Feb. 21, 1961 L. I. DANA ET AL 2,972,698

HIGH-INTENSITY LIGHT SOURCE

Filed Sept. 8, 1958 2 Sheets-Sheet 1

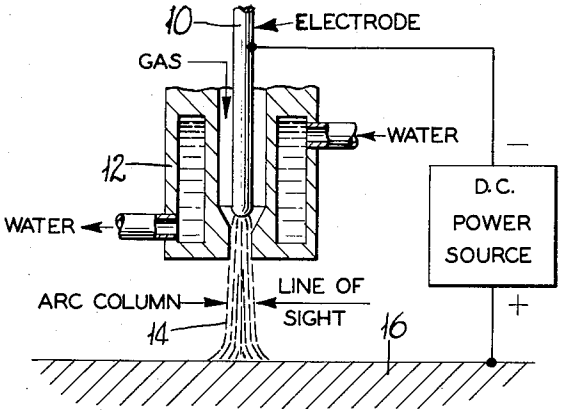


Fig. 1.

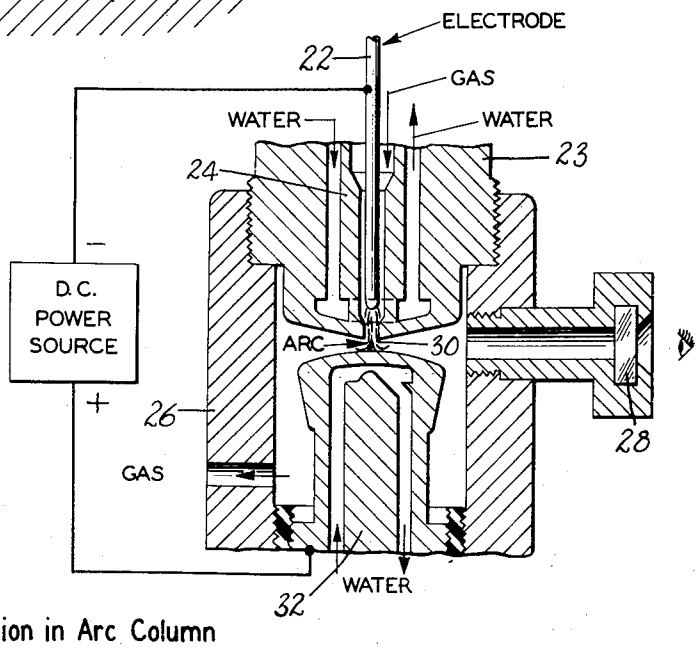


Fig. 2.

Brightness VS. Position in Arc Column

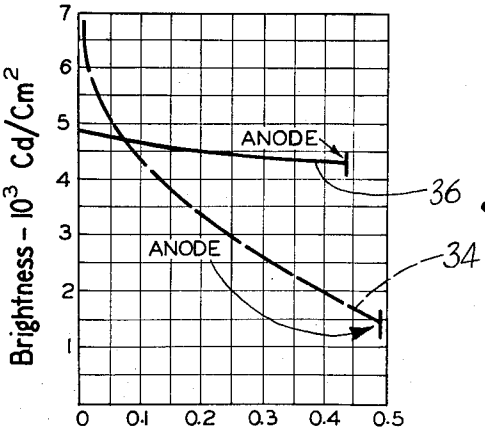


Fig. 3.

INVENTORS
LEO I. DANA
HAROLD S. MORTON, JR.
BY Barnwell R. King
ATTORNEY

Feb. 21, 1961 L. I. DANA ET AL 2,972,698

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Filed Sept. 8, 1958 2 Sheets-Sheet 2

Fig. 4.

