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THE WORLD OF TOMORROW

New Concepts, Ideas, Innovations in Aerospace, Technology and the Human Sciences

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NOVA

Content

ABSTRACT

In last years the author and other scientists have published a lot of new concepts, ideas, and innovations in aerospace, science, and technology. These ideas promise the revolutions in aerospace, technology and human life.

In aerospace these include the new method of flight - AB levitation. This method allows humanity to flight as bird, riches a very high speeds and free flight to space; the electrostatic ramjet and beam space propulsions; electrostatic magsail; high speed solar sail; a transfer of electricity in long distance at space; the space thermonuclear propulsion, the new electrostatic engine which can be used as driver for space launcher and accelerator of space ships, as an engine in new electrostatic high speed train; etc.

In technology these include the new mini-thermonuclear reactor, utilization of high altitude wind energy, protection from tsunami, control of local and global weather, converting of deserts and polar Earth regions in 'evergreen' gardens, high altitude gas pipeline, and so on.

In human science there include electronic immortality of people.

New ideas in space/aviation may be useful for flights in space and in planet atmosphere. Some of these have the potential to decrease launch costs thousands of times, other allow the speed and direction of space apparatus to be changed without the spending of fuel.

The author summarizes some revolutionary concepts, ideas, innovations, and methods for scientists, engineers, students, and the public. He seeks attention from the public, engineers, inventors, scientists for these innovations and he hopes the media, government and the large aerospace companies will increase research and development activity in these areas.

PREFACE

The new concepts, ideas, methods, and innovation are only considered. There are a lot of problems that must be researched, modeled, and tested before these ideas can be developed, designed, built, and utilized. In offered book we describe some of them in aerospace, technology, and humanity. Most of ideas are described in the following way: 1) there is a brief explanation of the idea including its advantages and short comings; 2) then methods estimation and computations of the main system parameters, and 3) a brief description of projects, including estimations of the main parameters.

The first and third parts are in a popular form accessible to the wider public, the second part is requires some mathematical and scientific knowledge of technical graduate students. The book gives the main physical data and technical equations in attachment which will help researchers, engineers, students and readers make estimations for their projects. Also inventors will find the extensive field an inventions and innovations in this book.

The author has published a lot of new ideas and articles and macroprojects about aerospace, technology, and human future in recent years (see General References at the end of the book). That is, the way he seeks to draw more attention to new ideas than the old ideas that are covered in many publications and are well-known to scientist and the public.

The book mainly contains material from the author’s articles published in the last few years.

PART A. NEW CONCEPTS AND IDEAS IN AEROSPACE

Chapter 1

AB LEVITATOR AND ELECTRICITY STORAGE*

ABSTRACT

The author researched this new idea – support of flight by any aerial vehicles at significant altitude solely by the magnetic field of the planet. It is shown that current technology allows humans to create a light propulsion (AB engine) which does not depend on air, water or ground terrain. Simultaniosly, this revolutionary thruster is a device for the storage of electricity which is extracted and is replenished (during braking) from/into the storage with 100% efficiency. The relative weight ratio of this engine is 0.01 - 0.1 (from thrust). For some types of AB engine (toroidal form) the thrust easily may be changed in any direction without turning of engine.

The author computed many projects using different versions of offered AB engine: small device for levitation-flight of a human (including flight from Earth to Outer Space), fly VTOL car (track), big VTOL aircrat, suspended low altitude stationary satellite, powerful Space Shuttle-like booster for travel to the Moon and Mars without spending energy (spended energy is replenished in braking when ship returns from other planet to its point of origin), using AB-devices in military, in sea-going ships (submarimes), in energy industry (for example. as small storage of electric energy) and so on. The vehicles equipped with AB propulsion can take flight for days and cover distances of tens thousands of kilometers at hypersonic or extra-atmosphere space speeds.

The work contains tens of inventions and innovations which solves problems and breaks limitations which appear in solution of these very complex revolutionary ideas.

Keyword: *AB levitator, levitation, non-rocket outer space flight, electric energy storage, AB propulsion, AB engine, Bolonkin*.

* Published in http://arxiv.org on ruary 28, 2007 (search “Bolonkin”).

1. INTRODUCTION

Free flight in the atmosphere as by birds was the ancient dream of people without aircraft. During 1964, the author developed his first gravity control theory [1]. The first realistic method for electrostatic levitation was offered and theoretically developed in report [2] and published in [3] Ch.15.

However, the electrostatic levitation is possible only along special electrostatic lines. Man (car, track) cannot fly in any direction and to any place in the Earth. Riding a vehicle with air engine (propeller or rocket) for thrust, such persons cannot even imagine or feel himself as being like a bird.

The offered new revolutionary method does not have these defects. It allows flight in any direction in Earth's using the internal electricity storage. It does not depend on the environment of air, water, ground and does not pollute regions or the planet in any way. It can operate in vacuum, in the outer space surrounding any planet (space body) having a natural or artificial magnetic field. The momentum ratio of magnet dipoles the Jupiter, Saturn, Earth, Mercury, Mars are 20,000, 500, 1, 3/5000, 3/10,000 respectively. Mars' moon Phobos, Magnetic Stars, White Dwarf also have the magnetic field up B = 80,000 T. The neutron stars Magnetar have the magnetic field up 10^{11} T.

That can change the thrust direction without turning of the engine, levitate without expending energy. That spends energy only for lifting and to overcome air drag, but lifting energy is returning when the apparatus descends. We do not lose energy if we flight in space or at planet not having an atmosphere and return to the initial take-off place. We can free flight to Moon or Mars without loss of the summary energy from a Low Earth's Orbit if a space apparatus has a same weight. Energy spended for the acceleration of apparatus will be returned when apparatus is braking.

This work contains conventional sections: 1. The short description of the offered AB levitator (that also may be used as friendly environmental electric car and other vihicle engine), its works; 2) Theory of innovation, and 3) Projects estimations. The first and third expositive sections are destined for non-specialist readers, the second part **-** for specialists.

2. BRIEF DESCRIPTION OF NEW REVOLUTIONARY INNOVENTION

The offered method embraces tens inventions and innovations: magnetic devices, superconductivity devices, electricity storage, compensation of magnetic forces, use of strong matters, defence from magnetic field, concentration of magnetic field, increasing of magnetic intensity, cooling systems, in protection from space radiation, special design of magnetic and cooling devices, and many others. Some of them are briefly described below.

1. Note from theory. It is well-known from physics when the conductor is moved in magnetic field that has an electromagnetic force and voltage between its ends. This force is computed by equation:

$$d\bar{F} = i[d\bar{l}\bar{B}], \tag{1}$$

where small vector $d\bar{F}$ is force (in Newtons) of small element $d\bar{l}$ of vector wire (in meters); $\bar{B}$ is intensity of the magnetic field, in Teslas; i is electric currency, in Ampers. Square brackets [ ] note a vector production.

For straight wire the equation (1) can be written in form

$$\bar{F} = i[\bar{l}\bar{B}], \quad \text{or} \quad F = ilB\sin(\bar{l},\bar{B}), \quad \text{or} \quad F = ilB_n, \tag{2}$$

where F is force, N; i is electric currency, A; l is wire length, m; B is magnetic field strength, T; B_n is projection vector $\bar{B}$ on perpendicular to plate contains the vectors $\bar{l}, \bar{B}$. The direction of force may be found by left hand rule: if magnetic lines enter into the human hand's palm, the fingers show the direction of electric currency, then the pollex shows the direction of magnetic force.

The electric tension (voltage), U, is computed by equations

$$U = lvB_n, \tag{3}$$

where v is wire speed, m/s.

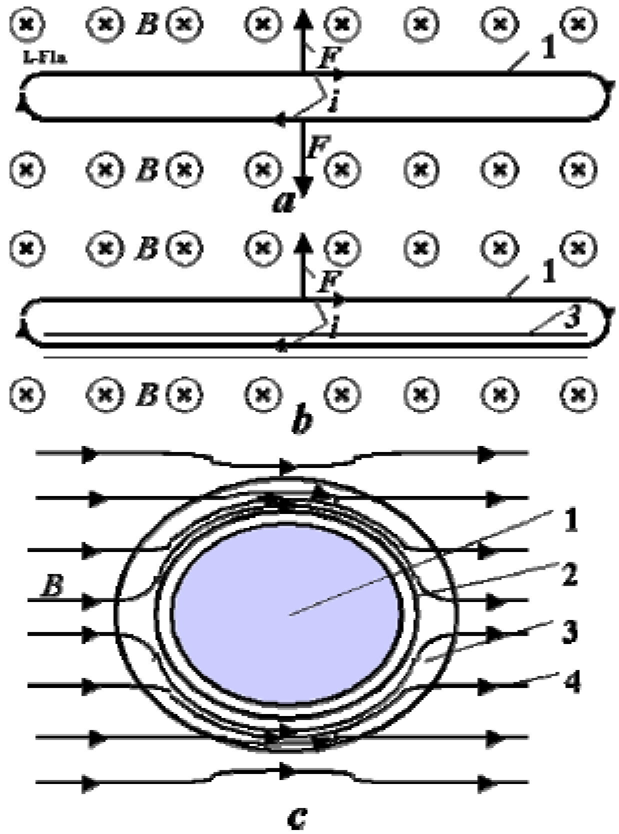
The force acts to the conductor and does not depend on wire speed. That explains why our devices can levite without movement.

The equations (1)-(2) allow easy computation of the force and voltage of conductor in magnetic field. However, if we estimate the force in Earth's magnetic field, this force is very small. The Earth's magnetic field strength in a middle latitude equals about $B \approx 3.4\times10^{-5}$ T. If the conductor has the currency i = 10 A and length l = 1 m, the force will be only F = 3.4×10^{-4} N. That very small force is enough for moving a compass needle, but not enough for moving a larger apparatus or for flight apparatus.

2. Design and work of AB levitator, engine and electric storage. Author offers to overcome this difficulty by use of superconductivity, which allows a big currency up 10^5 A/mm^2 and more. That means that one meter from superconductivity wire having cross-section area 3 cm^2 and mass 4.8 kg can create a force of about 2000 N. But superconductivity calls to mind two other main problems: the low temperature of superconductivity and a limited maximum self-magnetic field that destroys the wire's superconductibity.

These new problems we will consider later. Now, we consider the main principal difficulty: the Maxwell law says: in any closed loop electric circuit (without internal conductor) the total force (and electric intensity for constant magnetic flow) equals zero. That means the back conductor (Figure 1a) creates the same opposed force F and total force will be zero. The author offers the innovation which permits avoidance of this obstacle: *to protect a back wire from Earth's magnetic field* (Figure 1b). It is known, an iron (or other good magnetic) cover adsorbs the magnetic lines (Figure 1c) (see textbook "Electricity" by S.G. Kalashnikov, 1985, p. 219, Figure 167, Russian). The back wire inserted into the iron cover and insulated from it (Figure 1b).

That idea is used for AB thruster and AB levitator (Figure2). The author offers two main forms of these devices: cylindrical form (long or shirt cylinder) and toroidal form. Naturally, each of them has advantages and disadvantages. The cylindrical form is shown in Figure 2.



Notations: 1 - closed loop wire, 2 - electric insulator, 3 - protection (shield) from outer magnetic field (for example, iron, paramagnetic, ferromagnetic, etc.), 4 - lines of magnetic field, *F* - force, *i* - electric currency, *B* - magnetic field strength.

Figure 1. Explanation of design and work the conventional closed loop electric circuit into a magnetic field and offered AB device that creates force in the magnetic field. (a) Conventional electric circuit in the magnetic field. We have two opposed magnetic force F. (b) Electric circuit which has the back conductor protected from Earth's magnetic field. We have one force. (c) Magnetic lines flow around the back conductor. Direct exposure shield protects the back electric wire from Earth's magnetic field (cross-section of back wire 3 in "c").

The cylindrical AB thruster has closed loop superconductivity wires 4-6 (Figure 2) inserted into strong composed insulator 5 (that stuff is composed from strong fibers or whiskers). That is also important *innovation* because insulator perceives the gigantic magnetic tensile forces from superconductive wires. The safety force very strong depends from this insulator. The insulator is also stores the electric energy. The amount of stored energy depends from an insulator’s strength. Strong artificial fibers, whiskers, and nanotubes are preferable as the insulator (stuff). The known (for example, toroidal) superconductor electric storage has empty core. That needs in a strong heavy cover and cannot have a strong internal magnetic field. The design offered connects the straight and back wires 4, 6 in one body by the insulator and allows reaching a very strong magnetic field between wires 4 and 6 (see computation). The strong insulator also supports the superconductivity wire 4, 6 because superconductivity material has usually a small strength. The superconductive layer 11 is connected with wires 4. It is known that external magnetic field cannot penetrate the superconductive material more than 10^{-5} cm. The layer 11 accepts the Earth's magnetic field, passes voltage to the upper wire 4 and protects the top side of the lower back wire 6 from influence the Earth's magnetic field. The face plates 7 (or special internal cylinder made from thin ferro-magnetic (iron) material) also protects the internal side of the back wires 7 from Earth's magnetic field.

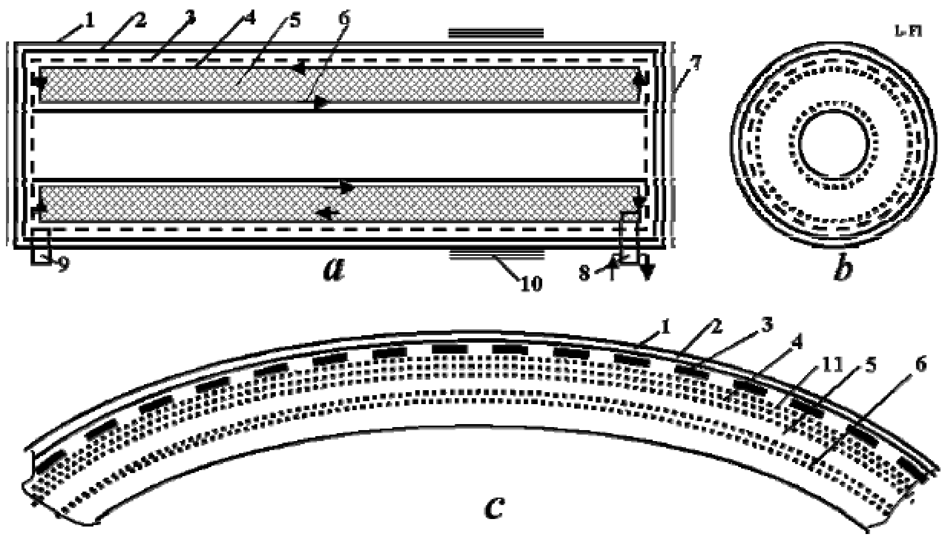


Figure 2. Cylindrical superconductivity AB engine for levitator, mobile and flight apparatus and vehicles. (a) Side view cross-section; (b) Forward view; (c) Cross-section of forward view. *Notations*: 1 - cover, 2 - heat high efficiency protection (multi- high efficiency screen-mirrors); 3 - channels of the cooling system (for example by liquid nitrogen), 4 - superconductive wires inserted into the strong light insulator, 5 - strong composite insulator, 6 - back conductor, 7 - side protection from Earth's magnetic field, 8 - charge and discharge device, 9 - pump for liquid refrigerant, 10 - mobile protections of device parts from Earth's magnetic field (for control value and direction of the levitation (thrust) force), 11 - superconductive thin layer connected to wires 4. That protects the wires 6 from Earth's magnetic field.

The cylindrical levitator may be short (Figure2') or has a thin envelope. This form is more suitable for air vehicles.

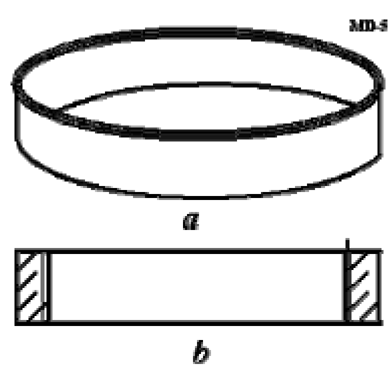


Figure 2'. Short cylindrical AB levitator and superconductive ring-storage of electric energy. (a) General view, (b) Cross-section of ring.

The levitator has channels 4 where the liquid refrigerant (for example, nitrogen) circulates by a pump 9. The levitator has an innovative heat protection: multi-screens vacuum prism mirror offered by author in [3] Chs.3A, 12. The loss of refrigerant by leakage is small (see computation) and unimportant to operation. In outer space the levitator is protected from Sun and Earth radiations by the same multi-screens protector and does not need liquid refrigerant and special cooling system.

The mobile sections 10 (from thin iron (ferro-magnetic), circle and semi-circle) allows defense of part of the outer cylindrical surface from Earth's magnetic field and change (move) position and value of levitation force. The charging and discharging of the electricity storage feature (insulator between wires 4 - 6) makes inductor 8 or special outer magnetic field. We do not spend energy when the levitator levitates or moves in horizontal direction. The energy in storage is automatically spent (or replenished) when apparatus is lifting (descent), is accelerated (braking), or having movement drag (air and friction drag). That way we can free (without spending of total energy) travel in space or non-atmospheric planet if we will return at previous place and doesn't change the final weight. That capability doesn't have any known engines. The efficiency of offered electricity storage is 100% and energy saved for an unlimited time period.

The AB levitetor can have a toroidal form (Figure 3). This form may be better for plate flight vehicles.

3. Control of AB levitator. The guidence and control of the levitating apparatis is easily accomplished. The control of the levitation force (value and direction) is presented in Figure 4. We can slope the levitative force *F* in any direction, to get a projection of this force to horizotal plate and move in any horizontal direction (without turning of apparatus!). Expecially that is comfortable for toroidal levitator (Figure 4h). We can also turn the apparatus around any axis. Our apparatus is neutral, but one can be stabilized quickly by the simplest gyroscopical device.

Our apparatus may be used for ground, sea ship, submarine vehicles as engine (thruster) and storage of electric energy.

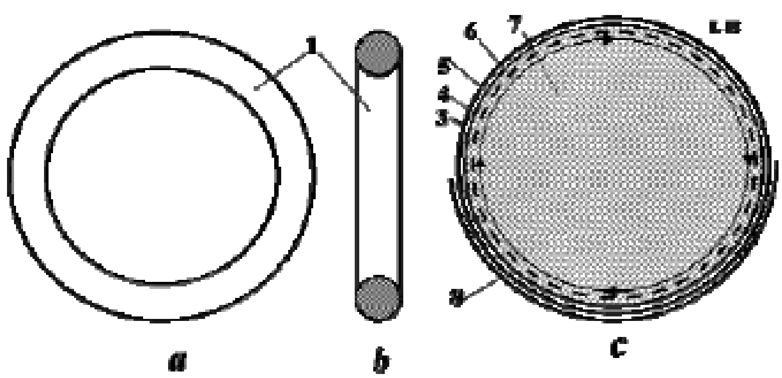


Figure 3. Toroidal form of AB levitator. (a) Top view, (b) Side view, (c) Cross-section. *Notations*: 1 - toroidal levitator and electric storige, 3 - envelope, 4- heat protection, 5 - refrigerent, 6 - superconductive wires, 7 - strong material, 8 - protection from Earth's magnetic field and mobile control of value and direction of levitate force.

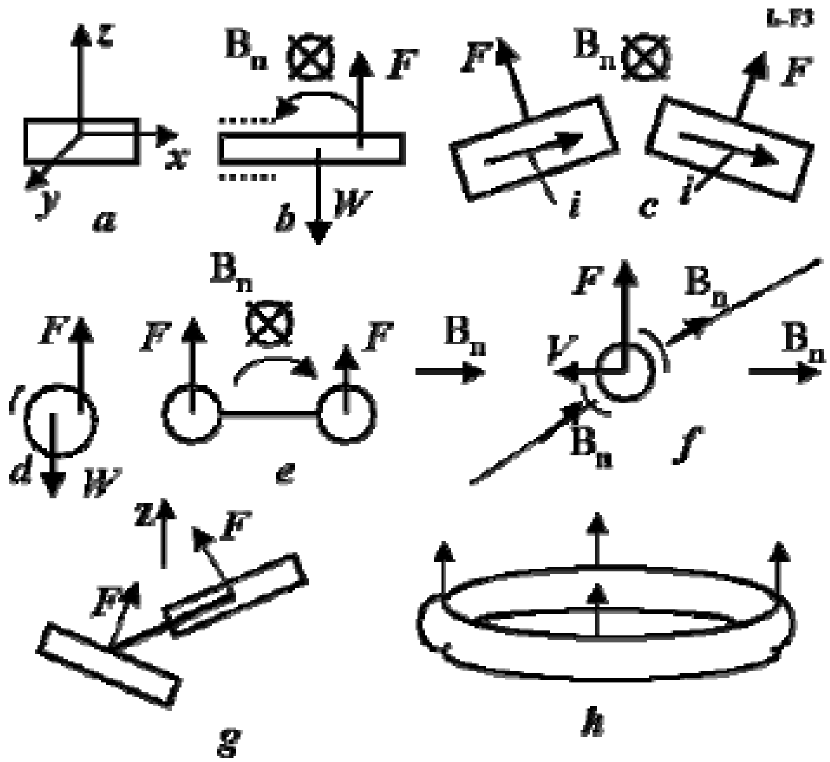


Figure 4. Control of value and direction of the levitation force. (a) Axis of cylindrical levitator. (b) The closing of part cylinder from Earth's magnetic fields (left end) moves the levitate force *F* from the center of gravity and creates the moment around axis *y*. (c) The slope of cylinder bends the force *F* and creates the horizontal force. (d) The closing of part cylinder from Earth's magnetic field moves the *F* from the center of gravity and creates the moment around axis *x*. (e) The different forces *F* of two connected cylinder create the moment around axis *x*. (f) Ferromagnetic antenns returns the Earth's magnetic field near levitator and produce force when the levitator moves along the lines of Earth's magnetic field. (g) The opposed slope of two connected cylinders create the moment around axis *z*. (h) Toroidal levitator. The closing of different parts of toroid create the different forces in these parts. That allows creating the slope of apparatus and horizontal force in any direction (include the value of the force).

The problem can be only apparent when we have *cylindrical motionless* thruster-levitator. When we move in West-East or East-West directions, we have full force *F*. When we move South-North (or back) and the main direction of an electric currency in thruster is same as the direction of the Earth's magnetic lines, the force *F* may be closed to zero (see eq. (1)). More exactly, a butt-end of the levitate cylinder crosses the magnetic lines and produce the force, but usually the butt-end area is significantly less than the side area of the cylinder and this force is small. Only toroidal levitator has same *l* in any direction. This defect may be corrected by many means. For example, the AB engine is turning and have West-East direction for any speed direction of vehicle; the vehicle has ferro-magnetic antennas (which change the local direction of the Earth's magnetic lines, Figure 4h)., the vehicle has zig-zag way, and so on. The toroidal thruster (Figure 3) does not have this problem.

4. Ferro-magnetic concentrator of outside magnetic lines. This innovation may be very useful. Ferro-magnetic matter collects the magnetic lines (magnetic field, magnetic flow). The electromagnetic induction is

$$B = \mu\mu_0 H \ , \qquad (4)$$

where B is magnetic induction in T, μ is magnetic permeability (in vacuum μ = 1), μ_0 = $4\pi\times10^{-7}$ is magnetic constant in N/A^2, H is magnetic induction in A/m.

Magnetic induction at the Earth's magnetic equator is 27.1 A/m. The maximum magnetic permeability are: for iron μ = 6100. for the steel Э 310 μ = 36,000 at H = 9.6 A/m (maximum B = 1.75 T); for permalloy (having 78.5 Ni) μ = 100,000 at H = 2 A/m, (B_{max} = 0.8). For iron (having 4.3% Si) B = 0.45 T at H = 40 A/m.

