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(54) **Pulse light stabilization for color spectrophotometric instrumentation.**

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Description

This invention relates to color spectrophotometric instrumentation, and more particularly, to an improved spectrophotometric system illuminated with a high intensity flashtube.

Xenon flashtubes are utilized in many different types of installations to provide very high intensity, short duration, light flashes. Generally, the flashtube consists of a glass enclosure with a pair of electrodes extending into the enclosure which is filled with a xenon gas. When an arc is struck between the electrodes, usually by energization from a capacitor discharge, a high intensity light flash results.

In general applications the life of a xenon tube is usually determined by the erosion of the arc electrodes through sputtering. The sputtering results in a metallic film that develops on the glass enclosure as well as an accumulation of metal particles within the enclosure.

Xenon flashtubes have also been used as a pulsed light source for spectrophotometric instrumentation according to techniques taught in G. P. Bentley et al Patent No. 3,458,261. The use of high intensity, short duration, pulse illumination has the advantages of providing a higher signal-to-noise ratio when measuring dark objects and of not distorting measurements by heating the object being measured.

A similar operating circuit making efficient use of the power source has been suggested in US—A—4 051 411 for high pressure sodium vapor discharge lamps.

However, with color spectrophotometric instrumentation the spectral nature of the light becomes more critical and the deterioration of the spectral stability as the tube ages appreciably shortens the acceptable life span of the flashtube. It has been found that in prior xenon flashtube spectrophotometric equipment the life of the xenon tube is limited to about 100 000 flashes. Beyond this point, the spectral distribution of the light generated in the flash becomes too erratic to provide acceptable spectrophotometric data. Although this life span may be acceptable in systems which are used periodically, it amounts to something like ten days in a continuously operating system which is too short for most commercial applications.

Summary of the invention

In accordance with the invention the current supplied to the xenon tube is reduced as compared to prior systems while maintaining approximately the same energy content per pulse applied to the electrodes. Quite unexpectedly, in addition to reducing the sputtering effects, this change has been found to result in a regeneration of the electrodes rather than the deterioration noticed in prior systems.

A new electrode is shaped to provide a fairly sharp point and, therefore, when the arc is struck between a pair of new electrodes, the arc follows a reasonably well defined path point-to-point. The electrode points wear down in use and gradually became rounded. With a rounded tip the arc path becomes erratic and, in the prior systems, this seems to result in erratic light generation that eventually limits the life span of the flashtube.

When operating according to this invention, it appears that enucleation sites develop on the surface of the electrodes and gradually build up metallic nodules that, in effect, form new points on the electrode. In a series of successive flashes, the arc is struck between the same points, i.e., either the original points or new points formed by the build-up of material during operation of the tube. Although there are treatises discussing various observed surface effects on arc electrodes, none of the treatises seem to describe the spheroidal nodule formation observed in actual experiments with the invention and, hence, the phenomena causing the enucleation and regeneration build-up of new points on the electrode cannot be explained.

Another unexpected phenomena concerns the spectral distribution of the flash. When operated in accordance with the invention, the spectral distribution of the flash shows a greater difference between successive flashes than had been observed in prior systems. Normally, such a variation in the spectral distribution would be undesirable and could very well render the flash unusable for spectrophotometric measurements. Surprisingly, however, it has been found that when the measured values are normalized at multiple spectral points (rather than at a single intensity normalization point) the system actually provides a lower deviation than was found with prior flash systems under similar circumstances. Thus, even though the actual spectral deviation is greater when operating according to the invention, the deviation after multiple point normalization is less thereby resulting in a superior system.

The invention has been found to improve the operating life span of a xenon flashtube in the spectrophotometer by an order of magnitude. Systems have been successfully operated in the laboratory for several million flashes without appreciable electrode deterioration, enclosure clouding from metallic film deposits or degradation of spectral stability.

Brief description of the drawings

Figure 1 is a schematic illustration of the circuit for energizing the xenon flashtube in accordance with the invention.

Figure 2 is a diagram showing a set of curves showing different flashtube energization characteristics.

Figures 3A, 3B and 3C are drawings illustrating various electrode surface conditions.

Figure 4 is a schematic diagram illustrating a spectrophotometer.

Figure 5A is a diagram showing the spectral distribution for a xenon flash; figure 5B illustrates the effect of single point intensity normalization and Figure 5C illustrates the effect of two point normalization.

Detailed description

Figure 1 is a schematic illustration of the circuit used to energize a xenon flashtube 1 in accordance with the invention. The flashtube consists of a glass enclosure 2 with electrodes extending into the enclosure filled with xenon gas. Electrode 4 acts as an anode and electrode 3 acts as a cathode. The flashtube also includes a wisker 6 connected to the anode and extending downwardly and outwardly toward the enclosure wall. A film 5 is deposited on the outer surface of the enclosure starting in the region opposite the free end of wisker 6, extending around the enclosure and down the side to connect to the cathode. The wisker and conductive film, described more fully in Goldberg Patent No. 3,758,819, are used to ionize the gaseous medium to trigger the arc in the flashtube.

Xenon flashtubes suitable for color spectrophotometric use are manufactured by U.S. Scientific Instruments type 2CR-n.

The xenon flashtube is energized by a pulse discharge from a capacitor 10. One plate of the capacitor is connected to anode 4 via the series combination of an inductance coil 12 and a diode string 13. The other plate of the capacitor is connected to cathode 3. The anode of a diode 14 is connected to the cathode 3 of the flashtube, and the cathode thereof is connected to the anode via coil 12 and diode string 13.

