

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 0 461 263 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

01.04.1998 Bulletin 1998/14

(21) Application number: **91900350.9**

(22) Date of filing: **22.11.1990**

(51) Int Cl.⁶: **H05H 1/32, F27D 11/08**

(86) International application number:
PCT/JP90/01530

(87) International publication number:
WO 91/10342 (11.07.1991 Gazette 1991/15)

(54) **Plasma torch with instable plasma arc**

Plasmabrenner mit instabil betriebemem Plasmabogen

Chalumeau à plasma à arc instable

(84) Designated Contracting States:
AT DE FR GB SE

(30) Priority: **04.01.1990 JP 12/90**
04.01.1990 JP 165/90
17.05.1990 JP 125355/90
08.08.1990 JP 208044/90

(43) Date of publication of application:
18.12.1991 Bulletin 1991/51

(73) Proprietor: **NKK CORPORATION**
Tokyo 100 (JP)

(72) Inventors:

- **INOKUCHI, Kazushige** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)
- **NAGAMUNE, Akio** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)
- **KOMINE, Isamu** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)
- **AO, Norio** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)
- **SEKINE, Hiroshi** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)

- **KANAO, Yoshiyuki** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)
- **KITANO, Yoshiyuki** NKK Corporation
Chiyoda-ku Tokyo 100 (JP)

(74) Representative: **Watkins, David et al**
Urquhart-Dykes & Lord,
91 Wimpole Street
London W1M 8AH (GB)

(56) References cited:

EP-A- 0 452 494	DE-A- 3 805 732
FR-A- 2 298 399	JP-A- 1 299 777
JP-A-56 143 700	JP-A-61 165 584
JP-B- 5 423 649	JP-B-62 055 069
JP-U- 1 135 174	US-A- 3 102 946
US-A- 4 013 866	US-A- 4 194 106
US-A- 4 242 562	

- **Patent Abstracts of Japan, Vol.14,**
No.507(E-0998) & JP-A-02/210799
- **Patent Abstracts of Japan, Vol.14, No.87(E-0937)**
& JP-A-01/299777

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 461 263 B1

Description

Technical Field

5 The present invention relates to a transferred plasma-arc torch which produces and uses a plasma arc for heating or melting purposes.

Background Art

10 A hot plasma is widely used as a source of very high temperature and high energy for such applications a heating and melting as well as reaction, surface treatment and other purposes. Particularly, it features that its high energy density has the effect of making the equipment compact and that the power input can be adjusted freely with improved response through the control of the atmosphere by a plasma working gas and the control of the current and the plasma length. Studies have recently been made to make the best use of these features in the steel making processes such
15 that the molten steel in a ladle or tundish is heated by a plasma so as to control the molten steel temperature or effect a refining reaction.

Basic types of plasma arc torches include the transferred arc type and nontransferred arc type. The transferred arc type is such that a voltage is applied between the electrode within the plasma-arc torch and an object to be heated thereby generating a plasma between the two, and generally a heating efficiency of 60 to 80% is obtained. On the
20 other hand, the nontransferred arc type is such that the plasma torch includes a negative electrode and a positive electrode so that a plasma is generated between the electrodes thereby blowing a hot gas like a combustion burner against an object to be heated, and the heating efficiency is 20 to 40%. Where the object to be heated has an electric conductivity as in the case of a metal, the transferred plasma-arc torch is used from the heat efficiency point of view.

A typical construction of the conventional transferred plasma-arc torches is shown in Fig. 1. In the Figure, numeral
25 (1) designates a plasma-arc torch, (2) an electrode, and (3) a nozzle. Generally, tungsten is used for the electrode (2) and it is enclosed by the nozzle (3). There are many instances where the nozzle (3) is a water-cooled copper nozzle or a ceramic nozzle. Numeral (4) designates a plasma a working gas such as argon or hydrogen and it is caused to flow between the electrode (2) and the nozzle (3). Numeral (5) designates an object to be heated, (6) a plasma arc, (7) insulating spacers, (8) a cooling water, and (9) electric terminals. Then, while the plasma is generated between the
30 forward end of the electrode (2) and the object (5) to be heated, the stable plasma arc (6) having a strong axial directivity is formed in the vicinity of the electrode (2) by the plasma working gas (4) whose flow is constricted by the nozzle (3).

In the conventional plasma-arc torch (1), in order to enhance the directivity and stability of the plasma arc (6) as mentioned above, the shape and arrangement of the electrode (2) and the nozzle (3) and the manner of flow of the plasma working gas (4) are determined. For this purpose, the forward end of the electrode (2) is pointed to have an
35 acute angle so that the plasma arc (6) extending along the axial direction is formed by a magnetic, pumping effect caused by a pinch force due to the current of the plasma itself at the plasma spot area where the plasma contacts with the electrode (2) or alternatively the gap between the nozzle (3) and the electrode (2) is reduced to less than several mm so that the flow velocity of the plasma working gas (4) is increased, thereby maintaining the plasma arc (5) which is stable in the axial direction.

40 As mentioned above, the conventional transferred plasma-arc torch takes notice of only the directivity and stability of the plasma arc (6) and it is in no way considered to make the plasma arc (6) unstable. Also, due to the fact that according to the conventional design, if the plasma arc (6) is caused to become unstable, there is the danger of producing a plasma between the nozzle (3) and the electrode (2) and causing a burning loss of the nozzle (3) and therefore importance is placed on the stabilization.

