



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.09.2020 Bulletin 2020/36

(51) Int Cl.:
H05B 41/32 (2006.01)

(21) Application number: **19160209.3**

(22) Date of filing: **01.03.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **ARC DISCHARGE LAMP SYSTEM AND APPARATUS COMPRISING AN ARC DISCHARGE LAMP SYSTEM**

(57) an arc discharge lamp system (1, 1a, 1b) with a first arc discharge lamp (3) and a second arc discharge lamp (5) one trigger transformer (7) is provided for trig-

gering both the first arc discharge lamp (3) and the second arc discharge lamp (5).

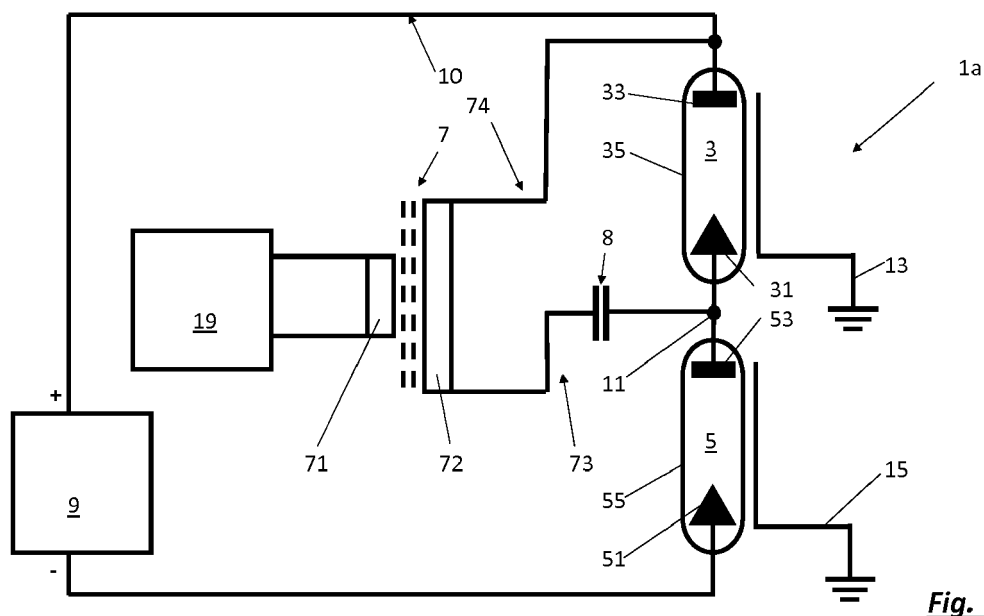


Fig. 1

Description

FIELD OF THE INVENTION

[0001] The invention relates to an arc discharge lamp system. The invention relates also to an apparatus comprising an arc discharge lamp system. Arc discharge lamp systems may be used for numerous different applications, including the provision of heat for manufacturing composite material components, in particular carbon composite materials, UV curing for example of polymers, sintering nano particle based products, rapid thermal processing, laser pumping, intense pulsed light applications, for example hair removal, or UV disinfection.

BACKGROUND OF THE INVENTION

[0002] In many applications, for example laser pumping, disinfection or curing, for instance in an apparatus comprising an arc discharge flashlamp system as described in WO 2017 134 453 A1, an arc discharge lamp system may be required to be operated with a predetermined minimal light output for nominal operation while at the same time not exceeding a certain size and/or weight.

[0003] An arc discharge lamp system usually contains a main energy storage, for example a storage capacitor that is connected across the arcing electrodes of the flashlamp. The voltage charge of this storage capacitor is normally, by itself insufficient to cause the gas between the arcing electrodes to ionize. Usually the gas is a noble gas, for example Xenon or Krypton. The ignition of arc discharge lamp system such as an arc and flash lamp, which may usually be described as triggering, requires an initial breakdown or ionization of gas within the lamp between its arcing electrodes. Triggering creates a voltage gradient (V/cm) in the gas sufficient to cause ionization. Ionization can typically be seen as a thin streamer between the two arcing electrodes, forming a conductive path which allows a main energy storage, for example a storage capacitor, to discharge across the arcing electrodes, thus leading to an intense flash. The energy required for ionizing or "triggering" can be provided by one of the different methods described in "Design Considerations for Triggering of Flashlamps" (2003) by Alex D. McLeod.

[0004] A common method for triggering an arc discharge lamp is called "external triggering". For external triggering, a trigger pulse is applied to a trigger electrode close to or in contact with a glass envelope of the arc discharge lamp, in particular flashlamp. The capacitance of the glass and possibly air couples the trigger pulse into the envelope where it exceeds the breakdown voltage of the gas surround the arcing electrodes, thereby forming spark streamers. The streamers propagate through the gas, eventually bridging the distance between the arcing electrodes. In many commercial instances, the trigger electrode is a wire spiraling around the outside of the arc discharge lamp's glass envelope.

External triggering is disadvantageous in that three wires are needed to connect to the lamp. Furthermore, the external trigger electrode must be insulated from any surrounding metalwork or equipment, and the required insulation (comprising air and/or another insulating material) requires a substantial amount of space.

[0005] Another common method for triggering arc discharge lamps, in particular flashlamps, particularly in high-power applications is called "series triggering". For series triggering, the arc discharge lamp comprises a trigger-transformer having high-voltage leads connected to the arc discharge lamp in series, one lead to an arcing electrode (anode or cathode) and the other one to the main energy storage, so that the lamp current travels through both the transformer and the lamp. The trigger transformer forms a spark inside the lamp, without exposing the trigger voltage to the outside of the lamp. The advantages include better insulation, reduced voltage requirement for a given lamp and more reliable triggering. However, series triggering leads to significantly higher expense in comparison to external triggering, mostly due to the secondary winding being required to carry the arc discharge lamp current (typically more than 30 A RMS, possibly more than 100 A RMS or even more than 1000 A RMS, at a flash voltage of more than 20 kV). This requires thick insulation between the turns. The large size conductor and the thick insulation both contribute the winding being large, which requires a large size magnetic core, such that series trigger transformers are relatively large, heavy and expensive. Furthermore, one of the lamp leads must be insulated for extra high voltage in addition to being rated to carry the lamp current.

