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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

April 5, 1971

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,413,510

Corporate Source : Lewis Research Center

Supplementary
Corporate Source :

NASA Patent Case No.: XLE-04501

Gayle Parker

Enclosure:
Copy of Patent

Nov. 26, 1968 W. R. KERSLAKE 3,413,510
ELECTRONIC CATHODE HAVING A BRUSH-LIKE STRUCTURE
AND A RELATIVELY THICK OXIDE EMISSIVE COATING
Filed Jan. 24, 1966

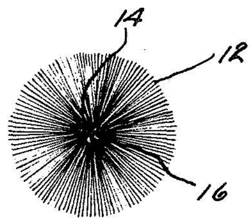

FIG. 2

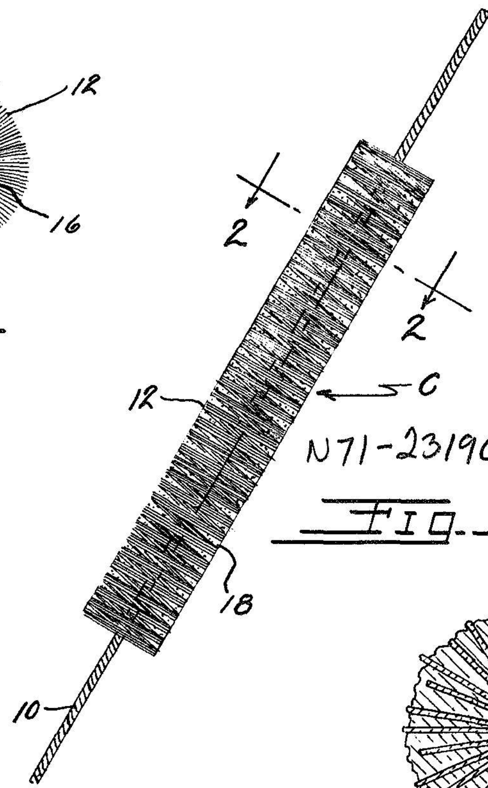

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FIG. 1

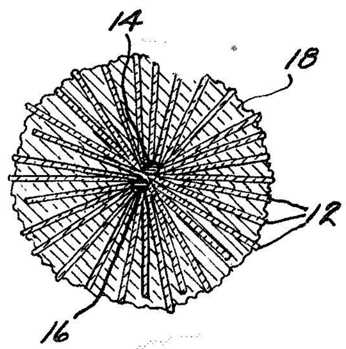

FIG. 3

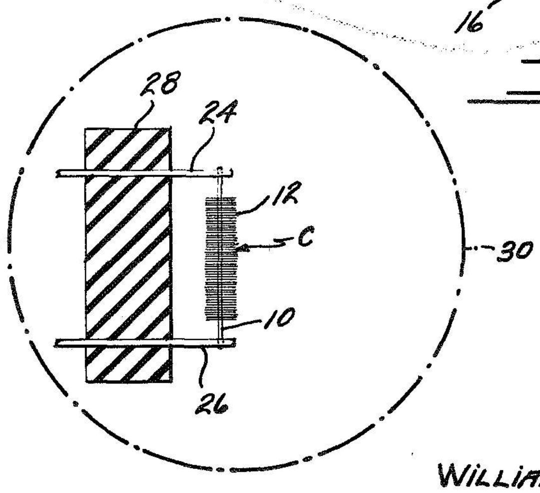

FIG. 4

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United States Patent Office 3,413,510 Patented Nov. 26, 1968

3,413,510

ELECTRONIC CATHODE HAVING A BRUSH-LIKE STRUCTURE AND A RELATIVELY THICK OXIDE EMISSIVE COATING

William R. Kerslake, Middleburg Heights, Ohio, assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

Filed Jan. 24, 1966, Ser. No. 522,794
2 Claims. (Cl. 313—231)

ABSTRACT OF THE DISCLOSURE

A cathode electrode formed by a twisted wire stem having bristles extending radially therefrom. The wire and bristles may be of iridium and/or tungsten, tantalum, molybdenum, or platinum. The bristles and stem are coated with barium oxide or preferably a mixture of barium-strontium-calcium oxides.

