June 30, 1953 J. R. DESCH 2,644,087

ELECTRONIC IMPULSE GENERATOR

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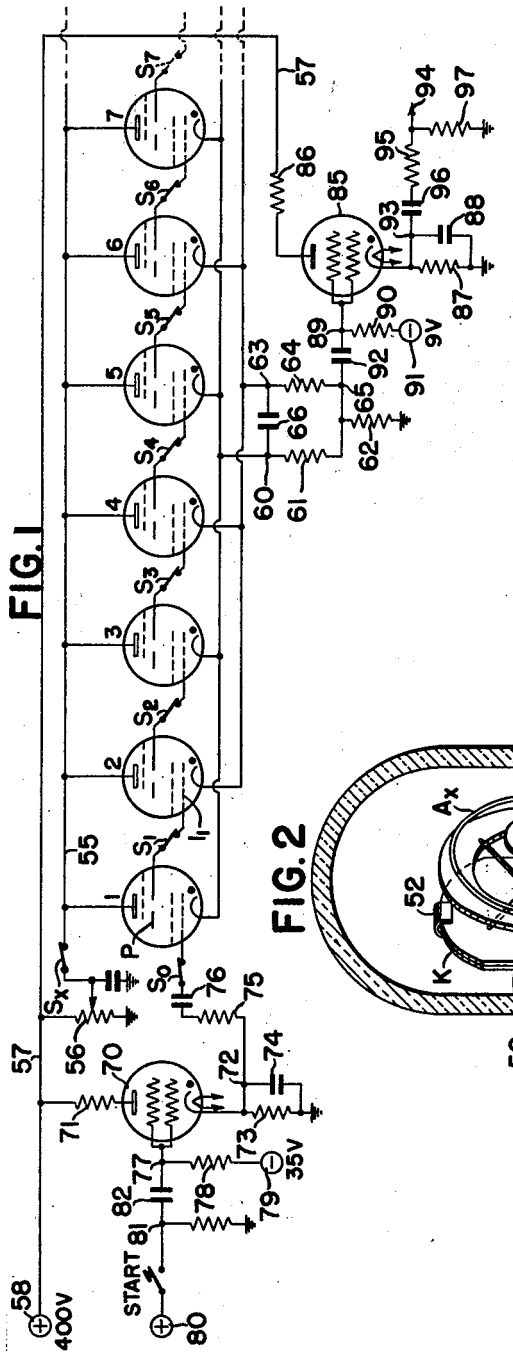

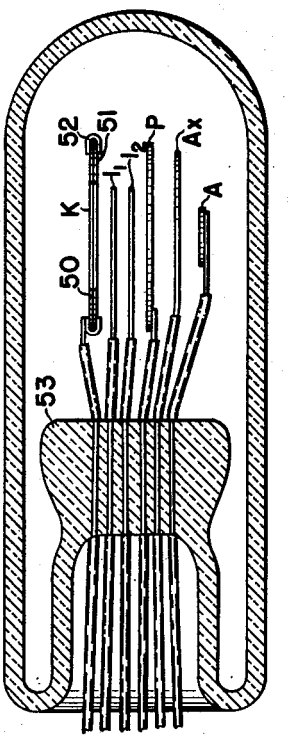

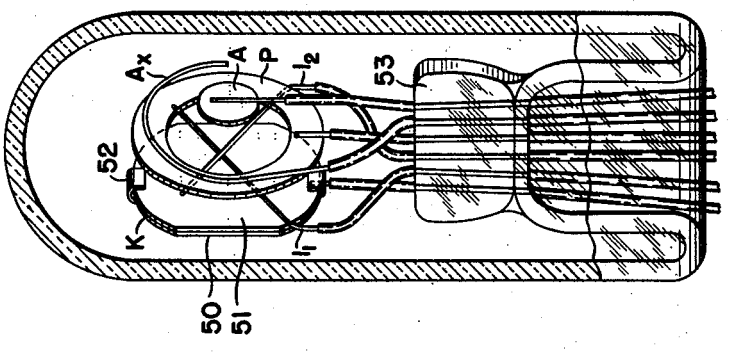

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ELECTRONIC IMPULSE GENERATOR

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This invention relates to a novel electron tube impulse generator for producing discrete numbers of impulses and in particular to an impulse generator which is simple in construction and which utilizes cold-cathode tubes.

