

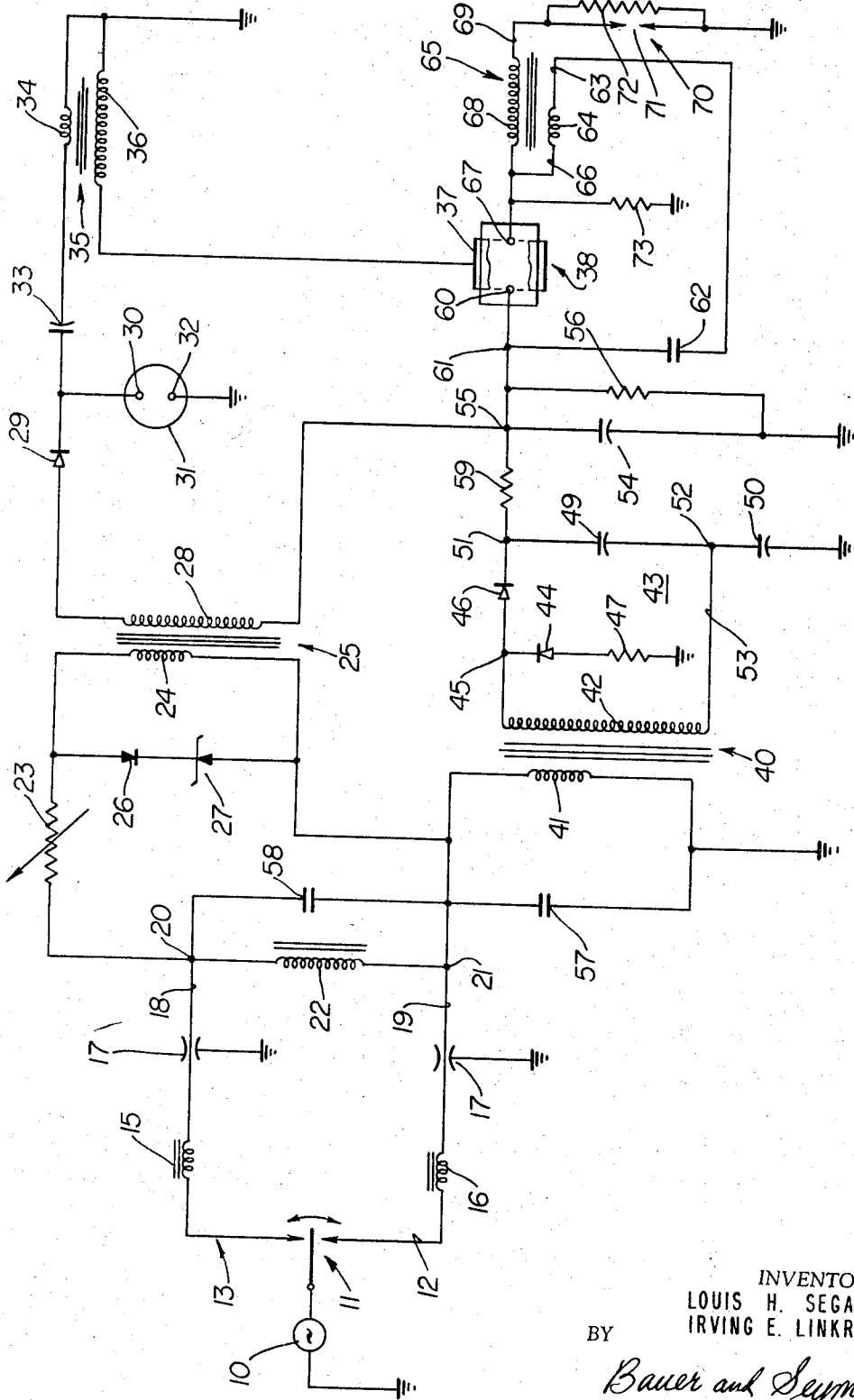
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L. H. SEGALL ET AL

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ELECTRICAL PULSE GENERATING APPARATUS

