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(54) **IMPROVED NOZZLE FOR A PLASMA ARC TORCH.**

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Description

The present invention relates to plasma arc torches, and more particularly to an improved nozzle construction for initiating an arc in such torches utilizing a high voltage, high frequency signal applied to either an electrode or to the nozzle.

The starting of plasma torches has for a long time been a problem area in plasma torch development and the focus of much engineering attention.

There are currently three know methods to initiate a plasma arc discharge and start a plasma arc torch: 1) the high frequency discharge or its relative, the high voltage spark discharge, 2) contact starting, and 3) an exploding wire technique. In each method, an arc is drawn in an ionizable gas between a cathode (an electrode) and an anode (a nozzle or component of a nozzle).

The oldest, and most widely used method is the high frequency, high voltage spark discharge method. The high voltage, high frequency generates charge carriers which create an electrical current path in the gas in the gap between the cathode and the electrode to establish D.C. flow of current, a pilot arc discharge. It is common practice to attach the high frequency coil to the power supply line leading to the electrode or the nozzle, but on smaller systems having a lower power rating, e.g., those characterized by a DC amperage of 200 or less, the high frequency coil is usually coupled to the power line for the electrode.

An example of this high frequency, high voltage starting method is described in U.S. Patent No. 3,641,308 to Couch, Jr., et al. A brief, high voltage pulse applied to the cathode initiates an arc across the gap to a nozzle which is connected through a switch and a resistor to ground. The workpiece is also grounded so that once the gas flow is initiated the arc will transfer from the nozzle to the workpiece. The switch is then opened so that the nozzle is electrically floating and the workpiece remains connected to ground. This general method of starting is also disclosed in U.S. Patent Nos. 3,082,314 to Arata et al; 3,131,298 to Browning; 3,534,388 to Ito et al; 3,619,549 to Hogan et al; 3,787,247 to Couch, Jr.; 3,833,787 to Couch, Jr.; and 4,203,022 to Couch, Jr. et al.

In prior art plasma arc torches the electrode has traditionally had a generally cylindrical configuration, whether a cylindrical disk seated in a solid copper tube as described in the aforementioned U.S. Patent Nos. 3,641,308, 4,203,022 or the electrode-nozzle arrangement shown and described in U.S. Patent Nos. 4,421,970; 4,791,268; and 4,861,962. In these prior art arrangements, the lower end of the electrode adjacent the nozzle typically has a cylindrical configuration. The immediately opposite nozzle surface typically mirrors the outer configuration of the electrode, or is smooth, conical and downwardly coverging. In both instances the nozzle includes a central exit port where the plasma arc exits the torch and attaches to the workpiece. It is significant that while the transition between the interior nozzle surface and the exit port may be a sharp corner, and while this corner may be closely spaced from the electrode, it is not located in a region where it is closer to the electrode than immediately adjacent portions of the nozzle.

US-A-4282418 describes a low power plasma arch torch for micro plasma welding according to the preamble of claim 1 and comprising a nozzle member according to the preamble of claim 9 and having an exit port and a needle point electrode, the exit port being provided with a raised annular edge facing the electrode such that the needle point is closest to the nozzle at the annular edge.

There are two principal problems with the prior art designs. First, when the arc is initiated it is sometimes difficult to induce the breakdown of the gas to start the plasma arc discharge. To reliably reach the breakdown potential to initiate the arc, the voltage level applied to the electrode is increased. This however, accentuates the electromagnetic noise interference problems associated with all high-frequency, high-voltage starting arrangements.

Another quite significant problem is the lack of reliability as to where on the electrode and nozzle the arc will initiate. This lack of control over the location of the arc causes wear problems. For example, if the high frequency spark begins high on the side of the electrode (away from the exit port), by the time it travels to the lower portion of the electrode, typically containing an electron emitting element, the DC current and voltage levels can be ramped up to a level such that double arcing occurs.
As is well known in the trade, double arcing will quickly destroy torch components such as the nozzle and the electrode.

In the prior art it is known to machine mark the electrode to facilitate breakdown of the gas at the mark on start up. However, to the best of applicant's knowledge, there has been no nozzle structure specifically designed to reduce the breakdown potential (and the elapsed time required to achieve breakdown) and to control the location of where the pilot arc is initiated by applying a high frequency, high voltage to either the nozzle or the electrode. This is particularly true where the high voltage, high frequency coil is attached to the power line leading to the nozzle, not the electrode. In this situation with prior art constructions, variations in the external configuration of the electrode would have little or no effect on the location of the arc.

It is therefore a principal object of the present invention to provide a nozzle construction or a plasma arc torch which reliably initiates an arc within a small, well-defined annular region of the electrode and the nozzle.

Another principal object is to reduce electrode wear as compared to comparable prior art nozzles in comparable torches operated under the same conditions.

