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SELF-CIRCULATING PLASMA DEVICE

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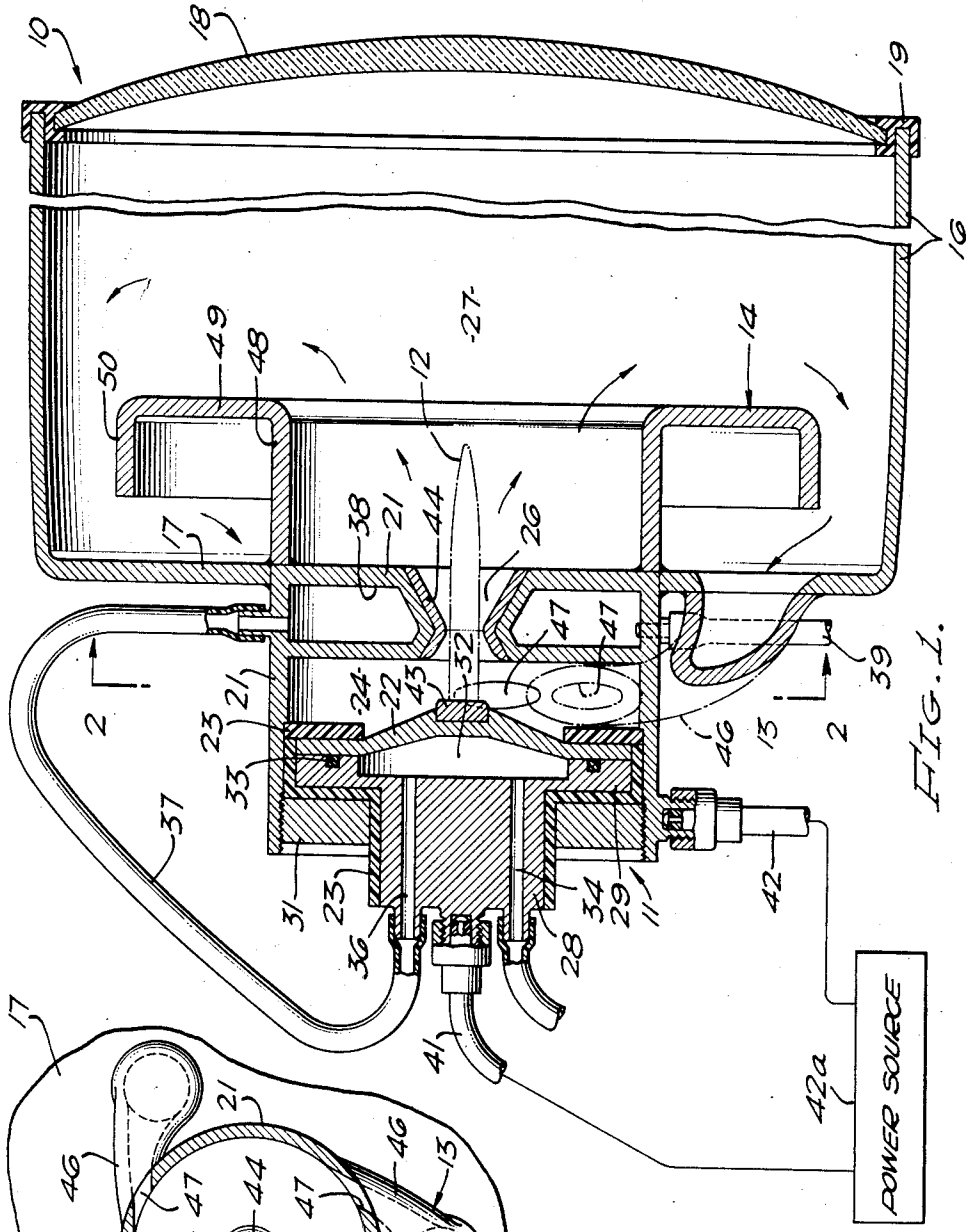

FIG. 1.