45 The conventional transferred plasma-arc torch (1) is constructed so as to generate a plasma arc (6) which is stable and having a strong axial directivity. Such stable plasma-arc (6) is naturally reduced in arc spreading and thus the object (5) to be heated is locally heated. As a result, where molten steel, for example, is heated, a localized temperature rise and evaporation of the molten steel are caused thereby giving rise to such problems as the nonuniformity of the temperature and the reduction in the heating efficiency and the yield. Also, in order to prevent the entry of nitrogen
50 and hydrogen into the molten steel, an inert argon is used for the plasma working gas (4), and further there are cases where an argon atmosphere is maintained in the heating chamber. At this time, as shown in the following Table 1, argon is low in applied voltage per unit plasma length as compared with the other gases and therefore the power input is decreased.

For instance, in a high-temperature argon atmosphere the voltage applied to the plasma is as low as between 0.1
55 and 0.2 V/mm and therefore the applied voltage becomes about 100 to 150 V at the most even if the plasma length is 500mm. Since the power input is the product of the voltage and the current, the only way to input a large power is to increase the current or to increase the number of plasma-arc torches. In particular, if the current is increased, there is a problem that not only the consumption of the electrode (2) is increased at a rate which is about the square of the

current but also the equipment cost of the power source and the power supply circuit is increased. Also, if the length of the plasma is increased in order to increase the voltage, the heating efficiency is deteriorated on the other hand, there is a limit to the length of the plasma due to the restriction on the equipment. In view of these points, it is desirable that the applied voltage per unit plasma length as high as possible.

TABLE 1

Comparison of potential gradients of arc columns in various gases and air (where the potential gradient of air = 1)	
Gas	potential gradient ratio
Argon	0.5
Air	1.0
Nitrogen	1.1
Carbon dioxide gas	1.5
Oxygen	2.0
Steam	4.0
Hydrogen	10.0

In addition, in view of the construction of the plasma-arc torch (1), if the electrode (2) is pointed to form an arc, in the event that the electrode (2) is consumed so that its forward end shape is deformed, the directivity of the plasma arc (6) is lost and the plasma jumps to the nozzle (3) thereby causing a burning loss of the nozzle (3). Also, the construction of the nozzle (3) must be adjusted so that the gap between the nozzle (3) and the electrode (2) becomes several mm and their central axes coincide with each other. Due to such sophisticated construction, there is a problem that damages tend to be caused to the nozzle (3) due to a change in the shape of the electrode (2) and a deflection of the plasma arc (6) caused by an external magnetic field.

Disclosure of Invention

It is an object of the present invention to provide a transferred plasma-arc torch having an increased energy density.

It is another object of the present invention to provide a transferred plasma-arc torch capable, of heating an object to be heated over the wide area thereof.

It is another object of the present invention to provide a transferred plasma-arc torch capable of reducing the consumption of the electrode thereby increasing its life.

It is another object of the present invention to provide a transferred plasma-arc torch capable of obtaining a high degree of controllability on the plasma arc.

It is another object of the present invention to provide a transferred plasma-arc torch which ensures a reduction in the size of the plasma-arc torch and a reduction in the operating cost.

These problems are solved with a plasma torch as defined in claims 1 and 6. Preferred embodiments of the present invention are defined in the dependent claims.

In accordance with one aspect of the present invention, the transferred plasma-arc torch utilizes a magnetic instability inherent to a plasma such that a plasma arc is made unstable fluidly to whirl it at a high velocity.

As a result, not only the applied voltage is increased but also the heating area is increased as compared with the conventional stable plasma arc.

As shown in Fig. 2c, once a plasma column (P) is bent, the magnetic field produced by the plasma current is intensified on the concave side but weakened on the convex side so that the bend of the plasma column (P) is further promoted by the magnetic pressure. Such magnetic instability of the plasma column (P) is called as a kink instability. At this time, if one end is made a fixed end and the other end is made a free end, the other end is oscillated by an electromagnetic force F produced by the previously mentioned magnetic field. While the description is made to dimensionally in connection with the Figure, in a three-dimensional space the similar magnetic instability generates an electromagnetic force F of a turning direction (Θ direction) about the electrode axis and the plasma column (P) starts a whirling motion.

The deforming force due to the kink instability is given by the following equation (1)

$$Fd = \frac{\mu_o}{4\pi R} I^2 \log \frac{\lambda}{Rc} \quad (1)$$

Here, F_d represents the deforming force per unit length, μ_0 the permeability in vacuum, I the current, λ the wave length of the disturbance, R the radius of curvature of the deformation, and R_c the radius of the plasma column (P). On the other hand, to correct this requires that the axial flow velocity of the plasma column (P) is increased to obtain the correcting force given by equation (2)

$$F_c = (I/R) \int \rho v^2 dS \quad (2)$$

Here, F_c represents the correcting force per unit length, ρ the density of the plasma, v the axial velocity of the plasma arc, and S the cross-sectional area of the plasma column (P).

The conventional plasma-arc torch (1) increases the axial velocity v to strengthen the correcting force F_c . On the contrary, in accordance with the present invention a magnetic instability (kink instability) is caused in the plasma arc so that $F_d > F_c$. In addition, in order that a radial plasma arc may be generated, a thermionic emission-type cathode having a stable cathode spot is used so that the end of the plasma on the plasma-arc torch side becomes a fixed end. Tungsten and carbon may be cited as typical thermionic emission-type cathode materials. Also, since molten steel or the like becomes a free end if it serves as the anode, the plasma arc is allowed to move around at a high speed over the surface of the molten steel, owing to the kink instability.