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for Governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to electronic cathodes and more particularly to cathodes used in electron bombardment ion thrustors.

The life span of cathodes used in ion thrustors has always been notoriously short. Oxide coated cathodes are the most efficient producers of electrons, yet the coating structure thereon invariably is short-lived. A cathode in such an application must be sufficiently hot to emit electrons and hence will lose material by evaporation. The cathode will also be coupled to or immersed in plasma discharge and thus will lose material because of sputtering erosion due to positive ion bombardment. The oxide coating must, therefore, be sufficiently thick to maintain a source of active material over relatively long periods of time. The thickness of such coatings is limited, however, by the ohmic resistance of the oxide material, which when subject to the emission current, causes overheating and destruction of the cathode. Previous low work function cathodes utilizing thin films of barium oxide emissive coatings have lasted but a few hours in the ion chamber of a mercury electron bombardment ion thrustor. Attempts have been made to construct barium oxide cathodes with thicker coatings by supporting and strengthening the oxide film with fine wires. These attempts resulted in a coating thickness of about one millimeter. When this type cathode was tested in a thrustor, the resulting maximum life span was only about 600 hours.

Most conventional oxide coated cathodes contain some type of heater coated with such oxide layer to a thickness of 0.001 inch to 0.004 inch. In an electron bombardment ion thrustor environment this thickness of oxide wears off in about 100 hours. Thrustor life times of 10,000 hours and more are needed for current applications. Therefore a coating many times thicker than 0.004 inch is required to endure, for example, 10,000 hours. However, it is a firm rule that coating thicknesses greater than 0.004 inch may not be used because the coating will be self-destructive. The reason for such self-destruction is that the electrons emitted from the surface must flow through the oxide thickness. This flow of electrons heats the oxide layer and thus, the thicker the layer, the more heat is produced until destruction of the layer occurs. Accordingly, the ideal cathode is one having a thick oxide coating yet overheating of such cathode is prevented by providing a free flow of electrons emitted therefrom.

Therefore, it is an object of the invention to provide

an electronic cathode having a substantially increased life span over that of present structures.

A further object of the invention is to provide an ion thrustor cathode having a high emission efficiency in coaction with a substantially thick coating of oxide.

A further object of the invention is to provide a cathode of the above type that is simple in construction, inexpensive to manufacture, and highly effective in operation.

Briefly the foregoing objects are accomplished by the provision of an ion thrustor cathode formed of an electrically conductive material configured in a twisted-in-wire style brush structure coated with a thick oxide emissive coating, said structure including a linear stem having a plurality of bristles extending radially outwardly therefrom. The stem and bristles may be formed of irridium and/or tungsten and/or tantalum and/or molybdenum and/or platinum group metals. The stem may be formed of a plurality of twisted wires each having a diameter of approximately 0.02 inch. The bristles, in the preferred form, are approximately 0.003 inch in diameter. Barium oxide or a mixture of barium-strontium-calcium oxides is a preferred form of coating.

With this structure, a thick oxide coating is achieved in coaction with a substantially free flow of emitted electrons from the ends of the wire bristles, such free electron flow preventing overheating of the coating. In addition, the wire bristles serve to physically reinforce the structure of the thick oxide layer. The wire bristles are formed so that as the cathode surface coating wears away, the wires also wear away without falling apart. The bristles may be roughened, bent, or spiraled to provide additional surface and mechanical holding power for the emissive coating. The emissive coating is applied to the brush (cathode) as a liquid-powder slurry and permitted to dry. In operation, the cathode is heated by passing an electrical current through the twisted wires comprising the stem. Activation of the cathode is accomplished by either (1) briefly overheating the cathode, (2) drawing emission current through the coating, or (3) bombardment of the cathode surface by ions from the thrustor discharge.

In the present invention, construction of a cathode containing a barium oxide emissive coating of five or more millimeters thickness is effective. Additionally, radial wires or bristles pass through the coating and serve as both electrical and thermal conductors to prevent self-destruction of the thick barium oxide layer. Specifically, the radial wires provide a path for the emission current and the input heater power to travel from the central twisted wires of the stem to the emitting surface. Also, as the emissive coating erodes away, the more durable bristles protrude above the cathode surface. Such protruding bristles intercept many of the ions coming from the mercury discharge that would normally sputter or fall on the barium oxide, thus reducing erosion of the emissive coating and prolonging the cathode life.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the drawings wherein:

FIGURE 1 is a front elevational view of an electronic cathode constructed in accordance with the invention;

FIGURE 2 is an enlarged sectional view taken along the line 2—2 of FIGURE 1;

FIGURE 3 is an enlargement of the view shown in FIGURE 2;

FIGURE 4 is a front elevational sectional view of an application of the present invention.

Although the invention is shown and described herein with reference to its use in a mercury electron bombardment ion thrustor, it will be understood that it may be employed in any suitable type of electronic apparatus using electronic cathodes.

Referring to FIGURES 1, 2 and 3, there is shown a cathode of the invention, generally designated as C, and formed of an electrically conductive material configured in a twisted-in-wire style brush structure, said structure including a linear stem **10** having a plurality of bristles **12** extending substantially radially outwardly therefrom. The stem **10** may be formed of a plurality of twisted wires **14** and **16** retaining the bristles therebetween in typical twisted-in-wire brush construction. The bristle portion is coated with any suitable oxide emissive coating **18** such as, for example, barium oxide. A coating thickness of approximately 5 millimeters has been found to be satisfactory, such thickness being measured from the longitudinal axis of the stem radially outwardly to the tips of the bristles **12**. The coating **18** is applied as a liquid-powder slurry and permitted to dry.

In a preferred form of the invention, the stem wires **14** and **16** are each 0.02 inch in diameter and each bristle **12** is 0.003 inch in diameter, said stem wires an bristles being preferably formed of tungsten and/or tantalum, although other like metals are satisfactory as previously mentioned. Although the stem is shown as linear, it may be bent to any suitable shape as required by any given application.

In practice, the cathode C (FIGURE 4) may be held in operative position by spaced electrically conductive leads **24** and **26** which, in turn, are retained by an insulator **28**, said structure being disposed in any suitable associated electronic environment such as an electronic tube, mercury electron bombardment ion thrustor, etc., generally represented as **30**.

With the present cathode construction, substantially thicker oxide coatings **18** may be employed resulting in operating lifetimes of 1250 to 3900 hours in comparison with an average of approximately 600 hours for the best of prior structures. This is achieved by the twisted-in-wire structure wherein the bristles **12** aid in the flow of emitted electrons and thus prevent overheating of the coating, such overheating being a prime cause of early failure in prior structures. Specifically, the bristles serve as both electrical and thermal conductors to prevent self-destruction of the thick barium oxide layer **18**, such bristles providing

a path for the emission current and the input heater power to travel from the central stem **10** to the emitting surface at the ends of the bristles **12**. Also, the bristles may be bent or roughened out to provide additional mechanical holding power for the coating **18**. Also, the bristles physically reinforce the structure of the oxide coating. In mercury bombardment ion thrustor applications, the protruding bristles **12** intercept many of the ions coming from the mercury discharge that would normally sputter or fall on the barium oxide coating, thus reducing erosion of such coating and prolonging the life of the cathode.

The terms and expressions which have been employed are used as terms of description, and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown or described, or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A cathode formed of an electrically conductive material configured in a twisted-in-wire style brush structure, comprising a linear stem having a plurality of bristles extending substantially radially outwardly therefrom and coated with an oxide emissive coating, said coating being at least five millimeters in thickness as measured from the longitudinal axis of said stem radially outwardly to the tips of said bristles.

2. The structure of claim **1** wherein the cathode is employed in a mercury electron-bombardment ion thrustor, said stem and bristles being formed of tantalum and tungsten, and said coating is barium oxide.

References Cited

UNITED STATES PATENTS

1,971,940	8/1934	Pirani	313—346 X
2,888,592	5/1959	Lafferty	313—346
3,259,782	7/1966	Shroff	313—346 X
3,262,262	7/1966	Reader et al.	60—202

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