June 2, 1970 TETUO GEJO ET AL 3,515,839

PLASMA TORCH

Filed April 1, 1968

FIG. 1

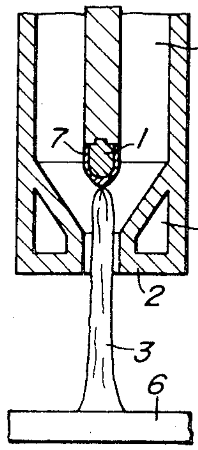


FIG. 2

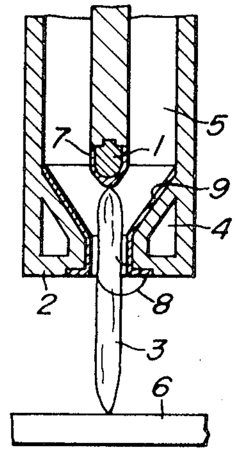
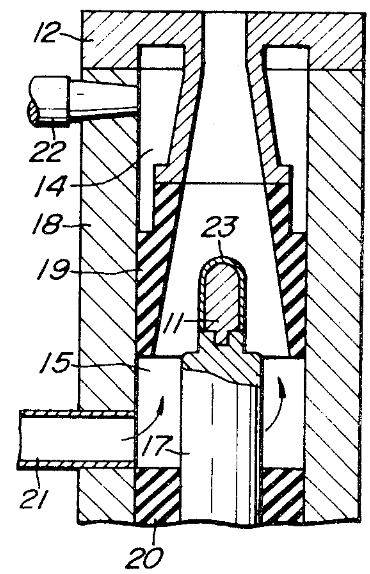
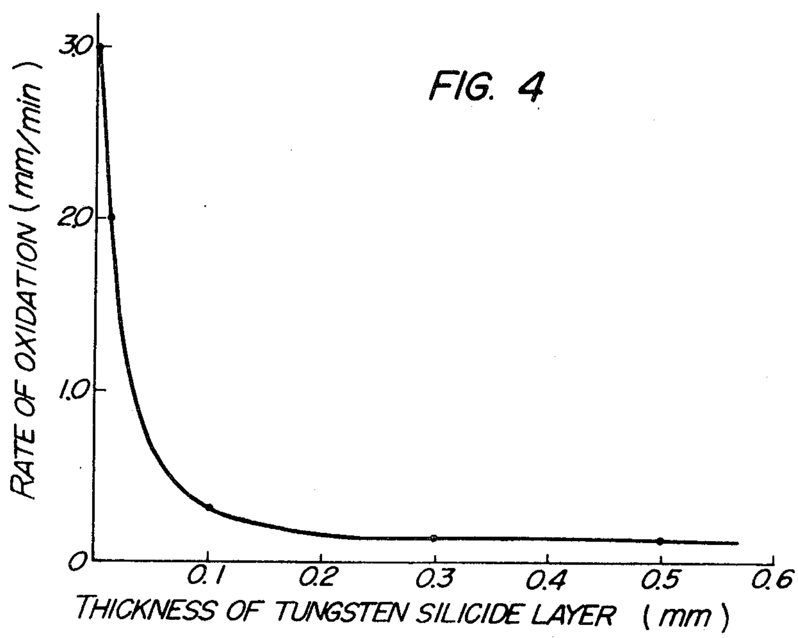


FIG. 3





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3,515,839
PLASMA TORCH

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U.S. Cl. 219—75 7 Claims

ABSTRACT OF THE DISCLOSURE

A plasma jet torch provided with a cathode made of tungsten or an alloy including tungsten as a principal component and whose surfaces are covered with tungsten silicide coating. According to said plasma jet torch, the rate of oxidation of the cathode when a plasma jet flame is generated with oxidizing arc gas can be reduced remarkably.

BACKGROUND OF THE INVENTION

This invention relates to a plasma torch for generating an intense plasma flame and more particularly to a plasma torch comprising an improved electrode.

Various methods of generating a plasma flame are known. Among them, a method of generating arc discharge or glow discharge and feeding work gas during the discharge is suitable for generating a particularly high energy plasma flame. The plasma flame provided in this way has a wide range of application in the processing of various materials (welding, spraying, cutting, etc.) and as a variety of heat sources.

