

Aug. 11, 1970

A. DUBOIS ET AL

3,524,087

NOZZLE WALL CONSTRUCTION FOR THERMOELECTRIC MACHINE

Filed Oct. 24, 1967

4 Sheets-Sheet 1

FIG. 1

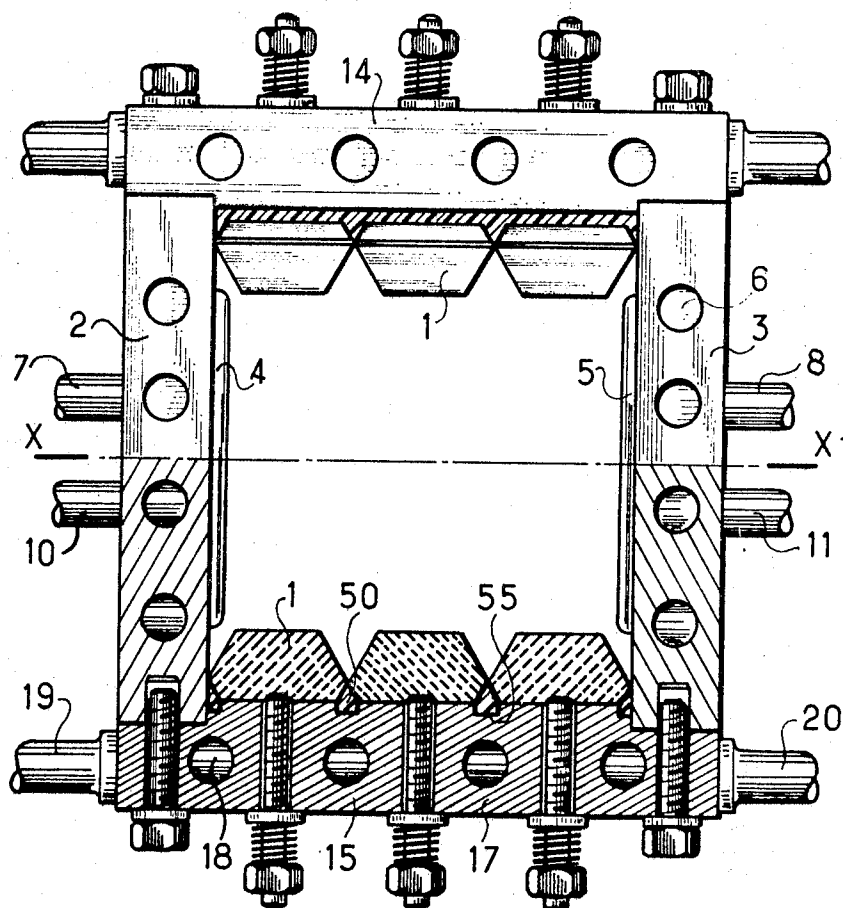


FIG. 2

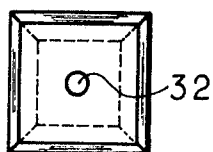
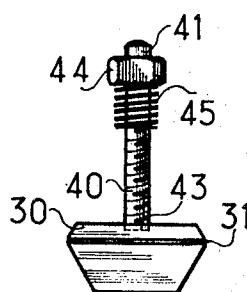