The charging circuit for capacitor 10 includes a transformer 7 and a full-wave bridge rectifier 8. The output of the bridge is connected across capacitor 10 through a current limiting resistor 11 (100 ohms).

The circuit parameters are selected to provide a high current pulse discharge to energize the xenon flashtube to produce a flash of appropriate intensity for reflectance or transmittance spectrophotometric measurements. Capacitor 10 is preferably of a 100 microfarad size and is preferably charged to a potential of about 570 volts. When fully charged the capacitor has an energy content of about 15 joules with a peak power of about 100,000 watts.

The trigger circuit for initiating an arc discharge includes a step-up transformer 22. The high voltage secondary of the transformer is connected across the anode and cathode 3—4 of the flashtube. One end of the primary winding is connected to the negative terminal of bridge 8 and the other end of the winding is connected to the positive bridge terminal via a capacitor 21 and a resistor 20. A switch 23 (which can be a solid state switch like a silicon controlled rectifier) is connected across capacitor 21 and the primary winding of transformer 22. Another suitable trigger circuit is described in Ward Patent No. 3,355,625.

Assuming both capacitors 10 and 21 are charged, then closure of switch 23 will provide a high intensity short duration flash. When the switch closes, capacitor 21 discharges to energize the primary of transformer 22 which in turn generates a potential on the secondary that tends to rise toward some high potential such as twelve kilovolts. Diodes 13 prevent this high potential from feeding back to further charge capacitor 10. When the potential across the anode-cathode circuit of the flashtube reaches 5—6 kilovolts, the wisker 6 and film 5 initiate ionization of the gaseous medium causing the gas to break down. This results in establishing an arc between electrodes 3 and 4 as main capacitor 10 discharges via inductance 12, diodes 13, anode 4 and cathode 3.

If coil 12 were omitted, as is conventional in prior art circuits, closure of switch 23 would result in a discharge of the nature shown by curve A in Fig. 2. The current flow through arc electrodes 3—4 would rise rapidly to about a 5,000 ampere peak and then diminish exponentially towards zero. The duration of the principal portion of the pulse is about 20—30 microseconds. The pulse diminishes substantially to zero in 50 microseconds.

The addition of inductance coil 12 and diode 14 alters the discharge as indicated by curve B in Fig. 2 so that it has a lower peak current and a longer duration. With the coil in the circuit, when capacitor 10 begins discharging, energy is first absorbed in the coil. The energy in the coil is thereafter dissipated and discharged into the flashtube by a current path through diode 14 bypassing capacitor 10.

For the specific xenon tube and other circuit parameters as specified above, the preferred inductance coil includes 40 turns of tightly wound number 14 gauge wire wound around a 3/8 inch diameter core form. Satisfactory operating results are achieved with coils ranging from 10 turns to 100 turns. The corresponding inductances are in the range of 1 henry to 10 henrys. The preferred 40 turn coil has an inductance of about 3 henrys. For the larger coils it is preferable to use layered windings in order to reduce resistance in the main current path and to reduce the size of the coil. The same inductance can be achieved in a layered coil using fewer turns.

When a 40 turn inductance coil as specified above is included in the circuit, the peak discharge current is reduced from 5,000 amperes to about 2,000 amperes as indicated in curve B in Fig. 2. The current drops substantially to zero at 80 microseconds. When used in spectrophotometry instruments peak currents in the range of 4,000 to 1,000 have been found to provide the desired results in accordance with the invention. These pulses have a duration in the range of 60 to 200 microseconds (based on substantially zero values).

Figure 3A illustrates the appearance of a pair of new electrodes 30 and 31 such as would be included in the xenon tube 1 as the anode and cathode respectively. Such electrodes are generally constructed from sintered tungsten with impurities such as a barium compound included therein. As can be seen in the drawing, the electrodes are shaped to provide points 32—33. When the arc is struck within the flashtube it travels from the point of one electrode to the point of the other electrode. Thus, with new electrodes having relatively sharp points the flashtube will provide a relatively stable arc of a fixed length and lateral location.

Figure 3B illustrates the appearance of the electrodes after use in prior type systems operated at about 5,000 ampere peak current without the inductance coil 12 in the circuit. As can be seen in the drawing, electrodes 33—34 have deteriorated and, after about 100,000 flashes would appear having rounded ends 35 and 36. With a rounded electrode the arc may originate from different random sites on the electrode resulting in variations in the arc length, variations in the lateral location of the arc, and undesirable variations in the spectral distribution of the flash. Such rounded electrodes provide erratic illumination and are unsatisfactory for spectrophotometric instrumentation.

The unexpected electrode regeneration effect observed in actual practice when operating in accordance with the invention causes changes in the electrode surface structure as shown in Figure 3C. In operation enucleation sites develop on the conical end surface of electrodes 37 and 38. Molecules of metallic material built up at the enucleated sites gradually forming spheroidal nodules 39 and 40 as shown in the illustration. When the original point of the electrode is worn down and becomes rounded, one of the nodule points such as at 39 or 40 takes over as the electrode point from which the arc originates. While one nodule point is the point of origination for the arc, nodules in other regions attract material and tend to grow and eventually take over as the electrode point. In this fashion there is a continual regeneration of the electrode providing a stable site for arc origination on successive flashes. Since the arc originates from a specific controlled point during successive flashes, the arc tends to be stable in length and lateral location.