As a device for generating a plasma flame by use of arc discharge, a torch discharge device composed of a cathode, a nozzle for ejecting a work gas provided in a way to surround said cathode and a power supply for causing a discharge between said cathode and said nozzle or between the other parts is used. A method of providing a plasma flame by generating arc discharge between said cathode and said nozzle and feeding a work gas to said discharge spot is called a non-transfer type method while a method of providing a plasma flame by generating discharge between said cathode and a part to be processed and feeding work gas to said discharge spot is called a transfer type method.

Such methods of generating a plasma flame which utilize arc discharge or glow discharge are advantageous in that a very high energy plasma flame is easily obtained. However, the temperature of the cathode and the nozzle becomes quite high, electrode materials having a high electroemissivity, a good thermal conductivity and a high melting point are necessary and, for example, thoriated tungsten has been mainly used. As work gas, non-oxidizing gas like argon, hydrogen, or nitrogen must be used.

However, the gas is relatively expensive and the methods are quite disadvantageous from an economic point of view when a large amount of work gas is necessary as in the case when a material is to be processed with the plasma flame. Accordingly, it is quite preferable if air can be used as work gas. However, no electrode having an oxidation resisting property sufficient to use a highly oxidizing gas has been known up to now.

SUMMARY OF THE INVENTION

An object of this invention is to provide a plasma torch comprising a cathode having a slow rate of oxidation sufficient to use oxidizing gas like air as work gas.

The plasma torch according to this invention comprises a cathode made of tungsten or an alloy including tungsten (e.g., thoriated tungsten) as a principal component whose surface is coated with tungsten silicide.

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The cathode of this invention coated with tungsten silicide is provided, for example, by making gaseous silicon compounds react with a cathode material shaped into a predetermined form at a high temperature and forming a tungsten silicide layer on the cathode surface. Another method wherein a tungsten silicide layer is formed by spraying a plasma flame is also effective.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic longitudinal sectional diagram of a cathode and a nozzle of a transfer type plasma torch according to an embodiment of this invention.

FIG. 2 is a schematic longitudinal sectional diagram of a cathode and a nozzle of a non-transfer type plasma torch according to another embodiment of the invention.

FIG. 3 is a schematic longitudinal sectional diagram of a plasma torch according to a further embodiment of the invention.

FIG. 4 shows the relation between the thickness of a tungsten silicide layer and the rate of oxidation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a schematic longitudinal sectional diagram of a transfer type plasma torch according to an embodiment of this invention. In a transfer type plasma torch, the inner walls of a nozzle **2** are maintained at a lower temperature than an electrode **1** in order to generate discharge between a work piece **6** and the electrode **1** and to generate a plasma flame **3** by feeding discharge gas to the discharge member from the discharge gas inlet **5**. By circulating a suitable amount of cooling water through a path for cooling water **4**, the oxidation of the inner walls of the nozzle **2** can almost be diminished. Accordingly, in many cases of a transfer type plasma torch, an oxidizing work gas can be used if a tungsten silicide coating **7** is provided to the cathode concentrically at the discharge spot.

FIG. 2 is a longitudinal sectional diagram of a non-transfer type plasma torch according to another embodiment of the invention. In a non-transfer type plasma torch, discharge **8** takes place between the cathode **1** and the nozzle **2**. Therefore, it is preferable to provide an oxidation resisting coating **9** made, for example, of Zirconia or alumina to the inner walls of the nozzle **2**. In the two kinds of plasma torches as described above, by utilizing, for example, the nozzle **2** or the work piece **6** as the cathode and the cathode **1** as the anode a discharge can similarly be caused therebetween.

A preferable example of such a plasma torch will be described hereinbelow. A cathode is formed by shaving one end of a tungsten bar including 2% thalium into a bullet shape and shaving the other end planely while providing a protrusion at the center. The size of the cathode is of the order of 15 mm. in length, 6 mm. in diameter, 3R in curvature at the top end part and 2 mm. ϕ x 4 mm. at the protruding part.