In case of a correct design the permeability can increase magnetic field by hundreds or thousands of times. It is used in ferro-magnetic antennas in small radio receivers. That also may be used in AB levitator, thruster, and engine for increasing the propulsion force. It is very important that the ferro-magnetic changes the direction of the magnetic lines near itself. The radius of collection (when magnetic wire is parallel to magnetic lines) equals approximately a length of the wire. The typical levitator with magnetic booster is shown in Figure 5. However, ferromagnetic method still needs more thorough, detailed investigation.

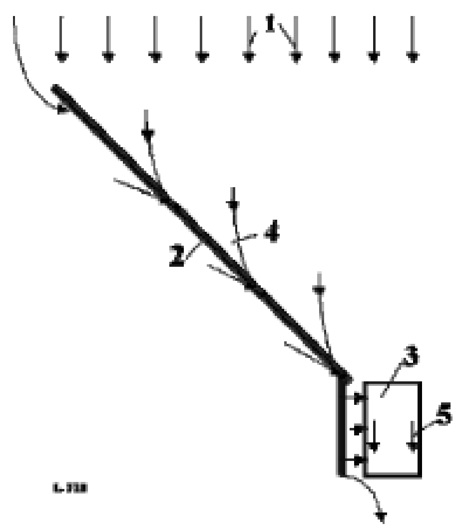


Figure 5. Ferro-magnetic collector of outside magnetic field. *Notations:* 1 - outside magnetic field, 2 – ferro-magnetic circuit, 3 - levitator, 4 - magnetic lines, 5 - electric currency.

5. Cooling system. Figure 6 shows some innovative methods of protection for the AB levitator in outer space (in vacuum). The simplest protection is a super reflective mirror (Figure 6a) offered by author in 1988 (see [3] Chs. 12, 3A). The superreflectivity screen-mirror gives deep cooling. The usual high reflectivity screen-mirror gives enough cooling (Figure 6b). The usual multi-screens protection also gives enough cooling (Figure 6c)(see the computation in Theoretical Section). The Earth's atmospheric levitator needs liquified nitrogen (or cheaper liquid air, oxygen) cooling system, but by using the super reflectivity multi-screen protection we have a very small heat flow and need very small amount of liquid nitrogen.

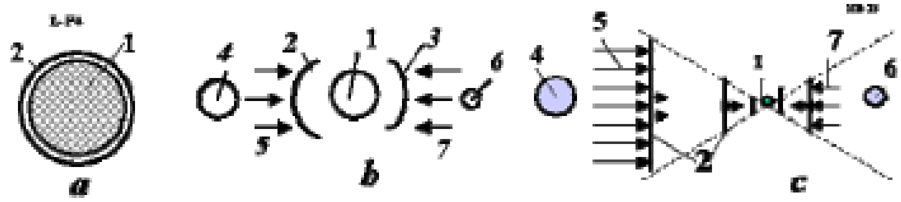


Figure 6. Methods of cooling (protection from Sun radiation) the superconductivity levitator (driver, thruster) in outer space. (a) Protection the levitator (engine) by the high super refletivity mirror. (b) Protection by high reflectivity screen (mirror) from Sun and Earth's radiation. (c) Protection by usual multi-screens. *Notations*: 1 - superconductive wires (engine); 2 - heat protector (super reflectivity mirror in Figure6a and a usual mirror in Figure 6c); 2, 3 - high reflectivity mirrors (Figure 6b); 4 - Sun; 5 -Sun radiation, 6 - Earth (planet); 7 - Earth's radiation.

6. Magnetic safety for Human life. The intensity of magnetic field used by the levitator is very high up 60 - 180 T. Is this dangerous for human health? My answer: if we have the correct design, the offered levitator contains *all* magnetic field inside the levitator (Figure 7). Outside of the levitator the magnetic field equals zero!

When the levitator design is correct, the magnetic field 6 from the internal (lower) circuit equals and opposed the magnetic field 5 from the outer (top) circuit is outside of the levitator. The magnetic field is located only between the lower and top circuits. Our design of superconductivity electric storage is different from common superconductivity ground storages. The first innovation is filling the internal core by a strong matter (stuff) which can keep the high tensile stress, the second innovation - we have only ONE turn (coil) of wire (the current superconductivity electric storages have a lot of turns and, as result, they are outward of the magnetic field).

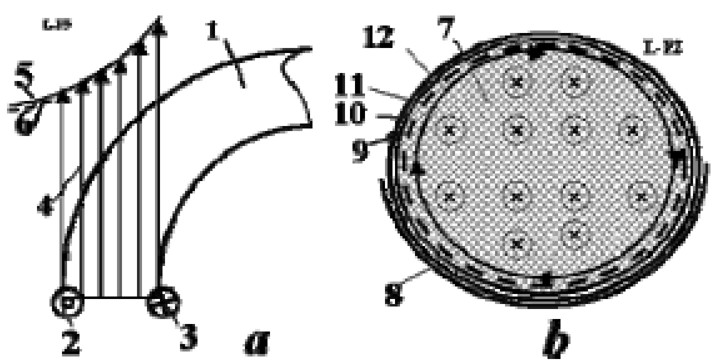


Figure 7. The magnetic field of the levitator. (a) Cylindrical levitator, (b) Cross section of the toroidal levitator. *Notations:* 1 - is cross section of cylindrical levitator; 2 - wire of top part of coil, 3 - wire of lower part of coil; 4 - magnetic lines; 5 - magnetic intensity fron lower part of coil; 6 - magnetic intensity from top part of coil (with minus); 7 - internal core from material (dielectric) having a high tensile stress; 8 - screen from outside (Earth) magnetic field, 9 - envelope; 10 - heat protection; 11 - cooling system; 12 - superconductivity electric wire and electric currency.

6. Artificial Magnetic field. The possibility of levitation can be increased thousands times by the artificial magnetic field. If the magnetic field has enough intensity, the people, car can fly without non-superconductivity levitators, the ground car can receive electric energy from variable magnetic field (it is a solution of a problem of an invironment and oil), the city resident can receive the electricity without wires, orbiting satellites and spaceships can receive the thrust and energy when they flyby over this region during their flights. That may be useful for big city having an dense street traffic. The computation of this case is in the Theoretical section and estimations in the Project section.

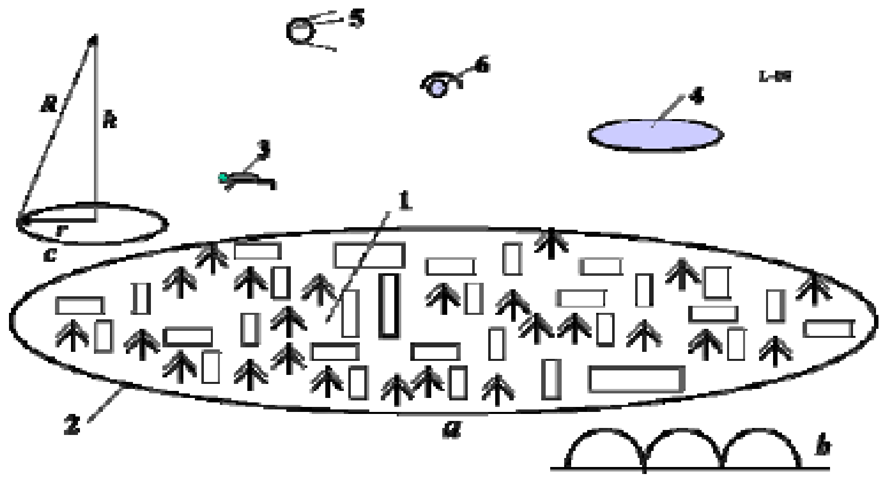


Figure 8. Artificial magnetic field. (a) City having the superconductivity electric ring. (b) Variation intensity of the magnetic field. *Notation:* 1 - city, 2 - superconductivity electric ring, 3 - fligth man, 4 - levitator in the form of a flight plate (UFO), 5 - Earth's satellite, 6 - levitative illumination lamp. R = ρ in Eq. (16).

3. THEORY AND COMPUTATION

1. Computation (Estimation) of the Levitation Force, Storige Energy, and Weight of Thruster

For estimation, the following equations of magnetodynamics are used:

$$F = ilB_n , \quad B = \mu_0 H , \quad H = i / 2\pi R \tag{5}$$

where all magnitudes are noted in the equations (1)-(4). The new magnitude R is the internal radius of cylindrical tube or toroid, m.

The important values presented the AB levitator also can be received from magnitodynamics. They are

$$w_v = \frac{B^2}{2\mu_0}, \quad w_m = \frac{w_v}{\gamma_S}, \quad v_{\max} = \sqrt{2w_m} = \frac{B}{\mu_0 \gamma_S}, \quad H_{\max} = \frac{w_m}{g} \tag{6}$$

where w_v is volume density of energy, J/m^3, that is also internal pressure into energy storage in N/m^2; w_m is mass density of energy releted to wire mass, J/kg; γ_s is density of stuff, kg/m^3; $v_{\max}$ is impulse of levitator stuff, m/s; $H_{\max}$ is maximum altitude which the stuff can self-lift at Earth, m. These values show the energetic properties of syperconductivity stuff. Computation of them are presented in Figures (9)-(11).

The mass of the levitation engine is sum of stuff, wire, cover and cooling and control systems. If engine is intended for great acceleration and does not need large storage of energy, the main mass is wire. If device is designed as big storage of electric energy, the main mass is stuff (80 - 95%). If device operates in outer space, we do not need a cooling system; in the atmosphere the cooling system increases the mass of the engine by 10 - 30%.

For engine having large storage energy, the magnitudes of Eq. (6) is better computed for γ_s - density of stuff. They may be also computed for γ_w is specific mass of wire (coil of levitator). The value of Eq. (6) may be computed for γ - density of engine. In this case v_{max} and H_{max} is maximum speed and maximum altitude which can reach engine without useful load.

Below are computations of Eq, (6).

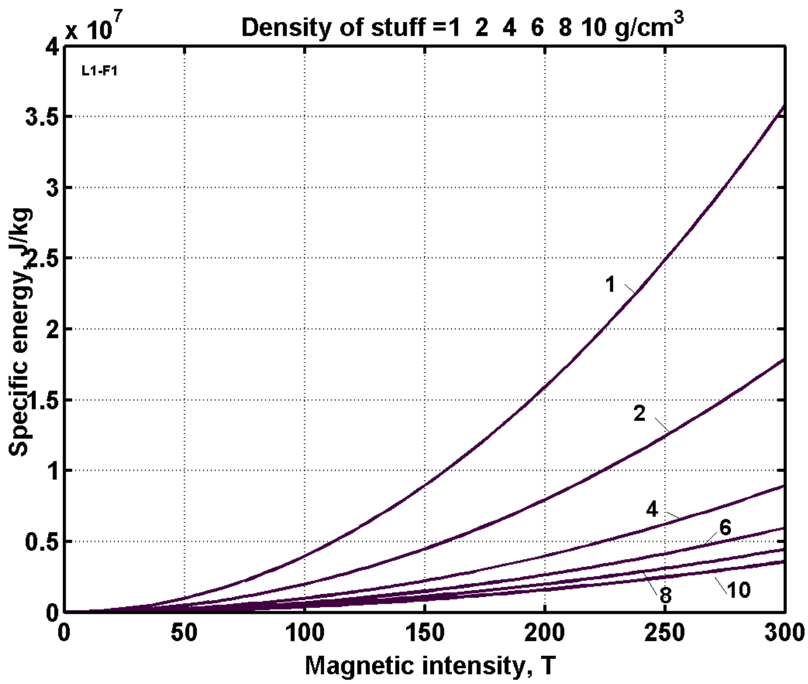


Figure 9. Specific mass energy of superconductivity AB levitation engine. These results may be applied to stuff, wire, and engine.

The AB storage energy is similar to the heating value of a conventional fuel or the specific energy of a rocket fuel. Automotive gasoline has heating value 40×10^6 J/kg, but internal combustion engine has efficiency coefficient about 0.3. That way we use only 12×10^6 J/kg. More over, the combustion engine requires oxygen (air) and contaminates the Earth's atmosphere. The liquid rocket fuel (fuel + oxidizer) has about 12×10^6 J/kg, the solid-rocket fuel has about 8×10^6 J/kg. As you see (Figure 9), the superconductive storage is the same with the rocket fuel. but it is sufficiently more for B > 250 T. Our advantage is 100% efficiency, absence of air pollution and multi-using, because we can recharge the storage device many times.That has also good prospect because then we can have greater safety maximum *B* and more strong stuff of energy storage in the future (nanotubes).

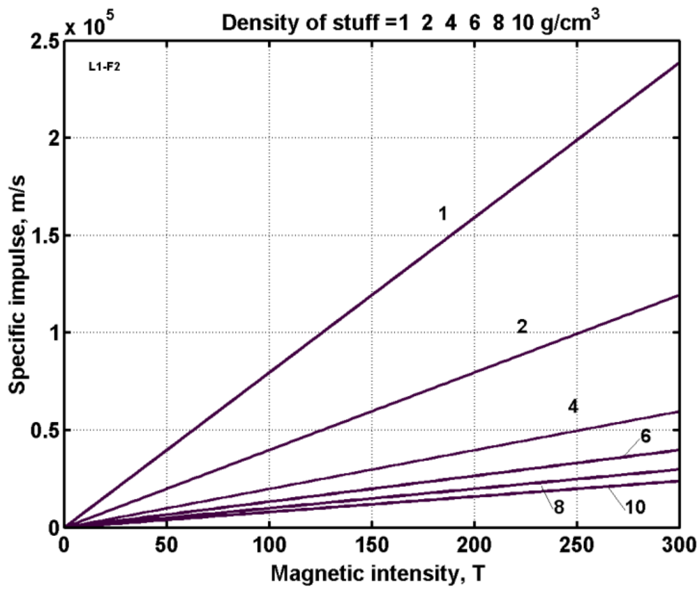


Figure 10. Specific impulse of supercondutivity engine. These results may be applied to wire, stuff and engine.

The specific impulse of current rocket fuel is about 2000 ÷ 2500 m/s for solid fuel, 3000÷3200 m/s for liquid fuel, and up 4000 m/s for hydrogen fuel. In our case, impulse is about 50,000 ÷ 100,000 m/s, in 20 ÷ 40 times more (Figure 10). Some electric propulsion has high impulse (10,000÷30,000 m/s), but they are technically complex, need large electric energy, and produce only a small thrust. Our propulsion contains energy in its electric storage, can have a big thrust and can be charged distantly from the Earth by artificial magnetic field.

2. Data

Magnetic field. Magnetic induction at the Earth's magnetic equator is 27.1 A/m ($B = 3.4\times10^{-5}$ T), at the magnetic pole H = 52.5 A/m. In some regions (for example, near Kurs, Russia) $H \approx 100$ A/m. Average Earth's magnetic field is about 5×10^{-5} T. Earth's field pulses with friquency 0.1 ÷ 100 Herzs and amplitude 1%. That may be uses for getting energy. Magnetic intensity at very high altitude is presented in Figure 12, [5], p. 133. We will use $B = 3.4\times10^{-5}$ T in our projects up to the altitude 500 km. The closed magnetic field has the small Martian satellite Phobos. The Sun, Mars and Jupiter have magnetic fields and magnetic stars have powerful fields too. The White Dwarf star has B ≈ 80,000 T. Neutron star Magnetar have B up 10^{11} T.

Figure 11 shows the volume density of energy and magnetic pressure into magnetic storage. Before B = 100 T we can use the conventional strong fibers as internal stuff of the superconductive storage (see Table 2 below), in interval B = 100÷250 T we must use whiskers, and over $B \geq 250$ T we need in nanotubes.

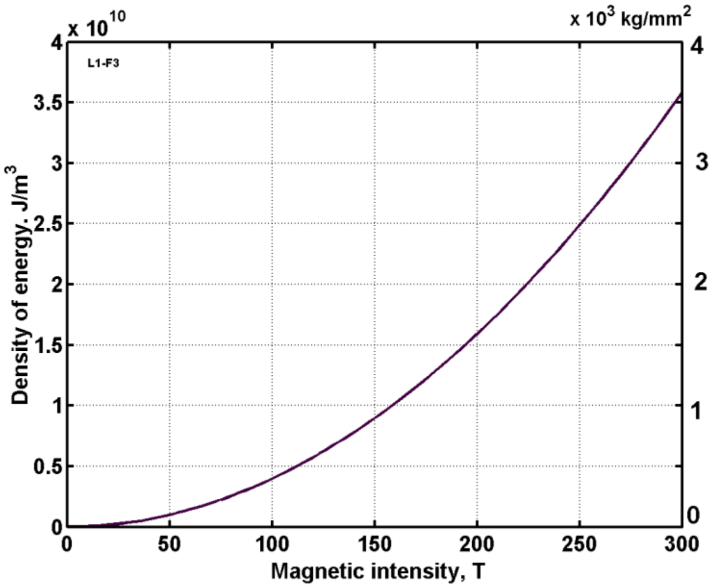


Figure 11. Volume energy of superconductivity storage. The right scale shows the internal pressure into energy storage.

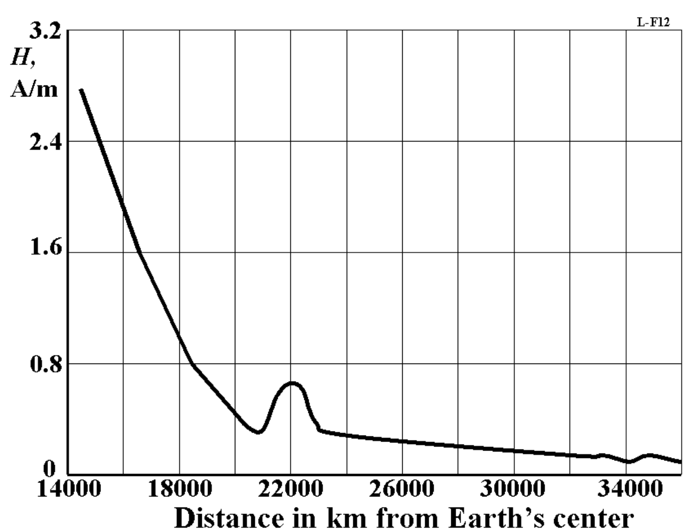


Figure 12. Earth's magnetic intensity far from the Earth's center.

There are hundreds of new superconductivity matters (type2) having critical temporature 70 ÷ 120 K and more.

Some of the superconductable material are presented in Table 1 (2001). The widely used $YBa_2Cu_3O_7$ has mass density 7 g/cm^3.

Table 1. Transition temperature T_c and upper critical field $H_{c2}(0)$ of some examined superconductors [4], p. 752.

Crystal	T_c (K)	H_{c2} (T)
$La_{2-x}Sr_xCuO_4$	38	≥80
$YBa_2Cu_3O_7$	92	≥150
$Bi_2Sr_2Ca_2Cu_3O_{10}$	110	≥250
$TlBa_2Ca_2Cu_3O_9$	110	≥100
$Tl_2Ba_2Ca_2Cu_3O_{10}$	125	≥150
$HgBa_2Ca_2Cu_3O_8$	133	≥150

The last decisions are: Critical temperature is 176 K, up 183 K. Hanotube has critical temperature 12 - 15 K, Some organic matters has temperature up 15 K. Polypropylene, for example, is normally an insulator. In 1985, however, researchers at the Russian Academy of Sciences discovered that as an oxidized thin-film, polypropylene can have a conductivity 10^5 to 10^6 higher than the best refined metals.

Boiled temperature of liquid nitrogen is 77.3 K, air 81 K, oxygen 90.2 K, hydrogen 20.4 K, helium 4.2 K [6].

Unfortutately, most superconductive material is not strong and needs a strong covering.

Material strong. Let us consider the following experimental and industrial fibers, whiskers, and nanotubes:

1. Experimental nanotubes CNT (carbon nanotubes) have a tensile strength of 200 Giga-Pascals (20,000 kg/mm^2). Theoretical limit of nanotubes is 30,000 kg/mm^2. Young's modulus is over 1 Tera Pascal, specific density γ =1800 kg/m^3 (1.8 g/cc) (year 2000).
   For safety factor n = 2.4, σ = 8300 kg/mm^2 = 8.3×10^{10} N/m^2, γ =1800 kg/m^3, $(\sigma/\gamma)=46\times10^6$. The SWNTs nanotubes have a density of 0.8 g/cm^3, and MWNTs have a density of 1.8 g/cm^3 (average 1.34 g/cm^3) Unfortunately, the nanotubes are very expensive at the present time (1994).
2. For whiskers C_D σ = 8000 kg/mm^2, γ = 3500 kg/m^3 (1989) [3, p. 33]. Cost about $400/kg (2001).
3. For industrial fibers σ = 500 – 600 kg/mm^2, γ = 1800 kg/m^3, $\sigma/\gamma = 2{,}78\times10^6$. Cost about 2 - 5 $/kg (2003).

Figures for some other experimental whiskers and industrial fibers are given in Table 2.

Table 2. Tensile strength and density of whiskers and fibers

Material Whiskers	Tensile strength kg/mm^2	Density g/cm3	 Fibers	Tensile strength kg/mm^2	Density g/cm^3
AlB_{12}	2650	2.6	QC-8805	620	1.95
B	2500	2.3	TM9	600	1.79
B_4C	2800	2.5	Thorael	565	1.81
TiB_2	3370	4.5	Alien 1	580	1.56
SiC	2100-4140	3.22	Alien 2	300	0.97
Al oxide	2800-4200	3.96	Kevlar	362	1.44

See Reference [3] p. 33.

3. Computation (Estimation) Method

For estimation AB levitator the author recommends the following method based on Eq. (4) and on usial equations for volum, mass area, etc:

(1) Take the need payload (or mass needs in movement) m_p, safety magnetic intensity B, and dencity storige stuff and wire γ_s, γ_w (You can use the Tables 1, 2). You find by Eq. (5) (or by Figs. 9-11) the magnitudes w_v, w_m, v_{max}, H_{max}. Check up the tensile stress of stuff from the internal magnetic pressure $p = w_v$ in N/m^2 or $p = 10^{-7}w_v$ in kg/mm^2 (Figure 9).

(2) Take the need flight data: altitude $H < H_{max}$, speed $V < v_{max}$, range L (H in m, V in m/s, L in m). The air drag D (in N) of your vehicle, the full mass m_x (in kg), or stuff mass m_s (in kg) of your vehicle may be estimated by equations:

$$D = C_x \frac{\rho V^2}{2} S, \quad m_x = \frac{m_s w_m - DL - E_{in}}{0.5V^2 + gH}, \quad m_s = k\frac{m_p(0.5V^2 + gH) + DL + E_{in}}{w_m - 0.5V^2 - gH} \tag{7}$$

where $C_x \approx 0.02 \div 0.7$ is coefficient of air drag; $\rho = 1.225$ kg/m^3 is air density at altitute $H \approx 0$; S is typical area of vehicle, m^2, for example, cross-section or wing area; $k \approx 1 \div 2.1$ reserve coefficient for lift force; E_{in} expenditure the energy for internal needs (for example, light), in J/kg; $g = 9.81$ m/s^2; m_p is useful mass of the vehicle, kg.

Equation (7) are recived from an energy balance of the levitation vehicle for $k = 1$.

$$m_x(0.5V^2 + gH) + DL + E_{in} = w_m m_s, \quad m_x = m_p + m_s \tag{8}$$

Look your attention in the second Eq. (7): if we do not move our apparatus, the mass it may be infinity. That means we can suspended our device (for example translator) in given point ($V = 0$) and does not spend energy its support (exsept stabilization and cooling).

(3) Find the minimal (internal) radius R_m of levitator (AB engine) and minimal currency i_m for lift force $F = gm_x$, $l = 2h$:

$$R_m = \frac{\mu_0 F}{4\pi h B B_n}, \quad i_m = \frac{F}{2 h B_n} \tag{9}$$

where h is the length (height) of levitator cylinder or small diameter of toroid, m.

