March 18, 1947. M. F. HASLER ET AL 2,417,489

SPECTROSCOPIC SOURCE UNIT

Filed July 14, 1943 2 Sheets-Sheet 1

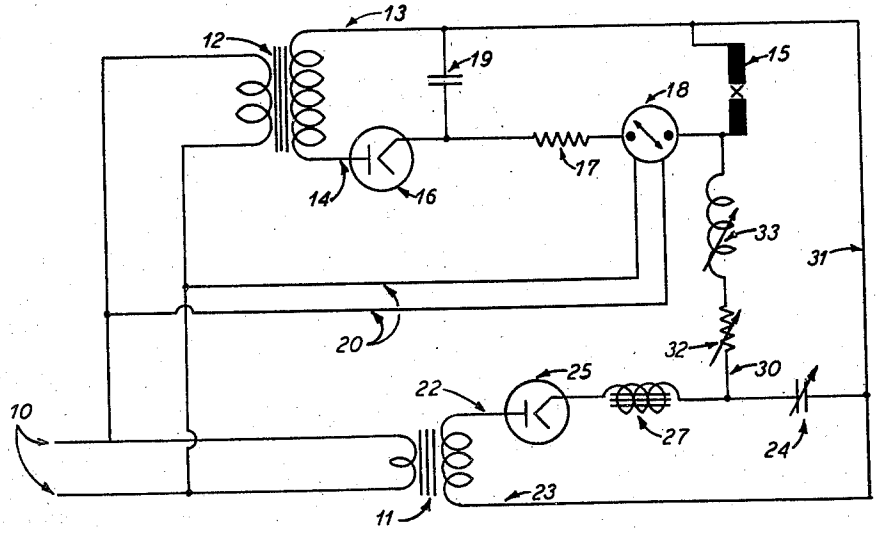


Fig. 1

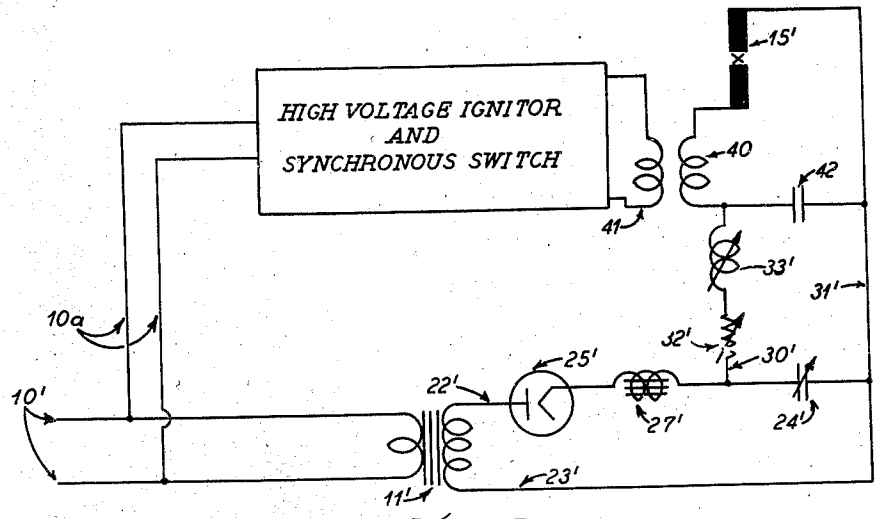


Fig. 2

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SPECTROSCOPIC SOURCE UNIT

Filed July 14, 1943 2 Sheets-Sheet 2

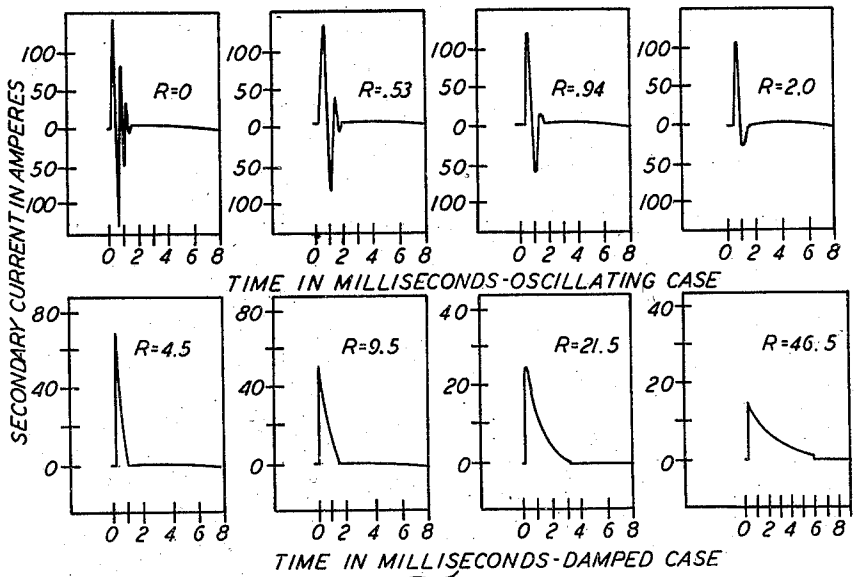


Fig. 3

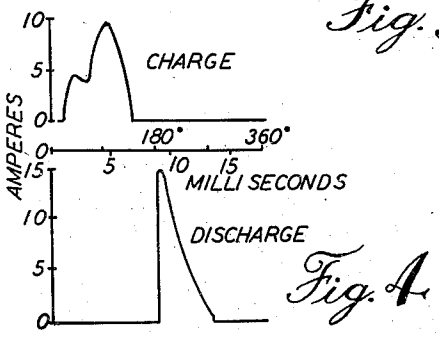
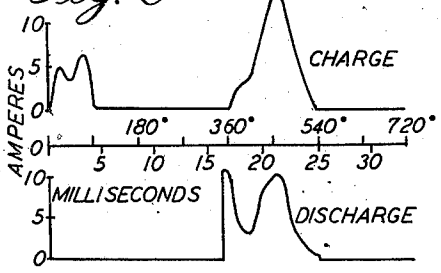


Fig. 4

Fig. 6



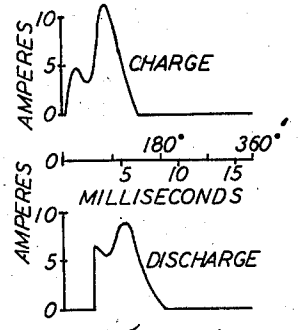


Fig. 5

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SPECTROSCOPIC SOURCE UNIT

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Application July 14, 1943, Serial No. 494,754

19 Claims. (Cl. 315—172)

1

This invention relates generally to the art of spectrochemical analysis, and more particularly to spectroscopic source units. In spectrochemical analysis, an electric discharge between terminals at least one of which consists of the sample to be analyzed vaporizes a small portion of the sample and the resulting light exhibits the spectrum of the various elements comprising the sample. The electric discharge has in some instances been in the nature of an arc, either A. C. or D. C., giving the characteristic arc spectrum, and in others has been in the nature of a spark, giving a somewhat different spectrum in which certain "spark-lines" are enhanced.

Before proceeding further, definitions of arcs and sparks appropriate to the subject in hand should be attempted. An arc may for spectrochemical analysis purposes be defined as that part of a discharge which starts about one millisecond after an electrode gap has been broken down and continues for the duration of the discharge, provided the current is of the order of magnitude of amperes. The time, one millisecond, was chosen because it takes about that length of time for a discharge to achieve thermal equilibrium. Before that time the discharge is in