

March 5, 1963

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3,080,501

PULSE COUNTING AND DISPLAY DEVICE

Filed April 5, 1960

4 Sheets-Sheet 1

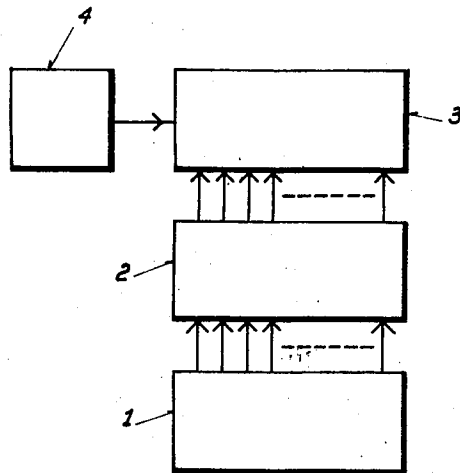


FIG. 1

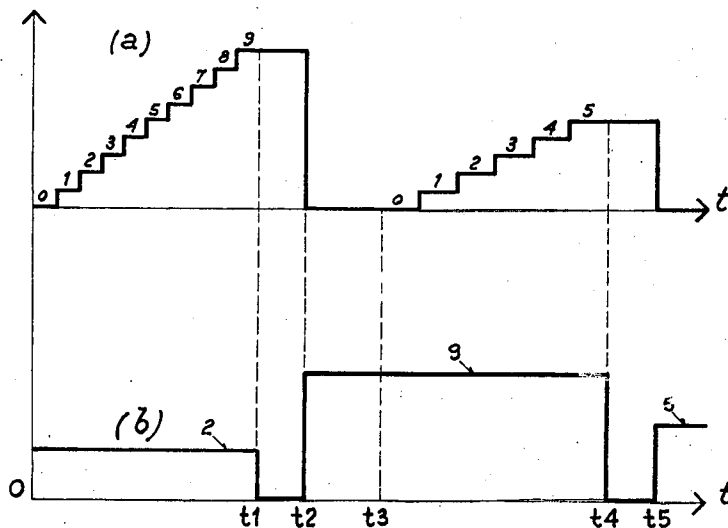


FIG. 2

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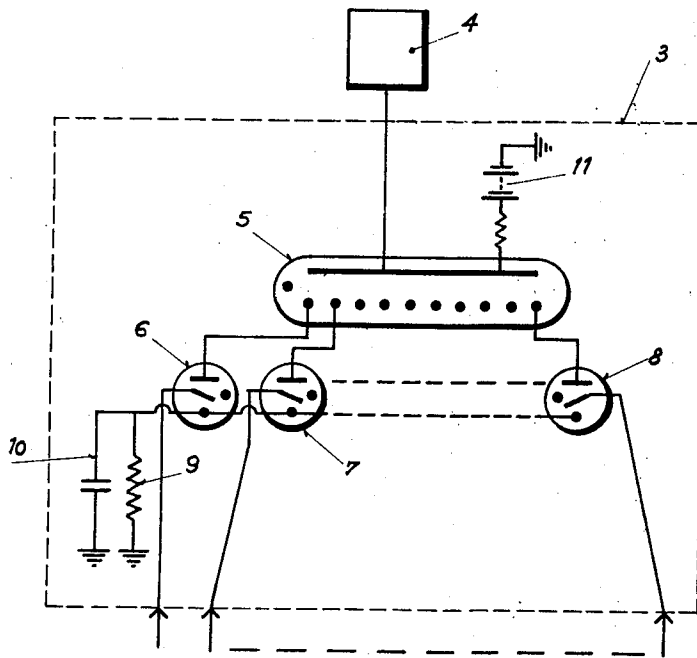


