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Free flights to other planets

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Abstract

In several important previous works [1,2,8-24], each based on the laws of conservation of energy and momentum, the author proposed a new type of rocket engine. The innovated rocket engine extracts energy from the atmosphere as it moves through the atmosphere and uses the harnessed energy to create a powerful propelling thrust. The author shows that if the mass of gas from which the engine is repelled is several times greater than the mass of gas that the engine brakes when receiving energy, then the thrust created by such an engine will be positive. This engine is capable of propelling aircraft to speeds of capable of reaching outer space. In addition, a direct compressor and a motor-generator were invented, in which compression and expansion – the generation of electricity, is produced by an electric field. The author also invented an external rocket-electric motor. All this can make a revolution not only in interplanetary space, but also in future aviation. The cost of fuel is about half the cost of a passenger's ticket in current aviation and almost 90% of the cost of a vehicle-to-space launch. The author uses the word "free" flight or launch in the sense of "without fuel consumption".

Keywords: dipole electric rocket engine.

Introduction

Since the late-1950s, people have been flying from Earth into outer space and a few have even visited the Earth's satellite, our luminous close-by Moon. But all these achievements were associated with such huge expenses for infrastructure and personnel as well as a lot of mined and manufactured material that only the richest country in the world, the United States of America, could afford. The first landing of 2 astronauts on the Moon in 1969 cost the US $136 billion (in 2005 prices). Each subsequent launch cost $1.2 billion in the prices of that time. A total of 6 launches to the Moon with astronauts were made before 1972. The launch was carried out by a 3-stage Saturn-5 rocket. The first stage of this rocket weighed almost 3000 tons, had a thrust of 33400 kN and gave the rocket a necessary velocity of 2.86 km/sec. The second stage had a thrust of 5115 kN and increased this speed to 6.84 km/s, and the height to 185 km. The third stage had a thrust of 1000 kN and brought the mass of 47 tons to the planet-escape flight path and speed to reach the Moon. The entire one-way flight lasted 12-13 days, and the time spent on the Moon was 1-3 days. This was a Grand achievement that no side of the World can repeat for half a century.

Real space exploration in the sense of mass flights of tourists to near-earth orbit, scientists to the Moon and Mars, automatic satellites to distant planets and their satellites, can only be conducted in future if the cost of space-flight can be reduced by hundreds or thousands of times. The author's research and inventions are dedicated to this goal.

Description

The main goal of the author is to reduce the cost of aviation and space-flights as much as possible. How does the author try to achieve this goal? First. His plan gets rid of a huge amount of expensive, cryogenic or toxic rocket fuel. Liquid oxygen and hydrogen require cryogenic installation and evaporate during long-term storage. In the event of an accident, even iron burns in oxygen. Dimetilgidrazina poisonous. A smart reader will say that a nuclear engine will provide unlimited energy! But a nuclear reactor gives off powerful and deadly radiation. So the radiation is unacceptable not only for living beings, but also generates radioactive isotopes in the matrials of the cosmic ship or space-ship. It is necessary to apply heavy dense protection against radiation, which eats up the advantages of a nuclear reactor. Not to mention its gigantic complexity.

The author solves this problem by using an new type of rocket engine [1,2, 8-24], which extracts energy from the planet's enveloping atmosphere and repels, thus, the rocket vehicle out of the atmosphere. In practice, the proposed rocket engine can fly and accelerate to cosmic speeds in any atmosphere. Almost all the planets in the solar system, with the exception of Mercury (and Earth's Moon), have atmospheres. The atmosphere of Mars is very thin and requires more time to accelerate and decelerate, but it can also be a region or human mobility as aviation! The gaseous composition of the atmosphere does not matter! The second important point is that the proposed Engine can be external to the aircraft, connected to it only by an electric field and can cover a large volume.

An important advantage of the proposed device is also its versatility and reusability. One and the same device can fly to different planets without alteration and serve continuously for many years. It is known that all giant and very expensive rockets are disposable and are turned into debris after each flight. However, Elon Musk promises to create a rocket, the first stage of which will land robotically and markedly reduce the cost of launching by 2-3 times. But this is not a truly drastic solution to the problem. And it is achieved by reducing the field load.

The proposed aircraft is similar to an airplane: it can fly to any point and fly for several years.