FIG. 3



FIG. 4



INVENTORS
ANDRE DUBOIS
DANIEL PARROT

BY: Craig & Antouelli
ATTORNEYS

Aug. 11, 1970

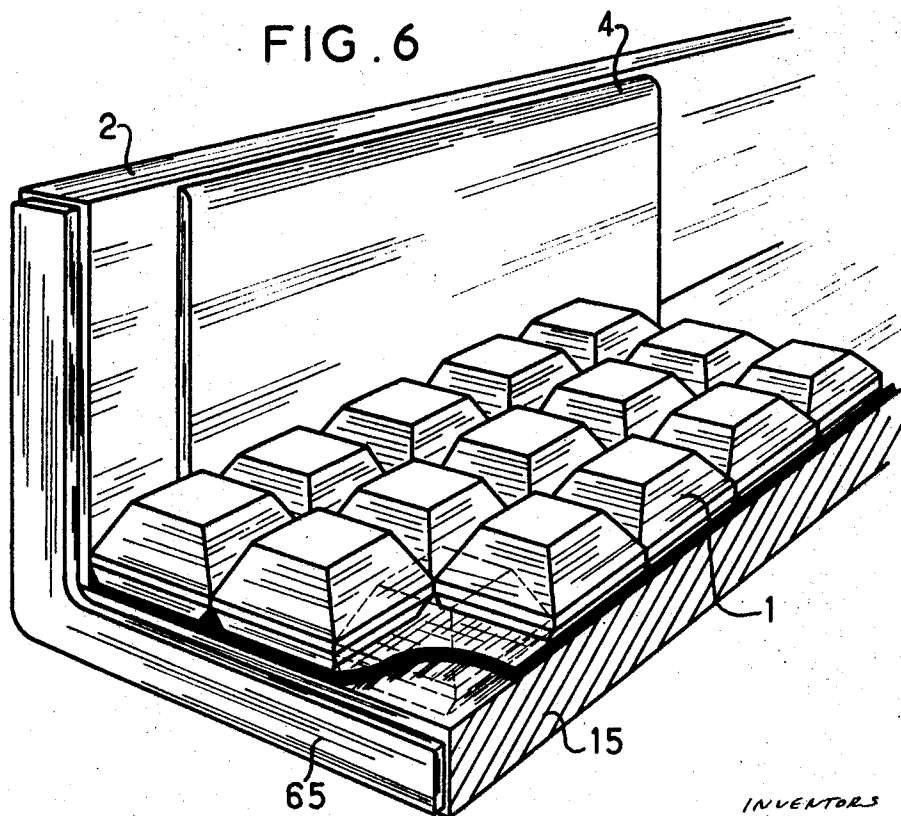
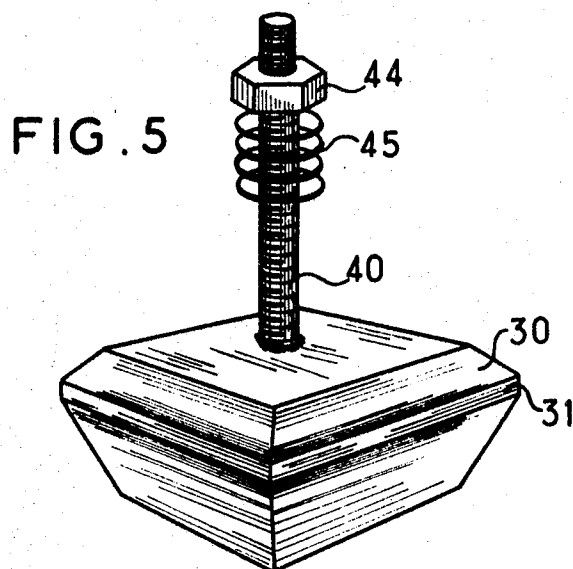
A. DUBOIS ET AL

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INVENTORS
ANDRE DUBOIS
DANIEL PARIZOT