As described hereinabove, in accordance with the plasma-arc torch of the present invention the thermionic emission type cathode is used. The plasma arc is perturbed so as to decrease the axial velocity of the plasma working gas and thereby cause a motion in the θ direction. As a result, the plasma arc whirls at a high speed in the θ direction and also it takes the form of a cone spreading radially from the cathode.

The shapes of the conventional stable plasma arc (6) and the unstable plasma arc (16) according to the present invention are comparatively shown in Fig. 2a and 2b, respectively. As will be seen from the Figures, the spread of the plasma arc (16) on an object (15) to be heated is greater than that of the conventional plasma arc (6) by more than 10 times thus ensuring a large area heating. Also, Fig. 3 shows the variations of the voltages (V) applied to the plasma arcs and (16), respectively, in cases where the distance $S(L)$ between the plasma-arc torches (1) and (11) and the objects (5) and (15), respectively, are varied. It will be seen that the voltage (VII) is applied which is 1.5 to 2 times the voltage (VI) applied in the case of the stable plasma arc (6) is twisted and bent thus increasing the substantial path and that the radiation of heat from the plasma arc (16) is increased due to its high velocity whirling motion thereby increasing the energy input so as to be in equilibrium therewith. Therefore, as compared with the conventional plasma-arc torch, the power input (VII) of 1.5 to 2 times is obtained even for improved same the (L) and both the improved energy density and the greatly increased capacity are attained.

In addition, since the object (15) to be heated is heated extensively and uniformly with the improved efficiency, not only the considerable evaporation due to the conventional, localized heating is reduced but also the yield is improved and the heating efficiency is enhanced. Also, due to the fact that the forward end shape of the electrode need not take the form of a pointed end shape, even if its shape is changed, there is no danger of the plasma arc jumping to the nozzle and the life of the electrode is increased. Moreover, the control of the forward end shape of the electrode and the gap between the nozzle and the electrode is made easy.

JP-A-2/210 799 discloses a transferred arc plasma torch for generating a plasma arc between an electron emission type cathode and an object to be heated, with gas supply means for supplying a plasma working gas around said cathode. The gas supply means comprises a nozzle surrounding the cathode and a spacer with gas supply channels provided within the nozzle in such way that the plasma gas is made to rotate around the axis of the plasma torch in a circumferential direction. In this way a magnetic instability of the plasma jet is caused so as to generate a radially widened jet. Thereby, the arc voltage is increased and the heating efficiency is improved.

In accordance with the present invention, the transferred plasma-arc torch is designed so that two gas streams, i.e., a gas stream which seals the cathode to reduce its oxidation loss and a gas stream which causes the plasma arc to whirl at a high velocity are combined. Thus, the transferred plasma-arc torch causes a shielding gas to flow around the electrode in the axial direction and it also includes a supply nozzle so that as for example, the plasma working gas containing a radial flow component is supplied to the outer side of the shielding gas.

The shielding gas flows around the electrode in the axial direction and the plasma working gas containing a radial flow component is blown out to the outer side of the shielding gas from the supply nozzle. As a result, while the electrode is enclosed and shielded by a gas curtain of the shielding gas, a plasma arc is formed which whirls at a high velocity in such a manner that its radius of whirling is increased as it moves away from the electrode due to the plasma working gas blown out to the outer side of the shielding gas from the supply nozzle. Thus, despite the fact that the generated voltage is high and the heating area is increased, the oxidation loss of the electrode can be decreased.

Further, in accordance with another aspect of the present invention, the transferred plasma-arc torch is designed so that the plasma working gas is caused to flow as a whirling flow between the nozzle and the electrode so as to

decrease the axial velocity of the plasma jet. In this way, the magnitude of F_d is increased.

Brief Description of Drawings

Fig. 1 is a diagram showing the construction of a conventional plasma torch.

Figs. 2a, 2b and 2c, are diagrams for explaining the behaviors and shapes of plasma arcs.

Fig. 3 is a graph showing the electric characteristics of a plasma.

Fig. 4 is a diagram showing the construction of a transferred plasma-arc torch according to another embodiment of the present invention.

Fig. 5 is a diagram showing the construction of the insulation spacer in the transferred plasma-arc torch of Fig. 4.

Figs. 6, 7 and 7B are diagrams respectively showing the constructions of the principal parts of transferred plasma-arc torches according to another embodiment of the present invention.

Fig. 8 is a diagram showing the construction of another example of insulating spacer.

Fig. 9 is a diagram showing the construction of yet another example of insulating spacer.

Best Mode for Carrying Out the Invention

Since the transferred plasma-arc torches of the embodiments shown in Figs. 4 to 9 are somewhat different in construction from the conventional apparatus of Fig. 1 and are also different in function and effect from the latter, each of the component parts is designated by a two-place numeral in which the first place is in common and the second-place 1 is added. Each of these embodiments shows a transferred plasma-arc torch (11) of 1 KA.

Tungsten which is one of thermionic emission-type cathodes is used for the material of an electrode (12) in the embodiments shown in Figs. 4, 6, 7a and 7b. The electrode (12) has a diameter of 20mm and its forward end is formed into a hemispherical shape, thereby deteriorating the formation of an arc jet due to the magnetic pumping effect of a plasma.

In the transferred plasma-arc torch of the embodiment shown in Fig. 4, holes (22a) of each insulating spacer (22) are parallel to the axis of the plasma-arc torch (11) as shown in Fig. 5 and the plasma working gas (4) is not whirled or disturbed by any obstruction but it is caused to flow in the axial direction of the plasma-arc torch (11) as in the conventional torch. Also, in the embodiment another nozzle (24) for whirling purposes is additionally attached to near the forward end of the nozzle (13). The outer nozzle (24) is formed into an annular shape and its discharge jet is formed circumferentially with an inward inclination downward thereby causing jet streams to cross one another at a position somewhat distant from the electrode (12).

