219-121• SR

11-09-71 OR 3,619,549

B, Out

United States Patent [11] 3,619,549

[72] Inventors **John A. Hogan**
Somerset;
Robert M. Gage, Summit, both of N.J.

[21] Appl. No. **47,840**
[22] Filed **June 19, 1970**
[45] Patented **Nov. 9, 1971**
[73] Assignee **Union Carbide Corporation**
New York, N.Y.

[54] **ARC TORCH CUTTING PROCESS**
6 Claims, 22 Drawing Figs.

[52] **U.S. Cl.** .... **219/121 P**
[51] **Int. Cl.** **B23k 9/00**
[50] **Field of Search** .... 219/75, 121 P

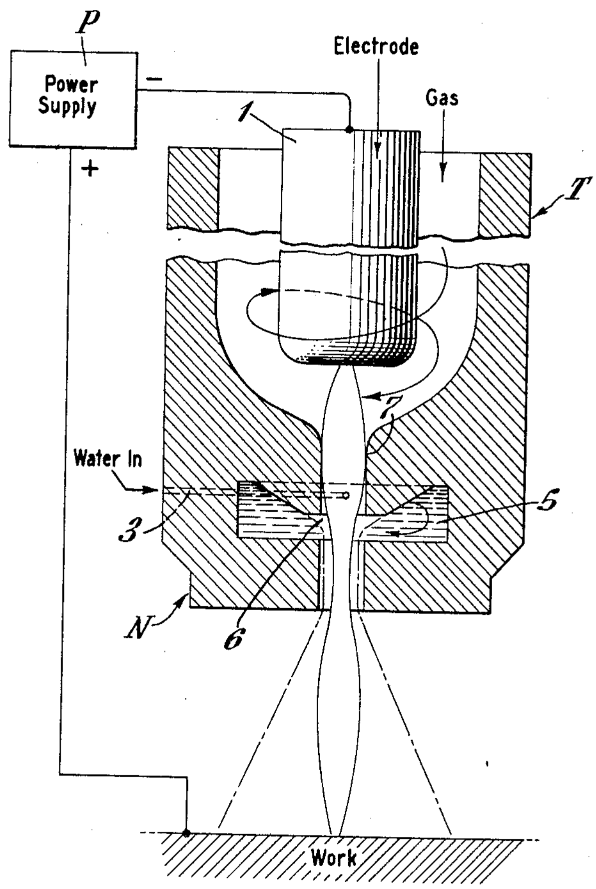
[56] **References Cited**

UNITED STATES PATENTS

2,906,858	9/1959	Morton, Jr.	219/121 P
3,149,222	9/1964	Giannini et al.	219/121 P
3,534,388	10/1970	Ito et al.	219/121 P

Primary Examiner—J. V. Truhe
Assistant Examiner—G. R. Peterson
Attorneys—Paul A. Rose, Harrie M. Humphreys and Dominic J. Terminello

ABSTRACT: High quality, square cuts are obtained in metals by an arc process wherein an arc is struck between an electrode and workpiece, a gas vortex is passed around the electrode and is directed into a constricting nozzle passage where a liquid, usually water, vortex swirling in the same direction as the gas vortex is introduced. The arc passes through the gas and liquid vortex and through the nozzle and is directed in a highly constricted state against the workpiece to be cut.



