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Arc Torch and Process—*JTST* Historical Patent #31*

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16 Claims. (Cl.219-75)

This invention relates to high pressure arcs of the, general type disclosed in my application Serial No. 524,353, filed July 26, 1955, now Patent No. 2,806,124, dated September 10, 1957, of which the present application is a continuation-in-part.

According to this invention the workpiece may be but is not necessarily in the arc circuit, the arrangement being such, however, that an effluent is provided which includes advantages of the work-in-circuit type. A feature is the use of a nozzle which is provided with a passage into which the arc and gas are delivered and from which the hot gas emerges after being forcibly confluent with the wall-stabilized, constricted arc. Material to be acted upon or used with the arc can be conveniently introduced into the arc stream between the electrodes.

More particularly, according to the present invention, there is provided a high pressure arc torch comprising spaced electrodes including a non-consumable nozzle having a passage into which the gas and the arc are delivered under pressure. A jet-like column of hot effluent is discharged from such passage after being forcibly confluent with the arc in the operation of such torch.

Broadly speaking the invention involves a high pressure arc process comprising feeding gas into and discharging such gas from a nozzle passage and establishing a high pressure arc in such passage. Such arc heats and ionizes such gas as it flows into and through the passage, thereby raising a substantial portion of such gas to arc temperature, and discharging a jet-like effluent column of hot ionized gas the shape and cross section of which are defined by such nozzle passage. The essential feature is that the gas entering the passage is forcibly constrained to enter and become for a finite time a part of the arc because the arc being constricted by the passage forcibly fills a substantial proportion of the passage cross section.

A portion of the arc forced into and contained within the nozzle passage is wall-stabilized in the same manner as is the wall-stabilized arc of Patent No. 2,806,124 mentioned above. The existence of effective wall-stabilization of a contained arc is described therein as evidenced by an increase in the axial voltage gradient of a portion of the arc within the nozzle passage as compared to a prior gas-shielded arc of the same gas flow and current. This voltage gradient is the rate of change of voltage with arc length and can be evaluated at any cross-section of a given arc. In Fig. 12, for example, of Patent No. 2,806,124 the voltage gradients at different nozzle cross-section diameters are given and compared with gradients in an open arc. Such curves need not specify the origin or destination of the arc nor in practical fact anything other than the conditions for the arc column at a cross-sectional plane of interest. Such curves are applicable to the portion of the arcs of the present invention which are contained within the passage of the nozzle electrode.

In the drawings:

Fig. 1 is a view in vertical section of an arc torch setup illustrating the invention;

Fig. 2 is a perspective view of a modification of the invention in which the arc electrodes are a refractory metal rod and a non-consumable annulus;

Fig. 3 is a perspective view of another modification in which four electrodes are employed, consisting of a rod, a nozzle, an annulus and the workpiece; and

Fig. 4 is a vertical sectional view illustrating a three-electrode modification of my arc torch.

As shown in Fig. 1, there is provided an arc torch setup comprising a pair of spaced electrodes 5 and 6 which are connected to opposite terminals of a suitable source of electric power 7, such as a generator, for energizing a high pressure arc across such electrodes. The electrode 5 is preferably a pencil or stick of thoriated tungsten, while the electrode 6 is preferably a tubular nozzle composed of copper having an orifice or outlet passage 8 axially aligned with the business end of said stick electrode 5. The nozzle is provided with an annular cooling water passage 9 about such orifice so that the annular electrode is substantially non-consumable in use. Gas, such as argon, is delivered to a chamber 10 in the nozzle 6 between the electrodes, so that the arc is forced into the orifice 8 by the flow of such gas therein and the arc is thereby wall stabilized. The gas is ionized by the arc in such orifice, is forced into the cross sectional shape of the orifice, and is discharged as a column of very hot jet-like effluent 11 which retains such shape for a substantial distance after leaving the orifice. Fluid cooling of at least a portion of orifice 8 by the cooling water circulated in passage 9 assures wall-stabilization of the arc. In use the effluent 11 is applied to a workpiece 12 which, as shown in Fig. 1, is not in the electrical circuit of the arc.