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INVENTORS
LOUIS H. SEGALL
IRVING E. LINKROOM

BY

Bauer and Seymour
ATTORNEYS

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ELECTRICAL PULSE GENERATING APPARATUS
Louis H. Segall, Sidney, and Irving E. Linkroum, Hancock, N.Y., assignors to The Bendix Corporation, a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

An electrical pulse generating system wherein untimed pulses of two levels of energy may be selectively supplied to a single load from a common source of electrical energy. The source is selectively connectable to different input terminals of two permanently linked condenser discharge circuits to selectively supply the source energy to one circuit or to divide the energy between the two circuits for charging the storage condensers in said circuits to preselected levels. One circuit is a power circuit for supplying pulses at one level of energy to the load independently of the other circuit through a control gap, and the other circuit is a trigger circuit selectively adapted for energization simultaneously with the power circuit to trigger the control gap when the power circuit is charged to supply a different level of pulse energy to the load.

This invention relates to electrical apparatus and in particular to a spark generating system for providing at a common load terminal a succession of voltage pulses at different selected energy levels from a single energy supply source.

A principal object of the invention is to provide electrical apparatus capable of selectively providing dual energy levels to a spark gap discharge device for start and continuous operation of a combustion engine or the like.

Another object of the invention is to provide electrical apparatus capable of selectively delivering two levels of energy to a storage device and controlling the discharge thereof through a spark gap discharge device.

Another object of the invention is to provide electrical apparatus having a control gap discharge device, including electrode means external thereto for receiving high energy impulses to ionize the same for conduction of different levels of stored energy.

Another object of the invention is to provide electrical apparatus for start and continuous operation of a combustion engine at two energy levels, the components of said system, although being rated for the higher energy level, are operated at low energy levels over considerable time intervals, thereby subjecting the components to less stress and strain to assure longer life of all components including the gap electrodes and thus creating greater operating efficiency of the overall system with reduced maintenance costs and greater reliability over the extended time period.

A still further object of the invention is to provide in a dual energy level ignition system for combustion engines electrical apparatus that is simple, rugged, and efficient.

The above and further objects and novel features of the present invention will more fully appear from the following detailed 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 diagram illustrating one form of electrical circuit embodying the invention.

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The embodiment of the invention illustrated in the accompanying drawing is, by way of example, shown in the form of a circuit for apparatus adapted for use as an untimed ignition system in combustion engines or the like and so-called jet and gas turbine engines.

As shown in the drawing, one suitable embodiment of the invention comprises, as a source of electrical energy, an alternating current generator 10 which may be connected to the remainder of the circuit by means of a single-pole, double-throw switch 11, interposed in the supply leads 12 and 13, the input to the circuit under consideration. Each input lead has connected thereto suitable encased low pass filter means 15, 16 for filtering out unwanted radio frequencies, noise frequencies and the like, thereby preventing said extraneous frequencies from feeding back to the generator source and to other apparatus supplied thereby. In the particular embodiment shown, the filter means comprises by-pass condensers 17 connected between ground and each power supply line, there being an inductance or choke coil interposed in each power supply line between the by-pass condensers and the power source. The power supply lines beyond filters 15, 16 are designated 18 and 19.

The lines 18 and 19 are connected to the opposite ends 20 and 21, respectively, of an inductance coil 22. The coil 22 has connected across it a variable resistor 23 and transformer primary coil 24 of transformer 25, the said resistor and transformer coil being series connected. Across transformer coil 24 there is connected a pair of diodes 26 and 27, series connected, diode 26 being a silicon type rectifier and diode 27 being a voltage regulator type Zener diode. The diode combination 26 and 27 basically constitutes a voltage regulating circuit wherein one-half of the voltage wave input to transformer 25 is clipped. This assists in producing the proper timing of the trigger pulse over the ignition system range of input voltage and frequency as embodied in the invention herein.

