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## Description

### Field of the Invention

This invention relates generally to glowing compensation cathodes, and more particularly to plasma compensation cathodes.

### Background of the Invention

There is known a glowing cathode (cf., Schats M.F."Heaterless Ignition of Inert Gas. Ion Thruster Hollow Cathodes" AJAA Paper, 1985) comprising a casing with a cylindrical insert secured to the inner surface of the casing and functioning as thermal emitter, a heater secured at the outer side of the casing, and an orifice secured to end face of the casing and acting as the outlet hole of the cathode. This construction of cathode requires high power heaters to heat thermal emitter to a temperature ensuring thermoionic emission sufficient for maintaining a stable discharge.

There is also known a plasma compensation cathode (cf., L.A. Artsimovich, et al "Razrabotka stationarnogo plazmennogo dvigatelya i ego ispytanie na iskusstvennom sputnike Zemli Meteor", Kosmicheskie issledovania, 1974, tom XII, vyp. 3, pages 455 and 456, Fig. 5). This compensation cathode has a casing with an outlet hole at one wall thereof, the casing accommodating coaxially to its outlet hole a tubular holder receiving a thermal emitter with a central through passage. The compensation cathode also includes a heater embracing the tubular holder, and heat screens positioned between the holder and casing walls. Connected to the tubular holder is a pipe for feeding gas to the interior of the casing and to the passage of thermal emitter through its inlet portion. This pipe is secured in the casing through an insulator.

During operation of the compensation cathode gas is conveyed through the tubular holder to the passage of the thermal emitter. Heated to a high temperature, the thermal emitter ensures emission of electrons sufficient for maintaining stable electric discharge between the inner surface of the thermal emitter and anode of the plasma source. After bringing the device to steady-state operation conditions the heater is deenergized, and the compensation cathode continues to operate automatically, whereby the preferred temperature level is ensured by the energy liberated in the catholyte layer approximating to the product of ionic current resulting from discharge by the potential drop at the cathode. However, in the course of operation the discharge can move from the passage of the thermal emitter to the interior of the tubular holder resulting in evaporation of the material of the holder and fouling of the passage with holder material to almost complete clogging. As a result, thermoemission surfaces tend to degrade, and thermoemission current tends to decrease thereby reducing the service life of the compensation cathode to only tens of hours. In addition, direct connection of the holder of thermal emitter to the gas feeding pipe leads to vigorous heat transfer from the emitter to outer structural parts, and consequently to move prominent catholyte potential drop ensuring the energy necessary for maintaining automatic operating conditions. More prominent catholyte potential drop also leads to reduced service life of the thermal emitter because of intensified ionic bombardment. In addition, tight contact of thermoemissive materials with the holder at high working temperatures is accompanied by active chemical interaction, such as penetration of boron followed by formation of metal borides, which in turn causes embrittlement and cracking of the holder material and thermal emitter to result in irreversible deformation of the holder. This disadvantageous effect is especially pronounced at starting operating conditions accompanied by the highest temperature levels, which limits the service life and reduces the total number of engagements of the compensation cathode. Also, the helical heater embracing the tubular holder is characterized by low rigidity to result in sagging and deformation of its coils resulting in possible contact of the coils with the holder or thermal screens and short-circuiting of the heater. This in turn leads to fewer engagements of the compensation cathode and reduced service life thereof. In addition, the working gas can contain negligible quantities of such admixtures as oxygen, water, or the like, tending to react at high working temperatures with the material of the thermal emitter and affecting the thermoemissive characteristics of the material. Extended operation for tens or hundreds of hours makes this disadvantageous effect even more prominent to reduce the service life of the compensation cathode.

### Summary of the Invention

The present invention aims at providing a plasma compensation cathode which would be so constructed as to lock discharge zone in the passage of the thermal emitter, prevent chemical interaction of the thermal emitter with the material of the holder and with the thermal system maintaining automatically the preferred temperature of the thermal emitter at minimised cathodic potential drop, and also to increase the rigidity of the heater and facilitate additional cleaning of gas from impurities.

The aim of the invention is attained by a plasma compensation cathode according to the claim.

The use in the proposed plasma compensation cathode of a thermal emitter with a special passage for feeding gas, a layer of chemically inert material, a system of coaxial heat screens, a support ring, an insulation sleeve, a getter, and mechanical filters makes it possible to substantially extend the service life and increase the total number of actuations of the cathode.

Brief Description of the Drawings

The invention will now be described in greater detail with reference to a specific embodiment thereof taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a general view of the proposed plasma compensation cathode; and

Fig. 2 is a section taken along line 11 in Fig. 1

Best Mode of Carrying out the Invention

A plasma compensation cathode comprises a casing 1 (Fig. 1) having an inlet hole 2. The casing accommodates coaxially a hollow holder 3 and a thermal emitter 4 with a central passage 5. The holder 3 is positioned inside casing 1 coaxially with the outlet hole 2 and embraced by a heater 6 fashioned as a spiral one end of which is secured to the casing and the other to the holder 3. The heater 6 is provided with a support ring 7 located at its midportion and functioning as an additional support point.