The proposed device is shown in Fig. 1. Although the aircraft looks like a supersonic aircraft (Fig.1A), it is fundamentally different from previous designs. The external motor has a dipole circuit, operates on the principle of an electric field and uses a high-voltage current. The electrodes (poles of the main dipole) are located at the beginning and end of the vehicle's fuselage. The auxiliary dipole (generating electricity) electrodes are located in the nose and approximately ¼ - ½ the length of the fuselage. Injectors 3 heavy charges (charged ions) are located in the nose of the fuselage. Injectors of negative charges (electrons) in the area of the second dipole electrodes. Injectors 3 inject charged ions. The ions accelerate and create a stream of ejected gas that moves the aircraft and keeps it, both at takeoff and landing, hovering motionless in the air. To neutralize the charge, electrons are injected at the end of the local flow. A light electrostatic generator driven by a conventional motor generates the sufficient amount of electricity for hovering. Due to the large area of the dipole engine, the fuel consumption for hovering is less than that of a helicopter. By adjusting the thrust of individual sections of the dipole, the aircraft styled vehicle can control its position and fly at low subsonic speed like a helicopter. To create a significant horizontal motion speed, the end electrodes 3-4 are activated, which creates a powerful electric field 6 around the fuselage (Fig. 1C). Ion injectors 3, located in the front of the fuselage, are turned on and the ions accelerate a huge flow of air, the diameter of which is approximately equal to the length of the fuselage. Thanks to this, we obtain a very low fuel consumption compared to a conventional screw, and even more so an air-jet (especially a special supersonic) engine. This scheme is appropriate for short-range aircraft. But it is also good for mass rapid long-range ballistic flights and mass or tourist flights into outer space.

FL-F1

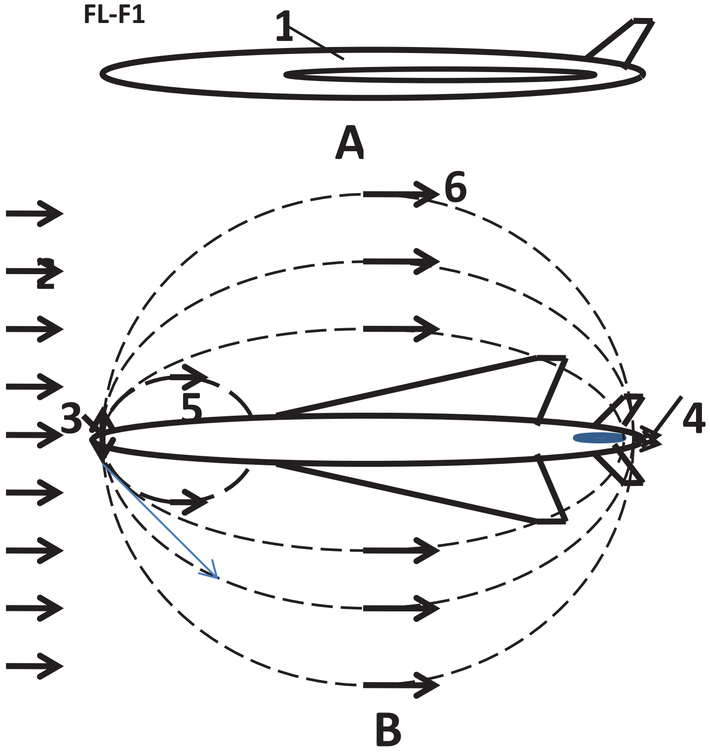

Fig. 1. Hypersonic (outer space) ion-electric dipole device with vertical take-off and landing and with an ion-field engine. *Notation*: **A** – side view of the apparate, **B**-top view of the apparate, 6-electric field around the apparate and the trajectory of the ions. 1- view of the device, 2-oncoming atmospheric flow, 3-ion injection into the electric field in flight mode and stationary hovering in the air (takeoff and landing), 4 – electron injection, 5-6 – electric field lines and ion movement, 3 – ion injector, 4 – electron injector.

The device usually starts as follows (Fig. 2). it is installed vertically or at an angle of about 45 degrees to the horizon. Above it, a mast is installed vertically or at the same angle, carrying sliding contacts.

FL-F2

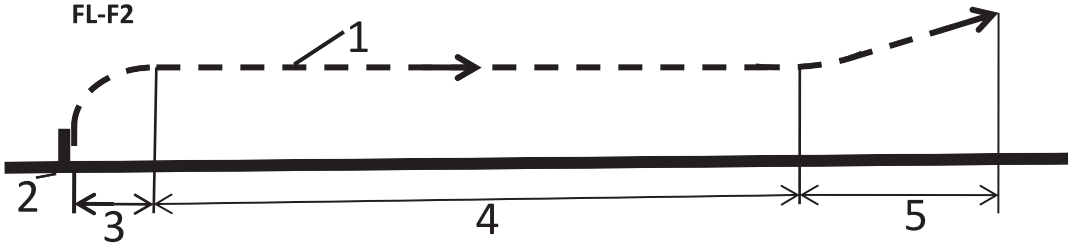

Fig.2. Start of the space flight. *Designations*: 1-acceleration trajectory in the atmosphere, 2-Launch mast with sliding contacts, 3-vertical launch, 4 – acceleration section in the atmosphere, 5-Spacewalk.

Mast delivers electrical energy nikodemou to inclined (or vertical start).

Starting at a speed of 100 -150 m/s or more, the trajectory curves to the horizontal direction and the proposed field dipole engine is activated. At low speeds, the wing pulls the device upwards. At high speeds, when the centrifugal force exceeds the weight of the aircraft, the wing creates, contrarily, a negative lift to keep the aircraft in stable horizontal flight in a dense atmosphere. If the device contains people, the acceleration can be limited to 3g. When the desired speed is reached, the wing helps to force an exit from the planetary atmosphere at the desired angle. For more detailed calculations and estimates, see the Moon and Mars launch calculations.

