PARTICLE PROPULSION DEVICE

FIG. 1

FOCUSING ELECTRODE
LINES OF CONSTANT ELECTRIC POTENTIAL
HIGH POTENTIAL
LOW POTENTIAL

ACCELERATING ELECTRODE

FIG. 2

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This invention relates to propulsion systems and more particularly to charged-particle electrical propulsion devices for providing thrust, especially in outer space. It is an object of this invention to provide a highly efficient propulsion device which accelerates electrically-charged dust particles to relatively high velocity to provide a reaction propulsion force. It is another object of this invention to provide a novel and efficient method of electrically charging ferromagnetic or paramagnetic dust particles for propulsion and other applications.

These and other objectives of this invention will become readily apparent from the detailed description of the drawings in which:

FIG. 1 is a schematic illustration in partial cross section of a single-element electric propulsion device;

FIG. 2 is a schematic illustration in partial cross section of a double-unit power device;

FIG. 3 is a schematic and partial cross section illustrating the charged particle propulsion device having an A.C. power supply;

FIG. 4 is a schematic illustration of a double-unit similar to FIG. 3; and

FIG. 5 is a diagrammatic illustration of the operation of the device shown in FIGS. 3 and 4.

Referring to FIG. 1, the charged particle electric device is generally indicated at 10 as having a non-magnetic cylindrical casing 12 which supports or contains a supply of particles 14, such as soft iron dust. The particles 14 are retained in the casing 12 by means of a solenoid coil 16 which is energized by any suitable electrical power supply such as the battery 18. The strength of the magnetic field which holds the particles within the casing 12 may be controlled by varying the current through the coil 16. This may be accomplished, for example, by means of a variable resistance or rheostat 20, or by varying the output voltage of the power supply if such control is provided.

The principle of this device is to obtain a controlled rate of expulsion of the charged dust particles in an aft direction so as to produce a desired thrust to this end. An accelerating electrode 30 is provided both to induce an electrical charge on the aft surface 34 of the dust particle core by means of a strong electric field between said electrode and said surface, and also to accelerate the particles for subsequent expulsion in the aft direction.

A suitable power supply 32 maintains a desired electrical potential between the particle core 14 and the accelerating electrode 30. In this instance the core 14 is charged positively while the electrode 30 will be at a negative or low potential.

Each of the particles P will be held by a certain magnetic force $F_M$ to the remaining particles in the core 14 while there will be a certain electric force, $F_e$, tending to pull the particles P from the aft surface 34. The force, $F_e$, arises because of the action of the electric field on the charged particles P on the aft surface 34. Since the dust particle core is an electrical conductor, any net electrical charge in the core must lie on the surface. The electric field 40, between the accelerating electrode 30 and the aft surface 34, depends on the shape of the accelerating electrode 30, the shape of the aft surface 34, the separation of the accelerating electrode 30 and the aft surface 34, and the difference in potential between the two. To obtain maximum charge on the particle P, the maximum attainable electric field on the aft surface is desirable. Under these conditions, the highest achievable electric potential is desired along with the smallest possible separation between the aft surface 34 and the accelerating electrode 30. In addition, the aft surface 34 may be made pointed and small in size compared to the surface of the accelerating electrode 30 in order to provide a local high strength electric field. On the other hand, the accelerating electrode should be smooth and free of any sharp edges or points to minimize local high electric field intensities. This latter consideration may be especially important when the accelerating electrode 30 is operated at negative potential in order to minimize current losses due to field emission of electrons. A magnetic force, $F_m$, acts on the particle due to the magnetic attraction of the dust core. When the electric and magnetic forces on the charged dust particle P are equal, i.e. $F_e = F_m$, the particle will detach itself from the remaining dust expellant surface 34. As the particle traverses the distance to the accelerating electrode, the magnetic force $F_m$ decreases rapidly because of the increasing distance from the core. Thus, as the particle P traverses the distance from the aft surface 34 to the plane of the accelerating electrode it has attained a relatively high velocity, such that its momentum will carry it in a aft direction past the accelerating electrode 30.

Since the propulsion device shown in FIG. 1 is for discharging positively charged particles, it tends to gain a negative charge unless electrons can be emitted. For this reason, an electron gun or emitter 48 is provided so that at some finite distance aft of the device, the positive and negative charges will neutralize.

A focusing electrode 24 may be utilized and may include a suitable power supply 24 connected to a common ground 26.

It may be desirable to provide a piston 50 which can be moved in an axial direction, for example, by means of a rack 52 and a pinion 54, which in turn may be driven by a suitable motor 56. This feature may be desirable in order to maintain the location of the charging surface 34 of the core at a predetermined distance from the focusing electrode 24 and the accelerating electrode 30.

FIG. 2 shows a device having a plurality of cores 60 and 62, the construction of each being substantially identical to the construction shown in FIG. 1. In this instance the power supply 64 will provide a positive charge at 66 and a negative charge at 68 on the surface of each of the cores 60 and 62, respectively. In this case, both devices provide a propulsive thrust while obtaining the same result as in FIG. 1 where a single core provides propulsive thrust and an electron emitter is necessary to maintain vehicle charge neutrality.