[0006] It is an objective of the invention to overcome disadvantages of the prior art, in particular to provide a pulsed or continuous arc discharge lamp and an apparatus comprising an arc discharge lamp system that may reliably operate at a predetermined minimal light output while not exceeding predetermined size and/or weight restraints. A contribution to the at least partial fulfillment of at least one, preferably multiple of the above objects is accomplished by the subject matter of the independent claims. The dependent claims realize preferred embodiments contributing to the at least partial fulfillment of at least one of the objectives.

SUMMARY OF THE INVENTION

[0007] According to an aspect 1 of the invention, an arc discharge lamp system comprises a first arc discharge lamp, a second arc discharge lamp and a trigger transformer for triggering both the first arc discharge lamp and the second arc discharge lamp. In a particular embodiment, both the first and second arc discharge lamps are flashlamps. In another embodiment, both the first and second arc discharge lamps are continuous arc lamps. In particular, the arc discharge lamp system comprises no more than one trigger transformer coupled to the first and second arc discharge lamp. Surprisingly, the inven-

tors found out that they can use just one trigger transformer for the triggering of two arc discharge lamps, thereby decreasing the overall size and weight of the arc discharge lamp system without detrimental effects to the light output. The arc discharge lamp system may include a third arc discharge lamp, a fourth arc discharge lamp or more than four arc discharge lamps also triggered by the same trigger transformer.

[0008] The arc discharge lamp system may be configured for treating the surface of a target object with flash radiation. In particular, treating with flash radiation may refer to heating carbon composites, UV curing for example of polymers, sintering nano particle based products, rapid thermal processing. The arc discharge lamp system may be configured for manufacturing a composite article from a composite material. The arc discharge lamp system may be configured for disinfection or decontamination of a target object, such as a medical product, a foodstuff product or a component of a container for a medical product or foodstuff product. The arc discharge lamp system may be configured for laser pumping. The arc discharge lamp system may be configured for intense pulsed light applications, for example hair removal, or UV disinfection.

[0009] In an embodiment 2 which may be combined with the aforementioned aspect of the invention, the first arc discharge lamp and the second arc discharge lamp are connected in series to one main power supply. The arc discharge lamp system may include a third arc discharge lamp, a fourth arc discharge lamp or more than four arc discharge lamps also connected in series to the main power supply.

[0010] In an embodiment 3 which may be combined with the aforementioned aspect or embodiment of the invention, the trigger transformer may be connected in series to the one arc discharge lamp and in parallel to another arc discharge lamp, in particular relative to a main power source of the lamps. The trigger transformer may be connected in series to the first arc discharge lamp and in parallel to second arc discharge lamp, in particular relative to a main power source of the lamps.

[0011] Alternatively, the trigger transformer may be connected in parallel to the first flashlamp and in series to second flashlamp, in particular relative to a main power source of the lamps.

[0012] In an embodiment 4 which may be combined with the aforementioned aspect or embodiments of the invention, the trigger transformer comprises at a primary winding, particularly including at least one turn, and a secondary winding, particularly including multiple turns, wherein the secondary winding has a second lead connected at a midpoint to the cathode of the first arc discharge lamp and to the anode of the second arc discharge lamp. The ratio of primary winding turns to secondary winding turns may be 1:10 or greater, in particular 1:20 or greater, more particularly 1:50 or greater. The primary winding may be coupled to a trigger drive circuit including a pulsed voltage generator for providing a pri-

mary trigger voltage pulse to the trigger transformer, which may transform the trigger voltage pulse to a secondary trigger voltage pulse. Connecting the second lead of the secondary winding of the trigger transformer to the midpoint advantageously provides both the first arc discharge lamp and the second arc discharge lamp with a voltage gradient for triggering. It shall be clear that the first lead of the secondary winding shall be connected to the main circuit as well.

[0013] In an embodiment 5 which may be combined with the aforementioned aspect or embodiments of the invention, the secondary winding has first lead connected to the anode of the first arc discharge lamp or to the cathode of the second arc discharge lamp.

[0014] In an embodiment 6 which may be combined with the aforementioned aspect or embodiments of the invention, a capacitor is provided between the secondary winding and the main circuit comprising the first and second arc discharge lamp. The provision of at least one capacitor between the secondary winding of the trigger transformer and the main circuit assists in coupling the (relatively fast) trigger voltage pulse from the trigger drive circuit into the arc discharge lamps connected in series in the main circuit. Furthermore, the capacitor may assist in decoupling the (relatively slow) flash voltage pulse that runs through the main circuit when the arc discharge lamps are operated from the trigger transformer. The capacitor may block lamp current from passing back through the trigger transformer. The capacitor may be configured to have a capacitance between 1 μ F and 1 nF. In particular, the capacitor may be configured to have a capacitance of less than 0,1 mF, particularly less than 50 nF. In a preferred embodiment, the capacitor may be configured to have a capacitance of 10 nF.

[0015] In an embodiment 7 which may be combined with the aforementioned aspect or embodiments of the invention, the capacitor is provided between the second lead of the secondary winding and the midpoint. In an alternative embodiment 8 which may be combined with the aforementioned aspect or embodiments 2 to 6 of the invention, the capacitor is provided between the first lead of the secondary winding and the first or second arc discharge lamp.

[0016] In an embodiment 9 which may be combined with the aforementioned aspect or embodiments of the invention, the trigger transformer is an external type trigger transformer. In comparison to series type trigger transformers, external type trigger transformers are generally lighter, smaller and cheaper.