With the transferred plasma-arc torch (11) constructed as described above, while a plasma arc (16) is generated between the forward end of the electrode (12) and the object to be heated in the condition where the nozzle (24) is closed, the plasma working gas (14) forms a linear stable plasma arc having a strong axial directivity in the vicinity of the electrode (12) (see Fig. 2a).

If the plasma working gas (14) containing the radial flow components is discharged from the outer nozzle (24), however, the flow of the whirling gas discharged from the nozzle (24) strikes on the plasma arc (16) in the vicinity of the crossing position, thereby promoting its magnetic instability. As a result, from near this position is generated a whirling stream tending to rotate about the axis of the plasma arc (16) and a whirling plasma is generated. The resulting condition is the same as shown in Fig. 2b. In other words, the plasma arc (16) is produced which is cylindrical in the vicinity of the electrode (12) to surround the latter and which increases in radius of whirling as it is moved away from the electrode (12).

Thus, by flowing the plasma working gas (14) from the nozzle (13) while surrounding the electrode (12), a cylindrical gas curtain is formed and the electrode (12) is shielded from the whirling plasma arc (16). As a result, even if the whirling plasma arc (16) entraps the oxygen in the air, no oxidation of the electrode (12) is caused and its consumption is reduced.

The transferred plasma-arc torch of the embodiment shown in Fig. 6 includes, in place of the annular nozzle (24) shown in Fig. 4 a nozzle (26) including one or more simple tubes whose forward ends are radially bent so as to cause a disturbance of the plasma.

On the other hand, in the transferred plasma-arc, torch of the embodiment shown in Figs. 7A and 7B a cylindrical flow rectifying device (28) whose outer diameter is intermediary between the outer diameter of the electrode (12) and the inner diameter of the nozzle (13) is disposed in the flow path of the plasma working gas (14) near the electrode (12). Then, a part of the plasma working gas (14) whirled by the insulating spacers (20) of such skew type as shown in Fig. 8 and flowing out from the nozzle (13) is rectified and discharged from the flow rectifying device (28) while surrounding the electrode (12). Then, the axial flow of the plasma working gas (14) rectified by the flow rectifying device (28) encloses the electrode (12), and at a position apart from the electrode (12) is formed a plasma arc (16) which spreads downward.

Since the plasma working gas (14) is whirled about the axis of the plasma-arc torch (11), as shown in Fig. 8, each of insulating spacers (20) includes holes (20a) for passing the gas and the holes are skewed with respect to the axis of the plasma-arc torch (11). By skewing the holes (17a) in this way, the gas stream is directed obliquely and a whirling motion is imparted to the plasma working gas (14). In order to impart a whirling motion to the plasma working gas (14), any other construction may be used so that as shown in Fig. 9, for example, the plasma working gas (14) may be directly supplied to a header 20b of each insulating spacer (20) so as to direct the gas from the header to the skewed holes (20a).

In the manner described above, while reducing the velocity component of a plasma arc (16) in the axial direction of the plasma-arc torch (11), a θ -direction velocity component is imparted to the plasma working gas (14) so that a magnetic instability is caused the plasma arc (16) and thus the plasma arc (16) whirling at high velocity is formed. Also, the thermionic emission-type cathode is used for the electrode (12) forming the cathode thereby forming the cathode spot stably and therefore the plasma arc (16) is generated which radially spreads toward an object (15) to be heated.

Further, since the gap between the forward end of the electrode (12) and the nozzle (13) is wide, even if the plasma arc (16) is instable, there is no danger of the plasma arc (16) jumping to the nozzle (13).

Then, the spreading toward the object (15) of the plasma arc (16) generated by the plasma-arc torch (11) is as great as about 200mm ϕ when the height of the plasma-arc torch (11) is 200mm, and the applied voltage increased to over 300V as compared with the applied voltage of as low as 170V in the case of the conventional stable plasma arc (6). Also, it has been confirmed that while the plasma arc (16) is fluidly instable, the voltage variation is so small that there is no problem from the practical point of view.

It is to be noted that while, in the above-described embodiments, tungsten is used for the electrode (12), any other thermionic emission-type cathode such as carbon may be used.

Claims

1. A transferred plasma-arc torch for generating a plasma-arc between an electron emission-type cathode and an object to be heated, comprising

first gas supply means (13, 22) for supplying a plasma working gas around said electron emission-type cathode (12), characterised in that the torch further comprises:

second gas supply means (24, 26) for blowing said plasma working gas against a plasma-arc generated from said electron emission-type cathode (12), said second gas supply means directing its flow convergently towards a point of said plasma-arc spaced from said electron emission-type cathode (12), whereby kink instability is induced in said plasma-arc.

2. A transferred plasma-arc torch as claimed in claim 1 further characterised in that said first gas supply means comprises:

an annular nozzle (13) formed radially externally of said electron emission-type cathode (12) for supplying plasma working gas around said electron emission-type cathode (12), and
an insulating spacer (22) provided within said nozzle for rectifying said plasma working gas, said spacer having a plurality of holes for passage of plasma working gas therethrough.

3. A transferred plasma-arc torch as claimed in claim 2 further characterised in that said holes through said insulating spacer (22) are disposed in parallel to the longitudinal axis of said torch.

4. A transferred plasma-arc torch as claimed in any preceding claim further characterised in that said second gas supply means is formed as an annulus outside said first gas supply means with a plurality of nozzles (24) directed towards a point in the plasma-arc which is spaced apart from said electron emission-type cathode (12).