Yet another principal object of this invention is to reduce the breakdown potential required to initiate an arc discharge in a given plasma arc torch. A further object in the present invention is to provide a nozzle construction which reduces electromagnetic interference during the high frequency, high voltage start up with other electrical and electronic components in the operating area.

A still further object of the present invention is to provide a nozzle construction with the foregoing advantages which is simple in construction, has a comparatively low cost of manufacture, and can be used as a replacement part for conventional nozzle of existing plasma arc torches.

According to the present invention a plasma arc torch and a nozzle have the features outlined respectively in claims 1 and 9.

A plasma arc torch includes an electrode and a nozzle mounted in a mutually spaced relationship at one end of the torch adjacent a workpiece. They are also mounted symmetrically with respect to the torch and each other about a common longitudinal axis. A flow of an ionizable gas passes through the torch and exits a central exit port in the nozzle which is aligned opposite the lower end of the electrode. A DC power supply is attached to the electrode and the nozzle and a high frequency, high voltage coil/generator is electromagnetically coupled to either the negative or positive output of the DC power supply.

The nozzle, which is typically cup-shaped, receives the electrode within the nozzle with a generally uniform spacing between the electrode in the opposite surfaces of the nozzle. The interior surface of the nozzle facing the electrode has a convex, inwardly projecting, circumferentially extending solid angle or "angle kink" portion. This angle kink is characterized by a minimum radius of curvature (whether a sharp corner, a rounded corner, or even some more complex cross-sectional shape) for a narrow annular region of this surface immediately opposite to the electrode and adjacent the central exit port of the nozzle. This annular region defines the location of preferential initiation of the plasma arc discharge. This kink angle is located at the closest approach between the electrode and the nozzle, and is displaced from the angle formed by the intersection of the central exit port in the nozzle and the interior surface of the nozzle.

In a preferred form, the angle kink is formed by the intersection of two conical surfaces having different angles of inclination with respect to the longitudinal axis. Comparatively flat angle kinks, e.g. one with an included angle of about 165° are effective. The electrode also has an outwardly projecting angle kink formed by the cylindrical side surface, or a conical transition surface of the lower end of the electrode, and a planar end face oriented perpendicular to the longitudinal axis. The electrode angle kink is also located at the point of closest approach between the electrode and the nozzle and it opposes the angle kink on the nozzle. The electrode and nozzle angle kinks are centered in circumferentially extending annular regions. Because of the minimum radius of the angle kink and the fact that the angle kink are located at local points of closets approach of the electrode and nozzle, 1) the electric field induced by the high voltage, high frequency starting signal is enhanced and 2) there is a reliable and rapid breakdown of the plasma at this region in preference to other locations on the electrode or nozzle.

These and further feature and objects of the present invention will be more readily understood from the following detailed disclosure of the preferred embodiments which should be read in light of the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a simplified schematic view of a high frequency, high voltage plasma arc initiation system utilising the nozzle of the present invention;

Fig. 2 is a detail view in side elevation partially in vertical section of the lower portion of the electrode and the nozzle shown in Fig. 1;

Fig. 3 is a view corresponding to Fig. 2 showing a prior art nozzle construction utilising smooth conical interior nozzle surface; and

Fig. 4 is a view corresponding to Fig. 2 of an alternative nozzle construction according to the present invention.

Detailed Description of the Preferred Embodiments

With reference to Fig. 1, a plasma arc torch 10 having a nozzle 12 and an electrode 14 is connected to a DC power supply 16. As shown, the positive output of the power supply 16 is connected by lead 18 to the nozzle 12 and the negative side of the power supply 16 is connected by lead 20 to the electrode 14. The plasma arc torch 10 can be any of a wide variety of currently available torch designs in the prior art. Suitable constructions are shown, example, in the aforementioned U.S. Patent Nos. 3,641,308; 4,203,022;

4,791,268; and 4,861,962. A high-frequency coil 22 can be coupled electromagnetically to either the positive lead 18, as shown, or the negative lead 20. The high-frequency coil/generator produces a high-voltage, high-frequency signal which is transmitted over the lead to the nozzle or the electrode. The high-frequency coil generator is of well known, conventional construction, as is the DC power supply. A typical high voltages produced by the coil/generator 22 are in the range typically 5,000 volts at frequencies in the range of 2 to 3 mHz.

During operation, a flow 24 of an ionizable gas is initiated through an electrode-nozzle chamber 25 exiting the torch through an exit port 44 in the lower face of the nozzle. It assumes a swirling flow path 24a between the lower end of the electrode and the nozzle just before it exits port 44 in the nozzle.

When high frequency is applied to the system via the coil 22, a high level oscillating electric field will be generated between the electrode 14 and the nozzle 12.

