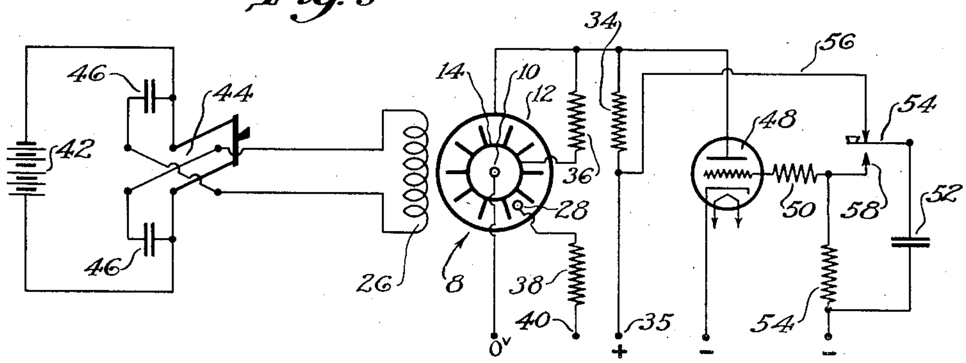


Fig. 6

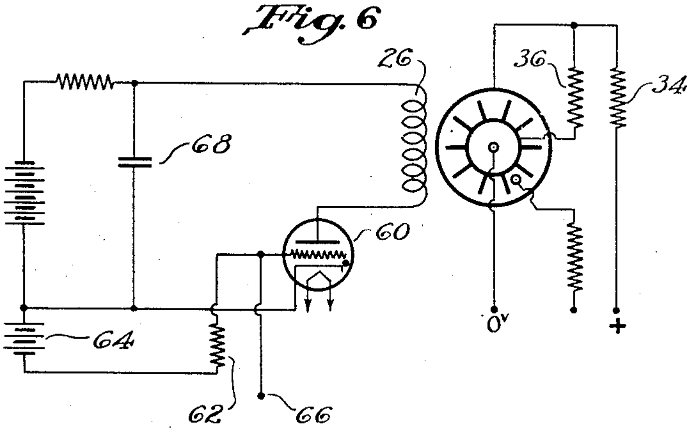
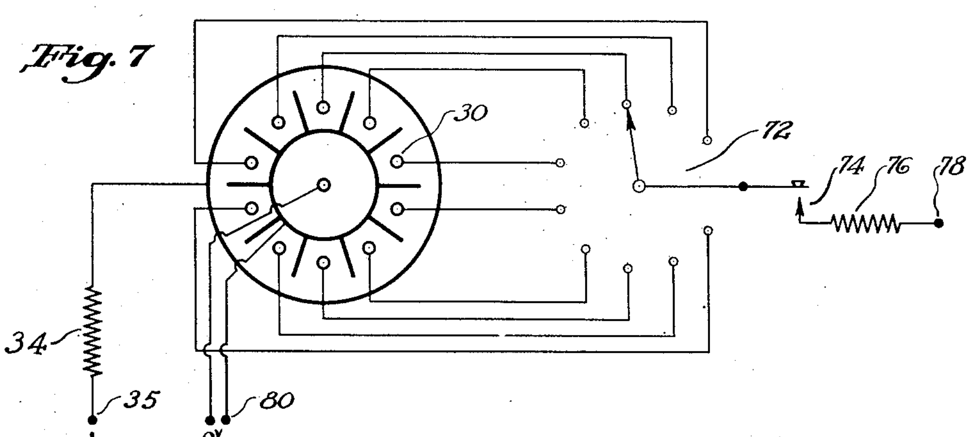


Fig. 7



Witness
Paul F. Bryant

Inventor
Wilcox P. Overbeck
by his attorneys
Fish, Hildreth, Cary & Jenney

Patented July 30, 1946 2,404,920

UNITED STATES PATENT OFFICE

2,404,920

ELECTRONIC DISCHARGE APPARATUS

Wilcox P. Overbeck, Waltham, Mass., assignor to Research Corporation, New York, N. Y., a corporation of New York

Application September 27, 1940, Serial No. 358,683

21 Claims. (Cl. 315—323)

1

The present invention relates to electronic discharge apparatus and circuits therefor, and more particularly to apparatus useful for counting and recording electrical impulses.

