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NOZZLE ASSEMBLY FOR ELECTRIC ARC SPRAY APPARATUS

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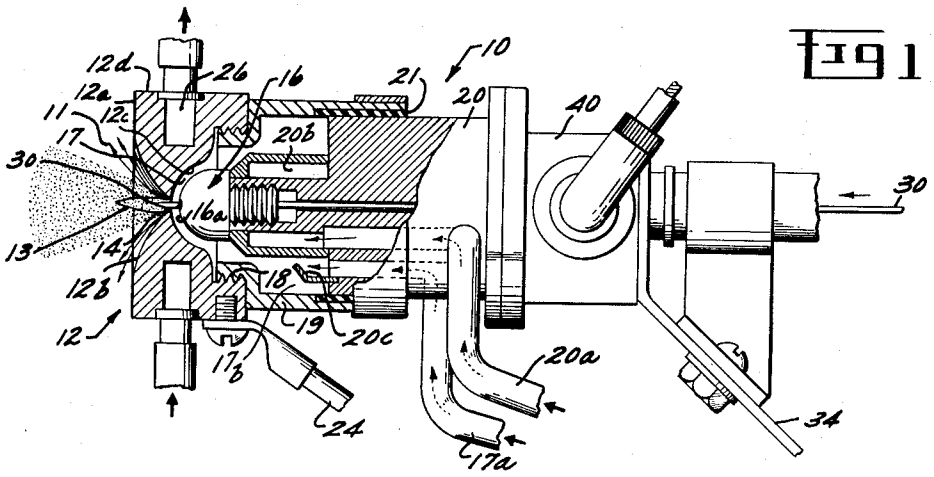


Fig 1

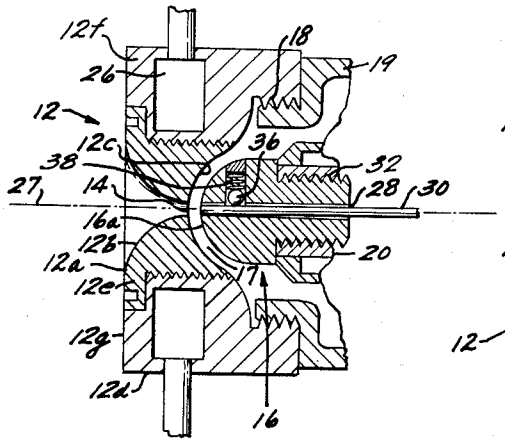


Fig 2

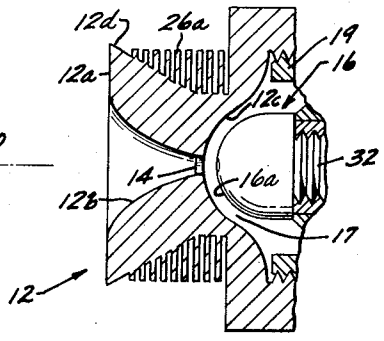


Fig 3

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NOZZLE ASSEMBLY FOR ELECTRIC ARC SPRAY APPARATUS

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This invention relates principally to a nozzle assembly for electric arc spray apparatus suitable for spraying a material, such as a metal, which is melted or vaporized in an electric arc.

The general method of operation of electric arc spray apparatus includes producing an electric arc between two electrodes and passing an elastic fluid such as air, gas or vapor through or around the arc to propel away from the arc and toward a workpiece material melted or vaporized in the arc. In some apparatus the electrodes are fed toward each other as both are consumed by the arc to supply melted or vaporized material. In other apparatus the electrode portions of the apparatus are not used as a source of melted or vaporized material but an additional material is introduced into the arc where it may act as an extension of one of the electrodes. The additional material is melted or vaporized and then becomes an effluent which is carried toward a workpiece by a fluid such as a gas. A major problem in electric arc apparatus prior to mine is that the control of the arc is not adequate to prevent the arc from partly consuming the electrode portions of the apparatus, from becoming extinguished, or from straying away from the vicinity of the material being melted or vaporized.

It is an object of this invention to provide a non-consumable electrode electric arc spray apparatus having a nozzle assembly in which the arc is held in an area which has been preselected for the melting, vaporizing, or ionizing of material to be directed toward a workpiece.