[0017] The first and second arc discharge lamp may be of the same type, in particular the first and second arc discharge lamp may be flashlamps or the first and second arc discharge lamps may be continuous arc discharge lamps. The first and second arc discharge lamp may be of the same design. Arc discharge lamps of the same design may be of the same design in regard to at least one design configuration, wherein design configurations include axial dimension, radial dimension, internal diam-

eter, arc length, gas type, gas composition and gas pressure. The first and second arc discharge lamp may be of the same axial dimension and/or radial dimension. The first and second arc discharge lamp may have the same internal diameter and/or arc length. The internal diameter can be defined as the inner diameter of the envelope, in particular glass envelope, of the arc discharge lamp. The arc length may be defined as the axial distance between the anode and the cathode of a respective arc discharge lamp. The first and second arc discharge lamp may be filled with the same gas or gas composition. The first and second arc discharge lamp may have the same gas pressure. One or more design configurations may differ by up to 20%, in particular up to 10%, more particularly up to 5%, respectively. In an embodiment 10 which may be combined with the aforementioned aspect or embodiments of the invention, the first arc discharge lamp and the second arc discharge lamp are identical in construction. By using arc discharge lamps that are essentially identical, a particularly simple main circuit design can be enabled.

[0018] In an embodiment 11 which may be combined with the aforementioned aspect or embodiments of the invention, the first arc discharge lamp and/or the second arc discharge lamp comprises an external earth plane. The provision of an external earth plane to one or both arc discharge lamps improves the generation of a voltage gradient in the respective arc discharge lamp.

[0019] In an embodiment 12 which may be combined with the aforementioned aspect or embodiments of the invention, the arc discharge lamp system is free of a summer voltage supply. In an embodiment 13 which may be combined with the aforementioned aspect or embodiments of the invention, the arc discharge lamp system is free of an external trigger wire in the vicinity of each arc discharge lamp. In an embodiment 14 which may be combined with the aforementioned aspect or embodiments of the invention, the arc discharge lamp system is free of a series type trigger transformer.

[0020] According to an aspect 2 of the invention, an apparatus is provided, comprising an arc discharge lamp system, the arc discharge lamp system comprising an arc discharge lamp and a trigger transformer connected in series to a first arc discharge lamp and in parallel to a second arc discharge lamp or a diode assembly, a head on which the at least one arc discharge lamp is mounted, and an actuator to move the head relative to a target object. The arc discharge lamp may be provided with an external earth plane. In particular, the arc discharge lamp system may be configured according to the aforementioned aspect 1 or embodiments 2 to 14. The apparatus may be configured for treating the surface of a target object with flash radiation. The apparatus may be configured for manufacturing a composite article from a composite material. The apparatus may be configured for disinfection or decontamination of a target object, such as a medical product, a foodstuff product or a component of a container for a medical product or foodstuff product.

The apparatus may be configured for laser pumping. The apparatus may be configured for intense pulsed light applications, for example hair removal, or UV disinfection. The head, the actuator and/or the entire apparatus may in particular be configured as described in WO 2017 134 453 A1 which is hereby incorporated by reference in its entirety.

[0021] An apparatus for heating and/or curing a target may have an average power of at least 6kW, at least 10 kW or at least 20 kW and/or at most 1 MW, at most 500 kW, at most 100 kW or at most 50kW. An apparatus for driving a laser may have an average power of at least 6kW, at least 10 kW or at least 20 kW and or at most 500 kW, at most 100 kW or at most 50kW. An apparatus for cosmetic or therapeutic treatment, in particular an IPL apparatus, may have an average power of at least 100 W, at least 500 W or at least 900 W and/or at most 5kW, at most 2 kW or at most 1.1 kW. An apparatus for driving a lasers 3 to 50kw (not limited). An apparatus for UV decontamination disinfection be run at a current of up to more than 1000 A at more than 1000 V.

[0022] In an embodiment 15 which may be combined with the aforementioned aspect 2, the trigger transformer is mounted on the head. The head may comprise a housing in which both the trigger transformer and the at least one arc discharge lamp are arranged. Arranging both the at least one arc discharge lamp and the trigger transformer on the head will rigidly mechanically connect the arc discharge lamp and the trigger transformer such that they are moveable together as a unit. The trigger transformer may be arranged in close proximity to the arc discharge lamp to allow for more efficient and less error prone triggering.

[0023] In an embodiment 16 which may be combined with the aforementioned aspect 2 or embodiments of the invention, at least two arc discharge lamps are mounted on the head. In particular the at least two arc discharge lamps are arranged side by side and/or parallel to one another. The arc discharge lamps may have a respective axis of rotation and those axis of rotation may be arranged parallel to one another. The arc discharge lamps may be arranged radially next to each other. The arc discharge lamps may be surrounded by the same reflector and/or ground plane. Alternatively, the arc discharge lamps may be arranged axially next to each other. The arc discharge lamps may be mounted end to end.

[0024] In an embodiment 17 which may be combined with the aforementioned aspect 2 or embodiments of the invention, the trigger voltage is applied to the diode assembly in its reverse direction. The diode assembly may have a reverse breakdown of at least 5kV, in particular at least 10kV. The diode assembly may comprise one or several diode junctions to be capable of carrying the main discharge current of the first arc discharge lamp during flash operation.

[0025] In an embodiment 18 which may be combined with the aforementioned aspect 2 or embodiments of the invention, the trigger transformer comprises a primary

winding and a secondary winding, wherein the secondary winding has a second lead connected at a midpoint between an electrode, particularly the anode or the cathode, of the first arc discharge lamp and to diode assembly. The trigger transformer can be of the design as described for embodiments 4 or 9. The first lead of the secondary winding maybe connected to the main circuit between the diode assembly and the main power supply. The second lead may be connected to the outermost layer of the coil. The second lead may be labelled secondary finish (SF).

[0026] In an embodiment 19 which may be combined with the aforementioned aspect 2 or embodiments of the invention, a capacitor is provided between the secondary winding and the main circuit comprising the first and second arc discharge lamp. The capacitor can be designed corresponding to that of embodiment 6. The capacitor may be arranged on the second lead or on the first lead of the secondary winding.

Flashlamp

[0027] A flashlamp as described herein with relation to the invention generally refers to an arc discharge lamp capable of emitting short light pulses or flashes. A flash lamp may comprise a trigger. A flashlamp produces intense, incoherent light emissions for a short duration of time. The duration of the flash or pulsed light emission may last for at least 0.1 μ s, at least 0.5 μ s, or at least 1.0 μ s. The duration of the flash or pulsed light emission may last for less than 500 ms, less than 200 ms, less than 100 ms, or less than 50 ms μ s. A preferred flash lamp pulse duration may be at least 1 ms and/or at most 20ms.