The secondary coil 28 of transformer 25 drives a voltage diode rectifier 29. The rectifier 29 has one terminal thereof connected to one extremity of transformer coil 28, the other rectifier terminal being connected to an electrode 30 of a control spark gap 31. The other electrode 32 of the spark gap 31 is grounded. Also connected to spark gap device 31 is a trigger condenser 33, one terminal thereof being connected to electrode 30 and the other terminal to the primary coil 34 of pulse transformer 35. The other extremity of primary coil 34 is grounded. The secondary coil 36 of pulse transformer 35 also has one extremity thereof connected between ground and primary winding 34 and the other extremity connected to an external electrode 37 of a control spark gap device 38.

A relatively high voltage rectifier circuit connected to the same supply source 10 is also provided and comprises a transformer 40 having one end of its primary winding 41 connected to terminal 21 of inductance coil 22 and the other end grounded. The secondary winding 42 of transformer 40 drives a voltage doubling circuit 43 comprising a diode 44 having one terminal thereof connected to the one extremity 45 of coil winding 42 and polarized in one direction, and another diode 46 having one terminal thereof connected to the same coil winding terminal 45, but polarized oppositely to diode 44. A resistor 47 is connected between the other terminal of diode 44 and ground. A pair of series connected capacitors 49 and 50 are connected between the other terminal 51 of diode 46 and ground, and the midpoint 52 of the series connected capacitors is connected to the other extremity 53 of secondary coil 42 of transformer 40. A condenser 57 is connected across primary coil 41 and a condenser 58 is connected across coil 22 so as to reduce or attenuate radio frequency interference which may be introduced

into the ignition system from other sources and produce faulty ignition or mis-firing.

The voltage doubling circuit may be constructed and may operate in the manner disclosed in Loudon U.S. Patent No. 3,299,339. When the voltage supply is in one phase, only diode 46 conducts, and it will conduct in one direction only and thereby cause capacitor 49 to charge in one direction. Upon phase reversal of the supply voltage, diode 44 alone conducts, causing capacitor 50 to charge, the charge being of the same polarity as that of the charge applied to capacitor 49. Since both capacitors are in series in their discharge circuit, their voltages will add, thus doubling the source voltage.

The capacitor terminal 51 has connected thereto a resistor 59, the opposite end of the resistor being connected to a terminal 55 of a storage capacitor 54, the other terminal of the capacitor 54 being grounded. The ungrounded terminal 55 of capacitor 54 is connected to the other end of transformer coil 28. A high ohmic valued resistive element 56 is connected across and in parallel with capacitor 54 to allow residual leakage therefrom after the cyclical discharge of the said capacitor to be described.

Terminal 55 of capacitor 54 is connected to an electrode 60 of spark gap 38 and has also connected thereto one terminal 61 of a capacitor 62, the other terminal of the capacitor 62 terminating in one of the extremities 63 of primary winding 64 forming part of a pulse transformer 65. The other end 66 of primary winding 64 is connected to the other electrode 67 of the spark gap device 38. The secondary winding 68 of transformer 65 has one extremity thereof also connected to spark gap terminal 67, the other extremity 69 of the said winding being connected to a discharge gap device or igniter plug 70 which contains the usual spark gap 71 which may, but need not necessarily, be shunted by a resistance 72 which may be in the form of a semi-conductive surface across the spark gap. The other side of the discharge gap device 70 is connected to ground. A low ohmic valued resistance element 73 has one terminal thereof connected to gap electrode 67 and the other extremity grounded.

For high level energy excitation the source voltage 10 is switched by switch 11 to the input lead side 12 so as to place full line voltage, which may be on the order of 100 to 120 volts at 400 cycles, across the transformer primary 41 of transformer 40. The voltage appearing across transformer 25 is reduced substantially to zero because the primary coil is effectively shorted out. On the other hand, the full source potential will appear across transformer 40 and the voltage appearing across discharge capacitor 54 will be relatively high.

The charging of condenser 54 to its peak voltage, as determined by the voltage doubling circuit 43, will cause a similar charging of condenser 62 to be effected. The charging of said condenser 62 will permit its voltage to appear across spark gap electrodes 60, 67 of spark gap 38, causing the gap to ionize and conduct. Upon conduction, condenser 62 will discharge through the spark gap 38, thereby permitting the current passing through the coil 64 to induce a large voltage in secondary coil 68. The large voltage across coil 68 will be applied across discharge gap 71, thereby causing the ionization and conduction thereof. When discharge gap 71 conducts, the storage condenser 54 will discharge therethrough to cause the ignition spark necessary for combustion.

