United States Patent

Rotolico et al.

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[54] **NOZZLE FOR A PLASMA GENERATOR**

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[52] **U.S. Cl.** .....**219/121 P**, 219/76, 313/231
[51] **Int. Cl.** **B23k 9/04**
[58] **Field of Search** .....219/75, 76, 121 P, 122; 313/231

[56] **References Cited**

UNITED STATES PATENTS

3,280,295	10/1966	Mondain-Monval et al.	219/76
3,174,025	3/1965	Johnson	219/75
3,183,337	5/1965	Winzeler et al.	219/75 X

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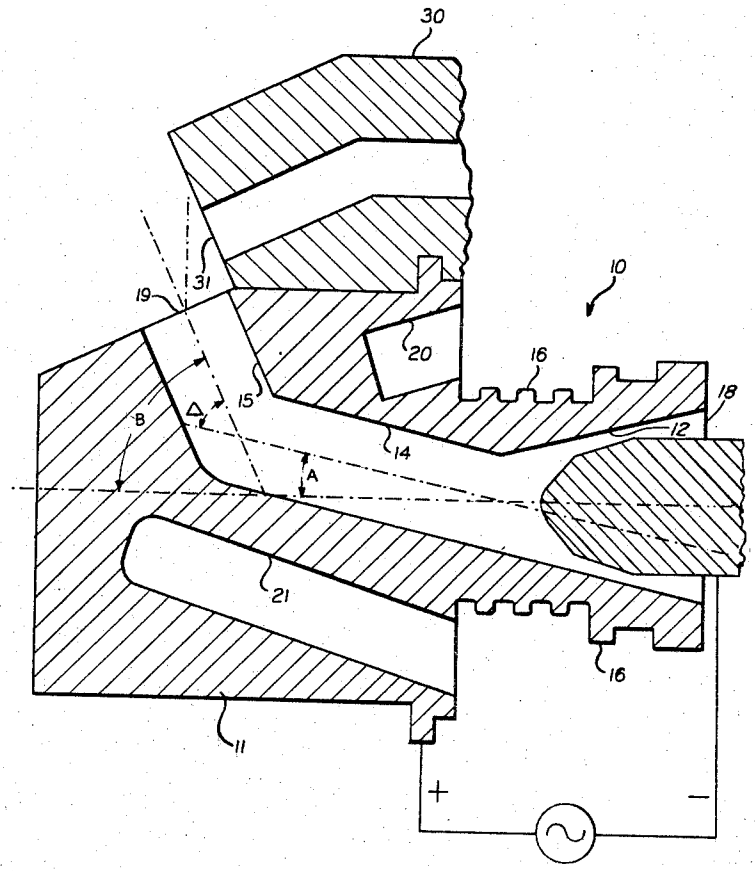
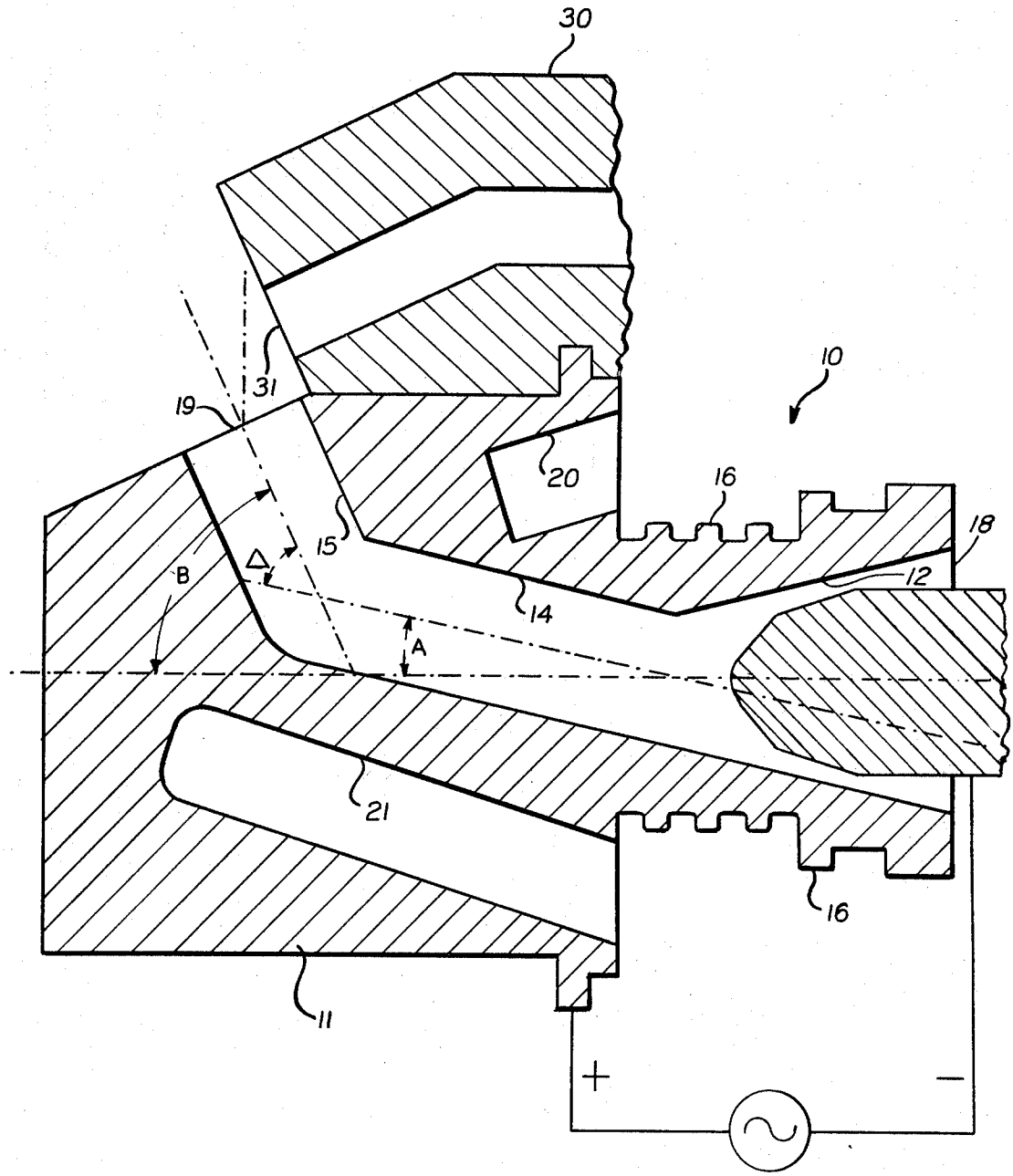
[57] **ABSTRACT**

