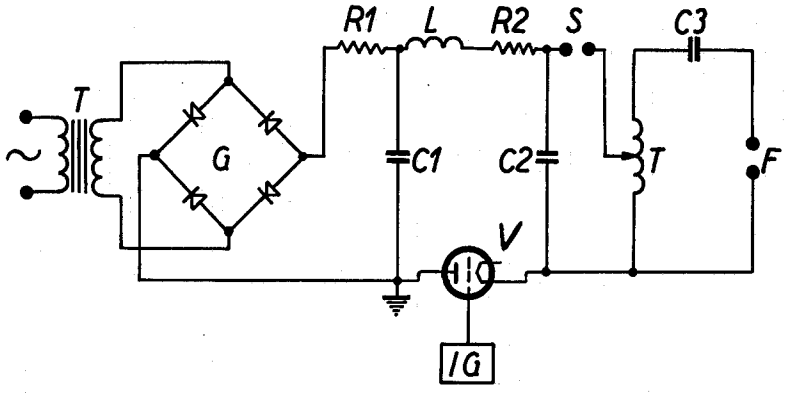
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ELECTRONICALLY CONTROLLED SPECTROSCOPIC HIGH VOLTAGE SPARK SOURCE

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ELECTRONICALLY CONTROLLED SPECTROSCOPIC HIGH VOLTAGE SPARK SOURCE

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This is a continuation-in-part of my copending application, Serial No. 688,694, filed Oct. 7, 1957, now abandoned.

In spectroscopic research work and spectrochemical analysis the self-ignited high voltage spark is frequently employed as light source. By self-ignited spark there is understood an electric discharge of a condenser charged to a relatively high voltage capable of breaking down a gap between two electrodes spaced several millimeters apart.

The production of sparks is carried out, in the case of spectroscopic light sources, in such a manner that condensers (working condensers) are charged from the A.C. mains and the then discharged through the analytical spark gap (eventually also through a controlling spark gap or spark gaps or electron tube connected in series with the analytical spark gap). To obtain correct operation of the spark source, the charging and discharging processes of the working condenser should be separated from one another. This is necessary because if, during the spark discharge and immediately after it, the supply voltage remains on the analytical and controlling spark gaps, in case of higher excitation energies and greater spark frequencies the deionization of the spark gaps is incomplete, consequently the network will be short circuited through them and a regular controlling of the spark discharges cannot be maintained. In other words, the spark source has to be formed in such a manner that, during charging of the condenser, no spark discharge shall take place, while during the discharge the condenser shall be completely separated from the charging network.

Recently, a further requirement consists in that in spark sources the starting of spark discharges shall take place with a small time scattering (jitter) of the order to magnitude of a microsecond relative to the moment of a given control signal, so that spark sources may be applied for the production of time resolved spark spectra. This can be realized by means of electronically controlled spark sources operating with high precision in time. In connection with the problem the following should yet be noted.

In order to perform spectroscopic analysis or investigations, and primarily spectrochemical analysis, a single spark discharge is not sufficient to produce a satisfactory spectrum on a photographic plate. To produce a satisfactory spectrum, many hundreds or even many thousands of successive discharges are necessary. These successive discharges must be resolved in time. That is, the particular time, during each discharge, in which a is, the particular time, during each discharge, in which a given spectrum occurs must be the same for each successive discharge. Thus, if it is desired to use that portion of the discharge occurring between 0.0 and 0.1 microsecond of a given spark discharge, the successive discharges must also be analyzed within the 0.0 to 0.1 microsecond range of the discharge. Thereby, the successive discharges being analyzed will always be coincident in time with respect to the portion of the period of a single dicharge during which they occur.

The procedure by which corresponding time periods of successive discharges appear at the same position on the photographic plate is known as time resolution. One manner in which this time resolution may be effected is by using a rotating mirror to direct the image of the arc or spark discharge to the admission slit of the spectrograph. With such an arrangement, each respective position along the slit will be illuminated with light originating from the same respective time periods during the radiation of each successive discharge. Correspondingly, every particular position on the spectrum line of a spectrum plate will be indicative of detection of the radiation arising from the same particular period during the discharge of each successive spark or arc. It is thus imperative that a high time resolution must be effected so that corresponding time portions of successive discharges will always appear at the same position on the spectrum line as photographed on a spectrum plate. In other words, to obtain a high time resolution, the superposition of the spectrum from successive discharges must be effected with a very high precision timewise. If this is done, corresponding increments of successive sparks or arc discharges will appear exactly on the same place on the slit of the spectrograph, and every successive corresponding spectrum will appear exactly on the same place on the photographic plate. It will therefore be apparent that a high time resolution is necessary when using a multitude of successive spark or arc discharges to produce a photographic spectrum on the photographic plate of a spectrometer.

The above mentioned requirement, manely that the charging and discharging processes be separated from one another, can be relatively easily met if a number of sparks per second equal to the frequency of the network has to be produced. In this case, by inserting a rectifier before the working condenser, the charging of the condenser takes place during one of the half cycles of the A.C. network whereas the discharge takes place during the other half cycle when the charged condenser is completely isolated from the mains by the rectifier. Hitherto the separation of charging and discharging processes was solved in this manner in the case of some spark sources.

In practical and scientific spectroscopic practice, however, in general a higher sparking frequency than the frequency of the network is desirable. A higher spark frequency results in shorter exposition times and in a higher analytical precision. Moreover, it is experimentally proved that the higher the sparking frequency, the higher is the stability of the discharge, and consequently, the smaller is the time scattering at the production of time resolved spectra. It should be noted further that the time-resolved spectroscopy for routine operation may only be, in general, possible using a spark frequency higher than the mains frequency. In the majority of cases, it is already sufficient if the frequency of the spark discharges is twice the frequency of the A.C. mains.

