

# Electric propulsion technology for nanosatellites

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Modern developments of propulsion systems for microsattellites include an interesting topic of electrospray propulsions. It is a type of electric jet propulsion system that uses an electric field to accelerate non-metallic particles. The propellant in the form of microparticles flows through the capillaries to the area of the electric field, where it gets accelerated and creates a reactive effect. These principles and experimental results are shown in detail in publication [1].

The disadvantage of these propellers, like most jet systems, is the limitation on the amount of propellant on board the vehicle. It is proposed to consider the options for the circulation of the propellant in a closed cycle.

Obviously, for vehicles of complex design, it is possible to organize forced circulation of the reactive mass. This scheme is shown in Fig.1, previously considered by the author in 1996 [2].

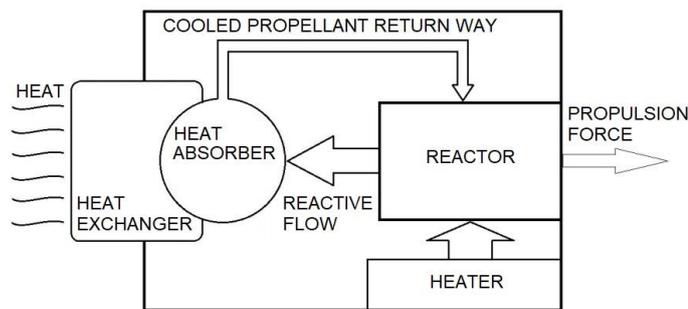


Fig. 1 Closed-loop reactive flow vehicle concept

For microsattellites, we can simplify the design by providing natural circulation of the working fluid or gas. An interesting solution to this problem can be found by drawing an analogy with the ideas of Thomas T. Brown, US patent number 3,187,206 dated June 1, 1965, application dated May 9, 1958. Figure 2 shows a diagram of this patent. The driving force is created when an electric field gradient acts on solid dielectric particles in an electric capacitor. For the variant with a liquid dielectric, conditions of circulation of dielectric particles in a closed volume are possible. With a successful solution of this problem, the operation time of such a propulsion drive is significantly increased, since the propellant is not consumed but it is circulating in the system.

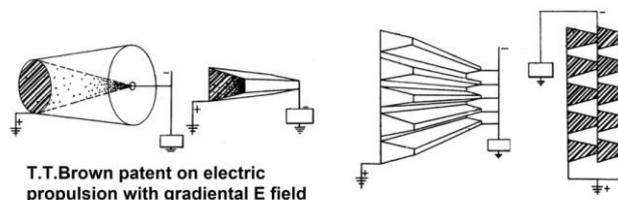


Fig. 2. Drawing from US patent number 3,187,206

In 1994, the author made some experiments in his home laboratory with a simple design, which is shown in Fig. 3. A sharp electrode is placed in a metal case, which is partially filled with a liquid dielectric.

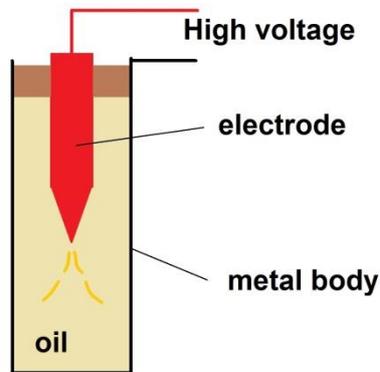


Fig. 3. Scheme of Frolov's experiment 1994

Vegetable oil was used in the experiment. The power supply voltage reached 10 kilovolts in a pulsed unipolar mode. Axial (vertical) propulsion force was detected when the power source is On. The reason for this force is the flow of liquid dielectric particles from the tip of the electrode. The effect can be called "internal emission".

The optimal shape of the body for creating circulation of a liquid or gas dielectric in this design can be the shape of a pear, Fig. 4.

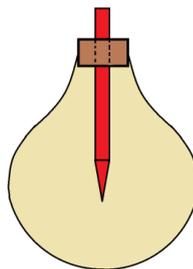


Fig. 4 A variant of the Frolov propeller body in the shape of a pear

The use of nanotechnology makes it possible to create conditions for the internal emission of propellant particles at a much lower power supply voltage than was shown in the 1994 experiment. In Fig. 5 shows a schematic diagram of a design in which emission occurs from the surface of an electrode covered with vertical nanotubes.

Note that not only liquid, but also certain substances in a gaseous state or in the form of vapors can work here as a propellant in this design.

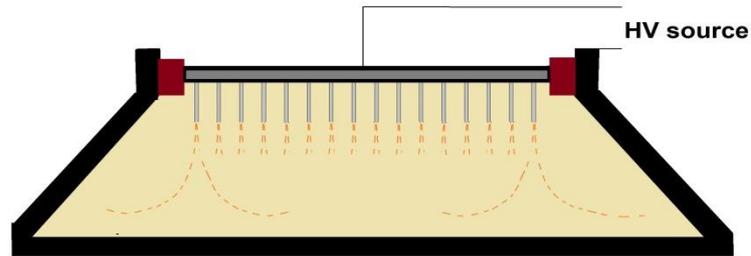


Fig. 5 Design option with nanotubes as emitters

The author invites partners to organize joint experiments on this topic, patent and commercialize the results.

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#### References

1. Christopher Tacon, UNIVERSITY OF SOUTHAMPTON Applications and Principles of Electro spray Spacecraft Propulsion, 2019.
2. Frolov A.V. report "The concept of gravity and experiments" at the conference "New ideas in natural science", 1996, St. Petersburg.