

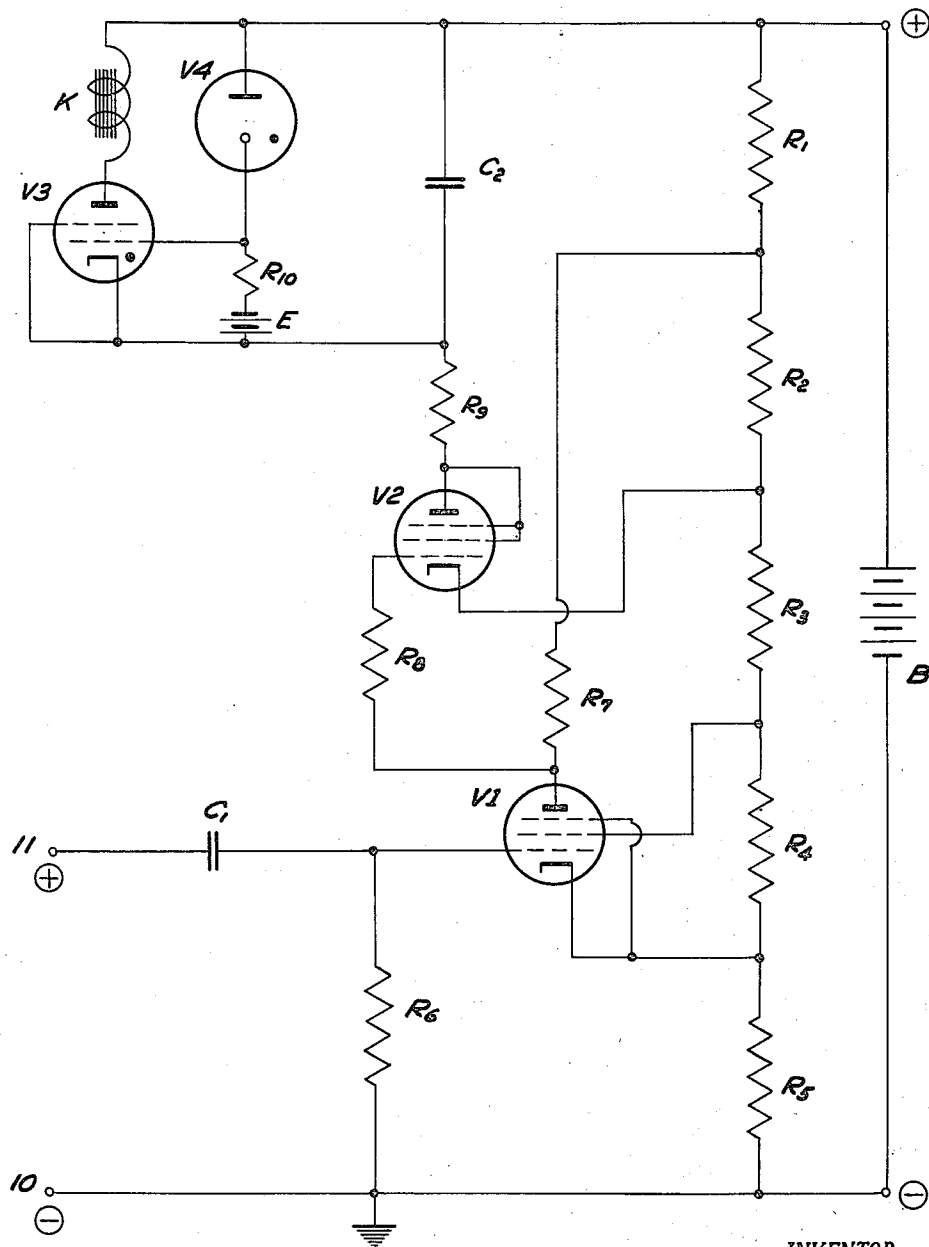
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ELECTRICAL INTEGRATOR

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ELECTRICAL INTEGRATOR

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This invention relates generally to an integra-
tor for integrating the time intervals of occur-
rence of a condition which is, or may be, re-
produced electrically, and, more particularly, to
a device for indicating the total time of existence
of an abnormal condition, such as sparking, in
electrical apparatus.

The specific device to be described herein has
been developed for the particular purpose of
indicating the total "outage" time which occurs
during the operation of electromagnetic isotope
separating apparatus. In such apparatus, as
is well known, a beam of ions containing a plu-
rality of isotopes is projected at a high velocity
by means of an accelerating voltage through, and
at right angles to, an intense magnetic field.
As a result, the original single ion beam is split
into a plurality of component ion beams, each
consisting solely of ions of a single mass weight,
and these component beams may be separately
collected at a receiver disposed at a focal point
in their travel.