FIG. 3 is substantially identical to FIG. 1 excepting that the core 70 is charged by means of an A.C. power supply 72. In this case, a certain time-varying voltage, $V_c$, is maintained by the core 70 and accelerating electrode 74. Intermittent pulsations of negatively and positively charged particles, as for example 76 and 78, are then obtained.

In this case there will be intermittent groups of charges of different sign emitted in an aft direction. Eventually, at some finite distance, these charges may intermingle to neutralize. In this way, a separate electron discharge mechanism is not required.

FIG. 4 is a combination of two cores 80 and 82, of the type shown in FIG. 3, but each of the cores is emitting pulsations of opposite sign at predetermined intervals.

FIG. 5 illustrates that it is necessary to achieve a certain absolute voltage field, $V_c$, before a charged particle is formed and accelerated in an aft direction. Therefore, for a predetermined period of time, each of the cores is discharging positively charged particles, at the peak periods.
of operation 90 and 92, and negatively charged particles at the trough periods of operation 94 and 96. During
interim operation, no particles are discharged in an aft
direction.
FIGS. 3 and 4 devices provide automatic neutralization
of the vehicle charge and eliminate the need of an electron
emitter.

As a result of this invention, a very simple propulsive
device has been provided which produces high thrust at
moderate current levels and has high efficiency without
appreciable thermal losses. Furthermore, no tankage or
boil-off losses as usually encountered in other propulsion
devices are experienced, and yet there is provided a simple
expellant feed, storage and handling system.

Although several embodiments of this invention have
been illustrated and described, it will be apparent that
various changes may be made in the construction and ar-
range ment of the various parts without departing from the
scope of this novel concept.

What it is desired by Letters Patent is:
1. A propulsive device comprising a source of particles
capable of being electrically charged, a casing forming a
container for said source including an aft opening, mag-
netic means for maintaining said particles positioned in
said casing, a power supply for charging said particles, and
electrode means located at a predetermined distance down-
stream of said opening for accelerating particles from said
source in an aft direction, including electrical means con-
ected thereto.

2. A propulsive device comprising a source of particles
capable of being electrically charged, a casing forming a
container for said source including an aft opening, means
for maintaining said particles positioned in said casing
including means for producing a magnetic field passing
through said particles, a power supply for charging said
particles, electrodes located at a predetermined distance
downstream of said opening for accelerating particles from
said source in an aft direction, including electrical means
connected thereto, and means for electrically neutralizing
the particle stream so accelerated at a predetermined dis-
tance downstream of the discharge point from said open-
ing.

3. A propulsive device according to claim 2 wherein said
means for neutralizing includes an electron discharge de-
vice.

4. A propulsive device according to claim 2 wherein said
means for neutralizing includes a second propulsive
device discharging particles having an electrical charge of
opposite polarity that than of said first-mentioned particles.

5. A propulsive device comprising a source of particles
capable of being electrically charged, a casing forming a
container for said source including an aft opening, mag-
netic means for maintaining said particles positioned sub-
stantially immobile in said casing, a power supply for
charging said particles, electrode means located at a pre-
determined distance downstream of said opening for ac-
celerating particles from said source in an aft direction,
including electrical means connected thereto, and means
for neutralizing the particles so accelerated at a predeter-
mined distance downstream of their discharge point from
said opening.

6. A propulsive device according to claim 5 wherein said
means for neutralizing includes an A.C. power supply
for discharging pulses of oppositely charged particles.

7. A propulsive device according to claim 6 including a
second propulsive device located adjacent to said first-
mentioned propulsive device and discharging charged par-
ticles in pulses of alternately opposite polarity at a pre-
determined frequency.

8. A propulsive device according to claim 7 wherein said
predetermined frequency of said second device is the
same as that of said first device.

9. A propulsive device comprising a source of ferro-
magnetic or paramagnetic particles capable of being elec-
trically charged, a casing forming a container for said
source including an aft opening, magnetic means for
maintaining said particles positioned substantially immo-
 bile in said casing, a power supply for charging said par-
ticles, and electrode means located at a predetermined
distance downstream of said opening for accelerating par-
ticles from said source in an aft direction, including elec-
trical means connected thereto.

10. A propulsive device according to claim 9 wherein said
means for maintaining particles within the casing until
accelerated therefrom includes a magnetic field.

11. A propulsive device comprising a source of ferro-
magnetic or paramagnetic particles capable of being elec-
trically charged, a casing forming a container for said
source including an aft opening, means for maintaining
said particles positioned substantially immobile in said
casing including means for producing a magnetic field
passing through said particles, a power supply for charg-
ing said particles, electrodes located at a predetermined
distance downstream of said opening for accelerating par-
ticles from said source in an aft direction, including elec-
trical means connected thereto, and means electrically
for neutralizing the particle stream so accelerated at a
predetermined distance downstream of the discharge point
from said opening.

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