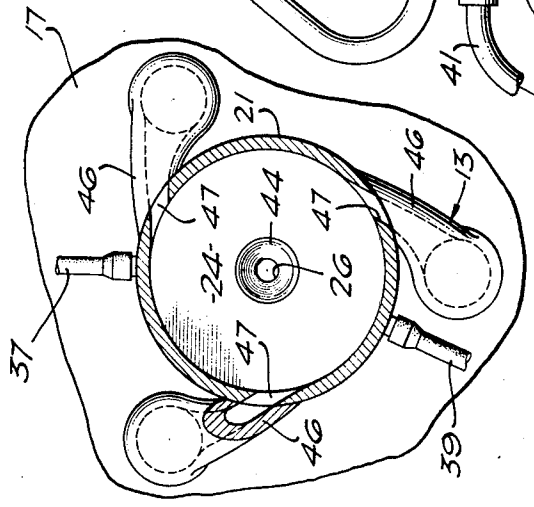

FIG. 2.

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SELF-CIRCULATING PLASMA DEVICE

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13 Claims. (Cl. 313—231)

This invention relates to a self-circulating plasma device, and more particularly to an electric lamp or light device making use of a plasma jet.

The majority of electric lamps or lights of the high-intensity type fall into two classes, one of which comprises arc lamps and the other of which comprises incandescent lamps. Both of these classes of electric lamps are subject to well-known limitations, particularly in regard to the current which it is practical to pass therethrough. Thus, increasing the current passed through an arc lamp is not practical, after a certain optimum current is reached, because the arc merely increases in cross-sectional area without effecting a proportionate increase in illumination. Furthermore, such extremely high current makes the electrode life undesirably short. With relation to incandescent lamps, an increase in the current passed through the filament, to a value above a certain optimum range, causes the filament to melt or otherwise deteriorate at an excessively rapid rate.

In view of the above and other factors and limitations relative to conventional high-intensity electric lamps, it is an object of the present invention to provide a high-intensity electric lamp which makes use of a plasma jet, and which incorporates electrodes through which very high currents may be passed without resulting in excessively rapid deterioration.

A further object of the invention is to provide an electrical plasma-jet device in which recirculation of gases is achieved solely as the result of the plasma jet itself and in the absence of auxiliary pumping means.

A further object of the invention is to provide means for effecting confinement of an electric arc, and formation of a plasma jet incident to such arc, in the absence of auxiliary pumping means for recirculating gases through the arc chamber.

These and other objects and advantages of the invention will be more fully set forth in the following specification and claims, considered in connection with the attached drawing to which they relate.

In the drawing:

Figure 1 is a longitudinal central sectional view of a plasma-jet lamp incorporating the present invention; and

Figure 2 is a fragmentary transverse sectional view taken on line 2—2 of Figure 1.

Stated generally, the apparatus comprises means **10** to define a sealed chamber, an electrical plasma-jet torch **11** adapted to discharge a plasma jet or flame **12** into the sealed chamber, and means **13** to effect recirculation of gas from the sealed chamber through the torch and thence back into the chamber. Baffle means **14** are provided to increase the length of the path through which the gas must flow in recirculating between the torch and the sealed chamber, thereby increasing the cooling of the gas to prevent building up of undesirably large amounts of heat in the apparatus.

The means **10** for defining the sealed chamber is illustrated in Figure 1 to comprise a generally cylindrical casing **16** formed of relatively thin metal. Casing **16** has a radial end wall **17** which is provided with a central opening to receive the casing of torch **11**, such torch casing being welded or otherwise sealingly associated with the wall **17**. The torch **11** is thus mounted coaxially relative to casing **16** so that the plasma jet **12** extends along the casing axis and toward a lens **18**, or other transparent wall portion, mounted at the end of casing **16** remote from the torch. The lens **18** is illustrated as being externally convex, and as being sealingly mounted on the casing **16** by means of a combination sealing and mounting element **19**.