An angular nozzle electrode for plasma generating devices is disclosed. The nozzle includes an inlet end, an intermediate portion and an outlet portion in angular relationship so as to maximize the function and operational life of the nozzle electrode.

10 Claims, 1 Drawing Figure





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NOZZLE FOR A PLASMA GENERATOR

BACKGROUND OF THE INVENTION

This invention relates to nozzles for use with plasma flame generators and in particular angular nozzles for use in plasma stream apparata.

Plasma flame generators and spray guns utilizing an electric arc and a flowing gas stream passed in contact with the arc are known and have been used successfully for commercial and experimental purposes. These devices generally consist of an electrode arrangement striking an arc therebetween, a nozzle and means for passing a stream of gas in contact with the arc and through the nozzle.

In generators of the transferred arc type which are generally used as torches for cutting, welding, and the like, the arc generally extends from an electrode such as a rod electrode or a flat face electrode, such as a disc, to the workpiece through a nozzle, such as a cooled nozzle, while a gas stream is passed concurrently through the nozzle with the arc.

In plasma flame generators of the non-transfer type, the arc is struck between an electrode pair, one of which is in the form of a nozzle, and the gas stream is passed in contact with the arc and through the nozzle.

Plasma flame spray guns, in principle, merely constitute plasma flame generators in which means are provided for passing a heat fusable material into contact with the plasma stream where it can be melted or at least softened and propelled, as for example, onto a surface to be coated.

In U.S. Pat. No. 2,960,594 to Thorpe, a plasma generator is described, in which the electric arc is constricted and elongated and passed at least part way down a nozzle by means of a sheath of plasma forming gas which, thus acting on the arc, is in itself converted to the plasma energy state, may be utilized as a heating medium. This plasma flame generator is well suited as the plasma flame generating portion of the plasma flame spray gun as described in U.S. Pat. No. 3,455,510 to Rotolico.