Fig. 4 shows a spectrophotometer used to make diffuse reflectance measurements throughout the visible spectrum in order to measure the color of a sample. This spectrophotometer includes a xenon flashtube 43 according to this invention. To provide diffuse illumination, a sample 41 is placed in an integrating sphere 42 which is a hollow sphere, the inside surface of which is covered with a white diffusing coating such as barium sulphate. Illumination is provided by the pulsed xenon flashtube. The xenon flashtube provides a short, intense pulse of illumination, which drops to substantially zero in 80 microseconds. Because of the short duration of sample illumination it is possible to measure moving samples, which typically move a negligible distance during the measurement. (See, e.g., G. P. Bentley et al U.S. Pat. No. 3,458,261). Also the high intensity and short pulse width renders an electronic system that is high-pass filtered insensitive to the effects of ambient light.

Rays of illumination emanating from the source, such as rays A, B and C, strike the diffusely reflective wall of sphere 42 and are then diffusely reflected as, for example, is ray B. Some of these diffusely reflected rays strike the sample, but most strike another portion of the sphere a second time. This process repeats until all rays are absorbed by the sample or the sphere wall, or are reflected by the sample out of the sphere through circular aperture 44. Aperture 44 is located so as to pass rays reflected at a small angle, e.g., 8°, to the sample normal.

The rays reflected from the sample are collected by a lens 45 and focused through slit 46. The purpose of slit 46 is to restrict the angular spread of rays that proceed through the remainder of the optical system. The rays that pass through slit 46 are collimated by a lens 47 and impinge on dispersive elements 48, which may be a prism or a diffraction grating. Fig. 4 illustrates a reflective diffraction grating, which is the preferred dispersive element.

Grating 48 separates the incident light into its component wavelengths by deviating each wavelength by a unique angle. For example, the red rays, which have a wavelength of 700 nm, follow rays R and R′, while the violet rays, which have a wavelength of 400 nm, follow rays V and V′. Lens 49 focuses these rays onto a linear array of discrete photodetectors 50, the red rays being focused at point R″ and the violet rays at point V″. All wavelengths between 400 nm and 700 nm are focused at points R″ and V″. The result is an image of the visible spectrum in the plane of photodetector array 50.

It is possible to replace lens 47, grating 48 and lens 49 by a single diffraction grating that is manufactured on a concave spherical surface. The spherical surface behaves as a mirror with the ability to focus rays of light. The use of such a concave grating, therefore, is entirely equivalent to the use of the two lenses and the grating shown in Fig. 4. It is also possible to replace one of both of the lenses by concave mirrors, which perform the same imaging function as the lenses they replace.

The photodetectors can be silicon photodiodes. Each photodiode measures only a narrow band of wavelengths. The width of this band depends on the width of slit 46 and the width of each photodiode. The wavelengths measured depend on the position in the array, of the detectors. The number of detectors in the array is equal to the number of different wavelengths that are simultaneously measured. In a typical arrangement, there are 16 detectors that measure from 400 nm to 700 nm in equal intervals of 20 nm in accordance with CIE (Commission Internationale de L'eclairage; French International Commission on illumination) standards. It has been found that the width and the center-to-center spacing of the detectors affect the accuracy of the measurements for some colors. Accordingly, the ratio of the detector width to the center-to-center detector spacing should be in the range of 0.6 to 0.9 and preferably about 0.8 for best results.

A pair of reference photodetectors 62 and 63 are located in holes in the sphere wall in order to monitor the intensity of the illuminating pulse. As will be described hereinafter in connection with Figs. 5A—5C, these detectors monitor the intensity at different wavelengths and, therefore, are provided with appropriate light filters. The signals derived from the detectors are used to "normalize" the signals derived from the detectors in array 50.

A portion of the sphere wall, known as the specular port 53, can be removed by means of a hinge assembly 54 in order that the sample not be illuminated by rays that would be specularly reflected (i.e., reflected as off a mirror) and subsequently measured. When the specular port 53 is removed, a light trap 55 prevents light that escapes through the hole in the sphere wall from deflecting about outside the sphere. The center of the specular port is located 8° from the sample normal, so that a ray of light emanating from the specular port will be specularly reflected in such a direction that it will pass out of the sphere through aperture 44.

In order to keep the spectrophotometer in correct calibration, a prism 56 can be inserted into the path of rays that are reflected by the sample. This prism deviates rays from the sample so that they are deflected up (in a direction out of the plane of Fig. 4, thereby missing collecting lens 45. Instead, rays that are reflected from a portion of the sphere wall above the sample are directed into collection lens 45 and are analyzed. Since the reflectance of the sphere wall is quite stable from day to day, this measurement can be used as a means of periodic calibration.

Fig. 5A illustrates the spectral distribution of the light from a xenon flashtube illumination with tungsten electrodes which, as can be seen, varies in intensity at different wavelengths. The light seems to include specific light bands as well as broad band distributions.

For simplicity, only eight detector measurements (a)—(h) are shown in Fig. 5A whereas, as previously mentioned, a typical system is likely to include sixteen or more such measurements.

If one of the detectors 62 (Fig. 4) is arranged to monitor the intensity of light at wavelength 70, as shown in Fig. 5B, this measured value is used by the processing electronics 51 (Fig. 4) to "normalize" for intensity variations. This is accomplished by dividing the measured values from the detectors 50 by the reference value measured by detector 62.