5. A transferred plasma-arc torch as claimed in any one of claims 1 to 3 further characterised in that said second gas supply means comprises one or a plurality of tubes (26) arranged outside said first gas supply means, the or each tube having its end oriented towards a point in the plasma-arc which is spaced apart from said electron emission-type cathode (12).

6. A transferred plasma-arc torch for generating a plasma-arc between an electron emission-type cathode and an object to be heated, characterised in that it comprises:

gas supply means (13, 20) for supplying a plasma working gas around said cathode (12), said plasma working gas being given whirl movement to induce kink instability in said plasma-arc, and
flow rectifying means (28), disposed between said gas supply means (13, 20) and said cathode (12), for rec-
tifying a part of said plasma working gas with whirl movement so as to seal said cathode (12) by means of the
rectified gas flow.

Patentansprüche

1. Übertragener Plasmabrenner zur Erzeugung eines Plasmabogens zwischen einer Elektronen emittierenden Kathode und einem zu erheizenden Objekt, mit einer ersten Gaszuführeinrichtung (13,22) zum Zuführen eines Plasmaarbeitsgases rings um die Elektronen emittierende Kathode (12), dadurch gekennzeichnet, daß der Brenner ferner aufweist:

eine zweite Gaszuführeinrichtung (24,26) zum Blasen des Plasmaarbeitsgases gegen einen Plasmabogen, der von der Elektronen emittierenden Kathode (12) erzeugt ist, wobei die zweite Gaszuführeinrichtung ihre Strömung konvergierend zu einem Punkt des Plasmabogens im Abstand von der Elektronen emittierenden Kathode (12) leitet, wodurch eine Instabilität gegen Knickung in den Plasmabogen eingeführt wird.

2. Übertragener Plasmabrenner nach Anspruch 1, dadurch gekennzeichnet, daß die erste Gaszuführeinrichtung aufweist:

eine ringförmige Düse (13), die radial außerhalb der Elektronen emittierenden Kathode (12) gebildet ist, zum Zuführen von Plasmaarbeitsgas rings um die Elektronen emittierende Kathode (12), und
einen isolierenden Abstandshalter (22), der innerhalb der Düse zum Rektifizieren des Plasmaarbeitsgases vorgesehen ist, wobei der Abstandshalter eine Anzahl von Löchern zum Durchtritt von Plasmaarbeitsgas durch denselben aufweist.

3. Übertragener Plasmabrenner nach Anspruch 2, dadurch gekennzeichnet, daß die Löcher durch den isolierenden Abstandshalter (22) parallel zur Längsachse des Brenners angeordnet sind.

4. Übertragener Plasmabrenner nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die zweite Gaszuführeinrichtung als Ring außerhalb der ersten Gaszuführeinrichtung mit einer Anzahl von Düsen (24) ausgebildet ist, die auf einen Punkt im Plasmabogen gerichtet sind, der einen Abstand von der Elektronen emittierenden Kathode (12) aufweist.

5. Übertragener Plasmabrenner nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die zweite Gaszuführeinrichtung ein Rohr oder eine Anzahl von Rohren (26) aufweist, die außerhalb der ersten Gaszuführeinrichtung angeordnet sind, wobei das oder jedes Rohr mit seinem Ende gegen einen Punkt im Plasmabogen gerichtet ist, der im Abstand von der Elektronen emittierenden Kathode (12) angeordnet ist.

6. Übertragener Plasmabrenner zur Erzeugung eines Plasmabogens zwischen einer Elektronen emittierenden Kathode und einem zu erheizenden Objekt, dadurch gekennzeichnet, daß er aufweist:

eine Gaszuführeinrichtung (13,20) zum Zuführen eines Plasmaarbeitsgases rings um die Kathode (12), wobei dem Plasmaarbeitsgas eine Wirbelbewegung erteilt wird, um in dem Plasmabogen eine Instabilität gegen Knickung einzuführen, und
eine Strömungsrektifiziereinrichtung (28), die zwischen der Gaszuführeinrichtung (13,20) und der Kathode (12) angeordnet ist, zum Rektifizieren eines Teils des Plasmaarbeitsgases mit Wirbelbewegung, um die Kathode (12) mittels der rektifizierten Gasströmung abzudichten.

Revendications

1. Chalumeau à plasma à arc transféré destiné à générer un plasma à arc entre une cathode du type à émission d'électrons et un objet destiné à être chauffé, comprenant

des premiers moyens de fourniture de gaz (13, 22), destinés à fournir un gaz de travail en plasma autour de ladite cathode du type à émission d'électrons (12), caractérisé en ce que le chalumeau comprend en outre:

des deuxièmes moyens de fourniture de gaz (24, 26), destinés à souffler ledit gaz de travail en plasma contre un plasma à arc généré par ladite cathode du type à émission d'électrons (12), lesdits deuxièmes moyens de fourniture de gaz dirigeant leur écoulement de manière convergente vers un point dudit plasma à arc séparé de ladite cathode du type à émission d'électrons (12),
 5 tel qu'une instabilité de torsion soit induite dans ledit plasma à arc.

2. Chalumeau à plasma à arc transféré selon la revendication 1, caractérisé en outre en ce que lesdits premiers moyens de fourniture de gaz comprennent:

10 une buse annulaire (13) formée radialement extérieurement à ladite cathode du type à émission d'électrons (12), pour fournir le gaz de travail en plasma autour de ladite cathode du type à émission d'électrons (12), et une entretoise d'isolement (22) prévue à l'intérieur de ladite buse, pour redresser ledit gaz de travail en plasma, ladite entretoise comportant une pluralité de trous pour le passage du gaz de travail en plasma à travers celle-ci.