Another object is to provide a nozzle assembly which controls the flow of expanding fluid away from the orifice and which inhibits ambient atmosphere from being drawn toward the orifice to avoid erratic operation and premature cooling of the material being sprayed.

Briefly stated, in accordance with one aspect of my invention, I provide an electric arc spray apparatus and particularly a nozzle assembly comprising a nozzle block acting as a first electrode and having an orifice, an external fluid guiding surface, and an internal fluid guiding surface. The nozzle block electrode cooperates with a second guidehead electrode to form an arc, the electrodes being spaced one from the other to form between the internal fluid guiding surface and an outer fluid guiding surface of the second electrode, a fluid carrying passage the walls of which form a segment of generally concentric shapes. Fluid directed by a means such as a baffle plate which may be located in the body of the apparatus to produce uniform flow through the passage, sweeps the arc toward the orifice holding it there for the purpose of melting, vaporizing or ionizing material passing through the orifice.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. My invention, however, both as to organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to my description

taken in connection with the accompanying drawings in which:

Fig. 1 is a cross-sectional view of one form of our apparatus in position in a main spray body;

Figs. 2 and 3 are fragmentary cross-sectional views of other forms of my nozzle block electrode and guidehead electrode in relative position one to the other.

The nozzle assembly with which my invention is principally concerned includes two spaced apart sub-assemblies electrically insulated one from the other and both included in a single master assembly such as a spray gun body shown generally at **10**, Fig. 1. The first sub-assembly is a nozzle block electrode shown generally at **12**, Fig. 1, which gives direction to melted, vaporized or ionized material and its carrying fluid which combine to form an effluent sprayed from the apparatus. Such block includes an external effluent guiding surface having a surface **12***a* substantially normal to axis **27**, Fig. 2, forming a peripheral surface around an expansion surface **12***b* of the external effluent guiding surface. Surface **12***a* acts as a resistance to ambient atmosphere drawn along lateral surface **12***d* by the effluent from orifice **14** and thus controls and limits the flow of ambient atmosphere toward the nozzle orifice **14**. If surface **12***a* forms a substantial acute angle with the axis **27**, toward body **10**, ambient atmosphere flows more readily toward the orifice **14** to cool prematurely effluent and rapidly close the orifice. The nozzle block electrode **12** and a second sub-assembly, the guidehead electrode **16**, Fig. 1, cooperate to produce an arc therebetween to melt, vaporize or ionize the material to be sprayed and also to guide a fluid such as a gas to spray the material thus melted, vaporized or ionized. The second sub-assembly **16** may guide the material to be sprayed to the arc.

My nozzle assembly in a preferred form, Fig. 1, includes a nozzle block electrode **12** having nozzle orifice **14** interconnecting the expansion portion **12***b* of the external fluid guiding surface with internal fluid guiding surface **12***c*. The cross-sectional shape of surface **12***b* is preferably convex to conform with a natural expansion shape of the fluid, such as a gas, shown generally by arrows **11**, as it passes from the nozzle orifice.

I have found that the optimum radius of curvature of the convex surface **12***b* varies with the materials being sprayed, the radius generally increasing with the melting point of the material. For example, in one piece of my apparatus I have found the following radii best for the material sprayed: aluminum—about 3/16 inch radius, stainless steel—about 1/4 inch radius and tungsten about 5/8 inch radius. It is to be understood, however, that under some conditions the trace of a plane through surface **12***b* and orifice **14** may be concave or straight as well as the convex shape which I prefer.

The internal guide surface **12***c* is spaced apart from but generally follows the contour of surface **16***a* of guidehead **16**. Thus in the region near orifice **14** where such surfaces face each other they define a generally uniformly shaped space or passage **17** to accommodate the flow of a fluid such as air, gas or a vapor. As shown in the drawing such space **17** is annular. A fluid directing means such as baffle plate **20***c*, Fig. 1, assures uniform flow around guidehead **16** thus preventing a non-uniform, one sided flow of gas. In addition, the provision of surfaces **12***c* and **16***a* uniformly separated one from the other overcome the difficulty of an arc drawn between two surfaces of different electrical potential tending to seek a path which is the shortest distance between two such surfaces.

Nozzle block electrode **12** includes connecting means such as threads **18** to connect the block physically but not electrically to the main spray assembly, for example to adjustable barrel **19** which itself may be of a non-

conducting material or which is physically connected to and forms a part of the body of the assembly shown generally at 20, Fig. 1, through an electrical insulating member such as 21. Connected with the nozzle block electrode is electrical conducting means 24 such as an electrical conducting wire to allow an electrical potential to be impressed between the nozzle block electrode and the guidehead electrode. I prefer to connect the nozzle block 12 to a positive connection and guide head 16, Fig. 1 to a negative connection to achieve a straight polarity connection.

I have found that the surface 12*a* of the external fluid guiding surface of nozzle block 12 should lie in a plane substantially normal to the axis through the opening or orifice 14 of a shape formed by the diverging surface 12*b* and preferably nearly perpendicular to a line 27, Fig. 2, drawn through the center of nozzle orifice 14 and the center of axial opening or passage 28 in guidehead 16 as best shown in Fig. 2. In many arrangements prior to mine, nozzle blocks or heads are streamlined by cutting back the corner formed by surfaces 12*a* and 12*d* Fig. 1. This affords a streamlined path for ambient atmosphere drawn toward orifice 14 by the vacuum around the orifice produced from the effluent.

My arrangement tends to block or resist such a back flow of ambient atmosphere. Such a vacuum has been seen to draw ambient air toward the orifice along such streamlined surfaces at a rate sufficient to prematurely cool the material being sprayed thus resulting in an accumulation of solidified material around the orifice, eventually to close completely that opening. Thus the existence of external surface 12*a* substantially normal to the direction of flow of effluent to act as an ambient fluid controlling surface at the periphery of my fluid expansion surface is an important feature of my nozzle block electrode 12. The size of surface 12*a* depends on the size of the apparatus used and the quantity and rate of effluent.

Because fo the heat generated by the electric arc produced between the nozzle block and guidehead, I prefer to cool the nozzle block as by the inclusion of a cooling jacket or trough 26, Fig. 1, through which coolants such as water or air may be circulated. Other cooling means such as projections or fins 26*a*, Fig. 3 may be provided.

The nozzle block electrode may be constructed to include an insert 12*e*, Fig. 2, removably mounted in an insert holder 12*f* to facilitate change or replacement of that portion of the block including surfaces 12*b* and 12*c*. Thus the periphery portion of the surface 12*b* of the insert cooperates with front surface 12*g*, Fig. 2, of the insert holder to form a continuous peripheral surface substantially normal to axis 27.

My apparatus also includes a guidehead electrode 16 having outer fluid guiding surface 16*a* cooperating with internal surface 12*c* of the nozzle block to form the space 17 as described ebfore.

The guidehead electrode may include therethrough a guidehead passageway illustrated as axial opening or passage 28 best shown in Fig. 2 to allow to pass through and afford directional guidance to a power, tube, rod or wire of the material to be sprayed which is illustrated as wire 30. Connecting means such as threads 32 join the guidehead electrode to the main spray assembly such as body 20 thus electrically connecting the guidehead and electrical current carrying means 34, Fig. 1, to impress an electrical potential on guidehead electrode 16 different from that of nozzle block electrode 12. Thus at the start of operation, an electric arc may be drawn between the nozzle block and the guidehead. Nozzle block electrode 12 and guidehead electrode 16 are adjustably connected with the main spray body so that an optimum distance may be set between the two for the striking of an arc.

If material being sprayed is initially in the form of a conducting wire as it passes toward the arc, the guidehead electrode may include, Fig. 2, a biasing means to push such wire into contact with guidehead 16 to afford better heat and electrical conduction between the wire and the guidehead. For example, a ball bearing 36 and means such as spring 38, Fig. 2 may be used.

In Fig. 1, the type of feed mechanism for wire type material shown by gear box 40 is a standard commercially available item and is therefore not shown in detail.

In the operation of my apparatus when assembled in a master assembly such as a spray gun, an electric arc is initially drawn between surface 16*a* of guidehead electrode 16 and surface 12*c* of nozzle block electrode 12. I prefer to start the flow of fluid such as air or an inert gas through a fluid receiving tube 17*a*, into fluid receiving passage 17*b* of the body and then against fluid distributing means such as baffle plate 20*c* and hence uniformly into passage 17 to act as an ionizing as well as cooling medium from the time of the initial arcing between the electrode surfaces 12*c* and 16*a*.

The flow of fluid may be adjusted either before or after striking the arc to a quantity and velocity sufficient to sweep the arc toward and maintain it at orifice or nozzle 14 but not of sufficient strength to extinguish the arc. Although I prefer to maintain fluid pressure between 45 and 100 pounds per square inch, the relative size of the parts of my apparatus will determine the quantity of fluid required. The fluid pressure required to produce a force sufficient to atomize the material and carry it to the workpiece varies directly with the density of the material being sprayed.

Once the arc has been struck and the fluid is flowing around the guidehead, the material to be sprayed, such as in the form of a conducting wire, is fed through axial passage 28 of the guidehead and into the arc. When wire is used, the wire itself then acts as one electrode with nozzle block 12 as the other, thus replacing guidehead 12 as one electrode. Fluid passing through nozzle orifice 14 is ionized forming ionized zone 13, Fig. 1. If, in my apparatus, the wire feed is stopped, the arc will again be maintained at the nozzle orifice between surfaces 12*c* and 16*a*. Once the wire begins to act as one of the electrodes, the magnetic field around the wire, created by the flow of current through the wire, tends to rotate the arc around the nozzle orifice 14 thus to produce uniform melting or vaporization of material.

Because of my arrangement of internal passage 17, the fluid flow maintains the arc in the vicinity of orifice 14 thereby preventing stray of the arc away from the material to be melted, vaporized or ionized; that is, since the distance between the surfaces 12*c* and 16*a* in the vicinity of the orifice are substantially uniform, the arc does not have a tendency to seek a shorter path at a point away from the orifice. Such arc straying results, in other apparatus, in the intermittent, irregular flow of melted or vaporized material and hence an erratic, non-uniform distribution of particles in effluent from the gun. My control of the arc's location through flow of fluid around guidehead 16 aided by baffle 20*c*, coupled with prevention of premature cooling through peripheral surface 12*a* of the nozzle block electrode, results in uniform reproducible outward flow of material. As material such as wire 30 is melted, vaporized or ionized, it is carried through and away from orifice 14 by the fluid.

As has been indicated above, coolant may be circulated through the nozzle block electrode and through the main body of the gun such as through tube 20*a* into a chamber such as 20*b*, Fig. 1, to dissipate heat created by the electric arc.

When an inert gas such as argon is used as the fluid, my apparatus produces a tool capable of melting and spraying metal in an inert atmosphere thus avoiding oxidation of the sprayed particles and resulting in stronger and more ductile sprayed deposits. My apparatus has the ability to deposit oxide free metal, to spray metal which cannot be melted with combustion type metallizing

apparatus, and to spray metals which are rapidly attacked by air at elevated temperatures.

With above understanding of the operations by means of which the present invention may be practiced, those skilled in the art will understand how to adapt existing apparatus and/or to build other machines to carry out the method aspects of the present invention.

What I claim is:

1. For use with electric arc spray apparatus, a nozzle assembly comprising a nozzle block electrode and a guidehead electrode, said nozzle block electrode including an internal fluid guiding surface and an external effluent guiding surface joining said internal surface at an opening in said nozzle block electrode, said external effluent guiding surface diverging from the opening and forming at its portion remote from the opening a peripheral surface normal to the axis through the opening of a shape formed by said diverging surface, said guidehead electrode being spaced apart from said internal fluid guiding surface of said nozzle block electrode and having an outer fluid guiding surface facing said internal fluid guiding surface of said nozzle block electrode therebetween to form uniformly spaced apart walls of a passage in the vicinity of the opening.

2. The nozzle assembly of claim 1 in which said guidehead electrode includes therethrough a guidehead passageway through which material is guided toward the opening in said nozzle block electrode and one end of which faces the opening.

3. The nozzle assembly of claim 2 in which said guidehead electrode includes a biasing means acting toward said guidehead passageway whereby material passing through said passageway toward the opening is biased against said guidehead electrode.

4. For use with electric arc spray apparatus, a nozzle assembly comprising a nozzle block electrode and a guidehead electrode, said nozzle block electrode including an insert removably mounted in an insert holder, said insert including an internal fluid guiding surface and an external effluent guiding surface joining said internal surface at an opening, said external effluent guiding surface diverging from the opening and forming at its portion remote from the opening in cooperation with a front surface of said insert holder a peripheral surface normal to the axis through the opening of a shape formed by said diverging surface, said guidehead electrode being spaced apart from said internal fluid guiding surface of said insert and having an outer fluid guiding surface facing said internal fluid guiding surface of said insert therebetween to form uniformly spaced apart walls of a passage in the vicinity of the opening.

5. For use with electric arc spray apparatus, a nozzle assembly comprising a nozzle block electrode including a concave internal gas guiding surface and an external effluent guiding surface joining said internal surface at an orifice, said external effluent guiding surface diverging along a convex curve from the orifice and forming at its portion remote from the orifice a flat peripheral surface normal to the axis through the orifice of a shape formed by said diverging surface, and a guidehead electrode spaced apart from said internal gas guiding surface of said nozzle block electrode and having a convex outer gas guiding surface facing said concave internal gas guiding surface of said nozzle block electrode to form therebetween a uniform annular passage in the vicinity of the orifice.

6. Electric arc spray apparatus including a body assembly having fluid receiving means, a nozzle assembly and connecting means joining said nozzle assembly to said body assembly, said nozzle assembly comprising a nozzle block electrode joined with said body assembly through said connecting means and including an internal fluid guiding surface and an external effluent guiding surface joining said internal surface at an opening, said external effluent guiding surface diverging from the opening and forming at its portion remote from the opening a peripheral surface normal to the axis through the opening of the shape formed by said diverging surface, and a guidehead electrode having an outer fluid guiding surface and joined with said body assembly through said connecting means in spaced relationship with said nozzle block assembly, said internal fluid guiding surface of said nozzle block electrode and said outer fluid guiding surface of said guidehead electrode facing one to the other therebetween to form uniformly spaced apart walls of a passage in the vicinity of the opening.

7. Electric arc spray apparatus including a body assembly having gas receiving means, a nozzle assembly and connecting means joining said nozzle assembly to said body assembly, said nozzle assembly comprising an external nozzle block electrode joined with said body assembly through said connecting means and including a concave internal gas guiding surface and an external effluent guiding surface diverging along a convex curve from an orifice and forming at its portion remote from the orifice a flat peripheral surface normal to the axis through the orifice of a shape formed by said diverging surface, and an internal guidehead electrode having a convex outer gas guiding surface and joined with said body assembly through said connecting means in spaced relationship with said nozzle block assembly, said internal gas guiding surface of said nozzle block electrode and said outer gas guiding surface of said guidehead electrode facing one to the other to form therebetween a uniform annular passage in the vicinity of the orifice.

8. The apparatus of claim 7 in which said body assembly includes a gas distributing means disposed in a gas receiving cavity connected with said gas passage whereby gas entering said apparatus is distributed uniformly through said gas passage.

9. For use with an electric arc spray apparatus including first and second electrodes, a nozzle block electrode comprising a continuous external effluent guiding surface and an internal fluid guiding surface, said external surface having a peripheral portion and a central diverging portion including an opening through which effluent may pass, said internal fluid guiding surface forming a passage with said fluid guiding surface of sad second electrode, whereby the intersection of a plane with the walls of said passage forms a trace of concentric shapes in the vicinity of the opening.

10. An electric arc spray apparatus nozzle assembly comprising: an inner electrode and an outer electrode assembled with but electrically insulated from said inner electrode, said outer electrode including an internal fluid guiding surface and an external effluent guiding surface joined with said internal fluid guiding surface at an opening in said outer electrode, said external effluent guiding surface diverging from said opening to guide expansion of effluent from the opening, said internal and said outer fluid guiding surfaces facing one to the other in spaced relationship therebetween to form uniformly spaced apart walls of a fluid carrying passage in the vicinity of the opening, said walls in the vicinity of the opening definng the shortest distance between the electrodes to confine arcing between electrodes to the vicinity of the opening.

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