(4) Find volume v, mass m_s (weight), and thickness of stuff δ of the cylindrical storage stuff:

$$\delta = \frac{m_S}{2\pi Rh\gamma_S}, \quad \text{or} \quad E = (m_x - m_p)w_m, \quad v = \frac{E}{m_v}, \quad m_S = v\gamma_s, \quad \delta = \frac{v}{2\pi R h}, \quad r = \frac{1}{\pi}\sqrt{\frac{v}{2\ldots}} \tag{10}$$

where E is energy into electric storage, J; $R > R_m$ is average radius of cylinder or toroid, m; γ_s is density of storage stuff, kg/m^3, r is small radius of toroid, m.

(5) Find the cross-section s and mass m_w of superconductivity wire:

$$s = i / j, \quad m_w \approx 2(h+\delta)s\gamma_w \tag{11}$$

$j \approx 10^5$ A/mm^2 = 10^{11} A/m^2 is dencity of the electric currency in superconductivity wire; γ_w is density of superconductivity wire, kg/m^3 (2000 ÷ 8000 kg/m^3).

(6) Total weight of levitation engine is sum of mass stuff plus mass wire $m = m_s + m_w$. It must be increased in 10 ÷ 20% for cooling system and cover.

4) Example of Computation. Levitation of a Flying Human

We want to design a levitation belt to lift a living human weighing 82 kg (Figure 3).

(1) Take the magnetic field into AB levitator B = 60 T; wire density γ_w = 8000 kg/m^3; For B = 60 T the magnetic internal pressure is $p = 10^{-7}$ w_v = 140 kg/mm^2. As the stuff may be taken the fiber (Table 2). the stuff density γ_s = 1800 kg/m^3, σ = 600 kg/mm^2. The computation gives (Eq. (5) or Figs. (9)-(11)): $w_v = 1.4\times10^9$ J/m^3, $w_m = w_v/\gamma_s$ = 7.8×10^5 J/kg .

(2) Take the flight speed V = 15 m/s = 54 km/s, range L = 100 km =100.000 m, altitude H = 100 m, E_{in} = 0, k = 2, h = 0.1 m. Compute the air drag: D = 1.4 N and stuff mass m_s = 0.36 kg (Eq. (7)).

(3) Compute minimal radius and currency in belt: R_m = 0.2 m, $i = 1.8\times10^8$ A (Eq. (7)).

(4) Compute volume, weight, and thickness of AB levitate belt (Eq. (8)): δ = 1.6 mm .

(5) Compute cross-section and weight of superconductive wire (Eq. (9)) for density of electric currency $j = 10^5$ A/mm^2: $s = 1.18\times10^{-3}$ m^2 , m_w = 1.89 kg.

The sum mass of stuff and wire is about 0.36 + 1.89 kg ≈ 2.25 kg. This levitator mass we must increase about in 0.5 - 1 kg for cover, control and cooling system. The total mass of levitator is about 3 kg.

The internal diameter is about 39 cm, outer diameter is about 42 cm, height of cylinder (belt) is about 12 cm (Figure3). Remainder the total lift force (together with man) is 82 kg.

These data are not optimal but acceptable for a market individual small vehicle (belt). The apparatus is based on current technology and can be made at present time (the many offered innovations and inventions must be used).

5) Computation of AB Levitation Launcher

For B = 140 T specific impulse of AB engine equals the specific impulse of a liquid rocket engine. However one quickly decreases (as in the second power) when B increases. The tensile stress of the stuff also rapidly increases. For B = 140 T it equals 780 kg/mm^2. That is acceptable for whiskers having maximum σ up 4000 ÷ 8000 kg/mm^2. The very high B > 200 T is very efficiency as electric storage but request nanotubes as the stuff.

The levitation launch has a many advantages, but in difference of rockets that does not spend a fuel mass. The weight of AB-engine is same in beginning and ending acceleration. As a result, the AB engine for high acceleration apparatus needs many stages of multi-launcher.

I recommend the following order of the estimation. Initially we do not include the wire mass, cover and the cooling system. Their mass is only 10 - 15% of the stuff mass. We take into account when we take the increased final useful weight of apparatus in 10 - 15%. They are included into in increased mass of stuff.

The initial data are: the mass m_p, final speed V, and final altitude H of apparatus (satellite, spaceship, or interplanetary probe). We take the equals distribute speed and altitudes between stages of the levitation accelerator.

In these conditions the mass of every engine stages may be estimated by equations:

$$m_n = a^n m_p, \quad \text{where} \quad a(N) = \frac{w_m}{w_m - 0.5(V/N)^2 - gH/N}, \quad n = 1,2,3,\dots,N \tag{12}$$

where N is number of stage (n is numbering from payload). This ratio is received from balance of energy.

The mass of stuff included mass wire, cover and cooling system in every stage may be estimated as below

$$m_s(n) = m_n / a(N) \quad \text{or} \quad m_s(n) = m_p / a^n, \quad n = 1,2,3,\dots,N \tag{13}$$

The other values (R_m, i_m, δ, s) are computed by equations above.

The example of computation the AB launcher for launching of spaceship m = 20 tons to Moon and Mars is in Projects section.

6) Artificial of Magnetic Field

The capability of levitation apparatus may be increased thousand times if we create the outside strong artificial magnetic field. In powerful artificial magnetic field we can achieve sustained flight without superconductivity devices. This field is useful in big city having heavy traffic congestion. The artificial magnetic field may be created by superconductivity ring of a large diameter. This field may be also useful for spaceship. When they flyby into artificial magnetic field the force increases hundreds of times.

The data of the artificial magnetic field and flight apparatus may be computed by equations:

$$F = ilB = jlsB = jvB, \quad v = ls = m/\gamma, \quad j = i/s, \quad r = \rho l/s, \quad E = i^2 r, \tag{14}$$

where F is lift force, N; i is electric currency, A; l is length of AB engine wire into open magnetic field, m; B is intensity of the artificial magnetic field, T; j is density of electric currency of AB engine, A/m^2; v is wire volume of engine, m^3; γ is wire mass density, kg/m^3; s is cross-section of wire, m^2; r is wire electric resistance, Ω; ρ is specific resistance of wire, Ω·cm; E is loess of energy into conventional (non-superconductivity) AB engine, J; m is wire mass, kg.

From Eq. (14) we can receive the following ratios for estimation of a data of the levitation vehicles (do not having the superconductive wires):

$$\frac{F_{kg}}{m} = \frac{jB}{2g\gamma}, \quad \frac{E}{m} = \frac{2\rho j^2}{\gamma} \tag{15}$$

where F_{kg} is lift force in kg. The number "2" appears because the coil has no active back wire. Aluminum wire has ρ =2.8×10^{-8} Ω·m (at room temperature) and mass density γ = 2800 kg/m^3. The maximum of a currency dencity for non-cooling wire is about j = 10^7 A/m^2 (10 A/mm^2). It is obvious, the first ratio in (14) must be over 1 for the levitation apparatus.

The intensity H of the artificial magnetic field at altitude (Figure 8c) may be computed by formula

$$H = \frac{iS}{2\pi\rho_h^3} \tag{16}$$

where S is area of the ground closed loop ring (enveloped by electric currency), m^2; the distance ρ_h equals approximately altitude for high height (Figure8c, $R = \rho_h$).

Weakness of artificial magnetic field is vertical direction of magnetic lines near ground surface. The magnetic force has horizontal direction. The levitation apparatus needs magnetic antennas (Figure 5) for lift force creation (or other method for changing the direction of the magnetic lines).

The artificial magnetic field and apparatus lift force may be created by permanent magnets.

The example of computation the levitation device for the flying individual human into artificial magnetic field are presented in section "Projects".

7) Computation of the Cooling System

The following equations allow direct computing of the proposed cooling systems.

1) Equation of heat balance of a body in vacuum

$$\zeta q s_1 = C_S \varepsilon_a \left(\frac{T}{100} \right)^4 s_2 \quad (17)$$

where ζ =1 – ξ is absorption coefficient of outer radiation, ξ is reflection coefficient; q is heat flow, W/m^2 (from Sun at Earth's orbit q = 1400 W/m^2); s_1 is area under outer radiation, m^2; C_s = 5.67 W/m^{2}K is heat coefficient; $\varepsilon_a \approx 0.02 \div 0.98$ is blackness coefficient; T is temperature, K; s_2 is area of body or screen, m^2.

2) Heat flow between two parallel screens

$$q = C_a \left[\left(\frac{T_1}{100} \right)^4 - \left(\frac{T_2}{100} \right)^4 \right], \quad C_a = \varepsilon_a C_S, \quad \varepsilon_a = \frac{1}{1/\varepsilon_1 + 1/\varepsilon_2 - 1} \quad (18)$$

where the lower index $_{1,\,2}$ shows (at T and ε) the number of screens. Every coventional screen decrease temperature aproximately in two times.

3) When we use the conventional heat protection the heat flow is computed by equations

$$q = k(T_1 - T_2), \quad k = \frac{\lambda}{\delta} \quad (19)$$

where k is heat transmission coefficient, W/m^{2}K; λ - heat conductivity coefficient, W/m·K. For air λ = 0.0244, for glass-wool λ = 0.037; δ - thickness of heat protection, m.

Table 3. Boiling temperature and a heat of varoporation of some relevant liquids [6]. p.68

Liquid	Boiling temperature, K	Heat varoparation, kJ/kg
Hydrogen	20.4	472
Nitrogen	77.3	197.5
Air	81	217
Oxygen	90.2	213.7
Carbonic acid	194.7	375

These data are enough for computation of the cooling systems.

Using the correct design of multi-screens, high reflectivity screen, and vacuum between screens we can get a very small heat flow and a very small expenditure for refrigerant (some grams per day in Earth). In outer space the protected body can have low temperature without special liquid cooling system (Figure 6).

For example, the space body (Figure 6a) with innovative prism reflector [3] Ch. 3A (ρ = 10–6, εa = 0.9) will have temperature 13 K in outer space. The protection Figure6b gives more low temperature. The usual multi-screen protection of Figure 6c gives the temperature: the first screen - 160 K, the second - 75 K, the third - 35 K, the fourth - 16 K.

4. PROJECTS

1. Flying (levitation) human was computed above in Theoretical section.

2. Flying car (see plan and equations above):

1. Take the data: magnetic intencity B = 60 T, γ_s = 1800 kg/m^3, γ_w = 8000 kg/m^3, form is *two* cylinders h = 1.5 m, $B_n = 3.4\times10^{-5}$ T.
2. Computation: $w_v = 1.4\times10^9$ J/m^3, P = 140 kg/mm^2, $w_m = w_v/\gamma_s = 7.8\times10^5$ J/kg.
3. For V = 20 m/s = 72 km/h, H = 1000 m, L = 1000 km = 10^6 m, $E_{in} = 7.2\times10^5$ W, C_x = 0.08, S = 1.5 m^2, we receive $D \approx 30$ N, m_s = 52 kg for one cylinder.
4. Minimal cylinder radius and currency (for lift force one cylinder F = 5500 N): R_m = 0.172 m, $i = 5.16\times10^7$ A.
5. Thickness of stuff: $\delta = 17.8\times10^{-3} \approx$ 18 mm.
6. Cross-section and mass of wire (one tube) for currency density $j = 10^5$ A/mm^2: s = 5.16 cm^2, m_w = 12.4 kg.
7. Total mass of levitation engine (two tubes): $m = 1.1\times2(52+12.4) \approx 142$ kg.

The levitation engine may be designed as two tubes which join to any CURRENT cars. The internal combustion engine, transmission, fuel tank may be removed.

The offered AB-engine not only saves the planetary invironment, releases a country from oil dependence, one spends energy sometimes less than when using a liqued fuel. The drag of usual car endures the friction of its wheels on the ground and some air drag. For friction coefficient 0.1 the friction drag for car mass 1000 kg is about 1000 N plus air drag 30 - 100 N. The flying car does not have wheel friction. That means AB car spends an energy for moving that is 20 times less than a conventional car. Make corrections that internal combustion engine has efficiency coefficient about 0.3 and a design can be done for a special flight light (without usual engine, transmission, wheels, etc.) car with small aerodynamic drag and AB engine has 100% efficiency and return the energy spent to lifting and acceleration of car. Moreover the AB car can fly in a straight line. If planet without atmosphere has natural or artifical magnetic field you can have a free flight to any planet place.

No problem to organize the air traffic for large numbers of the flying cars or flying people as is done for current aircraft and spacecraft. For example, in diapason of altitude 100-

200 m flying cars move from West to East, in diapason 200 -300 m they move from North to South, in next diapason - from East to West and so on.

3. Lavitation Aircraft with AB engine. Design the aircraft having a flight weight 100 tons.

1. Take $m_p = 10^5$ kg, $B = 120$ T, $\gamma_s = 2300$ kg/m^3, $\gamma_w = 8000$ kg/m^3.
2. Computation: $w_v = 5.7\times10^9$ J/m^3, $P = 570$ kg/mm^2, $w_m = w_v/\gamma_s = 2.48\times10^6$ J/kg .
3. For $V = 250$ m/s = 900 km/h, $H = 30{,}000$ m, $L = 10{,}000$ km = 10^7 m, $E_{in} = 3.6\times10^5$ W, $C_x = 0.06$, $S = 9.07$ m^2, $h = 14.5$ m (cylindrical tube is part of fuselage), we receive $D \approx 300$ N, $m_s = 2940$ kg.
4. Minimal cylinder radius and currency (for lift force of one cylinder $F = 10^6$ N): $R_m = 1.69$ m, $i = 10^9$ A.
5. Thickness of stuff: $\delta = 6.44\times10^{-3} \approx 6.44$ mm.
6. Cross-section and mass of wire (one tube) for currency density $j = 10^5$ A/mm^2: $s = 0.01$ m^2, $m_w = 112$ kg.
7. Total mass of levitation engine: $m = 2940 + 122 \approx 3062$ kg. Together with cooling system the mass of AB engine will be about 3.3 tons. The same way may be computed hypersonic or space aircraft. They can operate at very high altitude and have a small drag. That means they will spend very little energy per flight. If the aircraft will fly across space, the spent energy will be very small. We can also design the levitation space submarine with AB engine.

Figure 13. Possible form of levitation aircraft.

4. Levitation (stasionary) Satellite with AB engine. Compute AB engine for self-launch levitation stationary communication satellite located at an altitude of 40 km. This satellite can service a region within a radius of 700 km.

1. Take the data: magnetic intensity B = 60 T, γ_s = 1800 kg/m^3, γ_w = 8000 kg/m^3, form is cylinders, h = 0.2 m, B_n = 3.4×10^{-5} T, useful mass 80 kg.
2. Computation: w_v = 1.4×10^9 J/m^3, P = 140 kg/mm^2, $w_m = w_v/\gamma_s$ = 7.8×10^5 J/kg.
3. For V = 0, H = 40,000 m, L = 0, E_{in} = 0, k = 2. we receive m_s = 168.4 kg for one cylinder.
4. Take the total mass of apparatus 280 kg. Minimal cylinder radius and currency (for lift force one cylinder F = 2600 N): R_m = 0.63 m, i = 1.91×10^8 A.
5. Thickness of stuff: δ = 0,12 m.
6. Cross-section and mass of wire (one tube) for currency density j = 10^5 A/mm^2: s = 1.9×10^{-3} m, m_w = 1 kg.
7. Mass of levitation engine : m = 1.1×(168,4+1) ≈ 184.1 kg. Total mass of satellite is 184.1+80=264.1 ≈ 280 kg.

Figure 14. Possible form of levitation satellite and levitation vehicle.

6. Space Launch system. Compute the AB space launcher for launching the spaceships of mass 20 tons to Moon and Mars.

1. Take payload m_p = 25 tons =25×10^3 kg, B = 140 T, B_n = 3.4×10^{-5} T, γ_s = 2300 kg/m^3, γ_w = 8000 kg/m^3, final speed V = 11 km/s, final altitude is H = 200 km, number of stages N = 15.
2. Compute: w_v = 7.8×10^9 J/m^3, P = 780 kg/mm^2, $w_m = w_v/\gamma_s$ = 3.4×10^6 J/kg , v_m = 2600 m/s, H_m = 340 km.
3. Compute by Eq. (11) the mass of the last (N) stage: a = 1.1724, m(N) = 272 tons.
4. Compute the minimal radius and minimal currency of last stagy for length h = 20 m, F = 2.72×10^6 N: R_m = 2.86 m, i = 2×10^9 A, m_s(N) = 40×10^3 kg.
5. Thickness of stuff: δ = 14×10^{-3} ≈ 14 mm.
6. Cross-section and mass of wire for currency density j = 10^5 A/mm^2: s = 0.02 m^2, m_w = 6400 kg.

7. Total mass of the last stage without upper stages is 40 tons, total 272 tons.

All stages can be re-used for thousands of launchs. They can await the spaceship in flight and maintain levitation positions. When the spaceship returns and its mass is same to the launch mass, then all stages brake the spaceship and restore its energy. After landing they readied for the next free launch. Note, all stages are the thickness tubes which are inserted one into other.

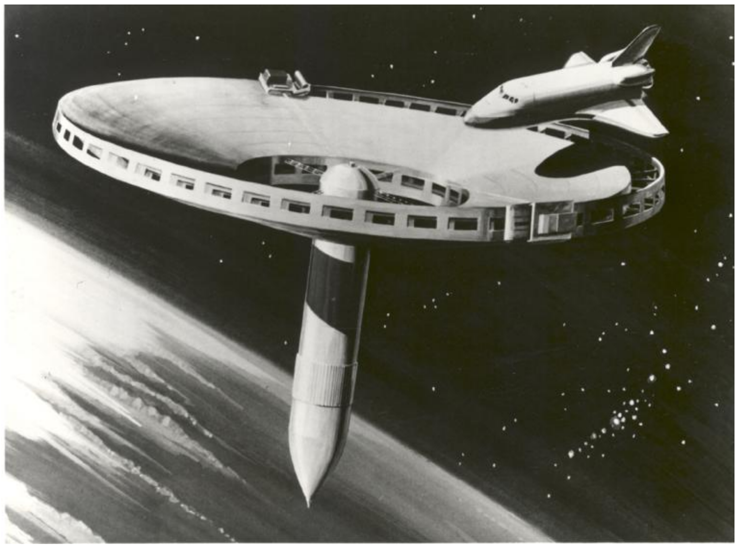


Figure 15. Possible form of space system.

7. Artificial Magnetic field. Let us take the supercoductive closed-loop cable-ring having radius R = 10 km inside a big city. The efficiency radius of this ring is about 20 km or the diameter of artificial magnetic field is about 40 km. That is enough for any big city. If the cross-section area of the cable is 0.15 m^2 and currency density is 10^{11} A/m^2, the magnetic intensity $B = \mu_o i/2R$ is about 1.9 T. Take for levitation devices the aluminum wire having ρ =2.8×10^{-8} Ω·m and γ = 2800 kg/m^3, $j = 0.35\times10^6$ A/m^2, B = 1.8. From ratios (15) we receive

F_{kg}/m = 11.5 or 115 N/kg, E/m = 2.45 W/kg.

If mass of flying man is 80 kg and together with levitation device that is 100 kg, the mass of wire will be m_w = 100/11.5 = 8.7 kg and the heat expenses of energy in levitation is 245 W or 8.8×10^5 J in hours. The good rechargable battery has storage of an energy about 70 Wh/kg = 2.5×10^5 J/kg. That means the 8 kg battery has energy $E = 20\times10^5$ J. That is enough for two hours of flight. If it has a speed V = 15 m/s = 54 km/h, our range equals more 100 km. The air drag for this speed requires about 1.4×10^5 J. The full weight of levitation device is about 17 - 18 kg.

The levitation car may be computed similarly, but it needs a small conventional engine for support of car battery. If we are not limited to strong expenditures of energy, the current density may be increases from 0.35 A/mm^2 up to 10 A/mm^2. That decreases the mass of wire by 30 times, but increases the heat loss in wire by two orders.

The constant artificial magnetic field does not need in support energy. That also may be used as storage electric energy for big city. If we use the supercondutivity devices, the artificial magnetic field may be small.

If magnitic field is made variable and one direction of magnetic intensity (see Figure 8b), this magnetic field will be able to pump the energy in the levitation engines and any special electric receivers having closed loop coil. We will not need a complex electric grid, which is in any big city. We can significently improve the parameters of city ring and flight non-superconductivity devices if we use well ferro-magnetic matter. If we use permanent magnits for ground and apparatus, the human, vehicles can flight withotut spenging a large energy.

8. Magnetic highway. The supercontactive cabel (having cross-section area s = 2.5 cm^2, j = 10^5 A/mm^2, B = 140 T) instelled on ground creates the magnetic intensity B = 1 T in distance up 5 m. The cars, tracks having enogh constant magnets (or AB-engine) can flight along this highway.

The initial data in all our projects are not optimal. Our aim - it shows that AB engine may be designed by current technology.

DISCUSSION

The simple experiments was made by physicist Dr.Sci. Mark Kriker are shown the magnetic force appear when a back currency wire is included into ferromagnetic tube. The sketch of Krinker's instellation is shown in Fig.16. The photo of instellation is presented in Fig. 17.

The force change the direction when we change the direction of magnetic lines include movement in gradient and anti-gradient of magnetic intencity. That exclude an explanation of movement by a gradient of the magnetic field.

For measure this force we need more complex and more precise devices and equipment.

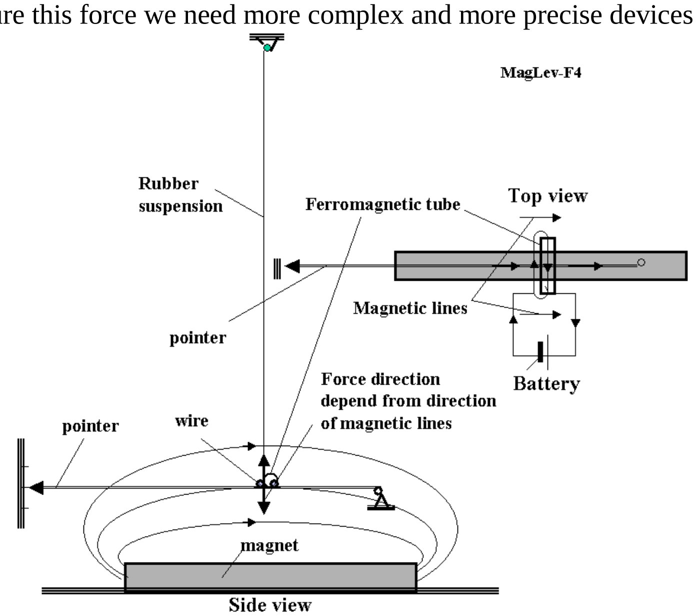


Figure 16. Sketch of Krinker's instellation for demonstration the magmetic force when back wire protected from the outer magnetic field. Data: ferromagnetic cylinder has: 28x18x10 mm; total wire of spool has length 1 m, impuls currency about 10 A; Magnetic field about 0.01 T.

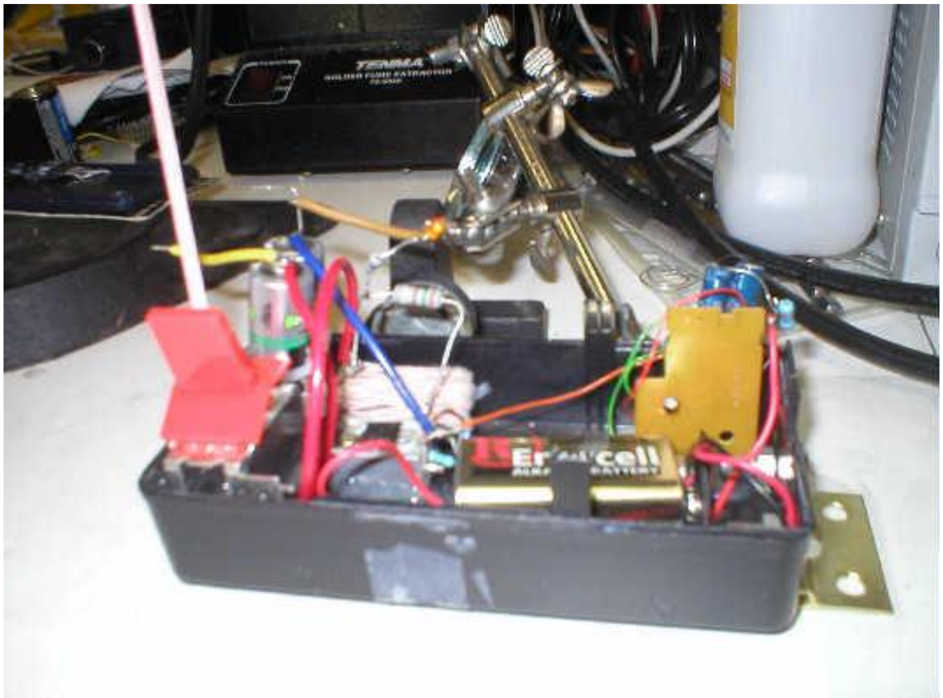


Figure 17. Instellation for Krinker's experiment. Additional devices use for non-contact turning in an electric currency.

