

Sept. 3, 1963

Z. FONBERG
ELECTRIC ARC TORCH

3,102,946

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2 Sheets-Sheet 1

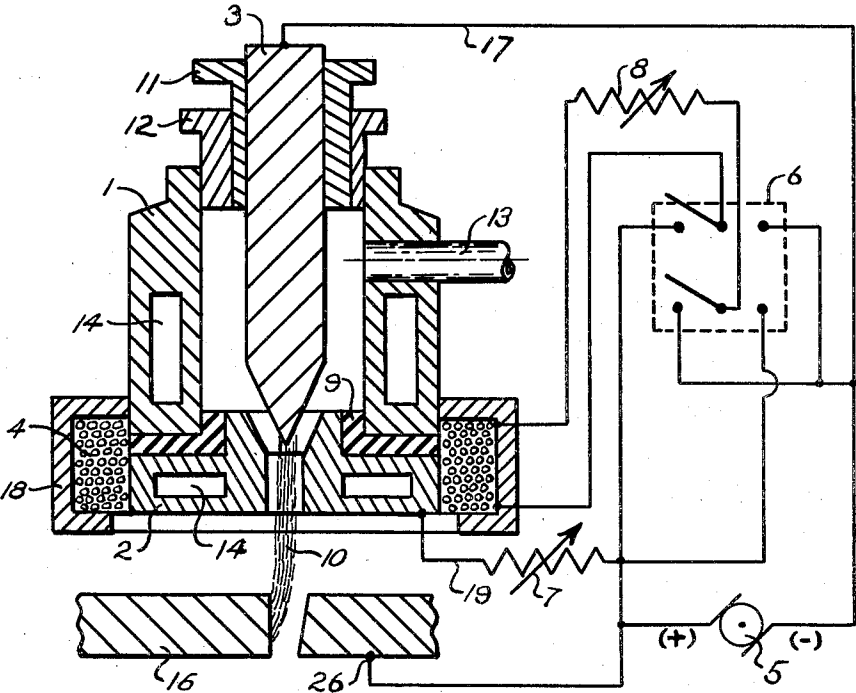


Fig. 1

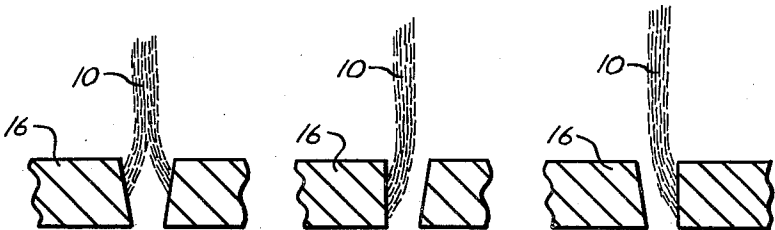


Fig. 2

Fig. 3

Fig. 4

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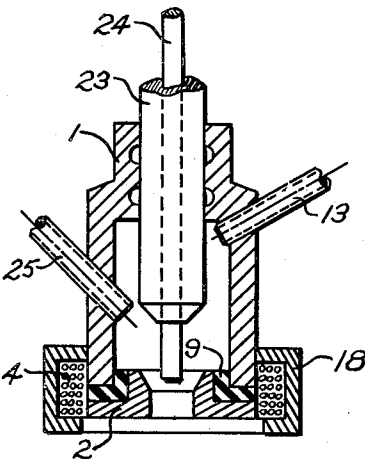
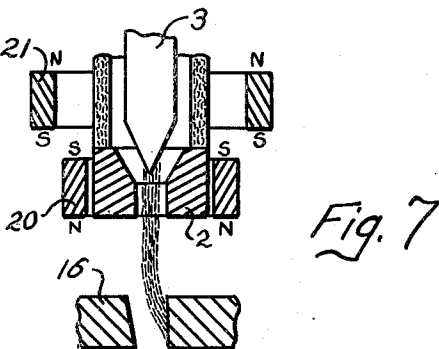
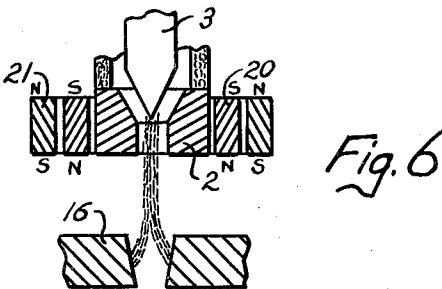
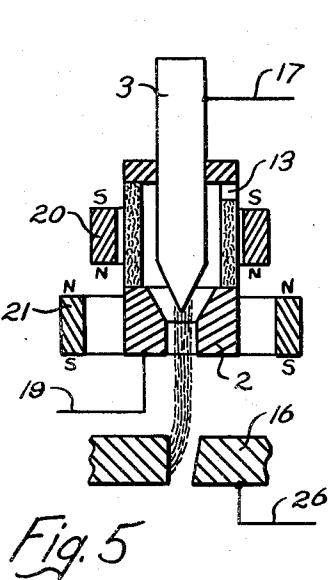