a transition stage that starts with a spark and gradually converts into an arc. This is equally the case whether the discharge originates by applying a sparking potential between the electrodes, as in the spark, or by electrode contact, as usually employed in the D. C. arc. The current of the order of amperes assures that arcs suitable for spectrochemical analysis are being considered, arcs that allow the detection and measurement of elements at extremely small concentrations.

Definition of a spark is somewhat controversial and accordingly more difficult. However, a spark may for present purposes be regarded generally as the initial breakdown of short duration of a gap under high voltage. It may be oscillatory or heavily damped. As noted above, an arc may be initiated by a spark, the first part of the discharge consisting of a spark which then converts into an arc.

An "arc-type" discharge results in relatively low electron velocities in the gap, such that electron bombarded atoms of the vaporized elements under test have their electronic configurations modified, but do not lose electrons. The resulting spectrum is of a characteristic type, and the discharge producing such a type is referred to as "arc-like" in character. A "spark-type" discharge produces high electron velocities, such as

2

are capable of stripping one or more electrons off the atom and exciting the remaining atom to a high energy state by imparting energy to the remaining electronic structure. The resulting spectrum has other characteristic lines, and a discharge productive of such a spectrum is referred to as being "spark-like," irrespective of exact definition of the term used.

Between discharges obtained from known so-called spark units and those obtained from true arc sources is a relatively wide range of relatively unexplored territory, and it is a general object of the present invention to provide a source unit capable of exploring this territory.

