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H. E. EDGERTON ET AL

3,148,307

FLASH LAMP

Filed May 18, 1961

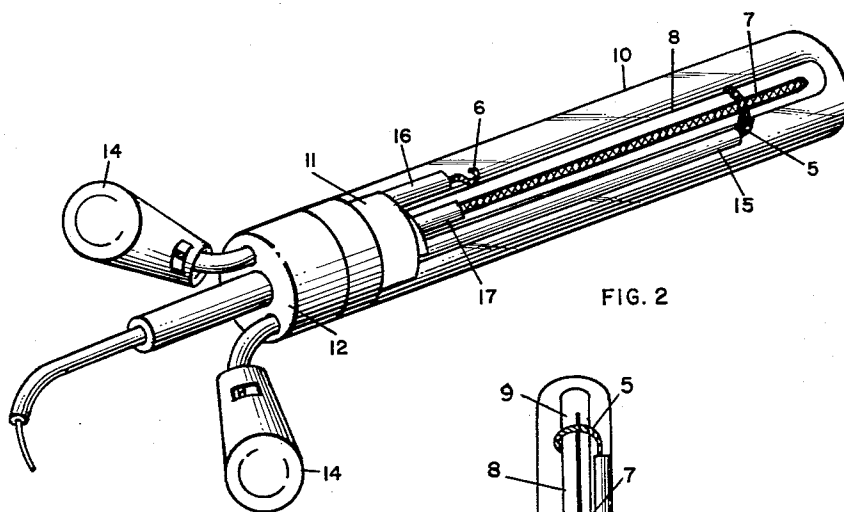


FIG. 2

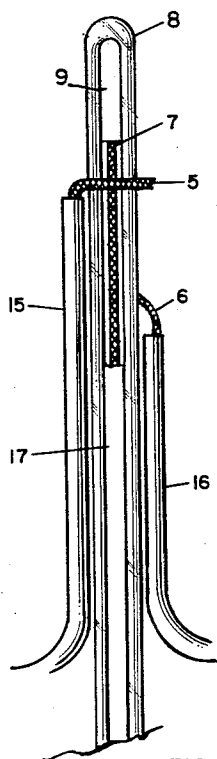
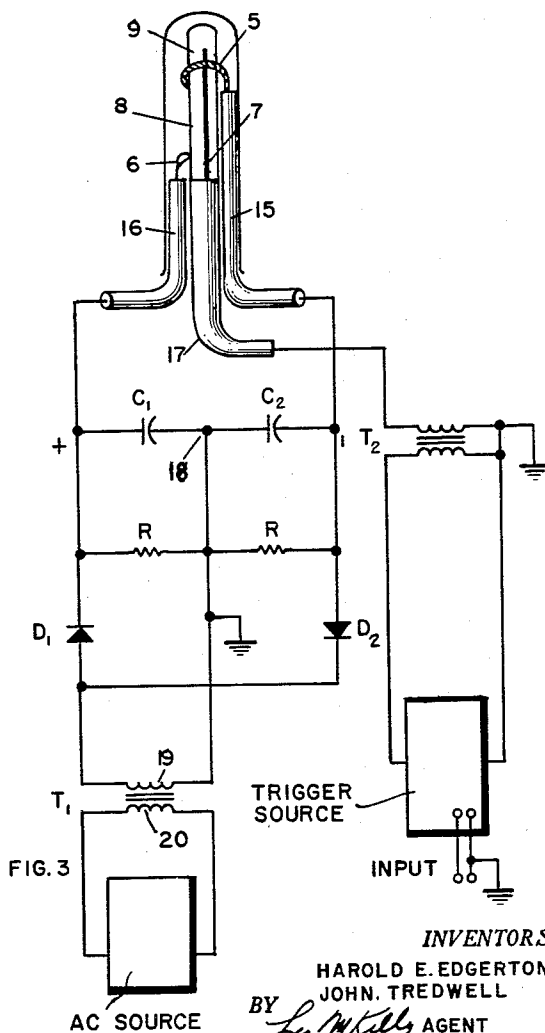


FIG. 1



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1

2

3,148,307

FLASH LAMP

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9 Claims. (Cl. 315-237)

This invention relates to electric-discharge lamps and more particularly to guided air sparks as sources of illumination.

Guided air sparks are well known in the art as sources of high intensity, short-duration light flashes for use in ballistic photography and other similar applications where extremely short duration flashes are required. The theory and some experimental applications of guided air sparks may be found in the paper entitled "New Developments in Guided Air Sparks" by E. P. Tawil, published by Academic Press, Inc., New York, N.Y., under the title "Proceedings of the Third International Congress on High-Speed Photography," pages 9 to 13 inclusive, and in the article entitled "Simple Electronic Devices for High-Speed Photography and Cinematography," by P. Fayolle and P. Naslin, published in vol. 5 (1954) of "High-Speed Photography," Society of Motion Picture and Television Engineers.

