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DIRECT CURRENT ARC HAVING REFLECTOR MEANS
SUPERIMPOSING A REVERSE COMPLEMENTARY
IMAGE ON THE ARC
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2,621,284

FIG. 1.

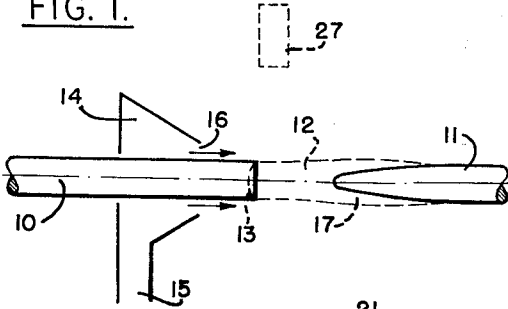


FIG. 2.

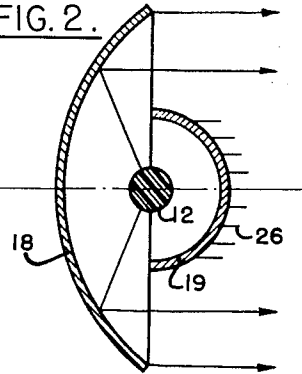


FIG. 3.

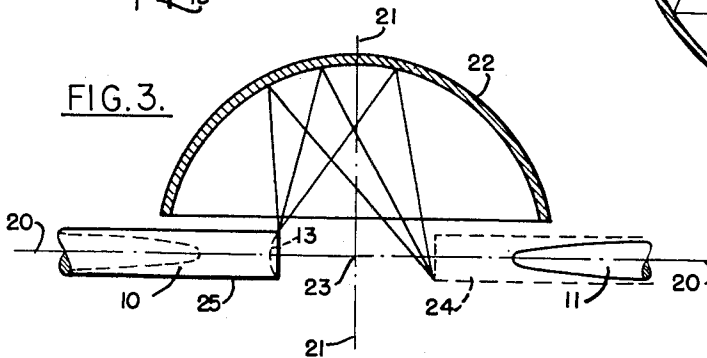


FIG. 4.

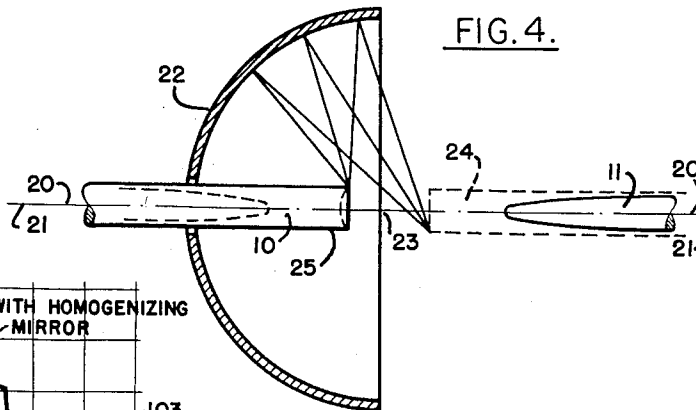
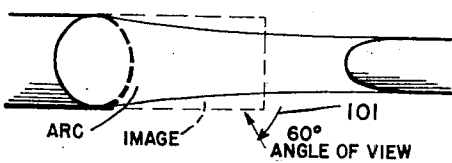
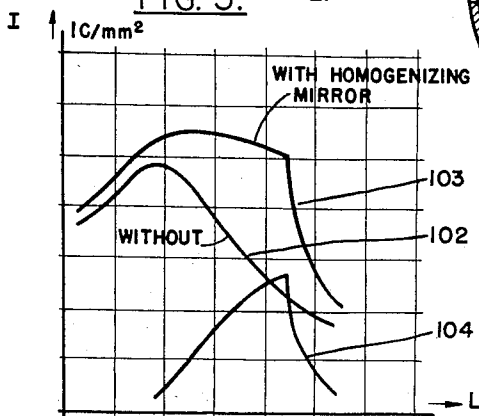


FIG. 5.



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DIRECT CURRENT ARC HAVING REFLECTOR
MEANS SUPERIMPOSING A REVERSE COM-
PLEMENTARY IMAGE ON THE ARC

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The present invention is concerned with increasing and improving the illumination obtainable from an arc source.

It is an object of the invention to compensate for the dark area normally surrounding the negative electrode of a carbon arc.

It is an object of the invention to distribute the incandescent gases constituting a carbon arc in such a manner that the light produced is maximized.