BY: *Craig & Antawell*
ATTORNEYS

Aug. 11, 1970

A. DUBOIS ET AL

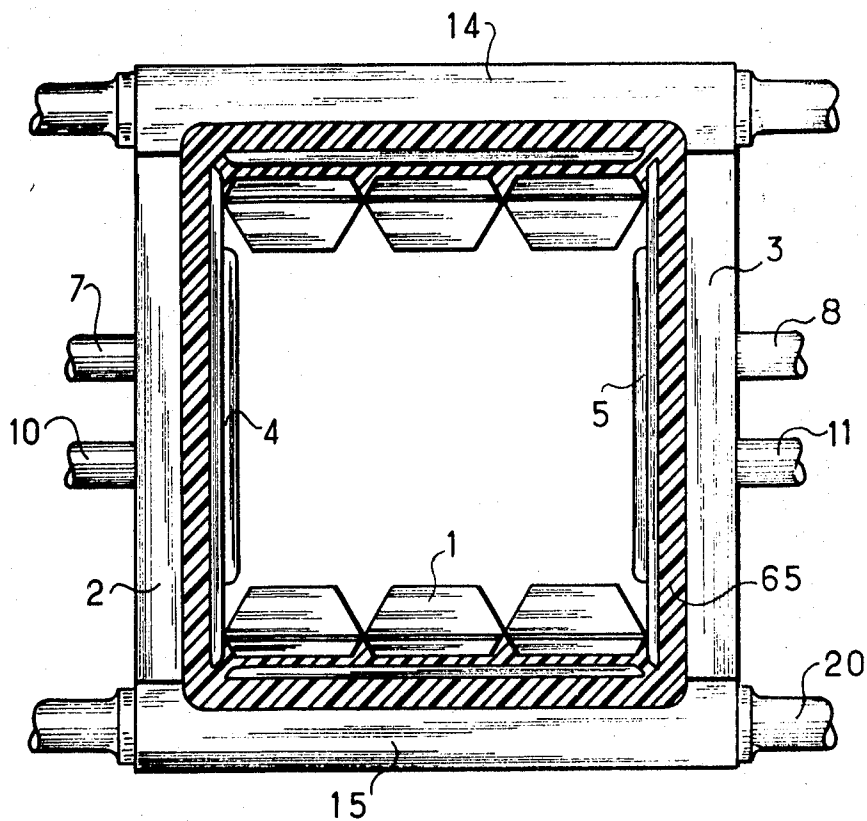
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FIG. 7



INVENTORS
ANDRE DUBOIS
DANIEL PARIZOT

BY: Craig & Antonelli
ATTORNEYS

Aug. 11, 1970

A. DUBOIS ET AL

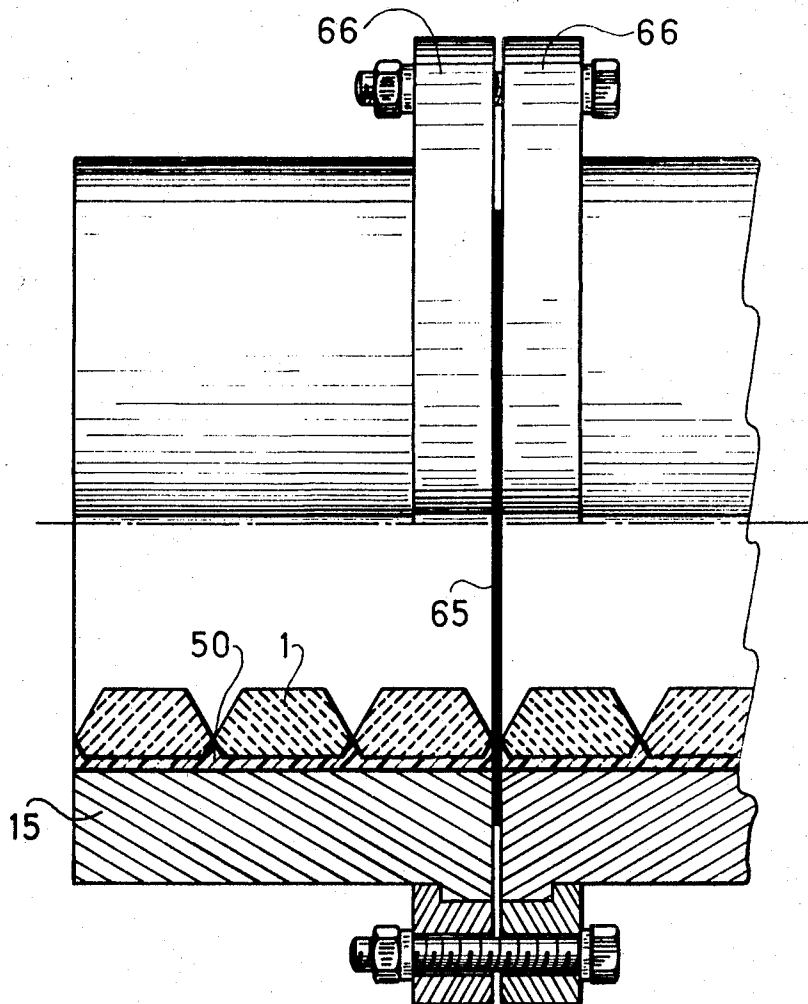
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FIG. 8