Briefly, the principle of guided air sparks is to impose a high voltage between two principal electrodes which are spaced from each other, in air, a distance such that it is impossible for a discharge to pass between them. In the prior art, each of the principal electrodes was a circular element surrounding an insulating member. One of the principal electrodes was connected to a high-voltage source while the other was grounded. A trigger electrode was mounted within the insulating member extending the full distance between the principal electrodes. The trigger electrode was connected through a large resistor to the principal electrode having the high voltage. The lamp was fired by rapidly dropping the voltage of the trigger electrode to ground, thereby causing shock ionization of the air at the surface of the insulating member between the principal electrodes with the result that a high-intensity of light flash of very short duration was produced.

The prior-art lamps employing this principle were complicated and expensive devices which were large and awkward, rendering them unsuitable to commercial units, and particularly, portable models. One major disadvantage of the prior-art lamps was that they could not be readily used with parabolic reflectors because the geometry of these lamps was such that external connections had to be made to both ends of the lamp. Another disadvantage of prior-art lamps was a short life due to shattering of the insulator, housing the trigger electrode, from the shock wave formed by the triggering action. A further disadvantage was that the trigger potential was limited to the maximum potential between the principal electrodes.

It is, therefore, an object of this invention to provide a guided air spark lamp which produces high-intensity short-duration light flashes but which is not subject to the aforementioned disadvantages.

Another object of this invention is to provide such a lamp wherein all external connections are made to one end thereby permitting it to be readily mounted in a parabolic reflector.

A further object is to provide a lamp of such simple construction that it may be quickly and easily repaired and rebuilt by the user.

Still another object of the invention is to provide such a lamp having an increased life.

Still a further object is to provide a removable trigger electrode connected to a much higher source of potential than that across the principal electrodes.

Other and further objects will be hereinafter explained and will be more particularly pointed out in the appended claims. In summary, the invention may be described as a guided air spark flash lamp having a pair of principal electrodes spaced from each other along an insulating member containing an elongated trigger electrode. All the leads connecting the electrodes to points outside the lamp are insulated from each other and so disposed to minimize the possibility of arcing while bringing them out one end of the flash lamp.

The invention will now be discussed in terms of the accompanying drawings, FIGURE 1 of which is a parallel perspective view of a preferred embodiment of the invention;

FIGURE 2 is a perspective view of the embodiment shown in FIGURE 1, enclosed in a protective envelope; and

FIGURE 3 is a schematic diagram showing the flash device and its associated circuitry.

Referring to FIGURES 1 and 2, the invention is shown in a preferred embodiment wherein an anode electrode 5 is shown spaced from a cathode electrode 6 along the outer surface of a hollow insulating member 8, for example, a glass or quartz tube. Within the hollow portion 9 of member 8, a trigger electrode 7 is disposed extending adjacent to the spacing between the anode 5 and the cathode 6. Cathode 6, the uninsulated wire end of an insulated conductor 16, is shown horseshoe-shaped to eliminate corona effect, and touching insulating member 8 for reasons hereinafter set forth. Similarly, the anode 5 is the uninsulated wire end of an insulated conductor 15. Conductor 15 is disposed on the opposite side of member 8 from conductor 16 to reduce the possibility of arcing. Anode 5 encircles member 8 in order to provide structural support for the anode and to position a portion of the anode 5 on the same side of member 8 as the cathode 6. By so doing, the shortest discharge path between the principal electrodes 5 and 6 is a straight line along the surface of member 8. For maintaining the principal electrodes 5 and 6 and the insulating member 8 in position, a means of securing conductors 15 and 16 and member 8 together, such as insulative tape 11, may be used. The trigger electrode 7 may be potted in an insulating material instead of the glass or quartz tube 8 or any similar means of insulating the trigger electrode from the principal electrodes may be employed.

The trigger electrode 7 is the uninsulated wire end of insulated conductor 17. The diameter of the insulated conductor 17 is chosen so that it is substantially the same as the inside diameter of hollow member 8. Thus, the trigger electrode 7 is held in position by friction when insulated conductor 17 is inserted into the hollow interior of member 8. By holding the trigger electrode in position by friction, it is obvious that the trigger electrode 7 and conductor 17 may be readily removed from member 8 and a new such trigger electrode 7 and conductor 17 may be inserted without deleterious effects upon the flash lamp. In this way different trigger pulse sources may easily be used.

Although it is not at all necessary for the operation of the lamp, a translucent envelope 10 (FIGURE 2) of glass or the like, may be positioned about the lamp to protect persons from the high voltage discharge between the cathode 6 and anode 5, and to provide additional structural stability as well as acoustical treatment to reduce noise. When this envelope 10 is used, a plug 12 with

openings for holding conductors 15 and 16, and member 8 in position may be placed in the base of the envelope. The plug 12 does not seal the envelope into an air-tight chamber and, thus, the air within the envelope equalizes to atmospheric outside the envelope.

