

April 9, 1968

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3,377,497

SELF-STARTING ARC LAMP

Original Filed March 15, 1965

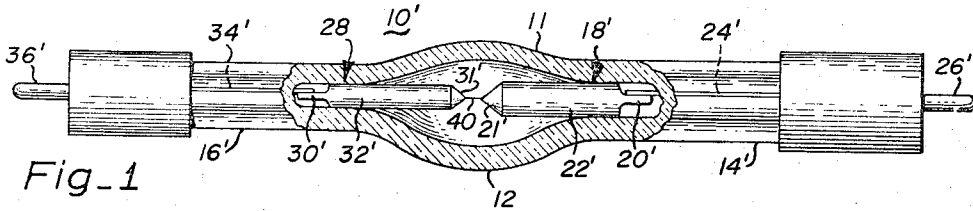


Fig. 1

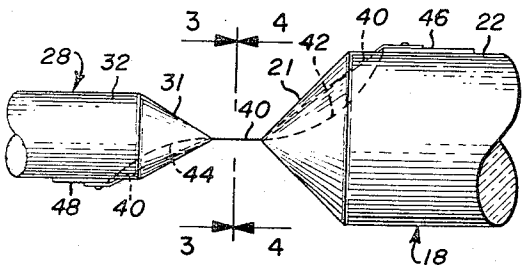


Fig. 2

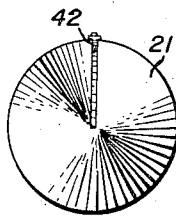


Fig. 3

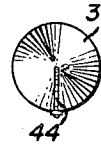


Fig. 4

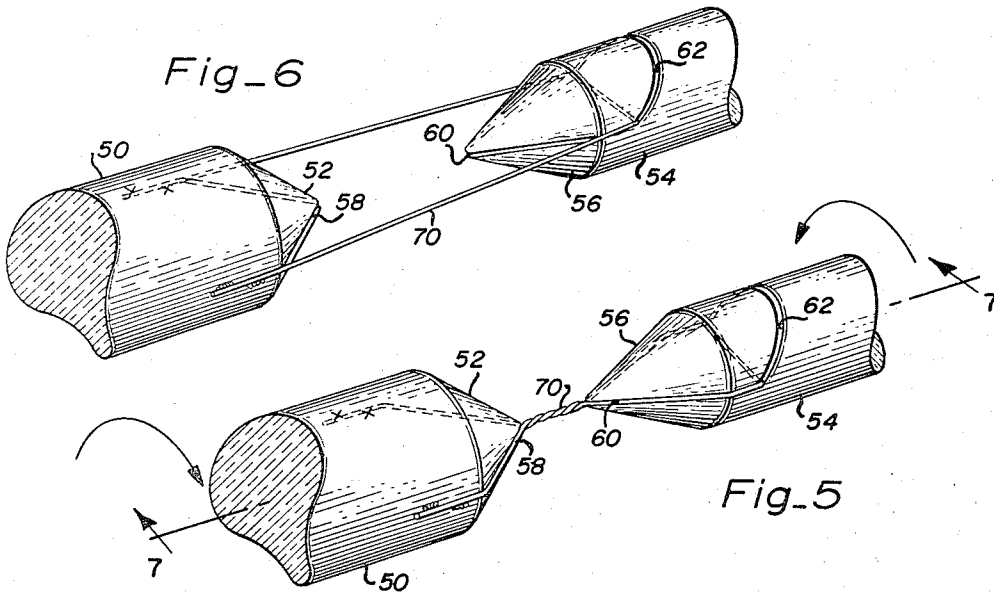


Fig. 6

Fig. 5

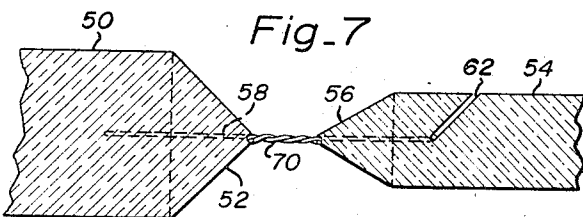


Fig. 7

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SELF-STARTING ARC LAMP

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Original application Mar. 15, 1965, Ser. No. 439,757, now
Patent No. 3,274,427, dated Sept. 20, 1966. Divided
and this application May 19, 1966, Ser. No. 554,933
7 Claims. (Cl. 313-184)

This application is a division of application Ser. No. 439,757 filed on Mar. 15, 1965, now Patent No. 3,274,427, which in turn is a continuation-in-part of application Ser. No. 258,717 filed Feb. 15, 1963, now Patent No. 3,256,459.

