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[54] **PLASMA GENERATOR WITH MAGNETIC FOCUSSING AND WITH ADDITIONAL ADMISSION OF GAS**
3 Claims, 6 Drawing Figs.

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[50] Field of Search 219/74, 75, 121, 123; 315/111; 313/161

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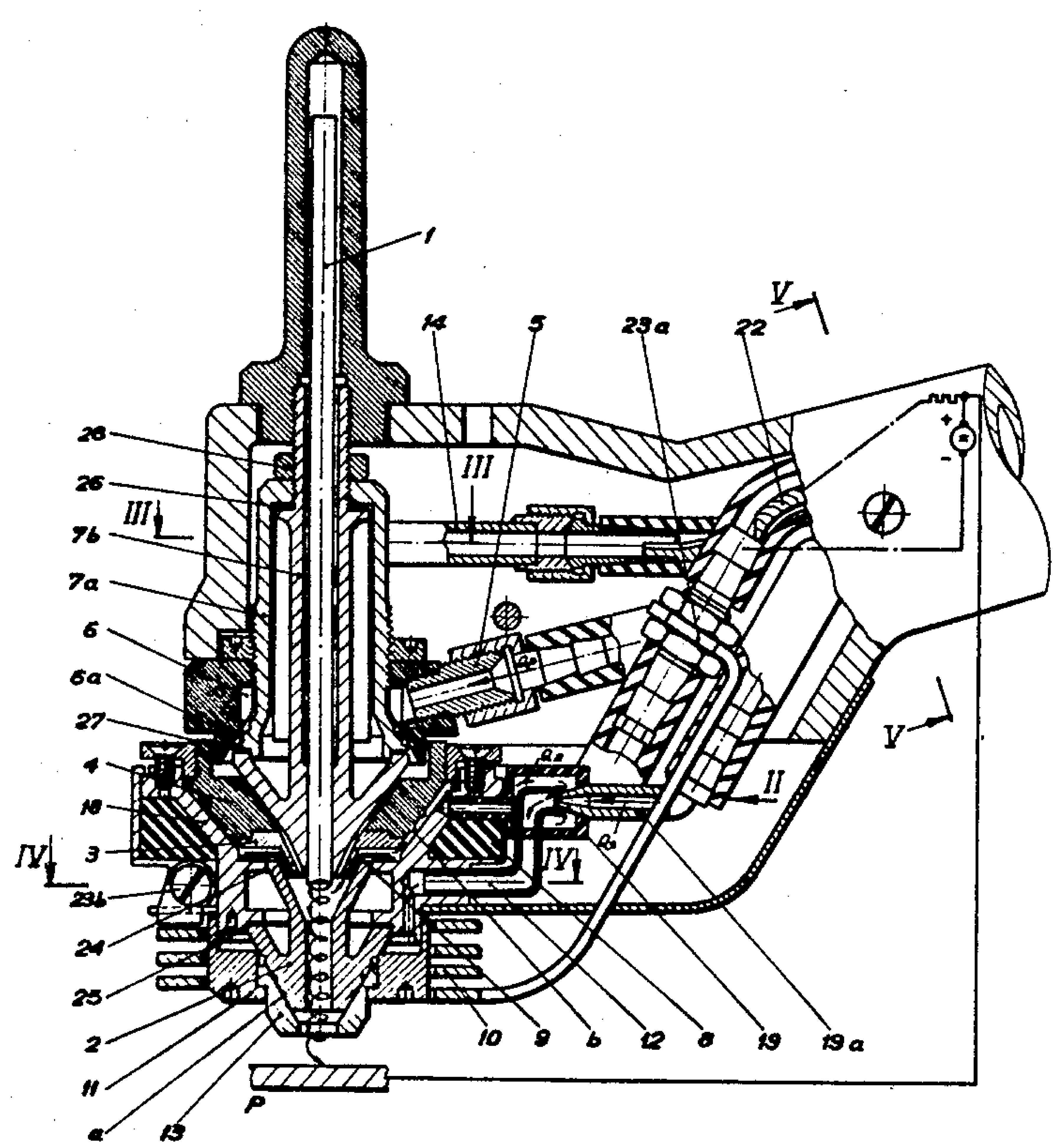
ABSTRACT: This invention relates to a plasma arc generator, operating with a DC or AC supply and having improved characteristics by virtue of arrangements for rotating the arc and the injected gas, which may be air or nitrogen for example. The plasma arc generator, is suitable for cutting, welding, built-up welding, (i.e. welding, in which a deposit of metals is built-up), metallizing and promoting chemical reactions.