Plasma spraying into smaller holes or bores presents difficulty with regard to accessibility of the area to be sprayed. For purposes of coating such areas angular nozzles such as those disclosed in the aforementioned U.S. patent to Thorpe were necessary. In these devices the outlet portion of the nozzle passageway is at a right angle to a central bore portion. While nozzles of this construction effectively operate, they require large quantities of cool water due to the large amount of heat absorbed by the walls of the nozzle during the arcing process. In addition, arcing within these angular nozzles causes erosion and pitting in the passageway thereby necessitating frequent replacement. Consequently, the use of this type of nozzle has not proven to be practical.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide an angular nozzle for a plasma flame generator which overcomes the aforementioned disadvantages of the prior art.

It is another object of the present invention to provide an angular nozzle electrode for a plasma flame generator which has a relatively long operational life.

It is yet another object of the present invention to provide a plasma flame generator angular nozzle which is capable of spray coating into small holes or aperatures.

BRIEF SUMMARY OF THE INVENTION

These and other objects are accomplished in the present invention wherein there is provided an angular nozzle electrode for a plasma generator. More specifically, the invention relates to an angular nozzle electrode having a nozzle body which contains a passage extending therethrough, the passage containing an inlet end, central intermediate portion and an outlet portion terminating as an exit port in the nozzle body. The intermediate portion of the nozzle passage extends at an angle to the inlet end and the exit portion extends at an angle to the axis of the intermediate portion. The angular nozzle electrode of the present invention enables the determination of optimum angles between the portions of the nozzle passage which results in a plasma gas directing medium which is both durable and effective in plasma spraying processes.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical section of the angular nozzle electrode of the present invention.

DETAILED DESCRIPTION OF THE DRAWING AND SPECIFIC EMBODIMENTS

Referring now to FIG. 1, there is demonstrated the angular nozzle electrode **10** of the invention. More specifically there is shown a nozzle body **11** through which extends a nozzle passage of three components, an inlet end designated as **12** which conically narrows to an intermediate portion designated as **14**, and an exit portion **15** terminating at exit port **19**. Additionally, the particular embodiment of FIG. **1** shows tubular blind bores **20** and **21** through which a coolant such as water can be circulated. Nozzle body **11** contains ribs **16** which facilitate the affixation of the nozzle to a plasma generator.

As can be seen from the FIG. intermediate portion **14** of the nozzle is at an angle to the axis of the inlet end and the outlet portion **15** is at an angle to the intermediate portion **14** and at a greater angle to the axis of the inlet end **12**. The angle at which nozzle component intermediate portion **14** deviates from the axis of the inlet end **12** is designated as A and the angle at which outlet portion deviates from the axis of the inlet end **12** is designated as B. The difference between the two angles in the FIGURE is designated as Δ. It has been found that for optimum operation of a plasma flame spray generator with the instant angular nozzle electrode, particular angles for the intermediate and exit portions, **14** and **15**, of the nozzle can be established. These particular angles enable a plasma generator to spray down into small holes without loss of the durability characteristics of the instant nozzle.

The optimum angular relationship between the intermediate portion **14** and the exit portion **15** of the angular nozzle has been empirically established by the following formula:

$$\sin (B - A) \cong 90\% \sin B$$

Using this empirical formula and optimum spraying angles for exit portion **15**, angle *B*, the corresponding angles for central intermediate nozzle portion **14**, angle *A*, can be determined.

To produce reasonably dense normal coatings it is necessary to spray with an angle to the substrate surface of usually not less than 45°. Spraying the substrate surface at an angle of from about 90° to 45° does not produce a very great change in the coating structure. When using the present nozzle electrode to spray into bores large enough to permit proper spray distance from the nozzle exit port **19** to the area being coated then it is preferable to have the angle of the exit portion, angle B, at or near **90°** so that the spray strikes perpendicularly. For holes which do not permit a proper spray distance, i.e., holes with diameters less than 5 inches, an exit portion angle B of about 45° is desirable. A practical all around preferred exit portion angle B would be about 65°.

Using the aforementioned empirical formula

$$\sin (B - A) \cong 90\% \sin B$$

the angles of the intermediate portion **14**, angle *A*, corresponding to the optimum angles of B, 45° to 90°, are calculated as being from 5° to 26°. For a preferred angle B of 65° the corresponding angle of A is about 10°.

It is to be understood that the above cited angles of A have been determined empirically by using the approximate formula referred to above. Therefore, variations of plus or minus 2° are considered to be within the purview of the present invention. Therefore, optimum angles of A would range from about 4° to 28°. It has been further established that a preferred angle A, having an angle B at 65°, would be in the range of from about 10° to 12°.