FIG. 3

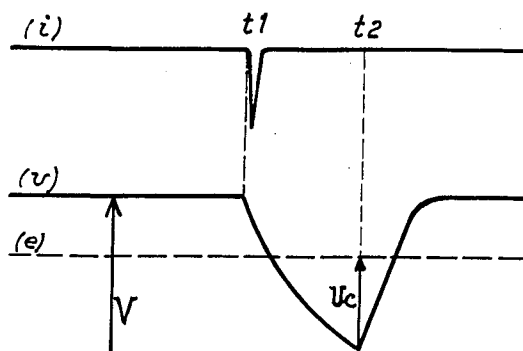


FIG. 4

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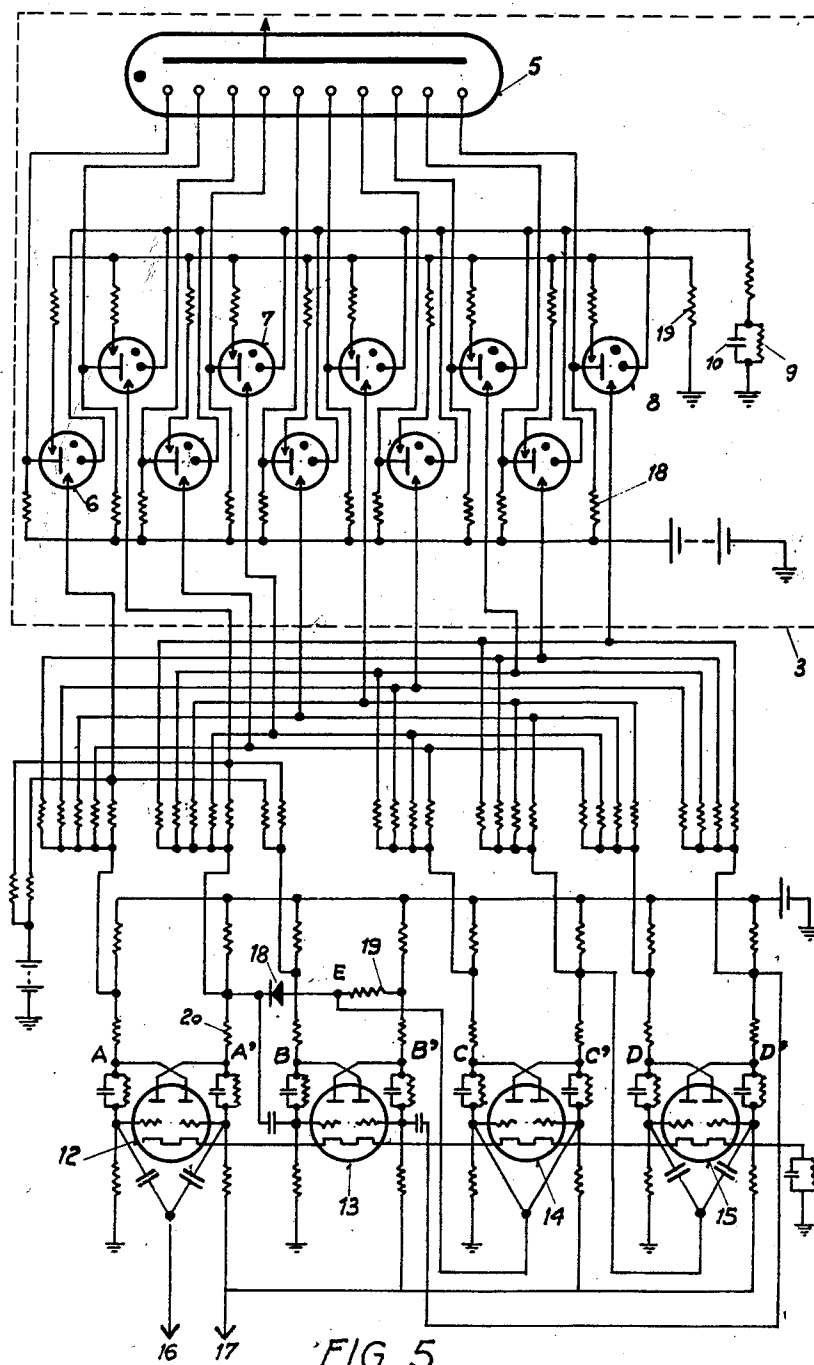
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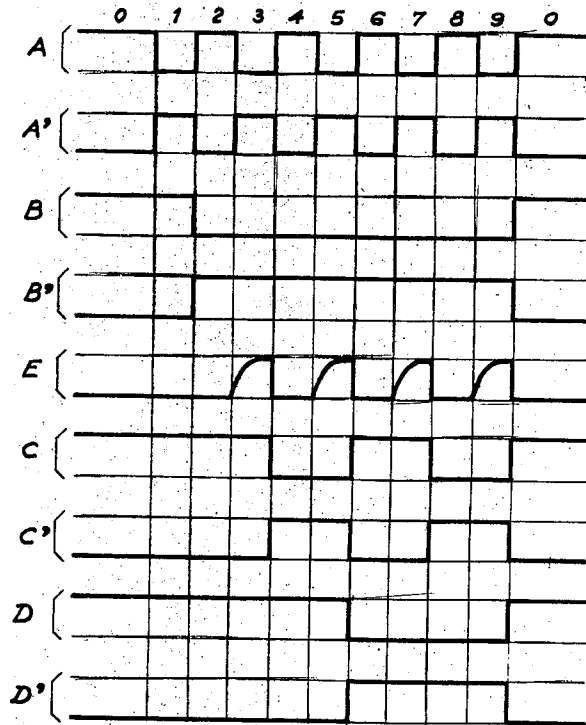