The ends of the anode and cathode conductors 15 and 16 external to the lamp are made short, each ending in a clamp 14 for direct connection to a discharge-capacitor terminal. By making the leads short between the capacitor and electrodes, loss of potential due to the impedance of the connectors is reduced.

The danger of arcing within the lamp is reduced by bringing the three insulated conductors 15, 16 and 17 out of the lamp in a linear arrangement where the insulation of each conductor, the spacing between adjacent conductors, and the insulation of the extension of member 8 all contribute to the electrical stability of the tube.

FIGURE 3 shows a circuit designed for operating the flash lamp of FIGURE 1. Discharge capacitors C_1 and C_2 are connected across the principal electrodes 5 and 6 by means of conductors 15 and 16. Capacitors C_1 and C_2 are charged from a source of alternating current potential through power transformer T_1 and rectifying means such as diodes D_1 and D_2 . One end of the secondary winding 19 of transformer T_1 is connected to ground while the other end is connected to the rectifying means. A point 18, intermediate the two capacitors C_1 and C_2 is also grounded. Resistors R , of high ohmic values, are used to shunt capacitors C_1 and C_2 to ground. Trigger electrode 7 is connected to a source of triggering impulses by conductor 17 through trigger transformer T_2 .

As an example, the flash lamp may have a spacing of 1 inch between the principal electrodes 5 and 6. Using capacitors C_1 and C_2 of 0.1 microfarad with a 10-kilovolt rating and shunt resistances R of 10 megohms, a 115-volt, 60-cycle A.-C. power supply energizes the primary winding 20 of power transformer T_1 . Secondary winding 19 steps up the voltage and feeds it to the diode rectifiers D_1 and D_2 . The high positive voltage (+8 kv.) passes through diode D_1 and the high negative voltage (-8 kv.) passes through diode D_2 . Capacitors C_1 and C_2 are connected across this voltage gradient of 16 kv. and are charged therefrom. The 16 kv. voltage difference is applied across the principal electrodes 5 and 6 of the flash lamp, but cannot possibly discharge therebetween because the gap spacing between the principal electrodes is one inch. Arcing is prevented at other points in the lamp by separation and insulation as previously pointed out.

The flash lamp can, however, be discharged by energizing trigger electrode 7 with a high voltage pulse. The source of the trigger pulse may be of the type described in United States Letters Patent No. 2,478,901, issued to applicant Edgerton on August 16, 1949. Such a trigger source may be activated by sound waves entering a microphone, light waves striking a photocell, electrical signals from other equipment, or by closure of contact members of a switch. Microphones and photocells are particularly useful in ballistics photography where the sound and light flash produced by the discharge of the weapon may be used to activate the trigger source thereby flashing the lamp. A high voltage triggering impulse, say of the order of 2 kilovolts is connected to the primary of trigger transformer T_2 . The trigger pulse is stepped up in the secondary winding to a very high voltage spike (70 kv. in this example) which is connected to trigger electrode 7. The trigger pulse causes a shock wave to be produced which passes through the insulating member 8. The air at the surface of the member 8 is shock ionized, thereby reducing the impedance between the principal electrodes 5 and 6 so that the charge on capacitors C_1 and C_2 may pass therebetween, producing a brilliant short-duration light flash. In the above example, with the flash lamp mounted in a 7-inch diameter,

parabolic reflector, a peak 50 million beam-candle-power flash of approximately one-half microsecond duration is produced.

A flash lamp such as that described above has been life tested and flashed 8,000 times without damage to any of the flash lamp elements.

By using air as the discharge medium rather than one of the gases usually employed in gas-filled electronic flash lamp, after-glow is greatly reduced thereby providing a flash of shorter duration. For example, flash lamps using air as the gaseous discharge medium are characterized as having about one-fifth the after-glow as compared to a similar flash lamp using xenon. The after-glow is even further reduced when the flash lamp is used at reduced atmospheric pressures such as at altitudes where the air is substantially less dense. This is another advantage of not sealing the lamp so that even when it is used in the protective envelope 10 the air pressure within and without the lamp is the same.

By not sealing the lamp, the effect of the shock-waves associated with sudden discharges is considerably attenuated with the resulting beneficial effect that the lamp is not subject to deterioration in the same degree as sealed lamps thereby increasing the life of the lamp.

The construction of the flash lamp is so simple that it can be repaired and rebuilt readily from easily obtainable parts. Although the above-mentioned life test showed a long and useful life, it is obvious that every such lamp will not be equally successful. The element which is most vulnerable is the insulating member 8 which is subjected to great shock. In the event of a malfunction of this or any other element, the lamp may be easily rebuilt.