Advantages of the proposed method.

These advantages, compared to existing aircraft and rocket space launch, are due to the new ion-field engine:

1. The ability to accelerate to comic speeds without fuel consumption.
2. The ability of vertical takeoff, landing and hovering like a helicopter.
3. High subsonic and supersonic flight speeds with low fuel consumption at launch.
4. The increase in payload due to the smaller amount of required fuel and the small weight ion-field engines. Efficiency.
5. The versatility of the aircraft. The same device can be used for short -, medium -, and long-range flights and outer space flights.
6. Capable of flying at high Earth altitudes (20-40 km).

Теория.

The theory of the field high-speed electric motor proposed by the author was described by the author in many of his works [1,2, 8-24]. The main advantage of the proposed engine: at high speeds, the rocket engine itself receives energy from part of the flow 1 and uses it to repel the device from another (larger) part of the flow 2. That is, the rocket engine produces thrust at high speeds without on-board stored fuel consumption! Conclusions based on the laws of conservation of energy and momentums are given in previous works [1,2, 8-24]. Here we produce final formulas for the applicable estimates.

$$P_1 = 0.5\eta\rho S_1V^3,\quad T_2 = (P_1/\Delta V_2) = (0.5\rho S_2P_1^2)^{1/3},\quad D = P_1/V = 0.5\eta\rho S_1V^2,$$

$$T = T_2 - D - Mg/K,\quad \Delta V_1 = (2P_1/\rho S_1)^{1/3},\ \Delta V_2 = (2P_2/\rho S_2)^{1/3},\quad P_2 = P_1\,. \qquad (1\text{-}2)$$

Here P_1 – power getting from air flow 1, W; $\eta \approx 0.5$ wind coefficient efficiency; ρ – air (gas) density, kg/m^3; S_1- cross section braking flow 1, m^2; S_2 -cross section accelerated flow 2, m^2; V -speed of flight, m/s; T_2 – trust from flow 2, N; T -additional, useful trust, N; ΔV_1- change speed of breaking flow 1, m/s; ΔV_2- change speed of accelerated flow 2, m/s; D – drag of flow 1, N (Flow 1 is a breaking flow, flow 2 is an accelerating flow); M – mass of flight apparatus, kg; $g = 9.81$ m/s^2 – Earth gravity; K – aerodynamic coefficient of flight apparatus.

From equations (1-2) and $T = 0$, we can get the maximum start mass of aircraft, which started vertical and having the ion lift wing, for given power or need the engine power for given mass.

$$M = (1/g)(0.5\rho SP_1^2)^{1/3} \text{ or } P = [(Mg)^3/0.5\rho S]^{0.5}, \qquad (3)$$

where S – area of the ion lift wing, m^2; P – power of the lift ion engine, W. In flight equation M (3) and maximum V are next (for $T = 0$):

$$M = (K/g)[T_2 - D] = (K/g)[(0.5\rho S_2P_1^2)^{1/3} - P_1/V],\quad V = P_1(0.5\rho S_2P_1^2)^{1/3} - Mg/\mathrm{K},$$

$$or\ \ V = P_1(0.5\rho S_2P_1^2)^{1/3} - X,\quad X = C_d\rho aV^2S\,. \qquad (4)$$

Where X is drag of the flight apparatus, N; a is speed of sound, m/s; $C_d \approx 0.1 \div 1.$ – Coefficient of wave drags. The power needed to hover in place like a helicopter and minimal landng speed is

$$P_0 = \left[\frac{(Mg)^3}{0.5\rho S}\right]^{1/2}, \quad V_m = \frac{1}{\eta^{1/3}}\left(\frac{Mg}{0{,}5\rho S_2}\right)^{1/2}. \qquad (5)$$

Flight time. The time of flight from orbit to orbit along the trajectory of the minimum pulse is approximately equal to half the time of the full rotation of the planet. The time of the full rotation of the planet can be found in Table 1 or calculated using the formula

$$t = \frac{2\pi}{\sqrt{K_0}} a^{3/2}. \qquad (6)$$

Here *t* is period of the planet's rotation, sec; *a* is the semi-major axis of the ellipse, m; $K_0 = g_0 R_p^2$ (where R_p is radius of planet, g_o -surface planet gravity) is the planet's constant. For Earth $K_0 = 3.9862 \cdot 10^{14}$ m^2/s^2.

Calculation of minimum impulses for the transition from orbit to orbit.

The necessary impulses (velocity changes) for the transition from orbit to orbit can be calculated using the following formulas

$$V_p = \sqrt{\frac{V_1^2 + V_2^2}{2}}, \quad \Delta V = V_1\left(\frac{V_1}{V_p} - 1\right), \quad \Delta V' = V_2\left(1 - \frac{V_2}{V_p}\right). \qquad (7)$$

Here V_1 is speed of the first orbit, m/s; V_2 is speed of the second orbit, m/s; V_p is the average speed of the orbits.

