

FIG. 2

IMPULSE GENERATOR

16

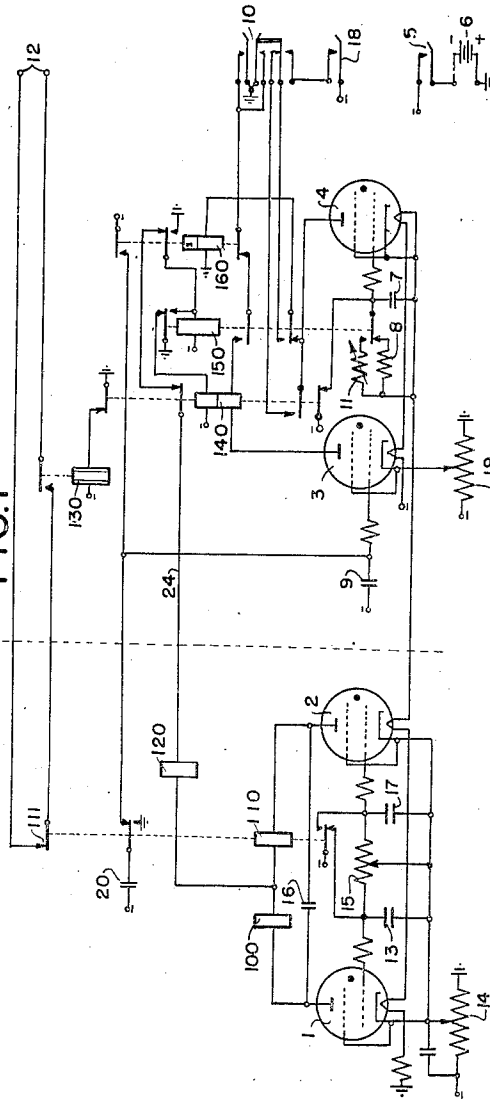
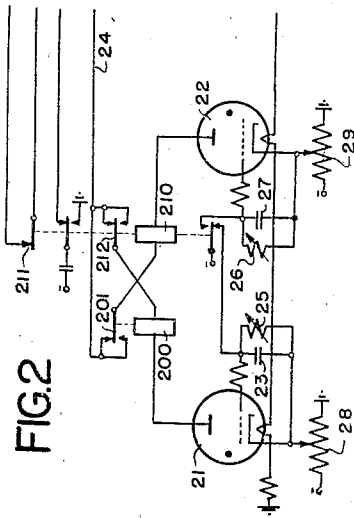
INVENTOR.
MC GREARY

HAROLD J. MC GREARY

BY

BY
Chas. H. Candy.

ATTORNEY



UNITED STATES PATENT OFFICE

2,458,283

IMPULSE GENERATOR

Harold J. McCreary, Lombard, Ill., assignor to
Automatic Electric Laboratories, Inc., Chicago,
Ill., a corporation of Delaware

Application October 23, 1944, Serial No. 560,076

8 Claims. (Cl. 315-245)

1

The present invention relates in general to impulse generators and particularly to impulse generators adapted for the control or testing of electromagnetic stepping switches and the like.

The principal object of the present invention is to provide a source of low frequency impulses that is stable in operation, compact in construction, flexible in adjustment, quiet in operation, and economical to produce.

A further object of the invention is to provide an impulse generator employing resistance and capacitance elements to determine the speed and make to break ratio of the impulses and including a novel circuit arrangement which provides independent adjustment of the speed and the make to break ratio.

Another object of the invention is to provide a means for causing any desired number of impulses to be produced in a series, either in a single group or repeated groups, and in the latter case to provide an adjustable spacing interval between successive groups.

A feature of the invention is the novel method of protecting the gas discharge tubes employed in the unit against the flow of destructive currents during the warm up period of the tubes.

Other objects and features of the invention will appear upon a further perusal of the specification taken in connection with the accompanying drawing, in which:

Fig. 1 is a schematic diagram of the impulse generator proper and the associated impulse counter and interval timer.