A significant aspect of the present invention is that the interior surface 26 of the nozzle has circumferentially extending (closed loop) projection or peak which is termed herein an angle kink 28. It is significant this angle kink 28 is located at the point of closest spacing between the nozzle 12 and the electrode 14, and represents a line of localized minimum gap separation between the electrode and the nozzle -- as compared, for example, to prior art constructions where the corner associated with the nozzle exit port may have a minimum radius of curvature, but is no closer to the electrode than adjacent portions of the surface. It has been found that this construction reduces the breakdown voltage between a narrow annular region 30 centered on the angle kink 28 and a narrow annular region 32 centered on an electrode angle kink 34. The electrode 14 has a conical tapered end surface 36 and a planar end face 38 oriented perpendicular to a common longitudinal axis 40 of the torch, the nozzle 12, and the electrode 14. The intersection of the surface 36 and the end face 38 defines the angle kink 34. The intersection of conical surface 26a (having an angle A of inclination of about 45° from the axis 40, as shown) and conical surface 26b (having an angle B of inclination of about 60° from the axis 40, as shown) defines the angle kink 28. In the preferred form shown, the angle kink therefore has an included angle of 165° and has a line intersection which is not rounded. The angle kinks 28 and 34 and their associated regions 30 and 32 are separated by a gap 42 in an electrode-nozzle chamber 25. While the angle kink 28 and 34 are shown as being directly opposite one another, and this is the preferred embodiment, such a precise opposite alignment is not essential to the operation of this invention.

It should be noted that the gap 42 between the angle kinks 28 and 34 is the point of closest spacing between the nozzle and the electrode, at least in the region immediately adjacent the angle kinks. As a result, the application of the high frequency to the nozzle 12 over the positive lead 18 concentrates the electric field strength at the nozzle angle kink 28 and provides a reliable breakdown in the zone between the annular regions 30 and 32. It is also significant that the angle kink 28 formed on the interior 36 of the nozzle has a minimum radius of curvature as compared to the radius of curvature of the adjoining portions of the surface so as to create a protrusion which produces the electric field enhancement discussed above. Similarly, the angle kink 34 on the electrode should have the smallest radius in the immediate region adjoining the point of closest spacing between the electrode and the nozzle at the gap 42.

If the high frequency coil 22 is attached to the negative lead 20 of the DC power supply, the breakdown voltage can be reduced between the annular regions 32 and 30 with respect to the remainder of the electrode-nozzle chamber 25. Further, by providing an angle kink 34 on the electrode and an angle kink 28 on the nozzle that are each characterized by a minimum radius of curvature, then there will be a strong electric field enhancement that the electrode angle kink 34 which tends to concentrate the electric field strength between the annular regions 30 and 32. This enhanced field strength in turn both assures that breakdown will occur between the zones across the gap 42 and that the breakdown potential will be reduced as compared to the potential required if the nozzle 12 had a simple conical configuration as depicted in Fig. 3.

Fig. 4 illustrates alternative embodiment of the present invention where the nozzle has a generally cylindrical interior configuration formed by a cylindrical side wall 12a' and a lower end wall 12b' that includes the exit port 44' (like parts being identified with the same reference number in the different embodiments). Again, the nozzle 12' is spaced symmetrically from the electrode 14'. The nozzle end wall 12b' is spaced closer to the opposite surface of the electrode than the side wall 12a'.

An angle kink 28' is formed on the inner surface 26' of the nozzle by the intersection of the generally planar inner surface portion 26a' defining the end wall 12b' and a conical surface 26b' extending between the exit port 44 and the inner surface portion 26a'.

The conical surface 16b' is typically inclined at about 10° from the plane of the surface portion 26b'. The angle kink 28' is located at appoint of closest spacing from the electrode 14', and preferably directly opposite an angle kink 34' formed on the lower end of the electrode. As shown, the angle kink 34' is the circumferentially extending solid angle defined by the intersection of a conical surface 36' and an end surface 38'. The electrode 14' has a cylindrical electron emitting insert 48 at the center of its lower end face 38', directly opposite the exit port 44.

The angle kinks 28' and 32' are centered in narrow annular regions 30', 32' which define a zone in which the plasma arc discharge will preferentially occur. The gap 42' between the angle kinks 28' and 34' is a point of closest approach.

In operation, the nozzle construction of the present invention, when used with a 200 ampere plasma torch of the type sold by Hypertherm, Inc. under the trade designation MAX 200, reduced the maximum breakdown potential by as much as 10% and reduced electrode wear by as much as 30%. Comparable reductions have been obtained with other torches under standard conditions. Moreover, the pilot arc discharge has been found to occur preferentially and reliably within a zone defined at its end by the annular regions 30 and 32.

While the angle kink on the nozzle has been described as formed by the intersection of combinations of conical and planar surfaces, it may be formed with a rounded cross-section, a rounded cross-section with a circumferentially extending ridge at its "peak", or a variety of other configurations which produce a protrusion with a minimum radius of curvature, in cross section, located at a point of closest spacing to the opposed cathode, or anode, and with this closest spacing being a localised point of minimum spacing. Also, while the angle kinks have been described and illustrated for the nozzle and electrode as being circumferentially extending, they could be formed to extend in annular displacement over less than 360° about the axis 40.