The central passage 5 of the thermal emitter 4 is blind at the side of admission of gas, and is communicated with the interior of the holder 3 by way of a central passage 8 (Fig. 2) made in the wall of the thermal emitter 4, the axis of this passage extending perpendicularly to the axis of the central passage 5, and longitudinal grooves 9 provided at the side surface of the thermal emitter 4 at location of the inlet holes of the through passage 8. Occupying the space between the inner surface of the holder 3 and side surface of the thermal emitter 4 is a layer 10 (Fig. 1) of material chemically inert at high temperatures to the materials of the holder 3 and thermal emitter 4. Positioned between the heater 6 and walls of casing 1 is a system of coaxial heat screens 11 connected successively through spacer rings 12 and secured at pipe 13 for feeding gas to define a sealed cavity 14 wherethrough the interior of the holder 3 communicates with the gas feeding pipe 13. A space between the holder 3 and pipe 13 accommodates a getter 15 positioned between mechanical filters 16, whereas the pipe 13 is secured in a support insulator 17. The heater 6 is separated from the system of heat screens 11 by an insulation sleeve 18 in which the support ring 7 is secured.

In operation of the proposed plasma compensation cathode the gas flows along the pipe 13 through the getter 15 and mechanical filters 16 to the interior of the holder 3, and then through the grooves 9 and through passage 8 to the central passage 5 of the thermal emitter 4. The heater 6 acts to heat the thermal emitter 4 to a temperature ensuring emission of electrons sufficient for sustaining a stable electric discharge between the inner surface of the thermal emitter 4 and anode (not shown) of a plasma source. After bringing the device to steady state operating conditions the heater 6 is deenergized and the compensation cathode operates automatically, whereby the required temperature level of the thermal emitter 4 is ensured thanks to the energy resulting from the discharge.

When the central passage 5 at the side of admission of gas is blind, the electric discharge in passage 5 can be stabilized by changing the pressure of gas and dimensions of the passage 5. This prevents fixation of discharge at the walls of holder 3 resulting in fouling and clogging of passage 5 of the thermal emitter 4, which facilitates maintaining the initial thermal emission from the inner surface of the thermal emitter 4 and substantially increases the service life of the compensation cathode. Positioning between the inner surface of holder 3 and side surface of the thermal emitter 4 of layer 10 of material chemically inert to the material of holder and thermal emitter 4 obviates chemical interaction and diffusion of materials thereby making impossible irreversible deformation of holder 3 and cracking of holder 3 and thermal emitter 4. The accompanying advantage is substantially increased number of actuations and extended service life of the cathode.

The system of coaxial heat screens 11 defining with gas feeding pipe 13 and holder 3 a sealed cavity 14 makes it possible to substantially reduce the heat flow from holder 3 of the thermal emitter 4 to outer parts of the cathode structure and, as a consequence, to reduce the potential drop at the cathode to the level of gas ionization potential and substantially extend the service life of the compensation cathode.

Provision of the support ring 7 secured in the insulation sleeve 18 allows to increase rigidity of the spiral of heater 6, prevent short-circuiting of the spiral of heater 6 (viz., engagement of the spiral coils with holder 3 or screens 11) even at a substantial deformation of spiral coils due to multiple engagement thermocycles. This again enables to increase the number of actuations and extend the service life of the compensation cathode.

Provision of the proposed compensation cathode with getter 15 positioned between mechanical filters 16 immediately at the location where the gas is admitted to the interior of the holder 3 affords extra fine chemical cleaning of gas from admixtures of oxygen, water, and the like, and ensures more stable thermoemission characteristics of thermal emitter 4 resulting in an extended service life of the compensation cathode.

Industrial Applicability

The invention can be used for neutralizing ion beams in accelerators with closed electron drift and extended acceleration zone, in accelerators with anodic layer and narrow acceleration zone, in plasma-ion accelerators, and also for compensating space and surface discharges.