By observing flashtube operations it has been found that in addition to intensity variations there are also spectral rocking variations such that the intensity of light at one end of the spectrum sometimes increases more than the intensity at the other end. Thus, if a single point intensity normalization is made at wavelength 70, for example, there may be deviations from the true value at other points in the spectrum. In general, as shown in Fig. 5B, these deviations could fall between the lines 71 and 72 as indicated by the shaded area and increase as the distance from the monitoring point increases.

To compensate for the spectral shifts it is preferable to also normalize at least one additional point such as wavelength 73 as shown in Fig. 5C. Reference detector 62 is used for this purpose. The two monitoring points 70 and 73 should be well separated as shown.

The preferred procedure for obtaining data for the spectral normalization is to use a standard white tile and record values for each of the detectors 50 and 63 after intensity normalization (detector 62). From this data an average value can be determined for each of the detectors 50 corresponding to each of the different measurable values from detector 63. These average values are placed in a look-up table and used for the spectral normalization. In use on an unknown sample, when a value is measured by detector 63 the correction factors corresponding to this measured value are obtained from the look-up table and used to modify the values obtained from the detectors 50.

With two point normalization as described above, correct values are assured at wavelengths 70 and 73, the normalization points, but some degree of deviation would still be expected at other points in the spectrum. This deviation, in exaggerated form, would be as indicated by the dashed lines 74 and 75 in Fig. 5C.

When the flashtube circuit is modified as shown in Fig. 1 according to this invention it was found that a greater spectral shift results. As shown in Fig. 5B, the deviation would fall between the dotted lines 76—77 without the inductance but increase to the area between lines 71 and 72 for a larger maximum deviation d_1 seemingly indicating that the illumination spectrum is less stable and not suited for spectrophotometric measurements.

Surprisingly, however, it was found that even though the deviation after intensity normalization is greater with the modification according to the invention, the deviation after two-point normalization is less. As shown in Fig. 5C the maximum deviation is reduced from d_2 to d_3 as is shown by the shaded area in Fig. 5C. The reason for this unexpected improvement is unknown.

Color spectrophotometric instruments are usually rated according to ability to repeat the same measurement. These ratings are in accordance with color difference values wherein a value of 1.0 is the just perceptible color difference detectable by the human eye. Repeatability is the RMS (root mean square) color difference value over a series of measurements on the same sample.

With the prior systems, single point intensity normalization would give erratic results with color difference values as high as 1 or 2. Similar systems with two point normalization would normally be in the range of .17 to .25 color difference. With the modification according to this invention, after two-point normalization, the repeatability performance improved to the range of 0.09 to 0.15 color difference.

The processing electronics 51 preferably includes a sample and hold circuit and an analog-to-digital converter connected to each of the detectors 50, 62 and 63, a read only memory (ROM) for the look-up table and a microprocessor programmed to carry out the normalization calculations indicated previously. The sample and hold circuits are controlled to provide a measurement window corresponding to the light pulse duration which would be between 60 and 200 microseconds and about 80 microseconds for the preferred embodiment illustrated in curve B in Fig. 2.

Alternatively, a hardwired digital logic system or an analog computational system could be used.

In the foregoing description preferred embodiments have been described. It should be obvious, however, that there are numerous variations within the scope of this invention which is more particularly defined in the appended claims.

Claims

1. Arc flash system including a pair of spaced tungsten electrodes (3, 4) located in a xenon gaseous medium within a transparent enclosure (2); a capacitor discharge circuit including a capacitor (10) so connected to said electrodes (3, 4) that, upon discharge, energy flows to the electrodes (3, 4) to create an arc in said xenon gaseous medium; a trigger circuit for ionizing said gaseous medium to initiate an arc between said electrodes (3, 4); an inductance (12) in the discharge path between said capacitor (10) and said electrodes (3, 4); and a bypass diode (13) connected across said capacitor (10) so that substantially all the energy in said capacitor (10) is transferred to said electrodes (3, 4), characterized in that the value of the inductance (12) is selected in a range of 1 to 10 microhenrys so that it decreases the peak current to a value in the range between 4 000 to 1 000 amperes.

2. The arc flash system of claim 1, characterized in that the inductance (12) decreases the peak current to a value of about 2 000 amperes.

3. A color spectrophotometer comprising a xenon flashtube (43) with tungsten electrodes (3, 4); a capacitor discharge circuit including a capacitor connected to energize said flashtube (43) upon electrical discharge; an inductance (12) in the discharge path between said capacitor and said flashtube (43) to reduce the peak current; a plurality of light measuring detectors (50) each operative to measure light from said flashtube (43) at a different wavelength after the light has been altered by a sample (41) being tested; at least two reference detectors (62, 63) for measuring light from said flashtube (43) at two different wavelengths where the light has not been altered by the sample (41) being tested; and electronic signal processing means (51) responsive to the signals from said detectors (50) and operative to modify the values from said measuring detectors (50) in accordance with the values of both reference detectors (62, 63) to normalize variations and correct for spectral shift, characterized in that said inductance (12) in the discharge path is an inductance having a value in the range of 1 to 10 microhenrys and decreases the peak current to a value in the range of 4 000 to 1 000 amperes.

4. The color spectrophotometer of claim 3 characterized in that the said inductance reduces the peak current to a value of 2 000 amperes.

5. The color spectrophotometer of claims 3 and 4 characterized in that it further includes a diode to bypass said capacitor to permit substantially complete energy transfer from said capacitor to said flashtube via said inductance.