The novel impulse generator includes a plurality of cold-cathode tubes connected together in a series for automatic sequential operation upon an initiation of the operation of the tubes, the connections to the tubes being extremely simple and requiring a minimum of circuit impedance components. Settable switches in the circuit can control the number of impulses which will be produced in a single cycle of operation of the impulse generator. The novel impulse generator not only has the advantage that its circuit is simple but also has the advantage that it will be economical to operate since no heaters are required for the tubes of the series.

Briefly, the novel impulse generator utilizes cold-cathode gaseous electron discharge tubes having at least an anode and a cathode forming a main gap, an igniter which cooperates with the cathode to form a starter gap, and a probe electrode located in the ionizable medium of the main gap and acquiring a positive potential when conduction occurs in the main gap. These tubes are connected in a series by connections which extend from the probe of one tube to the igniter of the next tube in the series so that once conduction is started in the series, the tubes of the series will become conducting one after another automatically, the positive potential acquired by a probe, as its tube conducts, causing the starting gap of the next tube to ionize to start conduction in the next tube. The cathodes of the tubes of the series are connected into two groups, with the cathodes of every other tube of the series being grouped together, and are connected over a resistance network containing an impulse producing resistor, to ground. Each time a tube of either group conducts, a potential impulse will be generated over the resistor. If desired, suitable amplifying and pulse shaping means can be provided to amplify and shape the impulses which are thus generated.

A blow-out circuit between the two groups of cathodes enables conduction beginning in a tube in one group to extinguish any previously conducting tube in the other group so that tubes will be extinguished as the firing action proceeds along the chain.

In order to control the number of impulses which will be produced, switches are provided in the circuits to the tubes to prevent further automatic firing of the tubes after the required number of impulses have been generated.

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Starting means are provided to fire the first tube of the series to start the sequential operation of the tubes.

It is an object of the invention to provide an extremely simple and economical impulse generator which is capable of producing desired numbers of impulses.

A further object of the invention is to provide an impulse generator using cold-cathode tubes in an extremely simple circuit which can be controlled to produce desired numbers of impulses.

With these and other incidental objects in view, the invention includes certain novel features of construction and combinations of parts, a preferred form or embodiment of which is hereinafter described with reference to the drawing which accompanies and forms a part of this specification.

Of the drawing:

Fig. 1 is a circuit diagram showing an embodiment of the novel impulse generator.

Fig. 2 is a perspective view of one of the cold-cathode tubes showing the shape and relative positioning of the electrodes.

Fig. 3 is a section through the tube of Fig. 2 showing the spacing of the electrodes.

Detailed description

In the following description, values of potential with reference to ground and values of resistance and capacitance, as well as tube types will be given. It is not intended that the invention be limited to these particular potentials or to the values of resistance specified herein, because the potentials used are merely selected as convenient potentials for the disclosure, and the values of the impedance elements of resistance and capacitance given correspond in relative value to the potentials chosen. Also, it is obvious that other equivalent types of tubes may be used and other potentials may be used, and, when this occurs, the values of the impedance elements can be adjusted accordingly to maintain the proper relationship between the various parts of the circuit.

Excellent results have been obtained from circuits constructed according to the invention, using values of resistance, capacitance and potentials to be given.

In the novel circuit as shown in Fig. 1, the impulses are generated by the operation of the desired number of cold-cathode tubes which are connected for automatic sequential operation.

One form of cold-cathode tube which can be

used is shown in Figs. 2 and 3 of which Fig. 2 is an enlarged perspective view and Fig. 3 is a section view which shows the side spacing of the electrodes.

The tube is provided with a plurality of electrodes, including, in order, a cathode K, two igniters I_1 and I_2, a probe P, an auxiliary anode A_x, and an anode A.