Existing types of electronic counting systems employ a series of trigger circuits so arranged that successive electrical impulses applied to the system cause a progressive triggering action from circuit to circuit. Such systems are known as counting rings. Each trigger circuit in the ring includes one or more electronic tubes. The system involves considerable complication, not only in the individual trigger circuits but also in the connections by which the progression is effected.

The principal object of the present invention is to provide a simple, reliable and inexpensive apparatus capable of accomplishing the functions of the more complex counting ring as well as additional functions to be hereinafter described; more specifically, to provide a single electronic discharge device to replace the several tubes of the counting ring and thereby to effect a corresponding simplification of the electrical circuits.

Another object is to provide apparatus of this nature in which the energy and time duration requirements of the received impulses are very small so that high operating speeds are possible.

With these and other objects in view as will hereinafter appear, the present invention consists of certain novel features of construction, combinations and arrangements of parts and modes of operation hereinafter described and particularly defined in the claims.

In the accompanying drawings, Fig. 1 is a sectional elevation of one form of device according to the present invention; Fig. 2 is an isometric view of the control electrode structure; Figs. 3 and 4 are diagrams illustrating the operation of the device; Figs. 5 and 6 are diagrams of circuits suitable for effecting the progressive operation of the device; and Fig. 7 is a diagram of a circuit employing a modified form of the invention.

The apparatus shown in Fig. 1 comprises an electronic discharge device having an envelope 8, enclosing an activated cathode 10 adapted to be indirectly heated by a tungsten filament in the usual manner. The tube contains a cylindrical anode 12, and between the cathode and anode there is provided a discharge control electrode, indicated generally at 14, to be presently described in detail. The electrodes are supported in concentric relation by mica insulators 16 and terminals therefor are brought out through the end seal of the tube. The tube is evacuated and filled

2

with an inert gas, preferably argon, at a pressure of the order of 1 mm. of mercury.

The construction of the control electrode 14 is shown in detail in Fig. 2. This electrode may conveniently be termed a grid, because of its function of controlling the discharge paths in the tube, although it differs markedly in construction and operation from any of the conventional grid structures employed in thermionic tubes. It comprises two cylinders 18 of equal diameter and placed end to end with a narrow gap 20 between them. The gap 20 is opposite the center of the cathode. A plurality of radiating fins 22 are welded to the outer surfaces of the cylinders, extending the full length of the grid structure and radiating outwardly in the space between the cylinder 18 and the anode 12. For use in counting applications based on the decimal system; the fins are ten in number and thus define ten separate discharge cells or compartments 24 of generally sectorial shape.

For some purposes the discharge space is subjected to an axial magnetic field generated by a coil 26 surrounding the envelope 8.

The operation of the device and its successful application to counting systems depend on a peculiarity of the tube, whereby the normal flow of current may be maintained at a value such that the discharge occupies only one (or any desired number) of the ten discharge paths. The characteristic is such that there is a nearly constant voltage drop through the tube for a wide range of current; hence the current may be maintained at any desired value by the use of limiting means, such as a resistor, in the anode circuit. It has been found that when the current is of a certain optimum magnitude related to the gas pressure and the area of the opening through the grid, the discharge will occupy one cell only. This optimum current, at a pressure of 0.5 mm. in argon, is about 25 milliamperes per square centimeter of opening (the opening being the area of that portion of the gap 20 between two adjacent fins). If the current were increased, the discharge would occupy two, then three, or any desired number of cells up to the full capacity. The preferred operation is with only one cell ignited at any time, although operation with ignition of a greater number of cells is entirely feasible.