Prior Art

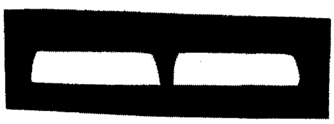


Fig.1a

Prior Art

Fig.1b

Prior Art

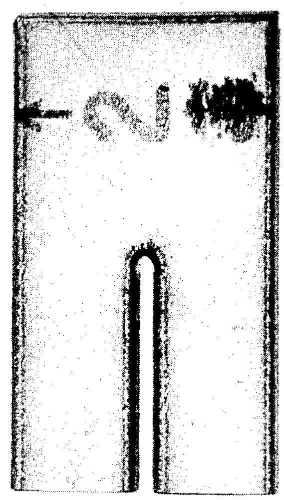


Fig.1c

Fig.2a

Fig.2b

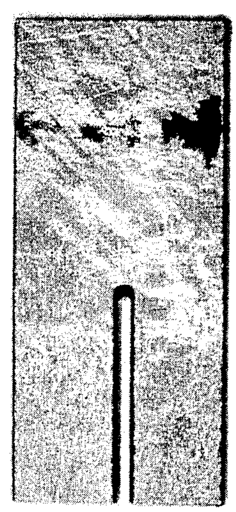


Fig.2c

INVENTORS
JOHN A. HOGAN
ROBERT M. GAGE
BY
ATTORNEY

Prior Art

Fig. 3a

Fig. 4a

Fig. 5a

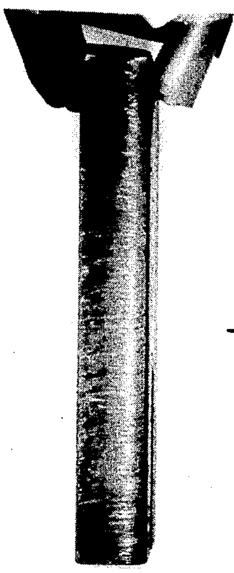


Fig. 3b

Prior Art

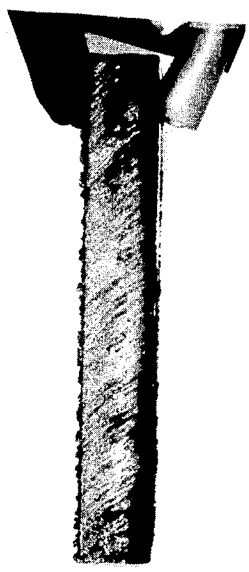


Fig. 4b

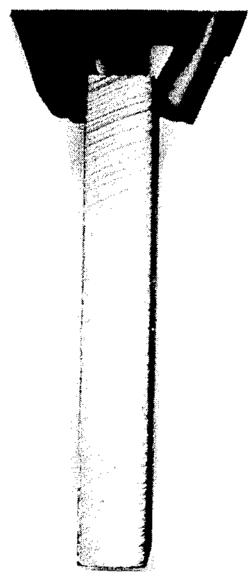


Fig. 5b

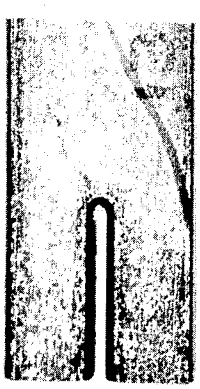


Fig. 3c

Prior Art

Fig. 4c

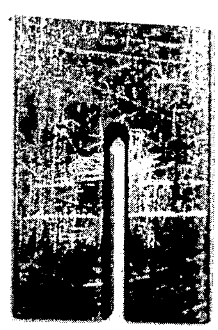


Fig. 5c

INVENTORS
JOHN A. HOGAN
ROBERT M. GAGE
BY Dominic J. Cimorelli
ATTORNEY

Prior Art

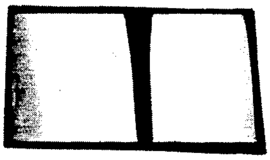


Fig. 6a

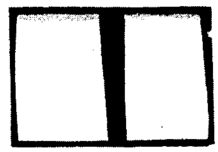


Fig. 7a

Prior Art

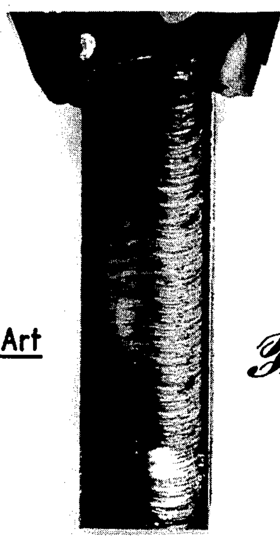


Fig. 6b

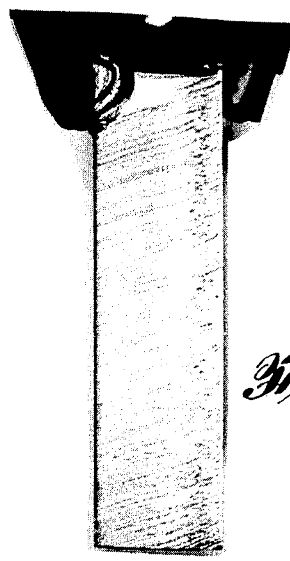


Fig. 7b

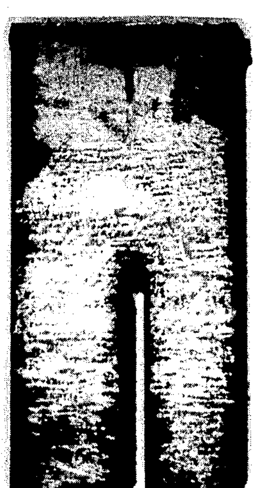


Fig. 6c

Prior Art

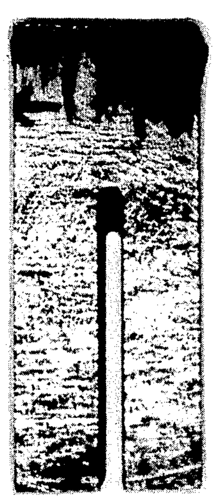


Fig. 7c

INVENTORS
JOHN A. HOGAN
ROBERT M. GAGE
BY Dominic J. Terminello
ATTORNEY

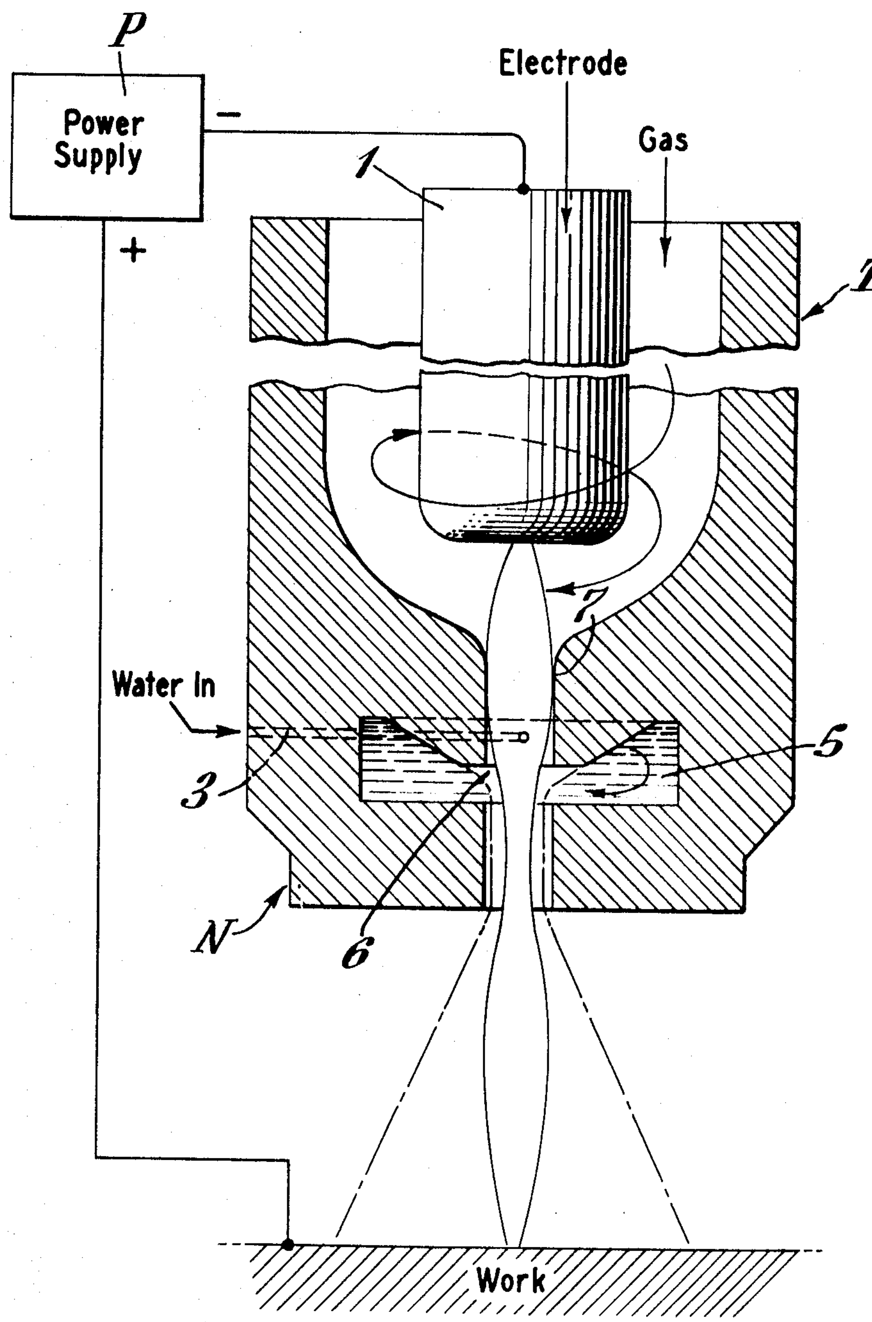


Fig.8

INVENTORS
JOHN A. HOGAN
ROBERT M. GAGE
BY
ATTORNEY

ARC TORCH CUTTING PROCESS

This invention relates to a process for cutting metals. More particularly this invention relates to a process for cutting metals with an arc constricted in a nozzle.