Arc discharge lamp

[0028] An arc discharge lamp comprises two arcing electrodes, namely a cathode and an anode. The anode and the cathode are contained within a sealed glass envelope (bulb) filled with a gas. The arcing electrodes may be arranged at either end of the bulb. The glass envelope may be made of fused quartz, borosilicate glass or quartz glass. Quartz glass may also be called synthetic silica glass. The gas may be a noble gas, including Argon, Xenon, or Krypton. The flashlamp is filled with a gas that, when triggered, ionizes and conducts a high current pulse to produce the radiation. The radiation may include visible (vis) light. The radiation may include ultraviolet (UV) light. The radiation may comprise infrared (IR) light. The gas within the flashlamp may exhibit extremely high electrical resistance such that the flashlamp will not conduct electricity from the anode to the cathode until the gas is ionized. Once triggered, the gas is ionized, and a spark or arc forms between the electrodes, allowing the voltage supply, particularly the capacitor, to discharge. Arc discharge lamps may be designed and/or controlled for pulsed or continuous operation. An arc discharge

lamp for pulsed operation may be called flashlamp.

Main power supply

[0029] The arc discharge lamp system according to the invention shall comprise a main power supply that may alternatively be called "capacitor charging power supply" or "main energy storage" and which may for example be storage capacitor to be connected to the arcing electrodes of the arc discharge lamp. Power supplies for arc discharge lamps, in particular flashlamps, are commonly known and for example described in "Design Considerations for Triggering of Flashlamps" (2003) by Alex D. McLeod. The main power supply may supply 200 V to 1000 V or even more to the arc discharge lamp system. The main power supply may supply a peak current or flash current of 100 A to 1000 A.

Trigger Transformer

[0030] A trigger transformer comprises two windings, a primary winding and a secondary winding, inductively coupled to one another. The windings may be wound onto a common core made of magnetic material. The core may comprise iron. The core may comprise several layers of iron separated by respective layers of an insulating material. The core may be moulded from a ferrite or an iron power material. The primary winding, in particular of a series type trigger transformer, typically has only one turn. Alternatively, the primary winding, in particular of an external type trigger transformer, may have several turns, such as 20 to 200 turns, in particular 50 to 150 turns or 60 to 100 turns. The secondary winding has to generate a high trigger voltage pulse, typically at least 5 kV or at least 10 kV and/or at most 100 kV or at most 50 kV. It may be preferred that the trigger voltage pulse is at least 20 kV and/or at most 30 kV. In the transformer, the ratio of the voltage (V_P) in the primary winding to the voltage (V_S) in the secondary winding is approximately proportional to the ratio of turns of the primary winding (N_P) to the turns of the secondary winding (N_S):

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

[0031] The trigger transformer thus provides a ratio of at least 1:10, 1:15 or 1:20 and/or at most 1:500, 1:250 or 1:100. Preferably, the ratio may be selected between 1:25 and 1:75, or between 1:40 and 1:60, in particular at 1:50. A relatively high ratio allows a relatively small voltage supplied by a trigger transformer drive circuit to the primary winding to generate a large trigger voltage pulse supplied in the secondary winding sufficiently high to ionize the gas of the arc discharge lamp. Trigger transformers are commonly known and sold as "external type" trigger transformers or "series type" trigger transformers.

[0032] The primary winding of the trigger transformer

is connected to a trigger transformer drive circuit comprising a trigger power supply. A trigger transformer drive circuit as commonly known is for example described in "Design Considerations for Triggering of Flashlamps" (2003) by Alex D. McLeod. The trigger transformer drive circuit may include a pulse generator for generating the primary current to be provided to the trigger transformer's primary winding.

External type trigger transformer

[0033] An external type trigger transformer may be designed for a maximum input voltage of 600 V or less, in particular 500 V or less, more particularly 400 V or less. An external type trigger transformer may be designed for an input voltage of at least 200 V or at least 300 V. An external type trigger transformer may be designed for a peak primary winding current of 150 A or less, in particular 100 A or less, more particularly 80 A or less. An external type trigger transformer may have a diameter or width of 20 mm or less, in particular 16 mm or less. An external type trigger transformer may have a length of 40 mm or less, in particular 35 mm or less.

Series type trigger transformer

[0034] A series type trigger transformer is designed such that the secondary winding of the transformer may repeatedly carry the total current of the flash lamp discharge or peak secondary winding current. A series type trigger transformer may be designed for a peak secondary winding current of at least 100 A, in particular at least 200 A, more particularly at least 500 A. A series type trigger transformer may be designed for a peak primary winding current of up to 10 000 A or up to 2000 A. The secondary winding resistance of a series type trigger transformer may be less than 0,5 Ohm, in particular less than 0,25 Ohm. The secondary winding resistance of a series type trigger transformer may be between 1 Ohm and 0,01 Ohm. The primary winding resistance of a external type trigger transformer may be much higher, typically 10 or 100 Ohms.

[0035] The Ampere (A) value of the current through lamp and possibly a series type trigger transformer secondary winding may be designated in A RMS (Amperes Root Mean Square). This A RMS current value is proportional the heating effect in a conductor, therefore it determines the maximum current that a conductor (e.g. transformer winding) can safely carry. The RMS root mean square calculation is commonly known in the art. For example, with a sine wave the RMS is considered 1.1 x average. In typical flashlamps with significantly peaking current (low mark space ratio), the RMS value may be much higher than the average. With a continuous DC lamp the RMS value may be equal to the constant current.

Ultraviolet (UV) light

[0036] An arc discharge lamp system according to the invention may emit ultraviolet radiation or light. According to DIN 5031-7, ultraviolet (UV) radiation refers to wavelengths from 10 nm to 380 nm. UV-A radiation may refer to ultraviolet light in the range of 315 to 380 nm. UV-B radiation may refer to the range of 280 to 315 nm. UV-C radiation may refer to the range of 100 to 280 nm. EUV radiation may referred to the range of 10 nm to 121 nm.