Fig. 8
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1

3,102,946

ELECTRIC ARC TORCH

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4 Claims. (Cl. 219-123)

This invention relates to a novel and advantageous method of containing and guiding plasma streams as generated in high-pressure arc torches. Such arc torches are utilized for the cutting of metals, for metal and ceramic spraying, and other heating applications. This invention is also useful for the guidance of plasma streams, where after forming the plasma a gas or other reactive material is added to the plasma. For example, in the plasma cutting of thick steel sections (slabs, plates, ingots, and the like) it is advantageous to add a reactive substance to the plasma stream.

Plasma is formed by means of an electric current passing between two electrodes. A high-pressure arc torch usually consists of a first electrode contained within a chamber. The arc passes from this electrode through, or at least part way through, a nozzle passage. In some cases the nozzle passage is part of the second electrode. Often, as in the case of metal cutting, the second electrode lies exterior to the torch itself, and, in fact, comprises the workpiece itself.

The arc column extending into, or through, the nozzle passage is composed of a plasma consisting of electrons and ions moving in helical paths. The axes of these helices are substantially parallel to the surface walls of the containing passage. The helical motion of these charged particles produces an effect similar to that of a magnetic coil which compresses and stabilizes the plasma stream. Such a compression of the plasma plays an important role in keeping the arc column spaced well away from the nozzle walls. Leaving aside complicated mathematical calculations based on theorems of Gauss and Maxwell concerning field distributions, it is known from these theoretical references that a magnetic field of 5,000 gauss in strength exerts a pressure of approximately one atmosphere on the plasma. Therefore, the self-induced magnetic field associated with a cylindrical arc influences the density of the plasma comprising that arc. As the geometry of this self-induced field depends on the motion of the electrons, the arc column can be guided by means of an axial magnetic field imposed from an outside source.

It is to be noted that plasma is an excellent electrical conductor, but which does not possess the mechanical rigidity of a solid conductor. Where the current flow through a rigid body is easily defined, the path of the current flow through a plasma is defined by the equilibrium of electromagnetic forces according to the laws of magnetohydrodynamics. Any attempt to stabilize the high temperature arc column by means of a mechanical structure such as a wall composed of a ceramic material leads to rapid melting of the wall itself. Conducting materials are better suited for arc stabilization. For instance, eddy currents generated in the conducting walls of the nozzle react on the plasma stream to isolate it from the nozzle walls. A further increase of the axial magnetic field strength, as achieved by utilizing an axis-symmetric coil, leads to further separation of the arc from the nozzle walls.

It is a principal object of my invention to provide an improved torch in which the orientation of the plasma stream may be controlled.

This object and other advantages of the invention will become apparent from the following description and drawings, in which:

FIGURE 1 is a longitudinal cross-sectional view of a high-pressure arc torch fitted with an axis-symmetric elec-

2

tric coil with a schematic view of the electrical power supply and one possible arrangement of the connections;

FIGURES 2, 3 and 4 are cross-sectional views of work pieces cut by torch-generated plasma streams;

FIGURES 5, 6 and 7 are cross-sectional views of the plasma torch fitted with magnets; and

FIGURE 8 is a cross-sectional view of a torch illustrating another feature of the invention.