- 15 3. Chalumeau à plasma à arc transféré selon la revendication 2, caractérisé en outre en ce que lesdits trous traversant ladite entretoise d'isolement (22) sont disposés en parallèle par rapport à l'axe longitudinal dudit chalumeau.

- 20 4. Chalumeau à plasma à arc transféré selon l'une quelconque des revendications précédentes, caractérisé en outre en ce que lesdits deuxièmes moyens de fourniture de gaz sont formés en un anneau extérieur auxdits premiers moyens de fourniture de gaz, avec une pluralité de buses (24) dirigées vers un point du plasma à arc, séparé de ladite cathode du type à émission d'électrons (12).

- 25 5. Chalumeau à plasma à arc transféré selon l'une quelconque des revendications 1 à 3, caractérisé en outre en ce que lesdits deuxièmes moyens de fourniture de gaz comprennent un ou une pluralité de tubes (26) agencés à l'extérieur desdits premiers moyens de fourniture de gaz, le ou chaque tube ayant son extrémité orientée vers un point du plasma à arc, séparé de ladite cathode du type à émission d'électrons (12).

- 30 6. Chalumeau à plasma à arc transféré destiné à générer un plasma à arc entre une cathode du type à émission d'électrons et un objet destiné à être chauffé, caractérisé en ce qu'il comprend:

des moyens de fourniture de gaz (13, 20), destinés à fournir un gaz de travail en plasma autour de ladite cathode (12), ledit gaz de travail en plasma recevant un mouvement de rotation pour induire une instabilité de torsion dans ledit plasma à arc, et

35 des moyens de redressement d'écoulement (28), disposés entre lesdits moyens de fourniture de gaz (13, 20) et ladite cathode (12), pour redresser une partie dudit gaz de travail en plasma avec un mouvement de torsion, de façon à obturer ladite cathode (12) au moyen de l'écoulement de gaz redressé.