A probe electrode consisting of a wire 28 passes through the lower mica insulator and extends upwardly into one of the discharge cells to a point slightly below the lower edge of the gap. The probe electrode has a suitable terminal passing through the tube seal. This electrode has two main purposes: first, it constitutes a means for starting the discharge in a known cell (which may be designated the number zero cell); and second, it can be used to obtain a count on the impulses which have been previously applied to the tube, as will be hereinafter explained. For some purposes a probe electrode in each cell is desirable; such a construction is shown diagrammatically in Fig. 7. The probe electrodes **30** extend through the entire length of the grid, and terminals for the several probe electrodes, as well as for the main electrodes, are preferably brought out through seals at opposite ends of the tube.

Before describing the circuits in which the device may be used, the theory on which the tube is believed to operate will be briefly explained. Under conditions to produce a current flow of the magnitude above mentioned and with no magnetic field applied, the current produces a diffused glow in one only of the discharge cells between two adjacent fins. The appearance of the glow as viewed from one end of the tube, is illustrated in Fig. 3. The glow is confined between two adjacent fins, although it fans out slightly beyond the outer ends of the fins and overlies the neighboring cells.

The glow pattern may be altered by applying sidewise (tangential) forces to the ions and electrons. This is most conveniently accomplished by applying an axial magnetic field, as by the coil **26**. When a field of moderate intensity is applied, the glow assumes the pattern of Fig. 4. Within the cell itself, the discharge becomes brighter and is concentrated toward one side, as indicated at *a*. At the inner and outer ends of the path beyond the edges of the fin, the ionized portions of the gas spread out and overlap the adjacent cell, as shown at *b* and *c*. As the field strength is increased, the pattern becomes more unsymmetrical, and the portion *a* becomes brighter and narrower. When a certain critical field strength is reached, the resistance of the portion *a* becomes too high to support the discharge through this path. The action becomes erratic and the flow of current may cease altogether.

After a discharge has been established in any single cell, the discharge may be shifted therefrom to the next cell by causing a momentary cessation or substantial reduction of current flow, followed by re-establishment of current prior to complete de-ionization of the gas. In Figs. 5 and 6 are illustrated two different methods of effecting this result. The system of Fig. 5 employs a steady magnetic field which produces a normally unsymmetrical discharge, and the transfer is effected by applying a potential impulse to the anode. In the system of Fig. 6 the normal discharge is symmetrical, and the transfer is effected by applying a rapid magnetic pulse. In any case the important result of effecting a definite precise progression is attained.

In Fig. 5 there is shown a tube **8** of the type illustrated in detail in Fig. 1, employing a single probe electrode. The anode **12** is connected through a resistor **34** to a terminal **35** to which is connected a source of positive potential. The resistor **34** is a current-limiting means by which the current is limited to a value such that the discharge occupies one cell only, or any desired number less than all of the cells. The anode is also connected through a resistor **36** with the grid **14**, which is thus maintained at a positive potential with respect to the cathode. The single probe electrode **28** is connected through a resistor **38** to a terminal **40** to which a source of potential, either positive or negative with respect to the cathode, may be applied. A magnetic field of constant intensity is provided by the coil **26** which is energized by a battery **42**. The connections from the battery to the coil include a reversing switch **44** to permit the field to be applied in either direction, condensers **46** being connected to the switch terminals to reduce transient surges during switching. The cell in which the probe electrode is located may be designated the number zero cell and the discharge may be started in this cell by applying a momentary positive potential to the terminal **40** while positive potentials are applied to the anode and grid. The discharge pattern, under the influence of the field, is then as shown in Fig. 4.

The remainder of the connections in Fig. 5 are illustrative of a satisfactory means for applying input impulses whereby the discharge is caused to progress from cell to cell. The pulse generating circuit comprises a triode **48** having its anode connected with the anode **12** and its grid connected through a resistor **50** with a discharge circuit which includes a condenser **52** and a resistor **54** connected to a source of negative potential. The cathode of the triode **48** is maintained at a negative potential with respect to the cathode **10**. A key **54** is provided with an upper contact connected by a wire **56** with the positive terminal **35**, whereby the condenser **52** is normally subjected to charging potential. When the key **54** is closed on the lower contact **58** which is connected with the grid circuit of the triode, the condenser **52** discharges through the resistor **54**, thereby applying a momentary positive potential to the triode grid to cause the anode circuit of the triode to become conducting and thus to cause a momentary reduction of the potential of the anode **12**. The time constant of the discharge circuit **52, 54** is very small, so that the potential of anode **12** rises quickly thereafter to its initial value. The result therefore, is the application of a very short negative pulse to the anode.

The negative pulse, in combination with the steady magnetic field, causes the discharge to shift completely from the originally active cell to the next. The conditions before the pulse is applied are as shown in Fig. 4. When the negative pulse is applied to the anode, the anode potential is insufficient to maintain the flow of electrons through portion *a* of the discharge path. The flow of current then ceases, but the gas remains ionized for an appreciable time thereafter. The anode potential must be re-established before the gas is de-ionized, whereupon re-ignition occurs in the next adjacent cell. This transfer to the next cell is due to the dominating effect of the still ionized regions *b* and *c*. Since the de-ionization time under the conditions herein described is about 500 micro-seconds, the total time of the pulse must be less than that value, that is, the anode potential must be re-established while ions still are present in portions *b* and *c* in order that the position of the new discharge may be precisely determined. Consequently, the tube is inherently one suitable for extremely high-speed operation.

It is believed that the connection **36** between anode and grid is of benefit in effecting transfer. Normally the grid is at a slight positive potential. When the pulse is applied, the grid potential as well as the anode potential is momentarily reduced and this reduction assists in impeding electron flow during transfer. Upon cessation of the pulse, the restoration of positive grid potential accelerates the electron flow and assists in starting the discharge immediately in the new path.

Successive pulses which may be applied as herein indicated or in any other suitable manner, will cause a progression of the discharge from cell to cell. The direction of progression depends on the direction of the magnetic field.

After a number of pulses have been applied, the position of the discharge may be observed visually through the upper end of the bulb and thus a count may be obtained of the applied pulses. With the tube 8 which employs a single probe electrode, an electrical determination of position may be made by reversing the field and applying pulses until a potential shift of the probe electrode is observed. This observation should be made with terminal 40 at a slight negative potential so that a positive ion current will be drawn from the discharge when the zero position is reached. Potential shifts of the probe may also be used to initiate carry-over pulses to actuate another tube, when it is necessary to count impulses whose number exceeds the capacity of a single tube.

In the circuit of Fig. 6 the progression is effected by applying pulses magnetically. The pulses are conveniently applied to the coil 26 through a thyratron tube 60, the grid of which is normally biased through a resistor 62 from a source of negative potential 64 sufficient to prevent conduction. When a source of positive potential is applied to the thyratron grid at terminal 66, the thyratron becomes conducting and allows a condenser 68 to discharge momentarily through the coil 26. The connections for tube 8 are the same as in Fig. 5.

In the system of Fig. 6 the normal conducting condition for the active cell is as illustrated in Fig. 3, since no magnetic field is applied except at the time of transfer. When the pulsing circuit operates, however, to energize the coil 26, the magnetic field builds up to a maximum and then decreases in a sine wave shape. During the initial rise of field intensity the discharge becomes asymmetric, as represented in Fig. 4. The field continues to increase to values which impede the flow of electrons through the tube, and it is believed that by the time the maximum field intensity is reached, current flow through the tube has substantially ceased. Whether or not there is a complete cessation of current during the increase of the field, the ensuing decrease of field causes ignition to take place in the neighboring cell. As in the system previously described, the transfer occurs by virtue of the dominating effect of the ionized regions b and c as the pulse decreases. The discharge may be caused to progress from cell to cell by applying successive magnetic pulses, and in a direction determined by the direction of the field.

Although the magnetic pulse method, as illustrated in Fig. 6, is entirely practical the electrical pulse method of Fig. 5 is ordinarily to be preferred, since it requires less energy and may be made to operate at a greater pulse speed. Furthermore, the maximum field intensity necessary to produce the shift magnetically is greater than the steady field intensity required in the circuit of Fig. 5.

In Figs. 5 and 6 the single probe tube is shown. In either of these circuits, however, the multiple probe tube heretofore mentioned may be employed. Such a tube makes it possible to obtain a count on previously received impulses without observing the cell in which the glow occurs, and without the necessity of applying reverse counting pulses. In Fig. 7 is shown a ten-probe circuit in which the probe electrodes 30 are connected to a selector switch 72, the movable arm of which is connected through a key 74 and a resistor 76 to a terminal 78. To determine in which cell the discharge is occurring at any given time, it is only necessary to apply a negative potential at 78, depress the key 74 and rotate the switch arm until current flow is indicated by the potential drop across the resistor 76.

The multiple-probe tube may be used in conjunction with either of the previously described types of pulsing circuits, the details of which are omitted from Fig. 7. The grid, which is here shown as merely connected to a terminal 80 would then preferably be connected through a resistor 36 with the anode terminal 35.

The ten-probe tube may also be used exactly as shown in Fig. 7, that is, without the magnetic stepping feature, as a simple positional storage device useful, for example, in storing intermediate data in computing applications. The discharge may be transferred to any desired cell by the application of a positive potential to terminal 78 while the selector switch is set in its proper position and the key 74 is depressed. Preferably the grid is maintained at a negative potential which prevents ignition anywhere until one of the probe electrodes is excited at positive potential.

The apparatus of the present invention may be employed for any stepping or progression operations. It not only accomplishes all the functions of the conventional counting rings but is capable of performing additional functions and with great reduction of circuit connections. For example, the device finds particular usefulness in computational applications, especially where great speed is required. In such connections the tube offers the advantage of operating in either direction with equal facility (depending on the direction of the field) so that it can be applied to subtraction as well as addition of pulses, a result which can be accomplished in conventional counting rings only by additional complications. Furthermore, the tube in its simplest form, without use of means to apply tangential forces, may be employed for storage of intermediate data.

It will be seen that the progression feature of the present invention depends on the formation of paths for discharge, which are separate from and independent of one another over portions of their length, but which lead into a common portion of the gas-filled space. A discharge, having been initiated in any path, is positionally biased toward the adjacent path, preferably by magnetic means, to form what may be viewed as a cloud of ionized gas in such a position as to pre-select the path in which reignition is to occur.

Although the preferred forms of the invention have been described, the invention is not to be considered as limited to such forms, but may be varied in many respects, so long as the fundamental features above noted are retained. As an example of one possible variation, the current may be such as to cause the discharge to occupy two, three or any selected number of cells less than the full number, in which case each of the several discharges will transfer under the pulsing operation. In details of construction, furthermore, the apparatus is susceptible of considerable variation. For example, the cylindrical electrode formation, while desirable for symmetry and uniformity of action in the several paths, is not essential; also the impulsing circuits may be any suitable type capable of applying pulses of sufficient magnitude within the time requirements dictated by the de-ionization properties of the tube.

The term "gas," as used herein, comprehends any ionizable substance, which exists in the tube as gas or vapor under operating conditions.

Having thus described the invention, I claim:

1. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, means for applying tangential forces to the ions to bias the discharge in any cell toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and means for reducing and re-establishing the current flow in a sufficiently short time, related to the de-ionization time of the gas, to shift the discharge to said adjacent cell.

2. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to one cell only, means for applying tangential forces to the ions to bias the discharge toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and pulsing means for momentarily reducing and reestablishing the current flow to shift the discharge to said adjacent cell.

3. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to one cell only, means for applying tangential forces to the ions to bias the discharge toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and pulsing means for momentarily reducing and re-establishing the anode potential, whereby the discharge shifts to said adjacent cell.

4. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to one cell only, means for applying tangential forces to the ions to bias the discharge toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and means for applying an impulse to said biasing means of sufficient magnitude to materially diminish the current flow momentarily, said impulse being related to the deionization time of the gas to cause re-ignition in said adjacent cell.

5. In an impulse counting system, a gas-filled envelope, an anode, a cathode, a grid having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, a magnetic field winding to apply sidewise forces to the ions in any cell in which a discharge occurs and thus to bias the discharge toward one side of the cell and to spread the discharge over the adjacent cell beyond the dividing means, and pulsing means for reducing and re-establishing current flow in a sufficiently short time, related to the de-ionization time of the gas, to shift the discharge to said adjacent cell.

6. In an impulse counting system, a gas-filled envelope, an anode, a cathode, a grid having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, means for generating a magnetic field to bias the discharge toward one side of any cell in which a discharge occurs and to spread the discharge over the adjacent cell beyond the dividing means, and pulsing means for reducing and re-establishing the anode potential sufficiently to cause cessation of the discharge in the originally active cell and to cause re-ignition in said adjacent cell, said pulsing means operating in a sufficiently short interval of time to re-establish the anode potential prior to de-ionization.

7. In an impulse counting system, a gas-filled envelope, an anode, a cathode, a grid having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, a magnetic field winding acting when energized to bias the discharge toward one side of any cell in which a discharge occurs and to spread the discharge over the adjacent cell beyond the dividing means, and pulsing means to apply to the winding a rapid pulse of sufficient maximum intensity to cause cessation of the discharge in the originally active cell and to cause re-ignition in the next cell.

8. An electronic discharge device comprising a gas-filled envelope, a heated cathode, an anode, a grid electrode comprising a cylindrical member between the anode and cathode, and fins attached to and extending radially from the cylindrical member toward the anode, the cylindrical member having discharge openings between the fins.

9. An electronic discharge device comprising a gas-filled envelope, a heated cathode, an anode, a grid electrode comprising a cylindrical member between the anode and cathode, fins attached to and extending radially from the cylindrical member toward the anode, the cylindrical member having discharge openings between the fins, and a probe electrode in one of the spaces between adjacent fins.

10. An electronic discharge device comprising a gas-filled envelope, a heated cathode, an anode, a grid electrode comprising a cylindrical member between the anode and cathode, fins attached to and extending radially from the cylindrical member toward the anode, the cylindrical member having discharge openings between the fins, and a plurality of probe electrodes in spaces between adjacent fins.

11. An electronic dicsharge device comprising a gas-filled envelope, an anode, a cathode, means for forming a plurality of discharge paths independent of each other over a substantial portion of their lengths, means for igniting one of the discharge paths, means for applying tangential forces to the ions in the ignited path to cause the discharge to overlie the neighboring path, and pulsing means to effect a momentary substan-

tial reduction and re-establishment of current flow in the device in a time interval less than the de-ionization time of the device, to effect cessation of discharge in the original path and re-ignition in the neighboring path.

12. An electronic discharge device comprising a gas-filled envelope, an anode, a cathode, means for forming a plurality of discharge paths independent of each other over a substantial portion of their lengths, means for igniting one of the discharge paths, magnetic means for applying tangential forces to the ions in the ignited path to cause the discharge to overlie the neighboring path, and pulsing means to effect a momentary substantial reduction and re-establishment of current flow in the device in a time interval less than the de-ionization time of the device, to effect cessation of discharge in the original path and re-ignition in the neighboring path.

13. An electronic discharge device comprising a gas-filled envelope, an anode, a cathode, means for forming a plurality of discharge paths independent of each other over a substantial portion of their lengths, means for igniting one of the discharge paths, means for applying a steady magnetic field to cause the discharge path to overlie the neighboring path, and pulsing means to effect a reduction and re-establishment of anode potential in a time interval less than the de-ionization time of the device, to effect cessation of the discharge in the original path and re-ignition in the neighboring path.

14. An electronic discharge device comprising a gas-filled envelope, an anode, a cathode, means for forming a plurality of discharge paths independent of each other over a substantial portion of their lengths, means for igniting one of the discharge paths, a magnetic field winding to apply sidewise forces to the ions in the discharge, and pulsing means for rapidly energizing and de-energizing the winding to cause cessation of discharge in the original path and re-ignition in the adjacent path.

15. An electronic discharge device comprising a gas-filled envelope, an anode, a cathode, a grid forming a plurality of discharge paths which are independent of each other over a substantial portion of their lengths, means for applying positive potentials to the anode and grid, current-limiting means to limit the discharge to less than the full number of paths, means for applying tangential forces to the ions in any ignited path to cause the discharge to overlie the adjacent path, and pulsing means to effect a reduction and re-establishment of anode and grid potentials in a time interval less than the de-ionization time of the device to effect cessation of discharge in any original path and re-ignition in the adjacent path.

16. An electronic discharge device comprising a gas-filled envelope, an anode, a cathode, a grid forming a plurality of discharge paths which are independent of each other over a substantial portion of their lengths, means for applying a positive potential to the anode, current-limiting means to limit the discharge to less than the full number of paths, means for applying tangential forces to the ions in any ignited path to cause the discharge to overlie the adjacent path, pulsing means to effect a reduction and re-establishment of anode potential in a time interval less than the de-ionization time of the device, and a connection between the anode and the grid to effect a similar reduction and re-establishment of grid potential.

17. An electronic discharge device comprising a gas-filled envelope, a cathode, an anode, a control electrode between the cathode and anode having openings for establishment of independent discharge paths therethrough, the control electrode having fins to divide the gaseous space into discharge compartments, said fins terminating short of the anode, and magnetic means to apply a magnetic field lengthwise of the fins to the discharge space.

18. A device for recording electrical impulses comprising a gas-filled envelope, a cathode, an anode, a grid having means to divide the gaseous space into separated discharge cells and having a discharge opening for each of such cells, anode-current-limiting means to cause the discharge to occupy less than all of the cells, and means for applying a magnetic field lengthwise of the cathode to the discharge space.

19. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, means for applying tangential forces to the ions to bias the discharge in any cell toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and pulsing means to apply a potential to said anode for a short period, related to the de-ionization time of the device, to effect cessation of discharge in the original cell and re-ignition in said adjacent cell.

20. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, means for applying tangential forces to the ions to bias the discharge in any cell toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and pulsing means to apply a potential to said grid for a short period, related to the de-ionization time of the device, to effect cessation of discharge in the original cell and re-ignition in said adjacent cell.

21. In an impulse counting or recording system, a gas-filled envelope, an anode, a cathode, a grid between the cathode and anode having dividing means to form separate discharge cells in a portion of the gaseous space, anode-current-limiting means to limit the discharge to less than all of the cells, means for applying tangential forces to the ions to bias the discharge in any cell toward one side of the cell and to cause the discharge to spread beyond the dividing means over the adjacent cell, and pulsing means to apply a potential to said anode and grid for a short period, related to the de-ionization time of the device, to effect cessation of discharge in the original cell and re-ignition in said adjacent cell.

WILCOX P. OVERBECK.

Certificate of Correction

Patent No. 2,404,920.

July 30, 1946.

WILCOX P. OVERBECK

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Column 2, line 41, for "about 25" read *about 20*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of October, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.