The subject of the invention is a self-ignited spark source operating with high precision in time, also suitable for the production of time-resolved spectra, with the aid of which the realization of a sparking repetition rate per second higher than the mains frequency is feasible in such a manner that the charging and discharging processes of the condenser supplying the excitation energy are completely separated from one another. The charging and discharging processes of the working condenser are separated from each other in such a manner that said condenser is charged with voltage pulses of a duration which is very short as compared with the duration of the half period of the mains supply voltage. Between the voltage pulses there is a voltage free interval. The voltage pulses of short duration are produced in an oscillatory circuit.

The appended drawing diagrammatically illustrates an embodiment of, and best way for, carrying out the invention, which however, is not limited to such embodiment. In the drawing the figure illustrates the circuit diagram of an electronically controlled high precision spectrographic light source.

F is the analytical spark gap and C2 is the working condenser supplying the excitation energy. C2 discharges through auxiliary control gap S and air-cored transformer T. The excitation energy is induced in the circuit T–C3–F. The role of condenser C3 will be explained later. C1 is a storage condenser, V is a controllable electron tube which is controlled by the pulse generator IG by control voltage signals of very short duration. The frequency of the control voltage signals delivered by pulse generator IG is variable. The working condenser C2 receives its charge from the storage condenser C1 through self-induction L, ohmic resistance R2, and tube V. Condenser C1 is charged through high voltage transformer T, rectifier G, and if, when condenser C1 is charged, a positive voltage signal is applied to the grid of tube V, which is ordinarily blocked by a negative bias, through the medium of a pulse generator G1, tube V will become conductive and charging of condenser C2 will commence. The task of the ohmic resistance R2 and of self-induction L is to diminish the current in the C1–L–R2–C2–V circuit to the permissible loading of tube V. Condenser C2 is charged to a voltage which corresponds to the break-down voltage of controlling spark gap S. As soon as the charging voltage of C2 has reached the breakdown voltage of S, the latter breaks down and C2 discharges through the path S–T.

Care must be taken that after the breakdown of S the supply voltage should be disconnected from this gap. This takes place in the following way: Owing to the design of the system, during the breakdown of S, condenser C1 has still a considerable charge, which begins to discharge in the form of an oscillation through the path L–R2–S–T–V. Besides the current limiting role of L, its secondary role is further to ensure the development of oscillations in this circuit. However, this discharge will have a duration of a quarter cycle of the frequency determined by the data of the above mentioned circuit, since as soon as the direction of the current flow changes gas filled tube V extinguishes and the charging network is isolated from the controlling spark gap S. The insertion of T and C3 is necessary to divert the discharging current of condenser C1 from the analytical spark gap F.

It is mentioned here that the natural frequency of the circuit C1–L–R2–S–T–V is so low, as compared with the natural frequency of circuit C2–S–T, that by the former induces practically no energy in the circuit T–C3–F.

In case of a single phase full wave rectification the number of sparks produced per second is twice the frequency of the mains, in case of a three phase half wave rectification it is threefold the frequency of the network, in case of a three phase full wave rectification it is sixfold the frequency of the network. If a large storage condenser is placed between R1 and the rectifier an unlimited number of sparks per second might be attained.

It is understood from what has been set forth above that this invention is not limited to the arrangements, devices, operations, conditions, and other details specifically described above and illustrated, and can be carried out with various modifications without departing from the scope of the invention as defined in the appended claims.

What I claim is:

1. A high voltage spectroscopic spark and arc source comprising, in combination, a device having an input for connection to a source of low frequency A.C. potential and producing relatively sharp output voltage pulses responsive to each half cycle of input potential and having a duration which is short in comparison with the duration of the half cycle of said potential source; rectifying means connected to the output of said device and adapted to produce rectified pulses corresponding to said output pulses; a charging circuit connected to the output of said rectifying means and including a high voltage energy storing means; a discharge circuit including a discharge condenser across said charging circuit; said discharge circuit further including a controllable electron tube which is normally current blocking and which is triggerable into conductivity and which then remains conductive when the current therethrough is above a specified value; means for triggering said controllable electron tube operable at the conclusion of the charging pulse on said energy storage means to trigger said controllable electron tube for current flow therethrough; and a further circuit across said discharge condenser, said further circuit including a controlling spark gap, an analytical spark gap, and circuit means whereby the discharge of said discharge condenser is effective first to break down said controlling spark gap and then to break down said analytical spark gap, said circuit means isolating said analytical spark gap from said charging circuit.

2. A high voltage spectroscopic spark and arc source comprising, in combination, a device having an input for connection to a source of low frequency A.C. potential and producing relatively sharp output voltage pulses responsive to each half cycle of input potential and having a duration which is short in comparison with the duration of the half cycle of said potential source; rectifying means connected to the output of said device and adapted to produce rectified pulses corresponding to said output pulses; a charging circuit connected to the output of said rectifying means and including a high voltage energy storing means; a discharge circuit including a discharge condenser across said charging circuit; said discharge circuit further including a controllable electron tube which is normally current blocking and which is triggerable into conductivity and which then remains conductive when the current therethrough is above a specified value; means for triggering said controllable electron tube operable at the conclusion of the charging pulse on said energy storage means to trigger said controllable electron tube for current flow therethrough; and a further circuit across said discharge condenser, said further circuit including a controlling spark gap and an air-cored self-inductance across said discharge condenser, an analytical spark gap and a further condenser being connected across said inductance, the discharge of said discharge condenser effective first to break down said controlling spark gap and then to break down said analytical spark gap, said further condenser and inductance isolating said analytical spark gap from said charging circuit.

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