

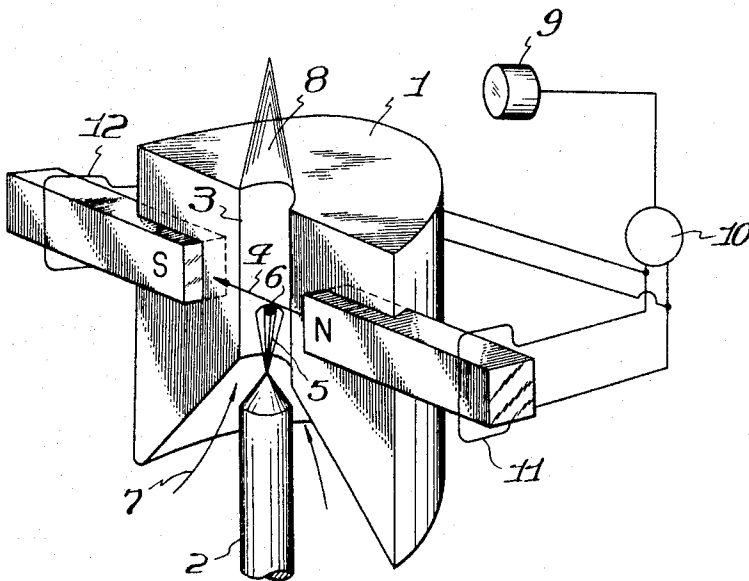
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MAGNETICALLY CONTROLLABLE PLASMA FLAME GENERATOR

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MAGNETICALLY CONTROLLABLE PLASMA FLAME GENERATOR

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2 Claims. (Cl. 315-111)

This invention relates to a new and original technique providing a controllable plasma flame generator.

In general, since a plasma flame generator requires a high-power discharge of an electric current of a number of tens of amperes or more and, in terms of electric power, of a number of kilo-volt-amperes or more, it is difficult to maintain its discharge in a stable state over a long period of time or to achieve fine adjustments of conditions such as the plasma flame length and temperature.

When a plasma flame of such a generator in operation is examined by means of high-speed photography, it is observed that the length and thickness of the ejected flame fluctuate with time, and it can be readily confirmed that, in accordance with these fluctuations, the intensity of light emitted from the flame also fluctuates. These fluctuations are, in all cases, of the order of approximately 10 percent or less. Accordingly, depending on the application, such fluctuations do not present a problem. However, in cases wherein the temperature and intensity of emitted light of the plasma flame is required to be stable with respect to time, as in the case of application of the flame as a light source for scientific instruments, or in cases such as that of its application as the working fluid in a supersonic wind tunnel, wherein stability of the velocity of the gas flow is required, there is a great probability of the above-said fluctuations becoming a problem because the stability of the plasma flame, in the operation of these instruments and apparatuses, becomes a determining factor influencing their performance.

Among the factors adversely affecting the stability of a plasma flame, the following three factors are the most important.

- (1) Migration of electrode foot points of the arc.
- (2) Fluctuation of current.
- (3) Fluctuation of gas flow rate.

Herein the electrode foot points of the arc designate the points where the arc connects to the electrodes (anode and cathode). That is, the arc current is supplied through these foot points.

It is an object of the present invention to prevent the occurrence of the above-stated migration of electrode foot points of the arc.

More specifically, the present invention contemplates providing a controllable plasma flame generator by a new and original technique which has been discovered and developed as a result of intensive experimental research.

The nature, principles, and details of the invention will be best understood by reference to the following description taken in conjunction with the accompanying drawing, which is a perspective view, partly in vertical section and partly in diagrammatical form, showing a preferred embodiment of the plasma flame generator according to the invention.

Referring to the drawing, the embodiment shown therein comprises, essentially, a thoriated tungsten cathode 2, a water-cooled copper anode 1 which has a plasma flame ejection nozzle 3 formed centrally therein, and means, to be described in greater detail hereinafter, to apply a magnetic field 4 across the said nozzle 3.

Application of a discharge voltage to the anode 1 and cathode 2 causes a discharge current 5 to flow between

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the tip of cathode 2 as the cathode foot point of the arc and one point on the anode 1 as the anode foot point. A gas flow 7 is supplied to flow upwardly past the sides of the cathode 2, past the discharge arc, and through the nozzle 3, whereby a plasma flame 8 is ejected upwardly from the exit of nozzle 3.