Fig. 2 is a schematic diagram of a modification of the impulse generator.

Referring now to Fig. 1, the two gas discharge tubes, 1 and 2, at the left of the figure with their immediately connected circuits constitute the impulse generator proper. A time delay network is connected in the grid-cathode circuit of each tube. Either one or the other of these circuits is connected to a source of biasing potential by contacts of relay 110 which is controlled by the anode current of one of the tubes. Whenever the grid potential of one of the tubes is reduced to the striking point, due to the gradual discharge of the condenser in its grid circuit, the tube fires and extinguishes the ionic discharge in the other tube thus causing relay 110 to alternately operate and release to transfer the source of biasing potential to the grid circuit of the tube which last fired.

The output impulses are obtained from contacts of relay 110. In order to produce impulses in groups other contacts of relay 113 are arranged to charge a condenser during the operated period of the relay and to discharge the condenser into a relatively larger condenser during the released period. The voltage on the large condenser is thus increased a definite amount for each operation of relay 110 and this voltage is used to con-

2

trol gas discharge tube 3. After a predetermined number of impulses have been produced tube 3 fires and stops further operation of the impulse generator for a variable time interval which is determined by the time delay network connected in the grid circuit of gas discharge tube 4.

To prepare the apparatus for use switch 5 is operated to connect the negative terminal of the battery 6 to all of the points in the circuit marked (—) thus completing a circuit to the heaters of all of the tubes in series, energizing the upper winding of relay 140, and charging condenser 7 to the potential existing across the series heaters of tubes 3 and 4. Relay 140 operates and opens the charging circuit for condenser 7. Condenser 7 slowly discharges through resistor 8 at such a rate that the voltage between the grid and cathode of tube 4 does not reach the striking potential until the cathodes of all of the tubes have had time to reach their normal operating temperatures. During this time tube 4 is the only one that has any potential applied to its anode and it is prevented from firing by the negative potential on its grid. When condenser 7 has discharged sufficiently tube 4 fires to energize relay 160. Relay 160 operates and closes a circuit to relay 150. Relay 150 operates, opens the circuit to the upper winding of relay 140, closes its locking circuit, prepares a circuit to the lower winding of relay 140, transfers relay 160 from the anode of tube 4 to contacts of key 10, and substitutes variable resistor 11 for resistor 8. If the lower contacts of key 10 are normal, relay 160 will still be connected to the anode of tube 4 through contacts of relay 140, but if the lower contacts of key 10 are operated the circuit to relay 160 and the anode circuit of tube 4 will be opened. In either event this latter circuit is opened when relay 140 restores, causing tube 4 to deionize and releasing relay 160. The restoration of relay 140 also recloses the charging circuit to condenser 7 and closes a circuit to relay 130. Relay 130 operates and connects contacts 111 of relay 110 to terminals 12 which are connected to the load circuit. The restoration of relay 160 connects ground to the anodes of tubes 1 and 2 from contacts of relay 150 and through contacts of relays 160 and 140.

The preceding operations protect the tubes during the warm up period. Assuming that key 10 is normal continuous impulses will now be produced as follows.

Tube 1 is prevented from firing when relay 160 restores due to the negative bias applied to its grid from break contacts of relay 110. Tube 2 has no bias voltage on its grid and consequently it fires to energize relay 113. Relay 113 operates and transfers negative battery from the grid of tube 1 to the grid of tube 2. Tube 2 will remain ionized however as its grid has no control of the anode current after the tube has fired. Condenser 13, which was charged to the potential existing