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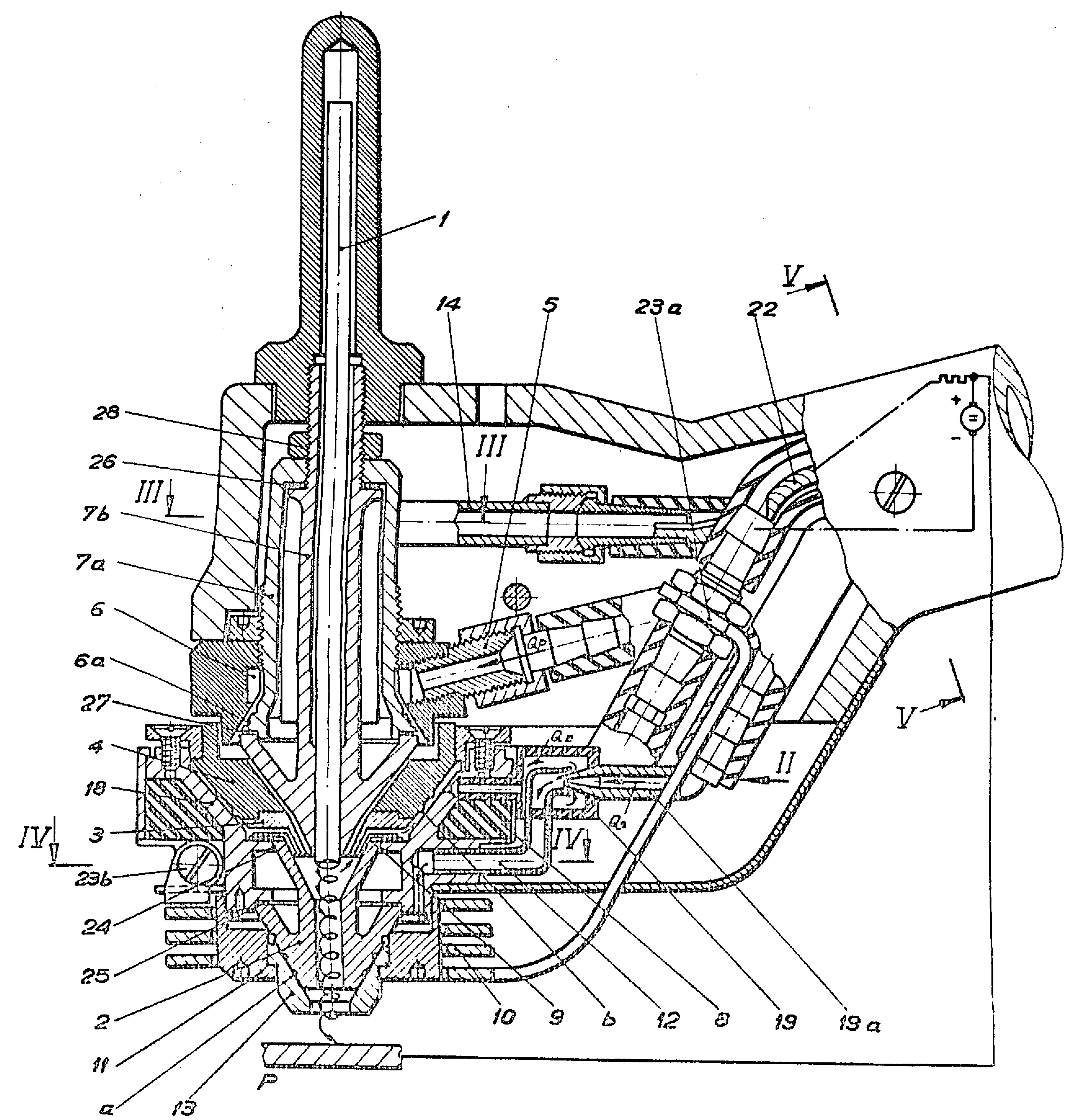

FIG. 1

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PLASMA GENERATOR WITH MAGNETIC FOCUSSING AND WITH ADDITIONAL ADMISSION OF GAS

Numerous types of plasma arc generators are known and utilized for cutting, buildup welding or metallizing, with or without a transferred arc. These generators, if utilized in systems with a transferred arc, present the disadvantage that they require the use of gas mixtures without oxygen or, in order to protect the cathode, the simultaneous utilization of an inert shielding gas, e.g. argon. For this reason the known methods for cutting or buildup welding or metallization have a reduced economical efficiency and due to the reduced concentration of the plasma arc, especially if utilized for the cutting of metals, they need a high consumption of electrical energy, and their efficiency and productivity is low.

There are also known plasma arc generators with magnetic focusing, the magnetic field being generated by coils placed on the body of the generator over the combustion chamber or at the output end of the nozzle.

These types of plasma generators have the disadvantage that, because of the high dispersion of the magnetic flux and of the lack of field concentrators, their focusing efficiency is low, or the disadvantage that due to the position of the coil at the output end of the nozzle, protection of the electrode is not realized.