This invention relates to arc lamps and a method for starting the arc, and more particularly to a self-starting arc lamp for one-shot operation.

As fully explained in the hereinabove referred to copending applications, arc lamps are in relative common use today for applications requiring very intense sources of light. For example, arc lamps are used for oscillographic photography, for solar simulation to determine deterioration due to sunlight, for search lights and the like. To start such arc lamps requires the initial application of a relatively high voltage starting pulse, which is typically 15,000 volts, and which is supplied by a "starting" power supply. The high voltage originally required to draw an arc between the electrodes is necessary for ionizing the gas between the electrodes to cause the arc to flash across the electrodes, the stages being Townsend discharge, glow discharge and arc discharge in the order stated. Once started, the arc is easily maintained by the application of power at a relatively low voltage, typically less than 30 volts, which is provided by a separate "sustaining" power supply.

For one-shot arc lamps, such as may be used in the optical tracking element of airborne vehicles, the requirement for a starting power supply in addition to the sustaining power supply has been a very serious limitation on their use. Not only must a starting power supply be carried by the airborne system for a single instant of use, but additionally, this power supply must be electrically interconnected with the sustaining power supply in such a manner that the sustaining power supply and the arc lamp itself will not be burned out by the starting pulse. Further, in case ribbon seals are utilized to form the conductive path through the envelope enclosing the electrodes, means must be provided to carefully limit the starting current to prevent burning out of the ribbons. Typically the energy of such a starting pulse in connection with ribbon arc lamps is limited to 2 watt-seconds.

The above identified copending application, Ser. No. 258,717, discloses an arc lamp in which a conductive fusion bridge spans the gap between the electrodes and forms a low resistance electrical path therebetween. The fusion bridge is shaped in such a manner that its cross-sectional area progressively increases axially, from a minimum area, in the direction of one or both of the electrodes.

To start the arc lamp therein disclosed, low voltage power from the sustaining power supply is applied to the electrodes to vaporize this bridge progressively from the minimum cross-sectional area outwards toward the electrodes. Until the minimum cross section area is vaporized, there is no gap to bridge. As soon as the minimum cross section area is vaporized a small gap is formed which increases in length until the whole bridge is vaporized and the arc is operating in its normal mode between the two electrodes.

This progressive vaporization of the fusion bridge is analogous to physically withdrawing one of two touching

electrodes until proper electrode spacing is achieved for normal arc operation. While this type of arc lamp is eminently suited for starting the arc, it has been found that for applications requiring survival to extreme environmental conditions, such as very severe shock and vibration, the rigid nature and the various modes of suspension of the fusion bridge did limit its survival capability somewhat. It was also found that a progressively increasing cross section area (tapered) fusion bridge added to the manufacturing cost of the arc lamp because of support and alignment requirements during the assembly operations, and that even so-called uniform cross section wires were apparently sufficiently non-uniform to effect progressive vaporization.

It is therefore a primary object of this invention to provide an improved self-starting arc lamp for one-shot operation.

It is another object of this invention to provide a self-starting bridgewire arc lamp which is rugged in construction and capable of surviving severe shock and vibration.

It is a further object of this invention to provide a self-starting one-shot bridgewire arc lamp which is inexpensive to manufacture and reliable in operation.

It is a still further object of this invention to provide a self-starting one-shot bridgewire arc lamp which is simple to manufacture and which, therefore, may be constructed by utilizing mass production techniques.