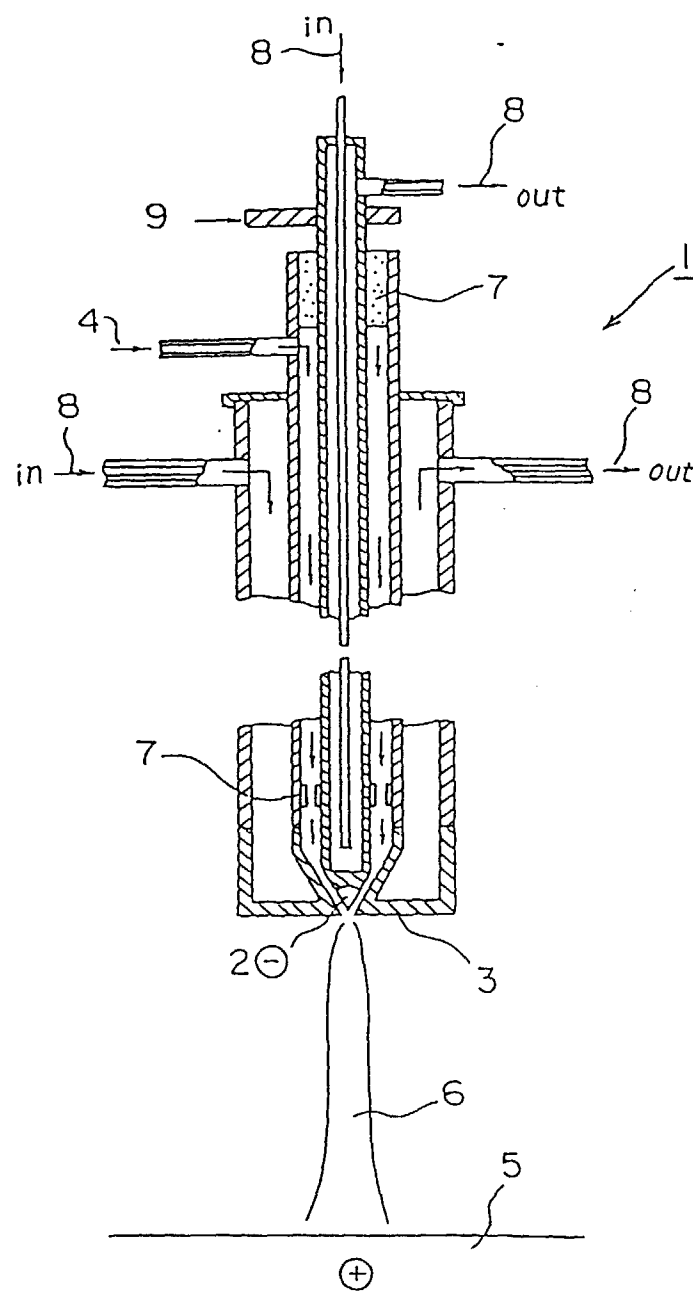


FIG. 1

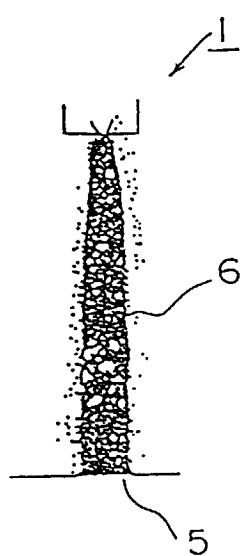


FIG. 2a

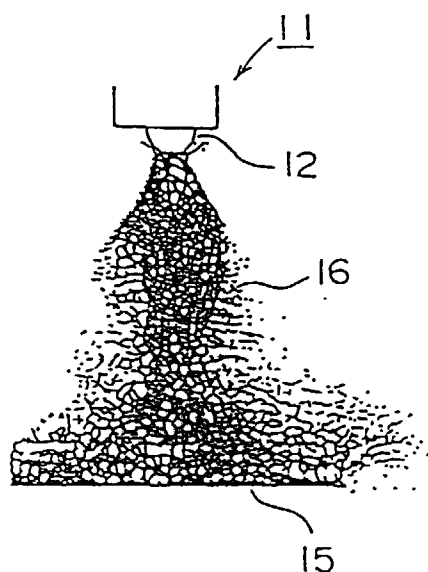


FIG. 2b

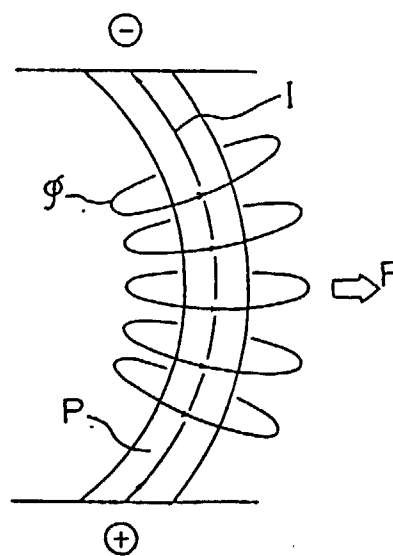


FIG. 2c

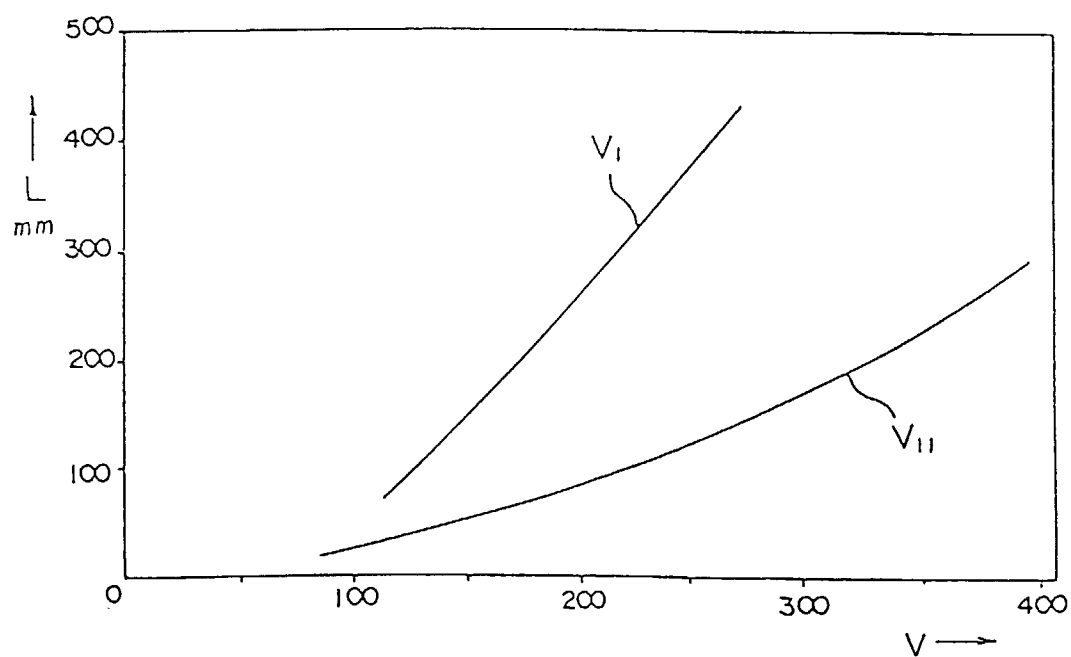


FIG. 3

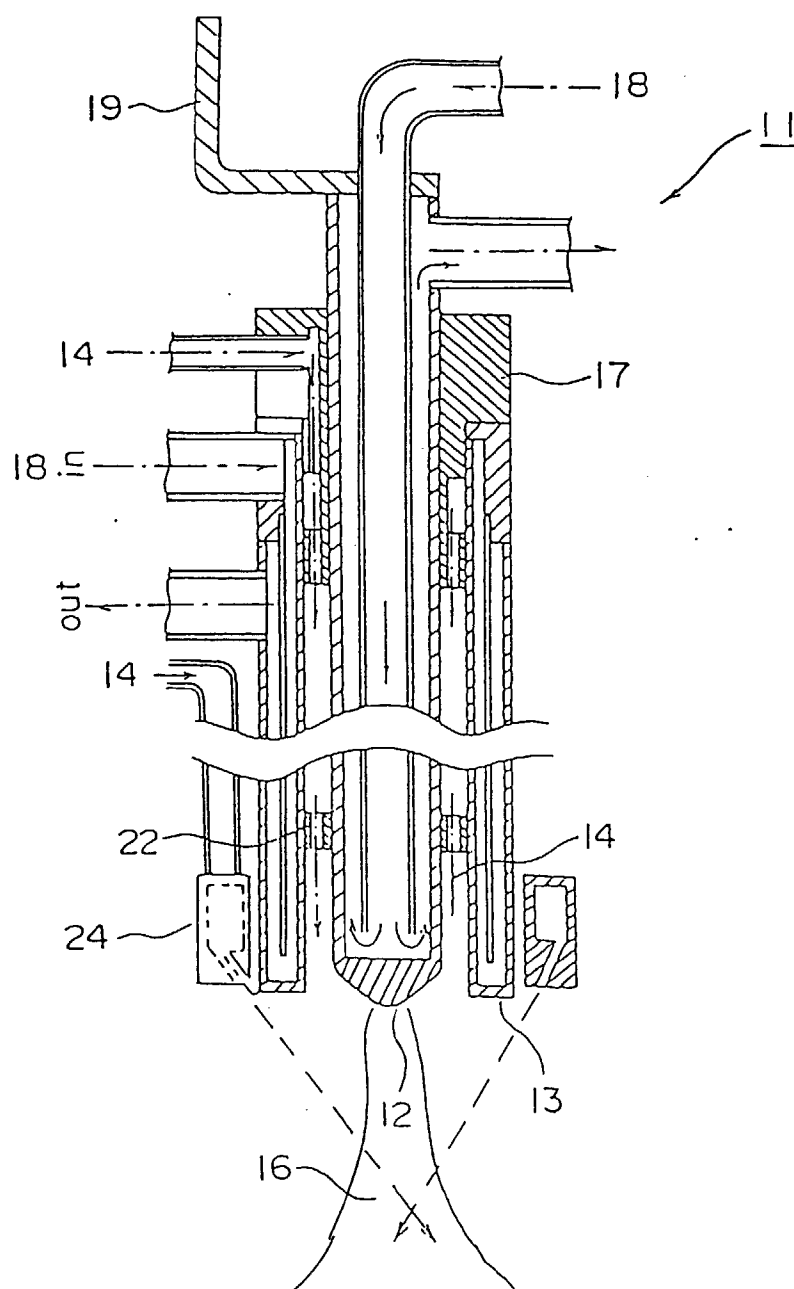


FIG. 4

