June 14, 1966 C. H. KELLER ET AL 3,256,459

ARC LAMP AND METHOD

Filed Feb. 15, 1963 2 Sheets-Sheet 1

Fig. 1

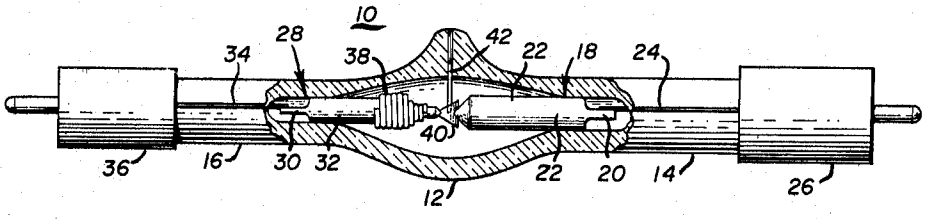
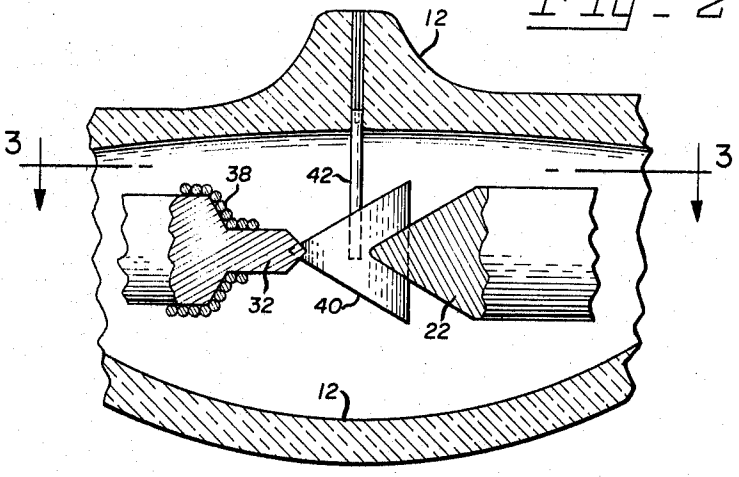


Fig. 2



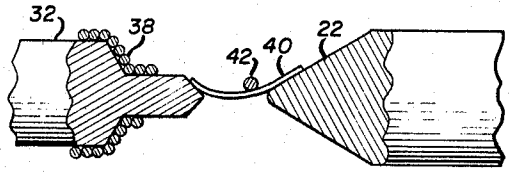


Fig. 3

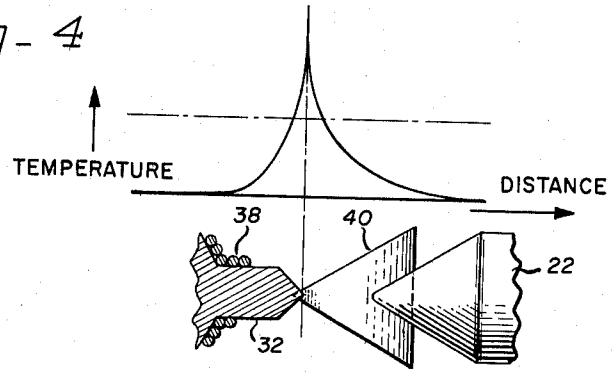
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June 14, 1966 C. H. KELLER ET AL 3,256,459

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Filed Feb. 15, 1963 2 Sheets-Sheet 2

Fig - 4



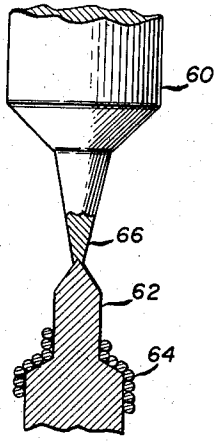


Fig - 5

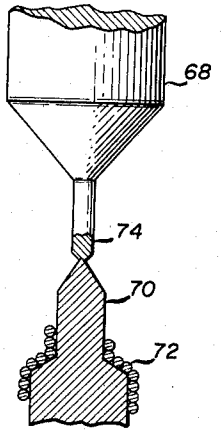
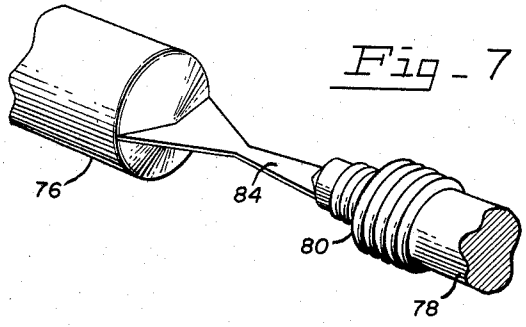


Fig - 6

Fig - 7



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United States Patent Office 3,256,459 Patented June 14, 1966

3,256,459

ARC LAMP AND METHOD

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Filed Feb. 15, 1963, Ser. No. 258,717
12 Claims. (Cl. 314—34)

This invention relates to arc light sources such as arc lamps and methods for starting the arc and, more particularly, to a self starting arc lamp which may be started, for one-shot operation, without the application of a high voltage starting pulse.