Certain difficulties stand in the way of adjustment or conversion of presently known so-called spark units to produce discharges more arc-like in character. To illustrate, we may consider the conventional high voltage alternating current spark unit in some detail. Such a unit usually consists of a high voltage transformer, providing from 10 to 40 kilovolts in the secondary, a condenser that is charged once every half-cycle by that voltage, and a discharge circuit connected across the condenser and consisting of inductance, resistance and one or more spark gaps in series. Such a circuit is self-igniting in that the power stored in the condenser is at a sufficiently high voltage to break down the gap or gaps at a certain time in the charging cycle. Once the gap is broken down, the discharge proceeds independently of the charging circuit, and is dependent entirely upon the values of C, L and R, capacitance, inductance, and resistance, and upon the voltage E to which the condenser was charged at the time of the breakdown. The current passing through the gap is, neglecting gap resistance,

$$i = -(EC^{\frac{1}{2}}L^{-\frac{1}{2}})(e^{-Rt/2L})(\sin tL^{-\frac{1}{2}}C^{-\frac{1}{2}})$$

where i is the current and t is the time after gap breakdown. The first term gives approximately the peak current for low damping; the second term, the damping; while the third term represents the oscillations.

Assuming large E, C and R, say 40,000 volts 0.02 microfarad, and 15 ohms, small L, a few microhenries, and a synchronous gap in series with the analytical gap, a discharge will be obtained with a peak amperage of about 750 amperes, a duration of about 1.7 microseconds, giving three half-cycles of about 0.6 microsecond per half-cycle. Such a discharge we speak of as being very spark-like, irrespective of exact definition of the term used. The spectrum obtained shows a consider-

able enhancement of spark lines over arc lines for all elements detected as compared to that obtained from an arc for the same sample.

The spark characteristics of this discharge are due, first, to the high current densities available which allow multiple electron-atom collisions and thus excitation of atoms to very high energy states, and second, to the small concentration of electrode atoms of low excitation potential that prevail in the gap, because of the very short duration of the discharge. This small concentration of electrode atoms does not limit the electron velocities by inelastic collisions with these atoms to the extent that large concentrations would, and thus everything favors the production of very spark-like spectra.

If this be considered as one of the most spark-like cases obtainable with conventional apparatus, it is interesting to speculate upon which modifications might be introduced to make the discharge more arc-like.

In the theory of oscillating circuits, the formula given holds only for $R^2/4L^2<1/LC$. If

$$R^2/4L^2=1/LC$$

the circuit is critically damped and no oscillation occurs, while if $R^2/4L^2>1/LC$ the circuit is over-damped and just as in the critically damped case, only a single pulse of current results. Thus, two directions of change are possible in the apparatus discussed previously that will markedly change the current vs. time characteristics. The first is the usual one employed where R/2L is made a great deal smaller by changing R and L in the circuit. R can be reduced to little more than the gap resistance, which is of the order of magnitude of an ohm, while L can be easily increased to 1000 microhenries. This changes the damping term enormously, thus lengthening the total time of discharge; likewise the maximum current—to 180 amperes, and the time per half-cycle—to 14 microseconds. If it were possible to charge the condenser to peak voltage and then let it discharge without interruption, a total time of discharge approaching a millisecond would be obtained for these circuit constants. Unfortunately the synchronous spark gap which must be used to allow the condensers to be charged to peak voltage, also limits the time of discharge due to its strong quenching action. Thus, though much more arc-like conditions can be obtained with a spark source unit under these conditions than under those considered previously, arc conditions satisfying our definition are not obtained.

The other direction of change is to make $R^2/4L^2$ large compared to 1/LC. Since we have considered about as small an L as possible in our first case, this can only be accomplished by increasing R. Increasing R to 20 ohms will provide a critically damped unidirectional spark. By increasing the resistance further, the maximum current would be dropped and the time of spark duration increased. The maximum time of discharge possible turns out to be about 100 microseconds, utilizing a resistance of ten thousand ohms. This gives a maximum current of a few amperes, which, over the short time available, provides only a small amount of luminous energy in the gap. This modification of the spark thus does not allow the production of true arc-like spectra, though it represents a trend in that direction.

Thus, one is forced to the conclusion that the conventional constants of the high voltage spark unit with synchronous gap are not such as to allow the production of true arc-like spectra. In fact, they are such that they do not allow much study of even the transitionary stages between spark breakdown of a gap and true arc conditions.