FIG. 6

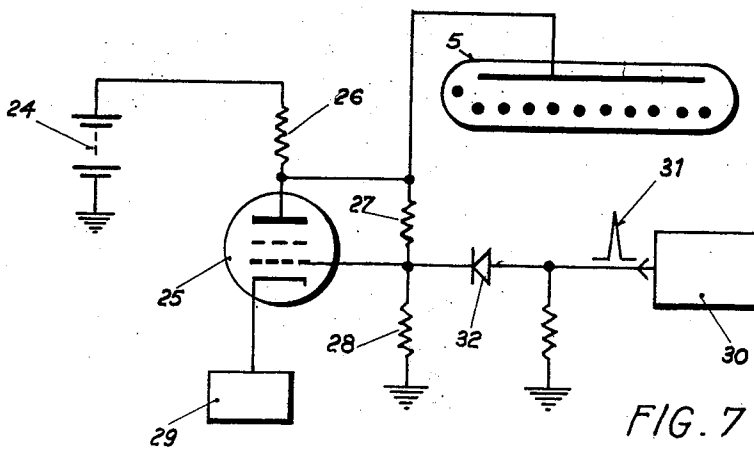


FIG. 7

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The present invention relates to electric pulse counting devices as used, for instance, in frequency meters, cycle-meters, electronic time-meters and other similar apparatus, wherein electric pulses derived, for instance, from the translation of a periodic event, are counted by a counter device commonly including electronic components or magnetic cores, the number of said pulses being subsequently displayed.

The invention is more particularly concerned with devices of this type wherein such a display is accomplished by utilizing the effect of electric glow discharges in gases or metal vapours.

In this type of devices, each of the successive pulses to be counted generally causes a glow discharge to be transferred either from one tube to another, or from one electrode to another in the same tube: when the last pulse defining a count has caused a last transfer of the glow discharge to take place, it will thus be necessary to provide a certain time interval for reading the resulting end count. During said time interval no input pulse can be applied to the counter; a further time interval must also be assigned for the resetting operation of the glow discharge: the existence of these idle periods for reading and resetting, during which the counting, and, if no provision is made for a highly complex storage device, also the measurement, are interrupted, results in a substantial limitation of the counting speed. This limitation is particularly troublesome on account of the fact that this type of device is generally making use of bi-stable trigger circuits having very short switching times.

It is therefore an object of the present invention to provide a pulse counting and numerical display device of the type mentioned, wherein the transfer of the glow discharge, the position of which defines the numerical indication to be displayed, occurs only during short intervals of time assigned thereto and separating the successive counting periods: in a counter provided with such a device, wherein the result of each counting operation remains on display until the end of the succeeding counting period, the idle reading time mentioned hereinabove is substituted by the very short time of transfer.

It will be noted that the device of the invention constitutes, in a way, an application of a specific and novel character of a generally known solution of the problem of transferring the count of a counter to a utilization device.

In certain conventional devices for converting voltages into numerical indications, a counter is used counting a number of pulses during a conversion cycle, the counting result, stored in the counter, being transferred to the utilization circuit, under the effect of a transfer pulse, only at the end of said conversion cycle.

This general solution has however not been applied, up to the present, to the display of the count of a counter, due to inherent difficulties for which the present invention provides novel solutions, more particularly adapted to the case where the display is based on the action of glow discharges in gases or metal vapours, and where the counter is of a type having, in combination, high speed trigger circuits and decoders including resistor matrixes.

According to a preferred embodiment of the invention, the numerical pulse counting and display device comprises a plurality of glow discharge spaces or gaps in a gas or a metal vapour, having each glow discharge initi-

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ing control means, adapted to be operated during said transfer intervals and inhibited during the counting periods.