The electrical plasma-jet torch **11** is illustrated to comprise a generally cup-shaped nozzle element **21** which also forms a major part of the casing of the torch, and into which is inserted in coaxial relationship a generally disc-shaped back electrode **22**. Combination insulation and sealing means **23** are provided between the nozzle and back electrodes **21** and **22** to maintain the same in mutually insulated relationship and to seal an arc chamber **24** formed between the back electrode and the radial front wall of the nozzle electrode. Chamber **24** is annular in shape and coaxial with the nozzle opening **26** which is formed centrally in the nozzle element. As will be set forth hereinafter, gas is adapted to recirculate from the arc chamber **24** through nozzle opening **26** into the first-mentioned sealed chamber (which may be given the reference numeral **27**) and thence back through the means **13** to chamber **24**.

Additional elements of the illustrated plasma-jet torch **11** include a base **28** having a radial flange **29** which bears against the peripheral portion of back electrode **22**. Such elements are maintained in assembled relationship by means of a retaining ring **31** which is threaded into the rear or skirt portion of nozzle element **21** and bears against the combination insulation and sealing means **23**.

Means are provided, particularly in larger devices through which large amounts of electric current are passed, to maintain the electrodes **21** and **22** relatively cool. Such means may comprise a water chamber **32** formed in the base element **28** adjacent back electrode **22** and suitably sealed by means of an O-ring **33**. Water is introduced from a suitable source into the chamber **32** by means of an inlet passage **34** in base **28**. From chamber **32**, water is discharged through an outlet passage **36** to an insulating hose **37** leading to an annular cooling chamber **38**. Chamber **38** is provided around the nozzle region of the nozzle electrode and discharges into a hose **39** leading to a suitable drain or recirculation device.

Electrical conductors **41** and **42** are suitably connected, respectively, to base **28** and nozzle **21**. Such conductors lead to a suitable source of electric current, indicated at **42***a*, which is preferably a relatively high-power source of direct current. Current entering base **28** through lead **41** is conducted to flange **29** and thence to back electrode **22**, the latter having a central refractory insert **43** formed of tungsten or the like. Another insert, numbered **44** and also formed of a refractory such as tungsten, is provided around the wall of nozzle opening **26**. After an electric arc has been struck between the inserts **43** and **44**, such as by momentarily impressing thereacross a high-voltage or high-frequency power source, the current flows through the inserts **43** and **44** to the main body of nozzle electrode **21** and thence back through lead **42** to the power source.

The means **13** to effect recirculation of gas between chambers **24** and **27** are illustrated to comprise a plurality of conduits **46** having relatively large end portions

communicating with chamber 27 at radial wall 17, and relatively small end or nozzle portions communicating tangentially with the arc chamber 24. As best shown in Figure 2, the illustrated conduits 46 are three in number and are equally circumferentially spaced about the nozzle element 21. The conduits 46 all extend in the same direction (Figure 2) and communicate with the chamber 24 through tangential inlet openings 47 in nozzle element 21. Conduits 46 have the effect of increasing the velocity of gas flowing therethrough and tangentially into chamber 24, causing a relatively rapid whirling or vortical flow of gas in the chamber 24 and surrounding the electric arc struck between inserts 43 and 44.

A certain amount of the whirling gas adjacent the vortex is greatly heated by the electric arc and forms the plasma 12 which streams through the nozzle opening 26 into chamber 27. For purposes of the present application, such plasma 12 may be defined as consisting of neutral gas, ions and electrons having high temperatures and velocities. The plasma 12 forms a brilliant and intense source of light, so that light rays are radiated and pass through the lens 18 for concentration and direction thereby.

In order to increase the velocity of the plasma jet 12, the nozzle insert 44 is illustrated as being shaped generally as a Laval nozzle. The resulting high plasma velocity has the effect of drawing gas into chamber 24 through inlet openings 47 at a substantial rate effecting the above-mentioned vortical gas flow in the chamber 24.

The gas provided in the chambers 24 and 27 may be of various types, such as argon or mercury vapor. The gas may be at atmospheric or higher pressures, or at pressures well below atmospheric.

The baffle means 14 is illustrated to comprise a tubular element 48 welded coaxially to the front peripheral portion of nozzle 21 radially inwardly from the inlets in wall 17 to conduits 46. Tube 48 has a radial flange 49 connected to a second and larger diameter coaxial tube 50 which is relatively close to the cylindrical casing element 16. The result is that gas entering chamber 27 through nozzle opening 26 must flow, as indicated by the arrows, radially outwardly past flange 49 and then back through the annulus between tube 50 and casing 16. The gas then flows into the conduits 46 and through tangential inlet openings 47 into chamber 24. As the gas flows through the annulus between tube 50 and casing 16, it is substantially cooled due to heat conduction through the casing wall. Such wall may be suitably water jacketed.

