

PATENT SPECIFICATION

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(54) PULSE GENERATING APPARATUS

(71) We, THE BENDIX CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of Bendix Center, Southfield, Michigan 48075, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

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

According to the present invention there is provided pulse generating apparatus comprising input terminals for connection to a unidirectional voltage source, output terminals for supplying electrical pulses, and a main condenser, a supplementary condenser and first and second gaps connected between the input and output terminals, the breakdown voltage of the first gap being lower than that of the second gap, the capacity of the supplementary condenser being smaller than that of the main condenser, and the connections being such that when neither gap conducts the main and supplementary condensers are charged in parallel from the input terminals until the first gap breaks down, whereupon the two condensers are connected in series across the second gap which then breaks down, the output terminals thereby being connected through the second one only of the gaps across the main condenser.

According to the invention there is also provided pulse generating apparatus comprising first and second input terminals for connection to a unidirectional voltage source, a main condenser having first and second terminals connected respectively to the first and second input terminals whereby the main condenser is charged through the input terminals,

a control gap connected in series with output terminals across the main condenser with the first terminal of the main condenser connected to a first terminal of the control gap and the second terminal of the main condenser connected to one of the output terminals, a supplementary condenser of smaller capacity than the main condenser having a first terminal connected to the first input terminal and a second terminal connected both through a resistance to the second input terminal and to the second terminal of the control gap, and a trigger gap connected between the first terminal of the supplementary condenser and the second terminal of the main condenser, the breakdown voltage of the trigger gap being lower than the breakdown voltage of the control gap, the arrangement being such that in operation when the trigger gap breaks down the main and supplementary condensers are connected in series across the control gap which then breaks down connecting the output terminals across the main condenser.

The single Figure of the drawing is a wiring diagram of one embodiment, by way of example, of an electrical pulse generating apparatus 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

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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 prevent interference from being transmitted to other circuits connected to the current source.

A voltage doubling circuit is connected across the secondary winding 12 of transformer 11 and supplies power to an energy storage circuit which is periodically discharged through a shunted surface ignition spark gap 29. The voltage doubler comprises a small condenser 15 which is connected across the secondary winding 12 through a diode or half wave rectifier 16, and a second small condenser 17 connected across winding 12 through a reversely polarized diode or half wave rectifier 19. With the diodes 16 and 19 poled as shown, when the condensers 15 and 17 are being charged their upper terminals will be positive to provide a high tension output with respect to ground 23. 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.

The high tension output of the voltage doubling circuit is connected through a diode 18 to one terminal of a large main storage condenser 20, the other terminal of which is connected to ground. The condenser 20 is shunted by a resistance 28 and the positive terminal of condenser 20 is connected through a control gap 25 to the ungrounded electrode of the 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 large resistance 30 and a small supplementary trigger 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 small 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 the smaller 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. When the voltage across condenser 31 reaches a certain value the first or 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 grounded through such gap, causing the condensers 20 and 31 momentarily to be connected in series through the trigger gap 36 and ground across gap 25, and the voltages of condensers 20 and 31 to be additive. Such added voltages exceed the 3,000 volt ionizing potential of the second or control gap 25. Gap 25 now breaks down and 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. After the voltages across both of the two condensers 20, 31 decrease to low values the gaps 25, 36 de-ionize and the cycle repeats itself.

It should be noted that the trigger gap 36

controls the ionization of the main discharge or control gap 25, and the control gap 25 connects the main tank condenser directly to the load, namely the spark gap 29. The trigger gap 36 in the disclosed circuit only conducts charge from the trigger condenser 31 and thus is subjected to only 5% 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 its starting. Such further circuit portion is energized from current source 13 when switch S is in its raised closed position, thus also de-energizing 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 ignitor 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
45	31	0.05 mfd
	Resistances	Ohms
	21 and 22	2,000
	30	1,000
	33	1,250
50	Transformers	Primary/secondary Turns Ratio
	11	600/5,000
	11'	600/9,500
	Coils	Number of Turns
55	27	each—14 No. 19 wire
	Gaps	Ionising Potential
	36	2.2 Kv
	25	3 Kv
	Stored Energy	
60	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 circuit may be modified. 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 through a rectifier 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.