The cathode K, which is a substantially round flat disc about .75 of an inch in diameter, is made of a sheet **50** of magnesium and a sheet **51** of nickel which are mounted on a support with the magnesium sheet facing the anode. The two sheets are fastened together at the support but are merely clipped together by a clip **52** at a point remote from the support to allow relative movement and prevent buckling due to the different coefficients of expansion of the two metals.

Adjacent the cathode are the two igniter electrodes which are made of .02 of an inch nickel wire. Igniter I_1 which extends across the cathode, parallel thereto and is spaced about .032 of an inch therefrom, can cooperate with the cathode to form a starting gap. Igniter I_2 also extends across the cathode, parallel thereto, but runs approximately at right angles to igniter I_1, and is spaced about 0.75 of an inch from the cathode. The igniter I_2 can be used with either the cathode or igniter I_1 to form a starting gap.

The probe P is a flat annular member made from sheet magnesium. Its outside diameter is substantially the same as that of the cathode and it is mounted parallel to the cathode about .160 of an inch therefrom. This probe lies adjacent the anode-cathode discharge path and can be influenced greatly by a discharge in the tube.

The auxiliary anode A_x also is made of .02 of an inch nickel wire and is curved to generally follow the shape of the probe P and lies between the probe and the anode A.

The anode A is a disc of nickel about .25 of an inch in diameter. It is mounted on a suitable support parallel to the probe and about .160 of an inch therefrom.

The supports for the various electrodes are insulated and extend through a press **53** at the bottom of the tube.

The tube was activated by pulse bombardment of the cathode and probe and is filled with argon gas at a pressure of 12 millimeters of mercury.

This tube has excellent operating characteristics and is very flexible in its use since the several electrodes intermediate the anode and cathode can be used in a variety of ways as igniters, as auxiliary cathodes, or as probes, as required in the circuit in which the tube is to be used.

A tube constructed as above will have a striking potential from igniter I_1 to cathode K of about 90 volts; from igniter I_2 to cathode K of about 140 volts; from probe P to cathode K of about 180 volts and from anode A to cathode K of about 300 volts. With the tube conducting and passing 5 milliamperes, it has a drop of about 67 volts between the cathode and either igniter I_1 or I_2; a drop of about 75 volts between the cathode K and the anode A; and the probe P will be about 60 volts more positive than the cathode.

The novel circuit using these tubes is shown in Fig. 1. While only seven impulse generating tubes of this type are shown in the chain, it will be clear that as many more can be included as are necessary to obtain the desired capacity.

The anodes of the impulse generating tubes **1** through **7**, which are tubes of the type shown in Figs. 2 and 3, are connected together over a common conductor **55** and switch S_x to the adjustable tap of a 10,000 ohm potentiometer **56** which is connected between ground and a conductor **57** to which a +400 volt potential is applied at terminal **58**. The switch S_x is normally closed but will be opened momentarily after each operation of the impulse generator.

The tap of the potentiometer **56** is adjusted to provide conductor **55** with an anode potential of about +250 volts, which conductor **55** is also coupled to ground over a stabilizing capacitor of 8 microfarads.

The cathodes of every other tube of the chain or alternate tubes, for instance, the odd numbered tubes, **1**, **3**, **5**, **7**, etc. are connected together and to ground over point **60**, resistor **61** of 22,000 ohms and resistor **62** of 15,000 ohms. Similarly the cathodes of the other tubes of the chain, the even numbered tubes **2**, **4**, **6**, etc. are connected together and to ground over point **63**, resistor **64** of 22,000 ohms and resistor **62** which is common to both sets of cathodes and across which an output impulse is generated at point **65** each time any one of the tubes of the chain conducts.

Points **60** and **63** are coupled through a blow-out capacitor **66** of .01 microfarad which enables conduction beginning in a tube of one group to cause any previously conducting tube of the other group to be extinguished.

The tubes are connected for sequential operation by chain connections between tubes, which chain connections extend from the probe P of a tube, over a normally closed switch S, to the igniter I_1 of the next tube, the connection between the **1** tube and the **2** tube being representative and extending from the probe of the **1** tube over the switch S_1 to the igniter I_1 of the **2** tube. When the **1** tube is conducting, the probe-to-igniter connection between the **1** tube and the **2** tube will cause the starter gap of the **2** tube to be ionized and pass sufficient starter gap current to cause main gap breakdown of the **2** tube and the consequent conduction in the **2** tube. Similarly conduction in the **2** tube will cause conduction to begin in the **3** tube and the automatic firing of the tubes will continue until a series connection is reached in which the switch S has been opened.