A hollow glass or quartz tube, preferably sealed at one end, may be used for the insulating member 8. Insulated wire conductors, for example single strand, 14-gage electrical wiring may be used for conductors 15, 16 and 17. By removing the insulation from the ends of the wiring, the conductors serve as electrodes. The anode electrode 5 is bent to encircle the rod while the cathode electrode is bent back on itself and inward to rest on the rod. The cathode 6 and anode 5 are separated from each other by one inch. The uninsulated end of the trigger wire within the rod extends at least this full one-inch distance. The anode wire 15 and the cathode wire 16 are taped to rod 8 to hold them in position, and are maintained on opposite sides of the rod 8. A glass envelope 10, such as a test tube may be placed over the tube elements and a spacer, such as a rubber plug 12, may be mounted in the opening of the test tube to keep the elements of the flash lamp and the test tube in position. Three holes in the plug 12, allow the passage of the rod 8 and conductors 15 and 16 out of the envelope.

From the foregoing it can be seen that this flash lamp is not only an efficient source of very brilliant, short-duration light flashes but it a simple device, easy and inexpensive to manufacture and repair. No expensive gases or tube sealing apparatus is required.

Further modifications will occur to those skilled in the art and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

We claim:

1. A flash lamp comprising:

an elongated, hollow insulating member having a side wall;

a pair of spaced principal electrodes disposed in air adjacent the outer surface of the side wall of the insulating member forming a discharge path therebetween in close proximity to the side wall of the member;

an elongated trigger electrode disposed within the insulating member substantially parallel to said discharge path but separated therefrom by the side wall of the insulating member;

5

means for maintaining said principal electrodes and said trigger electrode in position;

a pair of insulated conductors disposed on opposite sides of and substantially parallel to said member, said conductors separately connecting the principal electrodes to opposite sides of a source of potential normally ineffective to produce a discharge to pass between the spaced principal electrodes but which, when effective, causes a discharge therebetween producing a momentary brilliant flash of light; and
a third insulated conductor connecting said trigger electrode to a source of a high-voltage triggering impulse sufficient to shock ionize the air on the surface of the member in the region of the discharge path between the principal electrodes thereby rendering the lamp effective to produce the said discharge between the principal electrodes.

2. A flash lamp as claimed in claim 1 in which both principal electrodes are in physical contact with the outer surface of the side wall of the insulating member.

3. A flash lamp as claimed in claim 2 in which the trigger electrode is substantially co-extensive with the said discharge path between the principal electrodes.

4. A flash lamp as claimed in claim 3 in which the principal electrodes are a terminal portion of each of said pair of conductors extending beyond its insulation.

5. A flash lamp as claimed in claim 3 in which the trigger electrode is a terminal portion of said third conductor extending beyond its insulation.

6. A flash lamp as claimed in claim 5 in which the trigger electrode is removeable and replaceable without damage to the lamp or any of its parts.

7. A flash lamp as claimed in claim 4 in which one of the principal electrodes is curved about the insulating member so that at least one point on said one of the principal electrodes lies on a straight line along the surface of said member and which passes through a point on the other principal electrode.

8. A flash lamp comprising:

a hollow insulating member;

a pair of insulated conductors disposed on opposite

6

sides of and substantially parallel to said member and terminating at different points along said member, the opposite ends of said conductors being connected across a source of potential;

a first principal electrode formed by the uninsulated wire end of the longer of said pair of conductors curved about and in contact with the surface of said member;

a second principal electrode formed by the uninsulated wire end of the shorter of said pair of conductors and touching the surface of said member, said principal electrodes so positioned that a straight line along the surface of said member passing through a point on the second principal electrode also passes through a point on the first principal electrode, said principal electrodes spaced from each other a distance such that said source of potential is ineffective in discharging across said electrodes;

a third insulated conductor disposed removeably within said member and having an uninsulated wire end forming a trigger electrode substantially co-extensive with the space between the principal electrodes, said conductor being connected at its other end to a source of a high-voltage triggering impulse sufficient to shock ionize the air on the surface of the member in the region between the principal electrodes thereby permitting the said source of potential to discharge between the principal electrodes resulting in a momentary, brilliant flash of light; and

means for maintaining the said pair of insulated conductors and said member with said third conductor therein in the aforesaid position relative to each other.

9. A flash lamp as claimed in claim 8 in which the lamp is enclosed in a translucent envelope with all connectors passing through one end thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,716,198 McCallum ----- Aug. 23, 1955

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,148,307

September 8, 1964

Harold E. Edgerton et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 59, for "friciton" read -- friction --;
column 3, line 5, after "atmospheric" insert -- pressure --.

Signed and sealed this 2nd day of March 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents