

March 18, 1969

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3,433,991

PLASMA ARC DEVICE WITH CATHODE STRUCTURE  
COMPRISING PLURALITY OF RODS

Filed Sept. 19, 1966

Sheet / of 5

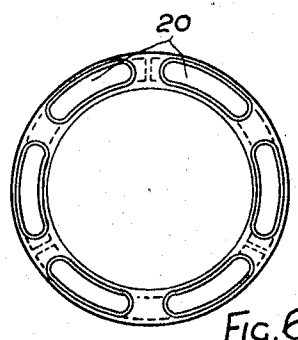
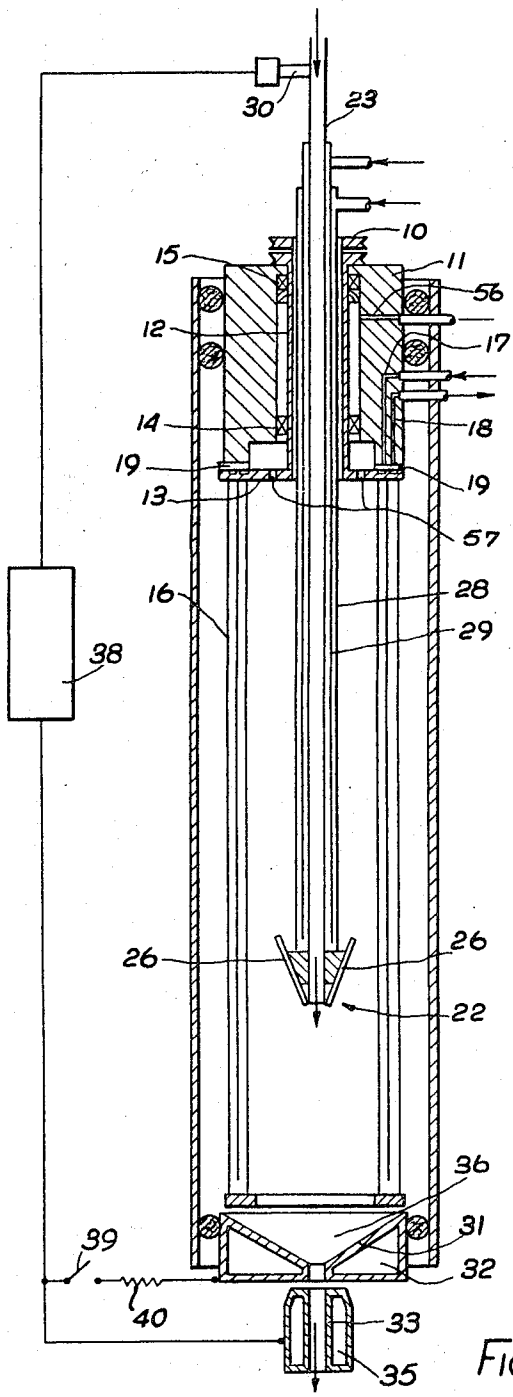


Fig. 6a.

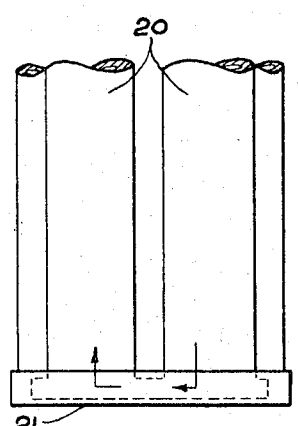


Fig. 6b.

FIG. 1.

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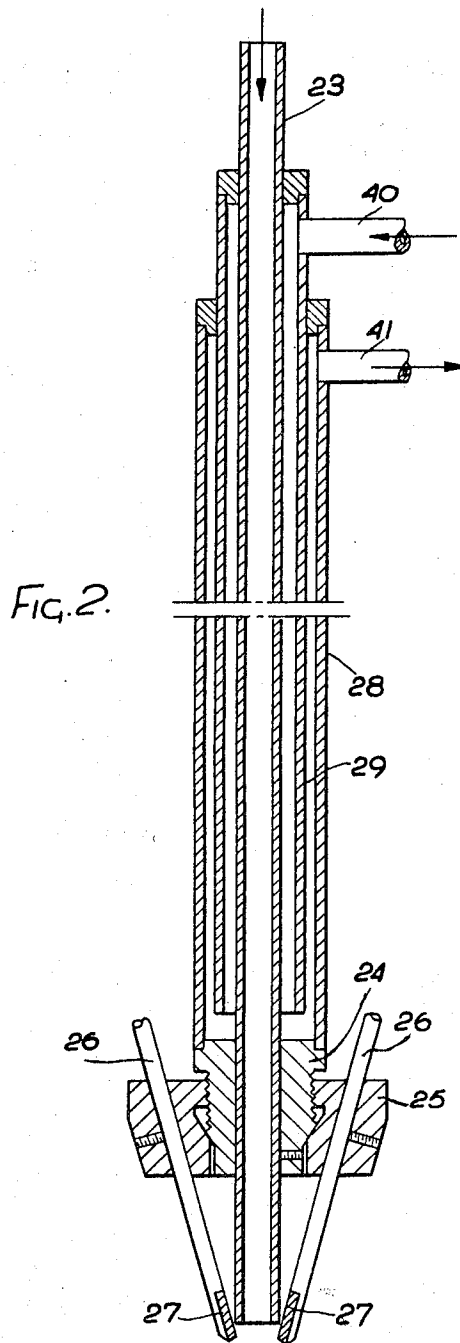
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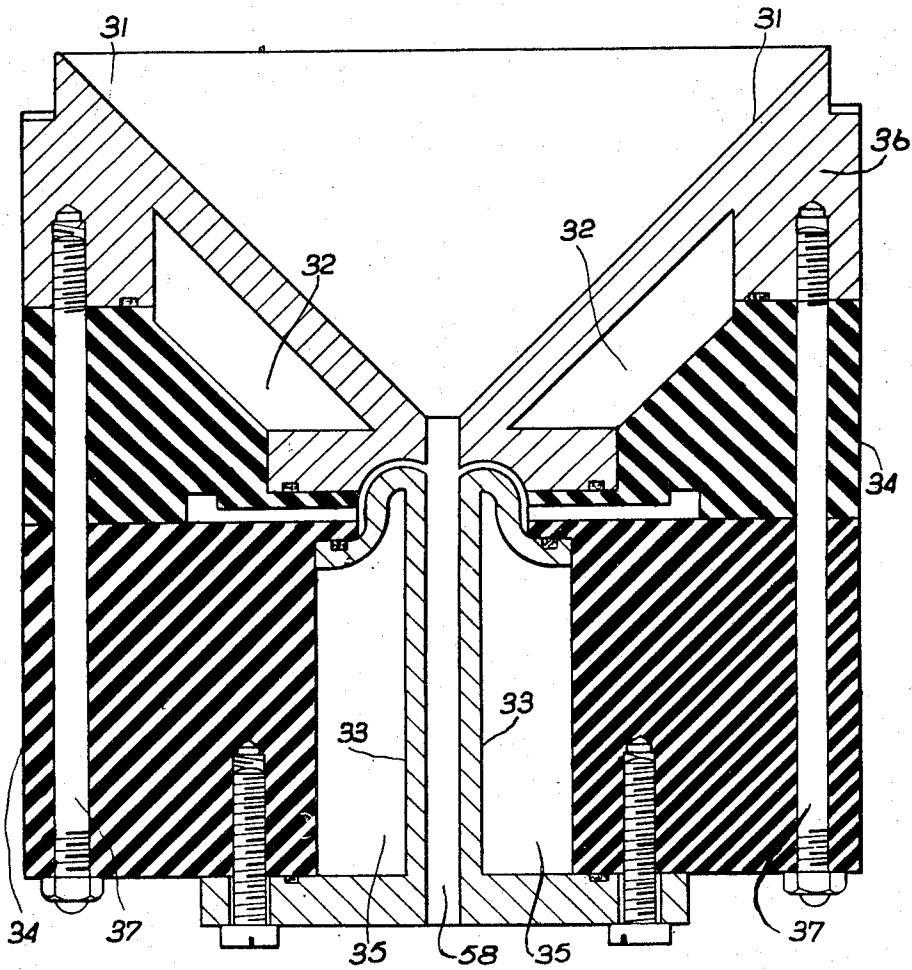


FIG. 3.

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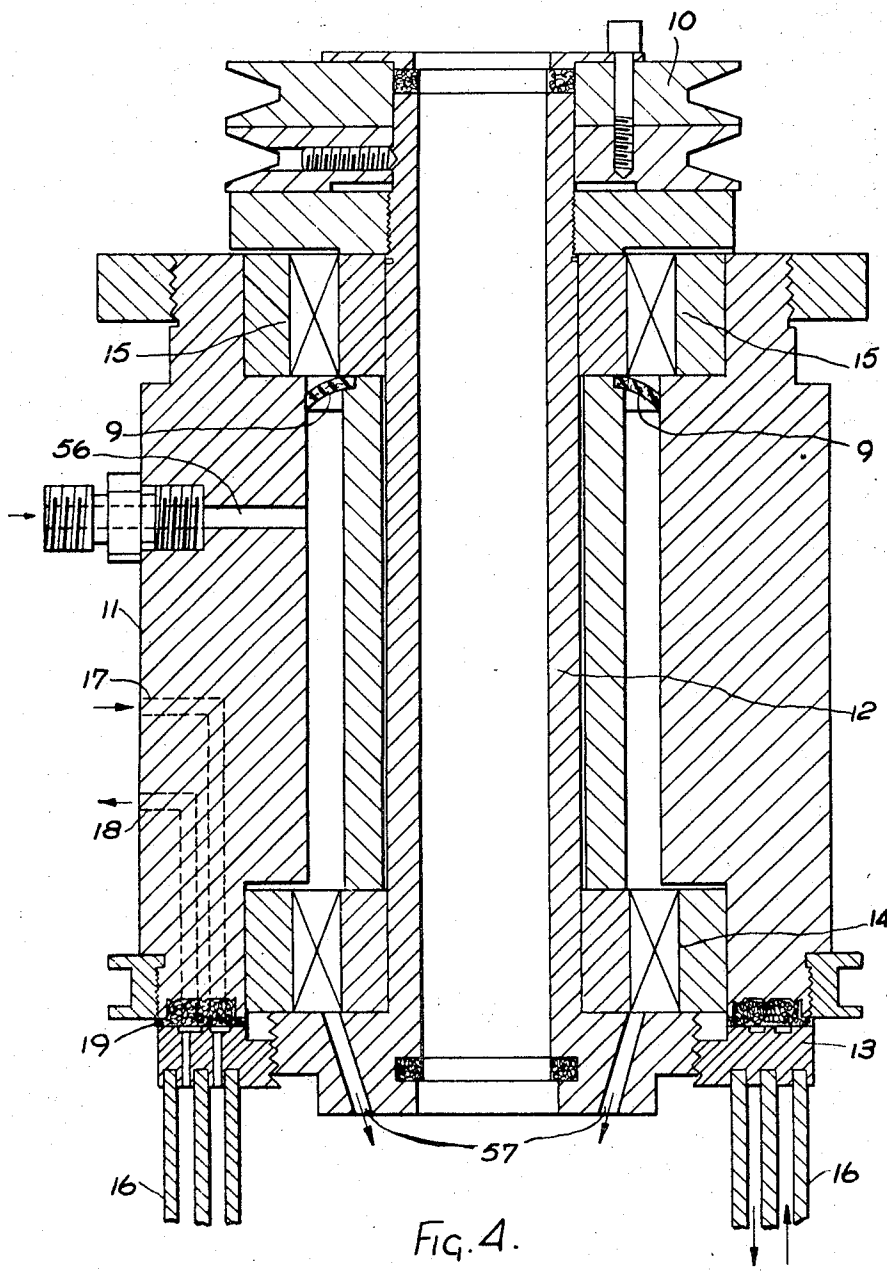
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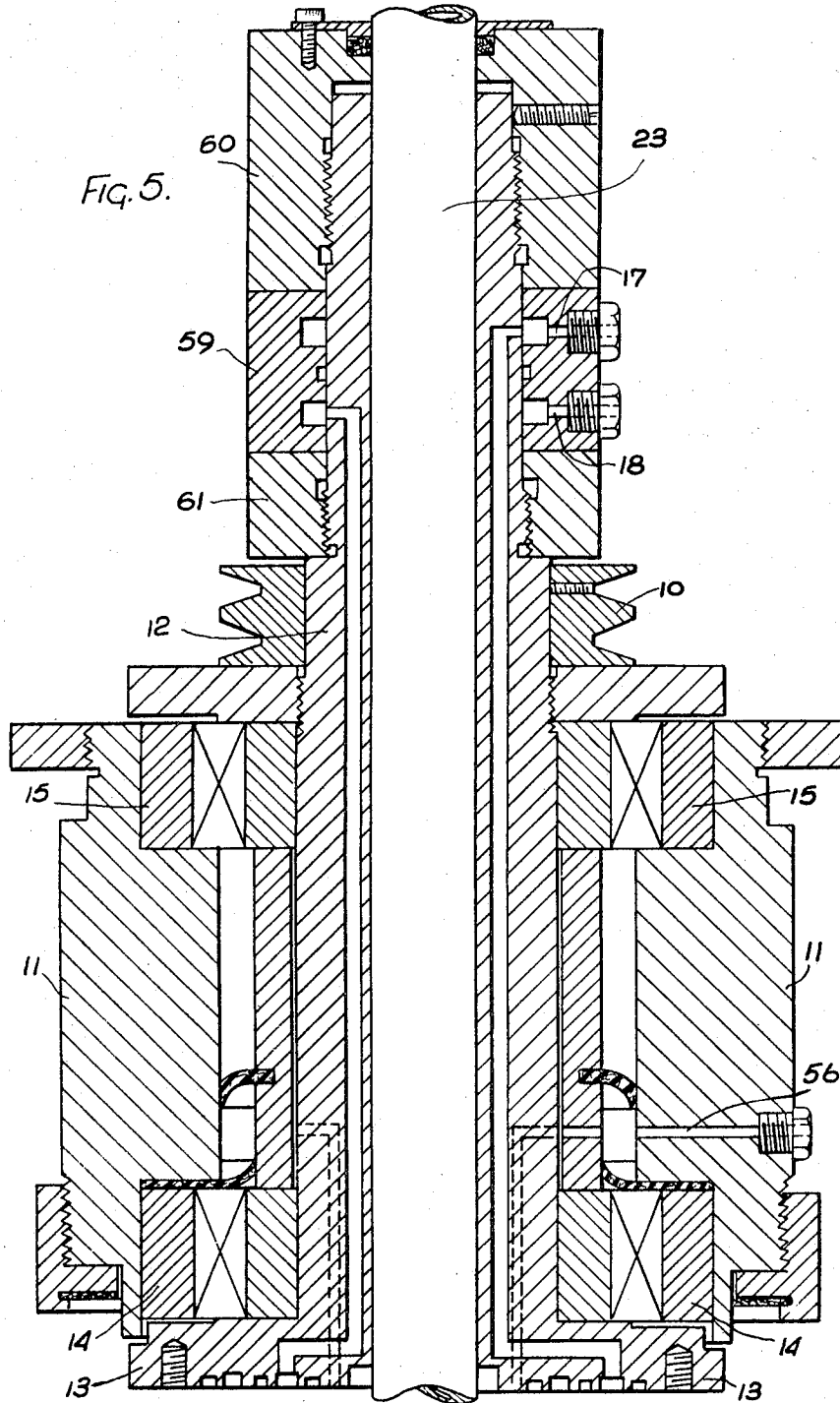
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## PLASMA ARC DEVICE WITH CATHODE STRUCTURE COMPRISING PLURALITY OF RODS