There are further known plasma generators fed with single-phase alternating-current, these generators having the disadvantage of the instability of the arc, thereby requiring in the arc circuit, a high frequency oscillator with high-voltage pulses. These generators load the distribution net work asymmetrically and cannot be utilized in systems with a transferred arc.

Known three-phase plasma arc generators need two or three electrodes, and for this reason the gas utilized must not contain oxygen and the thermal plasma obtained has a low degree of ionization. It must also be mentioned that the efficiency of such an installation, as used especially for promoting chemical reactions, is relatively low. As the electrodes are placed on different axes, which cannot coincide with the axis of the nozzle, this nozzle can have only a limited contraction; thus the degree of concentration of the thermal plasma produced in this way is also reduced.

Such generators cannot be satisfactorily utilized for welding, buildup welding or metallization, being suited only for special chemical reactions and they are characterized by a low efficiency and a rapid consumption of the electrodes.

The present invention enables all these disadvantages to be avoided or reduced.

According to the present invention there is provided a plasma arc generator comprising a nozzle, means for feeding gas through the nozzle and also through a peripheral passage around the nozzle, current supply means for establishing an arc between the nozzle and an electrode within the nozzle, the current supply means including a coil which carries the whole of the nozzle current and embraces a ferromagnetic core surrounding the nozzle, and a second coil embracing a second ferromagnetic core for creating a low-pressure zone at the said electrode to protect the same.

The two coils cause simultaneous rotation of the plasma arc inside as well as outside the nozzle and the introduction of air and other gases through the nozzle as well as outside the nozzle can be effected as to impart rotary motion to the gases. The relative senses of rotation can be so chosen as to increase the enthalpy and increase or reduce the consumption of energy, as appropriate for each application. Since air, instead of other gases, can be used in the case of cutting the economic efficiency is increased also.

The generator can readily be modified for AC use with a single electrode by using two mutually insulated nozzles, both coaxial with the jet axis. The phases of a three-phase supply arc connected to the electrode and two nozzles respectively. This permits gas mixture containing oxygen to be used without causing consumption of the electrode. Due to the rotation of the arc and to the direct injection of additional turbulent gas in the arc zone after the first nozzle, the efficiency of the generator is very high.

The invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a sectional view of a plasma arc generator embodying the invention, for direct-current operation;

FIG. 2 is a fragmentary lateral view taken in the direction of an arrow II in FIG. 1;

FIGS. 3 to 5 are sections taken on lines III–III, IV–IV and V–V respectively in FIG. 1; and

FIG. 6 illustrates the principles as applied to three-phase AC operation, of the generator shown in FIG. 1.

In the following will be described the functioning of the generator embodying the invention, in the case of cutting.

The generator of FIG. 1 generates an electric arc between a tungsten electrode **1** and a nozzle **2**, electrically isolated by a ceramic insulator **3** and a textolite insulator **4**. The air Qp (or other gaseous mixture) is introduced through a pipe connector **5** into an equalization chamber **6**. Helical channels **6*a*** provided around an electrode holder **7*a***, cause the gas to execute a turbulent motion, with a speed increasing as the electrode holder **7*b*** tapers downwardly within a correspondingly tapered passage through the insulator **4**. The maximum speed is reached at the lower end, in the zone between the ceramic insulator **3** and the cone of the electrode holder **7*b***. An adiabatic expansion then takes place in the zone of the nozzle **2**. Due to the rotation of the air Qp and especially to that of the electric arc, caused by a magnetic field generated by a coil **8** and concentrated by a core **9**, upon which is superposed a second field generated by a coil **10** and a core **11**, a low-pressure zone is produced around the electrode, which protects the electrode from oxidation.

In the case of cutting of metals, the sense of rotation created electromagnetically by the two coils **8** and **10** is identical with the sense of rotation of the gas Qp.

The rotation of the plasma jet caused by the intense magnetic field generated in the outside zone of the nozzle **2** by the coil **10**, through which passes the entire current of the nozzle **2** create a low-pressure zone outside the nozzle **2**, too.

In this low-pressure zone, a jet of air $Qs+QE$ or of other gaseous mixture is injected through a pipe connection **12** (methane gas, hydrogen etc.), this jet having also a turbulent character, due to the action of helical channels *a*, provided round the nozzle **2**, in the zone between the nozzle and a copper ring **13** shrouding the end of the nozzle. The superposition of the effects due to the intense magnetic field in the burning zone, generated by the coil **10** and concentrated by the core **11** and also due to the turbulent jet of air (or gas) $Qs+QE$, causes a pronounced concentration of the electric arc between the electrode **1** and a metal workpieces P. In the case of welding the rotation of the arc caused by the coil **10** is in the opposite sense to the rotation of the gas $Qs+QE$ outside the nozzle imparted by the channels *a*.