INVENTORS:
ANDRE DUBOIS
DANIEL PARIZOT

BY: Craig & Antonelli
ATTORNEYS

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NOZZLE WALL CONSTRUCTION FOR THERMOELECTRIC MACHINE

André Dubois, 33 Boulevard de Mondetour, 91 Orsay,
France, and Daniel Parizot, 94 Avenue Jean-Jaures,
Paris 19, France

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15 Claims

ABSTRACT OF THE DISCLOSURE

A nozzle for a thermoelectric generator wherein the walls extending between the electrode carrying walls are formed of a metallic portion on which is disposed on the inside surface thereof refractory elements of truncated pyramidal shape positioned in contiguous relationship.

The present invention relates to a nozzle element for a thermoelectric machine, particularly of the magneto-hydrodynamic type, and more particularly to the composition and configuration of the walls separating the electrodes in the M.H.D. nozzle.

It is well known that in an M.H.D. nozzle the electric field may be considered for purposes of analysis, in terms of the two components thereof; one of these E_T , called the transverse component, is perpendicular to the direction of flow of the plasma and equal to uB , wherein u is the speed of the plasma and B the induction at the interior of the nozzle; the other component of the electric field E_L , called the longitudinal component, is parallel to the direction of flow of the plasma and has the value βuB , wherein β designates the Hall effect coefficient of the generator. For nozzles which have large dimensions (several tens of thermic megawatts), these components of the electric field can produce voltages of several thousands of volts. As a result, it is of extreme importance that the walls of the nozzle separating the electrodes thereof be sufficiently insulated.

It is therefore an object of the present invention to provide a nozzle for an M.H.D. generator having partition walls which separate the electrodes in an extremely well insulated manner, both with respect to the longitudinal voltage component of the electric field and with respect to the transverse voltage component of the electric field.

It is another object of the present invention to make the nozzle elements in a manner such that they may be readily assembled.

The present invention relates to an M.H.D. nozzle element comprising at least two insulating walls, which nozzle element is characterized in that the insulating walls comprise a metallic portion equipped with ducts through which a refrigerating fluid flows and to which there are secured, on the side of the interior of the nozzle, elements made from a refractory material which have essentially a truncated pyramidal shape and are disposed side by side in such a way as to be contiguous with one another.

According to a particular embodiment of the present invention, the refractory elements are secured to the wall with the aid of a rod which is threaded on one extremity thereof, the other extremity of which is secured to the refractory elements by brazing, soldering or other similar means. The refractory elements are made preferably of pure fritted magnesia.

The present invention will be understood more fully on the basis of and with reference to the attached draw-

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ing which illustrates a preferred embodiment of the present invention that is given by way of example only and is not limitative thereof, and wherein:

FIG. 1 is a cross-sectional view taken along two distinct planes which are perpendicular to the axis of flow of the fluid of an M.H.D. nozzle embodying the present invention;

FIG. 2 illustrates a refractory partition wall element seen from below;

FIG. 3 is a side plane view of the element of FIG. 2;

FIG. 4 is a side plane view of a refractory element equipped with the fastening means therefor;

FIG. 5 is a perspective view of a refractory element equipped with the fastening means therefor;

FIG. 6 illustrates a portion of the extremity of a nozzle equipped with the assembling joint thereof;

FIG. 7 illustrates the unit of FIG. 6 as seen in an end view; and

FIG. 8 is a front view of two assembled nozzle elements.

FIG. 1 illustrates the pyramidal elements 1 which form the essential components of the partition walls according to the present invention. The upper portion of FIG. 1, above the axis XX' , represents a cross section of the nozzle through a plane perpendicular to the axis of flow of the plasma and extending through the line separating two rows of elements. The lower portion of FIG. 1, below the axis XX' , represents a cross section of the nozzle through a plane perpendicular to the axis of flow of the plasma and extending through the plane of symmetry of one row of elements.