The offered AB engines may be made by existing technology. We have a superconductivity material (see Table 1), the strong artificial fibers and whiskers (Table 2), the light cooling system (Table 3) for the Earth's atmosphere, and the radiation screens for outer space. The Earth has enough magnetic field, the Sun and many planets and their satellites (as Phobos orbiting Mars) has also magnetic field. The magnetic stars has powerful magnetic field, for example, White Dwarfs have magnetic field up B = 80,000 T, the neutron stars Magnetar have gigantic magnetic field up 10^{11} T. They may be used for interstellar flight. No problem to create the artificial magnetic field [6] on asteroids and planet satellites (for example, to create local artificial magnetic field on the Earth or Moon). We have a very good perspective in improving our devices because—especially during the last 30 years—the critical temperature of the supercoductive material increases from 4 K to 186 K and no theoretical limit for further increase. Moreover, Russian scientists received the thin layers which have electric resistance at room temperature in million times less then the conventinal conductors. We have nanotubes which will create the jump in AB engines, when their production will be cheaper. The current superconductive solenoids have the magnetic field $B \approx 20$ T.

AB engines can instigate a revolution in air, ground, sea and space transport. They allow individuals to fly as birds, almost energy-free (without loss of total energy or small expenses of energy) flight with hypersonic and space speed to any point of Earth and to other planets. The interstellar probes can use the magnetic fields of satellites and planet for braking and acceleration.

The AB engines solve the environment problem because they do not emit or evolve any polluting gases. They are useful in any solution for the oil-dependence problem because they use electricity and spend the energy for flight and other vehicles (cars) many times less than conventional internal combustion engine. In difference of a ground car, the levitation car flights in straight line to object.

The AB engines create the revolution in communication by the low altitude stationary suspended satellites, in energy industry, and especially in military aviation. They are very useful in lighting of Earth by additional heat and light Sun radiation because, in difference from conventional mobile space mirrors, they can be suspended over given place (city) and service this place.

It is interesting, the toroidal AB engine is very comfortable for flying discs (UFO!) and have same property with UFOs. That can levitate and move in any direction with high acceleration without turning of vehicle, that does not excrete any gas, jet, that does not produce a noise.

Note, physicists have discussed for a long time the possible changing of weight the superconductivity magnet. Some of them are getting the changing and announce it as revolutionary discovery; others are repeating the test and getting negative results. The reason may be in different position their magnets and screening of part superconductivity coil about direction of the Earth's magnetic field.

CONCLUSION

We must research and develop these ideas as soon as possible. They may to accelerate the technical progress and improve our life. There are no known scientific obstacles in the development and design of the AB engines, levitation vehicles, high speed aircraft, space launches, low aititude stationary communication satellites, cheap space trip to Moon and Mars and so on.

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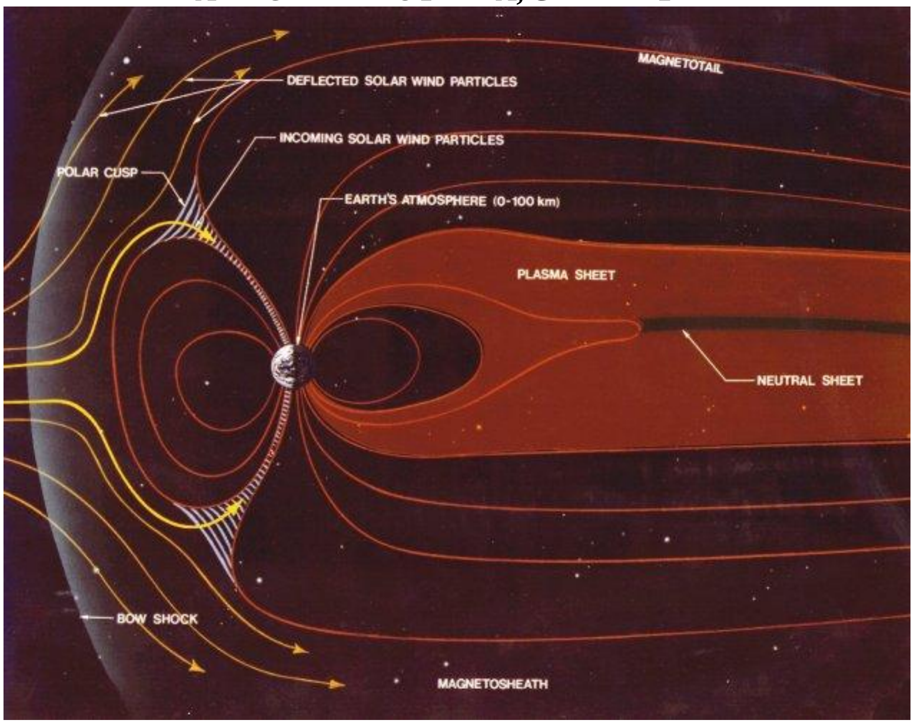
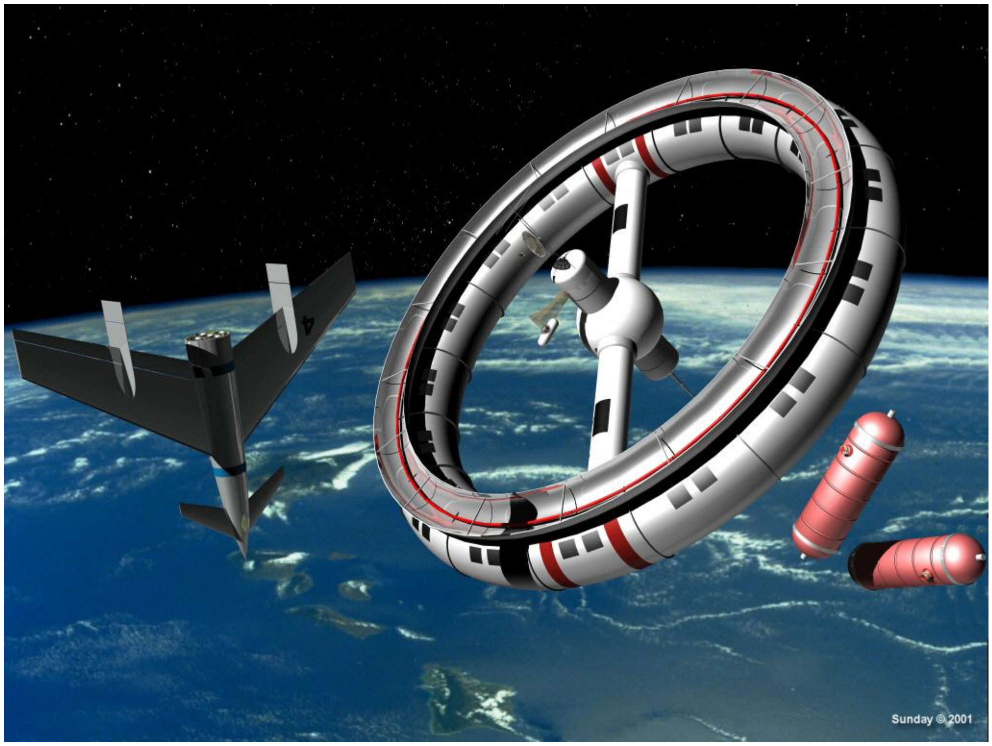
ATTACHMENT TO PART A, CHAPTER 1



Earth's magnetic field interaction with solar wing.

Magnetic field of Sun.

Attachment to Part A, Ch. 1. Possible forms of MagFly, Space Ships and Space Station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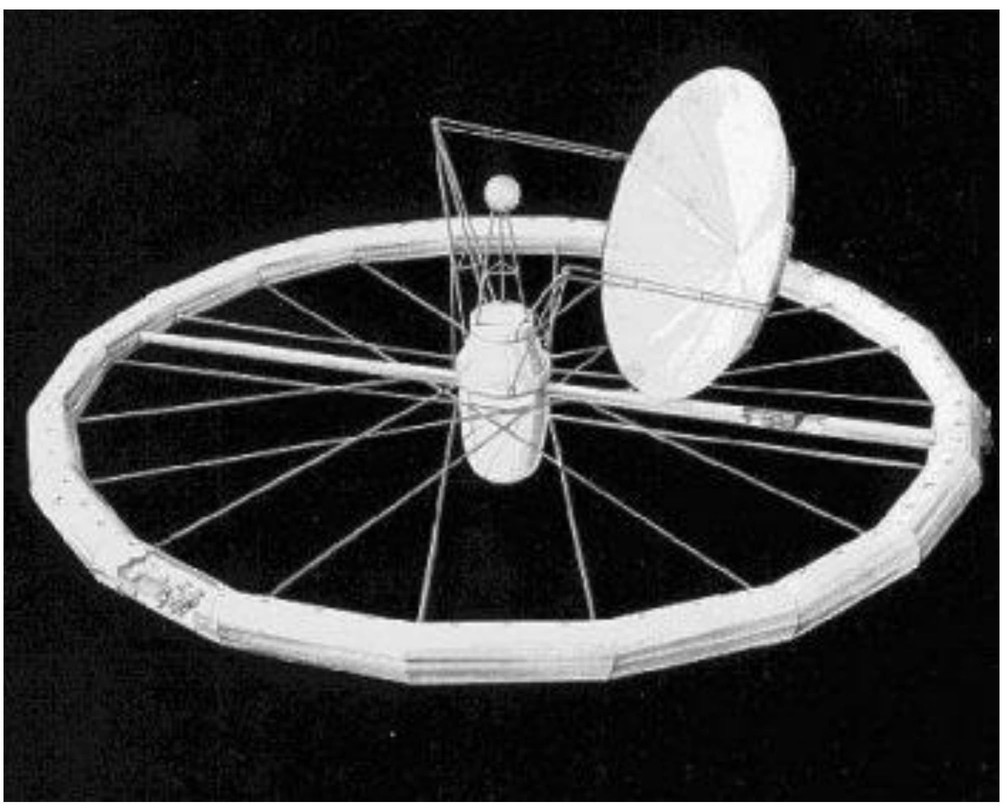

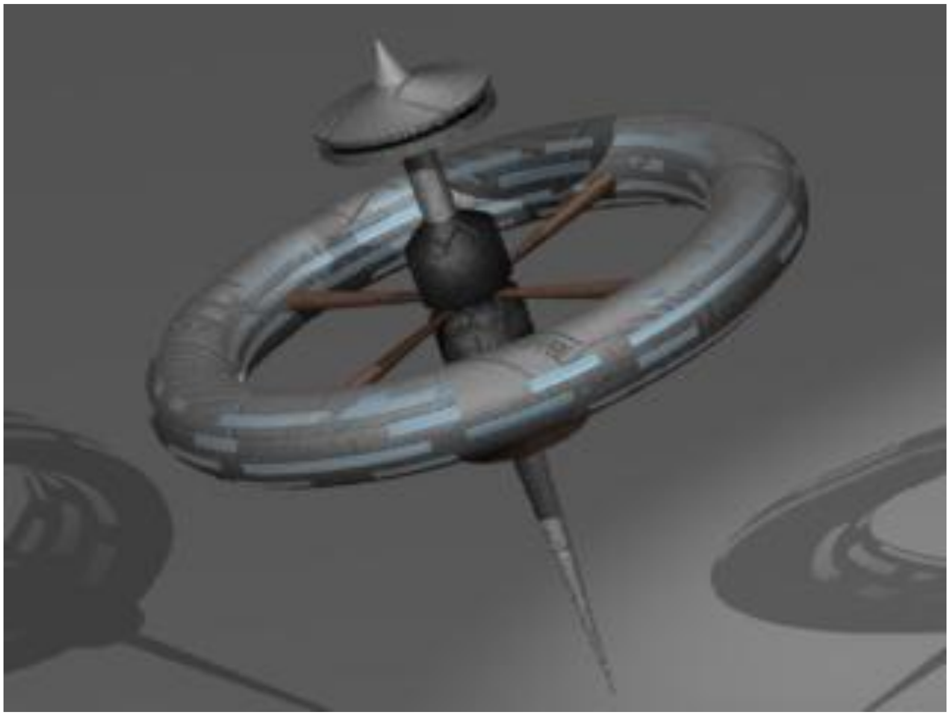


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Chapter 2

ELECTROSTATIC AB-RAMJET SPACE PROPULSION*

ABSTRACT

A new electrostatic ramjet space engine is proposed and analyzed. The upper atmosphere (85 -1000 km) is extremely dense in ions (millions per cubic cm). The interplanetary medium contains positive protons from the solar wind. A charged ball collects the ions (protons) from the surrounding area and a special electric engine accelerates the ions to achieve thrust or decelerates the ions to achieve drag. The thrust may have a magnitude of several Newtons. If the ions are decelerated, the engine produces a drag and generates electrical energy. The theory of the new engine is developed. It is shown that the proposed engine driven by a solar battery (or other energy source) can not only support satellites in their orbit for a very long time but can also work as a launcher of space apparatus. The latter capability includes launch to high orbit, to the Moon, to far space, or to the Earth atmosphere (as a return thruster for space apparatus or as a killer of space debris). The proposed ramjet is very useful in interplanetary trips to far planets because it can simultaneously produce thrust or drag and large electric energy using the solar wind. Two scenarios, launch into the upper Earth atmosphere and an interplanetary trip, are simulated and the results illustrate the excellent possibilities of the new concept.

Keywords: *Electrostatic ramjet space engine, ramjet space thruster, orbit launcher. Earth orbit space propulsion. Interplanetary propulsion, interstellar propulsion, AB-Ramjet space engine.*

INTRODUCTION

General. At present, we use only one method of launch for extra-planetary flight that being liquid-fuel or solid-fuel rockets. This method is very complex, expensive, and dangerous.

* Presented as Bolonkin's paper AIAA-2006-6173 to AIAA/AAS Astrodynamics Specialist Conference, 21-24 August 2006, USA.

The current method of flight has reached the peak of its development. In the last 30 years it has not allowed cheap delivery of loads to space nor made tourist trips to the cosmos, or even to the upper atmosphere, affordable. Space flights are very expensive and not conceivable for the average person. The main method used for electrical energy separation is photomontage cells. Such solar cells are expensive and have low energy efficiency.

The aviation, space, and energy industries need revolutionary ideas which will significantly improve the capability of future air and space vehicles. The author has offered a series of new ideas [1 - 60] contained in a) numerous patent applications, [3 - 18] b) manuscripts that have been presented at the World Space Congress (WSC)-1992, 1994 [19 - 22], the WSC-2002 [23 - 32] , and numerous Propulsion Conferences, [32 - 38] and c) other articles [39 - 59]

In this article a revolutionary method and implementations for future space flights are proposed. The method uses a highly charged open ball made from thin film which collects space particles (protons) from a large area. The proposed propulsion system creates several Newtons of thrust and accelerates space apparatus to high speeds.

History. The author started closed research in this area as far back as 1965 [1 - 2]. A series of patent applications [3 - 18] submitted during 1982 -1983 documented several methods and implementations for space propulsion and electric generators using solar wind and space particles. In 1987 these ideas were described in Report ESTI [16]. In 1990 the author published brief information about this topic [17] (see pp. 67 - 80) and in 1992 -1994 he reported on further research at the World Space Congresses -1992, 1994, 2002 [19 - 32] and his manuscripts [33 - 59].

Brief information about space particles and space environment. In Earth's atmosphere at altitudes between 200 - 400 km (Figure 8), the concentration of ions reaches several million per cubic cm. In the interplanetary medium at Earth orbit, the concentration of protons from the Solar Wind reaches 3 - 70 particles per cubic cm. In an interstellar medium the average concentration of protons is about one particle in 1 cm^3, but in the space zones HII (planetary nebulas), which occupy about 5% of interstellar space, the average particle density may be 10^{-20} g/cm^3 (10^7 $1/cm^3$).

If we can collect these space particles from a large area, accelerate and brake them, we can get the high speed and braking of space apparatus and to generate energy. The author is suggesting the method of collection and implementations of it for propulsion and braking systems and electric generators. He developed the initial theory of these systems.

SHORT DESCRIPTION OF THE IMPLEMENTATION

A *Primary Ramjet* propulsion engine is shown in Figure 1. Such an engine can work in one charge environment. For example, the surrounding region of space medium contains the positive charge particles (protons, ions). The engine has two plates 1, 2, and a source of electric voltage and energy (storage) 3. The plates are made from a thin dielectric film covered by a conducting layer. As the plates may be a net. The source can create an electric voltage *U* and electric field (electric intensity *E*) between the plates. One also can collect the electric energy from plate as an accumulator.

The engine works in the following way. Apparatus are moving (in left direction) with velocity V (or particles 4 are moving in right direction). If voltage U is applied to the plates, it is well-known that main electric field is only between plates. If the particles are charged positive (protons, positive ions) and the first and second plate are charged positive and negative, respectively, then the particles are accelerated between the plates and achieve the additional velocity $v > 0$. The total velocity will be $V+v$ behind the engine (Figure 1a). This means that the apparatus will have thrust $T > 0$ and spend electric energy $W < 0$ (bias, displacement current). If the voltage $U = 0$, then $v = 0$, $T = 0$, and $W = 0$ (Figure 1b).

If the first and second plates are charged negative and positive, respectively, the voltage changes sign Assume the velocity v is satisfying $-V < v < 0$. Thus the particles will be braked and the engine (apparatus) will have drag and will also be braked. The engine transfers braked vehicle energy into electric (bias, displacement) current. That energy can be collected and used. Note that velocity v cannot equal $-V$. If v were equal to $-V$, that would mean that the apparatus collected positive particles, accumulated a big positive charge and then repelled the positive charged particles.

If the voltage is enough high, the brake is the highest (Figure 1d). Maximum braking is achieved when $v = -2V$ ($T < 0$, $W = 0$). Note, the v cannot be more then $-2V$, because it is full reflected speed.

AB-Ramjet engine. The suggested Ramjet is different from the primary ramjet. The suggested ramjet has specific electrostatic collector 5 (Figure 2a,c,d,e,f,g). Other authors said the idea of space matter collection. But they did not give the principal design of collector. Their electrostatic collector cannot work. Really, for charging of collector we must move away from apparatus the charges. The charged collector attracts the same amount of the charged particles (charged protons, ions, electrons) from space medium. They discharged collector. All your work will be idle. That cannot work.

The electrostatic collector cannot adsorb a matter (as offered some inventors) because it can adsorb ONLY opposed charges particles, which will be discharged the initial charge of collector. Physic law of conservation of charges does not allow to change charges of particles.

The suggested collector and ramjet engine have a special design (thin film, net, special form of charge collector, particle accelerator). The collector/engine passes the charged particles ACROSS (through) the installation and changes their energy (speed), deflecting and focusing them. That is why we refer to this engine as the *AB-Ramjet engine*. It can create thrust or drag, extract energy from the kinetic energy of particles or convert the apparatus' kinetic energy into electric energy, and deflect and focus the particle beam. The collector creates a local environment in space because it deletes (repeals) the same charged particles (electrons) from apparatus and allows the Ramjet to work when the apparatus speed is close to zero. The author developed the theory of the electrostatic collector and published it in [53]. The conventional electric engine cannot work in usual plasma without the main part of the AB-engine - the special pervious electrostatic collector.

The plates of the suggested engine are different from the primary engine. They have a concentrically septa (partitions) which create additional radial electric fields (electric intensity) (Figure 2b). They straighten, deflect and focus the particle beams and improve the efficiency coefficient of the engine.

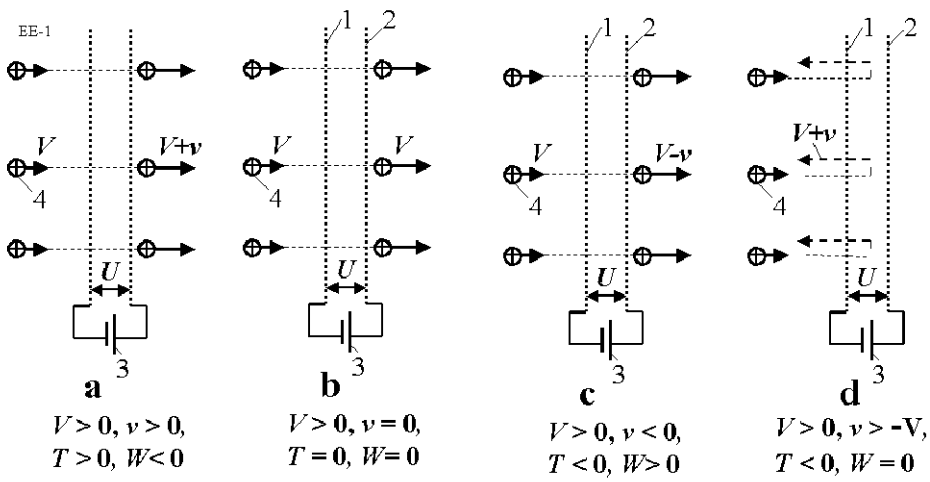

Figure 1. Explanation of primary Space Ramjet propulsion (engine) and electric generator (in braking),a) Work in regime thrust; b) Idle; c) Work in regime brake. d) Work in regime strong brake (full reflection). *Notation*: 1, 2 - plate (film, thin net) of engine; 3 - source of electric energy (voltage *U*); 4 - charged particles (protons, ions); *V* - speed of apparatus or particles before engine (solar wind); *v* - additional speed of particles into engine plates; *T* - thrust of engine; *W* - energy (if *W* < 0 we spend energy).

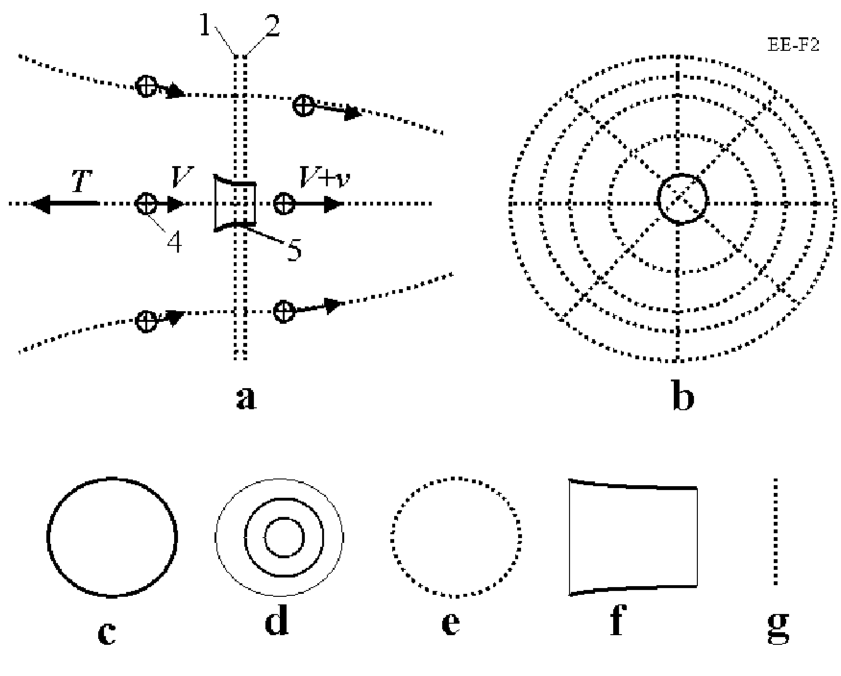

Figure 2. Space AB-Ramjet engine with electrostatic collector (core). a) Side view; b) Front view; c) Spherical electrostatic collector (ball); d) Concentric collector; e) cellular (net) collector; f) cylindrical collector without cover butt-ends; g) plate collector (film or net).

