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[54] **PULSE GENERATING APPARATUS**
13 Claims, 1 Drawing Fig.

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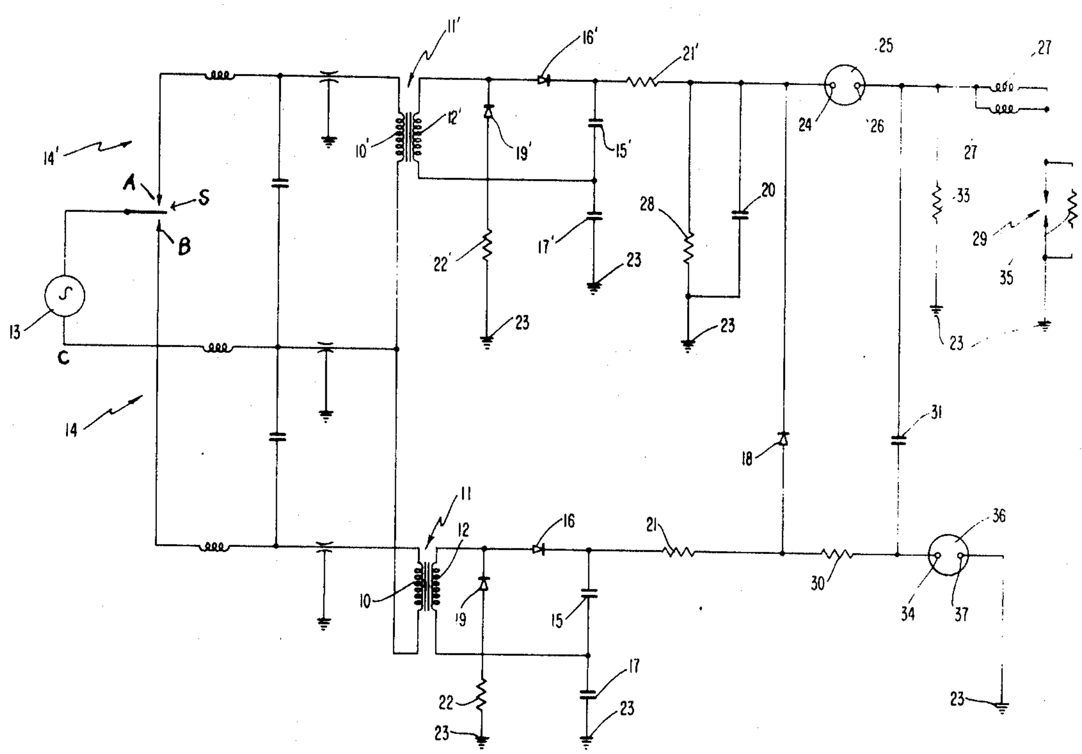
ABSTRACT: A condenser discharge type electrical pulse generating circuit, such as for a combustion engine ignition system, wherein two storage capacitors are charged in parallel to discharge across a relatively low-voltage trigger gap which connects the condensers in series to discharge across a higher voltage control gap and through a relatively low-voltage ignition gap which is connected in series with the control gap. The above circuit is disclosed herein as being used in combination with a second, alternatively employed ignition circuit which supplies higher energy pulses for short periods, as during the starting of the engine.