across the left hand portion of potentiometer 14 during the time that relay 110 was restored, commences to discharge through the left hand portion of potentiometer 15. After a time interval determined by the capacity of condenser 13 and the resistance of the left hand portion of potentiometer 15 that is in parallel with it the voltage across condenser 13 falls to a value which will cause tube 1 to fire. When tube 1 fires the potential on the anode of tube 2 is momentarily reduced by the capacitive coupling between the two anodes through condenser 16 causing tube 2 to deionize and thus release relay 110. The impedance 100 in the anode circuit of tube 1 is preferably a relay similar to relay 110 except that it is not provided with contact springs. Relay 110 restores and transfers negative battery back to the grid of tube 1. After a second time interval determined by the capacity of condenser 17 and the resistance of the right hand portion of potentiometer 15 that is in parallel with it the voltage across condenser 17 falls to a value which will permit tube 2 to fire. When tube 2 fires relay 110 is reoperated and the anode potential of tube 1 is momentarily decreased by condenser 16 causing it to deionize. The same cycle of events is repeated indefinitely causing relay 110 to be operated intermittently at a rate determined by the product of the voltage across the left hand portion of potentiometer 14 and the sum of the time constants of the parallel RC circuits in the grid circuits of tubes 1 and 2. If condensers 13 and 17 are equal, which is the preferable arrangement, the sum of the time constants of these two condensers and the portions of potentiometer 15 that are connected in parallel with them will be independent of the setting of potentiometer 15. In this case the setting of potentiometer 14 determines the voltage that the condensers are initially charged to and thus controls the speed of the impulses obtained from contacts 111 of relay 110 and the setting of potentiometer 15 determines the ratio of the closed time to the open time of these contacts, hereafter called the make-break ratio.

In order to prevent any change in the make-break ratio or in the impulse speed the impulse generator circuit has been arranged to use a common power supply for the anode circuits and the control grid biasing circuits of tubes 1 and 2. If a linear relation exists between the anode and the control grid voltages required for firing tubes 1 and 2 the time delay between the opening of the grid condenser charging circuit and the firing of the associated tube will be independent of the power supply voltage, assuming that the power supply voltage does not change during this period. This may readily be seen from the following equations.

Let

E_s = the power supply voltage which is subject to gradual variations,

e_{gs} = the grid striking potential,

e_p = the anode voltage

$= AE_s$, where A is a constant which depends on the setting of potentiometer 14.

$e_{gs} = Be_p$, where B is a constant determined by the tube characteristics,

$= ABE_s$

e_0 = initial grid voltage

$= (1-A)E_s$

e_g = instantaneous grid voltage

$= e_0 e^{-\frac{t}{RC}}$, where t is time starting from the instant the grid condenser charging circuit is opened,

then

$$\frac{e_g}{e_0} = e^{-\frac{t}{RC}}$$

5

$$t = RC \log \frac{e_0}{e_g}$$

the tube fires when $e_g = e_{gs} = ABE_s$, let t at this time = T

10

$$T = RC \log \frac{(1-A)E_s}{ABE_s} = KRC$$

where K is a constant depending on the tube characteristics and on the setting of potentiometer 14.

15

A number of tubes were found that had the proper characteristic necessary to obtain constant timing with a variable voltage supply. Typical examples are the types 884, GL-502, 2050, and 2051-02.

20

There are many occasions, particularly in testing electromagnetic stepping switches of the type commonly used in automatic telephone exchanges, where a series of a predetermined number of impulses is required rather than continuous pulses. A single series of impulses may be

25

obtained with the circuit of Fig. 1 by operating the lower contacts of key 10. This connects positive battery to the anode of tube 3 through the lower winding of relay 140 and prepares a circuit to relay 160 from key 18. When there is no

30

charge on condenser 9 a negative bias derived from the voltage drop across the left hand portion of potentiometer 19 is applied to the control grid of tube 3, but if relay 110 has been operating for some time there will be a charge on condenser

35

9 which overcomes this bias voltage causing tube 3 to fire and energize relay 140. Relay 140 operates, opens the circuit to relay 130 and opens the anode circuits to tubes 1 and 2 to stop further

40

impulsing. Relay 130 restores and opens the impulsing circuit to the load. In order to initiate the generation of a series of impulses, key 18, which is of the non-locking type, is operated momentarily. The operation of key 18 closes a circuit to relay 160 which operates, short circuits

45

condenser 9, opens a further point in the anode circuits to tubes 1 and 2, and opens the anode circuit to tube 3 through relay 140. Tube 3 deionizes and relay 140 restores, closing the circuit to relay 130. Relay 130 operates and closes the

50

impulsing loop to the load. When key 18 is released relay 160 restores, removes the short circuit from condenser 9, closes the anode circuits to tubes 1 and 2, and closes the anode circuit to tube 3 through the lower winding of relay 140.

