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2,881,352

DEVICE FOR THE SELECTION OF ELECTRIC PULSES ACCORDING TO THEIR HEIGHTS

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The present invention relates to a pulse selection circuit arrangement.

In certain devices, such as for example scintillation spectrographs, electric voltage pulses must sometimes be selected according to their heights so that in a counter only the pulses are counted, the height of which lies between two given limits. This can be done by means of two discriminators, of which one passes only pulses having at least a height V while the second passes only pulses having at least a height $V+w$, V being the lower limit and $V+w$ being the upper limit. In addition, provision is made of a so-called anti-coincidence circuit, to which the pulses which have been passed are supplied and which contains a gate circuit which operates so that, when the second discriminator passes a pulse, the pulse passed by the first discriminator cannot penetrate to the counter.

Such an anti-coincidence circuit has a limitation in that the pulse from the second discriminator arrives at an instant after the arrival of the pulse from the first discriminator due to the fact that the slope of the edges of the pulse is not infinitely steep. Consequently, a so-called memory system must invariably be used, in which the pulse from the first discriminator is stored for a certain period of time.

A second disadvantage consists in that the entire device is comparatively complicated and hence comparatively liable to disturbances and, in addition, it is difficult to keep the so-called channel width (w) constant for any value of V .

It has also been proposed to supply the pulses to one or more deflection electrodes of a cathode-ray tube which is provided with a number of collector electrodes. In accordance with the height of the pulse, a certain collector electrode has a charge imparted to it which is in turn supplied as a pulse to the counter through an amplifier. This method has the advantage that pulses lying in a plurality of channels can be counted simultaneously. There is, however, a limitation in that it is difficult to equalize the widths of all the channels, and also the current produced by the ray is usually too small for the capacitance of the anode to be sufficiently charged during the short duration of the pulse.

An improvement is obtained by first supplying the signal to a discriminator adjusted to V volts. The part of the pulse which is passed, i.e. the part exceeding V volts, is supplied, if required after amplification, to the deflector plates of a cathode-ray tube which thus need have only a single anode. When the pulse is too large, the electrons of the beam strike a point beyond the collector electrode; only if the height of the pulse lies between two accurately determined values, the anode is sufficiently charged during the duration of the pulse.

It was found in practice that this method also is not satisfactory in every respect, since the current of the electron beam is too small. In addition, the electron beam reciprocates over the anode on the occurrence of pulses which are too large. Consequently, with pulses which

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are too large and have sides with slopes which are not very steep, two undesirable pulses appear at the collector electrodes after each other.

It is an object of the present invention to provide a device in which the said disadvantages are eliminated or at least greatly reduced.

One starts from a device having a cathode-ray tube containing at least two collector electrodes, the pulses being applied to the deflecting system. In accordance with the invention, provision is made of feedback from at least one of the collector electrodes to the deflection system, so that the cathode-ray has not only an initial position but also at least one other stable position, means being provided by which the ray is automatically returned to the starting position after it has occupied the other stable position for a given period of time. The ray is caused to pass from one position to the other by the action of a pulse which is set up at the deflection system and the height of which lies within the desired limits, the said period of time being chosen so as to permit the satisfactory indication and counting of the pulse. Pulses of too great a height are not counted.

Preferably, the device is designed so that the cathode-ray can take up three different stable positions, and is caused to pass from the initial position to one of the stable positions under the action of a pulse the height of which lies between the given limits, so that a counting is performed; the ray passes from the initial position to the third stable position under the action of a stronger pulse, no counting being performed. The ray returns to the initial position from the third stable position after a given period of time.

In a preferred embodiment, use is made of a tube having a collector electrode system, of which a first collector electrode is provided with an aperture behind which a second collector electrode is arranged. A measuring or counting system is connected in the supply conductor to the second electrode. Such tubes are already used for other purposes and are known under the type number E80T. The voltage fed back to the deflection system is preferably taken from the first collector electrode which to this end is connected to the supply source through a high resistance.