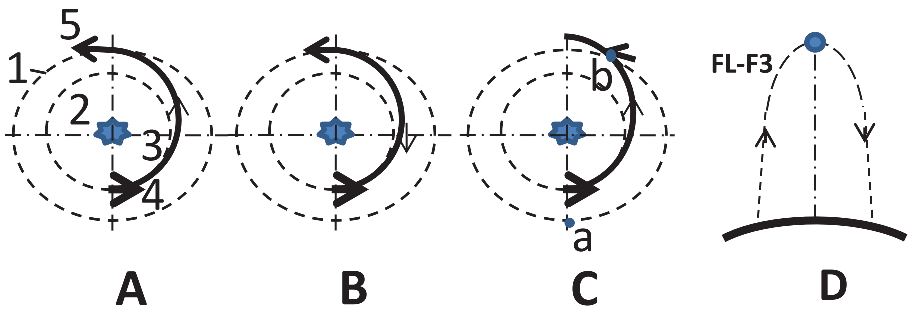

Fig. 3. Calculation of the minimum impulses for the transition from orbit to orbit. *Notation*: **A**-transition to a higher orbit (for example, Earth-Mars). 1 – higher orbit, 2-low orbit, 3-the Central body around which the planets or satellites rotate, 4-the acceleration pulse, 5-the top impulse of the ship. **B**-moving to a lower orbit (for example, returning from Mars to Earth). Here, the first braking pulse is made in the orbit of Mars, and the second pulse is made in the orbit of Earth. **C**-reduction of flight time at the expense of higher speed, **D**-flight to the satellite of the planet (for example, from Earth to the Moon).

Fig. 1C shows why the flight time decreases when the minimum pulse is slightly exceeded. The flight time is reduced not only by increasing the speed, but also by reducing the path. The length of half-orbit 1 from point "a “to point” b" can be 15-25% less than half of the orbit.

If only the ratio of the orbit radii $R = R_2/R_1$ is known, then the pulses can be calculated using the formulas

$$r = \frac{R_2}{R_1}, \quad \Delta V = V_1\left(\sqrt{\frac{2r}{r+1}} - 1\right), \quad \Delta V' = V_1 \frac{1}{\sqrt{r}}\left(1 - \sqrt{\frac{2}{r+1}}\right). \qquad (7)'$$

The “-“ sign on the pulse indicates that it is a braking pulse.

The acquired speed and mass consumption of a conventional rocket are calculated using the formulas

$$V=-w\ln\frac{M_k}{M_0},\quad \mu=\frac{M_k}{M_0}=e^{-V/w},\quad f=\frac{M_0-M_k}{M_0}, \tag{8}$$

where V is the increment of the rocket speed, m/s; w is the gas flow rate from the rocket, m/s; M_k is the final mass of the rocket, kg; M_0 is the initial mass of the rocket, kg; μ is the relative mass of the rocket body; f is the relative mass of the rocket fuel.

If the initial acceleration to the speed V_O = 100 m/s occurs along the mast with an overload $n = 3g$ and acceleration a = 30 m/s^2, then the length of the mast and the acceleration time are equal

$$S=\frac{v_o^2}{2a}=\frac{100^2}{2\times 30}=167\,m,\quad t=\frac{v_o}{a}=\frac{100}{30}=3.3\,\text{sec}. \tag{9}$$

If you use an inclined start and the speed does not exceed 100 m/s, then in the first approximation, you can neglect the atmosphere and the distance to the top of the trajectory, the maximum height and speed at the top are calculated using the formulas

$$s=\frac{v_0^2\sin 2\alpha}{2g},\quad H=\frac{v_0^2\sin^2\alpha}{2g},\quad v_k=v_0\sin\alpha, \tag{10}$$

where s is the distance to the top point (Fig. 2, distance " 3"), m; α is the initial angle, v_o is the initial velocity, m/s; g is the gravitational constant, m/s^2; v_k is the final velocity, m/s. For v_o=100 m/s and α = 45°, we get s = 500 m, H = 250+167= 417 m, v_k = 70 m/s.

For a ship with ordinary people, the overload cannot exceed $n=3g$, and a=30 m/s^2. At this overload and final speed, the acceleration length and time will be equal

$$s=\frac{V^2}{2a},\quad t=\sqrt{\frac{2s}{a}}, \tag{11}$$

As a result, we get:
V= 6 km/s, s = 600 km, t = 245 seconds. Ballistic trajectory.
V= 8 km / s, s = 1000 km, t = 258 sec. Satellite.
V= 12 km/s, s = 2400 km, t = 283 sec. Exit from Earth's gravity well.
V=16 km/s, s = 8533 km, t = 569 sec. Escape from the gravity of the Solar system.

Useful formulas. Formulas are useful for quickly estimating the thrust and path length of ions (molecules) :

$$T=\frac{1}{2}\eta\rho S_1V^2\left[\left(\frac{S_2}{\eta S_1}\right)^{1/3}-1\right]-X,\quad l=\frac{kT}{\sqrt{2}\pi\sigma^2p},\quad If\ X\approx 0, then\ T>0, if\ \frac{S_2}{\eta S_1}>1, \tag{11a}$$

where l is the ion mileage, m; k = 5.67 W/(m^2·K) Bolsman constant; T is the temperature, K; $\alpha \approx (0.3 \div 0.35)\cdot 10^{-9}$ m is the ion diameter, m; p is the pressure, PA.