The central charge can have a different form (core) and design (Figure 2 c,d,e,f,g,h). It may be:

(1) a sphere (Figure 2c) having a thin cover of plastic film and a very thin (some nanometers) conducting layer (aluminum), with the concentrical spheres inserted one into the other (Figure 2d),
(2) a net formed from thin wires (Figure 2e);
(3) a cylinder (without butt-end) (Figure 2f); or
(4) a plate (Figure 2g).

The design is chosen to produce minimum energy loss (maximum particle transparency - see section "Theory"). The safety (from discharging, emission of electrons) electric intensity in a vacuum is 10^8 V/m for an outer conducting layer and negative charge. The electric intensity is more for an inside conducting layer and thousands of times more for positive charge.

The engine plates are attracted one to the other (see theoretical section). They can have different designs (Figure 4a - 4d). In the rotating film or net design (Figure 4a), the centrifugal force prevents contact between the plates. In the inflatable design (Figure 4b), the low pressure gas prevents plate contact. A third design has (inflatable) rods supporting the film or net (Figure 4c). The fourth design is an inflatable toroid which supports the distance between plates or nets (Figure 4d).

Electric gun. The simplest electric gun (linear particle accelerator) for charging an apparatus ball is presented in Figure 4. The design is a long tube (up 10 m) which creates a strong electric field along the tube axis (100 MV/m and more). The gun consists of the tube with electrical isolated cylindrical electrodes, ion source, microwave frequency energy source, and voltage multiplier. This electric gun can accelerate charged particles up 1000 MeV. Electrostatic lens and special conditions allow the creation of a focusing and self-focusing beam which can transfer the charge and energy long distances into space. The engine can be charged from a satellite, a space ship, the Moon, or a top atmosphere station. The beam may also be used as a particle beam weapon.

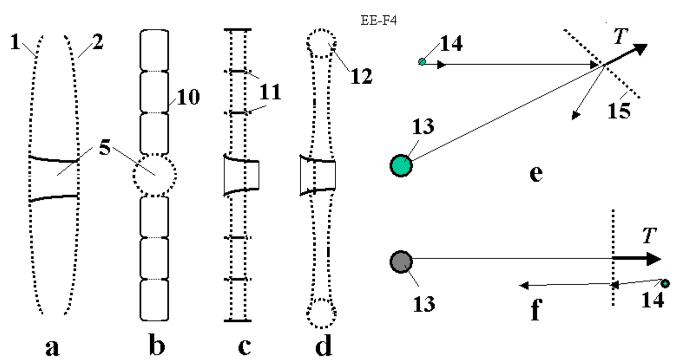

Figure 3. Possible design of the main part of ramjet engine. a) Rotating engine; b) Inflatable engine (filled by gas); c) Rod engine; d) Toroidal shell engine, e) AB-Ramjet engine in brake regime, f) AB-Ramjet engine in thrust regime. *Notation*: 10 - film shells (fibers) for support thin film and creating a radial electric field; 11 - Rods for a support the film or net; 12 - inflatable toroid for support engine plates; 13 - space apparatus; 14 - particles; 15 - AB-Ramjet.

Approximately tens years ago, the conventional linear pipe accelerated protons up to 40 MeV with a beam divergence of 10^{-3} radian. However, acceleration of the multi-charged heavy ions may result in significantly `more energy.

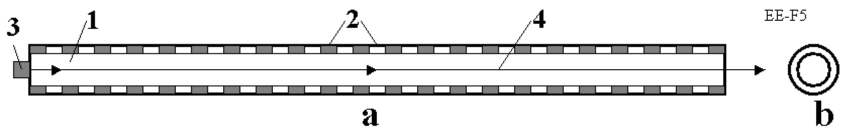

Figure 4. Electric gun for charging AB-Ramjet engine and transfer charges (energy) in long distance. a) Side view, b) Front view. *Notations*: 1 - gun tube, 2 - opposed charged electrodes, 3 - source of charged particles (ions, electrons), 4 - particles beam.

At present, the energy gradients as steep as 200 GeV/m have been achieved over millimeter-scale distances using laser pulsers. Gradients approaching 1 GeV/m are being produced on the multi-centimeter-scale with electron-beam systems, in contrast to a limit of about 0.1 GeV/m for radio-frequency acceleration alone. Existing electron accelerators such as SLAC <http://en.wikipedia.org/wiki/SLAC> could use electron-beam afterburners to increase the intensity of their particle beams. Electron systems in general can provide tightly collimated, reliable beams while laser systems may offer more power and compactness.

THEORY OF SPACE AB-RAMJET PROPULSION

The main part and innovation of the suggested system is the charged core. That may be a charged ball (Figure 2 c,d,e), a cylinder (Figure 2f), or a plate (Figure 2g). The big charge has some problems in space. We consider the major problems below.

1. Blockading of the Ball Charge (AB-Radius)

Blockading of the charge core by unlike particles is the main problem with this method. The charge on the core attracts unlike particles and repels like particles. The opposite charged particles accumulate near the core and block its charge. As a result, the area of ball (charged core) influence is many times less than the area of the interaction of the ball and the particles when there is no blockading. The forces are thus greatly reduced.

The author of this work proposed two models for estimation of the efficient charge radius, named AB-radius (radius of neutral working charge). That radius is analog of the Debaev shield radius for single charged particles in plasma theory. In the first model, the radius of the efficient area is computed as the area where particles of like charge to the ball are absent and the density of opposite-charged (unlike) particles is the same as the space medium. This model gives the lower limit of the efficient area. In the second model, the radius of the efficient area is computed as the area where the density of unlike particles is less than the space medium density because the unlike particles inside the efficient area have generally higher velocity than a those outside this area. The neutral area (neutral sphere) in model 2 is larger than in model 1. Model 2 is better, but this problem needs more detailed research.

It is possible to find the minimum distance which space electrons can approach a negatively charged ball. The full energy of a charged particle (or body) is the sum of the kinetic and potential electric energy. Any change of energy equals zero:

$$\frac{mV^2}{2}+E_p=0,\quad E_p=\int_{\infty}^{r}Fdr,\quad F=k\frac{qQ}{r^2},\quad E_p=kqQ\left(\frac{1}{\infty}-\frac{1}{r}\right)=-\frac{kqQ}{r},\quad \frac{mV^2}{2}-\frac{kqQ}{r}=0 \qquad (1)$$

where m is the mass of a particle [kg] (mass of a proton is m_p = 1.67·10 $^{-27}$ kg, mass of an electron is m_e = 9.11·10 $^{-31}$ kg); V is the speed of particle [m/s] (for solar wind V_s = 300 - 1000 km/s); E_p is the potential energy of a charged particle in the electric field [J]; F is the electric force, N; q is the electrical charge of a particle [C] (q = 1.6×10 $^{-19}$ C for electrons and protons); $k = 9\times10^9$ is coefficient, r is the distance from a particle to the center of the ball [m]; Q is ball charge [C].

From equation (1) the minimum distance for a solar wind electron is ($m = m_e$, $V = V_s$):

$$r_{\min}=\frac{2kqQ}{mV^2}=\frac{2K}{V_s^2}=\frac{2a^2Eq}{m_eV_s^2},\quad \text{where}\quad K=\frac{kqQ}{m},\quad Q=\frac{a^2E}{k},\quad K=\frac{a^2Eq}{m} \qquad (2)$$

where K is a coefficient; m_e is electron mass; V_s is the solar wind speed [m/s]; a is the radius of ball [m]; E is electrical intensity at the ball surface [V/m]. The maximum electrical intensity of the open negative bare charge is about 10^8 - 2×10^8 V/m in a vacuum.

For a = 6 m, $E = 10^8$ V/m, $V_s = 4\times10^5$ m/s we have $r_{min} \approx 8\times10^6$ km. The minimum distance of a hyperbolic particle trajectory from the punctual charged core is

$$c_h=R_eV,\quad K=\frac{a^2qE}{m},\quad p_h=\frac{c_h^2}{K},\quad H\approx V^2,\quad e=\frac{c_h}{K}\sqrt{H+\frac{K^2}{c_h^2}},\quad r_{\min}=\frac{p_h}{1+e} \qquad (2a)$$

where R_e is AB-radius efficiency of charged ball (see Eq. (4 - 5) later). All other values are parameters of the hyperbole and computed in (2a). The minimal radius of (2a) gives the lower estimation for the required radius of the engine plates. The above estimation of maximum plate radius for speed less 1000 km/s may be found from the equation

$$R_p=\frac{R_e^2V^2m}{qa^2E} \qquad (2b)$$

2. Minimumal Neutral Sphere (AB-Radius) around a Charged Ball

a) Model 1. Constant particle density. The charge density of the unlike space plasma particles inside a neutral sphere is equal to the density of solar wind. The minimum radius of the neutral sphere is

$$Q = \frac{4}{3}\pi R_n^3 d, \quad R_n = \sqrt[3]{\frac{3Q}{4\pi d}} = \sqrt[3]{\frac{3a^2 E}{4\pi k d}}, \quad d = 10^6 Nq \tag{3}$$

where d is density of solar wind [C/m^3]; R_n is the minimum radius of the neutral sphere [m]; N is the number of particles in cm^3.

b) Model 2. Variable particle density. Density of the unlike particles inside the neutral sphere will be less than the density of solar wind particles because the particles are strongly accelerated by the ball charge to approximately the speed of light. The new density and new corrected radius can be computed in the following way:

1) The speed of protons along a ball radius is (in the system connected to the particles)

$$V_r^2(r) = V_0^2 + 2K\left(\frac{1}{r} - \frac{1}{r_0}\right) \tag{4}$$

where $V_0 = V_s$ - proton speed at an initial radius of $R >> R_n$, and R_n is the radius of the neutral sphere.

2) Particle charge density, d_p, along a ball radius is

$$d_p = d_{po}\frac{V_0}{V_r(r)}, \quad d_{po} = 10^6 Nq / s^2, \quad s = \frac{S}{S_0} \tag{5}$$

where S is distance from the Sun in AU; S_0 = 1 AU; s is relative distance from the Sun; d_{po} is density at 1 AU.

3) Charge of the neutral sphere along a sphere radius is

$$Q_r = Q - 4\pi d_{po} V_0 \int_a^R \frac{r^2}{V_r(r)} dr \tag{6}$$

4) The AB-radius of the neutral (blocking) sphere can be found from the condition $Q_r = 0$.

Note. For our estimation we can find it using the stronger condition $Q_r = 0.5Q$, and call it the efficiency radius R_e of the charge Q. We use the stronger condition because model 2 may yield a more accurate result (with the speed V_r being slower).

The efficiency radius in Model 2 is significantly more than in Model 1. Model 1 gives the lower estimation of the efficiency radius; model 2 gives the top (more realistic) estimation of the efficiency AB-radius. In our computation we will use the model 2 with the note above.

3. Computation of Main Parameters of AB-Ramjet Propulsion

If we know the efficiency radius and voltage U between engine plates, we can develop the theory and compute all the main parameters of Space AB-Ramjet. The formulas and final equations are given below. All values are in metric system (SU).

1). *Additional speed v* of particles gained between engine plates.

$$\textit{From}\quad \frac{mv^2}{2} = qU \quad \textit{we} \quad \textit{get} \quad v = \pm\sqrt{\frac{2qU}{m}} \tag{7}$$

where m is mass of particle [kg](for proton $m = m_p = 1.67\times19^{-27}$ kg, for electron $m = m_e = 9.109\times10^{-31}$ kg); q - charge of particle [C], for proton and electron $q = 1.6\times10^{-19}$ C, U - electric voltage between plates [V].

2) *Mass m_s running through engine* in one second

$$m_s = 10^6 SVnm \tag{8}$$

where $S = \pi R_e^2$ is area of engine efficiency [m^2], n is number particles in 1 cm^3 (coefficient 10^6 in (8) transfer n in m^3), V is apparatus (or relative particles speed about apparatus, out of efficiency area (for example, Solar wind speed))[m/s].

3) *Thrust T* (or brake force, drag *D*)[N] of Ramjet engine is

$$T = m_s v, \quad T = nSV\sqrt{2mqU}, \quad D_{\max} = -2m_s V \tag{9}$$

The full maximum drag can be easily obtained in the conventional (Figure1) electric engine. But it is difficult to achieve in the AB-engine because collector of this engine requires very high voltage, $U_b = aE$. However, when plate voltage is zero, the AB-engine can easily achieve a slightly less than maximum drag via

$$D = c_4 m_s V\,, \tag{9a}$$

here c_4 = 0 - 2 is drag coefficient which depends from charged core. If c_4 is less 1, the drag is easily controlled using the plate voltage U.

4) Currency of particles flow through engine

$$I = nSVq\,, \tag{10}$$

5) Electric *power N* of particles flow

$$N = \pm IU \quad or \quad N_b = DV \tag{11}$$

where U is voltage between plates, V. This power is negative (we spend energy) when we get thrust and the power is positive when we brake, N_b is brake power.

6) *Voltage* of electricity induced in brake regime

$$U_b = \frac{mv^2}{2q}, \quad v < V \tag{12}$$

7) *Propulsion efficiency* coefficient.

a) For Ramjet engine the coefficient of propulsion efficiency equals

$$\eta = \frac{m_s v V}{0.5 m_s v^2 + m_s v V}, \quad or \quad \eta = \frac{1}{1 + 0.5\bar{v}}, \quad \bar{v} = \frac{v}{V} \tag{13}$$

b) For any rocket engine the coefficient of propulsion efficiency equals

$$\eta_R = \frac{TV}{TV + 0.5 m_s v^2}, \quad T = (V + v) m_s, \quad \eta_R = \frac{1}{1 + \frac{\bar{v}^2}{2(1+\bar{v})}}, \quad \bar{v} = \frac{v}{V} \tag{14}$$

Computation of equations (13) - (14) are presented in Figure 5.

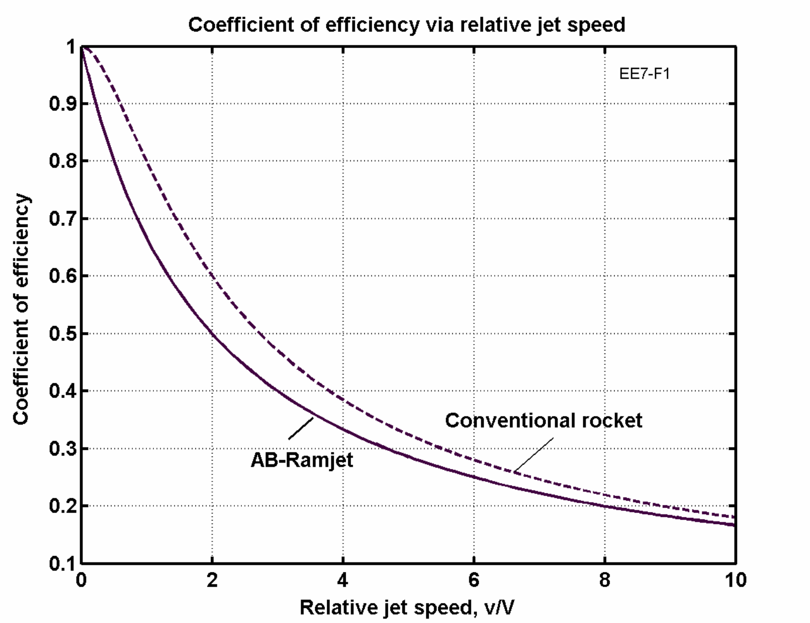

Figure 5. Propulsion coefficient of efficiencies for Ramjet and conventional rocket engine (includes conventional electric rocket thrusters) versus relative jet speed.

As can be seen, the efficiency of the conventional rocket engine seems better than of the AB-Ramjet. However, full engine efficiency is a product of the propulsion and terminal efficiencies. The terminal coefficient of the conventional (liquid) rocket engine is large, with a value of 0.68 (nozzle loss), while the terminal coefficient of the conventional rocket electric (ion) thruster is small. This is because the rocket ion thruster spends a lot of energy in the ionization of the jet mass. The proposed AB-engine's terminal coefficient depends on a transparency coefficient (discussed later) of plates and core and the terminal efficiency can be high. Note that the rocket propulsion having the high speed of the jet has low efficiency from an energy viewpoint. The rocket electric thruster with high specific impulse (jet speed) spends a significant amount of energy per unit of thrust. The photon rocket has top jet speed and the worst energy efficiency. The best efficiency (≈ 1) is achieved by a propulsion system which repels from a very large mass (for example, a planet). Our AB-Ramjet engine uses outer space mass. That is very big advantage in comparison to the conventional electric thruster and rocket which uses its own mass.

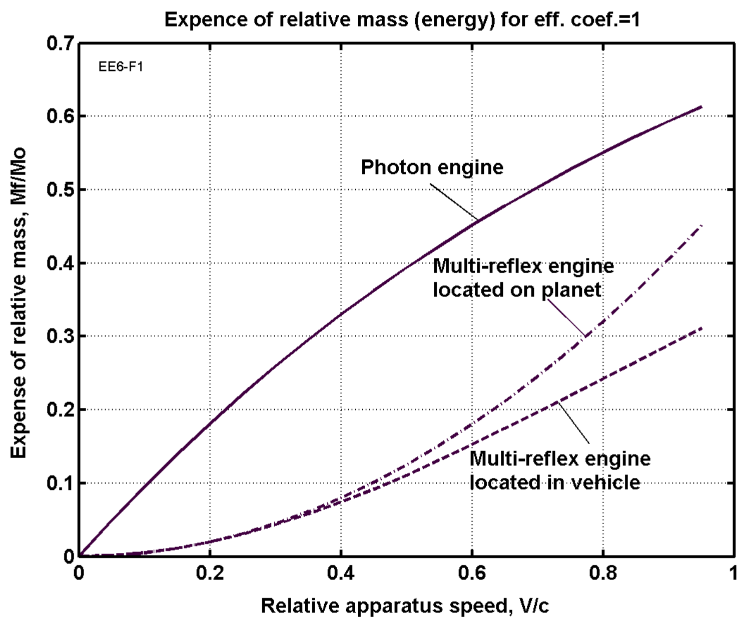

Figure 6. Expenses of relative mass (energy) versus relative apparatus speed for a different engines: photon engine, multi-reflex engine [52] located on the planet surface and located in the apparatus. The AB-Ramjet located between multi-reflex engine located on the vehicle and photon engine. The curve depends from a flow of space mass through engine. Transfer efficiency coefficient (mass to energy) equals 1. Computations made in system coordinate connected with apparatus. The relativistic effect (for Earth's observer) can change these results for high speed.

8) Final *relative speed* of different propulsion systems. Assume we can covert mass into energy and back with an efficiency coefficient of 1. Assume the system coordinate is connected with apparatus. Compare the relative fuel consumption.

a) Photon engine.

$$mdV = -cdm, \quad \frac{V}{c} = -\ln\left(\frac{M_k}{M_0}\right), \quad \bar{V} = -\ln \bar{M}, \quad \bar{V} = \frac{V}{c}, \quad \bar{M} = \frac{M_k}{M_0}, \quad \bar{M} = e^{-\bar{V}}, \quad \bar{M}_f = 1 - \bar{M} \qquad (15)$$

where M_k is final apparatus mass [kg], M_0 is start apparatus mass [kg], c is light speed, c = 3×10^8 m/s, $\bar{M}_f$ is a spend relative fuel consumption.

b) Apparatus repels from a planet using its own energy (fuel) (for example, multi-reflex engine [52] located in the apparatus).

From $\frac{M_k V^2}{2} = (M_0 - M_k)c^2$ we receive $\bar{V} = \frac{V}{c} = \sqrt{2\left(\frac{M_0}{M_k} - 1\right)} = \sqrt{2\left(\frac{1}{\bar{M}} - 1\right)}$,

$$\bar{M} = \frac{1}{1 + 0.5\bar{V}^2}, \quad \bar{M}_f = 1 - \bar{M}. \qquad (16)$$

c) Apparatus repels from planet using planet energy (fuel) (for example, multi-reflex engine [52] located on planet surface).

From $\frac{MV^2}{2} = M_e c^2$ we receive $\bar{V} = \frac{V}{c} = \sqrt{2\frac{M_e}{M_0}} = \sqrt{2\bar{M}_e}, \quad \bar{M}_e = \frac{1}{2}\bar{V}^2, \quad \bar{M}_f = \bar{M}_e$ (17)

where M_e is the mass spent on the planet surface.

The computation of the expense of mass (energy) for a perfect transfer of energy (coefficient of efficiency = 1) versus the relative apparatus speed is presented in Figure 6. Computations made in system coordinate connected with apparatus. The relativistic effect (for Earth's observer) can change these results for high speed.

Note that in many ways the AB-Ramjet engine is better than the photon engine (which is a dream of all space scientists). For example, if we want to reach the relative apparatus speed of 0.1*c*, the AB-Ramjet can spend 20 times less energy than the photon engine. Moreover, the AB-Ramjet engine can return spent energy (if it can transfer back self kinetic energy into mass with high efficiency). That means a space ship (using AB-Ramjet engine) can travel into space infinity time with stopping at planets (spending the mass for acceleration and return its mass in braking). But the photon engine losses part of self mass in the photon beam and can travel only limited time.

9) *Force between engine plates* is

$$f = -\frac{1}{2}\varepsilon_0 E^2 S_p \qquad (18)$$

where ε_0 =8.85×10 $^{-12}$ is electrostatic coefficient [F/m], S_p is plate area [m^2]. For S_p = 1 m^2, E =1000 V/m force f = - 4.425×10 $^{-6}$ N.

4. Ball (Central Charged Core) Discharge

The space apparatus or solar wind has high speed. This means the particles have a trajectory closed to a hyperbolic curve in the AB-area of charge influence and most of them will fly off into infinity. Only a proportion of them will travel through the ball. These particles decrease in speed and can discharge the ball. However, their speed and kinetic energy are very large because they are accelerated by the high voltage of the ball’s electric field (some tens or hundreds of MV). The necessary ball film (net) is very thin (measuring only a few microns). The particles pierce through the ball. If their loss of speed is less than their (apparatus) speed or the solar wind speed, their trajectory will be close to a hyperbolic curve and they will fly into space. If their loss of speed is more than the solar wind speed, their trajectory will be close to an ellipse, so they will return to the ball and, after many revolutions, they can discharge the ball if their perigee is less then the ball's radius. This discharge may be compensated using special methods.

There are several possible methods for decreasing this discharge (Figure 2c-g): a) A ball made of net; b), the central charge (core) has a cylindrical form (Figure 2f) without cover butt-end; c) the plates increase the particles speed to hyperbolic speed and reflect the returning particles. Note, the electric field does not depend on the form of the central charge at far distances, but does depend on the value of the charge.

Let us estimate the discharging of the plates and the central charge (ball, core).

1) If the plate or ball has a net design, the particles will cross only the wires of plate. Note, the maximum coefficient of light transparency c_1 is the ratio of the area of the wires, S_w, to the area of plate, S_p,

$$c_1 = S_w / S_p \tag{19}$$

2) The particles crossing the wire lose a part of their energy. This loss may be calculated as a brake coefficient c_2. The method of computation is described in the work [54].

The particle (proton) track in the matter can be computed in following way:

$$l = R_t/\gamma \,, \tag{20}$$

where l is track distance of the particles [cm]; $R_t = R_t\,(U)$ is magnitude (from a table) [g/cm^2]; γ is matter density [g/cm^3]. The magnitude of R_t depends on the kinetic energy (voltage) of the particles. For protons the values of R_t are presented in Table 1.