In the late 1950's, R. M. Gage disclosed in his U.S. Pat. No. 2,806,124 a method for constricting an arc in a nozzle. Since about 1957, this process has been ideally suited for Xcutting metals and has received wide acceptance as a significant improvement over oxyfuel gas and other methods of cutting metals, particularly those metals where oxyfuel gas was only useful with some difficulty or not at all. While the Gage process was a remarkable improvement over the state of the art at that time, the quality of the cuts obtained in some cases was not always that desired by the user. The industry constantly was seeking a way to obtain a nearly perfect square cut, without dross and a minimum of heat affected zone on the work at higher and higher cutting speeds. Many minor modifications were incorporated into the Gage process but up until now none resulted in both the high quality cuts desired with speed and ease of application to provide a widely accepted high quality cutting process.

Accordingly, it is the main object of this invention to provide a new improved process for arc cutting of metals which produces nearly perfectly square cuts.

Another object of the invention is to provide a cutting process which produces high quality cuts with essentially no dross and a minimum heat affected zone.

A further object is to provide an improved arc process for removing metal from a workpiece.

Another object is to provide a simple process for producing high quality cuts at high speed.

These and other objects will either be pointed out or become apparent from the following descriptions and drawings wherein:

FIG. 1*a*, *b* and *c* are photographs of cuts made in ¼-inch stainless steel with presently known constricted arc cutting techniques;

FIG. 2*a*, *b* and *c* are photographs of cuts made in ¼-inch stainless steel with the present invention;

FIG. 3*a*, *b* and *c* are photographs of cuts made in ½-inch stainless steel with a nozzle having a 4/32-inch diameter constricting passage by prior art cutting techniques;

FIG. 4*a*, *b* and *c* are similar to FIG. 3*a*, *b* and *c* with the exception that a nozzle was used having a 5/32-inch diameter constricting passage;

FIG. 5*a*, *b* and *c* are photographs of cuts made in ½-inch stainless steel using the techniques of the present invention and a 5/32-inch diameter constricting passage;

FIG. 6*a*, *b* and *c* are photographs of cuts made in 1-inch stainless steel with prior art techniques;

FIG. 7*a*, *b* of cuts made in 1-inch stainless steel with the techniques of the present invention;

FIG. 8 is a schematic diagram of a typical device for practicing the present invention.