55

Tube 3 is prevented from firing by the negative bias applied to its grid through condenser 9. This negative bias is derived from the voltage drop across the left hand portion of potentiometer 19 as previously mentioned. Tubes 1 and 2

60

again operate as previously described to cause relay 110 to intermittently open and close the load circuit at contacts 111. Each time that relay 110 operates it charges condenser 20 to the potential of battery 6 and each time that it restores it connects condenser 6 in parallel with condenser 9.

65

A part of the charge on condenser 20 is thus transferred to condenser 9 each time that relay 110 operates and restores. The voltage across condenser 9 thus increases in discrete, although

70

non-uniform, steps. The grid bias on tube 3, which is the voltage across the left hand portion of potentiometer 19 less the voltage across condenser 9, thus decreases a definite amount for each impulse. When the desired number of impulses have been produced, as determined by the

75

setting of potentiometer 19, the grid bias on tube 3 reaches the striking potential causing the tube to fire and energize relay 140. Relay 140 operates, removes plus battery from the anodes of tubes 1 and 2 to prevent further impulsing, and opens the circuit to relay 130. Relay 130 restores after its slow release period and opens the impulsing circuit. A similar cycle of operations is repeated each time that key 18 is momentarily operated. The particular arrangement of the impulsing circuit illustrated is intended for controlling automatic telephone switches of the Strowger type. These switches are seized by closing a loop circuit to them, are stepped by intermittently opening the loop, and are released by opening the loop for a half second or more. It should be apparent that other types of stepping switches or impulse controlled circuits may be operated in a different manner and that suitable modification might be made in the contact arrangement of relay 110 and the use of relay 130 to accommodate such variations without altering the spirit of the invention.

In some types of tests it is necessary to use repeated groups of impulses with a predetermined time interval between them. To obtain such repeated groups of impulses the upper contacts of key 10 are operated. The operations are the same as previously described for a single series of impulses except that tube 4 now operates relay 160 a predetermined length of time after the completion of each series instead of relay 160 being operated by key 18. At the end of a series of impulses relay 140 is operated when tube 3 fires. The operation of relay 140 opens the charging circuit to condenser 7 which proceeds to discharge through resistor 8. Resistor 8 is adjusted to provide the desired spacing interval between each series of impulses. When condenser 7 has discharged sufficiently tube 4 fires and energizes relay 160. Relay 160 operates, opens the circuit to relay 140 and the anode of tube 3, and short-circuits condensers 9 and 20. Relay 140 restores, opens the circuit to relay 160 and the anode of tube 4, and recloses the charging circuit to condenser 7. Tube 4 deionizes and relay 160 restores removing the short circuit from condensers 9 and 20, reclosing the anode circuit to tube 3 and closing the anode circuits to tubes 1 and 2 to start a new series of impulses.

The modified form of impulse generator shown in Fig. 2 may be substituted for the left hand portion of Fig. 1 by connecting the leads extending from Fig. 2 to the corresponding leads extending from the portion of Fig. 1 to the right of the dotted line. The chief difference in the operation of Fig. 2 is in the manner of causing the alternate tube to deionize whenever one of the tubes fires. In Fig. 1 this was accomplished by coupling the two anodes together through condenser 16. The coupling may also be increased by the use of the common impedance 120 in the anode circuits of tubes 1 and 2 to provide more positive operation although it is not essential. In Fig. 2 each of the relays in the anode circuits of the tubes is provided with contacts which are arranged to momentarily open the anode circuit of the alternate tube to deionize it whenever the relay operates. When positive battery is connected to the anodes of tubes 21 and 22 over lead 24 tube 22 will fire and energize relay 210. Relay 210 operates and transfers negative battery from condenser 23 to condenser 27. The application of negative battery to the grid of tube 22 will not interrupt the anode current of the tube as the