It is an object of the invention to superimpose upon an arc lamp reflector a reverse complementary image of the arc so that the light level of the negative dark area is brought up to that of the rest of the arc.

It is an object of the invention to make a carbon arc light source having a brilliant positive crater, a dark negative electrode area and a resultant irregular light distribution or gradient between electrodes into a light source which is maximum in both brilliance and homogeneity by first moving some of the glowing ionized vapors forming the arc away from the brilliant positive arc crater toward the dark negative electrode in such a manner that although the negative electrode area is still darker than the positive electrode area, the gradient or rate of change of light intensity or value between electrodes is often non-uniform but is usually and in the same direction, that is, constantly decreasing from the positive electrode to the negative electrode. When such an arc with a variable gradient of light level is combined with its reversed substantially complementary image not only is the light level throughout the arc the same, i. e., substantially zero gradient, but the light level is maximized because all practically available light is utilized.

Other objects will appear as the description continues. The following disclosed structure is intended to be illustrative of a few of the forms the invention may take and is not to be considered as limiting. In the drawing like numbers refer to like parts throughout.

In the drawings:

Fig. 1 is a schematic elevation of a carbon arc with means to distribute the arc.

Fig. 2 is a schematic sectional view of means for superimposing a complementary arc image.

Fig. 3 is a schematic sectional view of a second arrangement similar to Fig. 2 but with a main reflector having a smaller radius of curvature, for increasing the apparent homogeneity of the arc.

Fig. 4 is a schematic sectional view of a third arrangement for increasing the apparent homogeneity of the arc.

Fig. 5 is a graph of the illumination level measured along the arc column of Fig. 3.

Positive carbon 10 and negative carbon 11 have an arc 12 of incandescent carbon gas there be-

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tween maintained by current flow. The bright spot of the normal carbon arc is the crater 13 in the end of the positive carbon 10, the area around the end of negative carbon 11 being relatively dark. A first step in improving the arc as a light source is to move some of the hot gases from around crater 13 to the area around negative carbon 11. This may be accomplished by a nozzle 14 around positive carbon 10. Nozzle 14 may be made of metal or ceramic material as desired and mounted on the carbon holder together with the carbon feeder usual in carbon arc lamps. Nozzle 14 is shown in outline only and is connected to a supply line 15 through which a gas such as air is forced under pressure. If desired a gas such as nitrogen or carbon dioxide may be used to decrease the oxidation of carbons 10 and 11. Where the atmosphere of the arc itself is drawn off and recycled a higher arc efficiency is maintained. The gas is nozzled to obtain sufficient velocity and caused to flow through annular orifice 16 surrounding positive carbon 10. As shown in Fig. 1 the arc 12 is smoothed into a cylindrical column by the flow of the nozzled gas and concentrated between the electrodes 10 and 11. Parts of the arc 12 are caused to surround negative carbon 11 as at 17. This distribution of the incandescent gas of the arc gives a more uniform cylindrical light source.

While the above redistribution of the arc 12 aids in forming a satisfactory light source, the arc portion 17 is still relatively dark.

This is the first step. The pressure and volume of the air flow around arc 12 is so chosen that the distribution of the incandescent ionized gas yields a more uniform light source cylinder and in so far as is possible one in which the respective halves or selected portions are reasonably complementary. That is, although the light level along the arc is not uniform the critical peak at the crater has been ironed out and the dark area around the negative electrode filled in so that the blown arc plus its reversed complementary image yields a composite light source of uniform intensity along its length. This is true because if to each instantaneous value of light intensity along the arc is added its adjusted complementary value the result will be a constant value of light intensity along the arc. This of course assumes that the pressure and air volume are adjusted so that the arc portions are in fact complementary or reasonably so over a desired distance.

In carbon arc illumination system it is customary to use a reflector such as a concave mirror 18. The axis of the arc stream 12 can be placed in line with, or perpendicular to, the optical axis of concave mirror 18. The mirror 18 can reflect only a part of the light from arc 12 and although there is direct emanation that portion of the light

not utilized by main reflector 18 is not efficiently directed. It has been found that by placing an auxiliary mirror or reflector 19 so as to embrace the solid angle not included by the main reflector 18, a reversed image of the light source is superimposed on itself. Main reflector 18 now reflects both the light falling directly upon it from arc 12 and that reflected upon it by auxiliary reflector 19. Thus the arc 12, as seen from the main reflector 18, is a light cylinder with an approximately homogeneous brightness. The lumen output per unit of apparent arc cylinder area is a substantial constant within reasonable limits. With this arrangement, it appears to main reflector 18 as if arc 12 were burning between two positive carbons. By superimposing the image on to the actual arc to give a homogeneous brightness distribution along the arc cylinder axis, the average apparent brightness of the arc stream 12 is considerably increased. More usable light is obtained.