Normal operation of such isotope separating
units is recurrently interrupted for short periods
of time due to unavoidable sparking. The
sparking is, of course, accompanied by a sud-
den drop in the accelerating voltage, and this,
by affecting the velocity of projection of the
ions, causes the ion beams to be deflected
from their proper position on the receiver unit.
During such sparking intervals therefore the
isotope separating unit is ineffective for its
purpose of separately collecting the isotopes.
The summation of all such lost production time
during a run is termed "outage time," and for
various control and accounting purposes it is
desirable to have a quantitative knowledge of
such time. The present invention is adapted
to integrate or totalize the intervals of spark-
ing which occur during a run so as to pro-
vide a quantitative indication of outage. A re-
quirement of the design of such apparatus, of
course, is that this integration be carried on ac-
curately without regard to the intensity of par-
ticular sparks which occur.

Accordingly, it is an object of the present in-
vention to provide a method of and apparatus for
indicating the outage time due to sparking which
has occurred in a run of an isotope separating
unit of the electromagnetic type.

It is another object of the invention to provide
apparatus for integrating the time intervals dur-
ing which sparking has occurred in electrical ap-
paratus.

Another object of the invention is to provide
apparatus for integrating the total time of oc-
currence of a condition which may be reproduced
as, or is accompanied by, an electrical phe-
nomenon.

Other objects and advantages of the present

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invention will become apparent from the follow-
ing description, taken in connection with the ac-
companying drawing, wherein the single figure
is a wiring diagram of the electrical integrator of
the present invention.

Referring now to the single figure of the draw-
ing, a voltage divider consisting of resistors R_1 ,
 R_2 , R_3 , R_4 , and R_5 , connected together in series,
is connected across a direct voltage supply, in-
dicated as battery B. The various required po-
tentials for the integrating device are obtained
from various points on this voltage divider. The
negative terminal of the voltage divider is con-
nected to ground, as shown.

In an isotope separating unit of the electro-
magnetic type, the high intensity accelerating
voltage is ordinarily supplied through a voltage
regulator, and included within this regulator is
a voltage divider across which the total ac-
celerating voltage appears. Terminals 10 and 11
of the present device may be connected across
a portion of this voltage divider so that terminal
10 is connected to a grounded point on this volt-
age divider and terminal 11 is connected to a
point at a small positive potential with respect
thereto. Connected in series between terminals
11 and 10 are a large blocking condenser C_1 and
and a large resistance R_6 , as shown.

An amplifying vacuum tube, V_1 which may
be a pentode, as shown, is provided, having its
cathode and suppressor grid connected to a point
intermediate resistors R_4 and R_5 of the voltage
divider of the present device. The control grid
of vacuum tube V_1 is connected to a point in-
termediate blocking condenser C_1 and resistor R_6 .
The screen grid of vacuum tube V_1 is connected
to a point intermediate resistors R_3 and R_4 of the
voltage divider. The positive plate voltage for
the vacuum tube V_1 is obtained from a point
intermediate resistors R_1 and R_2 of the voltage
divider, this point being connected to the plate
of vacuum tube V_1 through plate resistor R_7 .

A second vacuum tube V_2 , which operates in
the nature of an electronic switch, as will here-
inafter be explained, is provided, this vacuum
tube V_2 having its cathode connected to a point
intermediate resistors R_2 and R_3 of the voltage
divider. The control grid of vacuum tube V_2 is
connected through limiting resistance R_8 to the
plate of vacuum tube V_1 . The screen and sup-
pressor grids of vacuum tube V_2 may be con-
nected to the plate of tube V_2 , which plate is con-
nected through plate resistor R_9 and integrating
condenser C_2 to the positive terminal of the volt-
age divider power supply.

Two electronic circuits are connected in par-
allel across the integrating condenser C_2 , the first
of these comprising a series circuit consisting of a
small biasing battery E, a resistor R_{10} , and a gas
type voltage regulating tube V_4 . The second

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electronic circuit paralleling integrating condenser C₂ consists of a series connection of a grid controlled gas type tube V₃, which may be a thyatron, and an electromagnetic type counter, schematically indicated at K. The control grid of thyatron V₃ is connected to the cathode of gas tube V₄.

During normal operation of the isotope separating unit, that is when no sparking is occurring, a steady accelerating voltage exists in the unit, and, accordingly, a small steady direct voltage is maintained between the terminals 10 and 11. This voltage, of course, operates to charge the condenser C₁ through resistor R₆ to an equivalent voltage, so that the control grid of vacuum tube V₁ is normally at substantially ground potential. Since the cathode of vacuum tube V₁ is maintained at a voltage slightly greater than ground potential by virtue of its connection to the slightly positive point intermediate resistors R₄ and R₅, the control grid of vacuum tube V₁ normally has a slight negative bias with respect to the cathode. This bias is such that the vacuum tube V₁ under these normal conditions is just conducting.