The switches S_0 to S_7 are operated by keys or other means to control how many impulses will be produced, by controlling how many tubes of the chain will be fired in sequence. If one impulse is desired then switch S_1 is opened, and after the **1** tube has become conducting and produced one impulse across resistor **62**, its probe potential, due to the open circuit at S_1, will be ineffective to cause the starter gap of the **2** tube to ionize and the sequential operation of the tubes of the chain will terminate. In a similar manner the opening of any of the switches will control the number of impulses that will be generated in any operation of the impulse generator. The momentary opening of switch S_x in the anode potential supply conductor to the tubes of the chain will insure that the last tube which is conducting at the end of an impulse generating operation will be extinguished to clear the impulse generator for a further operation.

The particular location and nature of the switches S_0 to S_7 etc. shown in Fig. 1 is merely illustrative and is not to be considered as the

only form which can be used. For instance, the switches in the chain connections could be normally open and the necessary switches could be closed to cause the desired number of tubes to operate. Also, the switches could be placed in the anode leads, S_0 in the anode lead for the 1 tube, S_1 in the anode for the 2 tube, etc. and be opened to disable the operation of their respective tubes and terminate the automatic firing of the tubes after the desired number of impulses has been generated.

It is clear from the circuits described above that the circuit of the impulse generating chain of tubes is very simple since it requires only three resistors and one capacitor in addition to the tubes and it is equally clear that the circuit is economical in its operation since no filament heater power is required for any of the impulse generating tubes.

An impulse generating operation can be initiated by any convenient starting means which can provide a strong positive impulse of short duration to cause the 1 tube to fire and become conducting. The form used in the embodiment illustrating the invention utilizes a gaseous tetrode thyratron tube **70** which is included in a self extinguishing circuit and can send a single strong positive impulse of desired short duration to the 1 tube for each operation of a start key.

The tube **70**, which is of the type designated 2050, has its anode connected over a resistor **71** of 470 ohms to the conductor **57** to which +400 volts is applied and has its cathode connected to ground over resistor **73** of 220,000 ohms and capacitor **74** of .003 microfarad in parallel. The potential of point **72** in the cathode circuit of tube **70** will rise sharply each time the tube conducts.

Point **72** is coupled over resistor **75** of 1 megohm capacitor **76** of 10 micro-microfarads and switch S_0 to the igniter I_1 of the 1 tube and will cause the 1 tube to be fired each time tube **70** conducts. While point **72** is shown coupled to only one series of impulse generating tubes in Fig. 1, it is to be understood that where several series of impulse generating tubes are used, they all could be coupled to point **72** and the one starting means could initiate the sequential operation in all of the chains.

Tube **70** is normally nonconducting because its shield grid and control grid are connected together and over point **77** and resistor **78** of 250,000 ohms to terminal **79** which is supplied with a potential of −35 volts. The tube may be fired by closing a start key which couples a sufficiently positive potential from terminal **80**, over point **81** and capacitor **82** of .0005 microfarad to point **77** to overcome the normal bias on the tube and cause it to conduct momentarily. Point **81** is coupled to ground over a resistor **83** of 100,000 ohms which allows the charge to leak off capacitor **82** when the start key is opened.

Accordingly, upon closing the start key, the impulse generator will be set into operation to produce a series of impulses at point **65** corresponding in number to the switch which was opened.

The output impulses at point **65** can be used to operate some desired means directly or may be amplified and shaped before use.

One form of amplifying and shaping means is shown in Fig. 1. This means includes a gaseous tetrode thyratron **85** of the 2050 type which is included in a self-extinguishing circuit. Tube **85** has its anode connected over a resistor **86** of 470 ohms to the +400 volt conductor **57** and has its cathode connected to ground over a resistor **87** of 330,000 ohms and capacitor **88** of .0005 microfarad in parallel. The circuit constants of this circuit are such that the tube will be extinguished automatically a short time after it conducts.