Claims

1. A plasma arc torch (10) that operates in a transferred arc mode on a workpiece but initiates first in a pilot arc mode where a nozzle (12, 12') acts in conjunction with an electrode (14, 14') mounted with the nozzle (12, 12') in a spaced relationship as one end of the torch to initiate a plasma arc discharge in a flow of ionizable gas passing between the electrode and the nozzle, said electrode (14, 14') having a generally cylindrical configuration; said nozzle (12) comprising a conductive member having a central exit port (44, 44') opposite an end surface (38) of said electrode for the plasma arc when it attaches to the workpiece that is asigned with said electrode;
characterised in that, said end surface (38, 38') of said electrode (14, 14') is generally transverse to the longitudinal axis (40, 40') thereof and said member includes a surface (26, 26') facing said electrode and adjacent, but spaced from, said exit port and having an angle kink (28, 28') formed therein and located at a point of minimum spacing between said electrode (14, 14') and said nozzle (12, 12') to produce said pilot arc preferentially and reliably in the region of said angle kink (28, 28') at a reduced breakdown potential when a high voltage, high frequency signal is applied across said electrode and said nozzle.

2. A plasma arc torch (10) according to claim 1 wherein said angle kink (28, 28'), (1) has a minimum convex radius of curvature as compared to the radius of curvature of adjacent portions of said surface and (2) is positioned at a point of minimum spacing (42) between said electrode (14, 14') and said nozzle (12, 12').

3. A plasma arc torch (10) according to claim 1 or claim 2 herein said electrode (14, 14') and said nozzle (12, 12') have outer (36, 36') and inner surfaces (26, 26') respectively facing one another across said spacing (42), said nozzle inner surface (26, 26') being located adjacent, but spaced from, said exit port (44, 44'), and said inner and outer surfaces each having an angle kink (28, 28'; 34, 34') formed therein.

4. A plasma arc torch (10) according to claim 1 or claim 2 wherein said angle kink (28, 28') extends continuously in a closed loop path oriented generally transverse to said longitudinal axis.

5. A plasma arc torch (10) according to claim 1, 2 or 3 wherein said angle kink (28, 28'; 34, 34') is formed by the intersection of a first conical (26a, 26a') surface and a second surface (26b, 26b').

6. A plasma arc torch (10) according to claim 5 wherein said second surface (26b, 26b') is also conical, but has a different slope than said first conical surface (26a, 26a') with respect to the longitudinal axis (40, 40').

7. A plasma arc torch (10) according to claim 3 wherein said angle kink (34, 34') on said electrode (14, 14') is located at a portion of said electrode that in normal operation experiences low wear and is adjacent, but spaced laterally from, the portion of said electrode (38, 38') immediately above said nozzle exit port (44,

44').

8. A plasma arc torch (10) according to claim 3 or claim 7 wherein said electrode angle kink (34, 34') and said nozzle angle kink (28, 28') are in an opposed spaced relationship at a point of minimum separation between said electrode (14, 14') and said nozzle (12, 12').

9. A nozzle (12) for a plasma arc torch (10) having a first substantially cylindrical inner surface (26), a transverse end portion containing an exit port (44) coaxial with the longitudinal axis of said inner surface (26) and a second surface (26a, 26b) extending between said inner cylindrical surface (26) and the entrance to said exit port (44),
characterised in that said second surface (26a, 26b) is defined by a first portion (26b) extending from said cylindrical surface (26) at a first angle (B) of inclination to the said longitudinal axis and a second portion (26a) extending to the entrance of said exit port (44) at a second angle (A) of inclination to the said longitudinal axis, said first angle (B) of inclination being greater than said second angle (A), the junction of said first and said second portions (26b, 26a) of said second surface forming a peak radially spaced from said exit port (44).

10. A nozzle (12) according to claim 9 for use in a plasma arc torch (10) according to any one of claims 1 to 8.

Patentansprüche

1. Plasmalichtbogenbrenner (10), der in einem Übertragungsbogenmodus an einem Werkstück betrieben wird, aber zuerst in einem Pilotbogenmodus iniziiert wird, wobei eine Düse (12, 12') in Verbindung mit einer Elektrode (14, 14') wirkt, die in einem Abstandsverhältnis zur Düse (12, 12') an einem Ende des Brenners angebracht ist, um eine Plasmalichtbogenentladung in einem Strom von ionisierbarem Gas zu iniziieren, das zwischen der Elektrode und der Düse durchströmt, wobei die Elektrode (14, 14') eine im wesentlichen zylindrische Konfiguration aufweist; wobei die Düse (12) ein leitendes Element umfaßt, das gegenüber einer Endfläche (38) der Elektrode eine zentrale Austrittsöffnung (44, 44') für den Plasmalichtbogen aufweist, wenn dieser an dem Werkstück angebracht ist, das der Elektrode zugewiesen ist;
dadurch gekennzeichnet,
daß die Endfläche (38, 38') der Elektrode (14, 14') im wesentlichen quer zu der Längsachse (40, 40') davon verläuft und das Element eine Fläche (26, 26') aufweist, die der Elektrode gegenüberliegt und in Nähe aber beabstandet von der Austrittsöffnung angeordnet ist und einen winkelförmigen Knick (28, 28') aufweist, der darin gebildet ist und an einer Stelle angeordnet ist, an welcher der Abstand zwischen der Elektrode (14, 14') und der Düse (12, 12') minimal ist, um den Pilotbogen vorzugsweise und zuverlässig in dem Bereich des winkelförmigen Knicks (28, 28') bei einem reduzierten Durchschlagpotential zu erzeugen, wenn ein Signal hoher Spannung und hoher Frequenz über der Elektrode und der Düse aufgebracht wird.

2. Plasmalichtbogenbrenner (10) nach Anspruch 1, bei dem der winkelförmige Knick (28, 28') erstens im Vergleich zum Krümmungsradius der angrenzenden Abschnitte der Fläche einen minimalen konvexen Krümmungsradius aufweist und zweitens an einer Stelle angeordnet ist, an welcher der Abstand (42) zwischen der Elektrode (14, 14') und der Düse (12, 12') minimal ist.

3. Plasmalichtbogenbrenner (10) nach Anspruch 1 oder Anspruch 2, bei dem die Elektrode (14, 14') und die Düse (12, 12') Außen-(36, 36') und Innenflächen (26, 26') aufweisen, die jeweils über dem Abstand (42) einander gegenüberliegen, wobei die Düseninnenfläche (26, 26') in der Nähe aber beabstandet von der Austrittsöffnung (44, 44') angeordnet ist, und die Innen- und Außenflächen jeweils einen winkelförmigen Knick (28, 28'; 34, 34') aufweisen, der darin gebildet ist.

4. Plasmalichtbogenbrenner (10) nach Anspruch 1 oder Anspruch 2, bei dem sich der winkelförmige Knick (28, 28') durchgehend in einer geschlossenen Schleifenbahn erstreckt, die im wesentlichen quer zur Längsachse orientiert ist.

5. Plasmalichtbogenbrenner (10) nach Anspruch 1, 2 oder 3, bei dem der winkelförmige Knick (28, 28'; 34, 34') durch den Schnitt einer ersten konischen (26a, 26a') Fläche und einer zweiten Fläche (26b, 26b') gebildet ist.

6. Plasmalichtbogenbrenner (10) nach Anspruch 5, bei dem die zweite Fläche (26b, 26b') ebenfalls konisch ist, aber bezogen auf die Längsachse (40, 40') eine andere Neigung als die erste konische Fläche (26a, 26a') aufweist.

7. Plasmalichtbogenbrenner (10) nach Anspruch 3, bei dem der winkelförmige Knick (34, 34') an der Elektrode (14, 14') in einem Abschnitt der Elektrode angeordnet ist, der bei normalem Betrieb geringen Verschleiß erfährt und in der Nähe aber seitlich beabstandet von dem Abschnitt der Elektrode (38, 38') unmittelbar oberhalb der Düsenaustrittsöffnung (44, 44') angeordnet ist.

8. Plasmalichtbogenbrenner (10) nach Anspruch 3 oder Anspruch 7, bei dem der winkelförmige Knick (34, 34') der Elektrode und der winkelförmige Knick (28, 28') der Düse in einem gegenüberliegenden beabstandeten Verhältnis an einer Stelle angeordnet sind, an der die Entfernung zwischen der Elektrode (14, 14') und der Düse (12, 12') minimal ist.

9. Düse (12) für einen Plasmalichtbogenbrenner (10) mit einer ersten im wesentlichen zylindrischen Innenfläche (26), einem querverlaufenden Endabschnitt, der eine Austrittsöffnung (44) aufweist, die koaxial mit der Längsachse der Innenfläche (26) ist, und mit einer zweiten Fläche (26a, 26b), die sich zwischen der zylindrischen Innenfläche (26) und dem Eingang zu der Austrittsöffnung (44) erstreckt,
dadurch gekennzeichnet,
daß die zweite Fläche (26a, 26b) durch einen ersten Abschnitt (26b), der sich von der zylindrischen Fläche (26) unter einem ersten Neigungswinkel (B) bezüglich der Längsachse erstreckt, und einen zweiten Abschnitt (26a), der sich unter einem zweiten Neigungswinkel (A) bezüglich der Längsachse zum Eingang der Austrittsöffnung (44) erstreckt, definiert ist, wobei der erste Neigungswinkel (B) größer ist als der zweite Neigungswinkel (A), wobei die Verbindungsstelle der ersten und zweiten Abschnitte (26b, 26a) von der zweiten Fläche einen Scheitel bilden, der radial von der Austrittsöffnung (44) beabstandet ist.