Attention is drawn to our Applications Nos. 45597/70 (Serial No. 1330504) and 45598/70 (Serial No. 1330505).

WHAT WE CLAIM IS:—

1. Pulse generating apparatus comprising input terminals for connection to a unidirectional voltage source, output terminals for supplying electrical pulses, and a main condenser, a supplementary condenser and first and second gaps connected between the input and output terminals, the breakdown voltage of the first gap being lower than that of the second gap, the capacity of the supplementary condenser being smaller than that of the main condenser, and the connections being such that when neither gap conducts the main and supplementary condensers are charged in parallel from the input terminals until the first gap breaks down, whereupon the two condensers are connected in series across the second gap which then breaks down, the output terminals thereby being connected through the second one only of the gaps across the main condenser.

2. Apparatus according to claim 1, wherein the first gap is connected in series with a resistor across the input terminals, the supplementary condenser being charged through the resistor.

3. Apparatus according to claim 1 or 2, including a diode connected in the charging path of the main condenser from the input terminals but not in its discharge path through the output terminals.

4. Apparatus according to claim 1, 2 or 3, including at least one further input terminal for charging the main condenser without charging the supplementary condenser.

5. Apparatus according to any of claims 1 to 4, including a resistor connected in series with the supplementary condenser.

6. Pulse generating apparatus comprising first and second input terminals for connection to a unidirectional voltage source, a main condenser having first and second terminals connected respectively to the first and second input terminals whereby the main condenser is charged through the input terminals, a control gap connected in series with output terminals across the main condenser with the

- first terminal of the main condenser connected to a first terminal of the control gap and the second terminal of the main condenser connected to one of the output terminals, a supplementary condenser of smaller capacity than the main condenser having a first terminal connected to the first input terminal and a second terminal connected both through a resistance to the second input terminal and to the second terminal of the control gap, and a trigger gap connected between the first terminal of the supplementary condenser and the second terminal of the main condenser, the breakdown voltage of the trigger gap being lower than the breakdown voltage of the control gap, the arrangement being such that in operation when the trigger gap breaks down the main and supplementary condensers are connected in series across the control gap which then breaks down connecting the output terminals across the main condenser.
5. Apparatus according to claim 6, including a resistor between the first input terminal and the junction between the first terminal of the supplementary condenser and the trigger gap.
10. Apparatus according to claim 6 or 7, including a diode between the first input terminal and the junction between the first terminal of the main condenser and the control gap.
15. Apparatus according to claim 8, including a diode between the first input terminal and the junction between the first terminal of the main condenser and the control gap.
20. Apparatus according to claim 8, including a diode between the first input terminal and the junction between the first terminal of the main condenser and the control gap.
25. Apparatus according to claim 8, including a diode between the first input terminal and the junction between the first terminal of the main condenser and the control gap.
30. Apparatus according to claim 8, including a diode between the first input terminal and the junction between the first terminal of the main condenser and the control gap.
9. Apparatus according to claim 8, including switch means adapted to selectively apply across the second input terminal and either the first input terminal or the junction of the diode, main condenser and control gap a respective unidirectional voltage.
10. Apparatus according to any of claims 1 to 9, including a spark gap connected across the output terminals.
11. Apparatus according to claim 10, wherein the spark gap is a shunted surface gap.
12. Apparatus according to claim 10 or 11, including a choke coil in series with the spark gap.
13. Apparatus according to claim 10, 11 or 12, wherein the breakdown voltage of the spark gap is smaller than that of the second gap or the control gap as the case may be.
14. Pulse generating apparatus constructed substantially as herein described with reference to and as shown in the accompanying drawing.
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This drawing is a reproduction of the Original on a reduced scale