Arc light sources, such as positive pressure short arc lamps, are in relatively common use today in applications requiring very intense sources of light. For example, such light sources find application for oscillographic photography, for solar simulation to determine deterioration due to sunlight, for search lights and the like. To start such lamps requires the initial application of a very high voltage starting pulse, typically 15,000 volts, supplied by a starting or trigger pulse power supply, to partially ionize the gas between the electrodes to flash the arc. Once started, the arc is maintained by the application of power at low voltage, typically around 12 volts provided by a sustaining or main power supply.

Since arc lamps usually support their electrodes within the stems of the pressurized glass or quartz envelope, and since current leads connected to the electrodes must be passed through the envelope and therefore must be very thin to facilitate sealing to the envelope, the energy applied by the starting pulse power supply must be carefully limited to prevent the generation of an excessive starting current which burns out the leads, usually referred to as ribbons. Typically, the energy of the starting pulse is limited to 2 watt-seconds. In addition to requiring a starting pulse power supply for supplying the high voltage starting pulse having a selected minimum voltage and a selected maximum energy, means must be provided for inter-coupling the starting pulse power supply with the main power supply which means must protect the main power supply and the arc lamp from being damaged or burned out by the starting pulse.

Starting pulse power supplies typically include a capacitor which is charged to the required starting pulse voltage and which has a storage capacity selected not to exceed the maximum permissible energy which the starting pulse may have. The starting pulse is prevented from reaching the main power supply by suitable filtering means. The necessary high voltage starting pulse may also be developed by an alternating current generator coupled by means of a first transformer to a spark gap circuit which in turn is coupled, by a second transformer, to an output circuit connected across the lamp electrodes. It is therefore seen that the necessity of providing a high voltage starting pulse requires the addition of much circuitry and equipment whose sole function is to start the arc and which is not needed to sustain the same.

In many applications, where it is desirable to provide an intense source of light, the weight, complexity, size and expense associated with the starting pulse power supply have been found a serious limitation on their use. For example, the use of arc lamps as intense light sources to which a modulated sustaining current may be applied for excellent discrimination against the sun have found little application so far as an optical tracking element in airborne vehicles because of the necessity to furnish a starting pulse power supply.

It is therefore a primary object of this invention to provide a positive pressure arc lamp which is started by connection to a main power supply without use of a high voltage starting pulse.

It is another object of this invention to provide an arc lamp which is so constructed that the application of power, normally designed to sustain the arc, also starts the arc.

It is a further object of this invention to provide a short arc lamp capable of being started and sustained, in one-shot operations, by connecting to a main power supply.

It is a still further object of this invention to provide a short arc lamp, particularly suited as the source of illumination for the optical tracking of an airborne vehicle, which is so constructed that it may be operated without the application of a high voltage starting pulse.

It is a still further object of this invention to provide an arc lamp which may be operated with a minimum of auxiliary circuitry and power sources and which therefore results in an arc lamp system which is lighter, smaller, more reliable and more economical than has been known heretofore.

It is also an object of this invention to provide a new and novel method of starting an arc lamp which offers great advantages where small size, low weight and high reliability are important factors.

Briefly, the arc lamp of this invention makes use of a conductive fusion bridge spanning the gap between the lamp main electrodes in the lamp envelope to thereby form a low resistance electrical path therebetween. The fusion bridge is so shaped and cross sectioned that application of the low voltage from the main power supply will vaporize this bridge progressively to thereby increase the effective electrode spacing until the arc is operating in its normal mode between the two main electrodes. The progressive vaporization of the fusion bridge is analogous to physically withdrawing one of two touching electrodes until the proper spacing is achieved for normal arc operation.

