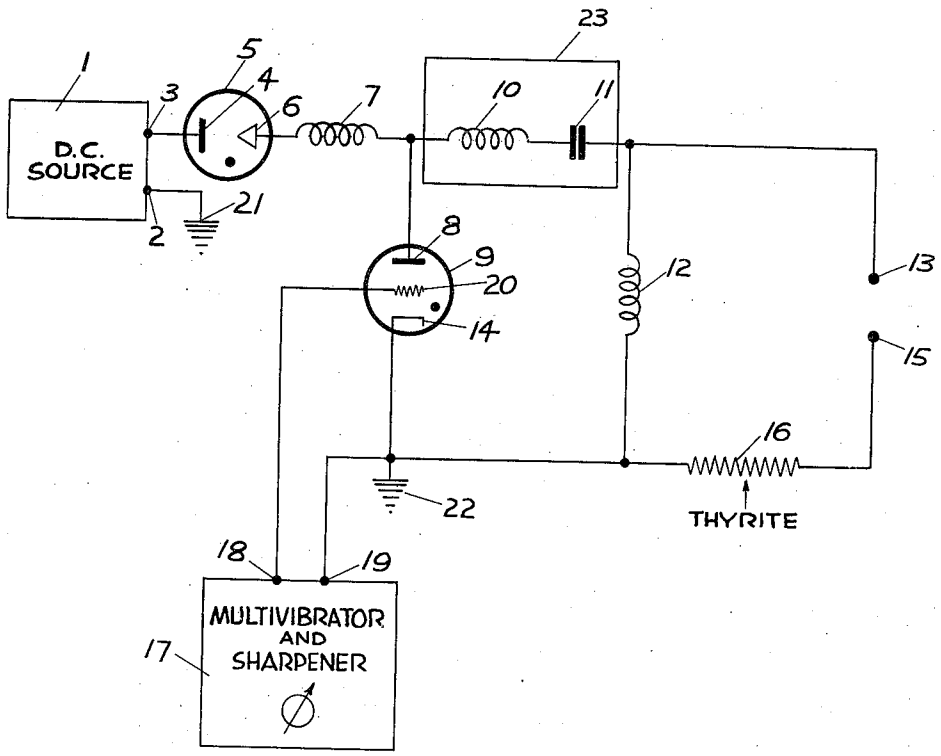
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ELECTRICAL CIRCUITS

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ELECTRICAL CIRCUITS

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This invention relates to electrical circuits, and more particularly to a novel spectroscopic arc source.

An object of this invention is to provide a high-voltage arc source, whereby a high ionization, and therefore a good spectrum, may be obtained.

Another object is to devise an arc source for use in spectroscopy, which utilizes a polarized voltage and current impulse which can be defined and which, therefore, can be reproduced by different experimenters who can, therefore, obtain uniform results from their spectrographic work.

A further object is to devise an adjustable arc source by an adjustment of which materials with low melting points can be exposed to high excitation voltages without danger of melting.

A still further object is to devise a high-voltage arc source which is relatively safe to personnel operating the same.

The foregoing and other objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein the single figure is a diagrammatic representation of one means for carrying out the invention.

Referring to the drawing, a source of direct current 1, which may be a rectifier supplied from an A. C. line, has one of its output terminals 2 connected to ground at 21 and the other terminal 3 connected to the anode 4 of a diode rectifier 5. Cathode 6 of the rectifier or blocking tube 5 is connected through a choke 7 to the anode 8 of a gaseous triode 9, preferably a hydrogen-filled thyratron. Anode 8 is connected, through a pulse-forming line or equivalent wave-shaping network 23 comprising a series-connected inductance 10 and a capacitance or condenser 11, to one end of a charging inductance 12 and also to one of the arc electrodes 13. The other end of the inductance 12 is connected to ground, as is cathode 14 of the thyratron or modulator tube 9, while the other arc electrode 15 is connected through a resistor 16 to ground.

A multivibrator and sharpener circuit 17, which produces unidirectional pulses repetitively at a variable rate and therefore may be termed a variable repetition rate pulser, has its output terminals 18 and 19 connected, respectively, to grid 20 of tube 9 and to ground at 22. The repetition rate of pulser 17 may be varied over a range of the order of zero to 6,000 cycles per second.

The energy necessary to produce an arc between spaced electrodes 13 and 15 is adapted to

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be supplied to said electrodes from the pulse-forming line or wave-shaping network 23, the capacitance 11 thereof providing a means for storing energy. Capacitance 11 functions as an energy-storing capacity and also functions in conjunction with the inductance 10 for generating a substantially rectangular wave. The energy-storing capacitance of the wave-shaping network 23 is adapted to be charged from source 1 through the anode-cathode path 4—6 of blocking tube 5, choke 7, inductance 10, and charging inductance 12.

The discharge of the capacitance of wave-shaping network 23 through the arc path 13—15 is timed by the controlled gaseous discharge device 9, which has its anode 8 connected to the positive side of the capacitance of the wave-shaping network 23 and its cathode 14 connected through the arc path 15—13 to the negative side of said capacitance. The control grid 20 of tube 9 is driven positive relative to the cathode 14 of said tube periodically by the repetitive pulse output of pulser 17, at a periodicity determined by the manually-adjustable setting of the repetition rate of said pulser. The charging inductance 12 has a high value of inductance and therefore does not interfere with the discharging of the capacitance through the arc path 13—15 and through tube 9.

Tube 5 acts as a blocking tube to prevent pulses of current from being sent back to the rectifier source 1 and to hold the voltage on the capacitance 11 constant until discharging of said capacitance occurs as a result of firing of tube 9.

The values of the inductances of choke 7, inductance 10, and inductance 12 are so correlated to the maximum frequency of pulser 17 as to give resonance charging of the condenser 11 in accordance with the expression

$$f < \frac{1}{2\pi\sqrt{LC}}$$

where f is the maximum frequency of pulser 17, L is the combined inductances of chokes 7, 10, and 12, and C is the capacitance of the condenser. By this arrangement the voltage across the condenser when charged is substantially double the voltage of source 1. Blocking tube 5 also functions to prevent an oscillatory discharge of the condenser through the source when said condenser has become charged to substantially double the source voltage. As a result of this voltage doubling effect, pulses of high voltage are applied to arc electrodes 13 and 15.

The resistor 16 is of the type having negative

resistance-current characteristics; that is to say, the resistor 16 is of the type whose resistance falls as the current therethrough increases. Preferably, the resistor 16 is a device of the type the resistance of which varies as a negative non-linear function of the current therethrough, so that as the current increases from zero the resistance decreases very sharply. Devices having resistance-current characteristics suitable for the purpose of this invention are known per se; for example, the device may be of the type known as "Thyrite," formed of a mass of silicon carbide crystals or similar material suitably bound together.

If the characteristics of the circuit are such that

$$R^2 > \frac{4L}{C}$$

then the discharge of the condenser is non-oscillatory. If it be attempted to avoid oscillations by increasing the resistance of the circuit so that the above inequality is achieved, then the energy available for the desired pulse would be greatly decreased, for, since the resistance of the arc during conduction would be low relative to the resistance of the circuit, much of the energy of the impulse would be lost in the resistance of the external circuit. In order to avoid oscillations and still preserve the character of the desired rectangular pulse and maintain this pulse at a high energy level, the resistor 16, having negative resistance-current characteristics, is provided in the discharge circuit of the condenser. During the period of the initial substantially rectangular pulse, the resistance 16 offers but small resistance to the current flow in the arc circuit since the current therethrough is high. Maximum energy is therefore supplied to the arc. When the current through the arc path falls to a low value, as the voltage on the condenser 11 reverses, the resistance of the resistor 16 becomes great, thus matching the resistance of the arc path which offers great resistance as the voltage thereacross drops to a level below which the arc will no longer conduct.

As is well known, an arc in air does not conduct at low voltages, and during the period that the voltage thereacross is rising to such a value that the arc path is conductive, its resistance is high; after the arc path becomes conductive, its resistance is relatively low until the voltage again drops to a value below which it is no longer conductive, at which time the resistance is again high. The resistor 16 matches these conditions, since its resistance is high when the current therethrough is low, and its resistance becomes low when the current therethrough is high. The high resistance of the circuit to the low current thus prevents a sharp reversal of the voltage across the arc path 13—15 so that the reverse voltage does not rise to a high level. The reverse voltage rises gradually and then dies away substantially exponentially since the resistance of the resistor 16 increases substantially exponentially as the current therethrough decreases. Accordingly, the current does not again reverse and there is no further impulse in the direction of the original rectangular impulse, so that oscillations after the main pulses are non-existent. Therefore, resistor 16 serves to damp the pulses. Also, the impulses supplied to the electrodes are substantially unidirectional, because the reverse voltage rises only to a level which is extremely small as compared to the level of the initial or main rectangular pulses.

By utilizing the capacitance of a wave-shaping network as the source of the stored energy for the arc impulses, substantially rectangular pulses may be obtained. Therefore, a series of high voltage unidirectional impulses of substantially rectangular wave shape, having a repetition rate determined by the setting of the variable pulser 17, are applied to the arc electrodes. Each individual pulse is of equal magnitude and is a definite multiple of the applied D. C. voltage.

In a practical embodiment of this invention, with an input to rectifier 1 of one k. v. a. at sixty cycles, pulses having a width of 0.05 microsecond, at 14 kilovolts and 1,000 amperes, were obtained.

Since the pulses are substantially rectangular, are unidirectional, and can be produced at a readily determinable repetition rate, they could be defined as a standard and could be readily reproduced by different equipments for uniform results.

Since the pulses are of high voltage, high ionization of the arc, and therefore also a good spectrum, may be obtained by the use of this invention. Also, since the voltage of the source 1 is not dangerously high and since the high-voltage output of the circuit is not steady but is only in the form of pulses, the arc source of this invention is relatively safe to personnel operating the same.

By reducing the repetition rate of the pulses, giving a proportionately longer cooling time between successive pulses, materials with low melting points can be exposed to high excitation voltages without danger of melting.

In the use of this invention as a spectroscopic arc source, the material to be spectroscopically analyzed is utilized as the negative arc electrode 15. Since substantially unidirectional high-voltage pulses are applied to the arc electrodes, this negative electrode emits from its surface a large number of particles of vapor, while the positive electrode 13 emits few particles, so that the vapor between the electrodes is composed mainly of particles of the material whose spectrum is desired. Both electrodes remain relatively cool during operation, so that they contribute little background to the spectrum, most of the spectrum being obtained from the highly-excited analytical vapor between the electrodes.

Of course, it is to be understood that this invention is not limited to the particular details as described above, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention within the art.

What is claimed is:

1. A spectroscopic arc source, comprising a pair of spaced electrodes one of which is comprised of a material whose spectrum is desired, a source of current, a pulse-forming network including an inductance and a capacitance between said source and said electrodes for storing electrical energy from said source, circuit means for repetitively discharging said stored energy through said electrodes, said inductance and capacitance being arranged to deliver said stored energy in the form of a series of substantially rectangular impulses.

2. A spectroscopic arc source, comprising a pair of spaced electrodes one of which is comprised of a material whose spectrum is desired, a source of current, a pulse-forming network including

an inductance and a capacitance between said source and said electrodes for storing electrical energy, means for charging the storage capacity of said network from said source through a circuit in shunt with said electrodes, an intermittently-operable discharge circuit for discharging said stored energy through said electrodes, said inductance and capacitance being arranged to deliver said stored energy in the form of substantially rectangular impulses, said discharge circuit through said electrodes including a series resistor having a negative resistance-current characteristic, said resistor having a zero current value at least equal to that required for critical damping of said discharge circuit.

3. A spectroscopic arc source, comprising a pair of spaced electrodes one of which is comprised of a material whose spectrum is desired, a source of current, a pulse-forming network including an inductance and a capacitance between said source and said electrodes for storing electrical energy from said source, an intermittently-operable discharge circuit for discharging said stored energy thorugh said electrodes, said inductance and capacitance being arranged to deliver said

stored energy in the form of substantially rectangular impulses, whereby the duration of discharge of said energy through said electrodes is maintained at a constant value.

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