The cathode formed in the way described hereinabove is heated in hydrogen gas flow of about 0.5 l./min. Then, hydrogen is made to bubble through silicon tetrachloride liquid held at about 20° C. at the rate of about 0.2 l./min. and is fed to the heated cathode. When silicon tetrachloride vapour is made to react with the heated cathode, a tungsten silicide layer of about 0.3 mm. in thickness is formed on the cathode in about 30 minutes.

An example of a plasma jet torch in which such a cathode is used is shown in FIG. 3. As shown, the cathode **11** is mounted on the end of a centrally disposed cathode support **17** made of a material such as copper, and the anode **12** functioning additionally as a nozzle is mounted, coaxially with the cathode **11**, on a cylindrical anode support **18** also made of a material such as copper. An annular electrical insulator **19** is disposed concentrically inside the anode support **18** in a way to surround the cathode **11** and to join the inner end of the nozzle **12**. Between the nozzle **12** and the support **18** thereof a path **14** through which a cooling water is circulated is formed. Means for supplying the cooling water to the path **14** and means for exhausting the cooling water therefrom are not shown. Another annular insulator **20** is disposed between the cathode support **17** and the support **18** at the lower part of the cathode support **17**. Arc gas is introduced into the torch through an inlet **21**. The anode support **18** is provided with a positive connection **22** for connection to a power source (not shown).

In an actual comparison test, a torch employing tungsten silicide electrode **23** as described above was used to generate a plasma jet flame under the operational conditions of a current of 300 amps, a voltage of 50 volts, an arc gas consisting of a mixture of argon of a flow rate of 30 liters/min. and air at a flow rate of 20 liters/min. and an electrode gap of 7 mm. The rate of oxidation in this embodiment was 0.15 mm./min.

On the other hand, when a plasma flame is generated under the same conditions as described hereinabove by use of a cathode not comprising a tungsten silicide layer, theh rate of oxidation is as large as 3.0 mm./min.

FIG. 4 is a curve showing the relation between the thickness of a tungsten silicide layer and the rate of oxidation. It will be apparent from this figure that the rate of oxidation becomes nearly constant when the thickness of the tungsten silicide layer exceeds 0.1 mm.

With the plasma jet torch according to this invention, the direct contact between the oxidizing component in work gas and tungsten or tungsten alloy composing a cathode can be prevented due to a tungsten silicide layer provided on the surface of the electrode and the oxidation resisting power of the electrode can be strengthened.

What is claimed is:

1. A plasma jet torch comprising a cathode, means for supporting said cathode, a nozzle concentrically surrounding said cathode and said supporting means and having a jet orifice for work gas in front of said cathode, means for feeding work gas to said jet orifice, and means for generating discharge between said cathode and said nozzle, wherein said cathode is composed essentially of tungsten and the surface thereof at the portion comprising the discharge spot has a tungsten silicide coating.

2. A plasma jet torch having discharging electrodes beween which a discharge is produced, one of the discharging electrodes being a cathode, a cathode support member, a nozzle concentrically surrounding said cathode and said cathode support member and having a jet orifice for work gas provided in front of said cathode, and means for feeding work gas to said jet orifice, wherein said cathode is composed essentially of tungsten and the surface thereof at the portion comprising the discharge spot has a tungsten silicide coating.

3. A plasma jet torch according to claim **1**, wherein a coating made of an oxidation resisting material is provided on the inner walls of said nozzle and around said jet orifice for the plasma flame.

4. A plasma jet torch according to claim **1**, wherein the thickness of said tungsten silicide coating is at least about 0.1 mm.

5. A plasma jet torch comprising a cathode, means for supporting said cathode, a nozzle concentrically surrounding said cathode and said supporting means and having a jet orifice for work gas in front of said cathode, means for feeding work gas to said jet orifice, and means for generating discharge between said cathode and an electrode in front of said nozzle, wherein said cathode is composed essentially of tungsten and the surface thereof at the portion comprising the discharge spot has a tungsten silicide coating.

6. A plasma torch according to claim **5**, wherein a coating made of an oxidation resisting material is provided on the inner walls of said nozzle and around said jet orifice for the plasma flame.

7. A plasma torch according to claim **5**, wherein the thickness of said tungsten silicide coating is at least about 0.1 mm.

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