The nozzle according to FIG. 1 includes in a known manner two walls 2 and 3 to which are secured in an insulated manner electrodes that have been indicated schematically at 4 and 5. These walls, preferably consisting of copper, are cooled by the circulation of refrigerating liquid in ducts, such as ducts 6, which are disposed within the wall and are in operative engagement with inlet conduits 7 and 8 and with outlet conduits 10 and 11. The present invention relates to the walls 14 and 15 which separate the electrodes and which, in the embodiment described herein, are perpendicular to the electrode-carrying walls. These walls comprise a metallic portion, such as 17, for example consisting of copper, which is cooled via ducts 18 by the circulation of a refrigerating fluid that is supplied through a conduit 19 and is discharged through a conduit 20.

The construction of the wall comprises a plurality of refractory elements 1 having identical dimensions mounted on the metallic portion 17, as shown in FIG. 1, which elements have essentially the form of a truncated pyramid with a square base and are grouped side by side, forming a perfectly squared or checkered design. The shape of these elements may also be chosen so as to differ from the square truncated form illustrated; for example, the elements may be cylindrical, cubic, or parallelepipedic as well. If the chosen shape is that of a truncated pyramid, it is desirable that the angle which is formed by two lateral faces adjacent each other be small. A good resistance to erosion is assured if, after the different thermal expansions above and below the mean value, the latter has essentially the form of a rectangular parallelepiped. In the various figures, the aforementioned angle has been shown in a rather exaggerated manner in order to facilitate the illustration.

The material of these elements is chosen in such a manner that the temperature T_0 to which they may be brought without harmful effects is sufficient to avoid, at the pressure prevailing in the nozzle, any deposit of the seed contained in the plasma. If the seed is a potassium salt, the material chosen will be preferably pure fritted magnesia.

According to a modified embodiment of the present invention, it is possible to also utilize any other refractory material, provided that the electric conductivity of this material is slight at low temperature. As a variation, the elements such as 1 may also be made from metal which is covered partially with an insulating material in such a manner as to insulate the same electrically with respect to one another and with respect to the metallic supports, such as supports 14 and 17.

In order to specify the manner of securing the refractory elements to the metallic wall, reference will be made to FIGS. 2, 3, 4, and 5, which are, respectively, a front view of a refractory element, a view of this element from above, and a front view and a perspective view of a refractory element provided with the fastening rod thereof.

It is apparent from FIGS. 2 and 3 that the refractory element 1 has a chamfered portion 30 on the side of its large base, which portion 30 is connected to the lateral walls of this element by means of a flat portion 31. Finally, a cavity or recess 32 having a cylindrical shape is disposed in the element at the center of its large base. The elements are provided, for purposes of their being secured to the wall, with a rod 40 which is threaded at one extremity 41 thereof (see FIGS. 4 and 5), the other extremity 43 of which is inserted into the cavity 32 and rendered integral with the element by brazing or similar means.

FIG. 5 illustrates the assemblage or coupling of a previously partially metallized element and of a rod 40 by means of tin-soldering. A second possibility of securing the refractory elements to the partition wall consists in either brazing or soldering the same. In that case, one realizes the economy afforded through elimination of rods and accessories. Under certain conditions of operation, the manner of fastening or attachment is important by reason of a required greater stability.

It is possible to now understand how the partition wall elements are assembled. The elements are arranged side by side in such a way as to adjoin or make contact with each other, the contact being brought about by means of the annular flat portion 31 thereof. They are screwed to the walls 14 and 15 by means of the rods 40 and locked with the aid of screwnuts 44 and washers 45, preferably of the Schnorr type.

The insulation of the wall is then completed by the injection of a polymerizable siliconized product into the spaces 50 (FIG. 1) which are formed between the walls and the chamfered portions 30, and between chamfered portions 30 on adjacent elements. The polymerization is effected after the injection. The material known commercially under the trade name "Silastene" will preferably be selected by reason of its resistance to heat, which allows the use thereof up to temperatures of 300° C., and also because of its chemical inertia with respect to the seed. The product known under the name of "P.R.L." is also very well suited for this purpose.

The continuous copper wall as well as the contact surface of the ceramic must be perfectly planar in order to assure a good thermal contact between adjacent elements and between an element and the adjacent wall. The metallic zone, whether hard-soldered or screwed in, must have a small cross section with respect to the surface of the refractory material so as to reduce the losses of electric insulation.

The cooled copper wall may, without detriment or drawback, have a potential very different from that of the plasma. In addition, it is possible to use as a heat-carrying fluid either water at high pressure, an organic liquid having a high boiling temperature, or a metal which is maintained in the liquid state, such as sodium.