Visible (vis) radiation

[0037] An arc discharge lamp system according to the invention may emit visible radiation or light. According to DIN 5031-7, visible (vis) radiation refers to wavelengths from 380 to 780 nm. Visible light may be divided into violet (380 to 420 nm), blue 420 to 490 nm), green (490 to 575 nm), yellow (575 to 585 nm), orange (585 to 650 nm) and red light (650 to 750 nm).

Infrared (IR) light

[0038] An arc discharge lamp system according to the invention may emit infrared radiation or light. According to DIN 5031-7, infrared (IR) radiation refers to wavelengths from 780 nm to 1 000 000 nm. IR-A radiation may refer to ultraviolet light in the range of 780 to 1400 nm. IR-B-radiation may refer to the range of 1400 to 3000 nm. Near infrared may refer to IR-A and IR-B radiation. UV-C radiation may refer to the range above than 3000 nm. UV-C radiation may be divided into mid wavelength IR (3 to 8 μm), long-wavelength IR (8 to 15 μm) and far infrared (15 μm to 1 mm).

[0039] Unless otherwise indicated, the terms "light" and "radiation" may be used interchangeably herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] The following schematic drawings show aspects of the invention for improving the understanding of the invention in connection with some exemplary illustrations, wherein

- Figure 1 shows an exemplary embodiment of arc discharge lamp system in accordance with the invention;
- Figure 2 shows a second exemplary embodiment of arc discharge lamp system in accordance with the invention;
- Figure 3 shows an exemplary embodiment of an apparatus including arc discharge lamp system in accordance with the invention; and
- Figure 4 shows another embodiment of an arc discharge lamp system useable in the apparatus according to the invention.

DETAILED DESCRIPTION

[0041] An arc discharge lamp system according to the invention is generally designated with the reference numeral 1. The arc discharge lamp system 1 comprises as its main constituents at least one arc discharge lamp 3, 5 and a trigger transformer 7 for triggering said arc discharge lamp 3, 5. For ease of comprehension, the same or similar reference numerals are used in the following description of the preferred embodiments to designate the same or similar components. Also for ease of comprehension, in the following description of preferred embodiments, the first and second lamps will generally be referred to as first flashlamp 3 and second flashlamp 5.

[0042] Figure 1 shows a first exemplary embodiment of an arc discharge lamp system 1a according to the invention. The arc discharge lamp system 1a comprises a first flashlamp 3 and a second flashlamp 5, both of which are connected in series to the main power supply 9. Each flashlamp 3, 5 comprise a respective pair of arcing electrodes 31 and 33 or 51 and 53, namely an cathode 31, 51 and an anode 33, 53. The electrodes of the respective flashlamp 3, 5 are contained within a glass envelope 35, 55 which is filled with a gas, preferably a noble gas, in particular Xenon.

[0043] The arc discharge lamp system 1a comprises a singular trigger transformer 7 for triggering both the first flashlamp 3 and the second flashlamp 5. The trigger transformer 7 comprises a first winding 71 and a secondary winding 72. The number of turns of the secondary winding is significantly larger than the number of turns of the first winding 71. For example, the first winding 71 may have exactly one turn ($N_P = 1$) and the second winding 72 may have 50 turns ($N_S = 50$).

[0044] The primary winding 71 of the trigger transformer 7 is connected to a trigger transformer drive circuit 19. The trigger transformer drive circuit 19 includes a pulse generator for providing a primary voltage pulse. In the trigger transformer 7, the primary voltage pulse V_P is transformed in a secondary voltage pulse V_S in the secondary winding 72 of a much larger magnitude than that of the primary voltage pulse, wherein the amplification can be similar or approximately equal to the ratio of the number of turns of the secondary winding (N_S) to the number of turns (N_P) of the primary winding 71. The skilled person is aware that with fast pulse transformers, the relation may be dependent on additional factors such as inter turn capacitance. A primary pulse V_P of 200 V could thus be turned by a trigger transformer 7 having a ratio of 1:50 to a 10,000 V secondary voltage pulse V_S , sufficiently high to provide a voltage gradient to the flash-tube to cause ionization of the gas therein such that the voltage supplied in the main circuit or serial circuit 10 can flow, discharging the main power source and causing a pulsed radiation of the flashlamp 3, 5.

[0045] In order to transfer the secondary voltage pulse to the serial circuit 10 including the first flashlamp 3 and the second flashlamp 5, the leads 73, 74 of the secondary

winding 72 are connected to the serial circuit 10. In the exemplary embodiment shown in figure 1 of the arc discharge lamp system 1a, the secondary winding 72 of the trigger transformer 7 are connected in series to the second flashlamp 5 and in parallel to the first flashlamp 3 in relation to the main power source 9. In relation to the trigger transformer 7, the first flashlamp 3 and the second flashlamp are connected in parallel, as the main power source 9 can be considered to act as a short circuit for the high frequency trigger pulses.

[0046] The embodiment of figure 2 of an arc discharge lamp system 1 to be differs from the first pulsed light sums 1 of the only in that the trigger transformer 7 is connected in parallel to the second flashlamp 5 and in series to the first flashlamp 3 in relation to the main power source 9. Also in the embodiment of figure 2, the first flashlamp 3 and the second flashlamp are connected in parallel. In relation to the trigger transformer 7, as the main power source 9 can be considered to act as a short circuit for the high frequency trigger pulses.

[0047] The secondary winding 72 of the trigger transformer 7 has a second lead 73 connected to the midpoint 11 between the cathode 31 of the first flashlamp 3 and the anode 53 of the second flashlamp 5.

[0048] It shall be noted, that the terms anode and cathode as used herein refer to the arrangement of the flashlamps 3, 5 in the series circuit 10 in relation to the main power source 9. The trigger transformer drive circuit 19 can provide a current flow in the same direction as that of the serial circuit or in the opposite direction. The circuitry of the trigger transformer drive circuit 19 and of the power supply circuit 9 can be adapted accordingly as is known by the person skilled in the art. In an advantageous embodiment, the trigger transformer drive circuit 19 can provide a current alternating in direction and/or polarity. In a preferred embodiment, a repetitive pulse train may be used for triggering, in particular using a typ 50 Hz supply.