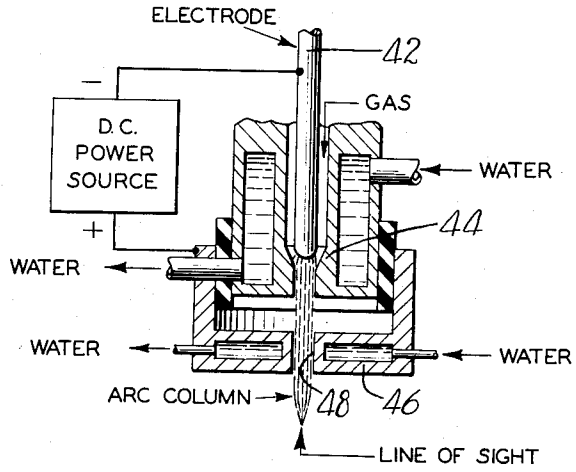
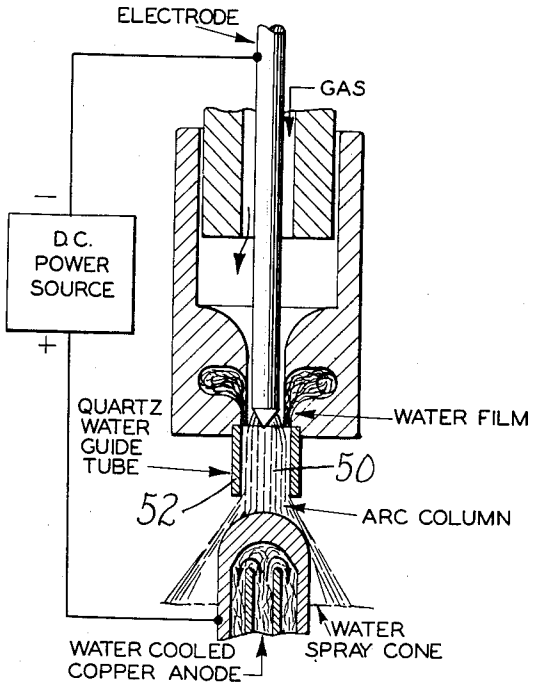


Fig. 5.



INVENTORS
LEO I. DANA
HAROLD S. MORTON, JR.

BY Barnwell R. King
ATTORNEY

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HIGH-INTENSITY LIGHT SOURCE

Leo I. Dana, Larchmont, N.Y., and Harold S. Morton, Jr., Gaithersburg, Md., assignors to Union Carbide Corporation, a corporation of New York

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9 Claims. (Cl. 313—231)

This invention relates to high-intensity light sources and, more particularly, to high-pressure collimated electric arcs for such purpose.

According to the invention a concentrated high-intensity light source is obtained by passing a desired gas through the constricted arc of an arc torch of the type disclosed by Gage Patent No. 2,806,124.

The transferred arc torch viewed "side-on" to the arc has utility as a light source in motion picture projectors, or in other applications where an extremely bright, relatively uniform, source of light is desired. The "end-on"-viewed transferred or nontransferred arc torch light source has utility where an extremely bright point of light is required.

In all of these light source applications, the stability of the constricted arc and the brighter, extended light provide unexpected advantages over the prior art electric arc light sources and, particularly, over prior light sources using xenon.

High-intensity light sources find important commercial applicaitons, particularly in motion picture projection work. In this application it is not sufficient to have merely a source of high total light output. The optics of the projection system make it desirable for this light to come from a concentrated, relatively even, illumination source.

The principal high-intensity light source now in use is the carbon arc. It is known in the art that arcs in xenon gas produce an extremely brilliant white light. Work has therefore been done in the field of developing a xenon arc light source which might supplement, and even replace, the carbon arc for some uses. Attempts were made in the known prior art xenon lights to increase the arc stability and to increase the area of high uniform brightness along the arc length by surrounding the arc with a narrow quartz tube, thus tending to wall-stabilize the arc. However, the arc current was limited by the poor heat conductivity of the wall-stabilizing quartz envelope. As a consequence, the quartz envelope of the prior art high-intensity xenon lights was moved farther from the arc column in order to increase the area for dissipating heat from this envelope. The collimation due to the tube was lost, and the arc was less effectively stabilized. The resulting nonuniform cross-sectional area of the arc column produced an extremely nonuniform brightness along the arc length, and the heat dissipation through the quartz envelope was still the power-limiting factor in this type of arc lamp.

The transferred arc torch produces an extremely stable, high-intensity arc column which has relatively uniform brightness along its length. This is apparently due to the wall-stabilized, constricted arc produced within this torch, wherein the gas flowing through the torch nozzle collinearly with the arc tend to maintain the constricted nature of the arc column over some distance from the end of the nozzle.

Any of the arc-supporting inert gases can be used with the torch, but the most useful gases with respect

to light output are the heavier inert gases—argon, krypton, and xenon. In particular, xenon is preferred because it produces the brightest and whitest arc light.

In the drawings:

Figure 1 is a fragmentary main view in vertical cross section of arc apparatus illustrating the invention;

Figure 2 is a similar view of a modification;

Figure 3 is a graph of brightness versus axial position in the arc column; and

Figures 4 and 5 are views similar to Figures 1 and 2 of additional modifications.

As shown in Figure 1, a 3/32-inch diameter tungsten electrode **10** was positioned coaxially within a 5/32-inch diameter water-cooled copper nozzle **12**. The electrode tip was set back 3/16-inch from the nozzle outlet. Argon gas at 20 c.f.h. was passed down around the electrode and out of the nozzle. An arc **14** was then struck from the electrode **10** to a water-cooled copper anode **16** and maintained at about 40 volts (D.C.) and 100 amperes. The arc brightness under these conditions was measured to be about 4380 candles/cm.^{2} by focusing the light from that portion of the arc just below the nozzle on a photometer. The current was then varied from 50 amperes to 200 amperes, and the average brightness of the arc just below the nozzle varied from 1710 to 6550 cd./cm.^{2} over this range of current.

This procedure was repeated with xenon gas passing at a rate of 15 c.f.h. through the transferred arc torch. The brightness of the portion of the arc just below the nozzle increased from 17,800 to 30,400 cd./cm.^{2} as the current was increased from 100 to 200 amperes.

As shown in Figure 2, an arc torch **23** comprising a 3/32-inch diameter tungsten electrode **22** positioned coaxially within a 1/8-inch diameter water-cooled copper nozzle **24** and set back 1/8-inch from the nozzle outlet was placed inside a pressure vessel **26** having a quartz window **28**. The vessel was filled with xenon. An arc **30** of 100 amperes and 21 to 38 volts (DCSP) was struck from the electrode to a water-cooled copper anode **32**. The arc brightness was measured by focusing a portion of the arc image through the quartz window onto a photometer. The xenon pressure in the vessel was then gradually increased in measured increments from atmospheric up to 360 p.s.i.g. The peak arc brightness increased from 21,900 cd./cm.^{2} to 120,000 cd./cm.^{2} as the ambient pressure was increased over the above range. For maximum brightness it can be seen that the present process is preferably operated above atmospheric pressure. In particular, it is preferred to operate in the range of 15 to 50 atmospheres' pressure.

One of the prime advantages of the transferred arc torch light source is the relatively uniform brightness produced along the arc column. Figure 3 shows a comparison of the results for a nonconstricted open arc in argon **34** and an argon-shielded transferred constricted arc **36**, under similar operating conditions.

The above information was obtained by viewing the arc from the side in the conventional manner employed with arc light sources. Occasionally an extremely bright point of light is required, for example, as the source of illumination for microscopy or Schlieren photography. For this application the arc can be viewed axially or "end-on." This is accomplished with the transferred arc torch by employing an anode having a hole in the center and by viewing the arc through this hole.

The following example gives data obtained for argon and xenon gases in an "end-on"-viewed transferred arc torch.

As shown in Figure 4, an arc torch was employed which consisted of a 3/32-inch diameter tungsten electrode **42** positioned coaxially within a 1/8-inch diameter water-cooled copper nozzle **44**. The electrode tip was set

back 3/16-inch from the nozzle outlet. A disc-shaped anode **46** having a 3/16-inch diameter hole **48** was positioned 1/8-inch below the torch nozzle. Argon was passed at a rate of 20 c.f.h. down through the torch while an arc was maintained at 150 amperes and 34.5 volts (D.C.). Arc brightness as viewed through the anode opening was 18,330 cd./cm.^{2}.

The above test was repeated using xenon gas at 3 c.f.h. and operating the torch at 200 amperes and 45 volts (D.C.). Arc brightness as viewed through the opening in the anode was 70,600 cd./cm.^{2}.

The nontransferred arc torch process (covered in active application Serial No. 539,794, filed October 11, 1955, now U.S. Patent No. 2,858,411, issued October 28, 1958) can also be employed as a point-of-light source. In this case no external anode is required, and the arc is viewed "end-on" through the torch nozzle.

The transferred and nontransferred arc torches, when used as point-of-light sources, have advantages in that the constricted arc enables one to obtain light sources which are more stable and brighter than point-of-light sources of the prior art.

It is often desirable to use a transparent non-conducting nozzle to constrict an arc column over a major portion of its length. This would enable a larger fraction of the radiation from the arc to be utilized and would eliminate the double-arcing problem often encountered with conducting nozzles at high degrees of constriction.

Figure 5 shows an inert gas constricted arc **50** established within a water vortex channel. A quartz water guide tube **52** was employed. This particular apparatus modification is described in more detail in copending application Serial No. 689,370, filed October 10, 1957, now Patent No. 2,906,858.

"Side-on" brightness determinations were made of this water-wall constricted arc using argon and viewing the column through the quartz and water walls. The arc column was constricted a small amount and had a brightness of 8,000 cd./cm.^{2} at 250 amperes.

What is claimed is:

1. A source of light comprising a pair of axially aligned electrodes spaced from each other to provide an arc gap, one of said electrodes consisting of a stick composed of tungsten, the other one of said electrodes consisting of a hollow member composed of copper, means for circulating cooling liquid through said hollow electrode to prevent it from overheating, means for energizing a high pressure electric arc between said electrodes including a source of direct current power connected to said electrodes so that said stick electrode is the cathode and said hollow electrode is the anode, means for feeding an annular stream of inert gas selected from the class consisting of argon, krypton and xenon along the end portion of said cathode adjacent such arc, and a cooled nozzle for such arc provided with an arc constricting outlet through which the arc and inert gas are discharged to produce an exposed column of a partially wall-stabilized inert gas electric arc, which is stable and characterized by relatively uniform brightness along the exposed arc length.

2. Method of producing light which comprises producing a wall-stabilized arc, passing an inert gas stream through such wall-stabilized electric arc so that such stream becomes part of such arc in the form of a column, the exposure of which provides a source of light, said exposed arc column being characterized by stability and stiffness by virtue of the fact that a portion of the arc column is wall-stabilized and such gas stream tends to restrict and stabilize the arc, the resulting exposed arc column also having relatively uniform brightness along its length.

3. A lamp comprising apparatus for producing concentrated high-intensity source of light consisting of an arc column comprising ionized xenon gas resulting from an electric arc which is wall-stabilized in and discharged from a constricting orifice, which apparatus includes the combination of a pair of axially aligned electrodes spaced from each other to provide an arc gap, one of said electrodes consisting of a stick, the other one of said electrodes consisting of a hollow member, means for circulating cooling liquid through said hollow electrode to prevent it from overheating, means for energizing a high pressure electric arc between said electrodes including a source of direct current power connected to said electrodes so that said stick electrode is the cathode and said hollow electrode is the anode, means for feeding an annular stream of xenon along the end portion of said cathode adjacent such arc, and a cooled nozzle for such arc provided with an arc constricting outlet through which the arc and xenon gas are discharged to produce such arc column of constricted light.

4. A high-intensity light source consisting of a wall-stabilized constricted arc torch, and means for discharging from such torch an exposed arc-gas effluent column, characterized by the use in such column of inert gas selected from the class consisting of argon, krypton, and xenon.

5. A method of producing light which comprises striking a high-pressure electric arc between a cathode and an anode inside a pressure vessel having a transparent viewing port; wall-stabilizing and collimating said arc by passing it through a cooled nonconsumable nozzle; passing an inert gas stream at a pressure above atmospheric along said cathode and through said arc-stabilizing nozzle so that said gas stream becomes collinear with said arc; said collimated arc light source being extremely stable and having relatively even brightness along its arc length.

6. A method according to claim 5, wherein said gas is maintained by said inert gas stream at 15 to 50 atmospheres' pressure within said pressure vessel.

7. A method of producing light which comprises striking a high-pressure electric arc between a rod cathode and an anode inside a pressure vessel having a transparent viewing port; wall-stabilizing and collimating said arc by passing it through a cooled nonconsumable nozzle; passing an inert gas stream selected from the class consisting of argon, krypton, and xenon at a pressure above atmospheric along said rod cathode and through said arc-stabilizing nozzle so that said gas stream becomes collinear with said arc, said collimated arc light source being extremely stable and having relatively even brightness along its arc length.

8. A method according to claim 7, wherein said gas is maintained by said inert gas stream at 15 to 50 atmospheres' pressure within said pressure vessel.

9. Method of producing high intensity light which comprises striking a direct current high pressure arc between spaced axially aligned electrodes, constricting such arc laterally by a nozzle having an orifice axially aligned with such electrodes, through which orifice such arc is maintained by a continuous flow of inert gas, while continuously cooling the inner wall of such orifice by flowing cooling water through a water passage in the wall of such nozzle, thereby constricting and wall-stabilizing such arc as the latter flows through and out of such orifice, providing a stable column of effluent of ionized inert gas of very high light intensity.

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