It should be noted that pulse counting systems are known which use a cathode-ray tube having an electrode provided with a number of apertures, the cathode-ray beam having a number of stable positions due to feedback from a collector system arranged behind said electrode to the deflection system.

In order that the invention may readily be carried into effect, it will now be described with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 is a schematic diagram of an embodiment of the pulse selection circuit arrangement of the present invention;

Fig. 2 is a graphical presentation to aid in explaining the operation of the embodiment of Fig. 1;

Fig. 3 is a schematic diagram of an embodiment of a circuit arrangement which may be utilized as the unit 15 of Fig. 1;

Fig. 4 is a schematic diagram of an embodiment of a circuit arrangement which may be utilized as the unit 16 of Fig. 1; and

Fig. 5 is a graphical presentation to aid in explaining the operation of the embodiment of Fig. 4.

In Fig. 1, use is made of a cathode-ray tube 1 which comprises a cathode, two deflecting electrodes 3 and 3', a collector electrode 2, a collector electrode system 4, 5 and a grid 25 by which the ray can be rejected. The anode 2 is arranged in the direction of movement of the electrons behind, and spaced away from, an aperture

in the electrode 4. The electrode 4 and the similarly designed electrode 5 are an integral structure.

Through a counter 6, the anode 2 is connected to a voltage which is stabilized by means of a resistor 8 and a glow-tube 7. The series-combination of the two latter elements is connected to a direct-current supply. The left-hand deflecting electrode is connected to the junction of two resistors 9 and 10 connected in series across the glow-tube, and consequently is at a constant voltage. The right-hand deflecting electrode is connected to the cathode of an amplifier tube 12, to the control-grid of which the pulses to be separated are supplied. Consequently, only the right-hand electrode acts as a deflecting electrode. The tube 12 is a cathode follower, the cathode of which is connected, through a stabilizer tube 14 and a resistor 13, to the negative terminal of the supply source and to ground. The control-grid of the tube 12 is also connected, through a resistor 11, to the positive terminal of the supply source. The elements 11, 13 and 14 are chosen so that suitable static voltages are applied to the control-grid of the tube 12 and to the deflecting electrode 3.

The control-grid of the tube 12 is also connected to the collector electrodes 4 and 5. Thus, the voltage which is produced across the resistor 11 and depends upon the current to the collector electrode system 4, 5, is applied to the control-grid of the tube 12, so that the collector system 4, 5 is fed back to the deflection system through the junction of the elements 13 and 14.

The pulses are supplied, through devices 16 and 17 described more fully hereinafter and through a diode 18, to the first control-grid of the tube 12 and act upon the electron beam by means of the deflecting electrode 3. A device 15 acts to produce a voltage by which the beam is interrupted.

The operation of the circuit arrangement of Fig. 1 may be explained with reference to Fig. 2. In Fig. 2, we show the relationship between the current to the collector system 4, 5 and the deflection voltage V_3 applied to the electrode 3, which voltage is plotted as the horizontal axis. The bias voltages are so chosen that in the initial position the cathode-ray beam is deflected to the right through a large angle.

The tube 1 is designed so that in this event the system 4, 5 is struck by a comparatively large number of electrons, which number decreases with increase of the voltage at the electrode 3, so that the descending branch of the curve I is produced which is shown at the right-hand side of Fig. 2. At a certain deflection of the beam a minimum occurs, after which the current is again increased to a maximum. When the deflection voltage is further increased, the beam arrives at the aperture in the electrodes 4 and 5, after which the major part of the electrons strikes the electrode 2, the curve I exhibiting the second minimum. Subsequently, as soon as the beam passes the left-hand boundary of the apertures, it will again strike the system 4, 5, so that the current to this system is again increased to a maximum. Then there is again a sharp drop.

In Fig. 2, II represents the relationship between the current to the electrode 2 and the deflection voltage which shows a maximum at the minimum of the curve I in accordance with the center position of the beam.