It is a still further object of this invention to provide a one-shot bridgewire arc lamp in which the arc is started and sustained by a single power supply, which is inexpensive to manufacture, extremely reliable in operation and can survive severe environmental conditions.

Briefly, the self-starting arc lamp of this invention accomplishes the stated object by utilizing a conductive wire of substantially uniform cross section for bridging the gap between the electrodes. The wire, also referred to as a bridgewire, may be of single or multiple strand construction and has its end portions securely held by spot welding to the electrode portion immediately following the tapered arc end. To achieve good centering of the wire between the points of the opposed electrodes and to hold the end portions securely against shock and vibration, one or more accommodation slots or grooves are cut into the peripheral surface of the conoidal arc end portions of the electrodes so that the bridgewire is axially suspended between the electrode points and firmly secured along the arc end portions.

Further objects and advantages of the present invention will become apparent to those skilled in the art to which the invention pertains as the ensuing description proceeds.

The features of novelty that are considered characteristic of this invention are set forth with particularity in the appended claims. The organization and method of operation of the invention itself will best be understood from the following description when read in connection with the accompanying drawing in which:

FIG. 1 is a view, partly in elevation and partly in cross section with parts broken away, of a self starting bridgewire arc lamp constructed in accordance with this invention;

FIG. 2 is an enlarged elevational view of the bridgewire and the adjacent electrode portion of the arc lamp shown in FIG. 1;

FIG. 3 is a view taken along lines 3-3 of FIG. 1;

FIG. 4 is a view taken along lines 4-4 of FIG. 2;

FIG. 5 is a perspective view of an alternate embodiment of this invention utilizing a multi-strand bridgewire between the electrodes;

FIG. 6 is a perspective view of the bridgewire and elec-

trodes of FIG. 5 illustrating the assembling operation; and

FIG. 7 is a view taken along lines 7—7 of FIG. 5.

Referring now to the drawing, and particularly to FIG. 1 thereof, there is shown a self starting bridgewire arc lamp 10 constructed in accordance with this invention. Illustrated arc lamp 10 is of the general class referred to as a "short" arc lamp which may be filled with an inert gas such as xenon. Such short arc lamps usually contain the gas under pressure which, at room temperature, typically is from between 3 to 15 atmospheres. At the operating temperature the gas pressure increases typically to about 15 to 40 atmospheres. The reason these lamps are referred to as "short arc" is because the anode and cathode are separated by a relatively short distance, typically 30 thousandths of an inch, to produce an intense arc. In prior arc devices the arc is started by the application of a high or firing voltage from a starting power supply which causes, in the order stated, Townsend discharge, glow discharge and finally arc discharge. Once started the arc is maintained by the low voltage power from a sustaining power supply. In the instant invention, the sustaining power supply also starts the arc.

Lamp 10 includes a pressurized envelope 11 which, for structural strength, has a spherical bulb portion 12 constructed of quartz to be transparent to short wave length radiation for well understood reasons. Envelope 11 also includes a pair of axially aligned stem portions 14 and 16 on opposite sides of bulb portion 12 and integral therewith.

Mounted in stem portion 14 is an anode 18 of refractory metal, usually swaged tungsten, which has a cylindrical main body 22, a tab portion 20 and a conical arc end portion 21. Tab portion 20 is welded or otherwise conductively connected to a thin conductive ribbon 24 which is sealed into the closed stem portion 14 and which provides a current connection to an external connector 26.

Mounted in stem portion 16 is a cathode 28, made of similar material as that used for anode 18, which likewise has a cylindrical main body 32, a tab portion 34 and a conical arc end portion 31. Main body 32 of cathode 28 is usually smaller in diameter than main body 22 of anode 18 as illustrated. As before, tab portion 30 is welded or otherwise conductively connected to thin conductive ribbon 34 which is sealed into the closed end portion of stem 16 and which serves as a current lead thereto. Ribbon 34 is electrically connected to an external connector 36. Power is applied to arc lamp 10 by connecting a power supply (not shown) across connectors 26 and 36.