6. The color spectrophotometer of claim 3 characterized in that the measuring window for said detectors is in the range of 60 to 200 microseconds and corresponds approximately to the duration of the light flash.

7. The color spectrophotometer of claim 6 characterized in that said measuring window is about 80 microseconds.

8. A method for obtaining color spectrophotometric measurements, comprising the steps of illuminating the sample (41) being tested by means of a xenon flashtube (43) energized by a peak current no greater than 4 000 amperes and a current pulse having a duration in the range of 60 to 200 microseconds; detecting the light after having been altered by the sample (41) to provide measured values at a plurality of different wavelengths; detecting the light from said flashtube which has not been altered by the sample (41) to provide reference values at at least two different wavelengths; dividing said measured values by one of said reference values to normalize for intensity variations; and modifying said measured values according to look-up values corresponding to the other of said reference values, whereby said look-up values are derived from data taken on a reference sample and are the average corrective values for the intensity normalized measured values at the detecting wavelengths correlated to the measured value of said other reference detector.

9. The method of claim 8 wherein said peak current is approximately 2 000 amperes and the peak duration is about 80 microseconds.

Patentansprüche

1. Bogenentladungsblitz-Vorrichtung mit zwei getrennt in einem mit Xenongas gefüllten durchsichtigen Behälter (2) angeordneten Wolfram-Elektroden (3, 4); einem Stromkreis mit einer Kapazität (10), die direkt mit den Elektroden (3, 4) der Blitzröhre verbunden ist, so daß bei Entladung den Elektroden (3, 4) Energie zufließt und ein Lichtbogen in der Xenongas-Etmosphäre ausgebildet wird; einer Triggerschaltung zur Ionisierung des Gases und zur Ausbildung des Lichtbogens zwischen den Elektroden (3, 4); einer Induktanz (12) zwischen der Kapazität (10) und den Elektroden (3, 4); und einer Umgehungs-Diode (13) parallel zur Kapazität (10) geschaltet, so daß praktisch die gesamte Energie den Elektroden (3, 4) zugeführt wird, dadurch gekennzeichnet, daß

der Wert der Induktanz (12) in einem Bereich zwischen 1 und 10 Mikrohenry liegt und so der Spitzenstrom auf einen Wert zwischen 4000 und 1000 Ampere reduziert wird.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Soitzenstrom auf einen Wert von 2000 Ampere begrenzt wird.

3. Farbspektrophotometer, bestehend aus einer Bogenentladungs-Blitzröhre (43) mit den Wolfram-Elektroden (3, 4); einem Stromkreis mit einer Kapazität (10), die direkt mit der Blitzröhre (43) verbunden ist; einer Induktanz (12) zwischen der Kapazität (10) und den Elektroden (3, 4) zum Reduzieren des Spitzenstroms; einer Anzahl von Detektoren (50) zum Messen des von der Blitzröhre (43) kommenden und durch das zu messende Muster (41) veränderten Lichtes in verschiedenen Wellenlängenbereichen; mindestens zwei Referenzdetektoren (62, 63) zum Messen des von der Blitzröhre (43) kommenden, nicht durch das zu messende Muster (41) veränderten Lichtes in zwei verschiedenen Wellenlängenbereichen; und eine elektronische Auswert-Vorrichtung (51), die auf die von den Detektoren (50) ausgehenden Signale reagiert und diese unter Berücksichtigung der Referenzsignale der beiden Referenzdetektoren (62, 63) zum Ausgleich von Schwankungen und Spektralverschiebungen verändert, dadurch gekennzeichnet, daß die Induktanz (12) einen Wert zwischen 1 und 10 Mikrohenry aufweist und der Spitzenstrom auf 4000 bis 1000 Ampere reduziert wird.

4. Farbspektrophotometer nach Anspruch 3, dadurch gekennzeichnet, daß die genannte Induktanz (12) den Spitzenstrom auf 2000 Ampere reduziert.

5. Farbspektrophotometer nach Anspruch 3, dadurch gekennzeichnet, daß dieses weiterhin eine Diode aufweist, durch die unter Umgehung der Kapazität eine vollständige Übertragung der gesamten Energie auf die Blitzröhre über die genannte Induktanz ermöglicht wird.

6. Farbspektrophotometer nach Anspruch 3, dadurch gekennzeichnet, daß die Meßzeit für die genannten Detektoren 60 bis 200 Mikrosekunden beträgt und damit etwa der Dauer des Lichtblitzes entspricht.

7. Farbspektrophotometer nach Anspruch 6, dadurch gekennzeichnet, daß die genannte Meßzeit 80 Mikrosekunden beträgt.

8. Verfahren zur Durchführung der spektrophotometrischen Messung nach den folgenden Verfahrensschritten:—Beleuchten des zu untersuchenden Musters (41) mittels einer Blitzröhre (43), die durch einen Strom von nicht mehr als 4000 Ampere und einem Stromimpuls von 60 bis 200 Mikrosekunden aktiviert wird;—Erfassen des durch das zu messende Muster (41) veränderten Lichtes, um Meßwerte in verschiedenen Wellenlängenbereichen zu erhalten;—Erfassen des Lichtes von der Blitzröhre (43), das nicht durch das zu messende Muster (41) verändert wurde, um Referenzwerte für mindestens zwei verschiedene Wellenlängenbereiche zu erhalten;—Teilen der gemessenen Werte durch einen der Referenzwerte zum Ausgleich von Intensitätsschwankungen; und—Modifizieren der gemessenen Werte entsprechend von Nachschlagetabellenwerten, die dem anderen der beiden Referenzwerte entsprechen, dadurch gekennzeichnet, daß die Nachschlage-Referenzwerte von Daten eines Referenzmusters abgeleitet werden, die mittlere korrigierte Werte für die normalisierten Intensitäts-Meßwerte bei den aufgefaßten Wellenlängen des anderen Referenz-Detektors sind.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß der Spitzenstrom etwa bei 2000 Ampere liegt und die Spitzenmeßzeit 80 Mikrosekunden beträgt.