In general, the solid angle of the auxiliary mirror symmetrically placed about the mid-point of the light cylinder is made equal to the solid angle of the main reflector. The illumination system of the combined auxiliary mirror and main reflector gives its maximum light output when the total angle of embrace of both reflectors with respect to arc 12 is 360 degrees. Such an arrangement for the case of a parabolic main reflector 18 is shown in Fig. 2 in which main reflector 18 subtends 180 degrees or one pi radians of the angle about the axis of carbon electrode 12 and auxiliary reflector 19 also subtends 180 degrees or one pi radians, making 360 degrees in all.

The auxiliary mirror may be used in a number of ways. For example, in Fig. 3 the axis 20 of arc stream 12 is perpendicular to optical axis 21 of main reflector 22. In Fig. 4 axes 20 and 21 coincide. The arc 12 is superimposed on itself by auxiliary mirror 19 when the center of curvature 23 coincides with the mid-point between the ends of carbons 10 and 11, which are then imaged at 24 and 25 respectively. From the view point of the main reflector or mirror 22 a practically constant arc brightness appears between the crater 13 in positive carbon 10 and its image 24. Beyond these limits the level of illumination rapidly decreases.

As shown in Fig. 3 where great homogeneity of light level is desired the focus 23 is displaced from the midpoint between electrodes toward the positive crater 13. This brings the reversed image 24 of crater 13 closer and makes a shorter effective combined arc image with some loss of light, but with a gain in homogeneity required by high fidelity reproduction with a photo electric cell.

It has been found that auxiliary mirror 19 becomes very hot when placed in close proximity to the arc 12 as the radiant energy it receives, while no more than that received by the main reflector 22, is concentrated in a relatively small mass with a limited radiating surface. This is true even though mirror 19 is an excellent reflector. While ceramic reflectors may be used a metal mirror is preferred. First, the metal itself can be polished to reflect. Where a plated reflecting coating is used the bond between the reflecting coat and the supporting metal is usually so good that they act as a single piece of metal. This is seldom true of metal coatings on ceramic mountings where high temperatures are involved. Second, metal reflectors are much more readily cooled. The rapid conduction of heat to all parts permits direct water cooling for highest efficiency. In general, however, forced air cooling is sufficient. The

back of a metal mirror acts as a suitable radiator of the absorbed heat. It may be finned as at 26 if desired, care being exercised that the fins 26 do not intercept the light.

Fig. 5 shows the illumination level with respect to position along the arc column of an arrangement such as shown in Fig. 3. In the graph the abscissa represents distance along the arc between the electrodes shown and the ordinates corresponding values of light level or brilliancy as determined by a sensitive light meter. The line of observation during the measurements was inclined by an angle of approximately sixty degrees to the axis of the arc column as indicated by arrow 101. The curve 102 shows the brightness of the arc column without an homogenizing mirror 22. Curve 103 shows the increase in brilliancy obtained by superimposing the inverse arc image on curve 102 and adding the two ordinates. Curve 104 shows the brilliancy of the arc image taken alone. Due to parallax resulting from the angle of observation the maximum brilliancy or peak of curve 102 will be seen to appear displaced somewhat to the right away from the edge of the crater. The brilliancy of the crater adds to the brilliancy of the arc column because of the search light effect of the incandescent hollow crater with its polar axis coinciding with the longitudinal axis of the arc column. The maximum brilliancy of the reversed image is somewhat lower than the arc column maximum due to the absorption losses within the ionized gaseous column and to the deviation from unity of the index of reflection of the reversing mirror. Curve 102 shows that the brilliancy of the homogenized arc column is practically or substantially uniform up to a certain point which corresponds to the location of the image of the separation edge between the arc column and the positive crater. Beyond that critical point, as shown by graph 103, the illumination level or brilliancy rapidly decreases.

It will be noted that the invention achieves its result as a practical matter. That is to say for practical purposes graphs 102 and 104 are complementary in sufficient degree to combine to produce a substantially or practically uniform portion in curve 103. Mathematical exactness in the sense of a curve portion parallel to the abscissa is not required, but of course the result improves as it is approached.

While I have described my invention in terms of physical structure, it will be readily understood that structure other than that described may embody the spirit of the invention. The claims are presented to set forth the invention in more general terms and the foregoing description is offered as an aid in their interpretation and is not to be taken to limit their scope. The detailed structures disclosed above are offered as specific examples or species of the generic terms appearing in the claims.