Main bodies 22 and 32 of anode 18 and cathode 28, respectively, are in axial alignment and facing arc end portions 21 and 31 are shaped to define cones whose apexes lie on the common anode and cathode axis. This geometry facilitates the drawing of the arc therebetween, and once formed maintains the arc in a definite position and prevents the arc ends from wandering over the electrodes.

Spanning the gap between electrode arc end portions 21 and 31, and in electrical contact therewith, is a fusible bridgewire 40 which has a substantially uniform cross section along its length. The preferred material of which bridgewire 40 is constructed depends, among other factors, on the particular application of lamp 10, its method of construction and the type of gas in its envelope. Generally speaking, bridgewire 40 may be made of any conductive metal such as iron, copper tungsten, molybdenum, platinum, tantalum, or the like, the particular metal selected depending on the above named factors.

In case of arc lamps which require bake-out during their construction, the material selected for bridgewire 40 would be a refractory metal which is capable of withstanding bake-out temperatures which typically range between 1400 to 1800° centigrade. In case of arc lamps filled with hydrogen, the preferred bridgewire material is a noble metal such as platinum or a platinum clad metal

such as tungsten. For arc lamps which are used in an environment subjecting them to severe shock and vibration, a refractory metal whose ductility remains unimpaired by the high bake-out temperatures is selected and in this connection tantalum has been found to be a preferred material. It is to be understood that materials other than those described hereinabove may be used for the construction of bridgewire 40, and that substantially all conductive materials are suitable. The particular conductive material chosen depends primarily on the environmental conditions which the bridgewire has to withstand.

The diameter of bridgewire 40, or more correctly its cross section area, must meet two conflicting requirements. Firstly, it should be as large as possible for ease of manufacture and assembly of the arc lamp and to have minimum electrical resistance. Secondly, it must be sufficiently small to fuse or burn out before the arc lamp is damaged by the initial current flowing therethrough.

The reason for the first requirement is obvious since fine wires are difficult to handle and tear easily. The second requirement is particularly important for ribbon seal lamps because such lamps are easily damaged by excessive currents which burn out the ribbon. The ribbons are typically rectangular in cross section, having a width of 60 to 125 thousandths and a thickness of 0.5 thousandth of an inch. It has been found that ribbons of the cross-sectional area just described can withstand a current of about 30 to 40 amperes for a period of about one-tenth of a second without burnout. This is particularly true where a quartz envelope is utilized which is shrunk upon the whole length of the ribbon and therefore conducts heat away from the ribbon. Accordingly, a cross-sectional area of bridgewire 40, which causes the bridgewire to fuse in less than one-tenth of a second upon application of a current of about 30 to 40 amperes, meets this requirement. For example, a tantalum wire having a diameter of about 6 thousandths of an inch has been found to meet this requirement. In case of rod seals, where the danger of lamp damage due to starting current flow is much reduced, a wire of greater diameter may be used.

Referring now particularly to FIGURES 2, 3 and 4, bridgewire 40 spans the gap between electrode arc end portions 21 and 31 which is typically 30 thousandths of an inch long. To support bridgewire 40 axially between the apexes of anode 18 and cathode 28, each electrode is provided with a substantially radial (lengthwise) slot shown at 42 and 44 respectively. Radial slots 42 and 44 have side walls parallel to and symmetric with respect to a radial (diametrical) plane of the electrode and a bottom wall which is curved and which extends from the apex of the electrode arc end to a convenient point on the cylindrical body of the electrode. The width of each slot is substantially the same as the diameter of bridgewire 40. Slots 42 and 44 lie on opposite sides of a common diametrical electrode plane so that opposite ends of bridgewire 40 are supported from opposite sides of the common diametrical plane. Of course, slots 42 and 44 need not be exactly opposite to one another as long as they are disposed in such a manner that the bridgewire is axially supported by the opposite slot ends at the electrode apexes against "falling out" of the slots. This requirement is best described by the criteria that the slots must be of a depth and must have a relative orientation such that, once the ends of the bridgewire are secured to the electrode bodies, attempted removal of the bridgewire from either slot puts the bridgewire under tension. Further, instead of the deep slots shown, shallow accommodation grooves may be substituted.