The above represents operation of the system for supplying high level energy at relatively high voltage, as for example when starting a combustion engine. For continuous operations as in the low level energy mode, the power source 10 is switched over by switch 11 to input lead 13. The full line power voltage now appears partly across inductor 22 and the primary winding 41 of transformer 40 which is in series therewith. The voltage across coil 22 appears substantially across the primary coil 24 of transformer 25, so that the said transformer will be energized as opposed to substantially no energization in

the previously described high level energy case. Also since transformer 40 now has less voltage applied thereto across its primary, it will be less heavily energized than in the previous high level energy mode. However, the condenser 33 will be charged to a voltage determined by the voltages appearing across secondary coil 28 and the voltage appearing across condenser 54. Since these voltages are series adding, the combined voltages will appear across the said condenser 33. This same relatively high voltage will accordingly also appear across spark gap 31, the said relatively high voltage being sufficient to cause ionization and conduction of the spark gap 31. Upon conduction of the spark gap 31, the condenser 33 will discharge therethrough and the resulting current flow will pass through coil 34 of pulse transformer 35. A high voltage will be induced in the secondary coil 36, this voltage appearing at electrode 37 to cause the ionization of gap 38. The spark gap thereupon will break down and conduct.

The ionization and conduction of spark gap 38, in the foregoing manner, permits the discharge of capacitor 62 and the current flow resulting therefrom to induce the high induced voltage across secondary coil 68 and discharge gap 71 as mentioned previously in connection with the high energy level operation. Discharge capacitor 54, having a relatively reduced voltage because of the lower voltage appearing across transformer 40, will nevertheless discharge through the spark gap 38 and discharge gap 71 after the same are thus rendered conductive. It can be appreciated here that because the voltage appearing across the discharge capacitor 54 is reduced over extended periods of time, i.e., during continuous low level mode operation of the combustion engine, the life of the said capacitor will be considerably extended and the probability of its failure in operation considerably reduced. Hence, reliability and cost considerations are considerably enhanced.

The circuit as shown in FIG. 1 representing an exemplary embodiment of the invention may have the particular component parts thereof rated in the following manner depending upon whether the circuit is operating at low or high energy levels:

(1) Low level operation, capacitor 33 is typically rated at .03 microfarad and 2.5 kv., will be charged to 2.5 kv. and capacitor 54, typically rated at 5.5 microfarads and 2 kv., will be charged to 1.0 kv., the voltage, 2.5 kv. being sufficient to cause conduction of spark gap 31, which is rated for breakdown purposes at 2.5 kv. Pulse transformer 35 will develop a voltage across its secondary 36, when capacitor 33 discharges, that is approximately 8.0 kv., enough when applied to electrode 37 to cause ionization and conduction of spark gap 38. The gap 38 is rated at 2.0 kv., but because of ionization it will break down at a reduced voltage, or 1 kv.; this voltage appearing on capacitor 54 as well as on capacitor 62 which is rated at 0.25 microfarad and 2.5 kv.

(2) High level operation, capacitor 54 is charged to 2.0 kv. and capacitor 62 is also charged to 2.0 kv., said voltage being sufficient to break down gap 38 which is rated for 2.0 kv.

Thus, it is seen that the ignition circuit provides two levels of energy output, one at 2 kv. and one at 1.0 kv., and that the output energy level can be selected by switching the power input selector switch.

Although only one embodiment of the invention has been illustrated in the accompanying drawing and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto but that it may be embodied in other specifically defined circuits. For example, other well known sources of pulsating or alternating current may be provided in lieu of the generator-transformer combination illustrated. Additionally, the various parts of the circuit may be rearranged with respect to each other without appreciably affecting the operation of the circuit.