*This series of historical patents concerned with thermal spray technology has been compiled by C.C. Berndt (SUNY at Stony Brook, NY) and K.A. Kowalsky (Flame-Spray Industries, Inc., NY).

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ARC TORCH AND PROCESS

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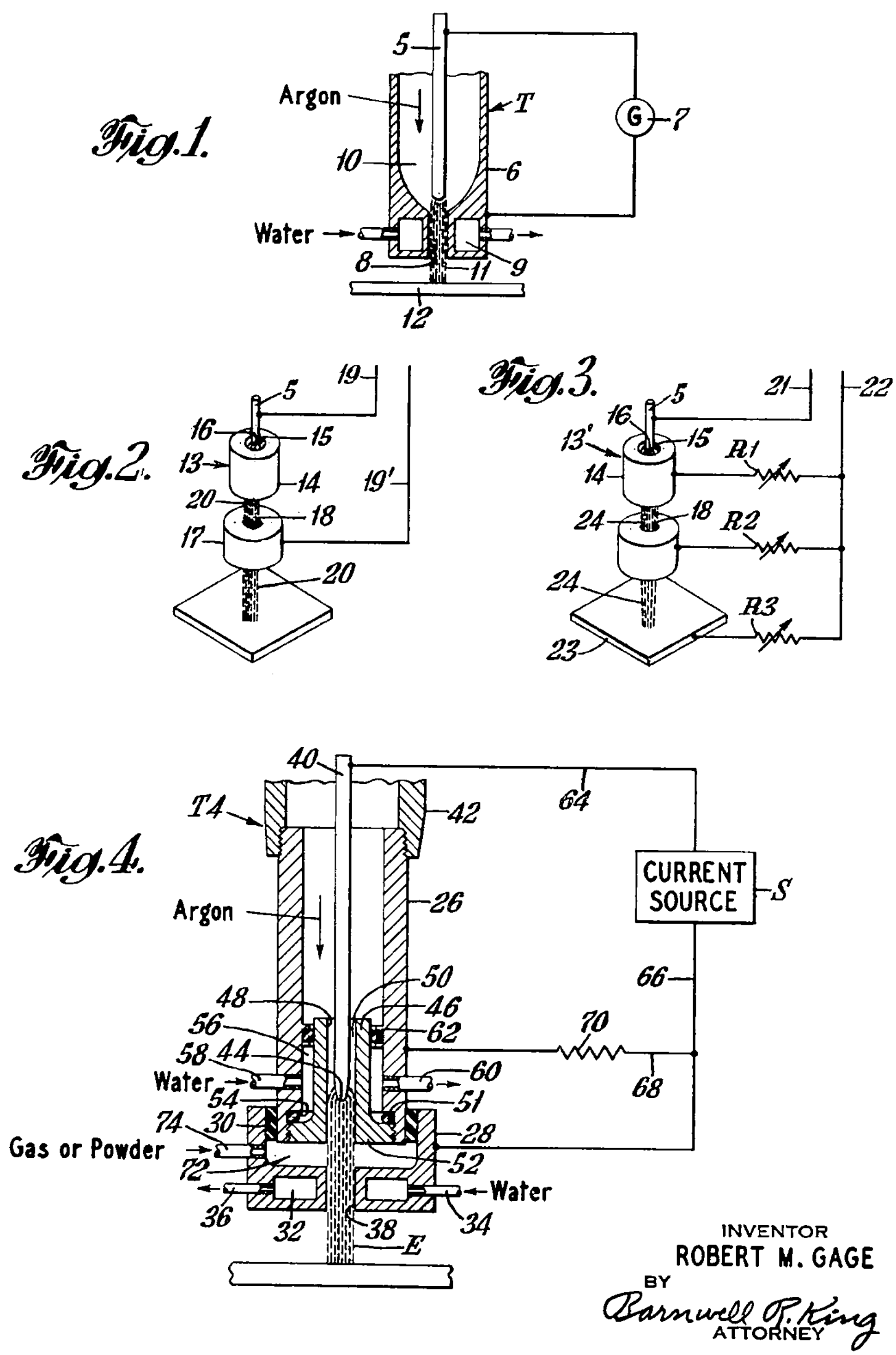

The electrode annulus is preferably made of high melting point material such as tungsten when it is to be the cathode, as in D. C.-R. P., and in the case of A. C.