In this manner bridgewire 40, upon being inserted into slots 42 and 44 (or shallow grooves), will bridge the gap axially and will be secure against displacement, particularly when the arc lamp is exposed to a severe vibration or shock environment.

To provide a good conductive connection between bridgewire 40 and the electrodes, platinum tabs 46 and

48 are spot welded respectively to anode 18 and cathode 28 and in close proximity to the ends of the slots in cylindrical bodies 22 and 32. Bridgewire 40 is then spot welded to tab 46 for conductive contact with anode 18, and to tab 48 for conductive contact with cathode 28.

In operation, a power supply (not shown) is connected across terminals 26 and 36 causing a current to flow through ribbon 24, cathode 18, bridgewire 40, anode 28 and ribbon 34, in that order. Since bridgewire 40 is highly conductive, the starting current will be high, say between 30 and 40 amps. This starting current will heat up ribbon 24, bridgewire 40 and ribbon 34, the temperature rise of the larger electrodes may be neglected. Since the cross-sectional area of bridgewire 40 is carefully selected to burn out before the ribbons, a gap will be formed as a section of the bridgewire is consumed. This, of course, reduces current flow.

Even though the theory of starting is not entirely understood, the following explanations are submitted without any intention to be bound thereby. One explanation is that since slots 42 and 44 have approximately the same width as the diameter of bridgewire 40, they are in good thermal contact with the bridgewire and the electrodes act as a heat sink. As a consequence thereof, the heat generated in bridgewire 40 by the starting current is carried away by the electrodes primarily from the portions of the bridgewire immediately adjacent to the electrodes to cause a hot spot at or near the center portion of the bridgewire. This causes the hot spot portion of bridgewire 40 to reach its melting point first and to commence fusion and to burn out. As soon as the center portion burns, an arc will form which will progressively consume the remaining bridgewire until the arc spans the gaps between the electrodes. As the width of the gap increases, the resistance between the electrodes increases and the current decreases thereby preventing damage to ribbons 24 and 34. Another explanation is that the so-called uniform cross section wire is sufficiently non-uniform to cause a hot spot at some portion corresponding to the smallest cross section portion of the wire at which fusion starts.

It is to be noted that in cases of rod seal arc lamps, in which there is little danger of damage to the arc lamp from high current, the cross-sectional area of the bridgewire may be larger to facilitate its handling during manufacture. This invention is applicable to both ribbon seal and rod seal arc lamps. The reason a ribbon seal arc lamp has been selected for illustration is because of the added consideration of the cross-sectional area of the bridgewire to prevent damage thereto. In all other respects, the above described configuration is equally applicable to rod seal arc lamps.

Referring now to FIGURES 5, 6 and 7, there is shown an alternate embodiment of a self starting bridgewire arc lamp which incorporates features providing certain manufacturing advantages. An anode 50 having an electrode arc end portion 52 of conical shape, and a cathode 54 having an electrode arc end portion 56 likewise of conical shape are supported within an envelope (not shown) which may be similar in all respects to envelope 12 of FIGURE 1. Arc end portions 52 and 56 are provided with wire reception means in the form of diametrically opposed shallow grooves 58 and 60 respectively as shown. Instead of grooves, the wire reception means may be formed by a slot which bisects the conical end portions and which has side walls substantially parallel to and symmetric with a diametrical plane. Additionally, cathode 54 is provided with a slanted deep slot 62 whose side walls make approximately a 45° angle with the axis of cathode 54.

A bridgewire 70, which is similar in most respects to bridge wire 40 of FIGURE 1 except that it has two strands twisted together, spans the electrode gap. If two-strand bridgewire 70 is utilized with a ribbon seal arc lamp, the combined cross-sectional areas of the individual strands are subject to the same limitations set forth

above, that is the bridgewire must fuse before the lamp is damaged. In case of utilization of a multistrand bridgewire in rod seal arc lamps, the limitation on the combined cross-sectional area of the bridgewire is of lesser importance.