10. Düse (12) nach Anspruch 9 zur Verwendung in einem Plasmalichtbogenbrenner (10) nach einem der Ansprüche 1 bis 8.

Revendications

1. Torche à arc de plasma (10) fonctionnant dans un mode de transfert de l'arc sur une pièce de travail, mais s'amorçant tout d'abord dans un mode d'arc pilote dans lequel une lance (12, 12') agit en coopération avec une électrode (14, 14') montée, avec la lance (12, 12'), dans une relation d'espacement à une extrémité de la torche, de manière à amorcer une décharge d'arc de plasma dans un courant de gaz ionisable passant entre l'électrode et la lance, l'électrode (14, 14') ayant une configuration généralement cylindrique ; la lance (12) comprenant un élément conducteur muni d'un orifice de sortie central (44, 44') opposé à une surface d'extrémité (38) de l'électrode de façon que l'arc de plasma, lorsqu'il s'attache à la pièce de travail, soit fixé par l'électrode ;

caractérisée en ce que la surface d'extrémité (38, 38') de l'électrode (14, 14') est généralement transversale par rapport à son axe longitudinal (40, 40'), et en ce que l'élément conducteur comprend une surface (26, 26') venant en face de l'électrode au voisinage mais en étant espacée de l'orifice de sortie, cet élément conducteur comportant une pliure d'angle (28, 28') formée dans celui-ci et placée en un point d'espacement minimum entre l'électrode (14, 14') et la lance (12, 12') de manière à produire l'arc pilote préférentiellement et de façon fiable dans la zone de la pliure d'angle (28, 28'), avec un potentiel de claquage réduit lorsqu'on applique un signal à haute tension et haute fréquence aux bornes de l'électrode et de la lance.

2. Torche à arc de plasma (10) selon la revendication 1, caractérisé en ce que la pliure d'angle (28, 28') : (1) présente un rayon de courbure convexe minimum comparativement au rayon de courbure des parties adjacentes de la surface et (2) est positionnée en un point d'espacement minimum (42) entre l'électrode (14, 14') et la lance (12, 12').

3. Torche à arc de plasma (10) selon la revendication 1 ou la revendication 2, caractérisée en ce que l'électrode (14, 14') et la lance (12, 12') ont des surfaces extérieure (36, 36') et intérieure (26, 26') venant respectivement en face l'une de l'autre de part et d'autre de l'espacement (42), la surface intérieure (26, 26') de la lance étant placée au voisinage mais en étant espacée de l'orifice de sortie (44, 44'), et les surfaces intérieure et extérieure présentant chacune une pliure d'angle (28, 28' ; 34, 34') formée dans celle-ci.

4. Torche à arc de plasma (10) selon la revendication 1 ou la revendication 2, caractérisée en ce que la pliure d'angle (28, 28') s'étend de façon continue suivant un chemin en boucle fermée orienté d'une façon générale transversalement par rapport à l'axe longitudinal.

5. Torche à arc de plasma (10) selon la revendication 1, 2, ou 3, caractérisée en ce que la pliure d'angle (28, 28'; 34, 34') est formée par l'intersection d'une première surface conique (26a, 26a') et d'une seconde surface (26b, 26b').

6. Torche à arc de plasma (10) selon la revendication 5, caractérisée en ce que la seconde surface (26b, 26b') est également conique mais présente une pente différente de celle de la première surface conique (26a, 26a') par rapport à l'axe longitudinal (40, 40').

7. Torche à arc de plasma (10) selon la revendication 3, caractérisée en ce que la pliure d'angle (34, 34') formée sur l'électrode (14, 14') est placée dans une partie de cette électrode qui, en fonctionnement normal, est soumise à une faible usure et se trouve adjacente mais en étant espacée latéralement par rapport à la partie de l'électrode (38, 38') située juste audessus de l'orifice de sortie (44, 44') de la lance.

8. Torche à arc de plasma (10) selon la revendication 3 ou la revendication 7, caractérisée en ce que la pliure d'angle (34, 34') de l'électrode et la pliure d'angle (28, 28') de la lance sont dans une relation d'espacement l'une en face de l'autre en un point de séparation minimum entre l'électrode (14, 14') et la lance (12, 12').

9. Lance (12) pour torche à arc de plasma (10), comportant une première surface intérieure essentiellement cylindrique (26), une partie d'extrémité transversale contenant un orifice de sortie (44) coaxial avec l'axe longitudinal de la surface intérieure (26), et une seconde surface (26a, 26b) s'étendant entre la surface cylindrique intérieure (26) et l'entrée de l'orifice de sortie (44), lance caractérisée en ce que la seconde surface (26a, 26b) est définie par une première partie (26b) partant de la surface cylindrique (26) sous un premier angle d'inclinaison (B) par rapport à l'axe longitudinal, et une seconde partie (26a) partant de l'entrée de l'orifice de sortie (44) sous un second angle d'inclinaison (A) par rapport à l'axe longitudinal, le premier angle d'inclinaison (B) étant supérieur au second angle (A), la jonction de la première partie et de la seconde partie (26b, 26a) de la seconde surface formant un sommet espacé radialement de l'orifice de sortie (44).