The elementary modification 13 of the invention shown in Fig. 2 also is supplied with a suitable arc gas, such as argon, which preferably is caused to flow in an annular stream about a suitable electrode 5 and then through a suitable nozzle 14 provided with an internal arc wall stabilizing and constricting elongated passage 15. Typically, according to the invention, the electrode **5** is of the pencil, rod or stick type provided with an arc-locus tip 16 axially aligned with an adjacent to one end of the nozzle 14. The other electrode 17 is an annulus providing an orifice 18 located, coaxially with the nozzle 14, opposite the electrode 5. The electrodes 5 and 17 are connected to a suitable source of electric energy by conductors 19 and 19′. The arc is thus drawn into and through the nozzle 14 by the electric field existing between electrodes 5 and 17, and is thus not dependent on gas force. The resulting unique jet-like column 20 of hot ionized gas issues from the open end of the nozzle 14 and then from orifice 18 of the torch.

In the modification 13′ shown in Fig. 3, conductor 21 is connected to electrode 5; and conductor 22 is connected to the nozzle 14, annulus 18, and work-electrode 23 through adjustable impedances such as resistors R1, R2 and R3, respectively. In this case current from nozzle 14 to electrode 5 serves to energize a pilot arc, and suitable adjustment of the resistors causes all or part of the arc column 24 to extend to and through orifice 18, and/or to the work 23, thus providing a simple yet sensitive control of heat distribution. In each case the arc passages laterally wall-stabilize and constrict the arc column or effluent 24.

The nozzle and annulus may be made of any suitable material such as copper and/or tungsten aid cooled with water. However, they may be made of any other suitable heat-conducting solid material and may be cooled in any convenient way.

As. shown in Fig. 4, there is provided a torch T4 of the invention which comprises a cylindrical shell 26 on the lower end of which is mounted a cup 28. The cup is electrically insulated from the shell by an annulus 30 of suitable insulating material, and is provided with an inner annular passage 32 through which a cooling liquid, such as water, is circulated between a water inlet 34 and outlet 36. The interior of the cup 28 is shaped to form an orifice 38 having a cylindrical wall that is axially aligned with a pencil-shaped cathode 40 which is composed of refractory material that is conductive, such as thoriated-tungsten. The cathode 40 is held in place by suitable means within an annular body 42 of the torch to which the shell 26 is attached.

The business or arc-locus end 44 of the cathode 40 is axially located within a nozzle 46 having a central hole 48, the cylindrical wall of which surrounds the end portion of such cathode 40 in spaced concentric relation, providing an annular passage 50 therebetween for the flow of suitable gas, argon (an inert gas that protects at least the electrode 40 from chemical attack) in this case, supplied through the interior of shell 26. The nozzle 46 is provided with an annular flange 52 at the lower end thereof that is threaded in the inner lower end portion of the shell 26, the connection being sealed by a silicone rubber O-ring 51 disposed between the upper edge of such flange and a shoulder 54 in the shell. The body portion of the nozzle is spaced from the inner wall of the shell to form a cylindrical space 56 therebetween for the circulation of a cooling liquid, such as water, that enters such space through an inlet 58, and flows therefrom through an outlet 60 in the wall of the shell. The upper end of passage 56 is sealed by an O-ring 62 that is disposed between the nozzle and shell.

The cathode 40 is electrically connected to the negative terminal of a current source S by suitable circuit means including a conductor or lead 64. In the case of direct current the positive terminal of such source S is electrically connected by means including an electrical conductor 66 to the cup 28, and to the shell 26 by a parallel conductor 68 comprising a ballast resistor 70. The cup is shaped so as to provide an internal chamber 72 having a lateral inlet 74 for the introduction of material such as gas or powder or liquid or any combination thereof.

As an example of the operation of the torch T4, Fig. 4, with a one-eighth inch diameter cathode 40 of tungsten, 5-60 C. F. H. of argon, 10 amperes of current flowing in the pilot arc circuit containing resistor 70, and a 300-ampere current flowing in the main arc circuit at 40 volts, a very hot gas effluent E is produced, which is non-reactive. The luminous effluent is, in appearance, similar to an oxy-acetylene, flame but can have three to six times higher temperature and is easily controlled up to ten or more inches in length. The effluent E melts sapphire or zirconia, and is useful for heating, brazing, soldering, or as a source of light of high intensity.

The torch T4 also may be used for chemical reactions by introducing a second gas into the chamber 72. This torch is remarkable in that the arc can be adjusted by varying current, gas composition and flow, and orifices to give an effluent E that is hot enough to melt tungsten, or cool enough to barely char wood.

The gases which are suitable for use in this invention may be any which are metallurgically compatible with the torch components and with the desired work operation, such as argon and/or hydrogen, for example, as well as other gases including those that are disclosed in my said application, Serial No. 524,353, now Patent No. 2,806,124.

The term "high pressure" arc as used herein is discussed (pages 290 and 325) by Cobine in his book "Gaseous Conductors," published in 1941 by McGraw-Hill and is to be understood to relate to self-sustaining gas discharges in the general pressure range above 1/20 atmosphere and generally in the current range of a few to thousands of amperes.

In addition to the uses mentioned above, the effluent may be efficiently used to cut, pierce, sever, scarf, gouge and desurface a workpiece by simply applying such effluent to the workpiece and relatively moving one with respect to the other as may be necessary. In the case of scarfing a metal workpiece, for example, the effluent is applied at an acute angle to the surface to be removed, melting and blowing away the surface metal. In the case of cutting or severing the effluent is used to form a kerf in the workpiece by progressively melting and blowing away the molten metal along a selected path as in the oxyacetylene process.

In order to determine for a given gas and flow rate if the operation of an arc torch is within the scope of the present invention, one can measure the arc current through a given nozzle passage cross-section for that portion of the arc column passing through such cross-section, and then compare the arc voltage gradient at these conditions with that taught herein as distinguished from that obtained in a prior gas-shielded open arc of same current.

1. A high pressure arc torch comprising an electrode in the form of a pencil, an electrode in the form of a nozzle, an electrode in the form of an annulus defining an orifice axially aligned with said pencil and nozzle, and an elec-

trode comprising a workpiece, means insulating said electrodes from each other, and means connecting one terminal of a source of current to such pencil and the other terminal to such nozzle, annulus and workpiece through separate impedances that are adjustable for establishing an arc column that originates at the tip of said pencil, flows through said nozzle and said annulus, and is discharged in the form of a stable column against said workpiece.

2. A high pressure arc torch comprising the combination of an elongated cathode, a shell surrounding such cathode in spaced relation providing a gas passage, a metal nozzle mounted on the outlet end portion of said shell, said nozzle and shell having spaced annular walls forming an annular cooling liquid passage, a metal cup mounted on the outlet end of said shell, means electrically insulating said cup from said shell, said cup and said nozzle being shaped to provide a transverse chamber therebetween, said cup having an elongated orifice of constant diameter and said nozzle having an elongated hole of constant diameter in axial alignment with said cathode, and said cup having an annular cooling liquid passage surrounding said orifice.
3. In combination with an arc flame torch as defined by claim 2, means supplying gas under pressure to the interior of said shell above said nozzle, means circulating cooling water through said cooling liquid passages, means supplying a relatively low current at relatively low potential to said cathode and nozzle, and means supplying a relatively large direct current at higher potential to said cathode and cup.
4. A high pressure arc torch comprising spaced electrodes for establishing an arc therebetween, means including a non-consumable nozzle through which a gas flow is established and in which at least a portion of said arc is wall stabilized, providing an effluent from said torch in the form of a hot gas stream the thermal intensity of which is controlled by such wall stabilizing nozzle.
5. A high pressure arc torch comprising spaced electrodes for establishing an arc therebetween, one of said electrodes being non-consumable and having a passage through which a gas flow is established, the wall of said passage acting to stabilize at least a portion of said arc, providing an effluent from said torch in the form of a hot gas stream that is controlled and directed by said wall stabilizing passage.
6. A high pressure arc torch comprising spaced electrodes for establishing an arc therebetween, one of said electrodes having an externally cooled nozzle passage through which an axial flow of gas is established, the wall of said nozzle passage acting to stabilize at least a portion of said arc, providing an effluent from said torch in the form of a hot gas stream that is controlled and directed by said wall stabilizing passage.
7. A high pressure arc torch comprising, in combination, a non-consumable stick electrode, a non-consumable electrode having an externally cooled nozzle passage, said passage being axially aligned with said stick electrode, means for supplying a stream of arc-shielding gas for longitudinal flow about the end of said stick electrode and through said nozzle passage, and means for connecting a high pressure arc energizing source of current to said electrodes, whereby an arc is established within said nozzle passage and a portion of such arc is wall stabilized, providing an effluent from said torch in the form of a hot gas stream that is controlled and directed thereby.
8. A high pressure arc torch comprising, in combination, a stick electrode, a nozzle having an arc wall stabilizing passage, an electrode providing an orifice, a means for supplying a stream of arc-shielding gas through said passage and orifice, and means for establishing an arc between said electrodes, whereby a portion of said arc is wall stabilized, providing an effluent from said torch in the form of a hot gas stream that is controlled and directed by said wall stabilizing passage.
9. A high pressure arc torch comprising, in combination, a stick primary electrode, a secondary electrode having a nozzle passage, another primary electrode having a nozzle passage, means for supplying a stream of arc-shielding gas through said secondary electrode passage and said primary electrode passage, means for establishing a secondary arc between said primary stick electrode and secondary electrode, means for establishing a primary arc between said primary electrodes, whereby a portion of said primary arc is wall stabilized, providing an effluent from said torch in the form of a hot gas stream that is controlled and directed thereby.
10. A high pressure arc process comprising feeding inert gas within a closed chamber, discharging such inert gas from said chamber through a non-consumable orifice, establishing between non-consumable electrodes a high pressure arc adjacent such orifice, such inert gas flow forcing the arc into the orifice whereby a portion of such arc is wall stabilized, and discharging a jet-like effluent of hot gas the shape and cross section of which are controlled thereby, said inert gas acting to protect at least of such arc-carrying electrodes from chemical attack.
11. A high pressure arc process comprising feeding gas through a nozzle passage and an electrode having an orifice, establishing an arc between a stick electrode and said orifice electrode that is wall stabilized by said nozzle passage, projecting said wall stabilized arc into said orifice electrode, and discharging therefrom a jet-like effluent of hot gas the shape and cross section of which are controlled.
12. A high pressure arc process comprising feeding a gas axially along a stick electrode, passing such gas axially through a secondary electrode orifice and a primary electrode orifice, establishing a pilot arc between said stick electrode and said secondary electrode, establishing a main arc between said stick electrode and said primary electrode, a portion of said main arc being wall stabilized, and discharging a jet-like effluent of hot gas controlled and directed thereby.
13. A high pressure arc process as defined by claim 10, that includes the additional step of fluid cooling at least a portion of such orifice to assure such wall-stabilization.

14. A high pressure arc process as defined by claim 13, that includes the additional step of introducing material selected from the class consisting of gas and powder into the torch for discharge therefrom with the inert gas in such effluent.
15. A high pressure arc process as defined by claim 12, that includes the additional step of introducing material selected from the class consisting of fluid and powder into the torch between such primary and secondary electrode orifices for discharge in such effluent.
16. A high pressure arc torch as defined by claim 2, that also includes means for supplying material selected from the class consisting of gas and powder to said chamber.

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