Utilization of a twisted multi-strand bridgewire has a number of manufacturing advantages, an important one being that the length of the bridgewire in the gap is adjustable by twisting. It is well-known that the length of the electrode gap is subject to rather stringent design specifications. Since the bridgewire should not sag and preferably should be slightly tensioned between the electrodes for greatest survival in a severe environment, utilization of a single strand bridgewire presents a number of manufacturing difficulties. Since the bridgewire ends are spot welded to the electrodes before final assembly, there is little or no adjustment possible. In case of a two-strand twisted bridgewire, adjustment of the bridgewire length in the gap is provided by twisting the electrodes in opposite directions until the wire is properly tensioned.

In assembling an arc lamp having a twisted bridgewire 70, the center portion of the wire is inserted into slot 62 and the two end portions are welded to the peripheral surface of anode 50, either directly as shown or by means of platinum tabs as illustrated in FIGURE 2. Thereafter, anode 50 and cathode 54 are rotated in opposite directions with respect to one another to start twisting the strand and to draw the two-strand portion into wire reception grooves 58 and 60 respectively or into slots. The electrodes are then moved to achieve proper gap spacing. Should the portion of bridgewire 70 spanning the gap be loose, rotation of one electrode with respect to the other will change the length until the bridgewire is properly tensioned. The envelope may then be sealed in the ordinary manner.

The operation of the arc lamp illustrated in FIGURE 5 is the same in all respects to that of FIGURE 1. As long as wire reception grooves or slots 58 and 60 are substantially of the same width as the diameter of bridgewire 70, good thermal contact between the wire and the electrodes is provided. This causes a hot spot at the center of the gap and therefore burnout will occur at the center of the gap.

There has been described a self starting bridgewire arc lamp in which the application of power from a sustaining power supply will cause the bridgewire to fuse and to draw an arc between the electrodes. The bridgewire may be of single or multiple strand configuration and made of a material selected in accordance with application, type and construction of the arc lamp.

While the above detailed description has shown, described and pointed out the fundamental novel features of the invention as applied to various embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a short arc lamp, including a pressurized envelope and a pair of spaced apart electrodes immovably disposed within the envelope which have arc ends defining an arc gap therebetween, the improvement in the form of a self starting feature comprising:

a pair of conductive strands of wire forming a fusion bridge conductively connected across the arc ends of said electrodes to bridge said arc gap, the portion of said pair of strands of wire disposed across the gap being twisted about each other, 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.

2. In a short arc lamp in accordance with claim 1 in

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which said twisted wire portion is axially disposed in said gap.

3. In a short arc lamp in accordance with claim 1 in which at least one of said electrodes includes a pair of diametrically opposed wire reception means disposed in the peripheral surface of the said electrode, and of said wire reception means having a width for snugly receiving a single strand of wire and accommodating one strand of wire of said fusion bridge.

4. In a short arc lamp in accordance with claim 3 in which each of said reception means commences at the tip of the electrode arc end and terminates short of the point of conductive connection of the strand of wire to said electrode.

5. In a short arc lamp in accordance with claim 4 in which the electrode including said diametrically opposed wire reception means is of substantially cylindrical configuration and has a conical arc end portion, and in which said diametrically opposed wire reception means extends along the entire conical arc end portion of the electrode, and in which portion of each accommodated strand of wire extends past said wire reception means and is conductively connected to the cylindrical surface of the said electrode.

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6. In a short arc lamp in accordance with claim 1 in which one of the end portions of one strand of wire is connected to one of the end portions of the other strand of wire to form a substantially U-shaped loop portion and a pair of leg portions which are twisted across said gap, and in which one of said electrodes is formed with loop reception means for receiving said loop portion.

7. In a short arc lamp in accordance with claim 6 in which each of said electrodes includes a pair of diametrically opposed wire accommodation means extending substantially from the tip of the electrode arc end lengthwise along the electrode, the diametrically opposed wire reception means in the electrode formed with said loop reception means being arranged symmetrically with said loop reception means.

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