The high rotation speed of the electric arc and of the plasma jet outside the nozzle **2** which causes the displacement also of the unionized particles of gas, in the entire zone of the electrical discharge, increases the vacuum surrounding the electrode **1**, which prevents its consumption in the presence of oxygen, contained by the gas Qp.

Due to the electromagnetic forces, generated by the coil **10** at the lower part of the generator and to the mechanical forces generated by the turbulent motion of the jet of air, $Qs+QE$ issuing through the passages *a*, the electric arc rotates outside the nozzle too (the direction of the arc rotation being the same as that of the gas $Qs+QE$ in the case of the cutting of metals) maintaining its position on the geometrical axis or axis of the generator.

When the generator is used for cutting, all rotations are made in the same sense both inside and outside the nozzle. Then the kinetic energy of the particles from the peripheral zone of the arc reaches a very high value which blows the molrotation, inside and outside the nozzle, in a sense contrary to the rotation of the gas.

As a consequency of the rotation of the arc and of the gas and because of the vacuum caused around the cathode resulting from the partial direct evacuation of a quantity of the gas, at the level of the electrode without the evacuate gas transversing the nozzle and as a consequence of the recycling of this gas which is reintroduced into the channels *a* around the nozzle **2**, the generator can work in the case of cutting, with air or with gas mixture, with a high content of oxygen, without utilizing inert gases for the protection of the cathode.

2. As the electrode is also cooled by a part of the gas Q_p and by the simultaneous creation of a low pressure in the zone of the cathode and as the reutilization of the same gas in the zone outside the nozzle causes cooling around the nozzle, the quantity of cooling water may be dispensed with.

3. The introduction in a zone outside the nozzle of some gas mixtures, in whatever proportion, for increasing the enthalpy of the plasma arc, or for intensifying the restitution of the stored energy into the cutting zone, contributes not only to the increasing of the efficiency but it intensifies to a high degree the penetration in the metal to be worked and in the case of utilizing the plasma arc for the cutting of plates it may be utilized for plates of a higher thickness.

4. The introduction of gas mixtures Q_s+QE in a zone outside the nozzle and the electromagnetic rotation of the arc, in this zone, caused by the series coil, determines a low-pressure and an intense local cooling of the nozzle, thus permitting a very high concentration of the arc.

5. In a system with a transferred arc, the utilization of a series coil prevents entirely the possibility of the formation of a secondary arc between nozzle and workpiece.

For this reason, the space between the nozzle **2** (FIG. **1**) and

the workpiece P can be very much reduced so that a considerable increase of the efficiency and safety in utilization is obtained.

6. The generator can be utilized with alternating single-, two- or three-phase current.

I claim:

1. A plasma arc generator comprising a nozzle (**2**) forming a frustoconical nozzle chamber converging in the direction of a nozzle mouth from which a plasma emerges; means (**6*a***) for feeding an ionizable gas (Q_p) into said chamber and along the exterior of said nozzle and therearound; and electrode (**1**) extending into said chamber; current supply means connected across said nozzle and said electrode for striking an arc within said chamber; and an electromagnetic coil (**10**) surrounding said nozzle and connected in series with said current supply means, said electrode and said nozzle for traverse by the entire current of said arc, and a ferromagnetic core (**11**) surrounding said nozzle and cooperating with said coil for generating a magnetic field causing the plasma issuing from said nozzle to rotate about the axis thereof; and a second electromagnetic coil (**8**) and a second ferromagnetic core (**9**) coaxial with said nozzle, said coils and said cores generating within said chamber a low-pressure zone around said electrode.

2. The plasma arc generator defined in claim **1**, further comprising means for evacuating a portion of the gas from said chamber immediately around said electrode, and helical channels (b) formed in the space between said electrode and the body of said nozzle communicating with the last mentioned means, and a sleeve surrounding said electrode and communicating with said chamber and channels.

3. The plasma arc generator defined in claim **2** wherein the last-mentioned means includes an ejector.

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[31] St 23 592

[54] **MACHINING PROCESS USING RADIANT ENERGY**
6 Claims, No Drawings

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[51] Int. Cl. B23k 15/00, B23k 27/00
[50] Field of Search .... 219/121 L, 121 EB, 69 R, 68, 70, 347—349, 338

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Attorney—Sandoe, Hopgood and Calimafde

ABSTRACT: A process using a beam of radiant energy, such as electron beams and laser beams, for removing material from a workpiece wherein the workpiece is made of a material which has a low degree of energy absorption for the kind of radiant energy used consists in finely distributing an auxiliary material having a high beam absorbing characteristic within the workpiece material in at least the portion thereof from which material by absorbing heat builds up vapor pressure which carries the adjacent molten material out of the work zone.