Flights to other planets.

The proposed method provides huge opportunities for flights to other planets from Earth.

First of all, these are completely free flights near all the planets of the Solar system and their satellites. Free delivery of satellites to planets and their satellites that have at lese dense atmospheres than Earth (such as Mars). [Of all the planets in the solar system, only Mercury has no atmosphere.] Free delivery of satellites to planets and their satellites that do have substantial dense atmospheres results. Free—that is, very low-cost—cargo delivery to planets and their satellites that have atmospheres is beneficially effected. Almost tens of tens and hundreds of times reduced the required burning during flights with return to Earth.

In addition, this invented means of spatial travel and transport has an excellent prospect for development, which scientists are working on in the automotive industry: if you create light electric energy storage devices, the proposed device will be able to accumulate braking energy in the atmosphere and any flights in outer space will be free (in the sense of virtually no fuel consumption).

Flight to Mars.

Let's estimate the main parameters of the flight to Mars (the starting mass of the ship is 100 tons).

1) To get out of The earth's gravity field to the tractor to Mars, we need speed:

$$V = V_2 + V_{1i} = 11200 + 3100 = 14300 \text{ m/s} = 14.3 \text{ km/s} , \qquad (12)$$

where V_2 is the second space speed of Earth, m/s; $V_{1\text{i}}$ is the speed of the first impulse of the transition orbit, m/s.

2) With a vertical start with a mast of H=170 m, acceleration 3g, the device will get a speed of V=100 m/s.

At this speed, it will easily switch to horizontal flight and from the engine AB (S_1=706 m^2, S_2=2860 m^2, p=1 kg/m^3) will get an acceleration of 1.67 g (see (1-2)):

$P_1 = 0.5\eta\rho S_1V^3 = 0.5\cdot0.5\cdot1\cdot706\cdot100^3 = 1.76\cdot10^8$ W; $T_2 = (0.5\rho S_2P_1^2)^{1/3} = 353$ ton, $D = P_1/V = 176$ ton,
X =10 ton, $T = T_2 - D - \mathrm{X} = 353 - 176 - 10 = 167$ ton, a=16.7 м/s^2, n =16.7/10.0 ≈ 1.67g. (13)

That is enough for the initial acceleration.

3) Check whether the AB engine can provide 3g acceleration in the middle section of the acceleration trajectory at a speed of V = 6 km/s and a flight altitude of H = 40 km (p = 4.10^{-3} kg/m^3)?

$P_1 = 0.5\eta\rho S_1V^3 = 0.5\cdot0.5\cdot4\cdot10^{-3}\cdot706\cdot6000^3 = 152\cdot10^9$ W; $T_2 = (0.5\rho S_2P_1^2)^{1/3} = 5100$ ton, $D = P_1/V = 2530$ ton,
X =0.78 ton, $T = T_2 - D - \mathrm{X} = 5100 - 2530 - 0.78 \approx 2570$, a=257 м/s^2, n =257.0/100 ≈ 25.7g > 3g. (14)

4) Check the traction on the final speed of V=14.3 km/s at altitude H = 80 km (ρ = 1.85$\cdot$10^{-5} kg/m^3)

$P_1 = 0.5\eta\rho S_1V^3 = 0.5\cdot0.5\cdot1.85\cdot10^{-5}\cdot706\cdot14300^3 = 9.53\cdot10^9$ W; $T_2 = (0.5\rho S_2P_1^2)^{1/3} = 134.8$ ton, $D = P_1/V = 66.8$ ton, X =237 N,
$T = T_2 - D - \mathrm{X} = 134.8 - 66.8 - 0.024 \approx 67.8$, a=6.78 м/s^2, n =6.78/10.0 ≈ 0.678g. (15)

By adjusting the ionizer flow rate and height we can ensure 3g acceleration over the entire trajectory acceleration in the Earth's atmosphere.

Upon its actual arrival in the gravitational field of Mars, the spacecraft will be captured by the gravitational field of Mars and, when falling on its thin gaseous carbon dioxide atmosphere, will develop the second cosmic speed of Mars about V_2 = 5 km/s. We show that this speed can be absorbed by braking in the Martian atmosphere using the AB engine. Take the density of the Martian atmosphere (CO_2 gas), $p = 10^{-2}$ kg/ m^3. Then when the engine is braking

$$P_2 = 0.5\eta\rho S_2V^3=0.5\cdot0.5\cdot10^{-2}\cdot2860\cdot5000^3=89.4\cdot10^{10} \text{ W}; \quad = P_2/V= 17900 \text{ ton}, \; X \approx 0 \text{ ton},$$
$$a=179 \text{ m/s}^2, \; n=17.9g. \qquad (16)$$

This solution is unacceptable for two reasons: a huge amount of energy will be released that cannot be quickly dissipated. Secondly, the acceleration of braking exceeds the 3*g* allowed for a person.