Revendications

1. Système de flash à arc comportant une paire d'électrodes espacées en tungstène (3, 4) situées dans un milieu gazeux de xénon à l'intérieur d'une enceinte transparente (2); un circuit de décharge de condensateur comportant un condensateur (10) connecté aux électrodes (3, 4) de façon que, lors de la décharge, l'énergie s'écoule jusqu'aux électrodes (3, 4) pour créer un arc dans le milieu gazeux de xénon; un circuit de déclenchement pour ioniser le mélange gazeux et amorcer un arc entre les électrodes (3, 4); une inductance (12) dans le trajet de décharge entre le condensateur (10) et les électrodes (3, 4); et une diode en dérivation (13) connectée au condensateur (10) de façon que la quasi-totalité de l'énergie du condensateur (10) soit transférée aux électrodes (3, 4), caractérisé en ce que la valeur de l'inductance (12) est choisie dans un plage comprise entre 1 et 10 microhenrys de façon à augmenter le courant de pointe jusqu'à une valeur comprise dans la plage allant de 4 000 à 1 000 ampères.

2. Système de flash à arc selon la revendication 1, caractérisé en ce que l'inductance (12) réduit le courant de pointe à une valeur d'environ 2 000 ampères.

3. Spectrophotomètre de couleur comprenant un flash électronique au xénon (43) avec des électrodes en tungstène (3, 4), un circuit de décharge de condensateur comportant un condensateur branché de façon à exciter le flash électronique (43) lors de la décharge électrique; une inductance (12) dans le trajet de décharge entre le condensateur et le flash électronique (43) afin de réduire le courant de pointe; une multitude de détecteurs de mesure de la lumière (50), chacun fonctionnant pour mesurer la lumière provenant du flash électronique (43) à une longueur différente après que la lumière ait été modifiée par un échantillon (41) en essai; au moins deux détecteurs de référence (62, 63) pour mesurer la lumière provenant du flash électronique (43) à deux longueurs d'onde différentes ou la lumière n'a pas été altérée par l'échantillon (41) en essai; et un moyen électronique (51) de traitement de signal répondant aux signaux provenant des détecteurs (50) et pouvant fontionner pour modifier les valuers des détecteurs de mesure

(50) en conformité avec les valeurs des deux détecteurs de référence (62, 63) afin de normaliser les variations et de corriger le décalage spectral, caractérisé en ce que l'inductance (12) dans le circuit de décharge est une inductance ayant une valeur dans la gamme 1 à 10 microhenrys et diminue le courant de pointe à une valeur comprise entre 4 000 et 1 000 ampères.

4. Spectrophotomètre de couleur selon la revendication 3, caractérisé en ce que l'inductance (12) réduit le courant de pointe à une valeur de 2 000 ampères.

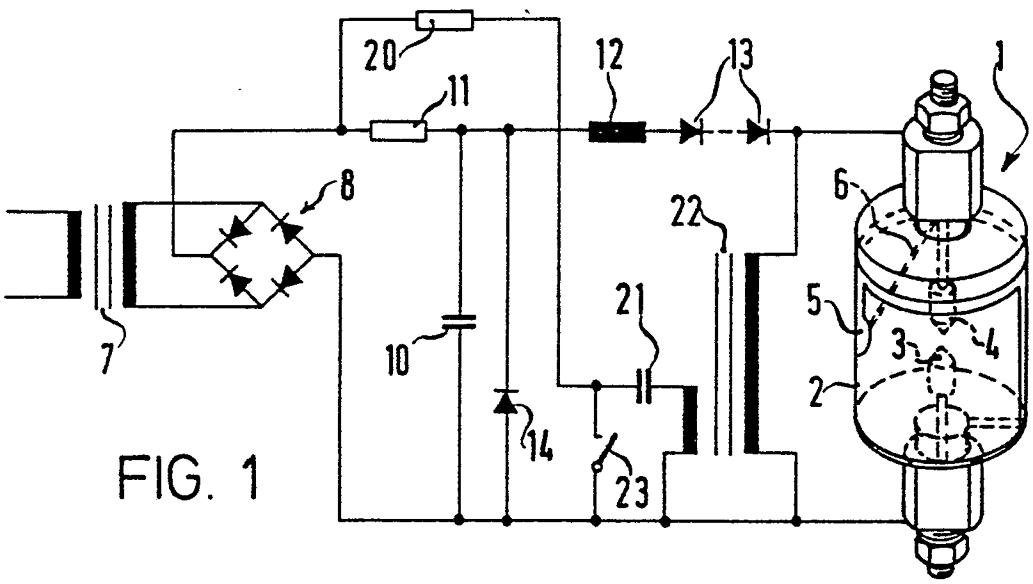
5. Spectrophotomètre de couleur selon les revendications 3 et 4, caractérisé en ce qu'il comprend en outre une diode pour contourner le condensateur et permettre un transfert d'énergie sensiblement complet entre le condensateur et le flash électronique via l'inductance.