Other objects and a better understanding of the invention may be had by reference to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a view, partly in elevational and partly in cross section with some parts broken away, of an arc lamp embodying the structural features of this invention;

FIG. 2 is an enlarged view, partly in elevation and partly in cross section with some parts broken away, of the main electrodes, fusion bridge and bridge support of the arc lamp shown in FIG. 1;

FIG. 3 is a view taken along line 3—3 of FIG. 2;

FIG. 4 is an illustrative diagram useful in the explanation of the operation of this invention; and

FIGS. 5, 6 and 7 are elevational and perspective views of different embodiments of the fusion bridge spanning the gap between the main electrodes as shown in FIG. 2.

As is well known in this art, xenon short arc lamps comprise generally an anode and a cathode sealed in a quartz envelope containing a relatively high pressure xenon atmosphere which, at room temperature, is typically from between 3 to 7 atmospheres which corresponds to about 15 to 30 atmospheres at operating temperatures. The anode and cathode are separated by a relatively short distance and produce an intense arc, started in prior art devices by the high voltage starting pulse from a high voltage power supply and sustained by the low voltage from a main power supply.

Referring now to the drawing, and particularly to FIGS. 1 to 3 thereof, there is shown a short arc lamp **10** constructed in accordance with this invention. Lamp **10** includes a pressurized envelope **12** which for structural strength is preferably of spherical form and which is constructed of quartz for well understood reasons. Envelope **12** is provided with axially aligned stems, shown as **14** and **16**.

Mounted in stem **14** is an anode **18** of refractory metal,

usually swaged tungsten. As illustrated, it comprises a rod-like portion **20** mounted in stem **14** and terminating at the arc end in an enlarged cylindrical portion **22**. The parts **18** and **20** are commonly integral and the tungsten is worked to the form illustrated. The end of portion **20** is welded to a thin conductive ribbon **24** which is sealed in stem **14** and which provides a current lead connection. Ribbon **24** is electrically connected to a lamp connector **26** to which external connections are made.

Mounted in stem **16** is a cathode **28** of refractory metal similar to that used for anode **18**. Also, cathode **28** consists of a rod-like portion **30** mounted in stem **16** and terminating at the arc end into an enlarged cylindrical portion **32** which is smaller than portion **22**. As before, parts **30** and **32** are usually integral and end portion of **30** is welded to a thin conductive ribbon **34** which is sealed in the end of stem **16** and which serves as a current lead thereto. Ribbon **34** is electrically connected to a metallic connector **36** to which external connections are made.

Cathode **28** is axially aligned with anode **18** and its cylindrical portion **32** has a diameter smaller than that of cylindrical portion **22** for well understood reasons. Also, cylindrical portion **32** has wound around it a coil **38** which acts to regulate heat dissipation from the cathode and to contain cathode conditioning materials to aid in stabilizing the arc at the cathode arc end. The arc end of both anode **18** and cathode **28** are shaped to define cones pointed towards one another to facilitate the formation of the arc therebetween and once formed, to maintain the arc in a definite position and to prevent the arc ends from wandering over the electrodes.

Spanning the gap between the arc ends of anode **18** and cathode **28**, and in electrical contact therewith, is a fusion bridge **40**. Bridge **40** is mechanically supported by a wire-like support element **42** sealed to envelope **12**. As a practical matter, support element **42** provides means of positioning bridge **40** during assembly of the arc lamp of this invention and, after properly positioning, element **42** is sealed to envelope **12**.

The term fusion bridge, as used herein, is defined as a conductive member of sufficient length to span the gap for conductive contact with opposite electrodes of an arc lamp. Also, it is of such cross section in the direction of current flow and comprised of such a material that the application of normal lamp operating power fuses (burns) the bridge in a short time which is usually selected to be sufficiently long so that the arc can follow and sufficiently short to establish the arc without undue delay. Typical burn out times are between 50 microseconds and 0.5 second with a preferred burn-out time of about 0.1 second.

A typical xenon short arc lamp pressurized to 6 atmospheres of xenon gas and having an arc gap of approximately ½ millimeter between electrodes may be designed to dissipate approximately 75 watts, at 13 volts and 5.8 amperes. In order to accommodate lamps with normal manufacturing variations in arc spacing, the typical lamp power supply is normally designed such that E–I curve of the power supply is approximately tangent to the locus of constant wattage line at the design center value of voltage and current, and delivers less than the short circuit current which would damage the lamp. These design criteria result in a power supply which acts as an approximate constant wattage supply for all lamps having characteristics close to the design center.

Accordingly, a typical power supply will have 35 volts output with no current flowing, and 10 amperes or less flowing with a short circuit across the output terminals, a condition which is approximated when fusion bridge 40 conductively connects the electrodes.