So we employ a different method, parachute braking. This method was developed by the author in one of his works [25] and calculations showed its effectiveness in a rarefied atmosphere. Take the area of the parachute *S*=3000 m^2 (diameter = 61.8 m). Then the resistance of the parachute and the acceleration will be

$$X=0.5C_d\rho aVS=0.5\cdot1\cdot10^{-2}\cdot3\cdot10^2\cdot5\cdot10^3\cdot3\cdot10^3=22.5\cdot10^6 \text{ N}=2250 \text{ ton}, \; a=22.5 \text{ m/s}^2, \; n=2.25g. \; (17)$$

Which is entirely acceptable.

As you can see, the braking is significant and it is possible to slow down if the path is long enough.

Find the minimum speed of the vehicle (hovering speed during vertical landing, (5)) in the Martian atmosphere

$$V_m = \frac{1}{\eta^{1/3}}\left(\frac{Mg}{0,5\rho S_2}\right)^{1/2} = \frac{1}{0.5^{1/3}}\left(\frac{10^5\cdot3.7}{0.5\cdot10^{-2}2860}\right)^{1/2}. = 203 \approx 200 \;\; m/s. \qquad (18)$$

Formula (18) gives that for a soft vertical landing on the LRE at this speed, approximately 3.5% of the rocket mass will be required (the rate of expiration of combustion products is taken *w*=3000 m/s.

Bottom line: the AB Rocket requires only 6.5-7% of the mass of conventional fuel for soft-landing delivery of cargo to Mars.

An artifact from Mars.

Consider now the return of astronauts from Mars on the same ship. Here the situation is much more complicated. The fact is, that when moving to its low orbit, the impulses must be braking. And brake impulse cannot be deducted from the second space velocity while the spaceship will not leave the gravitational field of a planet. That is, the first brake pulse, it is necessary to give the outside atmosphere. The creation of thrust by the AB engine in the void, the emptiness that is outer space, is essentially impossible. According to formula (7), these pulses are equal to

$$V_p = \sqrt{\frac{V_1^2+V_2^2}{2}} = \sqrt{\frac{24^2+30^2}{2}} = 27.2 \; km/s, \quad \Delta V = V_1\left(\frac{V_1}{V_p}-1\right) = 24\left(\frac{24}{27.2}-1\right) = -2.81 \; km/s,$$
$$\Delta V' = V_2\left(1-\frac{V_2}{V_p}\right) = 30\left(1-\frac{30}{27.2}\right) = -3 \; km/s. \qquad (19)$$

Let me remind you that V_1 and V_2 are the orbital velocities of planets (see Table 1). The second pulse relates to the earth's orbit.

This pulse can be absorbed by the earth's atmosphere. And the first pulse is -2.81 km/s, currently, we can make a regular LRE engine. The fuel consumption will be (formula (8), *w* =3 km / s):

$$\mu = \frac{M_k}{M_0} = e^{-\Lambda V/w} = 2.72^{-2.81/3} = 0.39\,. \tag{20}$$

This means that the pulse will spend 1- 0.39 = 0.61 the share of fuel from the mass of the device. If we add 0.065 for vertical landings on Mars and 0.01 for vertical landings on Earth, then the share of conventional fuel will be 0.685=68.5% or 2/3 of the mass of the spacecraft 100 tons. Compare that to 99% of the 3,000-ton mass of the Appolon rocket before it went to the Moon. The maximum rate of entry into the Earth's atmosphere can be V_2±3=11.2±3=14.2 km/s. But the AB engine can in principle extinguish any speed, extending the braking path to speed vertical hovering 30 m/s. According to formula (20), a vertical landing on the Ground will require fuel of about 1% of the vehicle's mass at the moment, i.e. 350 ÷ 400 kg.

Result: The proposed device is capable of delivering 96% of its mass to Mars with a soft landing and returning 30% of its initial mass to Earth. No spacecraft, even one in science fiction, is capable of doing this at the present time. The accelerated flight to Mars (and back) will take 7-8 months.

Flight to the Moon.

The international community plans to first establish an International base on the Moon and only then plan a crewed flight to our Solar System's planet Mars. From the point of view of modern technology, this is the only way to explore Mars. The moon is thousands of times closer to Earth and seems more re-accessible. The difficulty is only in the money and benefits from the development of the moon (and Mars). We are well aware of the conditions on all the planets and the moon. Only some scientists will agree to live there, and only temporarily.

Let's briefly consider the main data of the lunar flight of the device with the proposed engine. As a spacecraft, we will take the same one as for the flight to Mars with an initial mass of 100 tons. We will not consider vertical take-off, landing, and acceleration (deceleration) in the Earth's atmosphere to the second earth's cosmic velocity V_2=11.2 km/s. They are completely similar to the flight to Mars. The difference from Mars is that the Moon does not have an atmosphere and descent (and take-off) from it will require fuel consumption to extinguish (create) the second cosmic speed of the Moon V_2=2.4 km/s.