Table 1. Magnitude of R_t as a function of accelerated voltage $U = aE$, volts

U, MV	100	200	300	400	500	600	700	1000	2000	3000	5000
R_t g/cm^2	10	33.3	65.8	105	149	197	248	370	910	1463	2543

The proton energy is $U = aE$. For magnitudes a = 6 m, $E = 10^8$ V/m, proton energy $U = 600\times10^6$ V and ball cover density γ = 1.8 g/cm^3 the proton track is l = 197/1.8 = 109 cm. The loss of proton energy is proportional to the wire diameter or cover thickness. Consequently, the particles brake coefficient is

$$c_2 = \frac{d_w}{l} = \frac{\delta}{l} \tag{21}$$

where $d_{\rm w}$ is the diameter of the plate wires and δ is the thickness of the ball cover.

The full transparency coefficient c_3 and energy of loss E_L are

$$c_3 = c_1 c_2 \,, \quad E_L = c_3 E \tag{22}$$

where E is the energy of particle flow crossing the AB-Ramjet engine. Note, the energy loss across the cylindrical core (charge located on the tube) is small because particles are moved into the empty tube along its axis.

The safe ball cover thickness may be estimated using the following method. The solar wind proton energy is

$$E_d = \frac{m_p V_s^2}{2} \tag{23}$$

For $V_s = 400\times10^3$ km/s the proton energy is $E_d = 13.4\times10^{-17}$ J = $13.4\times10^{-17} \times 0.625\times10^{19}$ eV = 840 eV.

If the loss of proton energy is proportional to the cover thickness, the maximum safe cover thickness (which will not discharge the ball) will be

$$E_d = U\frac{\delta_{\max}}{l}, \quad or \quad \delta_{\max} = \frac{Ed(V_s)l}{U}, \quad U = aE \tag{24}$$

For a = 6 m, $E = 10^8$ V/m, the required ball cover thickness is $\delta_{\max}$ = 1.53 micron. For a = 4, 10 m $\delta_{\max}$ = 1.22 and 1.73 microns, respectively.

This magnitude is less than the ball thickness required for the charge stress (see [54]) for current cover matter. That way the net and cylindrical core is better then the thin-filmed spherical ball.

For electrons, the thickness of half absorption may be calculated using equation [54]

$$R_r = 0.095\frac{Z}{A}(aE)^{3/2} \quad [g/cm^2], \quad d_{0.5} = \frac{R_r}{\gamma}, \quad [cm] \tag{25}$$

Here Z is the nuclear charge of the ball matter; A is the mass number of the ball matter.

5. *Initial expenditure e*of electrical energy needed to charge the ball. The ball must be charged with electrical energy of high voltage (millions of volts). Let us estimate the minimum energy when the charged device has 100% efficiency. This energy equals the work of moving of the ball charge to infinity, which may be computed using the equation

$$W = \frac{Q^2}{2C}, \quad Q = \frac{a^2E}{k}, \quad C = \frac{a}{k}, \quad W = \frac{a^3E^2}{2k}, \tag{26}$$

where W is ball charge energy [J]; C is ball capacitance [F]; Q is ball charge [C]. The result of this computation is presented in Figure 7. As can be seen this energy not huge since it is only about 1 - 20 kWh for a ball radius of a = 5 m and the electrical intensity is 25 - 100 MV/m. This energy may be restored through ball discharge by emitting the charge into space using a sharp edge.

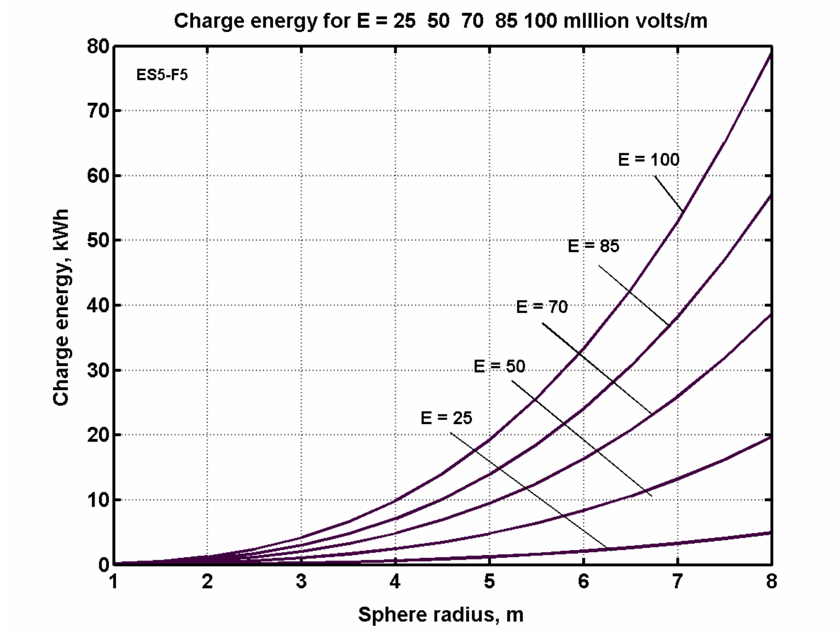

Figure 7. Initial expenditure of electrical energy needed to charge the space apparatus, a = 1- 8 m, electrical intensity is E = 25-100 MV/m and coefficient of efficiency = 1.

PROJECTS

Below the reader will find some examples which highlight the many benefits of the proposed AB-Ramjet engines. Our parameters are not optimal. Our purpose is simply the demonstration of the potential of AB-Ramjet propulsion.

Example 1. AB-Ramjets for Earth orbits

1. *Brief description of Earth's upper atmosphere.* The Earth's atmosphere consists of 79% nitrogen, 20% oxygen, and 1% other gases. The atmosphere of the Earth may be divided into several distinct layers. The first two are the troposphere (0 - 18 km) and the stratosphere (18 - 90 km). Above the stratosphere is the mesosphere and above that is the *ionosphere* (or *thermosphere*), where many atoms are ionized (gain or lose electrons so they have a net electrical charge). The Sun's ultra-violet radiation and solar wind ionize molecules of the top atmosphere. The ionosphere is very thin, but it is where the aurora takes place, and it is also responsible for absorbing the most energetic photons from the Sun and solar wind. The concentration of ions (= electrons) at day and night time is shown in Figure 8.

The ionosphere is divided into the layers D, E, F_1, F_2. Layer D contains ions of N_2 and O_2; the layers E, F_1, F_2 contain ions of O_2 and O.

2. *Estimations of AB-Ramjet engine data* for low-Earth satellite orbits. Computations are made for an apparatus (AB-Ramjet engine) having speed V_0 = 8 km/s, a concentration of O_2 ions = 10^5 ions/cm^3, and the electric intensity $E = 10^8$ V/m. The computation of the AB-radius

is presented in Figure 9. An electrostatic collector gathers ions from a surrounding area of more than10 km^2.

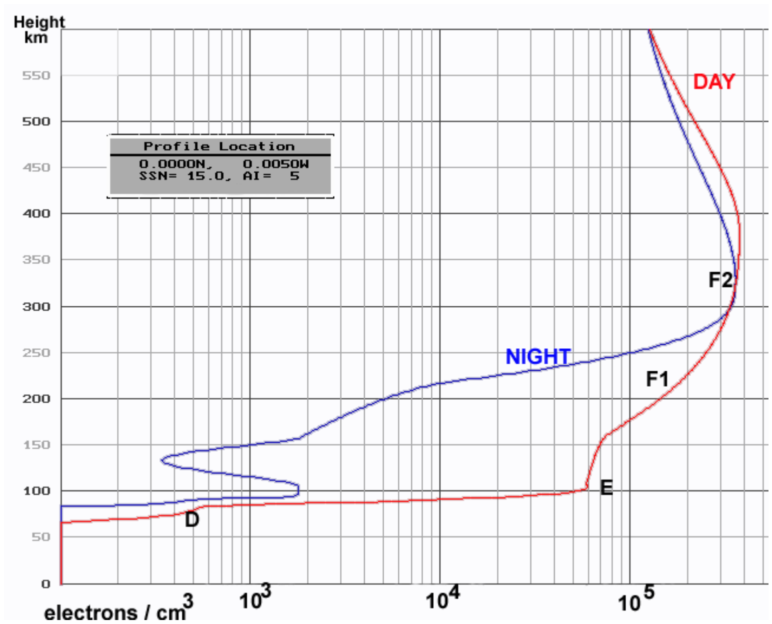

Figure 8. Concentration/cm^3 of ions (= electrons) in the day timeand night time in the D, E, F1, and F2 layers of ionosphere.

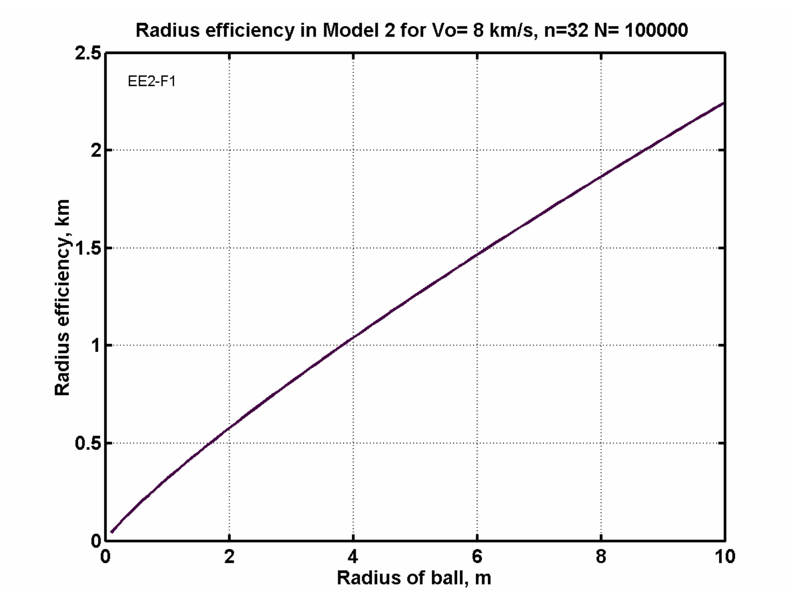

Figure 9. AB-radius of charge (radius of efficiency, catch area, clamp area) versus the charge (ball) radius for electric intensity E = 100 millions V/m, AB-Ramjet engine speed V_0 = 8 km/s, O_2 ion molar mass n = 32, ion density $N = 10^5$ ions/cm^3. Equations are [4 - 6].

Produced thrust and requested power are presented in figures 10, 11. As can be seen, the thrust is significant enough to change the satellite's trajectory and increase the apparatus' speed to a velocity close to that required for an interplanetary trip. The required energy may be obtained from a solar battery.

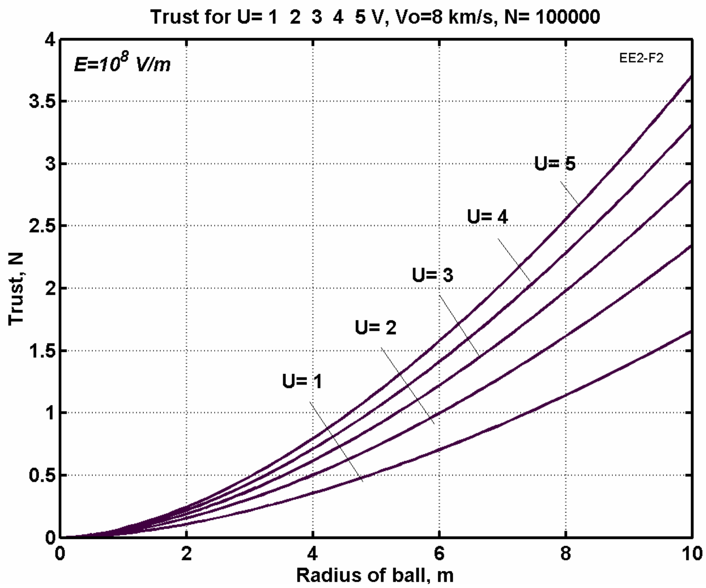

Figure 10. AB-Ramjet engine thrust versus radius of charge (ball) and plate voltage U =1 - 5 V for V_0 = 8 km/s, electric intensity E = 100 millions V/m, and ion density $N = 10^5$ ions/cm^3. Equation [9].

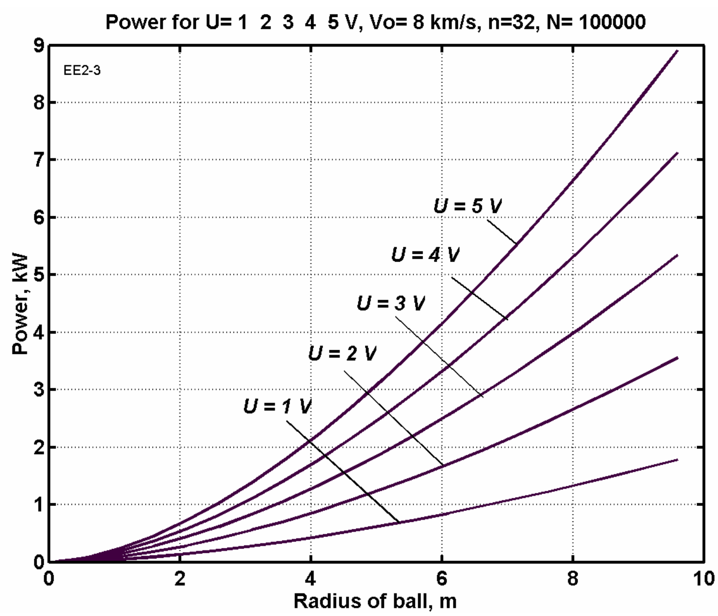

Figure 11. AB-Ramjet engine power versus radius of charge (ball) and plate voltage U = 1 - 5 V for V_0 = 8 km/s, electric intensity E = 100 millions V/m, and ion density $N = 10^5$ ions/cm^3. Equation [11].

Figure 12 shows the drag produced by the AB-Ramjet engine. Figure 13 shows the brake electric energy. This energy may be used by apparatus devices or transferred to other space apparatus.

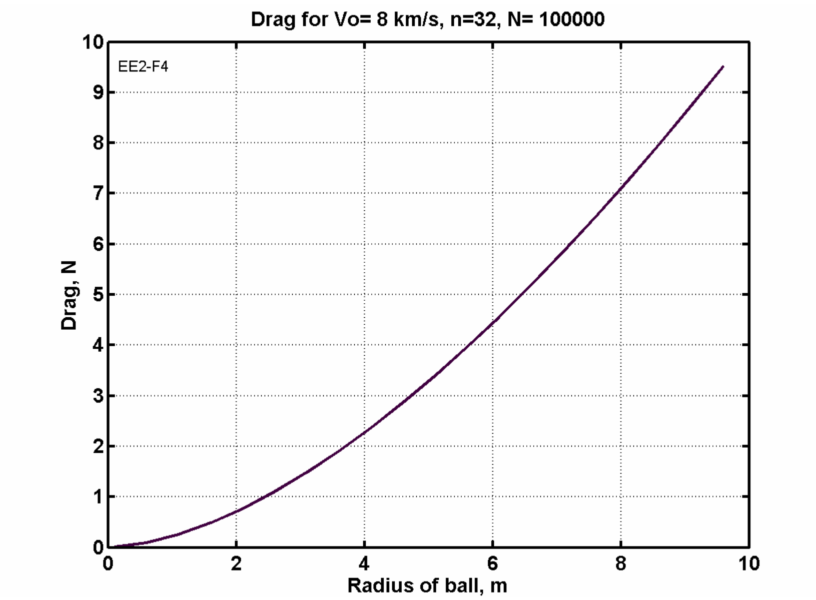

Figure 12. AB-Ramjet engine drag versus radius of charge (ball) for V_0 = 8 km/s, electric intensity E = 100 millions V/m, and ion density $N = 10^5$ ions/cm^3. Equation [9a].

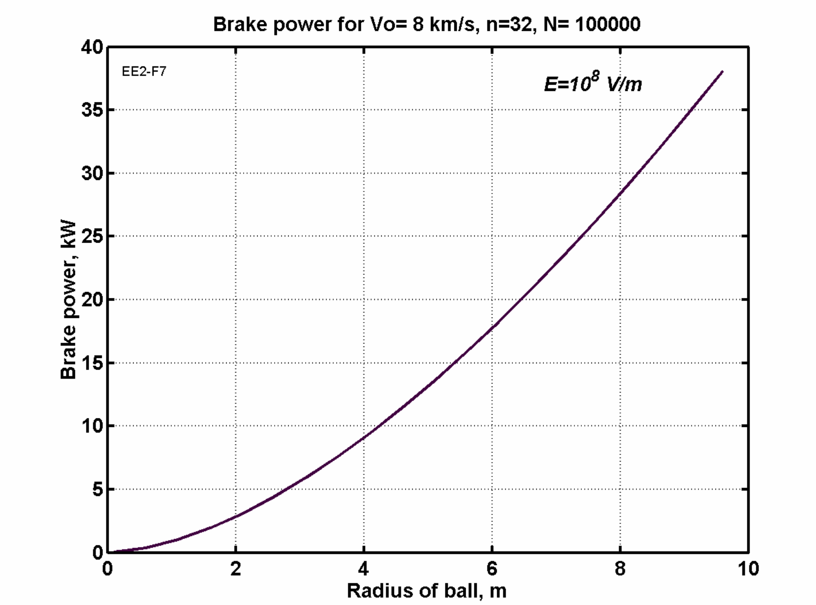

Figure 13. AB-Ramjet engine power versus radius of charge (ball) for V_0 = 8 km/s, electric intensity E = 100 millions V/m, and ion density $N = 10^5$ ions/cm^3. Equation [11].

The offered AB-engine may be used as an accelerator or brake for interplanetary space apparatus. The method of acceleration is shown in Figure 14. In the acceleration regime in region 7, the thruster of the AB-engine accelerates a probe and increases the apogee of the elliptic trajectory. In the final trajectory, the probe is separated from the engine, gets a small impulse, and flies away into space. When the probe returns from space flight, the sequence is reversed and the AB-engine works as brake.

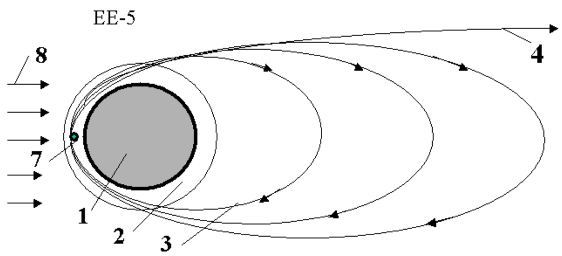

Figure14. Using the AB-engine as an accelerator and a brake for interplanetary flight. *Notation*: 1 - Earth, 2 - Earth's atmosphere, 3 - accelerator trajectories, 4 - final trajectory of interplanetary probe, 7 - region of acceleration and brake, 8 - solar light.

The particle mass flow and the electric current flow (computed by equation [8],[9]) are shown in figs. 15, 16. The electric current is significantly large, creating a magnetic field which helps to straighten the particle's trajectory.

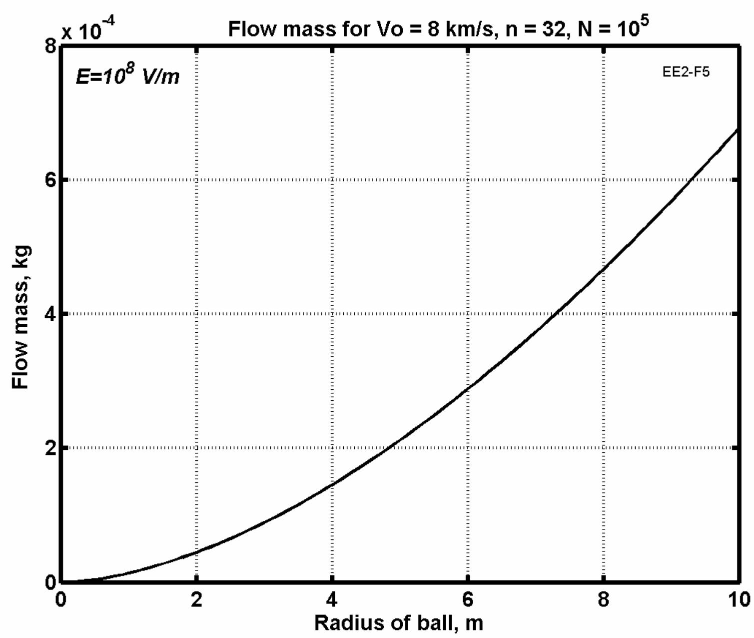

Figure 15. Ion mass flow through the AB-engine. Equation [15].

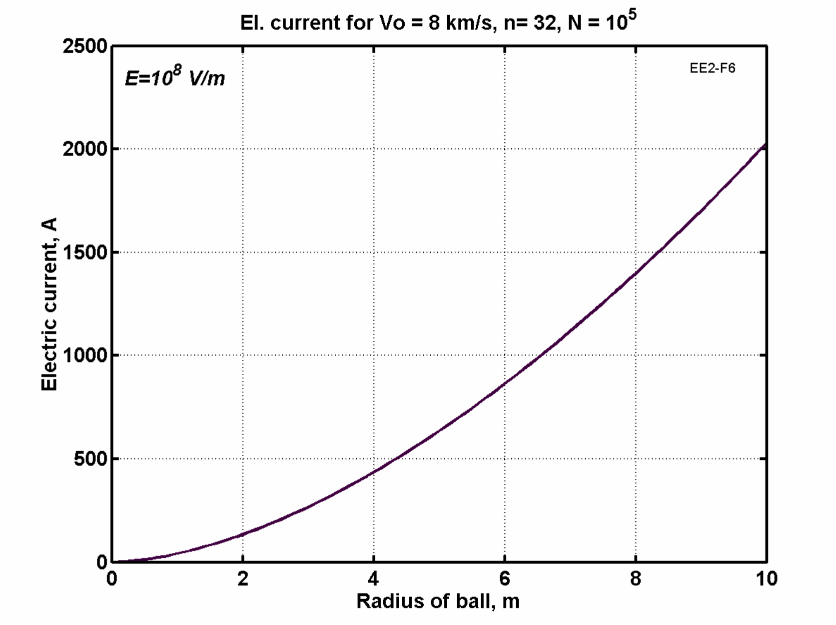

Figure 16. Electric current flow through the AB-engine. Equation [16].

The additional speed gained by the ions in AB-engine as computed by equation [7] via the interplate voltage is shown in figure 17. Acceleration is produced in the thrust regime and deceleration is produced in the brake regime.

Figure 17. The additional speed getting by ions when they move between engine plates.

The size of the plates computed by equation [2b] is shown in Figure 18. As can be seen, the size is very small and the plates can be located inside of the cylindrical charged core (Figure 2f).

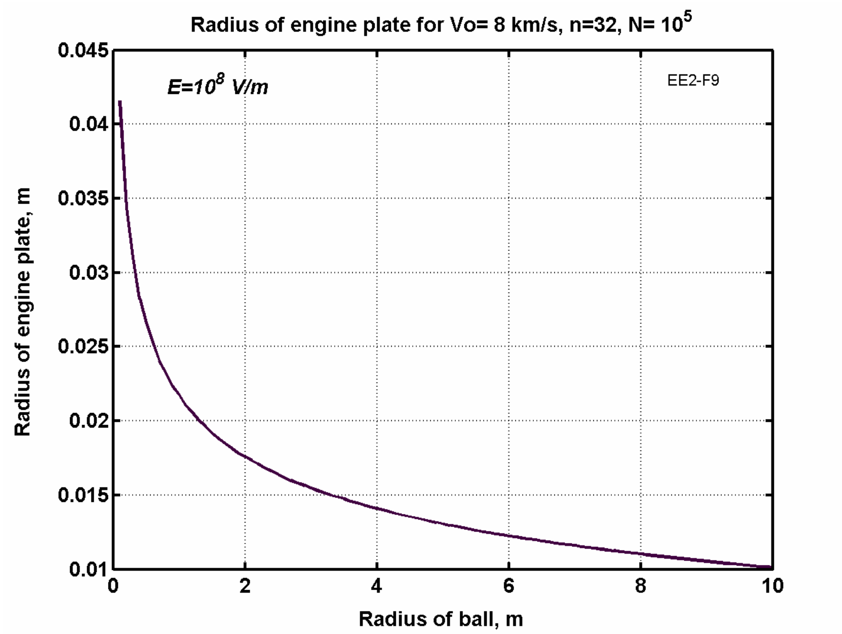

Figure 18. Size of AB-engine plates versus the ball radius. Equation [2b].