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7 Claims

### ABSTRACT OF THE DISCLOSURE

A plasma arc device of improved construction which enables greater efficiency of operation and reduced contamination of the materials treated by the device wherein the assembly includes a plurality of thoriated rods defining between them a frustoconical space and touching each other around a circular exit aperture from said assembly.

The present invention relates to plasma arc devices and in particular to improved constructions of such devices enabling greater efficiency of operation and/or reduced contamination of materials treated by such devices.

According to the invention there is provided a plasma arc device of which the cathode assembly is constituted in part by a plurality of thoriated rods defining between them a frustoconical space and touching each other around a circular exit aperture from said assembly.

The various features and advantages of the invention will be apparent from the following description of an exemplary embodiment thereof taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a section through a plasma arc device embodying the invention,

FIGURE 2 is a sectional view, to a larger scale, of part of the cathode assembly of the device of FIGURE 1,

FIGURE 3 is a sectional view, to a larger scale, of the anode assembly of the device of FIGURE 1,

FIGURE 4 is a sectional view, to a large scale, of one form of bearing assembly used in the device of FIGURE 1,

FIGURE 5 is a view similar to FIGURE 4 of another form of bearing assembly, and

FIGURES 6a and 6b are respectively horizontal and part vertical sections of a modified form of the arc enclosure of the device of FIGURE 1.

Referring to FIGURE 1, the device comprises a head block 11 which houses a hollow shaft 12 having a flange 13 at its lower end and a drive pulley 10 at its upper end. Shaft 12 is rotatably arranged in block 11 by means of a bearing assembly including lower and upper bearings 14 and 15. A cylindrical arc enclosure 16 formed of concentric copper cylinders is carried by flange 13 for rotation therewith. The space between the concentric cylinders of enclosure 16 is connected to a source of coolant (not shown) through pipes 17 and 18 and a grooved sealing ring 19 to permit the circulation of coolant through such space during operation of the device.

Extending through the interior of shaft 12 is a cathode assembly indicated generally by the reference 22 and shown in detail in FIGURE 2. Such cathode assembly comprises a block 24 through which extends a tube 23 for the introduction of material to be treated into the plasma arc, which tube, over the major part of its length, is surrounded by two further tubes 28, 29 constituting a cooling jacket and connected to a source of coolant (not shown) through conduits 40 and 41.

The outer surface of block 24 is screw-threaded and an internally screw threaded carrier ring 25 is screwed

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on to block 24. Ring 25 carries a number of thoriated tungsten rods 26 containing 2% thoria and constituting the cathode emitting elements, so spaced and angled that they define between them a frustoconical space and touch each other all the way round the lower, exit, end of tube 23 but out of contact with such end.

Over the shaded areas 27 (FIGURE 2) the rods 26 are treated to concentrate emission into these areas. The areas 27 are first coated with aluminum and are then treated to drive off the aluminum coating. This results in a local reduction and preferential migration of thorium to the areas 27.

The cathode assembly 22 is longitudinally adjustable in the enclosure 16 and electrical connection to the emitting elements 26 is effected by means of one or more carbon brushes 30 in sliding contact with the tube 28.

The bottom of enclosure 16 is constituted by a hollow anode assembly constituted by a starting anode 31 and a running anode 33 which assembly takes the form shown in FIGURE 3. The starting anode 31 comprises a hollow cone of copper formed in a block 36 formed with a passageway 32 for the circulation of a coolant through the block and with internally threaded bores to receive and engage the threaded ends of two bolts 37.

Bolts 37 pass through registering bores in two insulating blocks 34 which serve to hold the starting and running anodes in the desired relative positions within the anode assembly. The upper block 34 provides one surface of the passageway 32 and the lower block 34 provides one surface of a similar coolant circulating passageway 35 formed in the running anode 33. The latter is of tubular form and is bolted to the lower block 34 with its bore in register with an aperture in the centre of the conical starting anode 31 to form an outlet passage 58 for treated material from the enclosure 16. The junctions between faces of the starting anode 31 and the upper insulating block 34 and between the faces of the running anode 33 and the lower insulating block 34 are sealed by O-rings.

Gas introduced into enclosure 16, to mix with the material to be treated, either through the upper, inlet, end of tube 23, or through a tube connected to a duct 56 formed in block 11 and communicating with the interior of enclosure 16 through ports 57 in flange 13, also leaves enclosure 16 through the outlet passage 58 in the anode assembly. It serves to prevent plasma making electrical connection between anodes 36 and 33.

The bearing assembly constituted by block 11 and bearings 14 and 15 is shown to a larger scale in FIGURE 4 which also shows the arrangement of a gas seal 9 beneath the upper bearing 15 which prevents gas introduced through conduit 56 escaping through bearing 15. A modified form of this bearing assembly is shown in FIGURE 5 wherein the inlet and outlet pipes 17 and 18 instead of being formed in the block 11 are formed in a stationary block 59 between two rotating blocks 60 and 61 which are secured to an upward extension of the shaft 12. These pipes 17 and 18 extend through the wall of shaft 12, one on each side of tube 23 and connect with passages through the flange 13. This prevents coolant entering the enclosure 16.

Instead of the enclosure 16 being formed simply of three concentric cylinders to provide a cooling jacket as in FIGURE 1, it may be formed as a segmented cylinder as shown in FIGURES 6a and 6b. In this form of construction the space between the inner and outer walls of the cylinder constituting enclosure 16 is divided into six spaced hollow segments 20 interconnected for the circulation of coolant through them by hollow annular flanges such as 21. The coolant passes down one segment and up the next and so on. The space between the segments permit the interior of enclosure 16 to be viewed strobo-

scopically as the enclosure is rotated. Speeds of rotation of 350-500 revolutions per minute have been found satisfactory.

With the device above described connected to a power source 38, switch 39 and resistor 40 arranged as indicated schematically in FIGURE 1, the closing of switch 39 and longitudinal adjustment of cathode assembly 22 relative to the starting anode 31 causes the plasma arc to be struck and the rotation of enclosure 16 causes the gases inside such enclosure to rotate and expand the arc so that it occupies substantially the whole of the region between the anode and cathode and improves the efficiency of the device. The resistor 40 promotes the transfer of the arc from the starting anode 31 to the running anode 33 and once such transfer has taken place switch 39 can be opened to take the starting anode out of circuit.

Material introduced at the upper, inlet, end of tube 23 is treated by the plasma arc as it falls between the cathode 22 and the anode assembly. As the treated material falls out of the main arc region it first encounters the cooled surfaces of the starting anode and its temperature is reduced. The treated product is collected by such cooled surfaces 60 so that, in the main, it does not reach the running anode 33. The high velocity flow of gas through the chamber minimizes vaporization of anode material and tends to sweep away any ablated material thereby reducing or preventing the risk of contamination of the treated product by anode material.

I claim:

1. A plasma arc device comprising an open-ended container, a cathode assembly having a passageway there-through, a mounting for said cathode assembly arranged to close one end of said container, tubular support means supporting said cathode assembly in said mounting and registering with said passageway to form an entrance conduit into said container for material to be treated, and an anode assembly having a passageway therethrough arranged in spaced relation to said cathode assembly to close the opposite end of said container while permitting outflow of material treated in said device through the passageway in said anode assembly, said cathode assembly including a plurality of thoriated rods disposed to define a frustoconical space between them and to touch each other at their ends closest to said anode assembly, and said rods being preferentially emissive in the region of their touching ends.

2. A plasma arc device according to claim 1 wherein said anode assembly comprises a starting anode and a main anode said starting anode having a conical cavity therein confronting said opposite end of said container and an aperture therethrough in the centre of said cavity, said main anode having an aperture therethrough in reg-

ister with the aperture through said starting anode, the two registering apertures defining between them said passageway through said anode assembly.

3. A plasma arc device according to claim 1 wherein said mounting has a central aperture and said tubular support means of said cathode assembly is slidably arranged in said central aperture in said mounting to provide for adjustment of the position of said cathode assembly relative to said anode assembly to facilitate the striking of an arc therebetween.

4. A plasma arc device according to claim 1 wherein said mounting comprises relatively rotatable coaxial inner and outer parts, said device including an enclosure formed by at least one cylinder located within said container, said inner part being arranged to mount said tubular support means of said cathode assembly and said outer part being arranged to mount said enclosure, said mounting having secured to the outer part thereof means for rotating such outer part and said enclosure about the common axis of said inner and outer parts.

5. A plasma arc device according to claim 1 wherein said mounting comprises a mounting block having formed therein a passageway communicating at one end with the interior of said enclosure and terminating at its other end in a port for the admission of gas into said enclosure to mix with material introduced into said enclosure through said cathode assembly.

6. A plasma arc device according to claim 3 wherein said tubular support means comprises a double walled tube arrangement having at least one intermediate wall disposed in the space between the double walls and serving to define within said space a passageway for the circulation of coolant through said space.

7. A plasma arc device according to claim 4 wherein said enclosure comprises a double-walled tube arrangement having at least one intermediate wall disposed in the space between the double walls and serving to define within said space a passageway for the circulation of coolant through said space.

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219—121; 313—149, 32