This expense is equal to

$$\mu = \frac{M_k}{M_0} = e^{-\Lambda V/w} = 2.72^{-2.4/3} = 0.44\,; \qquad \mu = \frac{M_k}{M_0} = e^{-\Lambda V/w} = 2.72^{-4.8/3} = 0.2\,. \tag{21}$$

The first result shows that when delivering cargo 100-0.44=56% of the ship's mass should be conventional fuel for the LRE. The second result is that if astronauts want to return or deliver lunar raw materials and manufactured items to Earth, the fuel must be 100 – 20 = 80% of the spaceship's mass, or 80 tons. The flight of the Apollo rocket to the Moon required more than 3,000 tons of fuel. Compare this also with 6.5% for cargo delivery and 70% of the fuel mass for a launch from Mars. You can see that a flight to Mars on the proposed engine is more profitable than a flight to the Moon, due to the fact that Mars has an atmosphere. The flight time to the Moon is about 12-13 days.

Estimation of flow of mass and energy of the ionizer.

The mass of the Ion. Let's assume that the engine power is 5 MW. Let us take Lithium-7 as an ionizer. Consumption of N_1 ions per 1 kg of air

$$N_1 = Q/q = 5.74/1.6{\cdot}10^{-19} = 3.59{\cdot}10^{19}, \quad 1/s ,$$

here Q is the charge of 1 kg of air, C; $q = 1.6{\cdot}10^{-19}$C the charge of ion 1, C. Mass of ions in 1 kg of air is

$$M_1 = N_1 n m_p = 3.59{\cdot}10^{19}{\cdot}7{\cdot}1.67{\cdot}10^{-27} = 4.19{\cdot}10^{-7} \text{ kg/kg, air. } ,$$

where n is number of neurons the Lithium-7; m_p is mass of 1 neuron, kg.

Therefore, the power of the 5 MW ionizer consumption will be

$$G_i = G_a M_1 = 7.62{\cdot}4.19{\cdot}10^{-7} = 3.15.10^{-6} \text{ kg/s} = 11.4 \text{ gr/hour} .$$

Here G_a = 7.62 kg/sec is the air consumption of a conventional engine 5 MW. The fuel consumption of an aircraft conventional engine (having efficiency 100%) with a power of 5 MV is equal to

$$G_f = P/q = 5{\cdot}10^6/40{\cdot}10^6 = 0.125 \text{ kg/s} = 450 \text{ kg/hour}.$$

where q is the calorific value of kerosene MJ/kg.

Energy of ionization. The ionization energy is v = 5 eV. For an rocket engine with a power of 5 MV, i.e. current i = 43.74 A the energy of ionization is

$$P_i = iv = 43.74{\cdot}5 = 219 \text{ W}.$$

Therefore, the influence of the mass and energy consumption of the ionizer on the flight characteristics of the engine can be ignored. Many elements can be ionizers.

Note that to launch 1 metric ton of cargo in the low orbite, you need at least 16 – 20 tons of expensive, toxic and explosive fuel. The cost of launching 1 ton of cargo into space is 10 -15 million USA dollars. Even if Elon Musk reduces the cost of a normal launch by 2-3 times – this is not the solution to the financial expense problem, because the old method needs to drastically reduce the cost of launching, for example, by 100 times is simply impossible.

In addition, the proposed method would allow launches and operations of a spacecraft for years, like durable commercial and military airplanes.

The space flight of one rich human tourist (100 kg) cost 30-40 million USA dollars a decade ago. So far, only about even tourists have actually visited space. By now, the price has risen to $100 million, but the queue is still growing. Companies are developing new services: flying around the Moon, going into space, relaxing in an inflatable space hotel, flying around the Earth, etc.

High-speed cheap flights from continent to continent. The proposed apparate can be used for flights to any long distances near the Earth, for example, New York – London, Paris, Moscow, Beijing, travel around the Earth, etc. The flight is performed in the same way as the spacewalk. The aircraft accelerates in the atmosphere to a high speed (for example, up to 6 km/s). In the final section the trajectory due to the wings and thrust is deflected up to 30° and the device goes on a ballistic trajectory.

The data of the planets.

Below are the data of the planets that are not necessary for evaluating the flight.

Table 1. Data Of The Planets Of The Solar System.

lanetes	Distance to Sun **mln. км.**	Avarage speed in orbit **км/sec**	First cosmos speed **км/sec**	Second cosmos speed **км/sec**	Acceleration on planet **g** **m/sec^2**	Pressure, **bar** and basis atmospheric composition	Curculation period around Sun **Earth years**	Number of satellites	Radius of planetes **Thousend км.**
Mercury	58	48	3.1	4.3	3.7	-	0.241	0	2.43
Venus	108	35	7.328	10.36	8.7	P=93, CO_2	0.615	0	6.05
Earth	149.6	30	7.9	11.2	9.81	1, N_2	1.	1	6.378
Mars	228	24	3.56	5.03	3.7	0.006, CO_2	1.68	2	3.39
Jupiter	778	13	42.58	58	25	+, H_2	11.86	79	70.85
Saturn	1426	9.6	25.5	35.5	14	+, H_2	29.48	82	60.1
Uranus	2870	6.81	15	21.3	9.7	P=200, H_2	84.01	27	24.6
Neptune	4500	5.4	18	25	3.5	50, H_2	164.74	14	23.5
Pluto	5900	4.7	0.856	1.21	0.617	P=1 Pa, N_2	248.09	5	2.2
Sun	-	-	438	618	273.8	H	-	8	696
Moon	To Earth **384,440 км**	On Earth's orbite 1 км/сек	1.68	2.38	1.62	-	**27.3 days** around Earth	-	1.736
Satellie of Saturn **Titan**	To Saturn 1.22	On Saturn's orbite **5.57 км/сек**	1.867	2.639	1.3452	1.5, N_2	**16 days around Saturn**	-	2.576