The electromagnetic force created by the mutual interaction of the aforesaid magnetic field 4 and the discharge current 5 causes the arc anode foot 6, which, otherwise, would readily migrate, to be held constantly at a definite, fixed point. That is, any tendency of the arc anode foot 6 to advance from the said point toward the outside, that is, toward the exit of the nozzle 3, is prevented by the resulting increase in the electromagnetic force imparted to the discharge arc; and any tendency of the anode foot 6 to retract inwardly from the said point is prevented by the sweeping action of the gas flow 7. In this manner, it is possible to fix the position of the electrode foot point. In this case, it has also been found through experiments conducted by the present inventors that the length and emitted light intensity of the ejected plasma flame 8 readily vary in accordance with the intensity of the magnetic field 4. The reason for this is that one portion of the leakage flux intersects the discharge current 5 and has a tendency to press this discharge current against one side of the inner wall surface of the nozzle 3, and the degree of this tendency varies in accordance with the intensity of the magnetic field.

The present invention, in its principal aspect, makes possible control of the ejected plasma flame through utilization of the above-described characteristic.

The embodiment shown in the drawing is that of a plasma flame generator in which the plasma flame is so controlled as to cause its emitted light intensity to be constant. The afore-mentioned magnetic field 4 is created by magnetic field coils 11 and 12 provided with suitably adapted and disposed cores N and S. These magnetic field coils 11 and 12 are controlled by current supplied by a control circuit consisting of a photoelectric transducer 9 for measuring the emitted light intensity of the plasma flame 8 and an amplifier 10 for converting the output of the said photoelectric transducer 9 to the desired current value.

By effecting negative feedback of the fluctuation of the emitted light intensity of the plasma flame to the controlling magnetic field 4 by means of the apparatus arrangement described above, it is possible to reduce the fluctuation of the emitted light intensity. Such reduction of fluctuation is not limited merely to the emitted light intensity, it being possible, by effecting negative feedback of other fluctuations such as those of ripples in the power source and the gas flow rate, to cause such fluctuations to be cancelled.

Since a magnetic field of extremely low intensity suffices for control, the ejected plasma flame is not caused to assume an extremely non-symmetric configuration. If the symmetry of this configuration is particularly important, the symmetry of the configuration of the ejected flame can be maintained by causing the position of the electrode foot point of the arc to vary in a regulated manner by means of a periodically varying magnetic field, such as an alternating magnetic field or a rotating magnetic field.

For these problems and the problem of the magnetic field intensity, the optimum point must be suitably determined in accordance with the operational conditions and use of the plasma jet.

Although the foregoing description has been presented with respect to the case of automatic control by feeding back the emitted light intensity, it is also possible to control the state of generation of the plasma flame by manual

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control or in accordance to a predetermined control program. It is a unique advantage of the present invention that, in all cases, fine adjustment is possible with an extremely low power. Accordingly, the present invention is particularly effective as means for control of the state of generation of the plasma flame or for stabilization thereof.

It is to be observed, furthermore, that the direction of the magnetic field need not always be such as to cross perpendicularly relative to the discharge current direction. It will be apparent that the essential requirement is that the construction of the generator be such as to cause the two directions to cross each other.

While the invention has been described with a particular embodiment, it will be understood, of course, that modifications, changes and the like may be made therein without departing from its scope.

What is claimed is:

1. A controllable plasma flame generator which comprises: a rod-shaped first electrode; a second electrode surrounding said first electrode and having a nozzle; means for creating an arc discharge between the said two electrodes; means for introducing a gas current through the discharge path of this arc so that it may be jetted out of the said nozzle; means for impressing on the arc discharge path between said two electrodes a magnetic field which intersects therewith; and means for auto-

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matically varying the strength of the said magnetic field in response to variations in intensity of luminance of the jet plasma flame; whereby the conditions of arc discharge can be controlled optionally and in a stable manner.

2. A controllable plasma flame generator which comprises: a rod-shaped first electrode; a second electrode surrounding said first electrode and having a nozzle; means for creating an arc discharge between the said two electrodes; means for introducing a gas current through the discharge path of this arc so that it may be jetted out of the said nozzle; means for impressing on the arc discharge path between the said two electrodes a periodically varying magnetic field which intersects therewith; and means for automatically varying the strength of the said magnetic field in response to variations in intensity of luminance of the jet plasma flame; whereby the conditions of arc discharge can be controlled optionally and in a stable manner.

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