The alternative is the modification or conversion of arc-type source units to produce spectra more spark-like in character. The usual A. C. arc employed in spectroscopic analysis has a duration of from four to six milliseconds, and hence comes under the category of an arc by our definition. One approach of the present invention is to attempt the shortening of the duration of the A. C. arc until it is of the order of a millisecond or less.

Particular objects of the invention are the following:

To provide a source unit circuit capable of producing discharges both oscillatory and unidirectional and capable of being varied from time durations of much less than a millisecond (spark-like) to durations of several milliseconds (arc-like), to give a variety of excitation conditions ranging from spark to arc;

To provide a source unit circuit that charges a condenser to a definite predetermined voltage prior to each gap breakdown, so as to assure reproducibility of the quantity of electricity available for each discharge; and

To provide a source unit circuit in which only the analytical gap is in the discharge circuit, so that termination of the discharge will be dependent only on the discharge circuit and gap constants.

With this preliminary discussion in mind, the invention will now be best understood by referring to the following detailed description of an illustrative embodiment thereof, reference being had to the accompanying drawings, in which:

Fig. 1 is a schematic wiring diagram of a source unit in accordance with the invention;

Fig. 2 is a schematic wiring diagram of a modified source unit in accordance with the invention;

Fig. 3 is a chart showing oscillograms of discharges obtained with the circuits of Figs. 1 or 2 as resistance in the discharge circuit is varied;

Fig. 4 shows oscillograms of the charge and discharge currents in the power circuit when the discharge is initiated during the alternate half-cycles from the charge;

Fig. 5 shows oscillograms of the charge and discharge currents when the discharge is initiated during the charging period; and

Fig. 6 shows oscillograms of charge and discharge current with the discharge initiated after the condensers are charged but before the next charging cycle so that the discharge may utilize that charging power.

In Fig. 1, showing one simple specific exemplification of the invention, the input circuit, adapted to be furnished with electric power from commercial alternating current power mains (low frequency, e. g., 50 or 60 cycles), is designated at 10, and feeds electrical energy to the parallel connected primary windings of power and high voltage transformers 11 and 12, respectively.

The secondary winding of transformer 12 feeds a high voltage igniter comprising the circuit 13, 14 connected across the electrodes forming the analytical gap 15. In the specific form of Fig. 1 the circuit lead 14 includes rectifier 16, resistor 17 and a synchronous gap or switch 18, while a capacitor 19 is connected between lead 13 and lead 14 at a point between the rectifier and the resistor. The synchronous gap or switch 18 may be of any conventional nature, and have any

conventional arrangements whereby it will be closed in synchronous relation with the commercial frequency power current from the mains 10. It is here conventionally indicated as controlled or driven through circuit leads 20 fed from mains 10.

The secondary winding of transformer 11 feeds the power circuit 22, 23 across which is connected a variable condenser bank 24. A rectifier for the circuit 22, 23 is shown as placed in the lead 22, as at 25, and lead 22 is also shown as including an iron core inductance 27 serving as a surge suppressor.

A discharge circuit 30, 31, forming a part or continuation of power circuit 22, 23, and including a variable power resistor 32 and variable inductor 33, connects the condenser bank 24 across the analytical gap 15.

The above described circuit is merely one example of various possibilities within the scope of the invention; in particular, the ignitor is subject to wide modification, the only general requirement being that a high voltage ignitor be connected to the analytical gap, and have incorporated therein a synchronous switch arranged to be closed in synchronous relation with the power current. The ignitor circuit may be of various types, and the synchronous switch may also be of any desired nature, such as a rotary synchronous gap, a synchronous electronic switch triggered from the power circuit, etc., all as will be entirely evident to those skilled in the art. In fact, an auxiliary gap ignitor of any type whatsoever may be used, so long as its operation is synchronized with the charging of the power condenser. However, we may set forth typical constants of one illustrative circuit (that of Fig. 1) which has been found to give satisfactory results. The secondary voltage of ignitor transformer 12 may have a peak voltage of 15,000 volts, and the secondary of power transformer 11, a peak voltage of the order of 1,000 volts. Capacitor 19 may have a capacitance of .0025 mf. and resistor 19 may have a resistance of the order of 12 ohms. Variable capacitor 24 has a capacitance range of 1 to 60 mf. in steps of one mf. Variable resistance 32 has a resistance range of 1 to 400 ohms in steps of 1 ohm, and variable inductance 33 has a range of 25 to 400 microhenries.