[0049] In the embodiments of arc discharge lamp systems 1a and 1b shown in figure 1 and 2, respectively, a capacitor 8 is provided between the secondary winding 72 and the serial circuit 10. While the capacitor 8 is shown in figures 1 and 2 to be arranged on the second lead 73 of the secondary winding 72, which connects to the midpoint 11 between the flashlamps 3 and 5, the capacitor could alternatively be arranged on the first lead 74. In the embodiment shown in figure 1, the first lead 74 of the secondary winding 72 connects to the anode 33 of the first flashlamp 3. In the second embodiment of an arc discharge lamp system 1b showing figure 2, the first lead 74 of the secondary winding 72 connects to the cathode 51 of the second flashlamp 5.

[0050] The capacitance of the capacitor 8 be selected between 1 nF and 10 μ F. In particular, the capacitance shall be selected between 0.1 μ F and 5 nF. Particularly, the capacitance may be selected to be approximately 0.01 μ F. The provision of a capacitor 8 may be advantageous to promote the coupling of a fast trigger voltage

pulse to the lamps and/or to decouple the flash pulses or DC current of the serial conduit 10 from the trigger transformer 7.

[0051] Each flashlamp 3, 5 may be provided with a respective external earth plane 13, 15. In a preferred embodiment, the earth plane 13, 15 of both flashlamps 3, 5 may be the same. An external earth plane may be advantageous to increase the formation of the voltage gradient for triggering the flashlamps.

[0052] Figure 3 shows the apparatus 100 comprising an arc discharge lamp system 1, a head 101 on which the arc discharge lamp system one is mounted, and an actuator 103 to move the head 101 relative to a target object 105. In particular, the apparatus may be configured for manufacturing a composite article from a composite material, wherein the target object 105 would be the composite material and be heated and/or cured to form a composite article by the apparatus 100 using pulsed lighting.

[0053] In a preferred embodiment, such an apparatus 100 can be the apparatus or apparatus described in WO 2017 134 453 A1, which is hereby incorporated by reference in its entirety. Especially in such an apparatus including a head 101 that may be desired to move and/or accelerate rapidly, the use of a lightweight and small size arc discharge lamp system 1 providing a sufficiently large lighting output may be advantageous.

[0054] The arc discharge lamp system 1 of the apparatus 100 may be the arc discharge lamp system in accordance with the first aspect of the invention as described for instance in connection with the exemplary embodiment of arc discharge lamp systems 1a or 1b in relation to figure 1 and figure 2. Alternatively, the arc discharge lamp system 1 of the apparatus according to the second aspect of the invention might be an arc discharge lamp system 1c as shown in figure 4.

[0055] In the arc discharge lamp system 1c according to figure 4, exactly one flashlamp 3 may be provided and a trigger transformer 7 connected in series to said flashlamp 3 in series and in and in parallel to a diode assembly 17.

[0056] The diode assembly 17 allows for an external type trigger transformer 7 to be used, which is lighter, smaller and cheaper than a series type trigger transformers currently used, so that such an arc discharge lamp system of 1c would enable the apparatus 100 to avoid the use of the series type trigger transformer using cheaper and lighter components instead, without having to sacrifice additional space for an external trigger. The trigger transformer 7 may be mounted on the head 101 of the apparatus 100 as well.

[0057] An apparatus comprising two flashlamps 3 and 5 may advantageously be designed such that both flashlamps 3, 5 are mounted on the head 101 of the apparatus 100. In particular, the at least two flashlamps 3, 5 on the head 101 may be arranged parallel to one another. Arranging flashlamps with their axis of rotation parallel to one another on the head 101 allows to easily concentrate

the light emission of multiple lamps onto a target object 105 and/or into a light guide 107.

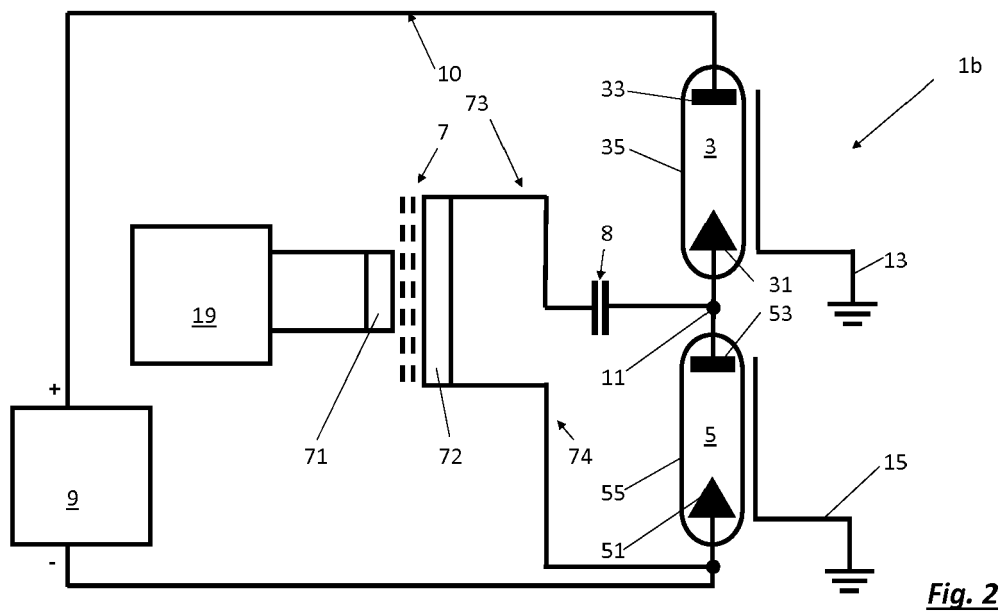
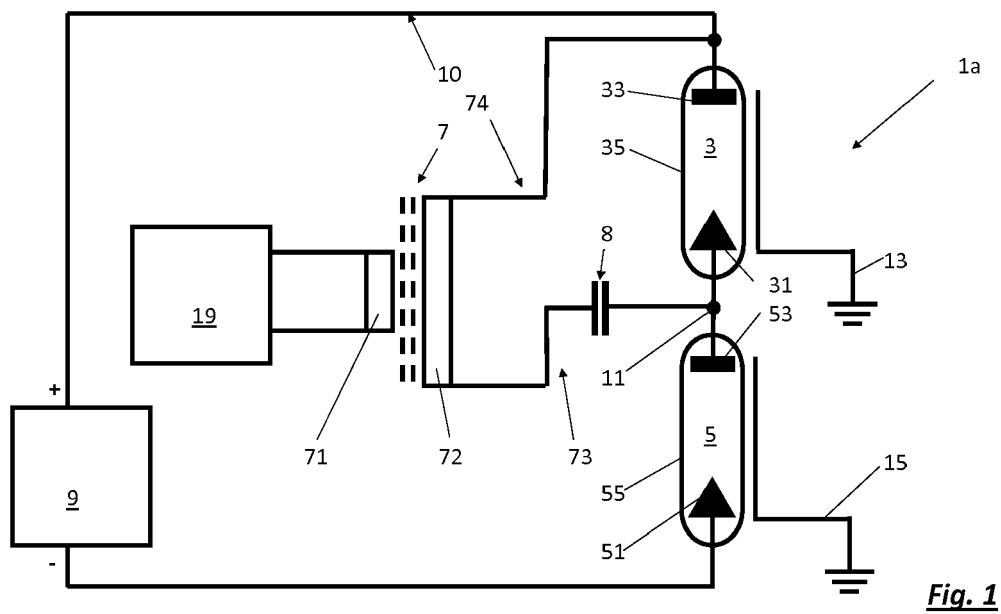
[0058] Turning now to the arc discharge lamp system 1c shown in figure 4, the trigger voltage secondary voltage pulse VS shall be applied to the diode assembly 17 in in the reverse direction of the diode assembly 17. Preferably, the diode assembly 17 has a reverse breakdown of at least 5 kV, in particular at least 10 kV. The diode assembly 17 may comprise one or more diode junctions such that the diode assembly 17 is capable to carry the main discharge current of the flashlamp 3.