6. Spectrophotomètre de couleur selon la revendication 3, caractérisé en ce que la fenêtre de mesure pour les détecteurs est comprise entre 60 et 200 microsecondes et correspond approximativement à la durée de l'éclair de lumière.

7. Spectrophotomètre de couleur selon la revendication 6, caractérisé en ce que la fenêtre de mesure a environ 80 microsecondes.

8. Procédé pour obtenir des mesures spectrophotométriques de couleur comprenant les étapes consistant à éclairer l'échantillon (41) en essai au moyen d'un flash électronique au xénon (43) excité par un courant de pointe ne dépassant pas 4 000 ampères et une impulsion de courant ayant une durée comprise entre 60 et 200 microsecondes; à détecter la lumière après avoir été modifiée par l'échantillon (41) de façon à fournir des valeurs mesurées à une multitude de longueurs d'onde différentes; à détecter la lumière provenant du flash électronique (43) qui n'a pas été modifiée par l'échantillon (41) de façon à fournir des valeurs de référence à au moins deux longueurs d'onde différentes; à diviser les valeurs mesurées par l'une des valeurs de référence pour normaliser les variations de l'intensité; et à modifier les valeurs mesurées selon des valeurs à consulter correspondant à l'autre des valeurs de référence, d'où il résulte que les valeurs à consulter sont obtenues à partir de données prises sur un échantillon de référence et sont les valeurs moyennes de correction pour les valeurs mesurées normalisées de l'intensité aux longueurs d'onde de détection liées à la valeur mesurée de l'autre détecteur de référence.

9. Procédé selon la revendication 8, caractérisé en ce que le courant de pointe est environ de 2 000 ampères et la durée de la pointe est environ de 80 microsecondes.


1
2
3
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23

FIG. 1

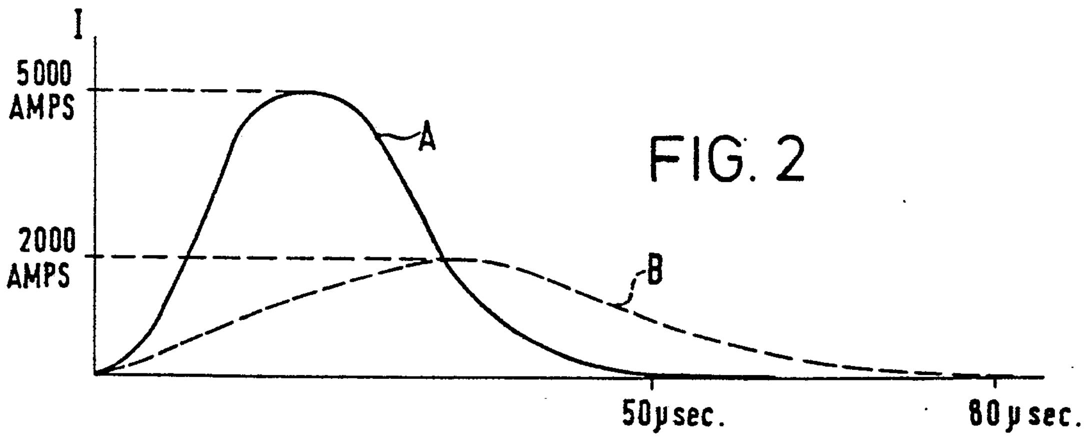
I
5000 AMPS
2000 AMPS
A
B
50μsec.
80μsec.