The current to the collector system 4, 5 flows through the resistor 11 and the voltage produced across this resistor acts upon the deflection system through the cathode follower 12. This action can be represented in the diagram by a straight line III, the slope of which depends upon the value of the resistor 11 and which intersects the curve I in points a , b , c , d and e . It can be proved that points a , c and e , which correspond to voltages a' , c' and e' at the deflecting electrode 3, correspond with stable positions of the cathode-ray, the electrostatic forces, in the event of an accidental deviation from this

position, varying so that the cathode-ray is returned to the initial position.

The various voltages are chosen so that, when no pulses are counted, the cathode-ray is in the position corresponding to the point a . The ray can be moved from one stable position to the other by the pulses. A pulse of a height lying between two determined values $a'-b'$ and $a'-d'$ causes the ray to move to a position corresponding to the point c . A pulse of larger amplitude causes the ray to move to a position corresponding to the point e . As will be seen from the graph of Fig. 2, a current flows to the anode 2 in the first case, whereas substantially no current flows thereto in the second case.

Provision is made also of a device 15, by means of which after a certain time after the beginning of the pulse the electron current is interrupted in the latter two positions. This time must be long enough to enable the capacitance of the collector electrode 2 to be sufficiently charged after the ray has assumed the second position, so that the pulse can bring about a recording in the counter device 6 with sufficient clarity. The interruption of the cathode-ray is ensured by applying a negative voltage to the grid 25. When this voltage has disappeared, the ray will re-assume the position corresponding to the point a . It will be seen from the above, that only those pulses are counted by which the cathode-ray is moved to the second stable position, since only in this case is there a current in the anode circuit of the tube 1.

In Fig. 2, b' and d' represent the voltages corresponding to unstable positions which are determined by points of intersection of the curve I with the line III. These points also determine the limits of the region, that is to say that voltage pulses lying within this region (starting from a') cause the ray to move so that it assumes the second stable position. Pulses having an amplitude which is less than the difference between the voltages corresponding to the points a' and b' do not act upon the position of the ray; pulses which are larger than the difference between the voltages corresponding to the points a' and d' cause the ray to move to the third stable position.

The third stable position could be dispensed with, if a device were provided ensuring that pulses of too large an amplitude deflect the ray, but interrupt the ray or return the ray to the initial position immediately.

Fig. 3 shows a circuit arrangement for the interrupter unit 15 of Fig. 1. Like elements are designated by reference numerals corresponding to those of Fig. 1. In Fig. 3, the cathode of the tube 12 is connected, through a capacitor, to the control-grid of the tube 19 which is connected as a cathode follower. From the cathode of this tube a voltage is taken which is supplied to the control-grid of a tube 22 through an adjustable capacitor 20 having a capacitance C .

The anode lead of the tube 22 includes a coupling resistor 24 and the cathode lead includes the usual parallel-combination of a resistor and a capacitor for the production of a bias voltage. The anode of a tube 22 is connected to the control-grid 25 through a capacitor 29. The control-grid of the tube 22 is also connected, through a resistor 21 of value R , to a point of positive potential and, through a normally conductive rectifier 23, to ground and also to the negative terminal of the supply source. The control-grid of the tube 19 is connected to a point of positive potential through a parallel-combination 28 of a resistor and a rectifier.

The circuit arrangement of Fig. 3 operates as follows:

When a pulse appears, the control-grid of the tube 12 is driven negative so that the voltage at the junction of the glow-tube 14 and the resistor 13 also drops abruptly. This sudden voltage drop is transmitted to the grid of the tube 19 and brings about a corresponding sudden change in voltage in the negative sense at its cathode. Consequently, the potential of the capacitor 20 is driven