Summary of operation

To summarize briefly the operation of the embodiment of the invention shown in the drawing, the chamber 27 is first provided with suitable gas, such as mercury vapor or argon, at a desired pressure which may be substantially below atmospheric. An electric arc is then struck between electrodes 21 and 22, such arc being maintained by current fed through the leads 41 and 42 from power source 42*a*. The current may be very large, for example hundreds of amperes. The arc normally strikes between inserts 43 and 44, since these are caused to be closer together than other portions of the electrodes.

The arc causes heating of the gas in chamber 24 and operates, in combination with the Laval nozzle, to effect streaming of the plasma jet 12 at high velocity through nozzle opening 26 and into chamber 27. This causes gas to flow from chamber 27 through conduits 46 and inlets 47 tangentially into chamber 24, in which it whirls around the arc and then passes through the nozzle opening 26 in a continuous recirculation operation. In whirling around the arc, the gas tends to confine it to a path between inserts 43 and 44. The relatively long length of the circulation path, and the relationship by which the gas must pass adjacent casing wall 16 radially outwardly of tube 50, causes substantial cooling of the gas prior to entry thereof into the chamber 24.

The resulting plasma jet 12 has, as previously indicated, a high intensity and comprises and excellent source of light. Such light is passed through the wall of chamber 27 at lens 18 for use in any desired manner.

It is within the scope of the invention to provide reflecting means in chamber 27 and around the plasma jet 12. Furthermore, it is within the scope of the invention to effect self-recirculation of part of the gas around the external portion of the plasma jet 12, that is to say on the side of nozzle opening 26 remote from back electrode 22. Means may be provided to effect pumping of gas through conduits 46 to insure proper initiation of the self-circulation cycle, but auxiliary pumping is discontinued after such initiation.

Various embodiments of the present invention, in addition to what has been illustrated and described in detail, may be employed without departing from the scope of the accompanying claims.

We claim:

1. An electric lamp, which comprises means to define a first chamber having at least one light-transmissive wall portion, an electrical plasma-jet torch having a nozzle opening communicating with said chamber, said torch having a second chamber therein communicating with said nozzle opening, and means to effect recirculation of gas between said first chamber and said second chamber and thence through said nozzle opening in the form of high-temperature plasma having substantial light-radiating characteristics.

2. The invention as claimed in claim 1, in which said last-named means is adapted to effect vortical flow of gas in said second chamber within said torch.

3. A high-intensity electric lamp, which comprises means to define a sealed chamber having at least one transparent or translucent wall portion, a nozzle element having a nozzle opening communicating with said chamber, and means to maintain an electric arc in the region of said nozzle opening and to effect continuous recirculation of gas through said nozzle opening solely as the result of said electric arc and in the absence of auxiliary pumping means.

4. A high-intensity electric lamp or light, comprising means to define a sealed gas-filled chamber having at least one light-permeable wall, a nozzle electrode having a nozzle opening therein communicating with said sealed chamber, a back electrode mounted in spaced and insulated relationship from said nozzle electrode, means to define an arc chamber communicating with said nozzle opening, said arc chamber being annular in shape and coaxial with said nozzle opening and encompassing at least a portion of said back electrode, means to maintain an electric arc in said arc chamber between said nozzle and back electrodes and in the vicinity of said nozzle opening, and conduit means having one end portion communicating with said sealed chamber and another portion communicating tangentially with said arc chamber to effect recirculation of gas between said chambers and through said nozzle opening into said sealed chamber, said gas being drawn into said arc chamber solely as the result of the presence of said electric arc and in the absence of auxiliary pumping means, said gas flowing vortically in said arc chamber and around said arc.

5. The invention as claimed in claim 4, in which baffle means are provided to cause the gas to follow a relatively long path in recirculating between said chambers.