When sparking occurs in the isotope separating unit, the accelerating voltage suddenly drops by a large amount, carrying with it the potential of terminal 11. Accordingly, sparking in the isotope separating unit is accompanied by a negative pulse on terminal 11, which pulse is transmitted through the condenser C₁ to the grid of vacuum tube V₁, thus cutting this tube off and rendering it non-conducting. The grid bias on tube V₁ under normal, that is, non-sparking conditions, is such that a drop in the grid potential of only one or two percent will render the tube non-conducting. Since the pulses which are impressed upon the grid of vacuum tube V₁ due to sparking in the isotope separating unit correspond to a dip in the potential of the control grid by an amount well in excess of one or two percent, the vacuum tube V₁ will be cut off completely immediately upon the occurrence of any substantial sparking in the isotope separating unit.

Due to the amplifying action of vacuum tube V₁, negative pulses impressed upon its control grid due to sparking in the isotope separating unit appear as intense flat-topped positive pulses on its plate, and these pulses are transmitted and impressed upon the control grid of vacuum tube V₂. The grid bias of vacuum tube V₂ is normally such that this tube is non-conducting, and the receipt of these flat-topped positive pulses cause the vacuum tube V₂ to become conducting. The grid of vacuum tube V₂ is driven so far positive upon the occurrence of these positive pulses that grid current flows in this vacuum tube through limiting resistor R₈, thus providing a plate current limiting action within this tube. Due to the amplifying action of tube V₁, and the limiting or clipping actions of tubes V₁ and V₂, the second tube V₂ can be thought of essentially as an electronic switch controlling the flow of a constant plate current in its plate circuit in response to the receipt of a negative pulse upon input terminal 11 substantially regardless of the intensity of this pulse. In this way, practically all sparks, which occur in the isotope separating unit, regardless of their intensity, are accompanied for their duration by a constant plate current flow in the plate circuit of vacuum tube V₂.

Since gas tubes V₃ and V₄ are normally non-

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conducting, the constant plate current of tube V₂ begins to charge integrating condenser C₂. Eventually condenser C₂ will become charged sufficiently so that the potential across gas tube V₄ will have reached its firing potential, whereupon this tube becomes conducting and the current through this tube begins to discharge condenser C₂ through resistor R₁₀.

The bias voltage on the control grid of thyatron V₃ is normally such that the tube is non-conducting. However, as soon as gas tube V₄ conducts, the surge of discharge current through resistor R₁₀ causes the control grid of thyatron V₃ to become sufficiently positive to allow this tube to fire. The resulting plate current of thyatron tube V₃, as it flows through counter K, causes this counter to register once. The large amount of current which is permitted to flow in the circuit when thyatron tube V₃ becomes conducting, is sufficient to instantaneously complete the discharge of condenser C₂ and return gas tubes V₃ and V₄ to their non-conducting state. When this has happened, if plate current is still flowing through vacuum tube V₂, that is, if sparking in the isotope separating unit has not yet been extinguished, the integrating condenser C₂ will again begin to charge and the cycle will repeat itself. In this manner, the counter K will continue to register at equal intervals as long as sparking continues.

It is apparent that, for the duration of a spark, a constant current flows into the parallel circuit which includes C₂, V₃, and V₄ in its three parallel branches, respectively. In this parallel circuit, the charge on C₂ determines the plate voltage of both V₃ and V₄. Since neither V₃ nor V₄ are conducting until the potential across C₂ reaches the critical value at which V₄ will fire, up until this time all of the current flowing into the parallel circuit must flow into C₂ tending to charge C₂ to this critical potential. When this critical potential has been reached, V₄ fires thus causing the firing also of V₃, as previously described. Since the external return circuit for each of these tubes is through the branch containing C₂, C₂ is immediately discharged by the tube currents. When C₂ has been sufficiently discharged, the potential across it will no longer support the discharge through tubes V₃ and V₄, which tubes are thus rendered again non-conducting. The whole parallel circuit has then returned to its initial condition and the cycle repeats itself.

Thus, it will be apparent that the counter K will continue to count at a constant rate during all intervals in which sparking is occurring in the isotope separating unit, and that counting will be initiated immediately upon the occurrence of a spark and will continue until such sparking is terminated. Due to the above-described clipping or limiting action of tubes V₁ and V₂, the rate of counting will be independent of the intensity of the sparks.