10. Lance (12) selon la revendication 9, destinée à être utilisé dans un chalumeau à arc à plasma (10) selon l'une quelconque des revendications 1 à 8.

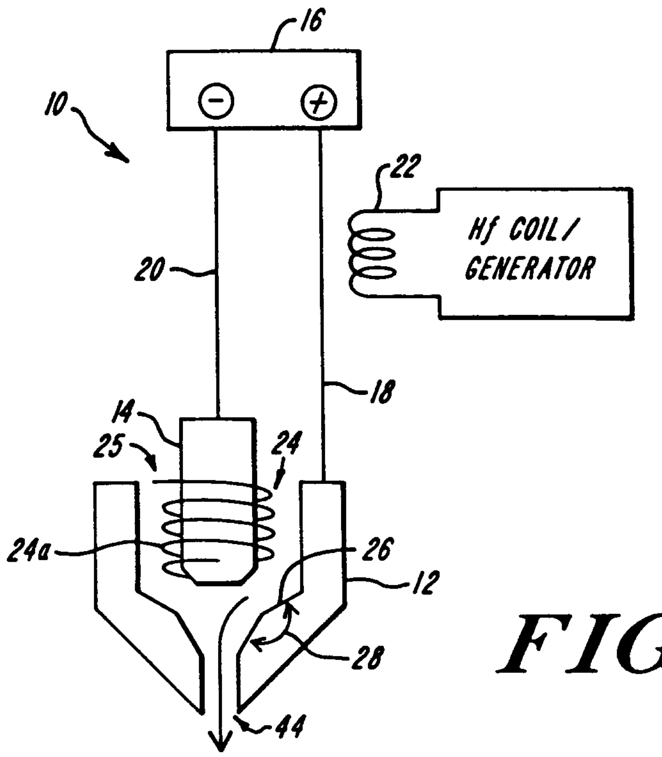
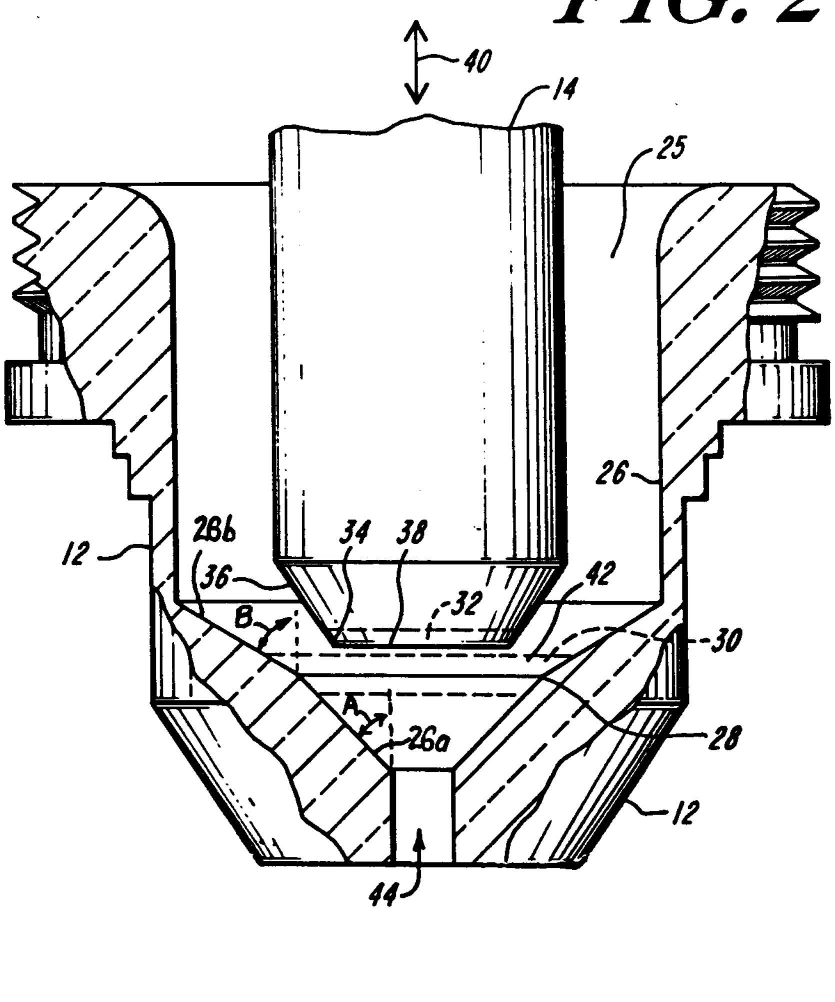