What is claimed is:

1. In electrical pulse generating apparatus a first condenser, a discharge circuit connected across said condenser comprising a first control gap having spaced main electrodes and a triggering electrode, means for charging said condenser to a voltage below the spark-over voltage of said gap, and triggering means for ionizing said gap to render the same conductive to the charge on said condenser, said last-named means comprising a second condenser, a charging circuit for the latter comprising in series therewith the secondary winding of a power transformer, said first condenser and the primary winding of a triggering transformer, a discharge circuit for said second condenser comprising a second control gap and said primary winding of the triggering transformer, and a triggering circuit comprising the secondary winding of the triggering transformer connected across said triggering electrode and a said main electrode, whereby the charge attained by said second condenser is the sum of the charge on said first condenser plus the charge supplied by said secondary winding of the power transformer.

2. Electrical apparatus as defined in claim 1 wherein the means for charging said condensers comprises an alternating current power supply, the primary winding of said power transformer, a second power transformer having a primary winding and a secondary winding in the charging circuit for said first condenser, an inductance connected in series with said last-named primary winding and means connecting the primary winding of said first-named power transformer across said inductance.

3. Electrical apparatus as defined in claim 2 comprising means for connecting said power supply across the primary winding of the second power transformer, whereby to charge said first condenser to the spark-over voltage of said first control gap without energizing the triggering means therefor.

4. Electrical apparatus as defined in claim 2 comprising means for connecting said inductance in series with the primary winding of said second power transformer across said power supply whereby said condensers are simultaneously charged.

5. Electrical apparatus as defined in claim 1 wherein the circuit parameters are such that said second condenser will be charged to the spark-over voltage of said second control gap before the charge on said first condenser attains the spark-over voltage of said first control gap.

6. Electrical apparatus as defined in claim 1 comprising a diode in said charging circuit for the second condenser.

7. Electrical apparatus as defined in claim 1 comprising rectifier means in the charging circuit for said first condenser.

8. Electrical apparatus for producing low and high level energy outputs to a combustion engine comprising: an energy source, a first spark gap having an electrode thereof grounded, first condenser means connected to the other spark gap electrode, stabilized voltage means driven by said energy source for charging the said first condenser to a first predetermined voltage level at the low level energy output, a second spark gap including an external electrode connected thereto, second condenser means connected across said second gap, voltage amplification means driven by said energy source for charging said second condenser means to a second predetermined voltage level, storage condenser means connected to said second gap and ground for receiving a charging voltage equivalent to said

second predetermined voltage, the said predetermined voltages being additive at the low level energy output across the said first condenser means, first transformer means connected to said first condenser means and second gap external electrode, a discharge gap having an electrode thereof grounded, and second transformer means connected between said second spark gap and discharge gap.

9. Electrical apparatus for delivering separate energy levels to a combustion engine for start and continuous operation comprising a first spark gap device, a second spark gap device, a first condenser connected to said first device, a second condenser connected to said second device, first and second voltage charging means for respectively charging said first and second condensers to preselected voltage levels in accordance with start and continuous operation of the combustion engine, means interposed between said first and second gap devices and responsive to the conduction of said first gap device during continuous operation to produce high voltages at the said second gap device to effect ionization and conduction thereof, and to allow the discharge therethrough of the charge on said second condenser, and means for receiving the discharge current of said second condenser at the preselected levels for producing an ignition spark at the said combustion engine.

10. Electrical apparatus for producing low and high level energy outputs to a combustion engine comprising a first spark gap having an electrode thereof grounded, first condenser means connected to the other spark gap electrode, a second spark gap including a triggering electrode connected thereto, second condenser means connected to said second spark gap, means for selectively charging said first and second condenser means, the charging voltages therefore being additive across the first condenser means to cause conduction of the first spark gap for low level energy output, first transformer means connected to said first condenser means and to the second gap triggering electrode, a discharge gap having an electrode thereof grounded, and second transformer means connected between said second spark gap and discharge gap.

11. Electrical apparatus according to claim 10 wherein said first transformer means includes a primary winding for receiving the discharge current of said first condenser during low level energy output operation to cause a high secondary ionizing voltage to appear at the second gap triggering electrode and thereby cause the conduction thereof.

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JOHN W. HUCKERT, *Primary Examiner*.

R. F. POLISSACK, *Assistant Examiner*.

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