The invention will be best understood from the following description and appended drawings wherein:

FIG. 1 is a block diagram of a pulse counting and display device according to the invention;

FIG. 2 is an explanatory diagram illustrating the operation of the device shown in FIG. 1;

FIG. 3 shows schematically a preferred embodiment of the indicator used in the device according to the invention;

FIG. 4 shows signal waveforms at various points of said device;

FIG. 5 is a connection diagram of the circuits of a specific embodiment of a counter arrangement;

FIG. 6 shows the waveforms at various points of the counter illustrated in FIG. 5; and

FIG. 7 is a preferred embodiment of the high-voltage supply means to one or several indicator and transfer pulse generating tubes.

Referring to FIG. 1, the counting and display device illustrated comprises essentially counting circuits including, for instance, vacuum or gas discharge tubes arranged in "decades," of a type known per se, and shown in block 1 in the drawing. The circuits present, in a plurality of points—for instance the anodes of the tubes of the decade—one or the other of two electric states. Each count is defined by a particular combination of said electric states and each combination is translated, by means of a decoder arrangement 2 which generally comprises gating circuits of the "AND" or "OR" type, into a signal consisting, on one of the decoder outputs, of a "preferential" potential which is either higher or lower than that occurring on all other decoder outputs.

Units 1 and 2 may be of conventional type, and the indicating unit 3 will be more particularly described.

As in the known devices of the type mentioned above, this indicator comprises a plurality of glow discharge spaces in number equal to that of the outputs of decoder 2, the glow discharge being adapted to be transferred from one discharge space to another by priming electrodes being controlled by the states of potential occurring at said outputs.

However, whereas in priorly known devices each transfer of a preferential potential (higher or lower) from one output of the decoder to another generally results in a corresponding transfer of the glow discharge in the indicator, according to the invention, the glow discharge transfer cannot take place unless a unit 4 (including, for instance, a pulse generator, as will be seen further in this description) has applied to indicator 3 a convenient electric state, which will be designated by "glow-discharge transfer control signal," or, simply "transfer signal."

FIG. 2 illustrates the operation of the device. In this figure, are plotted on the ordinates, as a function of time t plotted on the abscissae, in (a) the numerical indication corresponding to the position, at the output of member 2, of the preferential electric state mentioned above, in (b) the numerical indication corresponding to the position of the glow discharge in indicator 3.

The diagram of FIG. 2 shows that the indication displayed by unit 3 remains constant during the counting periods $(0t_1)$, (t_2, t_4) etc. During the counting period $(0t_1)$, for instance, indicator 3 marks the value 2, whereas the counter counts from 0 to 9. During the transfer interval (t_1, t_2) , the indicator jumps from value 2 to value 9, and remains at this latter value until the following transfer interval (t_4, t_5) , during which it jumps to value 5, which corresponds to the counter at the end of the counting interval (t_3, t_4) . The interval (t_2, t_3) is the resetting interval of the counter.

This method of operation enables the substantial idle

reading time mentioned hereinabove to be substituted by a transfer time interval (t_1, t_2), which may be considerably shorter. On the other hand, in certain applications in which the counting periods are reproduced at a fixed rate imposed by a time base, the latter may define the rate of production of the transfer signals, in such a manner that the operation of the device will be entirely automatic. Such a device is particularly adapted to follow the evolution of a variable magnitude.

FIG. 3 shows, diagrammatically, a preferred embodiment of the indicating unit (3, 4) illustrated in FIG. 2: reference numeral 5 designates a gas discharge indicator tube of the type in which illuminated digits are displayed, for instance of the type "Z 5 10 M" or "6 8 4 4 A"; reference numerals 6, 7, 8 designate gas discharge tubes for instance of the cold cathode type.

In a non-limitative embodiment of the device, ten cold cathode tubes have their priming electrodes connected respectively to the ten outputs of a decoder circuit associated with a counting decade, their anodes being respectively connected to the ten anodes of the indicator tube 5.

The cathodes of the cold cathode tubes are grounded through a resistor 9 connected in parallel across a capacitor 10. The anode of tube 5 is connected, on one hand, to a generator 4 adapted to provide negative pulses, which are the transfer signals previously mentioned and on the other hand, to the positive terminal of a high-voltage supply 11, the negative terminal of which is grounded. The circuit arrangement so far described is only given by way of explanation of the operation of the device and does not show the auxiliary elements of the circuit, which will be easily devised by those skilled in the art.