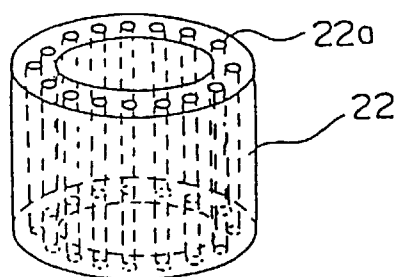


FIG. 5

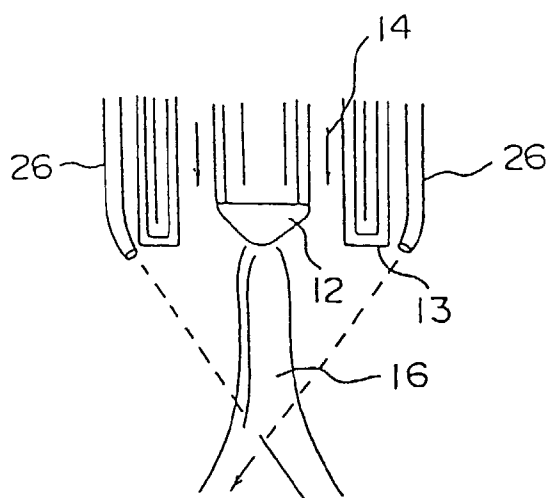


FIG. 6

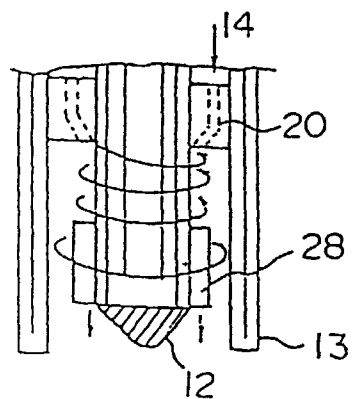


FIG. 7a

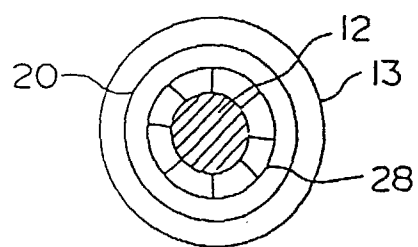


FIG. 7b

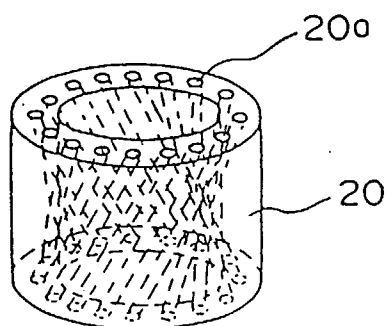


FIG 8

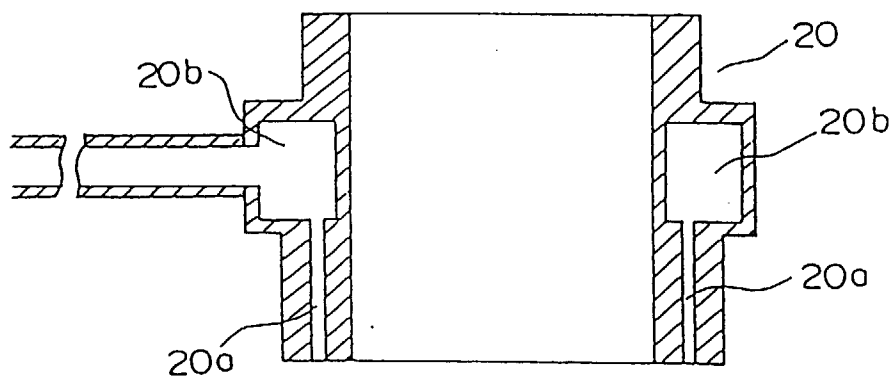


FIG. 9