The tube **85** has its shield and screen grids connected together and over point **89** and resistor **90** of 250,000 ohms to terminal **91** which supplies them with a blocking bias of − 9 volts.

Point **89** is coupled to point **65** over a capacitor **92** of 250 micro-microfarads. Each positive impulse at **65** will overcome the bias on tube **85** and will cause the tube to be operated momentarily.

As tube **85** operates, point **93** in its cathode circuit will become more positive and will produce a positive impulse on output conductor **94** which is connected to point **93** over a resistor **95** of 2.2 megohms and capacitor **96** of .0001 microfarad, and is connected to ground over a resistor **97** of 470,000 ohms.

An impulse generator of the type shown in Fig. 1 using cold-cathode tubes of the type shown in Figs. 2 and 3 will produce excellent output signals on output conductor **94**.

The manner in which the impulse generator is operated is as follows:

Switch S_x is opened momentarily and then closed to prepare the impulse generator for operation, also the switch S_0 to S_7 is opened which corresponds to the number of impulses desired, and finally the start key is operated.

Operation of the start key causes tube **70** to conduct momentarily and send a firing impulse to the igniter I_1 of the 1 tube to fire this tube and initiate the automatic sequential operation of the tubes of the series, which automatic operation will continue until the opened switch S_1 to S_7 is reached. Each firing of a tube in the chain will cause an impulse to be generated across resistor **62** so that the required number of impulses will be produced. These impulses will be amplified and shaped by the tube **85** and made available on the output conductor **94**.

While the form of mechanism herein shown and described is admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the one form or embodiment herein disclosed, for it is susceptible of embodiment in various other forms.

What is claimed is:

1. In an impulse generator capable of being controlled to produce a desired number of impulses, the combination of a plurality of cold-cathode tubes, each tube having at least an anode and cathode forming a main discharge gap, an igniter electrode cooperating with the cathode to form a starter gap, and a probe located in the region of discharge of the main gap and capable of exerting a control whenever conduction occurs in the main gap; a common anode potential supply for all the tubes; probe-to-igniter connections connecting the tubes in a series for automatic sequential operation, the effect of conduction on the probe in a tube of the series, as that tube conducts, causing ionization of the starter gap of the next tube of the series to initiate conduction in said next tube; means connecting the cathodes of the tubes of the series together in two groups with the cathode of every

other tube of the series being connecting to form each group; a circuit connecting the cathodes of one group over a first impedance and a second impedance in series to a source of cathode potential; a circuit connecting the cathodes of the other group over a third impedance, to said second impedance and said source of cathode potential; conduction in said tubes causing potential variations across said second impedance, which is common to the two groups of tubes, to produce an output impulse each time a tube in either group conducts; extinguishing means coupling the two groups of cathodes and enabling conduction beginning in a tube whose cathode is included in one group to extinguish any previously conducting tube whose cathode is included in the other group; starting means to fire the first tube in the series to initiate the impulse generating cycle; and control means selectively operable to prevent conduction in any selected tube of the series to interrupt the sequential operation of the tubes when the required number of tubes has been fired to generate the desired number of impulses.

2. An impulse generator as claimed in claim 1 in which the probe-to-igniter connections between the tubes of the series are simply conductors and have no connections to potential sources other than through conduction in the tubes.

3. An impulse generator as claimed in claim 1 in which the probe-to-igniter connections between tubes of the series are simply conductors and contain no impedance elements and in which the extinguishing means includes but a single capacitor for coupling the two groups of cathodes, whereby an extremely simple circuit is provided.