grid loses control once the tube has fired. Condenser 23 discharges through resistor 25 until the voltage between the grid and cathode of tube 21 reaches the striking potential. At this time tube 21 fires and energizes relay 200. Relay 200 operates and interrupts the anode circuit of tube 22 at contacts 201 during the time that the armature spring is traveling from the break to the make contact, which time interval is sufficient to deionize tube 210. Relay 210 therefore releases and transfers negative battery back to condenser 23 from condenser 27. During the time that relay 210 is releasing it also interrupts the anode circuit to tube 21 at contacts 212 but tube 21 fires as soon as this circuit is re-established because condenser 23 does not become charged rapidly enough to prevent the tube from firing. The rate at which condenser 23 charges is limited by the resistance of the right hand portion of potentiometer 28. Condenser 27 now discharges through resistor 26 until the voltage between the grid and cathode of tube 22 reaches the striking potential, at which time tube 22 fires and energizes relay 210 again. Relay 210 operates, transfers negative battery from condenser 23 to 27, and again momentarily interrupts the anode circuit of tube 21. This time tube 21 will remain deionized, as condenser 23 is fully charged, and will therefore release relay 200. Relay 200 restores and momentarily interrupts the anode circuit of tube 22 but without any permanent effect as the voltage across condenser 27 has not yet increased sufficiently to prevent the tube from firing. The above cycle of operations continues as long as the positive battery is applied to lead 24. The time interval during which contacts 211 are closed is determined by the adjustment of resistor 26 which determines the time required for condenser 27 to discharge, or by the setting of potentiometer 29 which determines the initial voltage to which condenser 27 is charged. In like manner, the time interval during which contacts 211 are open is determined by the adjustment of resistor 25 or the setting of potentiometer 28. In order to adjust the speed and maintain the make-break ratio constant both the open and the closed periods must be adjusted simultaneously with this arrangement.

In Fig. 2 triode type gas discharge tubes have been illustrated while in Fig. 1 tetrode types are shown. It has been found that either type may be used interchangeably. The examples previously cited include both types. The resistors shown connected in series with each of the control grids are merely to limit the current flowing to the grid when the tube is fired and play no part in determining the timing intervals.

What is claimed is:

1. In combination, a gaseous discharge tube having at least a cathode, a control electrode, and an anode, a relay having a winding connected between said anode and cathode, a normally charged condenser connected between said control electrode and cathode, a resistor, means controlled by the relay for causing said condenser to discharge through said resistor so as to initiate an ionic discharge in the tube after a predetermined time interval, said relay being operated when said discharge occurs, and means responsive to the operation of said relay for deionizing said tube whereby the relay is periodically actuated.

2. In combination, a pair of gaseous discharge tubes each having at least a cathode, a control electrode, and an anode, a relay connected be-

tween the anode and cathode of each tube, a source of biasing potential, circuit arrangements for causing varying voltages derived from said source of biasing potential to be applied between the control electrodes and cathodes of each of said tubes so as to alternately initiate ionic discharges therein, and switching means controlled by said relays for momentarily interrupting the anode circuit of the alternate tube in response to the initiation of a discharge in one tube whereby said relays are alternately and intermittently actuated.

3. An impulse generator comprising a gaseous discharge tube having at least a cathode, a control electrode, and an anode, a relay connected between said anode and cathode, circuit connected between said control electrode and cathode, means controlled by said relay, for causing a current to flow in said circuit so as to initiate a discharge in said tube after a predetermined time interval, said relay being operated when said discharge occurs, and means responsive to the operation of said relay for deionizing said tube whereby the relay is periodically actuated; characterized in the fact that a common voltage source is used for the anode supply and for the source of said current, and that the control electrode voltage necessary to initiate a discharge in the tube is a linear function of the anode voltage, whereby the rate at which said relay is periodically actuated is rendered, substantially independent of the voltage of said source within the working range of the impulse generator.

