March 18, 1969 D. WHYMAN 3,433,991

PLASMA ARC DEVICE WITH CATHODE STRUCTURE COMPRISING PLURALITY OF RODS

Filed Sept. 19, 1966 Sheet 1 of 5

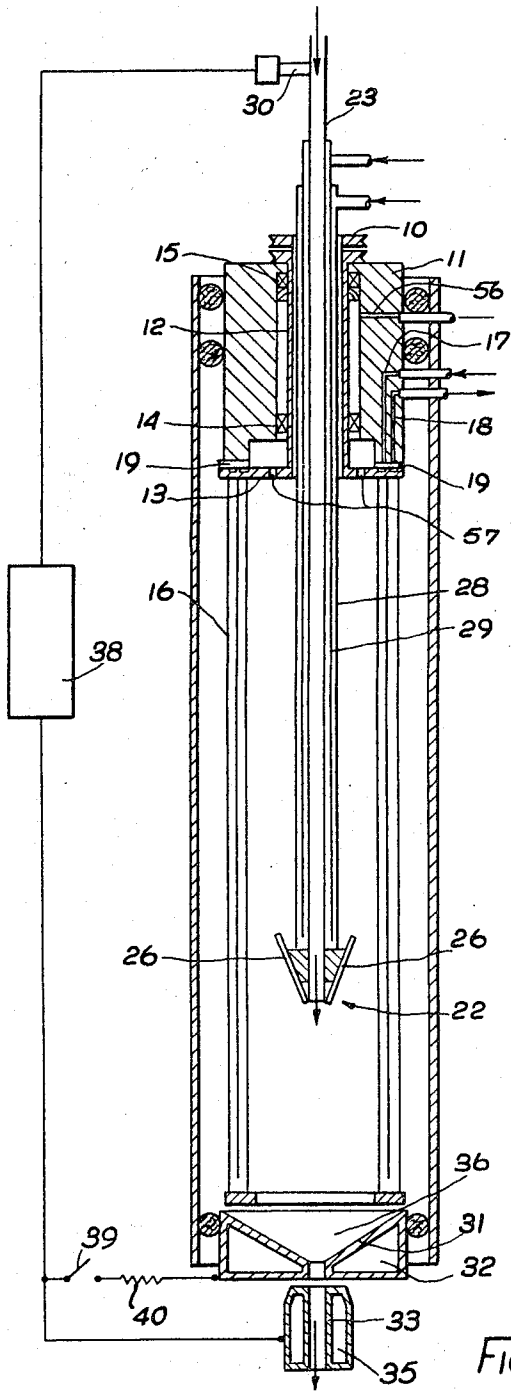


FIG. 1.

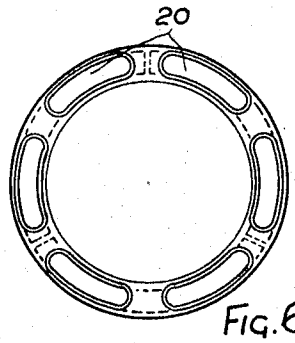


FIG. 6a.

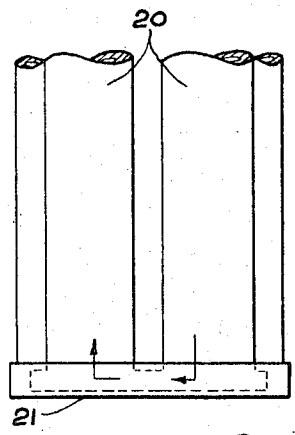


FIG. 6b.

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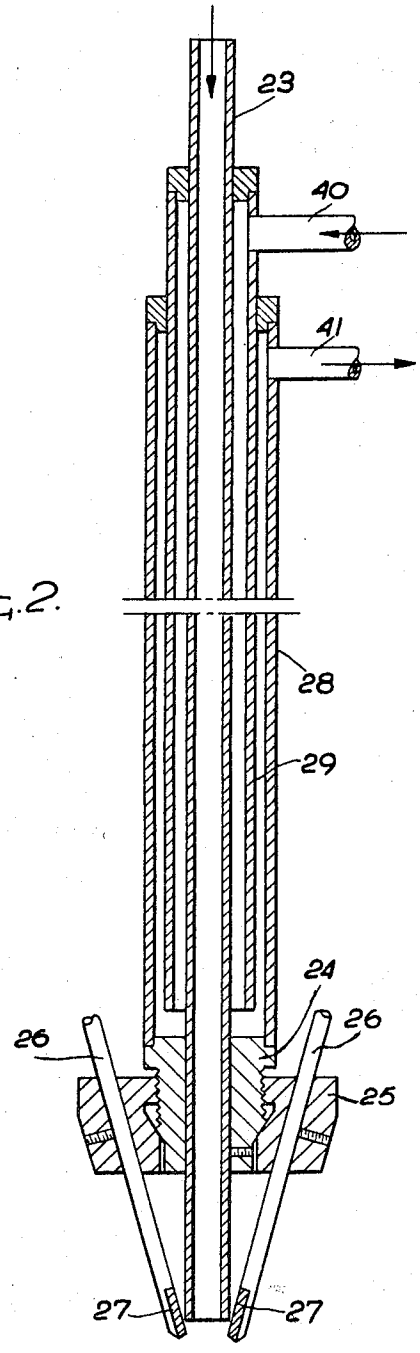
FIG. 2.

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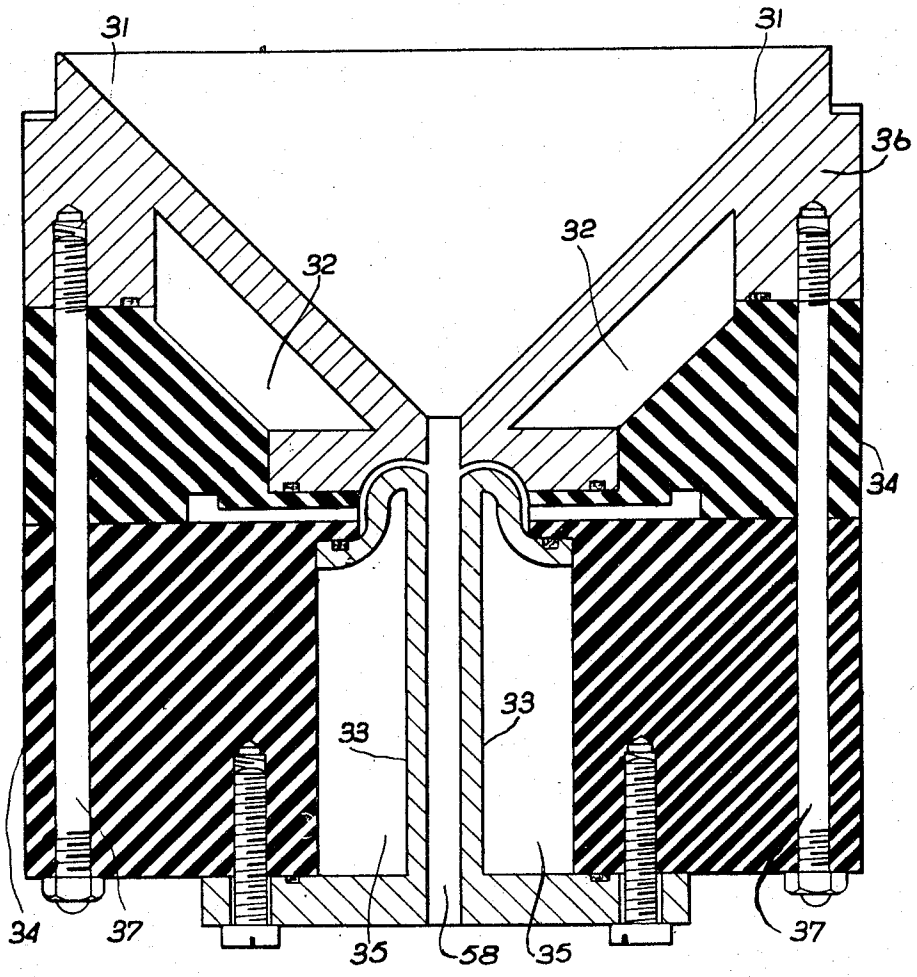


FIG. 3.

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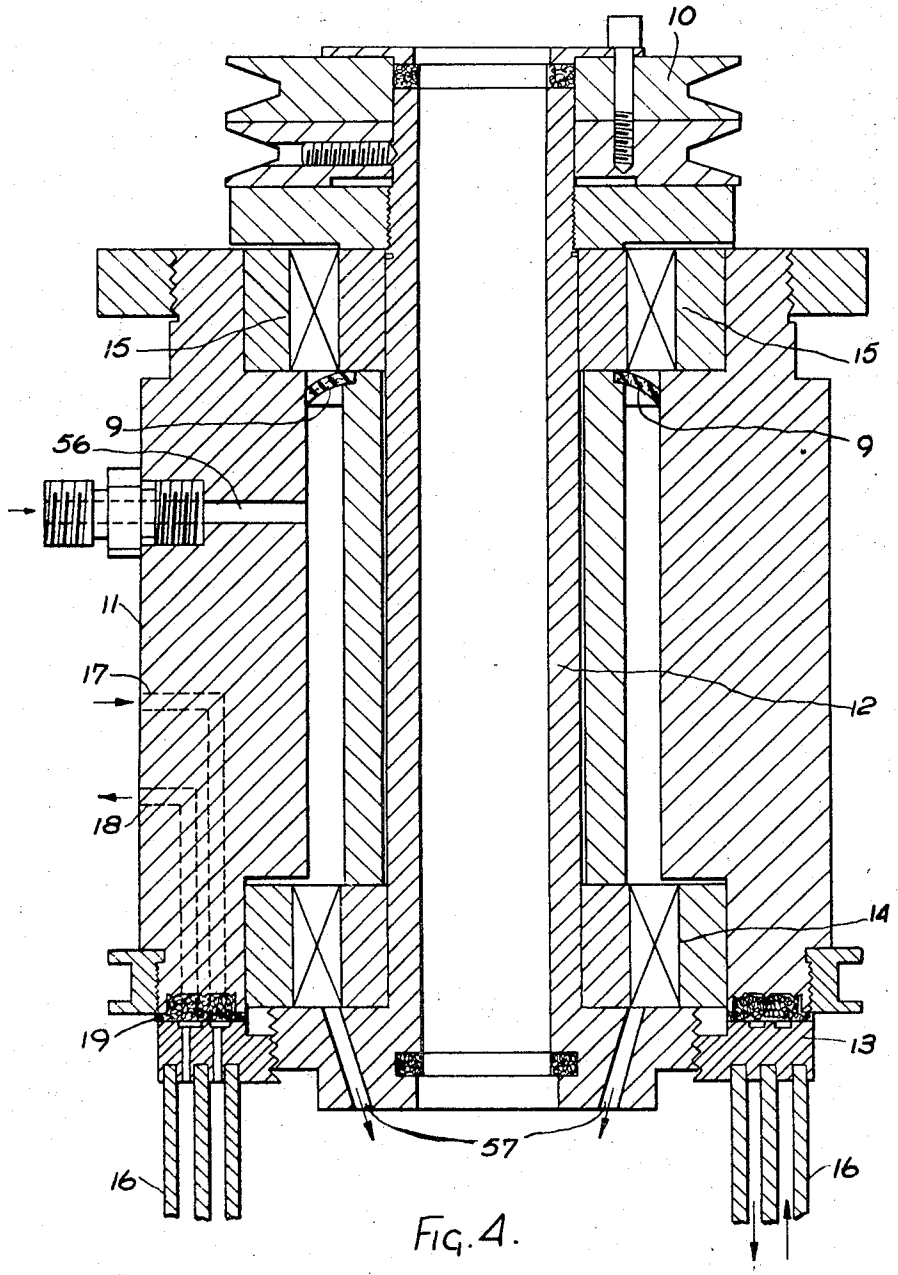


FIG. 4.