16
10
22
HF COIL/
GENERATOR
20
18
14
25
24
24a
26
12
28
44

FIG. 1

FIG. 2


40
14
25
26
12
28b
34
38
36
32
42
B
30
A
26a
28
12
44

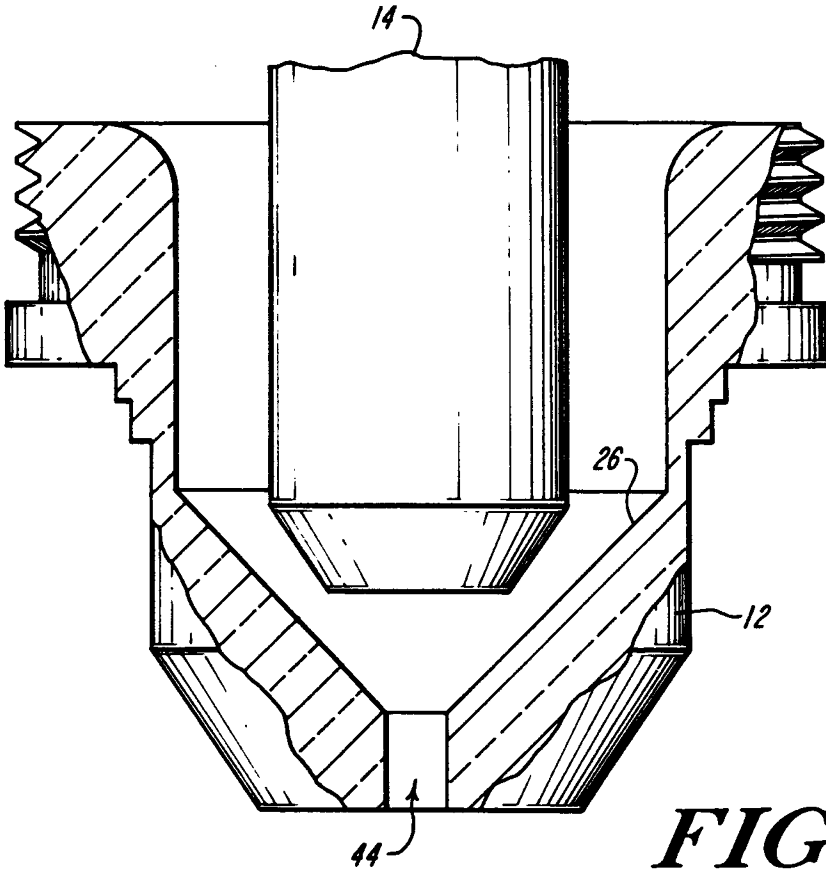


FIG. 3
PRIOR ART

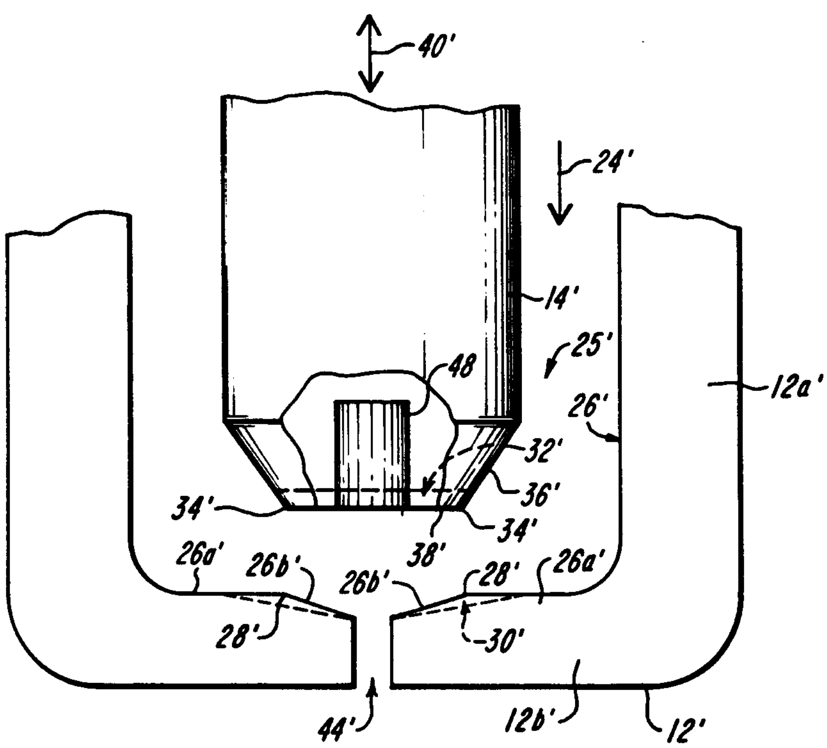


FIG. 4