There is additionally shown in FIG. **1** a powder feed element **30** through which heat fusable material to be flame sprayed is fed. The powder emanates from the powder exit port **31** and intersects the plasma flame spray emanating from the plasma flame exit port **19**. Heat fusable material to be flame sprayed, as, for example, powdered metal or ceramics which are conventionally sprayed in devices of this type, is passed through powder-feed element **30** by means of a small volume of a carrier gas, as, for example, inert gas such as nitrogen, helium, argon or the like.

Again, referring to FIG. **1**, nozzle **11** may be made of any electrically conductive material as, for example, copper, copper alloy, brass, aluminum, steel, or the like. However, the nozzle body may be made of insulating materials as, for example, synthetic resins, such as polyethylene, nylon or the like. In this instance, all or at least a portion of the nozzle bore should be lined with an electrically conductive material or provided with an electrically conductive insert.

It is to be further understood that while cooling elements **20** and **21** were external tubular arrangements in the embodiments described in FIG. **1**, any means of cooling the present plasma carrying nozzle electrode can be used. One example would be an annular configuration surrounding the nozzle passageway.

The novel construction of the present angular nozzle is applicable to all types of plasma generators and spray guns in which an arc-forming electric current is passed from a rod electrode, inserted at intake **18** and extending coaxially with the axis of the inlet end **12** into the nozzle and which is provided with means for passing a plasma forming gas in contact with the arc through the nozzle. For example, the present nozzle, excepting its angular configuration, is operable with a spray generator in the same manner as the outwardly tapered nozzle of U.S. Pat. No. 3,145,287 to Siebein et al. In addition, the present angular nozzle may be used in combination with any conventional extension tube.

While the invention has been described in detail with reference to the embodiments shown, various changes and modifications which fall within the spirit of the invention and the scope of the appended claims will become apparent to the skilled artisan. The invention is, therefore, only intended to be limited by the appended claims or their equivalents.

What is claimed is:

1. An angular nozzle electrode for a plasma generator, comprising a nozzle body having a passage extending therethrough, at least a portion of the wall of which is of electrically conductive material, said passage having an inlet end, an intermediate portion and an outlet portion terminating as an exit port, the axis of said outlet portion extending at an angle to the axis of said inlet end and at an angle to the axis of said intermediate portion greater than 0° but less than the angle to the axis of said inlet end, whereby to define three distinct portions of said passage.

2. Angular nozzle electrode, according to claim **1**, in which the axis of said inlet end, intermediate and outlet portions extend at angles to each other so that the sin of the angle between the axes of the outlet portion and intermediate portion is about nine-tenths of the sin of the angle between the axes of the outlet portion and inlet end.

3. Angular nozzle electrode, according to claim **2**, in which the axis of said outlet portion extends at angles of about 45° to 90° to the angle of said inlet end, and the axis of said intermediate portion extends at an angle of about 4° to 28° to the axis of said inlet portion.

4. Angular nozzle electrode, according to claim **3**, in which said inlet end of said passage conically narrows to said intermediate portion.

5. Angular nozzle electrode, according to claim **4**, in which the axis of said outlet portion extends at an angle of about 65° to the axis of said inlet end, and in which the axis of said intermediate portion extends at an angle of about 10° to 12° to the axis of said inlet end.

6. Angular nozzle electrode, according to claim **5**, including means for feeding flame spray powder in front of said exit port.

7. Angular nozzle electrode, according to claim **6**, forming the nozzle electrode on a plasma flame spray gun, having a rod electrode extending coaxially with the axis of said inlet end, means for generating an arc between said rod electrode and said nozzle electrode, and a source of plasma forming gas.

8. Angular nozzle electrode, according to claim **1**, forming the nozzle electrode on a plasma flame spray gun, having a rod electrode extending coaxially with the axis of said inlet end, means for generating an arc

between said rod electrode and nozzle electrode, and a source of plasma forming gas.

9. Angular nozzle electrode, according to claim 1, including cooling fluid passages extending in the nozzle body surrounding at least a portion of said first-mentioned passage.

10. Angular nozzle electrode, according to claim 1, including means for feeding flame spray powder in front of said exit port.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,707,615 Dated December 26,1972

Inventor(s) Anthony J. Rotolico and Eduardo Romero

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Front page, under "Inventors" "Edwardo" should read

--Eduardo--

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents