Nov. 22, 1966 R. E. HUNTER 3,286,467

PLURAL NEEDLE ELECTRODE ELECTROSTATIC THRUST DEVICE

Filed Jan. 19, 1965 2 Sheets-Sheet 1

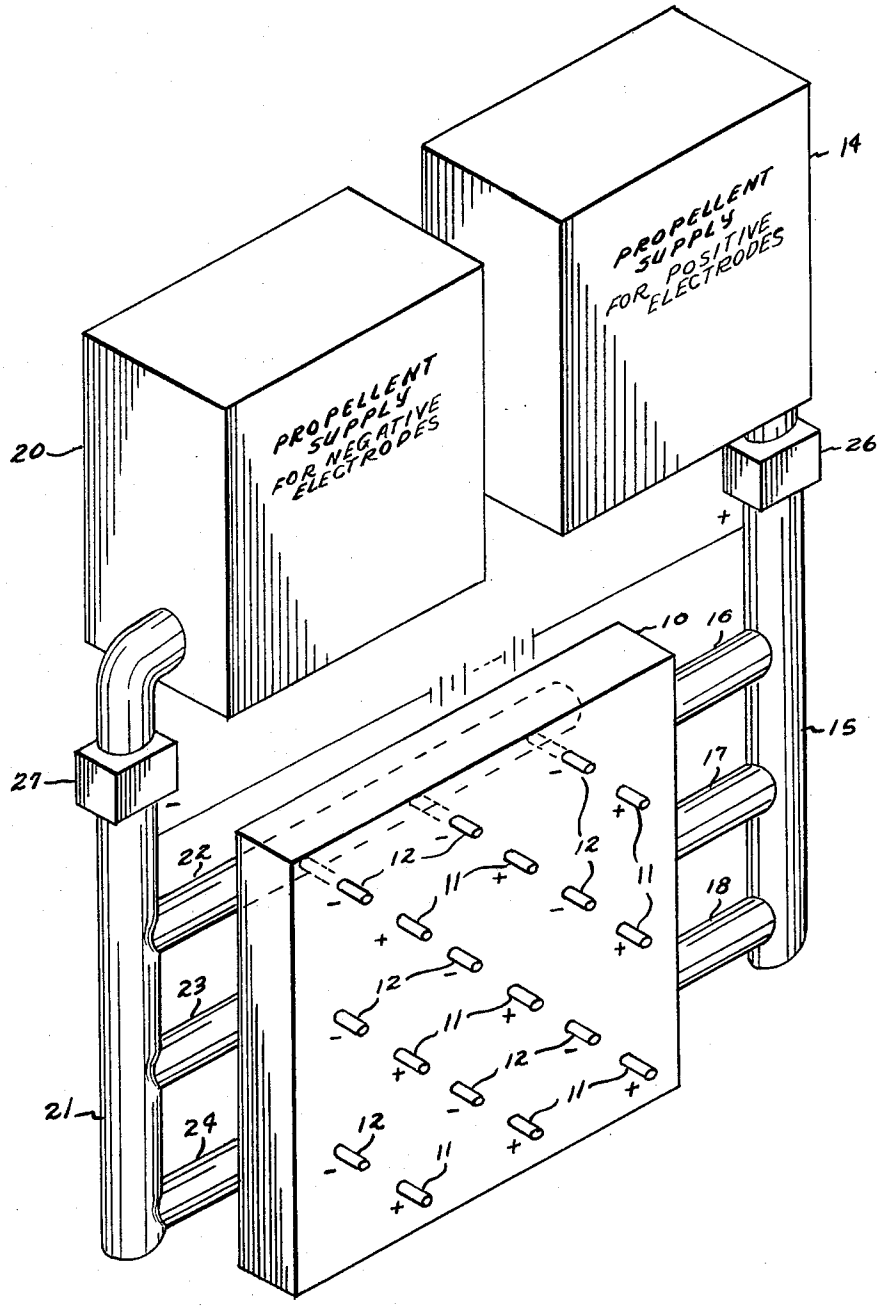


Fig-1

INVENTOR.
ROBERT E. HUNTER
BY Harry A. Herbert Jr.
ATTORNEY
Richard J. Killoran
AGENT

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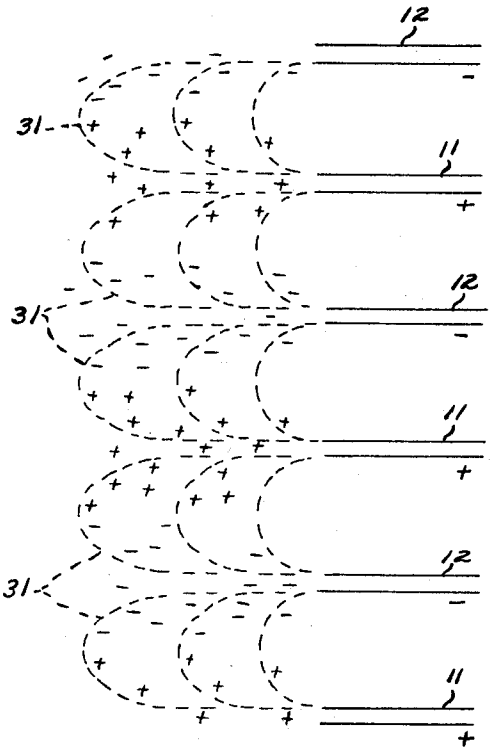


Fig. 2

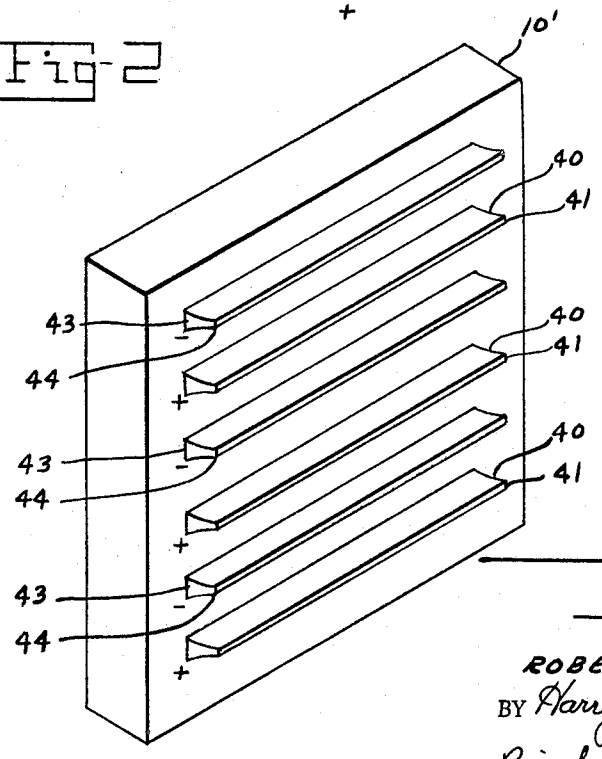


Fig. 3

INVENTOR.
ROBERT E. HUNTER
BY Harry A. Herbert Jr
ATTORNEY
Richard J. Killoren
AGENT

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PLURAL NEEDLE ELECTRODE ELECTROSTATIC THRUST DEVICE

Robert E. Hunter, Waynesville, Ohio, assignor to the United States of America as represented by the Secretary of the Air Force

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3 Claims. (Cl. 60—202)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to an electrostatic thrust device which uses electrostatically accelerated charged particles to provide the thrust.

One object of the invention is to provide an electrostatic thrust device which makes the use of conventional focusing and acceleration electrodes and charge neutralizing apparatus unnecessary.

A further object of the invention is to provide an electrostatic thrust device which has a more compart construction than prior art devices.

These and other objects will be more fully understood from the following detailed description taken with the drawing, wherein:

FIG. 1 is an isometric schematic view of a thrust device according to one embodiment of the invention;

FIG. 2 is an electric field plot for a portion of the device of FIG. 1; and,

FIG. 3 is an isometric schematic of a modification of the thrust portion of the device of FIG. 1.

Experimental research has been conducted for some time on the production of charged particles by spraying liquids from the ends of capillary needles maintained at a high positive electrical potential.

It has always been assumed that, when such thrust devices are built, they will incorporate more-or-less conventional ion optic electrode configurations with beam neutralization by electrons. However, the particle emission characteristics of the needles are such as to provide particles of various sizes (charge-to-mass ratio) in a widely divergent stream. These two properties promise to make the focusing and acceleration of beams of these particles a very serious problem. Interception of some of the particles by the accelerating electrodes would cause erosion of the electrodes and severely limit the lifetime and reliability of the thrustor.

According to this invention, an array of capillary apertured electrodes are provides, each spaced from the adjacent electrodes and, each connected to an electrical potential of a polarity opposite to that of its immediate neighbor. All of the electrodes of one polarity are connected to a common propellent reservoir with another reservoir being provided for the electrodes of opposite polarity.

Reference is now made to FIG. 1 of the drawing which shows a block of insulating material **10** having a plurality of positively charged capillary needles **11** and a plurality of negatively charged capillary needles **12** projecting therethrough. A liquid propellant is supplied to the positively charged needles **11** from a propellent supply **14** through tubes **15, 16, 17** and **18**. Liquid propellant from propellent supply **20** is supplied to the negatively charged needles **12** through tubes **21, 22, 23** and **24**. The liquid propellant is under pressure in propellent supplies **14** and **20**. The positive voltage is supplied to needles **11** from a positive high-voltage supply connected to tube **15** and the negative voltage is supplied to needles **12** from a negative high-voltage supply connected to tube **21**. Pressure control devices **26** and **27** control the pressure of the fluid supplied to the needles **11** and **12**.

One device built used needles with an inside diameter of 6 mils and a length of 1½ inches. The needles were spaced .788 inch along the tubes **16, 17, 18, 22, 23** and **24**. The rows of negative needles **12** were spaced from the rows of positive needles by a distance of .394 inch. The insulation material used for block **10** was Teflon. A mixture of 5 grams sodium iodide per 100 milliliters of glycerin was used as the propellant for both the positive and negative needles. The supply tank gauge pressure was 5 p.s.i. With the positive and negative needles held at voltage of plus 4 kilovolts and minus 4 kilovolts, respectively, a paper pendulum hung in front of the device was deflected at an angle of 7 degrees from the vertical. The deflection of the paper pendulum was found to be less at lower needle voltages. When used in a vacuum such as for space use, other pressures and voltages would be used. Also, other propellants could be used such as sodium bromide in glycerin, sulfuric acid in glycerin, or other propellent materials commonly used in charged particles acceleration devices.

One possible theory of the operation of the device will be given with reference to FIG. 2. The alternate needles **11** and **12** of opposite polarity set up fringe fields as shown schematically at **31** in FIG. 2. The charged particles are then accelerated by these field lines and would return to the electrode of opposite polarity if they were not met by charges of opposite polarity and neutralized. However, since they are neutralized, they continue to flow at a high velocity away from the needle electrode structure.

Other structure and arrangements than shown in FIG. 1 may be used. For example, as shown in FIG. 3, elongated capillary channel electrodes or other capillary apertured electrodes may be substituted for the needle electrodes. FIG. 3 shows a block of insulation material **10'** as in FIG. 1, with a plurality of elongated positively charged capillary channel electrodes **40** with elongated apertures **41**, alternatively spaced from a plurality of elongated negatively charged capillary channel electrodes **43** with elongated apertures **44**. The remaining structure may be the same as in FIG. 1 and, therefore, is not shown in this figure.

While two propellent supply tanks have been shown, the propellant may be supplied from one tank when the same propellant is used for both positively and negatively charged electrodes, if a sufficiently high-resistance path is provided, between the electrodes and propellent supply, to keep leakage current to an acceptable level. Also, other materials and arrangements than those shown and described may be used. The number of needles shown is merely for illustrative purposes as more or less needles may be used in an actual device.

There is thus provided an electrostatic thrust device which may be used to electrostatically accelerate charged particles.

While certain specific embodiments have been described in detail, many changes may be made without departing from the general principles and scope of the invention.

I claim:

1. An electrostatic thrust device, comprising: a plurality of uniformly spaced capillary aperture electrodes; means for providing a flow of propellent fluid material through said electrodes; means for mounting said electrodes for directing streams of propellant into the ambient; means for connecting certain of said electrodes at a high positive potential; means for connecting the remainder of said electrodes at a high negative potential; said electrodes at a high positive potential being inter-

spersed between and adjacent said electrodes at a high negative potential with each electrode being at an opposite electrical polarity than each of the immediately adjacent electrodes, said electrodes being located in predetermined positions for electrically accelerating said streams of propellant solely through the interaction of the electric fields between said electrodes for producing an electrically neutralized flow of high velocity particles into the ambient.

2. The device as recited in claim 1 wherein said capillary aperture electrodes are needle electrodes.

3. The device as recited in claim 1 wherein said capillary aperture electrodes are channel electrodes.

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MARK NEWMAN, *Primary Examiner.*

CARLTON R. CROYLE, *Examiner.*