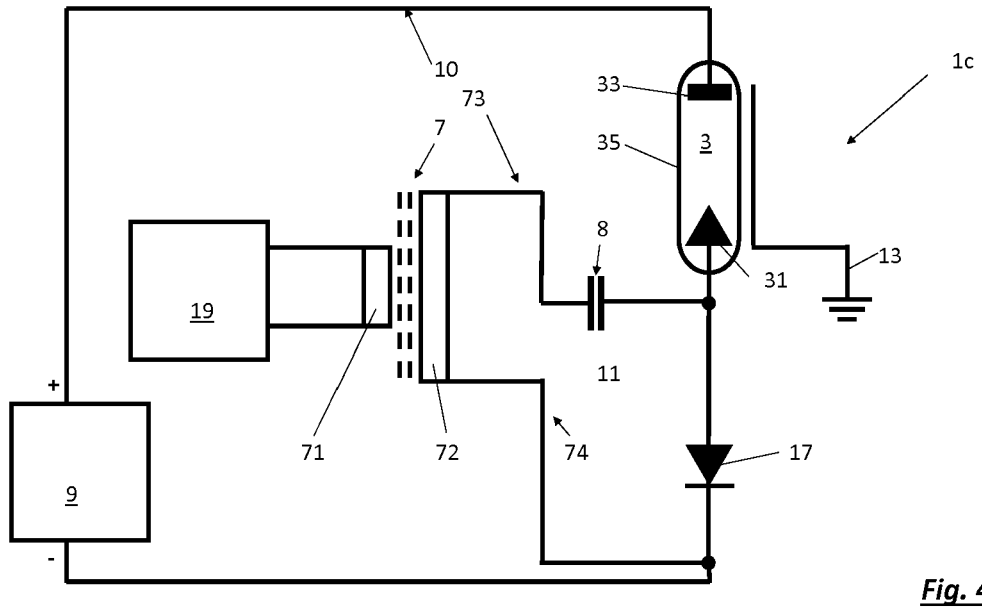
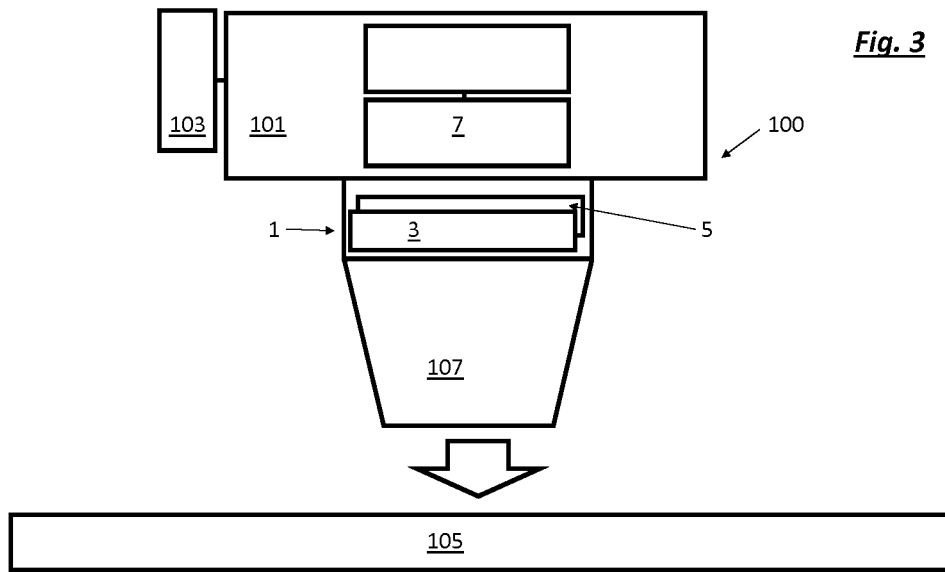
[0059] The features disclosed in the claims, the specification, and the drawings maybe essential for different embodiments of the claimed invention, both separately and in any combination with each other.

Claims

1. A arc discharge lamp system (1, 1a, 1b) comprising a first arc discharge lamp (3), a second arc discharge lamp (5) and one trigger transformer (7) for triggering both the first arc discharge lamp (3) and the second arc discharge lamp (5).
2. The arc discharge lamp system (1, 1a, 1b) of claim 1, wherein the first arc discharge lamp (3) and the second arc discharge lamp (5) are connected in series to one main power supply (9).
3. The arc discharge lamp system (1, 1a, 1b) of claim 1 or 2, wherein the trigger transformer (7) comprises at a primary winding (71), particularly including at least one turn, and a secondary winding (72), particularly including multiple turns, wherein the secondary winding (72) has a second lead (73) connected at a midpoint (11) to a cathode (31) of the first arc discharge lamp (3) and to an anode (53) of the second arc discharge lamp (5).
4. The arc discharge lamp system (1, 1a, 1b) of claim 3, wherein the secondary winding (72) has a first lead (74) connected to an anode (33) of the first arc discharge lamp (3) or a cathode (51) of the second arc discharge lamp (5).
5. The arc discharge lamp system (1, 1a, 1b) of one of the preceding claims, wherein a capacitor (8) is provided between the secondary winding (72) and the main circuit (10) comprising the main power source (9), the first arc discharge lamp (3) and the second arc discharge lamp (5).
6. The arc discharge lamp system (1, 1a, 1b) of claims 3 or 4 and 5, wherein the capacitor (8) is provided between the second lead (73) of the secondary winding (72) and the midpoint (11).

7. The arc discharge lamp system (1) of claims 3 or 4 and 5, wherein the capacitor (8) is provided between the first lead (74) of the secondary winding (72) and the first arc discharge lamp (3) or the second arc discharge lamp (5). 5
8. The arc discharge lamp system (1, 1a, 1b) of one of the preceding claims, wherein the trigger transformer (7) is an external type trigger transformer. 10
9. The arc discharge lamp system (1, 1a, 1b) of one of the preceding claims, wherein the first arc discharge lamp (3) and the second arc discharge lamp (5) are identical in construction. 15
10. The arc discharge lamp system (1, 1a, 1b) of one of the preceding claims, wherein first arc discharge lamp (3) and/or the second arc discharge lamp (5) comprises an external earth plane (13, 15). 20
11. The arc discharge lamp system (1, 1a, 1b) of one of the preceding claims, wherein the arc discharge lamp system (1, 1a, 1b) is free of a simmer voltage supply and/or free of an external trigger wire in the vicinity of each arc discharge lamp. 25
12. An apparatus (100) comprising an arc discharge lamp system (1, 1a, 1b, 1c) in particular according to one of the preceding claims, the arc discharge lamp system (1, 1a, 1b, 1c) comprising an arc discharge lamp and a trigger transformer (7) connected in series to a first arc discharge lamp (3) and in parallel to a second arc discharge lamp (5) or a diode assembly (17), a head (101) on which the at least one light source (1, 1a, 1b, 1c) is mounted, and an actuator (103) to move the head relative to a target object (105). 30 35
13. The apparatus (100) of claim 12, wherein the trigger transformer (7) is mounted on the head (101). 40
14. The apparatus of claim 12 or 13, wherein at least two arc discharge lamps (3, 5) are mounted on the head, wherein in particular the at least two arc discharge lamps (3, 5) are arranged parallel to one another. 45
15. The apparatus of one of the claims 12 to 14, wherein the trigger voltage is applied to the diode assembly (17) in its reverse direction, wherein the diode assembly having a reverse breakdown of at least 5kV and/or wherein the diode assembly (17) comprises several diode junctions to carry a main discharge current of the first arc discharge lamp (3). 50 55







EUROPEAN SEARCH REPORT

Application Number
EP 19 16 0209

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 3 846 811 A (NAKAMURA Z ET AL) 5 November 1974 (1974-11-05)	1-11	INV. H05B41/32
A	* column 7, line 31 - line 60; figure 8 *	12-15	
Y,D	WO 2017/134453 A1 (HERAEUS NOBLELIGHT LTD [GB]) 10 August 2017 (2017-08-10)	12-15	
A	* pages 5, 6, 21; figures 9,11 *	1-11	
Y,D	Alex D. Mcleod: "Design Considerations for Triggering of Flashlamps", 4 August 2004 (2004-08-04), XP055442151, Retrieved from the Internet: URL:https://web.archive.org/web/20040804204513/http://optoelectronics.perkinelmer.com:80/content/whitepapers/TriggeringFlashlamps.pdf [retrieved on 2018-01-18] * page 8 - page 8; figures 4B, 5B *	12-15	
A	US 3 914 648 A (FRIEDMAN HERBERT W ET AL) 21 October 1975 (1975-10-21) * column 3 - column 5; figure 1 *	1-15	TECHNICAL FIELDS SEARCHED (IPC)
X	US 3 723 887 A (PANICO J) 27 March 1973 (1973-03-27) * line 32 - line 47; figures 2, 2a, 3 *	1,3-11	H05B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 July 2019	Examiner Erskine, Andrew
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-15

Arc discharge lamp system and apparatus

1.1. claims: 1-11(completely); 12-15(partially)

Arc discharge lamp system and apparatus using only one trigger transformer to trigger two arc discharge lamps

1.2. claims: 12-15(partially)

Apparatus comprising an arc discharge lamp using a trigger transformer in parallel with a diode assembly.

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-07-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO 2017134453 A1	10-08-2017	BR 112018015746 A2 CA 3013451 A1 CN 108602212 A EP 3411210 A1 JP 2019507693 A KR 20180107222 A US 2018339434 A1 WO 2017134453 A1	08-01-2019 10-08-2017 28-09-2018 12-12-2018 22-03-2019 01-10-2018 29-11-2018 10-08-2017
US 3914648 A	21-10-1975	NONE	
US 3723887 A	27-03-1973	NONE	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2017134453 A1 [0002] [0020] [0053]

Non-patent literature cited in the description

- **ALEX D. MCLEOD.** *Design Considerations for Triggering of Flashlamps*, 2003 [0003] [0029] [0032]