In its broadest aspect, the invention resides in a process for removing metal by establishing an arc between an electrode and a workpiece. A vortical flow of gas is introduced around the arc. A vortical flow of liquid having the same direction as the vortical flow of gas is introduced around the flow of gas and the arc. The arc, gas and liquid are then passed through a nozzle and against a workpiece to remove metal from the workpiece.

As was indicated above, various modifications have been made in the plasma arc cutting process described by R. M. Gage in U.S. Pat. No. 2,806,124. Such modifications were made in an effort to improve cut quality, speed of cut and economics of the process, among other things. One of the early modifications was to introduce a vortical flow of gas into the arc zone in hopes of improving cut quality and to prevent the arc current from passing through or destroying the nozzle walls, usually by causing a catastrophic condition known as "-double arcing." However, if the nozzle is small, less than four thirty-seconds inch in diameter, the vortical swirl of gas will not necessarily eliminate double arcing during the start. Consequently, up until now, attempts to utilize swirling or vortical flows of gas with small orifices to improve cut quality resulted in processes which required rather complicated sequencing of gas flows and currents in order to avoid double arcing.

One of the major advantages of the present invention is that not only is better cut quality achieved even over the best cuts now obtainable, but they are achieved with a much simpler process at cutting speeds much higher than speeds now obtainable with the best high quality plasma cutting techniques.

It is postulated that the remarkable cut quality is obtained in the present invention, with a minimum danger of nozzle destruction because the walls of the nozzle constrict the arc as is taught by Gage in U.S. Pat. No. 2,806,124, but added arc constriction is provided by the swirling flow of liquid which is both a more effective coolant and constrictor and is more resistant to the passage of current than is gas alone.

The invention is predicated on the discovery that the coexistence in an arc constricting passage containing both a gas vortical flow and liquid vortical flow having the same direction of swirl will produce unexpectedly high quality cuts in metals.

It long has been known to use a swirling or vortical flow of gas in the process taught by Gage to improve cutting performance. Likewise, it has been taught by H. S. Morton in U.S. Pat. No. 2,906,858 to pass a swirling flow of liquid around an arc to constrict it. However, up until now, notwithstanding the fact that both of these teachings are well known in the art, no one has attempted to combine a swirling flow of gas and swirling flow of liquid (preferably water). Applicants have found that when a swirling flow of gas surrounds the arc and coexists in an arc constricting passage with a swirling flow of water, both swirls having the same direction, unexpectedly high quality cuts are obtained with relative ease. The same quality cuts cannot be obtained by only a swirl gas or only a swirling liquid around an arc. For example, referring to the photographs in the drawings and particularly FIGS. 1*a*, *b* and *c* and 2*a*, *b* and *c*, it will be evident that the cuts made in ¼-inch stainless steel with a nozzle having a 4/32-inch constricting passage with swirling or vortical gas where rounded at the top surface (FIG. 1*a*) had a dark appearance along the cut surface (FIG. 1*b*) and had a heat affected area on the top surface (FIG. 1*c*). Cuts made with the inventive concept produced essentially square cuts (FIG. 2*a*), clean cut surface (FIG. 2*b*) and essentially no heat affected area (FIG. 2*c*). Similar comparison can be made by studying FIG. 3–7 which illustrate cuts made in thicker materials under similar conditions.

As will be noted from the photographs, cuts made with the inventive swirling vortex of liquid had a good side to the right of the kerf which is within 2° of being square. The left side of the kerf was within 8° of being square. The reason for this asymmetry is that the clockwise swirl of the cutting gas and liquid causes the anode spot and, therefore, the maximum power density to occur on the right side of the kerf. This phenomena is not detrimental in shape cutting since the high quality side is always on the same side of the kerf.