When a conductive fusion bridge spans the electrode gap and provides such a low resistive path between the electrode, the initial current is around 10 amperes. Accordingly, in the typical example given above, the fusion bridge is so shaped and constructed that power of less than 75 watts at say a starting current of 10 amperes and a final current of say 6 amperes completely disintegrates bridge **40** in about 0.1 second. For example, a triangularly shaped fusion bridge of molybdenum of flat stock having a thickness of about one-half thousandths of an inch has a burn-out time of approximately 0.1 of a second.

As a result of the application of this current, the fusion bridge heats up rapidly and soon reaches its melting point at which time fusion commences. In case of the triangular-shaped bridge **40**, the temperature distribution prior to the commencement of fusion is shown by curve **50**, FIG. 4. Curve **50** is a plot of position as abscissa superimposed upon the gap region of a lamp with a fusion bridge **40**, against temperature as ordinate. Line **52** indicates the melting temperature of the material of fusion bridge **40**. As is readily seen, the temperature is greatest where the cross section is smallest, namely at the apex of the triangle joined to cathode **28** where the current density is greatest. Consequently, fusion occurs there and continues progressively to the right until bridge **40** is entirely consumed. During such progressive consumation, the arc is drawn from cathode **32**, at a rate depending on the rate of consumation, to anode **22**.

The material of which fusion bridge **40** is formed is not critical and may be selected on the basis of melting point and conductivity. However, in certain applications, particularly where the arc is to provide a radiation of say the xenon spectrum, it has been found desirable to utilize a material which does not change the properties of pressurizing gas. For example, with xenon lamp a fusion bridge of molybdenum has been found not to effect the spectral radiation materially, a property which may be important for certain applications of optical tracking where high discrimination against other light sources is desired.

Referring now to FIGS. 5, 6 and 7, there are shown different embodiments of fusion bridges with which this invention may be practiced. For example, FIG. 5 shows an anode **60**, a cathode **62** surrounded by a coil **64** which defines a gap with the anode which is spanned by a fusion bridge **66** of conical shape. As before, because of the progressively decreasing cross section along the length of bridge **66**, the current density is greatest at the apex of the cone-shaped bridge which therefore will reach its melting temperature first and bridge **66** will progressively melt towards anode **60**.

FIG. 6 shows a gap defined between an anode **68** and a cathode **70** having a coil **72** wound about its outer periphery. The gap is bridged by a fusion bridge **74** of cylindrical shape with a conical end portion contacting cathode **70**. Again, since the current per unit cross section is greatest at the conical end portion of bridge **74**, the same will burn progressively towards anode **68**. Since in this embodiment a major portion of bridge **74** is of uniform cross section it is possible that a large length of bridge **74** may reach the melting temperature at the same time and cause the gap to enlarge very rapidly. However, it has been found that the arc usually follows sufficiently rapidly to start the arc. This situation may be analogized with the slow mechanical withdrawal of one electrode from the other to establish the arc and then a rapid widening of the gap to the proper electrode spacing.

FIG. 7 shows still another embodiment of this invention in which the gap between an anode **76** and a cathode **78**, having a coil **80**, is spanned by a fusion bridge **84** shaped in the form of a flat member cut to resemble a pair of isosceles trapezoids having a common narrow top (placed end-to-end). The opposite wide base lines may be provided with V-shaped cutouts to fit over the conical arc ends of electrodes **76** and **78**. It is interesting to note that bridge **84** is consumed from the center, where the constriction is located, and then outwardly so that the gap is enlarged substantially uniformly towards both electrodes simultaneously.

In operation, the main power supply is connected across lamp connectors **26** and **36** which immediately initiates

maximum current flow since the electrode gap is bridged by a conductive fusion bridge. The fusion bridge is preferably of progressively changing across section so that it progressively disintegrates as the temperature passes the melting point of the bridge. The progressive disintegration of the fusion bridge increases the disintegrated gap drawing the arc progressively from the cathode to the anode in the same manner as a mechanically movable anode would do.

It will be understood that the embodiments illustrated in FIGS. 5, 6 and 7 are but three examples of many possible bridge configurations and that many others will become obvious in view of the teachings made herein.

There has been described a self starting arc lamp which together with the arc initiating and maintaining system is light, small, economical and reliable. The arc lamp of this invention is constructed for one shot operation much in the same manner as airborne vehicles in which it finds an important application.