6. The invention as claimed in claim 4, in which nozzle means are provided at said nozzle opening to increase the flow velocity of gas passing through said opening from said arc chamber into said sealed chamber and in the form of high-temperature light-radiating plasma.

7. An electric lamp, which comprises means to define a sealed chamber, said means including a lens

portion mounted in at least one wall of said sealed chamber, an electrical plasma-jet torch having a nozzle opening communicating with said sealed chamber and disposed opposite said lens portion for transmission of light therethrough, said nozzle opening being defined by a nozzle electrode shaped to increase the rate of gas flow therethrough into said sealed chamber, said torch including a back electrode spaced from said nozzle opening and also including an annular arc chamber disposed between said nozzle and back electrodes coaxial with said opening, the distance between said electrodes being a minimum near the axis of said arc chamber, and conduit means connecting said sealed chamber to said arc chamber and disposed to introduce gas tangentially into said arc chamber for vortical flow therein and subsequent flow through said nozzle opening into said sealed chamber solely as the result of the presence of an arc between said electrodes in the vicinity of said nozzle opening.

8. The invention as claimed in claim 7, in which said means to define said sealed chamber includes a heat-conducting wall portion and baffle means to effect recirculation of gas along said heat-conducting wall portion to thereby effect cooling of said gas prior to entry into said conduit means.

9. A self-recirculating plasma device, which comprises a nozzle element and a back electrode mounted in spaced relationship, means to define a sealed chamber communicating with said nozzle element on both sides of the nozzle opening therein, and means including said back electrode to maintain an electric arc in the vicinity of said nozzle opening and to effect recirculation of gas through said nozzle opening solely as the result of the presence of said arc and in the absence of auxiliary pumping means.

10. A self-recirculating plasma device, which comprises an electrical plasma-torch having a nozzle electrode and a back electrode, said nozzle electrode having a nozzle opening therein, means to define an annular chamber between said nozzle and back electrodes and communicating with said nozzle opening, said chamber being coaxial with said nozzle opening, means to define a second and gas-filled chamber externally of said torch and communicating with said nozzle opening on the

side thereof opposite said annular chamber, recirculation means connecting said last-mentioned chamber with said annular chamber and adapted to effect introduction of gas from said last-mentioned chamber tangentially into said annular chamber, means to maintain a high-current electric arc between said electrodes in said annular chamber and in the vicinity of said nozzle opening, said arc serving to effect vortical flow of gas in said annular chamber and discharge of gas through said nozzle opening in the form of high-temperature plasma.

11. The invention as claimed in claim 10, in which said recirculation means are adapted to increase the velocity of gas flowing therethrough prior to tangential introduction thereof into said annular chamber.

12. The invention as claimed in claim 10, in which the wall of said nozzle opening is shaped as a Laval nozzle to increase the velocity of gas flow therethrough.

13. A self-recirculating plasma light, which comprises an electrical plasma torch having a nozzle electrode and a back electrode, said nozzle electrode having a nozzle opening therein, means to define a gas chamber between said nozzle and back electrodes and communicating with said nozzle opening, means to define a second gas chamber externally of said torch and communicating with said nozzle opening on the side thereof opposite said first-mentioned gas chamber, said last-named means including at least one light-transmissive wall portion, recirculation means connecting said second gas chamber with said first-mentioned gas chamber and adapted to effect introduction of gas into said first-mentioned gas chamber independently of said nozzle opening, and means to maintain a high-current electric arc between said electrodes in said first-mentioned gas chamber and in the vicinity of said nozzle opening, said arc serving to effect recirculation of gas from said second gas chamber through said recirculation means into said first-mentioned gas chamber and thence through said nozzle opening back into said second chamber and in the absence of auxiliary pumping means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,779,890 Frenkel ---------- Jan. 29, 1957

Notice of Adverse Decision in Interference

In Interference No. 91,649 involving Patent No. 2,929,952, G. M. Giannini, and A. C. Ducati, Self-circulating plasma device, final judgment adverse to the patentees was rendered Mar. 9, 1962, as to claims 1, 3 and 9.

[*Official Gazette, April 17, 1962.*]

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