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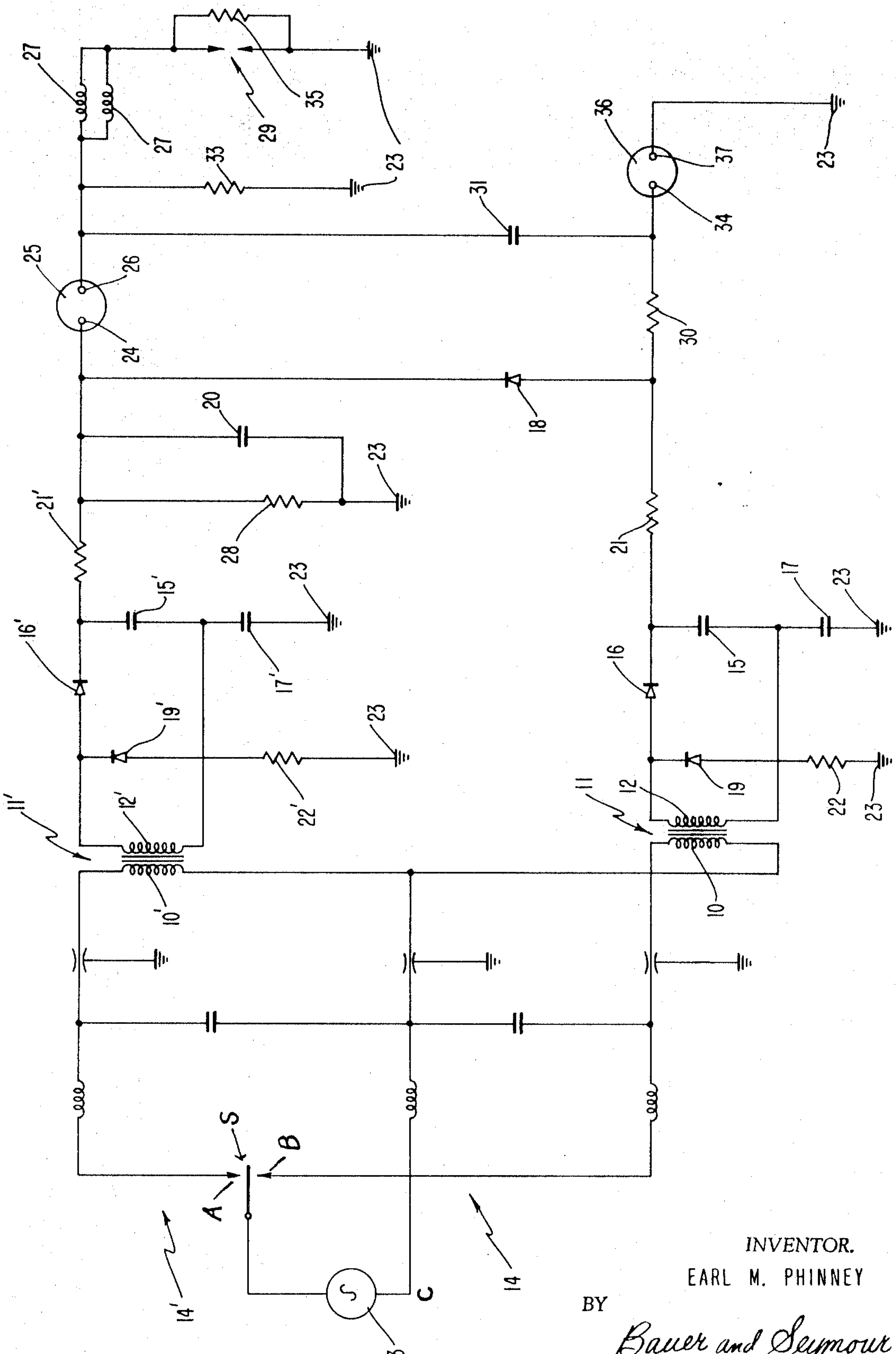

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PULSE GENERATING APPARATUS

This invention relates to electrical apparatus and more particularly to means for controlling the operation of electrical pulse or spark generating apparatus having an intermittently discharged storage condenser.

An object of the present invention is to provide novel control means for an electrical pulse or spark generating apparatus of the type indicated.

Another object is to provide novel control means for an electrical pulse or spark generating apparatus incorporating a storage condenser which is intermittently discharged through a control gap.

A further object is to provide means for controlling breakdown of the control gap, such means being subjected to only a small part of the energy which is discharged through the control gap.

A still further object of the invention is to provide a control means for electrical pulse generating apparatus which is simple, rugged, and long lived, and which provides maximum power output for a given input voltage.