4. In combination, a gaseous discharge tube having at least a cathode, a control electrode, and an anode, a relay connected between said anode and cathode, a circuit having a time constant connected between said control electrode and cathode, means controlled by said relay for causing a current to flow in said circuit so as to initiate an ionic discharge in the tube after a predetermined time interval, said relay being operated when said discharge occurs, means responsive to the operation of said relay for deionizing said tube whereby the relay is periodically actuated, a condenser, means controlled by said relay for altering the charge on said condenser a predetermined amount for each operation of the relay, and means for terminating the periodic actuation of said relay in response to the charge on said condenser reaching a predetermined value.

5. An impulse generator comprising a pair of gaseous discharge tubes each having at least a cathode, a grid, and an anode, an anode circuit for said tubes including a relay, a grid circuit for said tubes associated with contacts of said relay so as to cause ionic discharges to be alternately initiated in said tubes in response to intermittent operation of said relay, means responsive to the initiation of a discharge in either one of said tubes for deionizing the other tube whereby said relay is intermittently operated, a condenser, means controlled by said relay for altering the charge on said condenser a predetermined amount for each operation of the relay, and means responsive to the charge on said condenser reaching a predetermined value for terminating the intermittent operation of said relay.

6. An impulse generator comprising a pair of gaseous discharge tubes each including at least a cathode, a control electrode, and an anode, a source of potential, a first resistor connected between said control electrodes, a second resistor

connected across said source, adjustable taps on said resistors connected to said cathodes, a pair of condensers individually connected between the control electrodes and cathodes of said tubes, a third condenser connected between the anodes of said tubes, a pair of impedances individually connected between the anodes of said tubes and the positive terminal of said source, at least one of said impedances being a relay, contacts on said relay normally connecting the negative terminal of said source to the control electrode of one of said tubes, said relay being operated in response to the firing of the other of said tubes to transfer the negative terminal of said source from the control electrode of said one tube to the control electrode of said other tube thereby causing said one tube to fire a predetermined time interval thereafter, said third condenser causing either tube to be extinguished in response to the firing of the other tube whereby said relay is periodically actuated, the adjustment of the taps on said first and second resistors determining the ratio of actuated to released intervals and the rate of periodic actuation, respectively, of said relay.

7. An impulse generator comprising two gaseous discharge tubes, each having at least a cathode, a control electrode, and an anode; a condenser connected between the control electrode and the cathode of each tube, a source of bias potential for charging said condensers alternately, a discharge circuit connected across each of said condensers for discharging each at a predetermined rate, either one of said tubes becoming ionized in response to the potential of the corresponding condenser reaching the firing point of said tube, means responsive to the ionization of either one of said tubes for deionizing the other of said tubes and for transferring said source from the condenser associated with said other tube to the condenser associated with said one tube, said tubes firing alternately at intervals determined by the discharging rates for said condensers.

8. In an impulse generator as claimed in claim 7, an adjustable voltage divider connected across said source to determine the potential for charging said condensers, said divider being adjustable to change the sum of the intervals required for discharging said condensers while the ratio of the intervals remains constant, a resistive element in each of said discharge circuits, and means for adjusting said resistive elements simultaneously to change the ratio of said intervals while the sum thereof remains constant.

HAROLD J. McCREARY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,979,054	Scheer	Oct. 30, 1934
2,059,562	Curtis et al.	Nov. 3, 1936
2,073,701	Lazzarini	Mar. 16, 1937
2,080,273	Holmes	May 11, 1937
2,104,142	Swart	Jan. 4, 1938
2,153,202	Nichols	Apr. 4, 1939
2,282,916	Wolf	May 12, 1942
2,297,119	Williamson et al.	Sept. 29, 1942
2,323,019	Dohle	June 29, 1943
2,350,888	Hall	June 6, 1944
2,359,967	Brown	Oct. 10, 1944