FIG. 2

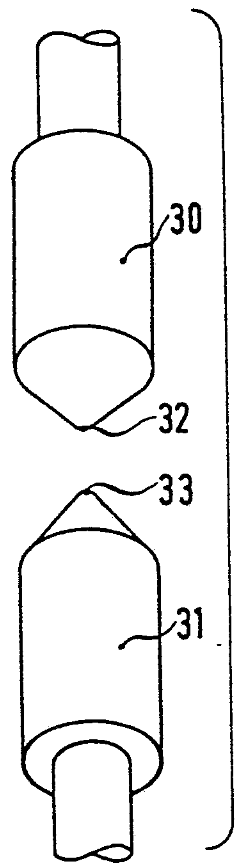

FIG.3A

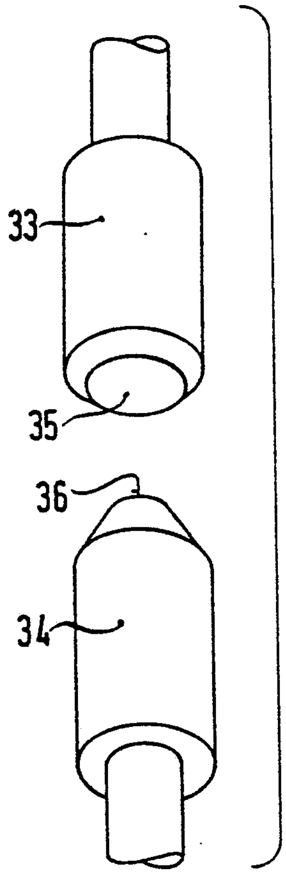

FIG. 3B

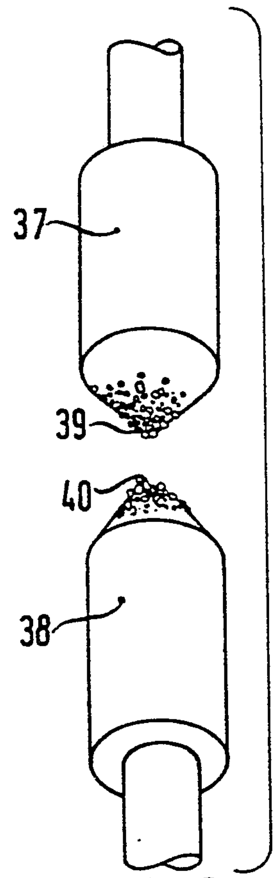

FIG.3C

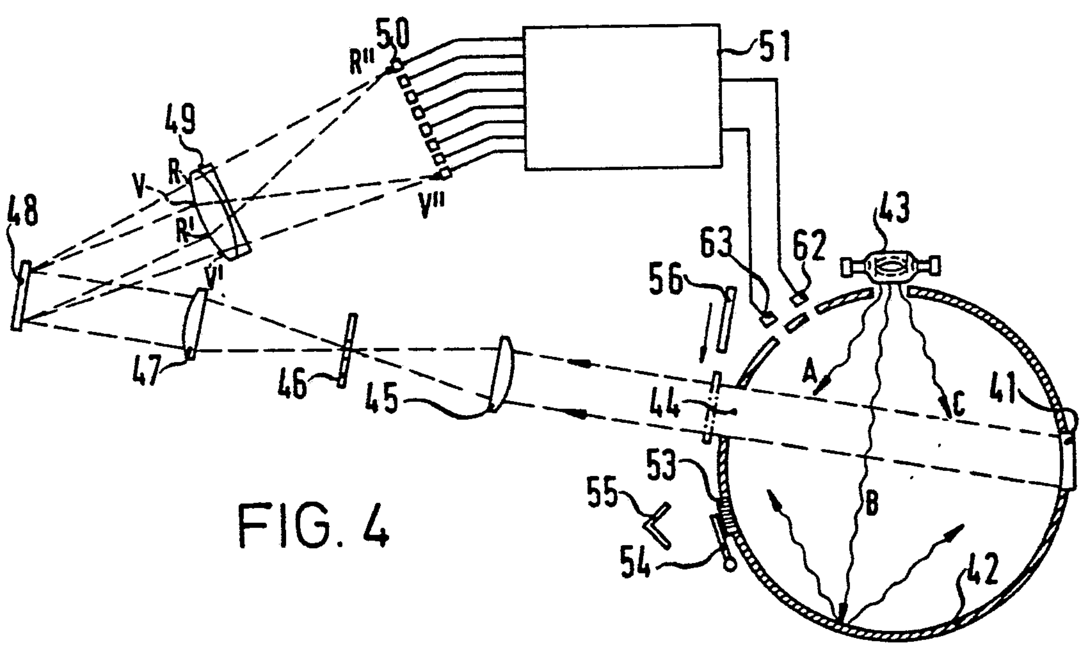

FIG. 4

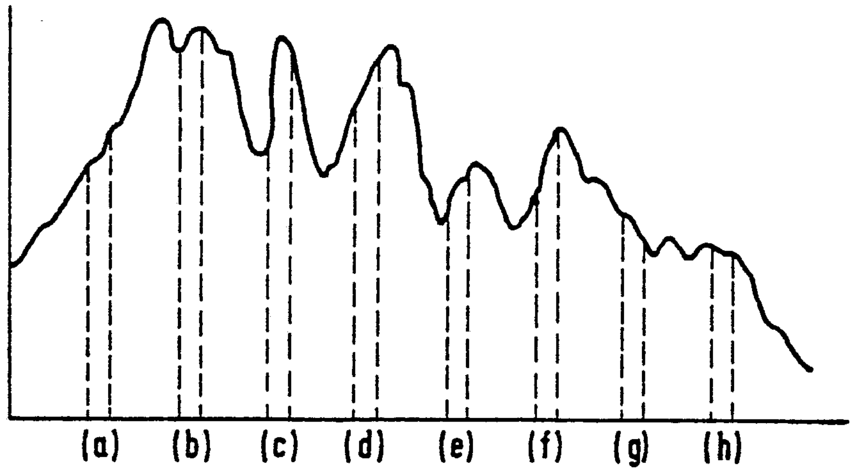

FIG. 5A

FIG. 5B

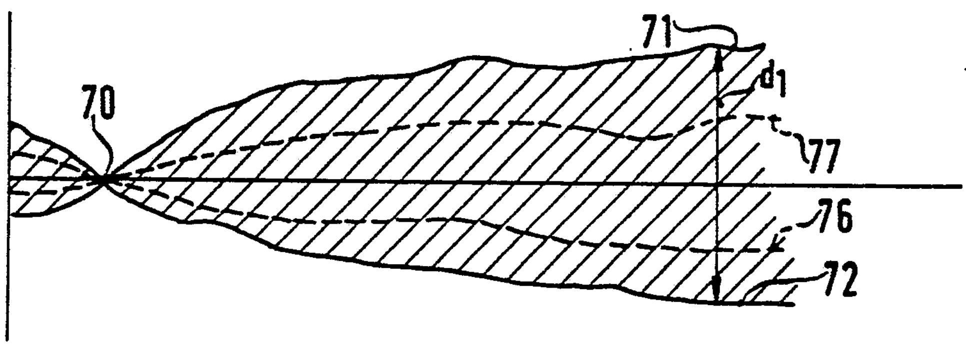

FIG. 5C