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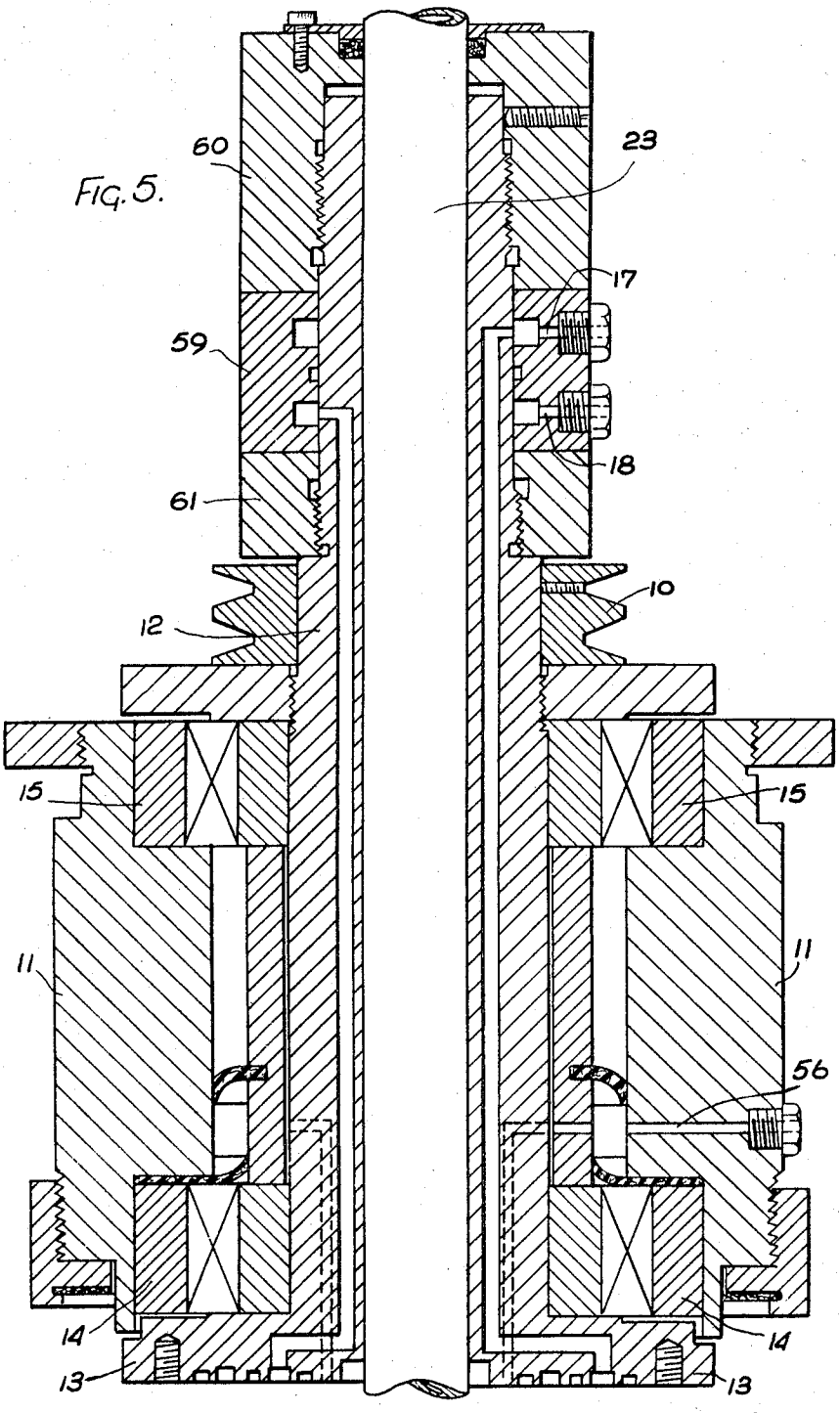
FIG. 5.

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3,433,991

# PLASMA ARC DEVICE WITH CATHODE STRUCTURE COMPRISING PLURALITY OF RODS

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U.S. Cl. 313—231 7 Claims
Int. Cl. H01j 17/26, 61/28; B23k 9/00

## 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 6*a* and 6*b* 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 conrected 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



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 6*a* and 6*b*. 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.

Wtih 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 therethrough, 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 register 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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