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negative at the beginning of the pulse so that the tube 22, which initially was conductive, is cut off and the voltage at the anode of this tube is increased. However, this does not affect the tube 1, since with respect to this voltage increase the control-grid 25 of said tube 1 is connected to ground through a diode 30. The capacitor 20 is now gradually charged through the resistor 21, so that the tube 22 again becomes conductive. As a result, the voltage at the anode of the tube 22 will be decreased. This voltage drop is transmitted, through a capacitor 29, to the control-grid 25 of the tube 1, so that the electron flow or current in the tube 1 is attenuated. This current also flows through the resistor 11. The voltage at the electrodes 4 and 5 and consequently the voltage at the control-grid of the tube 12 is increased. The voltage increase is transmitted by the cathode of the tube 12, through the cathode follower-connected tube 19, to the tube 22. Thus, the tube 22 becomes more highly conductive, so that the voltage at the anode of said tube 22 decreases. This voltage drop completely cuts off the electron beam in the tube 1. When the stray capacitance of the control-grid of the tube 12 is again charged to an extent such that the voltage is reached which the grid has in the normal position of the tube 1, the diodes 28 and 23 become conductive so that there is no further voltage decrease at the anode of the tube 22. Through a resistor 31, the control-grid 25 of the tube 1 will re-assume its normal voltage, so that the electron beam re-assumes its initial position. The cut-off period of the current through the tube 22 and consequently the time of the rejection of the cathode-ray in the tube 1 is related to the product $R_{21}C_{20}$. This product can be chosen by adjustment of the capacitor 20 or the resistor 21.

The circuit arrangement is designed for a negative polarity of the pulses, the tube 1 having a normal position corresponding to the point *a* (Fig. 2). The circuit arrangement may also be adapted to positive pulses, the normal position corresponding to the point *e*.

Fig. 4 shows a circuit arrangement for the unit 16 of Fig. 1, by means of which the desired channel can be chosen. The pulses are supplied, through a capacitor, to the grid of an amplifier 26 and taken from the anode thereof. The grid voltage is taken from a potentiometer 27. The grid voltage is driven more or less negative in accordance with the required channel. With high negative values of the grid-voltage, only very high pulses will be transmitted by the tube 26 and only very high pulses are counted by the device described with reference to Fig. 1. With lower negative values of the grid voltage, a greater number of pulses can exceed the threshold value. The higher pulses are rendered inoperative in the device described above.

This is shown diagrammatically in Fig. 5. In the diagram, a number of pulses are indicated by vertical lines. It may be required to count the pulses the peaks of which lie between V and $V+w$. The unit 16 is in this case adjusted so that the threshold therein lies at the value h .

In the unit 17 of Fig. 1 the pulses passed by the unit 16 are amplified so that they are made to conform with the desired limit values.

While the invention has been described by means of a specific example and in a specific embodiment, we do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode and at least two collector electrodes, means for varying the deflection electrode voltage in accordance with the current in one of said collector electrodes comprising a feedback circuit coupling said one of said collector electrodes to said deflection electrode and means connected to said feedback circuit for providing an initial stable position and at least another stable posi-

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tion for said electron beam in accordance with the current in said one of said collector electrodes, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial stable position to said other stable position only by an input pulse having an amplitude greater than a predetermined minimum value, and means for returning said electron beam from said other stable position to said initial stable position after a predetermined period of time after the initiation of said input pulse.

2. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode and at least two collector electrodes, means for varying the deflection electrode voltage in accordance with the current in one of said collector electrodes comprising a feedback circuit coupling said one of said collector electrodes to said deflection electrode and means connected to said feedback circuit for providing an initial stable position and at least two other stable positions for said electron beam in accordance with the current in said one of said collector electrodes, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial position to a second stable position only by an input pulse having an amplitude greater than a predetermined minimum value, said electron beam being moved from said initial position to the third stable position only by an input pulse having an amplitude greater than a predetermined maximum value, pulse counting means, means for transmitting a pulse from said cathode ray tube to said counting means only when said electron beam is in said second stable position, and means for returning said electron beam from one of said second and third stable positions to said initial stable position after a predetermined period of time after the initiation of said input pulse.

3. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode and at least two collector electrodes, means for varying the deflection electrode voltage in accordance with the current in one of said collector electrodes comprising a feedback circuit coupling said one of said collector electrodes to said deflection electrode and means connected to said feedback circuit for providing an initial stable position and at least two other stable positions for said electron beam in accordance with the current in said one of said collector electrodes, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial position to a second stable position only by an input pulse having an amplitude greater than a predetermined minimum value, said electron beam being moved from said initial position to the third stable position only by an input pulse having an amplitude greater than a predetermined maximum value, pulse counting means connected to the other of said collector electrodes, said electron beam striking said other of said collector electrodes only when the said electron beam is in said second stable position thereby applying a pulse to said counting means, and means for returning said electron beam from one of said second and third stable positions to said initial stable position after a predetermined period of time after the initiation of said input pulse.

4. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode, a first collector electrode having an aperture therein and a second collector electrode positioned to receive electrons passing through said aperture, means for varying the deflection electrode voltage in accordance with the current with the current in said first collector electrode comprising a feedback

circuit coupling said first collector electrode to said deflection electrode and means connected to said feedback circuit for providing an initial stable position and at least two other stable positions for said electron beam in accordance with the current in said first collector electrode, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial position to a second stable position only by an input pulse having an amplitude greater than a predetermined minimum value, said electron beam being moved from said initial position to the third stable position only by an input pulse having an amplitude greater than a predetermined maximum value, pulse counting means connected to said second collector electrode, said electron beam being adapted to strike said second collector electrode only when the said electron beam is in said second stable position thereby applying a pulse to said counting means, and means for returning said electron beam from one of said second and third stable positions to said initial stable position after a predetermined period of time after the initiation of said input pulse.

5. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode and at least two collector electrodes, a source of supply voltage, means for varying the deflection electrode voltage in accordance with the current in one of said collector electrodes comprising a feedback circuit coupling said one of said collector electrodes to said source of supply voltage and a point on said feedback circuit for providing an initial stable position and at least another stable position for said electron beam in accordance with the current in said one of said collector electrodes, said last-mentioned means comprising a relatively large resistance resistor connected between said source of supply voltages and a point on said feedback circuit in proximity to said one of said collector electrodes, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial stable position to said other stable position only by an input pulse having an amplitude greater than a predetermined minimum value, and means for returning said electron beam from said other stable position to said initial stable position after a predetermined period of time after the initiation of said input pulse.

6. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode and at least two collector electrodes, a source of supply voltage, means for varying the deflection electrode voltage in accordance with the

current in one of said collector electrodes comprising a feedback circuit coupling said one of said collector electrodes to said deflection electrode, said feedback circuit including a cathode follower circuit having an input connected to said one of said collector electrodes and an output connected to said deflection electrode and means connected to said feedback circuit for providing an initial stable position and at least another stable position for said electron beam in accordance with the current in said one of said collector electrodes, said last-mentioned means comprising a relatively large resistance resistor connected between said source of supply voltage and a point on said feedback circuit between said one of said collector electrodes and said input of said cathode follower circuit, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial stable position to said other stable position only by an input pulse having an amplitude greater than a predetermined minimum value, and means for returning said electron beam from said other stable position to said initial stable position after a predetermined period of time after the initiation of said input pulse.

7. A pulse selection circuit arrangement comprising a cathode ray tube having electron beam producing means, a deflection electrode and at least two collector electrodes, means for varying the deflection electrode voltage in accordance with the current in one of said collector electrodes comprising a feedback circuit coupling said one of said collector electrodes to said deflection electrode and means connected to said feedback circuit for providing an initial stable position and at least another stable position for said electron beam in accordance with the current in said one of said collector electrodes, means for applying electrical input pulses to said deflection electrode through said deflection electrode voltage varying means in a manner whereby said electron beam is moved from said initial stable position to said other stable position only by an input pulse having an amplitude greater than a predetermined minimum value, said input pulse applying means comprising means for supplying only input pulses having amplitudes above a predetermined minimum value through said deflection electrode means, and means for returning said electron beam from said other stable position to said initial stable position after a predetermined period of time after the initiation of said input pulse.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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Cornelis Nauta et al

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 74, strike out "with the current", second occurrence; column 7, line 31, for "said source of supply voltage and a point on said feed-" read -- said deflection electrode and means connected to said feed- --; line 37, for "voltages" read -- voltage --.

Signed and sealed this 3rd day of November 1959.

(SEAL)

Attest:

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