The time constant of the integrating circuit may be adjusted as desired by varying the value of plate resistor R₉ or the value of integrating condenser C₂. It is desirable to have these values such that the counter K will register many times during the normal interval of duration of a spark in the isotope separating unit. The time constant of the integrating circuit may be adjusted such that the counter K indicates actual hours and fractions of hours of outage or sparking time.

Since many changes in the above construction, and many apparently widely different embodiments of the invention could be made without

departing from the scope thereof, it is intended that all matter contained in the above description, or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense. In particular, it will be stressed that the integrating device of the present invention is not limited in its application to intergrating the outage time of an isotope separating unit, but, in fact, may be employed to integrate the time intervals of duration of any condition which may be accompanied by a change in potential across input terminals 10 and 11.

What is claimed is:

1. Apparatus for integrating the intervals of duration of electrical pulses comprising, a parallel circuit, said circuit having a condenser in one path thereof, a first gas tube in another path thereof, and a second gas tube and a counter arrangement in series in still another path thereof, said gas tubes being connected in their respective paths so that their respective plate-cathode currents form the respective path currents, and means responsive to said pulses for causing to flow into said parallel circuit for the duration of said pulses a current which is substantially constant and independent of the intensity and duration of said pulses.

2. Apparatus for integrating the intervals of duration of electrical pulses of a random nature in respect to shape, amplitude and duration comprising, means for receiving said pulses, amplifying and clipping means responsive to said pulses for producing, for the duration of said pulses, concurrent flat-topped current pulses of an amplitude substantially independent of the intensity of said input pulses, a condenser connected in series with the output of said amplifying and clipping means to receive the entire current of said flat-topped pulses and to be charged by said flat-topped pulses, means connected in parallel with said condenser permitting the discharge of said condenser upon the attainment of a critical condenser potential, and means for counting the number of charge-discharge cycles experienced by said condenser.

3. Apparatus for integrating the intervals of duration of electrical pulses comprising, input means for receiving said pulses, a first vacuum tube normally biased barely above cut-off, means for supplying said pulses to the grid of said vacuum tube, a second vacuum tube having a limiting resistor in its grid circuit, means connecting the plate of said first tube to the grid circuit of said second tube, a condenser connected in the plate circuit of said second tube, means connected in parallel with said condenser permitting the discharge of said condenser upon the attainment of a critical condenser potential, and counting means responsive to discharge of said condenser.

4. Apparatus for indicating the total outage time due to erratic sparking of an electromagnetic isotope separating unit comprising, means for receiving a signal from said unit corresponding to the accelerating potential thereof, amplifying and clipping means responsive to variations of said signal from a normal value for causing, for the duration of said variations, a current flow the intensity of which is substantially independent of the duration and intensity of said variations, a condenser connected to be charged by said current, means connected in parallel with said condenser permitting the discharge of said condenser upon the attainment of a critical condenser potential, and counting means responsive to discharge of said condenser.

5. Apparatus for integrating the intervals of duration of electrical pulses comprising a parallel circuit having three parallel branches, the first of said branches including a condenser, the second of said branches including a voltage source, a resistance, and a first gas tube, in series, and the third of said branches including a second gas tube and a current actuated counter in series, said gas tubes being connected in their respective branches so that their respective plate-cathode currents form the respective branch currents, said second gas tube having a grid for control thereof, a connection between the grid of said second gas tube and a point intermediate said resistance and said first gas tube, and circuit means responsive to said pulses for causing to flow into said parallel circuit, as a whole, for the duration of said pulses, a current of substantially constant amplitude.

6. Apparatus for integrating the intervals of duration of electrical pulses comprising, a parallel circuit, said circuit having a condenser in one path thereof, a gas tube in a second path thereof, and a grid controlled gas tube and a counter arrangement in series in a third path thereof, said gas tubes being connected in their respective paths so that their respective plate-cathode currents form the respective path currents, said circuit including means, including a connection between the control grid of said grid controlled gas tube and said second path, for firing said grid controlled gas tube in response to the firing of the gas tube in said second path, and means responsive to said pulses for causing to flow into said parallel circuit for the duration of said pulses a current which is substantially constant and independent of the intensity and duration of said pulses.

7. Apparatus for integrating the intervals of duration of electrical pulses of a random nature in respect to shape, amplitude, and duration comprising, means for receiving said input pulses, amplifying and clipping means responsive to said pulses for producing for the duration of said pulses concurrent flat-topped current pulses of an amplitude substantially independent of the intensity of said input pulses, and a three path parallel circuit connected in series with the output of said amplifying and clipping means to receive the entire current of said flat-topped pulses, said circuit having a condenser in one path thereof, a first gas tube in another path thereof, and a second gas tube and a counter arrangement in series in still another path thereof, said gas tubes being connected in their respective paths so that their respective plate-cathode currents form the respective path currents.

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