Operation of the circuit of Fig. 1 is as follows:

A half-wave rectified current flows from the secondary of transformer 12 to charge the condenser 19 to a predetermined peak voltage. This condenser being charged, and the synchronous gap 18 then closing, the condenser then discharges across the gap 15 through the resistor 17. It is to be understood that the synchronous gap 18 is closed once each cycle, and the time of closure is adjusted to occur after the completion of the charging of the condenser 19. The synchronous gap is of course open by the time the next charging begins.

During the charging of the condenser 19 through rectifier 16 from transformer 12, the power condenser 24 is being charged to a predetermined peak voltage through the rectifier 25 from the power transformer 11. The presence of the rectifier 25 prevents the condenser from discharging through the circuit 22, 23, and the analytical gap 15 is too wide for a discharge to take place thereacross under the voltage to which condenser 24 has been charged. Discharge of condenser 24 across gap 15 is accordingly deferred until the gap is fired by discharge from condenser 19, which occurs upon closure of synchronous gap 18 during the half-cycle succeeding the charging half-cycle. Upon such closure of synchronous gap 18, condenser 19 discharges across analytical gap 15, and said gap being broken down, power condenser 24 then discharges thereacross, and the gap being ionized, such discharge continues to termination, despite relatively short duration of the igniting discharge from condenser 19.

Fig. 4 shows, above, an oscillogram of the charging current of the condenser 24, and below, an oscillogram of the discharge current from said condenser. Attention is directed to the fact that the charging current drops to zero before the start of the discharging current, indicating clearly their complete independence. As heretofore mentioned, the point of initiation of the discharge is adjustable with the synchronous gap in the ignitor circuit, and although this point can be adjusted with great precision, it is of small significance so long as the discharge starts after the charging has ceased, and ends before the next charging begins. This is in contradistinction to the usual synchronous gap adjustment wherein such adjustment determines the exact voltage to which the condensers are charged.

Thus, breakdown of the gap is performed with the low powered ignitor circuit, and the main discharge then proceeds independently of the constants of the ignitor circuit. This provides the great advantage of allowing relatively long discharges, the duration of which depend only upon the power circuit and gap constants. An incidental practical advantage of the arrangement is that the synchronous gap only carries the low power of the ignitor circuit, and hence its sparking electrodes have a very long life.

By utilizing the indicated relatively low voltages in the power circuit, it is feasible to employ very high values of capacitance. This allows overdamped discharges to be employed which possess long time constants and which pass large amounts of energy through the analytical gap. Thus, this type of discharge, which was impractical in the case of standard spark units due to the capacitance available, becomes a practical mode of operation.

It should be mentioned that in practice it has been found important for reproducibility of results that the capacitor 19 in the ignitor circuit of Fig. 1 be charged to an accurately predetermined voltage.

In Fig. 2 we have shown a modified coupling of the ignitor to the analytical gap. In this instance we have shown the ignitor and synchronous switch merely in block diagram, since the ignitor portion of the circuit as well as the synchronous switch are particularly subject to variation, and many substitute arrangements will occur to those skilled in the art. The power portion of the circuit is essentially the same as in Fig. 1, and corresponding circuit elements are accordingly designated by like reference numerals, but with the numerals primed in the case of Fig. 2. The two circuit leads 10*a* from the input circuit 10' to the ignitor and synchronous switch indicate conventionally the synchronizing connection by which the synchronizing switch is closed in proper cyclical relation with the input current in the circuit 10'. The discharge circuit 30', 31' which connects the power condenser 24' across the analytical gap 15' contains variable resistor 32' and variable inductor 33', and

it also includes, between the inductor 33' and the gap 15', the secondary winding 40 of a transformer whose primary 41 is fed by the output of the synchronously switched ignitor. The inductance of the winding 40 is made small relatively to that of inductor 33'. A high frequency by-pass condenser 42, of a capacity of the order of .01 mf., is connected from a point between inductor 33' and winding 40 to the circuit lead 31' on the other side of the gap.

The operation of the circuit of Fig. 2 is essentially the same as that of Fig. 1, with the exception of the manner in which the igniting discharge is conveyed from the ignitor to the gap. In the case of Fig. 2, the oscillating discharge current in the output circuit of the ignitor, initiated by closure of the normally open synchronous switch, sets up an oscillatory discharge current in the oscillating circuit made up of winding 40, condenser 42, and the gap. The gap being thus broken down, discharge of power condenser 24' thereacross proceeds as before. The circuit of Fig. 2 has the unique advantage, however, that no leakage occurring between the two sides 30' and 31' of the discharge circuit will adversely affect the igniting discharge voltage applied across the gap. As a matter of fact, any such leakage actually means greater conductance, and hence enhanced applied voltage across the gap.