## Claims

1. A plasma compensation cathode comprising a casing (1) accommodating coaxially with its outlet hole (2) a hollow, tubular holder (3) which is embraced by a heater (6), and a thermal emitter (4) with a central passage (5) communicating with the interior of the holder (3), whereby said thermal emitter is positioned within the holder, the cathode further comprising coaxial heat screens (11) interposed between the heater (6) and walls of the casing (1), and a pipe (13) for feeding a gas to the interior of the holder (3), said pipe being secured in a support insulator (17), CHARACTERIZED in that the central passage (5) of thermal emitter (4) is blind at the end of the emitter which is closer to the gas admission through the pipe, and communicates with the interior of the holder (3) by way of a through passage (8) made in the wall of the thermal emitter (4) so that its axis intersects the axis of the central passage (5), and longitudinal grooves (9) along the side surface of the thermal emitter (4) from the location of the inlet holes of the through passage (8) to the end of the emitter which is closer to the gas feeding pipe (13); a getter (15) is positioned between mechanical filters (16) at the location where the gas is admitted to the interior of the holder; whereby the interior of the holder (3) communicates with the gas feeding pipe (13) through a sealed cavity (14), said cavity being defined by clearances between the coaxial heat screens (11) which are successively connected by spacer rings (12) and secured at the gas feeding pipe (13), a space between the inner surface of the holder (3) and side surface of the thermal emitter (4) accommodating a layer (10) of material chemically inert at high temperatures to the material of the holder (3) and the thermal emitter (4), whereby the the cavity (14) accommodates the getter (15) positioned between the holder and the gas feeding pipe; and the heater (6) at a midportion thereof is provided with a support ring (7) which is secured in an insulation sleeve (18) separating the thermal heater (6) from the coaxial thermal screens (11).

## Patentansprüche

1. Plasmaneutralisationskathode, die umfaßt ein Gehäuse (1), das koaxial mit seinem Auslaßloch (2) einen hohlen, rohrförmigen Halter (3) aufnimmt, der von einem Heizer (6) umgeben ist, und einen thermischen Emitter (4) mit einem zentralen Durchgang (5), der mit dem Inneren des Halters (3) in Verbindung steht, wobei sich der thermische Emitter in dem Halter befindet, wobei die Kathode ferner umfaßt koaxiale Wärmeschirmungen (11) die zwischen dem Heizer (6) und Wänden des Gehäuses (1) angeordnet sind, und ein Rohr (13) zum Einspeisen eines Gases in das Innere des Halters (3), wobei das Rohr in einem Tragisolator (17) befestigt ist,
dadurch gekennzeichnet,
daß der zentrale Durchgang (5) des thermischen Emitters (4) an dem Ende des Emitters, das der Gaszugabe durch das Rohr (3) näher liegt, blind ist, und mit dem Inneren des Halters (3) über einen Hindurchgang (8), der in der Wand des thermischen Emitters (4) derart vorgesehen ist, daß seine Achse die Achse des zentralen Durchgangs (5) schneidet, und mit Längsrillen (9), die entlang der Seitenoberfläche des thermischen Emitters (4) von der Stelle der Einlaßlöcher des Hindurchgangs (8) zu dem Ende des Emitters, das dem Gasspeiserohr (13) näher liegt, in Verbindung steht; ein Getter (15) sich zwischen mechanischen Filtern (16) an der Stelle, wo das Gas dem Inneren des Halters zugegeben wird, befindet; wobei das Innere des Halters (3) mit dem Gasspeiserohr (13) über einen abgedichteten Hohlraum (14) in Verbindung steht, wobei der Hohlraum durch Zwischenräume zwischen den koaxialen Wärmeschirmungen (11), die der Reihe nach über Abstandsringe (12) verbunden sind und an dem Gasspeiserohr (13) befestigt sind, festgelegt ist, wobei ein Raum zwischen der inneren Oberfläche des Halters (3) und einer Seitenoberfläche des thermischen Emitters (4) eine Schicht (10) eines Materials aufnimmt, das bei hohen Temperaturen gegenüber dem Material des Halters (3) und des thermischen Emitters (4) chemisch inert ist, wobei der Hohlraum (14) den Getter (15) aufnimmt, der sich zwischen dem Halter und dem Gasspeiserohr befindet; und wobei der Heizer (6) an einem Mittelabschnitt davon mit einem Tragring (7) versehen ist, der in einer Isolationsbuchse (18) angebracht ist, die den thermischen Heizer (6) von den koaxialen thermischen Schirmungen (11) trennt.

## Revendications

1. Cathode de compensation à plasma comprenant un boîtier (1) logeant de manière coaxiale avec son orifice de sortie (2) : un support tubulaire, creux, (3) qui est entouré par un filament de

chauffage (6) et un émetteur thermique (4) avec un conduit central (5) communiquant avec l'intérieur du support (3), ce par quoi ledit émetteur thermique est placé à l'intérieur du support, la cathode comprenant en outre des écrans thermiques coaxiaux (11) interposés entre le filament de chauffage (6) et les parois du boîtier (1) ; et un tuyau (13) pour délivrer un gaz à l'intérieur du support (3), ledit tuyau étant fixé dans un isolateur support (17) ;

caractérisé en ce que le conduit central (5) de l'émetteur thermique (4) est aveugle à l'extrémité de l'émetteur qui est la plus proche de l'admission de gaz par le tuyau, et communique avec l'intérieur du support (3) par un conduit traversant (8) pratiqué dans la paroi de l'émetteur thermique (4) de sorte que son axe coupe l'axe du conduit central (5) et avec des rainures longitudinales (9) le long de la surface latérale de l'émetteur thermique (4), allant de l'emplacement des orifices d'entrée du conduit traversant (8) à l'extrémité de l'émetteur qui est la plus proche du tuyau de délivrance de gaz (13) ; en ce qu'un dégazeur (15) est placé entre des filtres mécaniques (16) à l'emplacement où le gaz est admis à l'intérieur du support ; ce par quoi l'intérieur du support (3) communique avec le tuyau de délivrance de gaz (13) par l'intermédiaire d'une cavité étanche (14), ladite cavité étant définie par des espaces entre les écrans thermiques coaxiaux (11) qui sont reliés de manière successive par des bagues d'écartement (12) et fixés au tuyau de délivrance de gaz (13), l'espace entre la surface intérieure du support (3) et la surface latérale de l'émetteur thermique (4) contenant une couche (10) de matière chimiquement inerte aux températures élevées par rapport aux matières du support (3) et de l'émetteur thermique (4) ce par quoi la cavité (14) contient le dégazeur (15) placé entre le support et le tuyau de délivrance de gaz ; et en ce que le filament de chauffage (6), au droit de sa partie centrale, est pourvu d'une bague support (7) qui est fixée dans un manchon isolant (18) séparant le filament de chauffage thermique (6) des écrans thermiques coaxiaux (11).

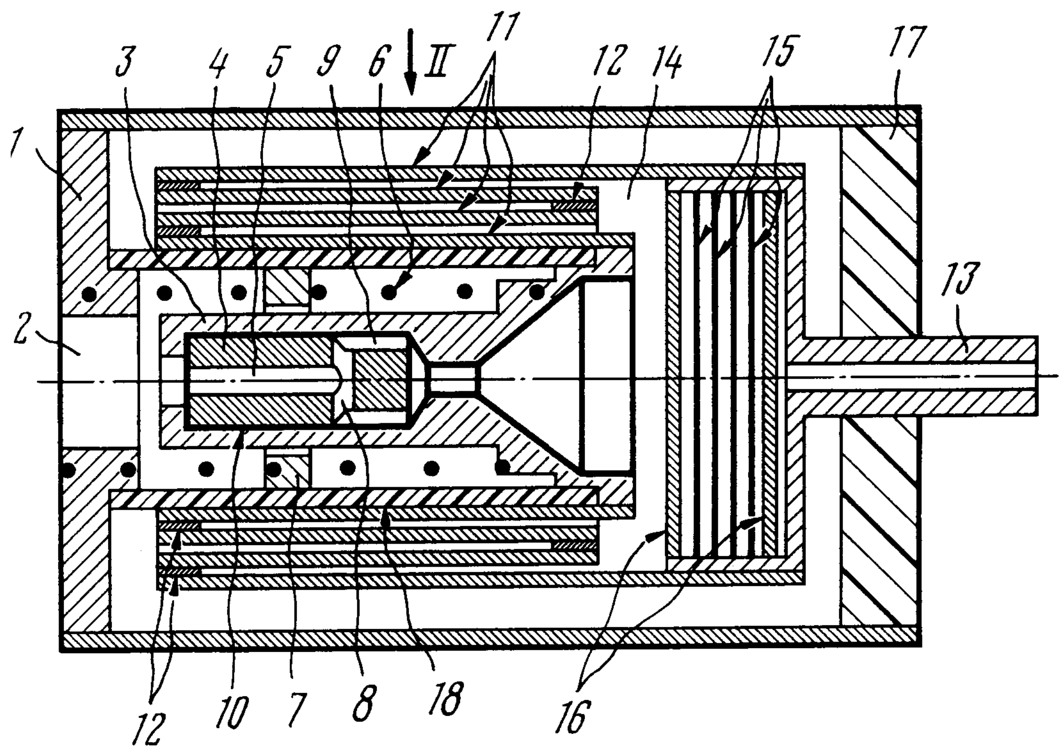


FIG. 1

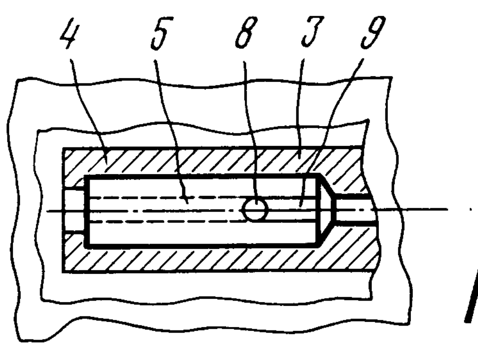


FIG. 2