Yet another object of the invention is the provision of a dual-energy circuit which employs a substantial number of components in common, one part of the dual-energy circuit being of the above-indicated type.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only, and is not intended as a definition of the limits of the invention.

The single FIGURE of the drawing is a wiring diagram of one embodiment of an electrical pulse or spark generating circuit in accordance with the invention.

The circuit shown in the drawing is adapted for use as an untimed ignition circuit for jet and gas turbine-type engines. The invention is not, however, limited to such uses or systems.

The ignition circuit shown is a dual-energy system wherein one part, the upper part in the drawing, is adapted for intermittent operation at a high level of energy delivery, and the other part of the circuit, which includes some of the components of the one part, is adapted for continuous or substantially continuous operation at a lower level of energy delivery. Both parts of the circuit are of the condenser discharge type. The lower energy, continuous service circuit will be described first. Parts in the portion of the higher energy, intermittent service circuit, which will be described later, which are the same or substantially the same as those of the first-described circuit will be designated by the same reference characters with an added prime.

The lower energy part of the circuit shown is energized by a suitable source 13 of alternating electrical current or a source of interrupted direct current which is connected to input terminals B and C of such part of the ignition circuit upon the placing of switch S in its lower closed position. The current source is connected to the primary winding 10 of a power input transformer 11 having a secondary winding 12. The circuit includes a radio frequency filtering means 14 which is preferably, although not necessarily, employed, the means 14 being interposed between the power source and the transformer 11 to attenuate high frequency noise generated within the ignition circuit and thus preventing interference from being transmitted to other circuits connected to the current source.

A voltage doubling type of energy storage means is connected across the secondary winding 12 of transformer 11. Such storage means is incrementally charged by the energy source through transformer 11; the energy storage means is periodically discharged to a pulse absorbing load, which in this instance is an ignition spark gap 29. The storage means comprises a small condenser 15 which is connected across the secondary winding 12 through a diode or half-wave rectifier 16, a second small condenser 17 connected across winding 12 through a reversely polarized diode or half-wave rectifier 19, and a main relatively large tank condenser 20 connected across condensers 15 and 17 in series.

The high-tension side of the charging circuit is connected through a diode 18 to one terminal of a main storage condenser 20, the other terminal of which is connected to ground. The condenser 20 is shunted by a resistance 28. It will be apparent that with the diodes 16 and 19 connected as shown, when the condensers are being charged the lower terminals of condensers 15, 17, and 20 are negative whereas the lower terminal of a condenser 31, to be described, is positive. The diodes 16 and 19 may be protected against damage, the operating life thereof may be enhanced, and the required rating thereof may be minimized by providing current limiting resistors 21 and 22 in the circuit, as shown. One side of the above-described energy storage means is shown as being connected to a common ground 23, and the high-potential side thereof is connected through a control gap 25 to the ungrounded electrode of an ignition spark gap 29. It will be understood that, if desired, all of the points in the circuit designated 23 may be connected by a common ungrounded conductor.

The input electrode 24 of control gap 25 is connected to the high-potential side of the ignition circuit beyond the main tank condenser 20. The output electrode 26 of the control gap 25 is connected to the input terminal of two parallel connected choke coils 27, the output terminals of the coils 27 being connected to the ungrounded electrode of the ignition spark gap 29, the other electrode of which is connected to ground. The gap 29 is of the low-tension, shunted gap type, the electrodes of the gap being bridged by a surface resistance schematically shown at 35.

Connected across the series connected diode 18 and control gap 25 is a circuit having a resistance 30 and a small condenser 31 in series. Connected to the high-potential side of the ignition circuit between one terminal of the condenser 31 and the choke coils 27 is one terminal of a resistance 33, the other terminal of which is connected to ground. The other terminal of condenser 31 is connected beyond resistance 30 to the input electrode 34 of a trigger gap 36, the other electrode 37 of which is connected to ground. The ionizing or breakdown voltage of the trigger gap 36 is substantially less than that of the control gap 25; the breakdown voltage of the ignition gap 29 is less than the breakdown voltage of the trigger gap 36.