Referring now to FIG. 8, an arc torch is shown at T. The torch T is connected on one side to a power supply P. The other side of the power source is connected to the work. The torch, shown diagrammatically, includes a nonconsumable electrode 1. Such electrode may be, for example, a tungsten electrode or a thoriated tungsten electrode. Preferably, however, such electrode consists of a water cooled copper holder having a tungsten insert. The insert material can be, if desired, zirconium or other equivalent material. The nonconsumable electrode 1 is in axial alignment with the center passage 7 in the nozzle N. The nozzle N is provided with tangential fluid injection ports 3. In the preferred embodiment, four tangential ports are provided. However, any number of injection ports may be used without departing from the spirit and scope of this invention. Other liquids may be used as the fluid; however, water is preferred. In this embodiment, the water enters the torch through the injection ports 3 and achieves vortical flow in the chamber 5. The chamber 5 has an annular outlet 6 in the center passage 7. The vortical flow of liquid leaves the chamber 5 and surrounds the arc and vortical flow of gas passing through the passage 7. In a preferred embodiment, the passage 7 has a diameter of five thirty-seconds inch and a throat length of twelve thirty-seconds inch. However, larger or smaller diameter passages may be used depending on the thickness of material being cut. For example, for material thicknesses greater than about 1 inch, the center passage 7 may be enlarged. As was indicated above, the center passage 7 provides arc constriction as taught by Gage. However, the nozzle passage 7 is large enough (five thirty-seconds inch) so as to minimize the possibility of a double arc situation in the current range of up to about 400 amps. When the liquid is injected into the nozzle passage 7, the arc is further constricted by the vortical flow of liquid from the chamber 5. Thus, the equivalent of a smaller nozzle passage is achieved while minimizing the danger of destroying the nozzle.

Table 1 below summarizes examples of the invention which produced cuts of the quality shown in the photographs. In the preferred embodiment, nitrogen is the gas utilized; however, it should be understood that the gas is not critical except that it should be compatible with the material being cut. While water is preferred to form the constricting fluid vortex since it is obviously the most accessible and cheap liquid to use, other liquids might be used. Water is the preferred liquid because in practice, as will be noted from the photographs, cuts made with water exhibit essentially no heat affected zone and little or no dross on most materials. Also, water minimizes surface discoloration caused by excessive heat normally generated by the arc. Further, in addition to the arc constricting effect of the water, hydrogen and oxygen gases are added to the arc column itself from the water, thereby providing the well-known benefits of these gases for cutting as described, for example, in R. M. Gage's U.S. Pat. No. 2,862,099, issued Nov. 25, 1958.

While the invention has been described to certain embodiments involving certain preferred arrangement of parts, it should be understood that variations in such arrangements may be made by those skilled in the art without departing from the spirit and scope of this invention.

CUTTING CONDITIONS

Material	Thickness (in.)	Cutting gas (N^2) at (c.f.h.)—	Cutting speed (i.p.m.)	Water flow rate (g.p.m.)	Arc current (amps) DCSP	Nozzle
Aluminum	¼	170	160	.4	275	5/32 inch diameter constricting passage with 12/32 throat length.
	½	170	125	.4	300	Do.
	1	170	80	.4	400	Do.
Carbon and stainless steels	¼	170	125	.4	275	Do.
	½	170	100	.4	300	Do.
	1	170	50	.4	400	Do.

What is claimed is:

1. Process for removing metal from a workpiece comprising:

establishing an arc between an electrode and a workpiece;

maintaining a vortical flow of gas around said arc;

introducing a vortical flow of liquid having the same direction as said vortical flow of gas around said flow of gas and said arc;

directing said arc, gas flow and liquid flow through a nozzle and against a workpiece to thereby remove metal from said workpiece.

2. Process according to claim 1 wherein said vortical flow of gas and said arc are passed through an arc constricting passage in said nozzle.

3. Process according to claim 1 wherein said arc, gas flow and liquid flow are passed through an arc constricting passage in said nozzle.

4. Process according to claim 1 wherein said vortical flow of liquid is introduced in the nozzle.

5. Process according to claim 4 wherein said vortical flow of liquid is introduced in an arc constricting passage in said nozzle.

6. Process according to claim 1 wherein said liquid is water.

* * * * *