The presence of the polymerizable material prevents the contact of the seed with the metal of the wall of the nozzle. In addition, one may advantageously provide in the wall, at the level of the separating lines between rows of refractory elements, grooves having either a rectangular or

a trapezoidal cross section, such as grooves 55, which enhance the adherence of the polymerizable material by increasing the contact surface thereof with the metal of the wall, and which extend the escape lines of the electric field, thus allowing for an increased insulation effect.

The fluid-tightness of the nozzle is obtained by means of a joint made from polymerizable material which is disposed on the end face of the nozzle element, as has been shown in FIGS. 6, 7, and 8, which illustrate, respectively, the extremity of a nozzle portion or section equipped with its fluid-tight joint designed for the attachment thereof to a similar nozzle, an end view of a nozzle according to the present invention, and a partial cross-sectional view of two assembled nozzle elements. The joint 65 of polymerizable material is disposed without discontinuity on the front face of the nozzle in the form of a band of relatively slight thickness.

The length of the nozzle equipped with a partition wall according to the present invention may reach one meter; however, it is also possible to place such elementary nozzles end-to-end so as to provide a nozzle of large dimensions. Supports or straps 66 mounted on the extremities of the elementary nozzles on the outer part thereof and assembled by means of screws and nuts make it possible to complete or accomplish the attachment of adjacent nozzles without introducing metallic clamps in contact with the plasma.

We have shown and described one embodiment in accordance with the present invention. It is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to a person skilled in the art and we, therefore, do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

What is claimed is:

1. An M.H.D. nozzle having at least two walls carrying electrodes separated by at least two insulating walls, each comprising a metallic portion extending between said electrode carrying walls and an insulating portion provided on said metallic portion on the side of the interior of the nozzle with insulating truncated pyramid shaped elements grouped side by side in an adjoining fashion, said elements being chamfered over the entire circumference thereof in proximity to one of the bases.

2. A nozzle according to claim 1, wherein said elements are secured to the metallic portion of the insulating wall by means of a screw, one extremity of which is brazed on a base of the element and the other extremity of which extending through said metallic portion is equipped with a nut-screw.

3. A nozzle according to claim 2, wherein a cavity is disposed at the center of one of the bases of the refractory element for the insertion of said screw.

4. A nozzle according to claim 1, wherein grooves are disposed in said metallic portion adjacent each of the lines of separation of the insulating elements provided thereon.

5. A nozzle according to claim 4, wherein said grooves are filled with a polymerized silicone elastomer.

6. Nozzle according to claim 1, characterized in that the space left free between the metallic portion of the wall and the chamfered portions of two adjacent elements is filled with a polymerized silicone elastomer.

7. A nozzle according to claim 6, wherein grooves are disposed in said metallic portion adjacent each of the lines of separation of the insulating elements provided thereon, said grooves also being filled with a polymerized silicone elastomer.

8. A nozzle according to claim 6, wherein the front face of said nozzle formed on the end faces of each of said walls is provided with a layer of polymerizable silicone forming a coupling for connection to another identical nozzle.

9. A nozzle according to claim 6 wherein the metallic portion of each insulating wall is provided with cooling

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means including ducts for circulating cooling fluid there-through.

10. A nozzle according to claim 1 wherein said insulating elements are made of metal coated with a refractory material.

11. A nozzle according to claim 1 wherein the pyramidal sides of said elements are joined to the chamfered surfaces thereof by means of side surfaces disposed perpendicularly to the bases of said elements.

12. A nozzle according to claim 11 wherein said elements are positioned on said metallic portions in a checkerboard arrangement with adjacent elements contacting firmly by way of their side surfaces.

13. A nozzle according to claim 12 wherein the angle formed between the pyramidal sides of adjacent elements is an acute angle.

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14. A nozzle according to claim 6, wherein said insulating elements are made of refractory material capable of withstanding a temperature at least equal to that of the boiling point of the seed of the plasma at the pressure prevailing in the nozzle.

15. A nozzle according to claim 6, wherein said elements are made of pure fritted magnesia.

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DAVID X. SLINEY, Primary Examiner