4. In an impulse generator for generating desired numbers of electric potential impulses, the combination of a plurality of gaseous electron discharge tubes, each tube being a cold-cathode tube having at least an anode and a cathode forming a main discharge gap, an igniter cooperating with the cathode to form a starter gap, and a probe electrode located in the ionizable medium of the main gap and capable of exerting a control when conduction occurs in the main gap; a common anode potential supply to which the anodes of all the tubes are directly connected; circuits connecting the tubes in a series for automatic sequential operation, the circuits between adjacent tubes of the series containing no impedance elements and extending from the probe of a tube to the igniter of the next tube of the series and deriving potential solely from conduction in the tubes, and said circuits enabling the probe in a tube, as that tube conducts, to cause ionization of the starter gap in the next tube of the series to initiate conduction in said next tube of the series to initiate conduction in said next tube; means connecting the tubes of the series into two operational groups by connecting the cathodes of alternate tubes in the series together to form the groups; an extinguishing circuit coupling the two groups so that conduction beginning in a tube in one group in the series will cause any conducting tube of the other group to be extinguished; circuits connecting each group of cathodes over a separate impedance to a common impedance so that conduction in any tube of either group will cause a potential change across the common impedance to provide an output impulse; means to initiate the sequential operation of the tubes of the series; and control means selectively operable to prevent conduction in any selected tube of the series to interrupt the sequential operation of the tubes when the required number has been fired to generate the desired number of impulses.

5. In an impulse generator capable of being controlled to produce a desired number of impulses, the combination of a plurality of cold-cathode tubes, each tube having at least an anode and cathode forming a main discharge gap, an igniter electrode cooperating with the cathode to form a starter gap, and a probe located in the region of discharge of the main gap and capable of exerting a control whenever conduction occurs in the main gap; a common anode potential supply to which the anodes of all the tubes are connected; probe-to-igniter connections connecting the tubes in a series for automatic sequential operation, the effect of conduction on the probe in one tube of the series, as that tube conducts, causing ionization of the starter gap of the next tube of the series to initiate conduction in said next tube; means connecting the cathodes of the tubes together in two groups with the cathode of every other tube being connected together to form each group; a capacitor coupling the two groups of cathodes; a circuit connecting the cathodes of one group over a first resistor and a second resistor in series to a source of cathode potential; a circuit connecting the cathodes of the other group over a third resistor to said second resistor and said source of cathode potential, said first and third resistors having the same value and producing cathode potential variations as the tubes conduct which variations are transmitted across said capacitor coupling to enable conduction beginning in a tube, whose cathode is in one group, to cause a tube, whose cathode is in the other group, to be extinguished; conduction in a tube of either group producing a potential variation across said second resistor to provide an output impulse each time a tube of either group conducts; starting means to fire the first tube in the series to initiate the impulse generating cycle; and control means selectively operable to prevent conduction in any selected tube of the chain to interrupt the sequential operation of the tubes when the required number of tubes has been fired to generate the desired number of impulses.

6. In a cold-cathode tube impulse generator capable of being controlled to produce a desired number of impulses, the combination of a plurality of cold-cathode tubes, each tube having at least an anode and cathode forming a main discharge gap, an igniter electrode cooperating with the cathode to form a starter gap, and a probe located in the region of discharge of the main gap and capable of exerting an external control whenever conduction occurs in the main gap; a common anode potential supply to which the anodes of all tubes are directly connected; probe-to-igniter connections connecting the tubes in a series for automatic sequential operation, the connections containing no impedance elements and deriving potential solely from conduction in the tubes and enabling the probe in one tube of the series as that tube conducts to cause ionization of the starter gap of the next tube of the series to initiate conduction in said next tube; means connecting the cathodes of alternate tubes of the series together to form two groups; a blow-out capacitor coupling the two groups; a circuit connecting the cathodes of one group over a first impedance and a second impedance in series to a source of cathode potential; a circuit connecting the cathodes of the other group over a third impedance to said second impedance and said

source of cathode potential; conduction in any of the tubes causing a potential variation across said second impedance to produce an impulse each time a tube in either group conducts; impulse amplifying and shaping means controlled by the impulses produced across said second impedance and operable to produce an output impulse of the desired amplitude and shape each time one of the tubes of the series conducts; starting means to fire the first tube in the series to initiate the impulse generating cycle; and switches in said probe-to-igniter connections which are selectively operable to open the series connection between any selected tubes of the series to interrupt the sequential operation of the tubes when the required number of tubes has been fired to generate the desired number of impulses.

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