In one successful embodiment the power transformer 11 steps up the supply voltage, which in this instance may be assumed to be 400 cycle, 115 volt, to a level in excess of 1,400 volts peak. Each half cycle of this voltage is rectified by one of the diodes 16, 19 to charge one of the doubler condensers 15, 17. The voltage across condensers 15, 17 is additive and therefore the voltage charging the main storage condenser 20 and trigger condenser 31 is in excess of 2,500 volts peak.

While the storage condenser 20 is being charged, condenser 31, which is then connected in parallel therewith, is charged through resistance 30, the charging circuit for condenser 31 being completed to ground through resistance 33. As above explained, with the diodes 16, 19 disposed as shown, the input electrode 24 of the control gap 25 is positive with respect to the output electrode 26 thereof. When the trigger gap 36 breaks down, the positive end of condenser 31, that is, that connected to electrode 34 of the trigger gap 36 is momentarily to be connected in series through the trigger gap and the voltages of condensers 20 and 31 to be additive. Such added voltages exceed the 3,000-volt ionizing potential of the main control gap 25. Gap 25 now begins to conduct the charge of the main storage condenser 20 through the choke coils 27 and the ignition gap 29 to ground, gap 29 having now been rendered conductive by subjecting it to a voltage in excess of its ionizing voltage.

It should be noted that with this type of circuit the trigger gap 36 controls the ionization of the main control gap 25. The normal ionization voltage of the control gap 25 is much higher than the level at which is is triggered. The trigger gap 36 in the disclosed circuit is subjected to only 5 percent of the energy being discharged through the control gap **25**. As a result, the life of the trigger gap **36** is greatly increased.

The portion of the circuit thus far described is adapted for continuous operation, as for constantly supplying low energy level ignition sparks to an operating engine. In the circuit shown, there is provided a further circuit portion which supplies high-energy level ignition sparks to an engine during this starting. Such further circuit portion is energized from current source **13** when switch S is in its raised closed position, thus also deenergizing the transformer **11** of the first described circuit part. A voltage doubler is supplied by the secondary **12'** of transformer **11'**; the output of the voltage doubler **16'**, **19'**, **15'**, and **17'**, is applied through a resistor **21'** to the junction between the condenser **20** and electrode **24** of control gap **25**. It will be apparent that in this mode of operation, condenser **31** is not charged during the charging of condenser **20**.

The voltage supplied by secondary **12'** of transformer **11'**, when doubled by the voltage doubler, exceeds the breakdown voltage of the control gap **25**. When condenser **20** is charged to a potential exceeding the breakdown voltage of gap **25** and hence of igniter gap **29**, the condenser **20** discharges its energy through control gap **25**, choke coils **27**, and ignition gap **29**.

Typical values of component parts which make up the above described system are as follows:

Condensers	
20	2.24–2.86 mfd.
31	0.05 mfd.
Resistances	Ohms
21 and 22	2,000
30	1,000
33	1,250
Transformers Turns Ratio	Primary/Secondary
11	600/5,000
11'	600/9,500
Coils	Number of Turns
27	each—14019 wire
Gaps	Ionizing Potential
36	2.2 Kv.
25	3 Kv.