Referring to FIGURE 1, the cutting torch is composed of a body 1, a nozzle 2, and an electrode 3. The nozzle 2 is insulated from piece 1 by a ring 9. The torch is provided with cooling jackets 14 in which gas, or liquid, can be circulated. The torch is provided with a pair of eccentric sleeves 11 and 12, the relative position of one to the other governing the position of the electrode 3 relative to the axis of the torch. The novel and useful feature of the invention consists of an electric coil, or solenoid, 4, which is placed around the torch and which can be moved along the axis of the torch. The coil may be fitted with the ferro-magnetic casting 18 which envelops the coil on its outside cylindrical surface and which substantially covers the front and rear faces to reduce magnetic resistance. When supplied by an electric current, the coil 4 generates a magnetic flux in the casing 18 and also in the arc passage. The flux on the inside of the coil is in the direction of the axis of the torch and in the direction of the motion of the plasma stream. By reversal of the current direction in the coil 4, the sense of the magnetic field is also reversed, the flux lines, however, remaining in the direction of the torch axis.

The system is fitted with a power supply 5 and means to regulate the electric current and voltage. A reversing switch 6 governs the direction of the current flow in the coil 4. The workpiece 16 to be cut is located near the nozzle 2 of the torch and is connected to the power supply 5. When coil 4 is not energized, the plasma stream 10 issues symmetrically from the nozzle passage. In this case the workpiece is cut as shown in FIGURE 2. Note that the cut is characterized by equally sloping sides. When coil 4 is energized, the square cut edge of FIGURES 1 and 3 is produced. Reversal of the current in coil 4 leads to the square cut of the right edge as shown in FIGURE 4. The ability of this invention to produce straight cut edges represents a major improvement over present arc cutting torches.

It is often advantageous to place the lead contact 26 at certain locations on the piece being cut. For example, when cutting a circular shape in a plate, I have found it is best to place the contact 26 at a position approximating the center of the circle. The entire circumferential edge of the circle can be made square, either the hole or the cut-out circle, depending upon the direction of current flow.

Another useful feature of the invention is a method of regulating the position of electrode 3. By means of turning eccentrics 11 and 12, electrode 3 may be positioned off-center relative to the centerline of the nozzle passage. This eccentric position provides for an inclination of the axis of the arc column or plasma stream. The amount of this inclination may be controlled to provide a square cut edge.

Instead of the electric coil 4, a permanent magnet or plurality of magnets may be used to generate the axial magnetic field. The torch is then fitted with the magnets 20 and 21 of FIGURES 5, 6 and 7 (or one permanent magnet can be reversed to produce the same result). By rearranging and moving axially the magnets 20 and 21, desirable cuts are obtained. To obtain a desired cut edge (usually square) the magnetic field strength may be varied. The thickness of the plate being cut, the gas type and flow rate, as well as the current level are vari-

3

ables which, in addition to the magnetic field strength, govern the inclination of the arc column.

FIGURE 8 illustrates a novel method for introducing a rod of material to be deposited on a surface of a workpiece, or for facilitating a cutting or welding application.

Although the discussion relates to the cutting of a workpiece, my invention is suitable to other applications including welding, metallizing, and the like.

While I have described various embodiments of my invention by way of illustration, it will be understood that modifications within the spirit and scope of the claims appended hereto may well occur to persons skilled in this art.

I claim:

1. In an electric arc torch having a first electrode in spaced relation to a nozzle, means for establishing an electric arc from said first electrode through said nozzle to a workpiece, and means for generating a magnetic field with flux lines lying parallel to the axis of said nozzle.
2. A torch according to claim 1, including means for varying the intensity of said field.
3. A torch according to claim 1, including means for reversing the sense of said field.

4

4. In an electric arc torch having a first electrode in spaced relation to a nozzle, means for establishing an electric arc from said first electrode through said nozzle to a workpiece, means for introducing gaseous elements under pressure through said nozzle to form an arc-plasma stream, and means for diverting said stream as it emerges from said nozzle including an axi-symmetric coil disposed around said nozzle, and a source supplying electrical energy to said coil.

References Cited in the file of this patent

UNITED STATES PATENTS

510,777	Coffin	Dec. 12, 1893
1,740,381	Weed	Dec. 17, 1929
1,921,572	Kinnard	Aug. 8, 1933
2,428,849	Kratz et al.	Oct. 14, 1947
2,944,140	Giannini et al.	July 5, 1960
2,945,119	Blackman	July 12, 1960

FOREIGN PATENTS

1,201,825	France	July 15, 1959
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