An example of the above is the use of a magnetic focusing coil 27 to compress the hot ion cloud around crater 13 and move the incandescent gas toward negative electrode 11. Again electrostatic fields may be applied to the arc stream 12 to accelerate ions in their flow and cause the stream 12 to take a more uniform cylindrical shape.

It will be appreciated with the use of coincident axes 20, 21 as shown in Fig. 4 a blown arc or its magnetic equivalent obtained with a coil 27 is necessary. A polar diagram of illumination from the common positive crater indicates no light from the brilliant crater passes the plane normal

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to the electrode at the crater end. The three-dimensional light level diagram of the crater forms an oblate spheroid tangent to the crater 13.

This spheroid is directed away from reflector 22. On the other hand a blown arc produces an intensity diagram in the form of a torus surrounding the arc cylinder and having a substantial portion directed toward reflector 22 positioned as in Fig. 4.

I claim:

1. In combination in a direct current arc lamp assembly, a positive carbon electrode having a brilliant crater, a negative electrode, means to move portions of the ionized gas forming the arc away from said crater and toward said negative electrode to form a corrected arc column having a light distribution over an effective portion of the distance between said electrodes of such value that for each point of said effective portion the sum of the light value of a given point of said portion plus the light value superimposed by a corresponding point of the reversed image of said portion is substantially a constant for all such pairs of points when superimposed in additive relation, a main reflector for said light producing corrected arc column having a focal point adjacent said column, a spherical auxiliary reflector embracing a large solid angle of the order of pi radians and having a focal point positioned to reflect a reversed image of said corrected arc column upon said column, said main reflector serving to project a beam of brilliant homogeneous light combining the beams from said corrected column and said reversed image, whereby a carbon arc having an irregular light gradient is given a light gradient of such character over an effective portion of the distance between electrodes so that when combined with its complementary reversed image the combination produces a beam of light having substantially the same level of intensity along a length corresponding to said portion suitable to be condensed to produce an intense homogenous image of its source comprising the corrected portion of the arc column and its reversed image in complementary relation.

2. The combination set forth in claim 1, said means to move portions of the ionized gas forming the arc comprising nozzle means surrounding said positive electrode to direct an annular stream of gas around and along said positive electrode and the arc between said electrodes to form a short, smooth, brilliant arc-light source cylinder between said electrodes.

3. The combination set forth in claim 2, having means to cool said auxiliary reflector to retain its accuracy as an optical surface.

4. The combination set forth in claim 3, said means to cool said auxiliary reflector comprising fins on the side thereof removed from said arc and serving both to increase the radiating capacity of the said auxiliary reflector and the structural strength thereof to minimize warping.

5. The combination set forth in claim 1, the optical axis of said reflectors being normal to the axis of said electrodes.

6. The combination set forth in claim 1, the optical axis of said reflectors being coincident with the axis of said electrodes.

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7. In combination in a direct current arc lamp assembly, a positive carbon electrode having a brilliant crater, a negative electrode, means to move portions of the ionized gas forming the arc away from said crater and toward said negative electrode to form a corrected arc column having a light level distribution along an effective portion such that when added to the reversed image of said portion the composite source has a substantially uniform light level, a main reflector for said light producing corrected arc column having a focal point closely adjacent said portion, a spherical auxiliary mirror embracing a solid angle of the order of pi radians having a focal point also closely adjacent said portion and positioned to reflect a reversed image of said corrected arc column upon said column adjacent the said focal point of said main reflector, said main reflector serving to project a beam of brilliant homogeneous light combining the beams from said corrected column and said reversed image, whereby a carbon arc having an irregular light gradient is given a substantially uniform light gradient between electrodes and combined with its reversed image to produce a beam of light having substantially the same level of light intensity throughout and suitable to be condensed to produce an intense homogeneous image of its source comprising the corrected arc column and its reversed image in complementary relation.

8. In combination in a direct current arc assembly, a positive carbon electrode having a brilliant crater, a negative electrode, said electrodes being constructed and arranged to form an arc therebetween, a main reflector for said arc, a spherical auxiliary reflector embracing a large solid angle of substantially one pi radians having a focal point positioned to reflect a reversed image of said arc upon said arc, said main reflector serving to project a beam of brilliant homogeneous light combining the beams of said arc and its reversed image, whereby a carbon arc having an unequal light level distribution along an effective portion is combined with a reversed complementary image of said arc to produce a uniform lighting effect.

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