STORED ENERGY

High-energy circuit—10.0–13.7 Joules
Low-energy circuit—5.4–7.5 Joules

Although only a single embodiment of the invention has been illustrated and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto but may be embodied in specifically different circuits. For example, the main tank or storage condenser **20** may be incrementally charged by means other than the voltage doubling system shown. For example, such condenser may be charged directly from the secondary winding of a step-up transformer powered by an alternating current source. Such transformer may also be powered by an interrupted direct current source. Various other changes may also be made, such as in the electrical values suggested herein by way of example, and in the types of rectifiers illustrated without departing from the scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. Electrical apparatus having a source of electrical energy, a multisection storage condenser connected to said source so as to be incrementally charged thereby with sections of the condenser connected in parallel, a load circuit including a discharge gap connected to be energized by the discharge of one section of the storage condenser, a first control gap interposed between said one section of the storage condenser and the discharge gap, a second control gap having a breakdown potential less than that of the first control gap and less than the voltage of the charge attainable by the parallel connected sections of the storage condenser, first circuit means connecting the second gap to another section of the storage condenser to that the second gap is ionized and rendered conductive when the charge on the parallel connected sections of the storage condenser reaches the breakdown potential of said second gap, and second circuit means for thereupon connecting said sections of the storage condenser in series and subjecting the first gap to the full voltage of the series connected sections of the storage condenser to as to ionize the first gap and render the same conductive to discharge said one section of the storage condenser to the discharge gap independently of the second gap.

2. Electrical apparatus according to claim **1** wherein the storage condenser has two sections, and the second circuit means includes the second gap interposed between the junction between the condenser sections and a common conductor to which the load circuit is connected.

3. Electrical apparatus according to claim **1** wherein said one section of the storage condenser has a capacity which is substantially greater than that of the other condenser section.

4. Electrical apparatus according to claim **1** wherein the discharge gap is a shunted surface gap.

5. Electrical apparatus according to claim **1** comprising a choke coil interposed between the first control gap and the discharge gap.

6. Electrical apparatus according to claim **4** wherein the spark-over voltage of the discharge gap is less than the breakdown potential of the first gap.

7. Electrical apparatus according to claim **1** wherein the breakdown potential of the first gap is less than the sum of the voltages of the charges attained by said sections of the storage condenser when the second gap is ionized.

8. A dual-energy electrical pulse generating apparatus having two sources of electrical energy, a multisection storage condenser, means selectively connecting the condenser to a first of said sources so as to be incrementally charged thereby with the sections of the condenser connected in parallel, a load circuit connected to be energized by the discharge of the storage condenser, a first control gap interposed between at least one section of the storage condenser and the load circuit, a second control gap having a breakdown potential substantially less than that of the first control gap and less than the voltage of the parallel connected sections of the storage condenser as charged by said first source, first circuit means connecting the second gap to the storage condenser so that the second gap is ionized and discharged when the parallel connected sections of the storage condenser reach their charged condition, and second circuit means for thereupon connecting said sections of the storage condenser in series and subjecting the first gap to the full voltage of the series connected sections of the storage condenser so as to ionize the first gap and discharge said one section of the storage condenser to the load circuit, and alternatively operated means selectively connecting said one section only of the storage condenser across the second of said sources to be charged thereby, whereby the first control gap is then discharged when the charge on the said one section of the storage condenser attains the breakdown potential of the first gap.

9. A dual-energy electrical pulse generating apparatus according to claim **16**, wherein said one section of the storage condenser substantially exceeds the other section thereof in capacity, and the second source of electrical energy has a potential greater than that of the first source.

10. Electrical pulse generating apparatus comprising a source of electrical energy, first and second storage condensers connected in parallel across said source to be simultaneously charged thereby, a control gap having a predetermined breakdown potential, a triggering gap having a breakdown potential less than that of said control gap, a control circuit comprising said condensers and said gaps in series, a triggering

circuit comprising said second condenser and said triggering gap in series, whereby said triggering gap is rendered conductive by the charge on said second condenser when it attains the breakdown potential of said triggering gap, thereby connecting said condensers in series across said control gap to render the latter conductive, and a load circuit including a load connected in series with said control gap across said first condenser independently of the triggering gap.

11. Apparatus as defined in claim **10** wherein said load includes a spark gap having a spark-over voltage less than the

breakdown potential of said triggering gap.

12. Apparatus as defined in claim **11** comprising a second source of electrical energy for alternatively charging said first condenser to the breakdown voltage of said control gap, and means for isolating said second source from said second condenser.

13. Apparatus as defined in claim **12** wherein said isolating means is a diode.

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