Example 2. Interplanetary AB-Ramjet

Brief information about the solar wind. The Sun emits plasma which is a continuous outward flow (solar wind) of ionized solar gas throughout our solar system. The solar wind contains about 90% protons and electrons and some quantities of ionized α-particles and gases. It attains speeds in the range of 300-750 km/s and has a flow density of 5×10^7 - 5×10^8 protons/ electrons/cm^{2}s. The observed speed rises systematically from low values (300-400 km/s) to high values (650-700 km/s) in 1 or 2 days and then returns to low values during the next 3 to 5 days (Figure 19). Each of these high-speed streams tends to appear at approximately 27-day intervals or to recur with the rotation period of the Sun. On days of high Sun activity the solar wind speed reaches 1000 (and more) km/s and its flow density is10^9 - 10^{10} protons/electrons/ cm^{2}s with 8 -70 particles per cm^3. The Sun has high activity periods several days each year.

The pressure of the solar wind is very small. For full braking it is in the interval $2.5\times10^{-10} \div 6.3\times10^{-9}$ N/m^2. This value is doubled when the particles have full reflection. The interstellar medium also has high-energy particles. Their density is about 1 particle/cm^3.

Estimation of main parameters of the AB-engine. Let us estimate the main parameters of the AB-Ramjet engine for interplanetary apparatus. Interplanetary apparatus using a charged ball for solar wind drag was considered by the author in [54]. This work shows a great potential for these apparatus.

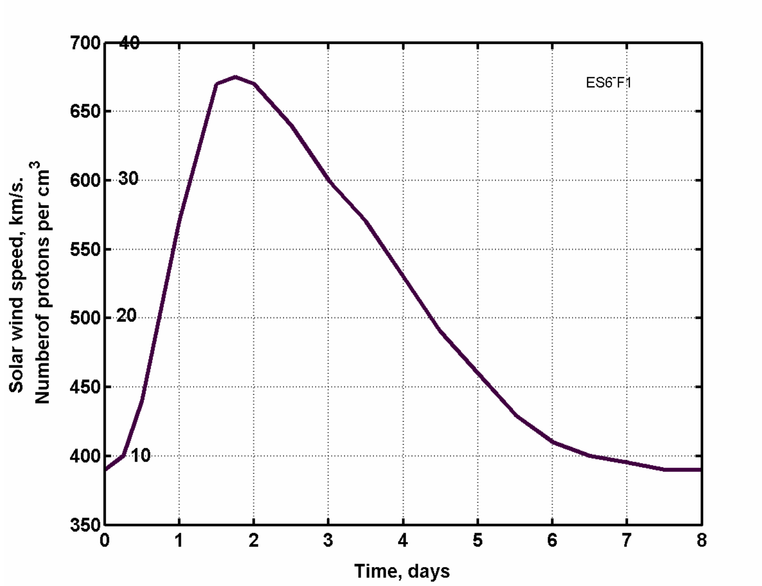

Figure 19. Speed and density variations in solar wind. The speed is in km/s, the density is in protons/cm^3.

The suggested AB-Ramjet engine (Figure 2) is different from the propulsion engine in [54]. The AB-Ramjet has plates which can produce thrust, work as a generator of electrical energy, create stronger drag, and improve the control of the value and direction of both the drag and thrust. The central charge has a cylindrical form which dramatically decreases the discharging of the central charged core. The proposed AB-Ramjet can simultaneously produce useful drag (or thrust) and electric energy. It may seem astonishing, but an AB-Ramjet located in the strong solar wind would be capable of achieving a speed between 400 - 750 km/s. If we install the wind engine in a conventional space ship, the engine will produce sufficient energy and drag which would also useful if space ship moved in the wind direction. The drag produced by solar wind is a useful thrust for moving from Earth to outer Earth orbit: Saturn - Pluto. It may appear that this apparatus is lacking because it can only move away from the Sun. However, that is not the case. The AB-ramjet apparatus can decrease the orbit speed and the Sun's gravity will move it back to Earth orbit.

Estimates of the main parameters of the AB-ramjet interplanetary engine and apparatus are given below. The equations used in computing the estimates are in theoretical section [Eqs. 4 -6]. Figure 20 shows the AB-radius of the efficiency area (catch area, clamp area) versus the charge radius of ball. Data used for computation: electric intensity E=100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3.

Mass and charge flow (electric current) through the AB-engine were computed using equations [8] and [9]. Results are presented in figs. 21 and 22 for the following conditions: electric intensity E=100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3. The flow mass is small (5 milligram/s), however the electric current is large.

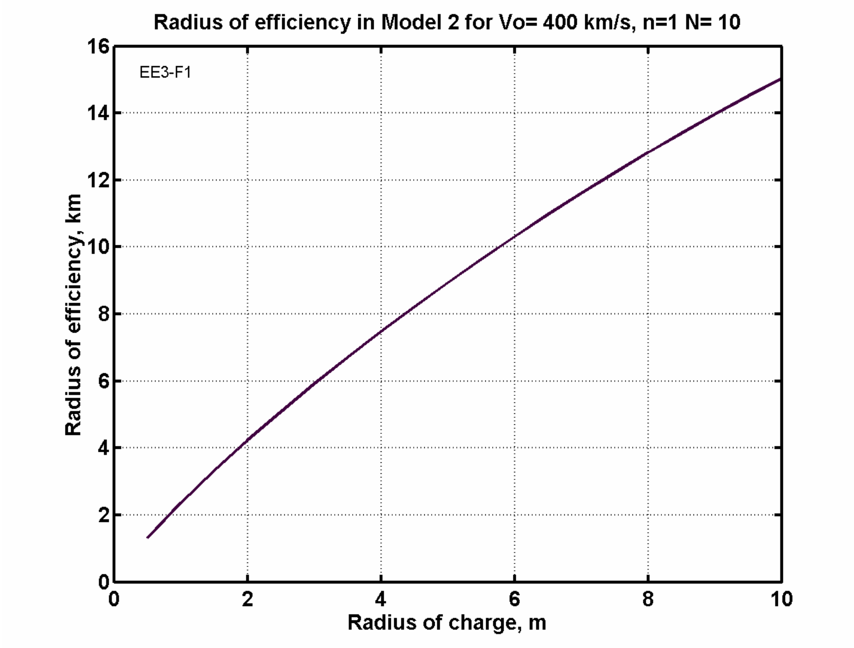

Figure 20. Radius of efficiency (catch area, clamp area) versus the charge radius for electric intensity E = 100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3. Equations are [4 - 6].

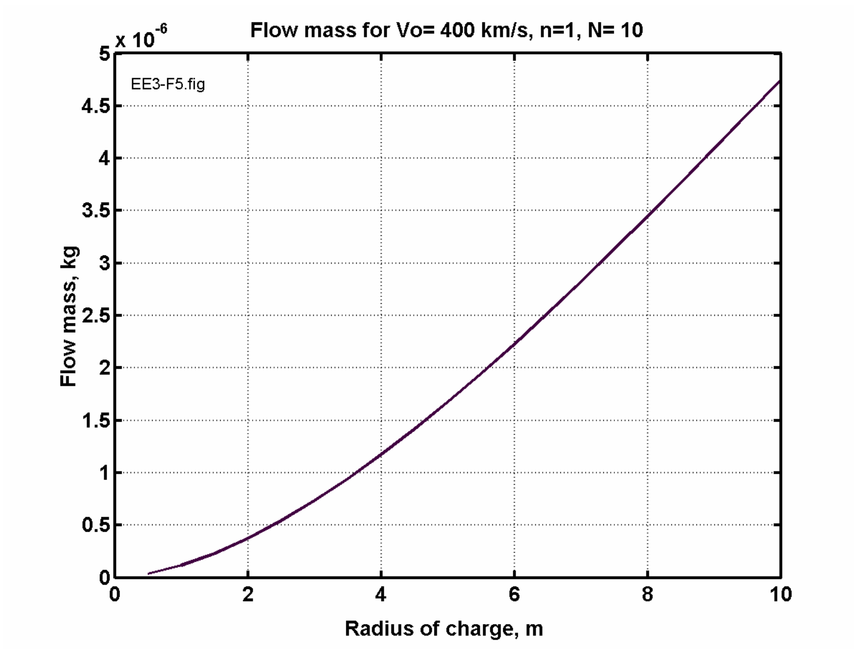

Figure 21. Flow of particles mass through the AB-Ramjet engine versus the charge radius for electric intensity E = 100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3.

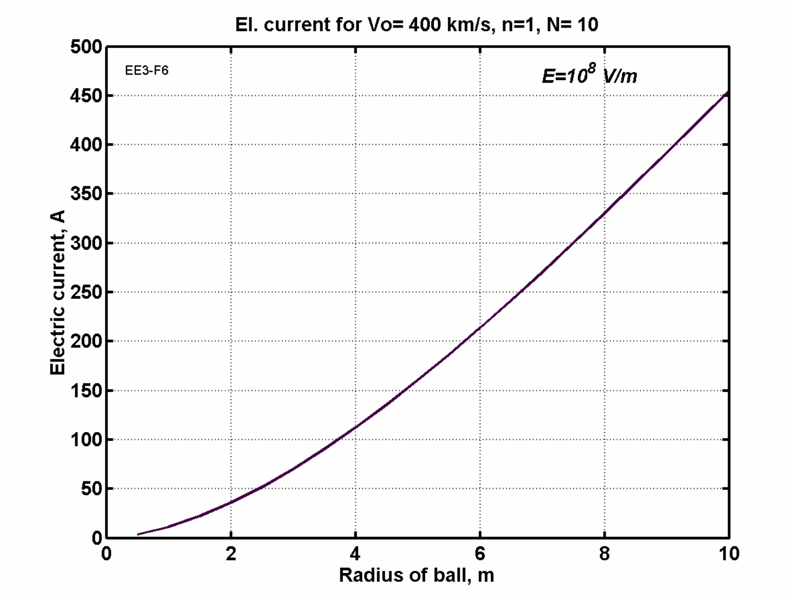

Figure 22. Flow electric currency through the AB-Ramjet engine versus the charge radius for electric intensity E = 100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3.

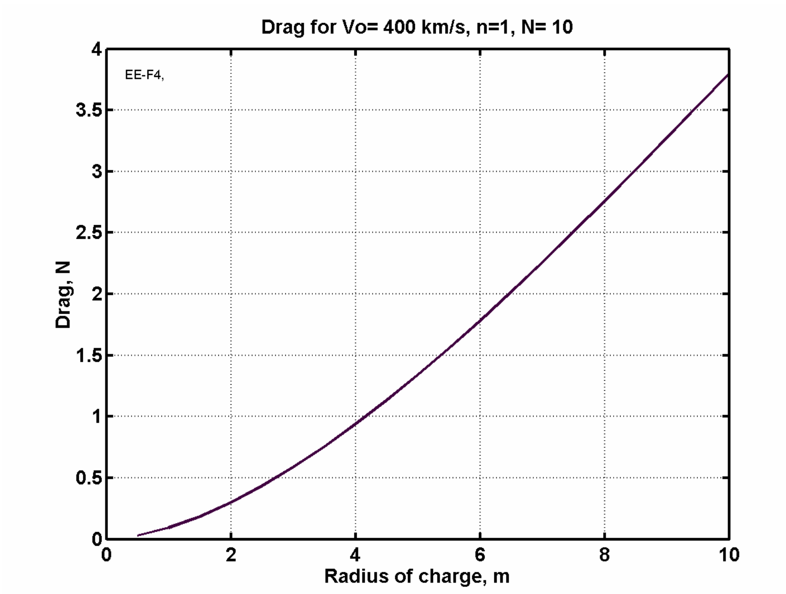

Figure 23. Maximal drag versus the charge radius for electric intensity E =100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3. Full reflection.

Figure 23 shows the maximal drag for full reflection versus the charge radius computed via equation 9a for the conditions: electric intensity E = 100 millions V/m, solar wind speed V_0 = 400 km/s, solar wind density N = 10 protons/cm^3. As can be seen, the useful drag is sufficiently large and can produce significant acceleration for space apparatus. More detailed computations for the conventional charge are presented in [54].

Thrust versus voltage between plates is shown in Figure 24 and the required energy for it is presented in Figure 25. For a thrust of 0.2 N, the required power is 4.5 kW. We can increase the voltage and obtain more thrust but the needed energy may not be acceptable for the apparatus. If we change polarity of the plates, we get the same energy (Figure 26) from apparatus braking, plus additional drag.

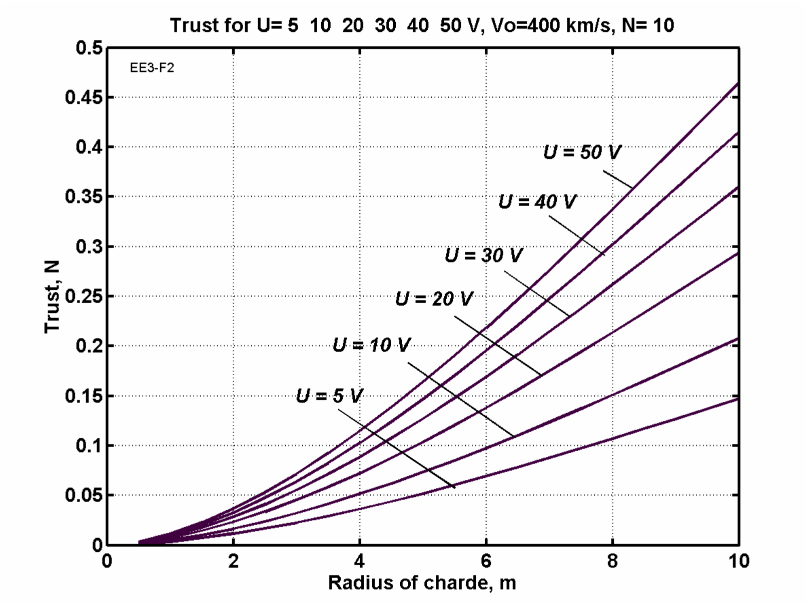

Figure 24. AB-Ramjet engine thrust versus radius of charge and plate voltage for V_0 = 400 km/s and flow density 10 protons/cm^3.

The maximum energy and half of full reflection drag will be obtained when the positive value of (V_0 - V) > 0 is close to zero. Here V_0 is solar wind speed and V is apparatus speed (positive direction from Sun). Using equation [7] ($mV^2/2 = eU$), for a wind speed V_0 = 400 km/s, the calculation gives U = 835 V. This means for a highly charged ball, U = 0 produces good reflection of the protons, near maximum drag, and zero positive electric energy. A U slightly less than 835 V produces near maximum energy and a drag close to half of the maximum drag (Figure23). The computation for this case is presented in Figure 26. The power is significantly large and the engine may be used for both the apparatus and the charging of the electrostatic collector (core).

Let us find the size of the electrostatic collector. The maximal size of the plate radius is between the parameter R_h and the minimal radius of the hyperbolic trajectory. These magnitudes are presented for the outermost particles in Figure 27. The computation shows a particle flow that has maximum density in the plate center and small density in the plate ends.

We can determine a plate radius by the lower curve. For a charge (ball) radius of 10 meter, a plate radius of 20 meters is sufficient.

Let us estimate the discharging power for a radius of central charge of 10 meters. Let the wire diameter of the engine plate net be 0.1 mm with a cell size of 10×10 cm.

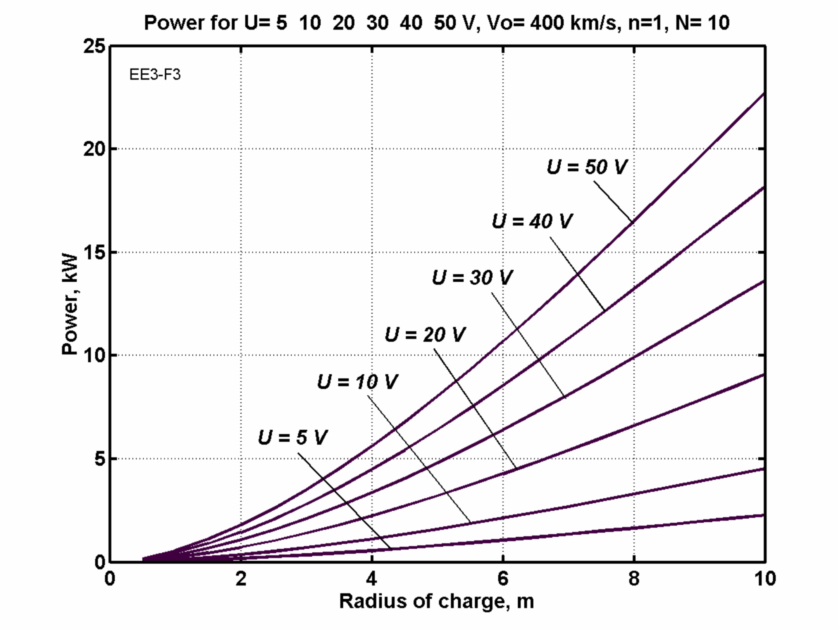

Figure 25. Requested AB-Ramjet engine power for thrust versus radius of charge and plate voltage for V_0 = 400 km/s and flow density 10 protons/cm^3.

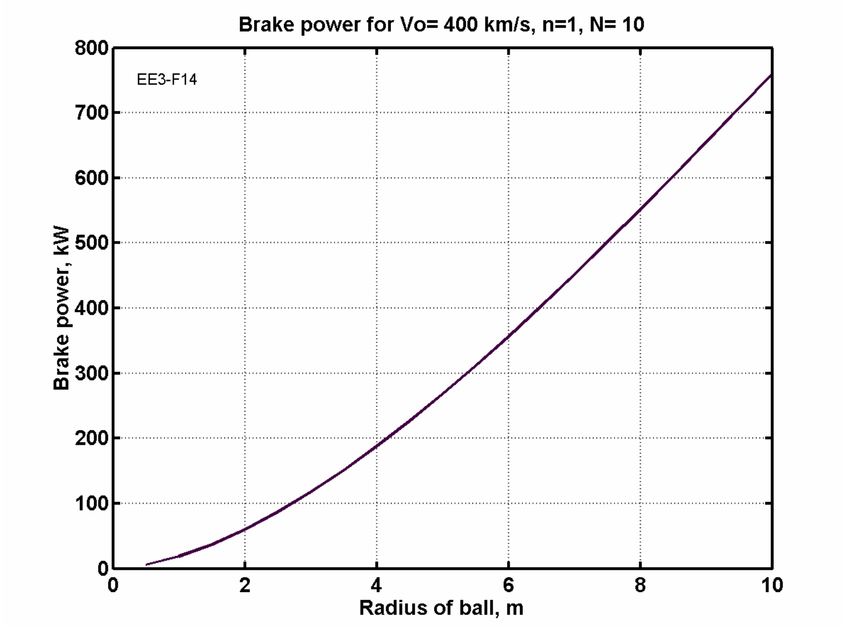

Figure 26. The maximum electric energy which can be obtained from the AB-Ramjet engine versus charge radius. In this case the drag (half of full drag) accelerates the apparatus to far planets.

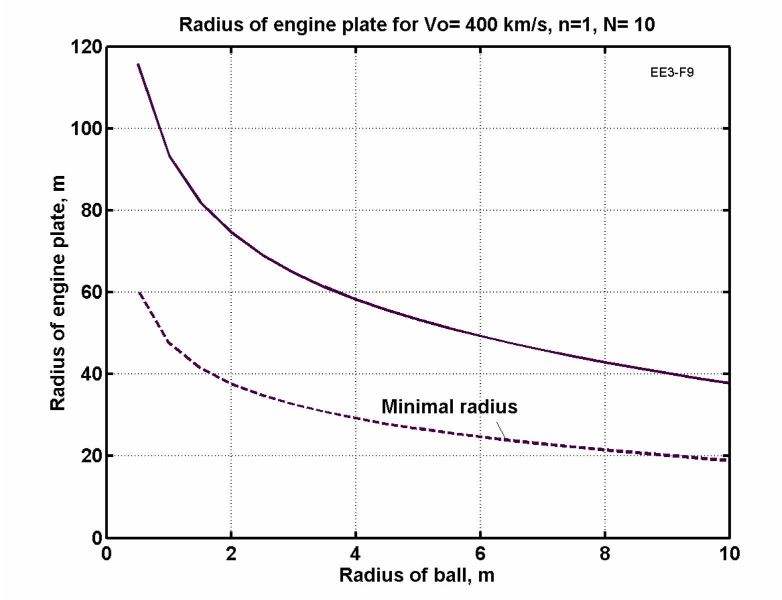

Figure 27. The minimal radius and parameter R_h of hyperbolic trajectory of outermost particles.

The light transparency coefficient is $c_1 = 4\times(0.001)^2 = 4\times10^{-6}$ (Eq. [19]. The brake coefficient of wire is $c_2 = 10^{-5}$ (Eq. [21]). The total transparency coefficient is $c_3 = c_1\times c_2 = 4\times10^{-11}$ (Eq. [22]). Loss of energy in the plate is $L = c_3IU = 4\times10^{-11}\times450\times10^9 = 1.8$ W. If we take into consideration the cylindrical central charge and other support elements and increase this value by 10, 100, 1000 times, the brake power (750 kW, Figure 26) will be enough for the compensation this energy.

The maximum electric force between plates for a distance of 2 meters and a voltage of 1000 V is 0.14 N (eq. [18]). This means the support elements can be very light. The mass of the two quadratic plates of size 20×20 m having aluminum wires is 1.7 kg.

CONCLUSION

The primary research and computations of the suggested AB-engine show the numerous possibilities and perspectives of the space AB-ramjet engines. The density of the charged space particles is very small. But the proposed electrostatic collector can effectively gather the particles from a huge surrounding area and accelerate or brake them, generating thrust or braking on the order of several Newtons. The high speed solar wind allows simultaneously obtainment of useful drag (thrust) and great electrical energy. The simplest electrostatic gatherer accelerates a 100 kg probe up to a velocity of 100 km/s [54]. The probe offers flights into Mars orbit of about 70 days, to Jupiter orbit in about 150 days, to Saturn orbit in about 250 days, to Uranus orbit in about 450 days, to Neptune orbit in about 650 days, and to Pluto orbit in about 850 days.

The suggested electric gun is simple and can transfer energy (charge by electron beam) over a long distance to other space apparatus.

The author has developed the initial theory and the initial computations to show the possibility of the offered concepts. He calls on scientists, engineers, space organizations, and companies to research and develop the proposed perspective concepts.