The circuit as thus described meets the objectives preliminarily outlined. The usual limitations in time constants associated with the conventional spark source are entirely eliminated. Fig. 3, above, shows oscillograms of oscillatory discharges of increasing damping and decreasing duration as the series resistance of the discharge circuit is gradually increased. Fig. 3, below, shows critically dampened discharges beginning with a duration of the order of a millisecond and gradually increasing as the series resistance of the discharge circuit is further increased. Arc-type spectra are obtained with the discharge represented by the upper oscillogram to the left and the spectra become increasingly spark-like as series discharge circuit resistance is increased, becoming very spark-like for the conditions represented by the last oscillogram above and the first oscillogram below. The spectra gradually become more arc-like in character as the discharge circuit resistance is then further increased until the last oscillogram below is reached. The first and last oscillograms thus represent arc-type discharge conditions, giving arc-like spectra; however, while these conditions resemble one another insofar as the duration of discharge and the spectra produced are concerned, the oscillatory condition of the one case and the critically dampened character of the other develop some useful differences in the spectra. The two middle conditions represented comprise a heavily damped spark-like oscillatory discharge, and a critically damped spark-like unidirectional discharge.

The series of oscillographs of Fig. 3 were obtained simply by increasing the series resistance of the discharge circuit. A series of representative results can also be obtained by beginning with a highly damped spark of short duration, and gradually increasing the inductance and decreasing the resistance of the discharge circuit to obtain longer and longer oscillating discharge periods, and more and more arc-like spectra. Another series of results can be obtained by starting with the critically damped case, and increasing the resistance to obtain longer and longer unidirectional discharge periods. These two last-mentioned studies are, however, in effect telescoped into one another by the series of tests represented in Fig. 3, in which merely the resistance parameter is varied. The variable resistance and variable inductance can be regarded as a variable resistor and inductor combination, in which either the resistor, or the inductor, or both, may be made variable to vary the type of discharge.

The phase of the ignitor circuit may be changed 180°, so that it causes a discharge to be initiated during the charging cycle of the power circuit, giving the results represented in Fig. 5. In this case, the discharge gap is broken down during the charging of the power condenser 24, whereupon said condenser discharges across the gap, and current from the power transformer 11 also discharges across the gap, continuing until the half-cycle is ended. The duration of the discharge may thus be controlled by varying the time of initiation, and the discharge is in the nature of an interrupted D. C. arc.

Fig. 6 shows another alternative mode of operation of the unit, involving a combination of the overdamped discharge and the discharge represented in Fig. 5. The power condenser 24 is charged during the first half-cycle. During the next half-cycle preferably immediately preceding the next following half-cycle, the synchronous gap closes and the ignitor circuit breaks down the analytical gap, so that the charged power condenser discharges thereacross. This discharge continues into the next charge period which adds a power discharge derived from the power transformer. The discharge is thus in the nature of a condenser discharge followed by a rectified power discharge. The discharge occurs only on alternate cycles, since the power condenser is empty on the other alternate cycles and is hence (assuming 60 cycle power) of a 30 cycle frequency, and is of very long duration, up to sixteen milliseconds.

The system thus provides for the obtainment of a wide variation in spectra, and permits exploration through the entire region from oscillatory arc conditions through oscillatory and critically dampened spark conditions to critically damped arc conditions.

For a discussion of the appearance of the spectra of discharges that are intermediate the arc and the spark, as obtained with the new source unit of the present invention, see "A new spectroscopic source unit," by M. F. Hasler and H. W. Dietert, Journal of the Optical Society of America, April, 1943, vol. 33, No. 4, pp. 218–228.

We claim:

1. In a spectroscopic source unit, the combination of: an analytical gap consisting of two spaced electrodes, a power circuit connected across said two gap electrodes, a power condenser in said power circuit adapted and arranged to be charged by current supplied to said power circuit and to discharge across said gap upon ignition of the latter, a low frequency source of unidirectional condenser-charging current impulses for said power circuit, a high voltage ignitor circuit conductively connected across said two gap electrodes and adapted to initiate discharge thereacross, and a synchronous switch adapted to periodically close said ignitor circuit in a synchronous relation with the low frequency current impulses supplied by said source.

2. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit ararnged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said power condenser to be charged unidirectionally and only on alternate half-cycles, an ignitor embodying a discharge circuit adapted and arranged to periodically supply a breakdown voltage to said gap, and a synchronous switch controlling the discharge of said ignitor in a synchronous relationship with the low frequency current supplied by said alternating current power source.

3. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser in said power circuit arranged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a resistor and an inductor in series circuit between said power condenser and said analytical gap, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said power condenser to be charged unidirectionally and only on alternate half-cycles, an ignitor embodying a discharge circuit, adapted and arranged to periodically supply a breakdown voltage to said gap, and a synchronous switch controlling the discharge of said ignitor in a synchronous relationship with the low frequency current supplied by said alternating power source.

4. In a spectroscopic source unit, the combination of: two spaced electrodes forming an analytical gap, a high voltage ignitor circuit connected across said two gap electrodes, a condenser across said ignitor circuit adapted to discharge across said gap, a power circuit connected across said two gap electrodes in parallel with said ignitor circuit, a power condenser connected across said power circuit, a variable resistor and a variable inductance in circuit between said power circuit and said analytical gap, a resistor and a synchronous gap in circuit between said ignitor circuit condenser and said analytical gap, and means for energizing said ignitor and power circuits with pulsating unidirectional currents to charge said condensers, said synchronous gap being timed to close following charging of said ignitor circuit condenser.

5. In a spectroscopic source unit, the combination of: two spaced electrodes forming an analytical gap, a high voltage ignitor circuit connected across said two gap electrodes, a condenser across said ignitor circuit adapted to discharge across said gap, a power circuit connected across said two gap electrodes in parallel with said ignitor circuit, a power condenser connected across said power circuit, a variable resistor and a variable inductance in circuit between said power circuit and said analytical gap, a resistor and a synchronous gap in circuit between said ignitor circuit condenser and said analytical gap, and means for energizing said ignitor and power circuits with half-wave rectified alternating currents to charge said condensers, said synchronous gap being timed to close following charging of said ignitor circuit condenser.

6. In a spectroscopic source unit, the combination of: two spaced electrodes forming an analytical gap, a high voltage ignitor circuit connected across said two gap electrodes, a condenser across said ignitor circuit adapted to discharge across said gap, a power circuit connected across said two gap electrodes in parallel with said ignitor circuit, a power condenser connected across said power circuit, a variable resistor and a variable inductance in circuit between said power circuit and said analytical gap, a resistor and a synchronous gap in circuit between said ignitor circuit condenser and said analytical gap, and means for energizing said ignitor and power circuits with in-phase half-wave rectified alternating currents to charge said condensers, said synchronous gap being timed to close following charging of said ignitor circuit condenser.

7. In a spectroscopic source unit, the combination of: an analytical gap, a high-voltage ignitor circuit connected across said two gap electrodes, a condenser across said ignitor circuit adapted to discharge across said gap, a power circuit connected across said two gap electrodes in parallel with said ignitor circuit, a power condenser connected across said power circuit, a variable resistor and a variable inductance in circuit between said ignitor circuit condenser and said analytical gap, and means for energizing said ignitor and power circuits with 180° out-of-phase half-wave rectified alternating currents to charge said condensers, said synchronous gap being timed to close following charging of said ignitor circuit condenser.

8. In a spectroscopic source unit, the combination of: two spaced electrodes forming an analytical gap, a high voltage ignitor circuit connected across said two gap electrodes, a condenser across said ignitor circuit adapted to discharge across said gap, a power circuit connected across said two gap electrodes in parallel with said ignitor circuit, a power condenser connected across said power circuit, a variable resistor and a variable inductance in said power circuit between said power condenser and said analytical gap, a resistor and a synchronous gap in said ignitor circuit between said ignitor circuit condenser and said analytical gap, a source of alternating current power, means fed from said source of power for impressing a relatively high voltage across said ignitor circuit, a half-wave rectifier in said ignitor circuit ahead of said ignitor circuit condenser, means fed from said source of power for impressing a voltage across said power circuit, and a half-wave rectifier in said power circuit ahead of said power circuit condenser, said synchronous gap being timed to close following charging of said ignitor circuit condenser through said rectifier, whereby said condenser discharges across said analytical gap to thereby permit said power circuit condenser to discharge across said analytical gap.

9. In a spectroscopic source unit, the combination of: two spaced electrodes forming an analytical gap, a power circuit, a power condenser connected across said power circuit, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit

causing said power condenser to be charged on alternate half cycles, a discharge circuit forming a continuation of said power circuit connecting said power condenser across said two gap electrodes, a variable resistor and inductor combination in series in said discharge circuit, a by-pass condenser connected across said discharge condenser on the gap side of said resistor and inductor combination, and a synchronous high voltage gap ignitor having an output circuit inductivity coupled to said discharge circuit at a point between said by-pass condenser and one of said gap electrodes.

10. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said power condenser to be charged unidirectionally and only on alternate half-cycles, and an auxiliary ignitor for said gap operated synchronously with said alternating current supplied by said alternating current power source to periodically ignite said gap and thereby initiate power discharge thereacross.

11. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said power condenser to be charged unidirectionally and only on alternate half-cycles, and an auxiliary ignitor for said gap operated synchronously with said alternating current supplied by said alternating current power source to ignite said gap each time said power condenser is charged by a power current impulse in said power circuit and thereby initiate power discharge thereacross.

12. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said power condenser to be charged unidirectionally and only on alternate half-cycles, and an auxiliary ignitor for said gap operated synchronously with said alternating current supplied by said alternating current power source to ignite said gap following the termination of each complete charging of said power condenser by a power current impulse in said power circuit and thereby initiate power discharge across said gap.

13. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impluses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said power condenser to be charged unidirectionally and only on alternate half-cycles, and an auxiliary ignitor for said gap operated synchronously with said alternating current supplied by said alternating current power source and adjusted to ignite said gap immediately preceding the said alternate condenser charging half-cycles and thereby initiate power discharge thereacross.

14. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impluses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a variable resistor and inductor combination in said power circuit between said condenser and said gap, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said condenser to be charged unidirectionally and only on alternate half-cycles, and an auxiliary ignitor for said gap operated synchronously with said alternating current supplied by said alternating current power source to periodically ignite said gap and thereby initiate power discharge thereacross.

15. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition of the latter, a variable resistor and inductor combination in said power circuit between said condenser and said gap, a low frequency alternating current power source for said power circuit, said source being of a voltage incapable of breaking down said gap via said power circuit, half-wave rectifier means in said power circuit between said source and said power condenser causing said condenser to be charged unidirectionally and only on alternate half-cycles, and an auxiliary ignitor for said gap operated synchronously with said alternating current supplied by said alternating current power source to ignite said gap each time said power condenser is charged by a power current impulse in said power circuit and thereby initiate power condenser discharge thereacross.

16. In a spectroscopic source unit or the like, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser across said power circuit arranged to be charged by current impulses flowing in said power circuit and to discharge across said gap upon ignition

of the latter, a variable resistor and inductor combination in said power circuit between said condenser and said gap, power means for establishing periodic unidirectional condenser-charging current impulses in said power circuit, said power means operating at insufficient voltage to breakdown said gap via said power circuit, and an auxiliary gap ignitor synchronized with the flow of said periodic condenser-charging current impulses to ignite said gap and thereby initiate power condenser discharge thereacross.

17. In a spectroscopic source unit, the combination of: two spaced electrodes forming an analytical gap, a power circuit connected across said two gap electrodes, a power condenser in said power circuit adapted and arranged to be charged by current supplied to said power circuit and to discharge across said gap upon ignition of the latter, a low frequency source of unidirectional condenser-charging current impulses connected to said power circuit, a high voltage ignitor adapted and arranged to supply a breakdown voltage across said two gap electrodes, and a synchronous switch adapted to periodically operate said ignitor in a synchronous relation with the low frequency current impulses supplied by said source.

18. In a spectroscopic source unit or the like, the combination of a power circuit, a power condenser connected in parallel thereacross, a pair of spaced electrodes forming an analytical gap connected across said power circuit in parallel with said power condenser, a resistor and inductor combination in series in said power circuit between said condenser and said gap, an electric power source of low voltage connected to said power circuit and adapted to create periodic condenser charging current impulses in said power circuit, the voltage of said source being insufficient to charge said condenser to a voltage capable of breaking down said gap, and an auxiliary gap ignitor synchronously operated with said condenser charging current impulses to periodically ignite said gap in step with charging of said condenser and thereby iintiate condenser discharges across said gap.

19. In a spectroscopic source unit or the like, the combination of a power circuit, a power condenser connected in parallel thereacross, a pair of spaced electrodes forming an analytical gap connected across said power circuit in parallel with said power condenser, a resistor and inductor combination in series in said power circuit between said condenser and said gap, an electric power source of low voltage connected to said power circuit and adapted to create periodic condenser charging current impulses in said power circuit, the voltage of said source being insufficient to charge said condenser to a voltage capable of breaking down said gap, and an auxiliary gap ignitor embodying a high voltage discharge circuit arranged to discharge across said gap and including synchronous switching means synchronized with said condenser charging current impulses to create a breakdown voltage across said gap following each charging of said power condenser.

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