What is claimed is:

1. The method of starting and operating an arc lamp, including a pressurized envelop and a pair of spaced apart electrodes immovably disposed within said envelop having arc ends defining an arc gap therebetween, said method comprising the steps: conductively spanning said arc gap with a fusion bridge which melts when subjected to normal arc lamp sustaining power; and applying normal arc lamp sustaining power across said electrodes to melt said fusion bridge to first establish the arc and to thereafter sustain the once established arc.

2. In a short arc lamp, including a pressure envelop and a pair of spaced apart electrodes immovably disposed within the envelop which have arc ends defining an arc gap therebetween, the improvement in the form of a self starting feature comprising: a conductive fusion bridge conductively connected across the arc ends of said electrodes to bridge said arc gap, said fusion bridge being dimensioned so that the electrical energy, normally applied across said electrode to sustain a once established arc, consumes said fusion bridge by melting to establish the arc.

3. In a short arc lamp having a pair of spaced apart electrodes, defining a gap therebetween, immovably disposed within a pressurized envelop, the improvement in the form of a self starting feature comprising: a consumable conductive fusion bridge conductively connected across the arc ends of said electrodes and bridging said gap, the cross-sectional area of at least one portion of said fusion bridge being sufficiently small so that the electrcal energy, normally applied to the short arc lamp to sustain a once established arc between said electrodes, melts said fusion bridge at said portion to thereby establish an arc, the cross-sectional area of said fusion bridge increasing along its direction of extension on either side of said portion.

4. In the combination of an arc lamp in which a pair of spaced apart electrodes are disposed within a pressurized envelope to define a gap of predetermined length therebetween, and a low voltage power supply having a power output commensurate with sustaining a once established arc which is connectible across the electrodes, the self starting feature in the arc lamp comprising: a consumable conductive fusion bridge conductively connected to the arc ends of said electrodes and bridging said gap, said fusion bridge being comprised of a conductive material and having a minimum cross sectional area at least at some portion along the direction of electrode current flow such that application of electric power from power supply raises its temperature at said portion above its melting point to initiate an arc which progressively

widens by progressively consuming said bridge until the arc operates across the arc ends of said electrodes.

5. An arc lamp comprising:

a sealed envelope having disposed therein an anode and a cathode defining a gap therebetween;

separate electrical conductor means connected to said anode and cathode and passing through said envelope for connection with a source of electrical energy; and

a consumable conductive fusion bridge within said envelope and disposed in said gap and in electrical contact with said anode and said cathode, said fusion bridge having a minimum cross sectional area at least at some portion along its length which is consumable by the electrical energy normally required to maintain a once established arc across the gap in the arc lamp.

6. An arc lamp in accordance with claim **5** which further includes an envelope supported mounting means for supporting said fusion bridge between said anode and said cathode.

7. An arc lamp in accordance with claim **5** in which the cross sectional area of said fusion bridge increases progressively along at least a portion of its length to one side of said minimum cross sectional area.

8. An arc lamp in accordance with claim **5** in which said fusion bridge is of flat stock and triangular in shape.

9. An arc lamp in accordance with claim **5** in which said fusion bridge is conical in form and mounted so that the vertex of the cone is touching said cathode.

10. An arc lamp in accordance with claim **5** in which said fusion bridge is substantially cylindrical in form having a conically shaped end portion in contact with said cathode.

11. An arc lamp in accordance with claim **5** in which the cross sectional area of said fusion bridge progressively increases along at least a portion of its length to either side of said minimum cross sectional area.

12. A one-shot, self starting arc lamp system comprising in combination:

a short arc lamp including a pressurized envelope and a pair of spaced apart electrodes immovably disposed within said envelope and defining an arc gap therebetween;

a power supply connectible across said electrodes for starting and thereafter operating said short arc lamp, said power supply having an electrical voltage and wattage output which is commensurate with the voltage and wattage required to maintain a once established arc said gap; and

a consumable conductive fusion bridge within said enevelope and disposed across said gap and in electrical contact with said electrodes, said fusion bridge having a minimum cross sectional area at least at some portion along its length which fuses when said power supply is connected across said electrodes to thereby establish and thereafter maintain an arc across said gap.

References Cited by the Examiner

UNITED STATES PATENTS

412,599	10/1889	Coffin	219—100
1,898,060	2/1933	Noble	219—145 X
2,215,300	9/1940	Ryde	313—184
2,391,611	12/1945	Back	315—241 X
2,472,923	6/1949	Schmerber	219—146 X

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