This operation will be better understood by considering the waveforms shown in FIG. 4:

- (i) indicates the waveform of the transfer signal, the amplitude of which is nil except at times such as t_1 when generator 4 produces a negative pulse;
- (v) shows the waveform of the cathode voltage of that one of the cold cathode tubes wherein a discharge occurs, and
- (e) the potential of the priming electrode subjected, on account of the state of the counter, to a potential more positive than that of all the others.

Considering, for instance, one time instant comprised between 0 and t_1 (FIG. 2), and assuming that, from the previous operation of the counter, tube 7, which corresponds to the numerical value 2, is lighted, as well as the discharge gap defined by the cathode of indicator tube 5 connected thereto: then, the cathodes of the cold cathode tubes are at a potential V (FIG. 4), equal to the difference between the high tension, on one hand, and the sum of the sustaining voltage of the discharge in tubes 5 and 7, on the other hand. It is obvious that, at said instant, no other tube may be primed, since the breakdown voltage between the anode of the indicator tube and the cathode of any one of the other cold cathode tubes is substantially higher than said sum.

The negative transfer pulse generated at the instant t_1 causes a sudden decrease of the potential on the anode of tube 5 and, on account of its transmission to the cathodes of the cold cathode tubes through the resistor capacitor assembly (9, 10), causes the potential of said cathodes to be slowly decreased, as shown by waveform v, in FIG. 4. FIG. 4 shows that the time constant of this resistor-capacitor assembly is sufficient, during the very short decaying time of the transfer pulse, for the potential decrease on said cathodes to be small; consequently, the potential difference between said cathodes and the anode of tube 5 will become smaller than the sustaining value of the discharge, and the latter will extinguish.

It will be noted that this extinction requires that the pulse transfer amplitude should be sufficient and that its

duration, while distinctly lower than said time constant, should be greater than the de-ionizing time of the tubes.

The potential of the cathodes will continue to decrease up to an instant t_2 when its difference with the previously defined potential e reaches the priming value of U_c of that gap of the indicator tube and of the cold cathode tube which corresponds to that of the outputs of the decoder which is at a potential e .

At this instant, the glow indication is transferred, for instance, onto the value 9 in the non limitative example illustrated in FIG. 2.

The discharge then causes a fast rise of the voltage across the cathodes of the cold cathode tubes to take place, up to the value V, as illustrated in FIG. 4.

It follows, obviously, as previously mentioned, that no other cold cathode tube may break down before the instant t_2 of the succeeding cycle, so that the indication of the counter is, in a way, stored up by indicating member 3 during a counting cycle.

It will be noted that, in FIG. 1, unit 1 does not necessarily represent a single decade: several decades, and consequently, several indicator units having for instance each six cold cathode tubes such as that shown in FIG. 3, may be assembled and controlled by a common signal transfer generator 4.

It will also be noted, on the other hand, that, in indicator 3 of which one embodiment is illustrated in FIG. 3, the indicator tube 5 may be dispensed with; in this case, the anodes of the cold cathode tubes will be directly connected, on one hand to the transfer signal supply source 4 and, on the other hand, to the high-voltage source 11, the numerical indication being then defined, for each count, by the position of that of the tubes in which a discharge is maintained. The operation of such a device will be similar to that which has been previously described.

FIG. 5 illustrates an indicator device 3 comprising essentially ten thyratron tubes such as 6, 7 and 8, and one indicator tube 5, connected in a circuit arrangement similar to that of FIG. 3, certain particular details of which are shown: for instance, the anodes of the thyratrons are connected to a high-voltage supply source 17, through resistors such as 18. The pre-ionizing electrodes of the thyratrons are also shown, connected to the ground through resistors such as 19. The high-voltage anodic supply of tube 5 and the transfer pulse generator are shown separately in FIG. 7, to be described later in this specification. By way of a practical example of application of indicator 3, a counting arrangement is shown connected to the control electrodes of the ten thyratrons, and comprising essentially, in the non limitative example described, four bi-stable electronic trigger circuits having each a double-triode (12, 13, 14 and 15, respectively).

This counting arrangement comprises an input 16 to which are applied the negative pulses to be counted, and a resetting terminal 17, grounded during the counting operation, and onto which a negative pulse is applied for the resetting of the counter.

FIG. 6 illustrates the method of operation of the decade comprising the four flip-flops shown and diode 18.

The waveforms are represented at the points A, A', B, B', E, C, C', D and D' of the circuit arrangement, after reception of the successive pulses to be counted 1, 2, 3, 4, 5, 6, 7, 8, 9, between the initial state 0 and the final state 0, in which the potential is high for all the points not marked by a "prime," and low for all the "primed" points.

It is to be specified that this method of operation is based on the assumption that resistance 19 is high as compared with the anode resistances (such as 20) of the trigger circuits.

FIG. 6 shows that to each count value corresponds a combination, distinctive of said value, of the potential states of the eight points A, A', B, B', C, C', D, D'. In the example of FIG. 5, the decoding of said combina-

tion, i.e. its translation into a "preferential" potential, and, more particularly, into a potential higher than all the others, on a single one of said ten inputs of indicator 3, is made by means of a combination of resistors such that the potential of each of the ten inputs of indicator 3 should be—to within a factor—the sum of the potentials of the four outputs of the group AA', BB', CC', DD', which are at a high potential for the value of the corresponding count (for instance, the input of indicator 3, adapted to display the number 5, will be connected to outputs A', B', C', D).

FIG. 7 illustrates a preferred embodiment of the anodic supply device of indicator tube 5 (or of the cold cathode tubes, in the alternative embodiment wherein the indicator tube is eliminated). This device comprises a non stabilized high-voltage source 24 and a conventional regulating system, in which the regulated voltage is collected at the anode of a pentode (25, in FIG. 7) through a bridge connection (resistors 26, 27, 28). The cathode of the pentode is fed by a potential which is adjusted to a much lower value than that which it is desired to obtain, said potential being derived from source 29.

The pentode has a low current output, substantially independent of the variations of the voltage derived from source 24, so that the voltage applied to the anode of tube 5 is stable, except at the instants when generator 30 applies positive pulses 31 to the control grid of pentode 26 through diode 32: said pulses will then cause the pentode to operate at a saturation level and give rise to a sudden fall of potential on the anode of tube 5; this potential fall constitutes a negative transfer pulse. The arrangement in FIG. 7 will thus deliver both the stabilized supply high voltage of one or a plurality of indicator tubes and the transfer pulses.

In the practical application of the device of the invention to a frequency-meter or an electronic time-meter of the conventional pulse counting type, the positive pulses applied to diode 32 are obtained simply by differentiation and by shaping of the trailing edge of the triggering signals which open the electronic gate which transmits the pulses produced by the time base generator of the device.

What is claimed is:

1. A pulse counting and display device comprising, in combination: display means having a plurality of glow discharge gaps; an anode and a cathode bounding each of said discharge gaps, which have each a discharge initiating electrode; means for counting recurrent electric

pulses during successive counting periods comprising transfer time intervals having substantially shorter duration, said counting means having a plurality of outputs respectively connected to the respective discharge initiating electrodes of said glow discharge gaps; means for applying a negative transfer pulse to said anodes at the beginning of each of said transfer time intervals, and a resistor-capacitor assembly connected to said cathodes.

2. A pulse counting and display device comprising, in combination: a plurality of cold cathode tubes each having a cathode, an anode and a priming electrode; a numerical readout tube having an anode and a plurality of cathodes, said cathodes being respectively connected to the respective anodes of the cold cathode tubes; an electronic counter having a plurality of outputs respectively connected to said priming electrodes; means for supplying negative pulses to the anode of said numerical read-out tube and a resistor-capacitor assembly connecting the anode of said numerical read-out tube to the cathodes of said cold cathode tubes.

3. A pulse counting and display device comprising, in combination: a plurality of cold cathode tubes each having a cathode, an anode and a priming electrode; a numerical readout tube having an anode and a plurality of cathodes, said cathodes being respectively connected to the respective anodes of the cold cathode tubes; a decade electronic counter having a plurality of outputs; a decoder unit having a plurality of inputs respectively connected to the outputs of said decade electronic counter and a plurality of outputs respectively connected to said priming electrodes; means for supplying negative pulses to the anode of said numerical read-out tube and a resistor-capacitor assembly connecting the anode of said numerical read-out tube to the cathodes of said cold cathode tubes.

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