\+ - Jupiter and Saturn are gas giant planets with a low upper atmosphere temperature.

Estimates of some parameters of planetary flights. Possible problem.

Distance and time of acceleration of the vehicle in the atmosphere. Acceleration of vehicles with healthy normal people is limited by overload $n = 3g$, acceleration $a = 30$ m/s^2. By adjusting the flow rate of the ionizer, we can always lower the maximum rocket thrust to the desired and needed value. This will only affect the acceleration and deceleration distance. It is also easy to change the thrust direction by switching the poles. The maximum thrust depends on the ionizer flow rate and atmospheric density. The ionizer consumption during flight in the atmosphere is small and we neglect it in our estimates. Note that the proposed engine can also operate in the void as a conventional ion engine, if there is an energy source. AB the engine converts braking energy into electricity. If there is no necessary storage of this energy, then you have to slow down the braking speed in order to have time to disperse it in space. If the device, in the future, will have the necessary storage of energy, it can fly around the planets indefinitely.

Possible difficulties*. When testing the proposed engine in its initial version (Fig. 1), a problem may arise – low thrust compared to the theory. This is due to the fact that the ions do not have time to spread evenly over the entire volume of the electric field. To counteract this unwanted phenomenon, the author suggests "whiskers" (Fig.4B,4C), which contain many injectors of ions and electrons, and also make the electric field more uniform.*

In tubular engines (see [1,2, 8-24] , these can be thin grids at the inlet and outlet. Their reactivity is small, but they can make a mixture of charged and neutral particles more uniform.

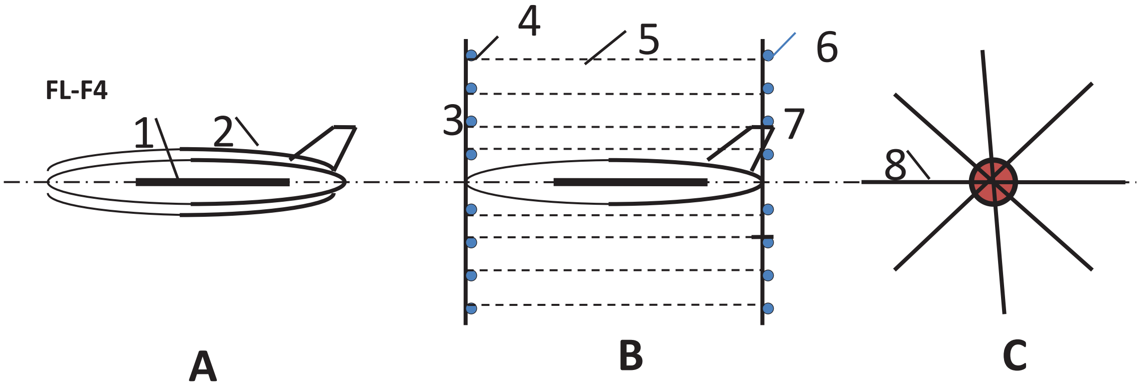

Figure 1

Fig 4. *An aircraft with an AB engine.* Designations: ***A****-apparatus in flight with a folded ion and electron injector;* ***B****-apparatus with open ion and electron injectors (side view);* ***C*** *– front view of the apparatus with open injectors; 1 – apparatus; 2,3,7,8,4 – rods-holders of injectors; 4 – ion injectors; 5 – electric voltage lines; 6 – elktron injectors.*

Another method of delivering ions and electrons to an external ion engine is that the ions and electrons are delivered by powerful long-range injectors.

Discussion.

As these estimates show, the proposed rocket engine, if successfully further researched and industrially developed, means a huge breakthrough in aviation, space, rocket technology, transport and energy. This reduces the cost of delivering cargo and people to space by tens or hundreds of times, reduces the cost of long-distance flights, and opens up new opportunities for launching drone and crewed aircraft and spacecraft. The study and verification of the theoretical foundations of the proposed method is not difficult and can be carried out on desktop models and in existing wind-tunnels. The system only needs small sources of ions. The disadvantage of the proposed rocket engine is the lack of traction at the start—that is, at zero speed. However, if airfields are equipped with sliding contacts for power supply or detachable accelerators are used during launch, the aircraft can be accelerated to high-speed and launched from existing airfields (see [1,2, 8-24]). In addition, the devices can be launched vertically using a mast and ground-based power plants.
The same idea may be used in the wind energy and ground and sea transport.

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