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(Some of these works the reader finds in author side: http://Bolonkin.narod.ru/p65.htm and http://Arxiv.org searth: Bolonkin)

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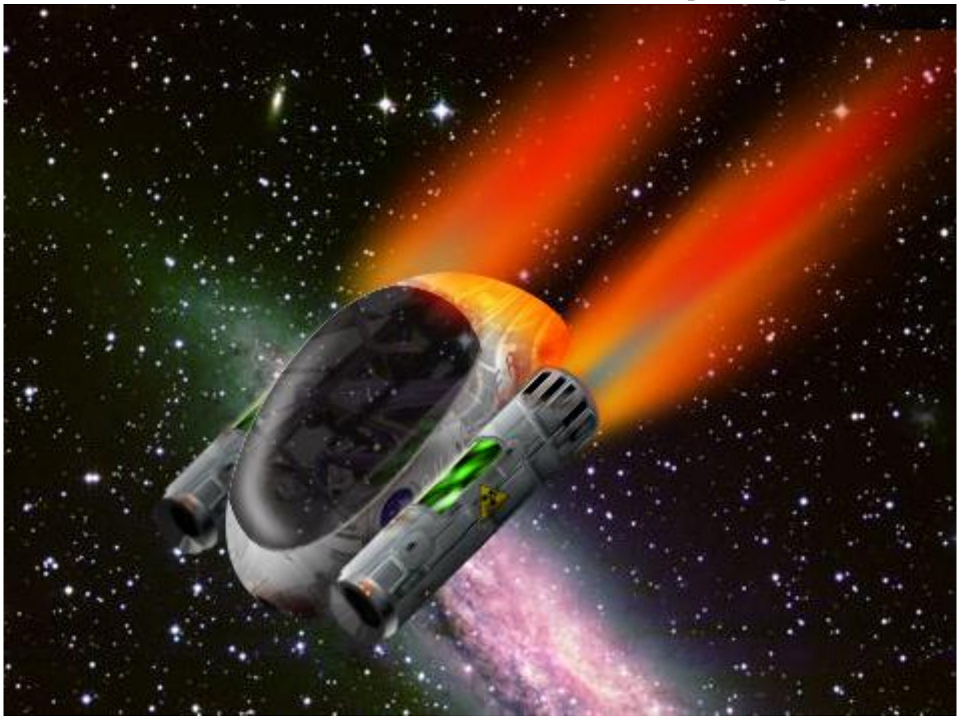
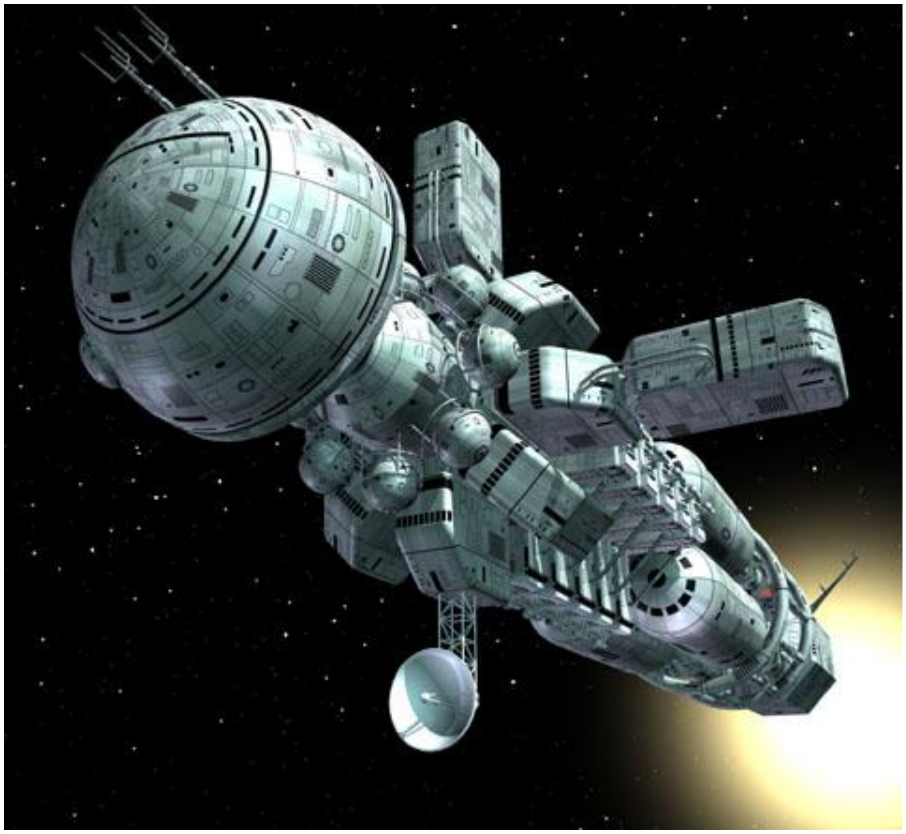
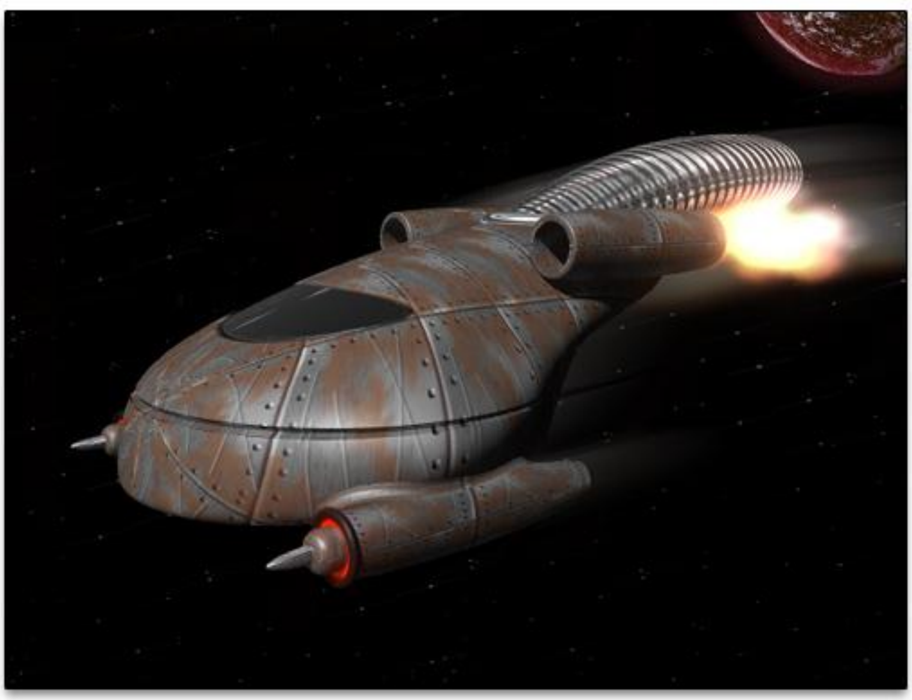
Attachment to Part A, Ch. 2. Possible form of space ships







Chapter 3

BEAM SPACE PROPULSION*

ABSTRACT

In this Chapter author offers a revolutionary method - non-rocket transfer of energy and thrust into Space with distance of millions kilometers. The author has developed theory and made the computations. The method is more efficient than transmission of energy by high-frequency waves. The method may be used for space launch and for acceleration the spaceship and probes for very high speeds, up to relativistic speed by current technology. Research also contains prospective projects which illustrate the possibilities of the suggested method.

Keywords: *space transfer of energy, space transfer of thrust, transferor of matter, transfer of impulse (momentum), interplanetary flight, interstellar flight*.

INTRODUCTION

Transportation of energy, matter, or impulse is very important for long period space trips especially for lengthy distance voyages. The spaceship crew or astronauts on planets can need additional energy or ship thrust. Most people think that is impossible to transfer energy a long distance in outer space except electromagnetic waves. Unfortunately, electromagnetic waves have a big divergence and cannot be used at a long distance (millions of kilometers) transfer.

However, the space vacuum is very good medium for offered method and special transfer of energy and momentum.

Brief history. About 40 years ago scientists received plasma flow having speed up 1000 km/s, power 10 kW, mass consumption 0.1 g/s, electric current up million amperes.

However, the application of plasma beam into space needs a series of inventions, innovations and researches. In particular, they include methods of decreasing the plasma divergence, discharging, dispersion of velocity, collection the plasma beam in space at long

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distance from source, conversion of the beam energy into electricity and other types of energy, conversion of plasma impulse (momentum) in space apparatus thrust, conversion of plasma into matter, control, etc.

The author started this research more then forty years ago [1]. The solutions of the main noted problems and innovations are suggested by author in early (1982-1983) patent applications [2] - [12] (see also further development in [13]-[31]) and given article. In particularly, the main innovations are:

1. Using neutral plasma (not charged beam);
2. Using ultra-cool plasma or particle beam in conventional temperature;
3. Control electrostatic collector which separates and collects the ions at spaceship;
4. Control electrostatic generator which convert the ion kinetic energy into electricity;
5. Control electrostatic ramjet propulsion;
6. Special control electrostatic mirror-reflector;
7. Recombination photon engine;
8. Recombination thermo-reactor.
9. Research is made for conventional and relativistic particle speeds.

About 20 years ago the scientists received the ultra-cold plasma having the ion temperature lower then 1×10^{-3} ^{o}K. Velocity dispersion was $10^{-4} \div 10^{-6}$, beam divergence for conventional temperature was 10^{-3} radian.

If plasma accelerator is designed special for getting the ultra-cold plasma, its temperature may be appreciably decreased. There is no big problem in getting of cold ions from solid electrodes or cold electrons from solid points where molecular speed is small.

DESCRIPTION OF INNOVATION

Innovative installation for transfer energy and impulse includes (Figure 1): the ultra-cold plasma injector, electrostatic collector, electrostatic electro-generator-thruster-reflector, and space apparatus. The plasma injector creates and accelerates the ultra-cold low density plasma.

The Installation works the following way: the injector-accelerator forms and injects the cold neutral plasma beam with high speed in spaceship direction. When the beam reaches the ship, the electrostatic collector of spaceship collects and separates the beam ions from large area and passes them through the engine-electric generator or reflects them by electrostatic mirror. If we want to receive the thrust in the near beam direction ($\pm 90^{o}$) and electric energy, the engine works as thruster (accelerator of spaceship and braker of beam) in beam direction and electric generator. If we want to get thrust in opposed beam direction, the space engine must accelerate the beam ions and spend energy. If we want to have maximum thrust in beam direction, the engine works as full electrostatic mirror and produces double thrust in the beam direction (full reflection of beam back to injector). The engine does not spend energy for full reflection.

The thrust is controlled by the electric voltage between engine nets [19], the thrust direction is controlled by the engine nets angle to beam direction. Note, the trust can brake the ship (decrease the tangential ship speed) and far ship (located out of Earth orbit) can return to the Earth by Sun gravity.

Note also, the Earth atmosphere absorbs and scatters the plasma beam and the beam injector must be located on Earth space mast or tower (up 40 ÷ 60 km, see [20, 21]) or the Moon. Only high energy beam can break through atmosphere with small divergence. The advantage: the injector has a reflector and when the ship locates not far from the injector the beam will be reflected a lot of times and thrust increases in thousand times at start (Figure 2) (see same situation in [22]).

The proposed engine may be also used as AB-ramjet engine [19], utilizing the Solar wind or interstellar particles.

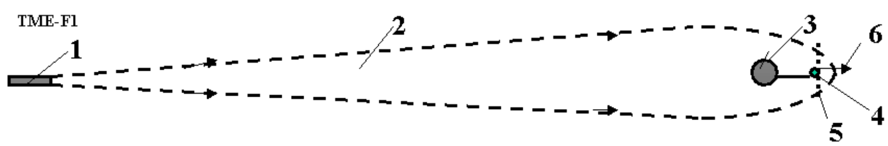

Figure 1. Long distance space transfer of electric energy, matter, and momentum (thrust). *Notations* are: 1 - injector-accelerator of neutral ultra-cold plasma (ions and electrons), 2 - plasma beam, 3 - space ship or planetary team, 4 - electrostatic ions collector (or magnetic collector), 5 - braking electric nets (electrostatic electro-generator-thruster-reflector), 6 - thrust.

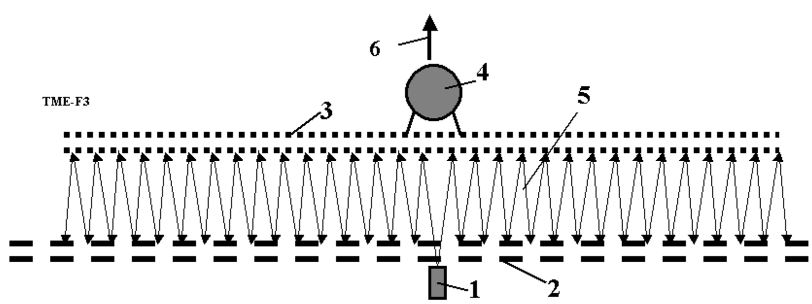

Figure 2. Multi-reflection start of the spaceship having proposed engine. *Notations* are: 1 - injector-accelerator of cold ions or plasma, 2 , 3 - electrostatic reflectors, 4 - space ship, 5 - plasma beam, 6 - the thrust.

The electrostatic collector and electrostatic generator-thruster-reflector proposed and described in [19]. The main parts are presented below.

A *Primary Ramjet* propulsion engine is shown in Figure 1 Chapter 2. Such an engine can work in charged environment. For example, the surrounding region of space medium contains positive charge particles (protons, ions). The engine has two plates 1, 2, and a source of electric voltage and energy (storage) 3. The plates are made from a thin dielectric film covered by a conducting layer. The plates may be a net. The source can create an electric voltage U and electric field (electric intensity E) between the plates. One also can collect the electric energy from plate as an accumulator.

The engine works in the following way. Apparatus are moving (in left direction) with velocity V (or particles 4 are moving in right direction). If voltage U is applied to the plates, it is well-known that main electric field is only between plates. If the particles are charged positive (protons, positive ions) and the first and second plate are charged positive and negative, respectively, then the particles are accelerated between the plates and achieve the additional velocity $v > 0$. The total velocity will be $V+v$ behind the engine (Figure 1a, Ch. 2). This means that the apparatus will have thrust $T > 0$ and spend electric energy $W < 0$ (bias, displacement current). If the voltage $U = 0$, then $v = 0$, $T = 0$, and $W = 0$ (Figure 1b, Ch.2).

If the first and second plates are charged negative and positive, respectively, the voltage changes sign. Assume the velocity v is satisfying $-V < v < 0$. Thus the particles will be braked and the engine (apparatus) will have drag and will also be braked. The engine transfers braked vehicle energy into electric (bias, displacement) current. That energy can be collected and used. Note that velocity v cannot equal $-V$. If v were equal to $-V$, that would mean that the apparatus collected positive particles, accumulated a big positive charge and then repelled the positive charged particles.

If the voltage is high enough, the brake is the highest (Figure 1d, Ch.2). Maximum braking is achieved when $v = -2V$ ($T < 0$, $W = 0$). Note, the v cannot be more then $-2V$, because it is full reflected speed.

AB-Ramjet engine. The suggested Ramjet is different from the primary ramjet. The suggested ramjet has specific electrostatic collector 5 (Figure 2a,c,d,e,f,g, Ch. 2). Other authors have outline the idea of space matter collection, but they did not describe and not research the principal design of collector. Really, for charging of collector we must move away from apparatus the charges. The charged collector attracts the same amount of the charged particles (charged protons, ions, electrons) from space medium. They discharged collector, work will be idle. That cannot be useful.

The electrostatic collector cannot adsorb matter (as offered some inventors) because it can adsorb ONLY opposed charges particles, which will be discharged the initial charge of collector. Physic law of conservation of charges does not allow to change charges of particles.

The suggested collector and ramjet engine have a special design (thin film, net, special form of charge collector, particle accelerator). The collector/engine passes the charged particles ACROSS (through) the installation and changes their energy (speed), deflecting and focusing them. That is why we refer to this engine as the *AB-Ramjet engine*. It can create thrust or drag, extract energy from the kinetic energy of particles or convert the apparatus' kinetic energy into electric energy, and deflect and focus the particle beam. The collector creates a local environment in space because it deletes (repeals) the same charged particles (electrons) from apparatus and allows the Ramjet to work when the apparatus speed is close to zero. The author developed the theory of the electrostatic collector and published it in [26]. The conventional electric engine cannot work in usual plasma without the main part of the AB-engine - the special pervious electrostatic collector.

The plates of the suggested engine are different from the primary engine. They have concentric partitions which create additional radial electric fields (electric intensity) (Figure 2b, Ch.2). They straighten, deflect and focus the particle beams and improve the efficiency coefficient of the engine.

The central charge can have a different form (core) and design (Figure 2 c,d,e,f,g,h, Ch.2). It may be:

(1) a sphere (Figure 2c, Ch. 2) having a thin cover of plastic film and a very thin (some nanometers) conducting layer (aluminum), with the concentric spheres inserted one into the other (Figure2d, Ch. 2),

(2) a net formed from thin wires (Figure 2e, Ch. 2);
(3) a cylinder (without butt-end)(Figure 2f, Ch. 2); or
(4) a plate (Figure 2g, Ch. 2).

The design is chosen to produce minimum energy loss (maximum particle transparency - see section "Theory"). The safety (from discharging, emission of electrons) electric intensity in a vacuum is 10^8 V/m for an outer conducting layer and negative charge. The electric intensity is more for an inside conducting layer and thousands of times more for positive charge.

The engine plates are attracted one to the other (see theoretical section). They can have various designs (Figure 3a - 3d, Ch. 2). In the rotating film or net design (Figure 3a, Ch. 2), the centrifugal force prevents contact between the plates. In the inflatable design (Figure 3b, Ch. 2), the low pressure gas prevents plate contact. A third design has (inflatable) rods supporting the film or net (Figure 3c, Ch. 2). The fourth design is an inflatable toroid which supports the distance between plates or nets (Figure 3d, Ch.2).

Note, the AB-ramjet engine can work using the neutral plasma. The ions will be accelerated or braked, the electrons will be conversely braked or accelerated. But the mass of the electrons is less then the mass of ions in thousands times and AB-engine will produce same thrust or drag.

Plasma accelerator. The simplest linear plasma accelerator (principle scheme of linear particle accelerator) for plasma beam is presented in Figure 4, Ch. 2. The design is a long tube (up 10 m) which creates a strong electric field along the tube axis (100 MV/m and more). The accelerator consists of the tube with electrical isolated cylindrical electrodes, ion source, and voltage multiplier. The accelerator increases speed of ions, but in end of tube into ion beam the electrons are injected. This plasma accelerator can accelerate charged particles up 1000 MeV. Electrostatic lens and special conditions allow the creation of a focusing and self-focusing beam which can transfer the charge and energy long distances into space. The engine can be charged from a satellite, a spaceship, the Moon, or a top atmosphere station (space tower [19, 28]). The beam may also be used as a particle beam weapon.

Approximately ten years ago, the conventional linear pipe accelerated protons up to 40 MeV with a beam divergence of 10^{-3} radian. However, acceleration of the multi-charged heavy ions may result in significantly more energy.

At present, the energy gradients as steep as 200 GeV/m have been achieved over millimeter-scale distances using laser pulsers. Gradients approaching 1 GeV/m are being produced on the multi-centimeter-scale with electron-beam systems, in contrast to a limit of about 0.1 GeV/m for radio-frequency acceleration alone. Existing electron accelerators such as SLAC <http://en.wikipedia.org/wiki/SLAC> could use electron-beam afterburners to increase the intensity of their particle beams. Electron systems in general can provide tightly collimated, reliable beams while laser systems may offer more power and compactness.

The cool plazma beam carries three types of energy: kinetic energy of particles, ionization, and dissosiation energy of ions and moleculs. That carry also particle mass and momentum. The AB-Ramjet engine (discribed over) can utilise only kinetic energy of plasma particles and momentum. The particles are braked and produce an electric current and thrust or reflected and produce only thrust in the beam direction. If we want to collect a plasma matter and to utilize also the ionization energy of plasma (or space invironment) ions and dissociation energy of plasma molecules we must use the modified AB-Ramjet engine discribed below (Figure 3).

The modified AB-engine has magnetic collector (option), three nets (two last nets may be films), and issue voltage (that also may be an electric load). The voltage, *U*, must be enough for full braking of charged particles. The first two nets brake the electrons and precipitate (collect) the electrons on the film 2 (Figure 3). The last couple of film (2, 3 in Figure3) brakes and collects the ions. The first couple of nets accelerate the ions that is way the voltage between them must be double.

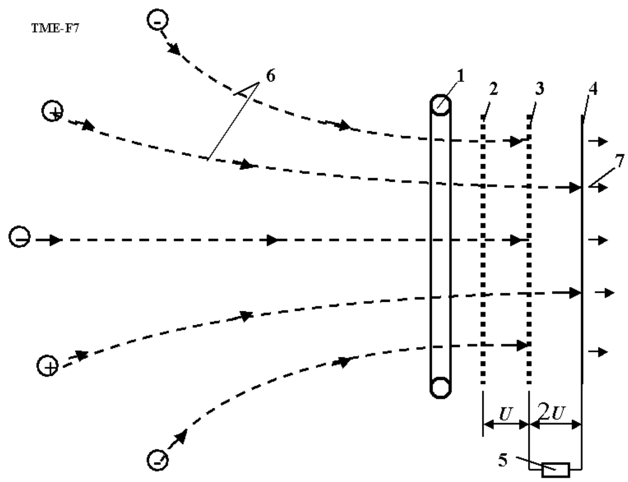

Figure 3. AB-engine which collected matter of plasma beam, kinetic energy of particles, energy ionization and dissociation. *Notations*: 1 - magnetic collector; 2 - 4 - plates (films, nets) of engine; 5 - electric load; 6 - particles of plasma; 7 - radiation. *U* - voltage between plates (nets).

The collected ions and electrons have the ionized and dissociation energy. This energy is significantly (up 20 - 150 times) more powerful then chemical energy of rocket fuel (see Table 1) but significantly less then kinetic energy of particles (ions) equal *U* (in eV) (*U* may be millions volts). But that may be used by ship. The ionization energy conventionally pick out in photons (light, radiation) which easy are converted in a heat (in closed vessel), the dissociation energy conventionally pick out in heat.

The light energy may be used in the photon engine as thrust (Figure 4a) or in a new power laser (Figure 4b). The heat energy may be utilized conventional way (Figure 4c). The offered new power laser (Figure 4b) works the following way. The ultra-cool rare plasma with short period of life time located into cylinder. If we press it (decrease density of plasma) the electrons and ions will connect and produce photons of very closed energy (laser beam). If we compress very quickly by explosion the power of beam will be high. The power is only limited amount of plasma energy.

After recombination ions and electrons we receive the conventional matter. This matter may be used as nuclear fuel (in thermonuclear reactor), medicine, food, drink, oxidizer for breathing, etc.

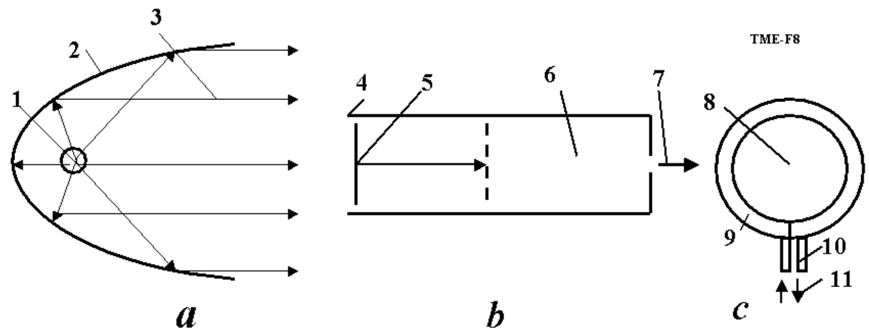

Figure 4. Conversion of ionization energy into radiation and heat. a - photon engine; b - power laser (light beamer); c - heater. *Notations*: 1 - recombination reactor; 2 - mirror; 3 - radiation (light) beam; 5 - piston; 6 - volume filled by cold rare plasma; 7 - beam; 8 - plasma; 9 - heat exchanger; 10 - enter and exit of hear carrier; 11 - heat carrier.

TRANSFER THEORY OF THE HIGH SPEED NEUTRAL ULTRA-COLD PLASMA AND PARTICLES

Below are the main equations and computations of neutral ultra-cold plasma beam having velocity up to relativistic speed. These equations received from conventional mechanics and relativistic theory.

Note a ratio β

$$\beta = \frac{V}{c}, \quad \beta_S = \frac{V_S}{c} \tag{1}$$

where V is plasma beam speed, m/s; c = 3×10^{8} is light speed, m/s; V_s is projection of a ship speed in beam direction.

1. *Relative relativistic time,* $\bar{t}$, for observer moving together with beam is

$$\bar{t}' = \frac{t'}{t} = \sqrt{1-\beta^2} \tag{2}$$

where t' is time for observer moving together with beam (system coordinate connected with beam)[s], t is time for Earth's observer [s]. Computation of Eq. (2) is presented in Figure 5. The beam time decreases for relativistic speed. That means the beam divergence is also decreased and beam energy may be passed for long distance.

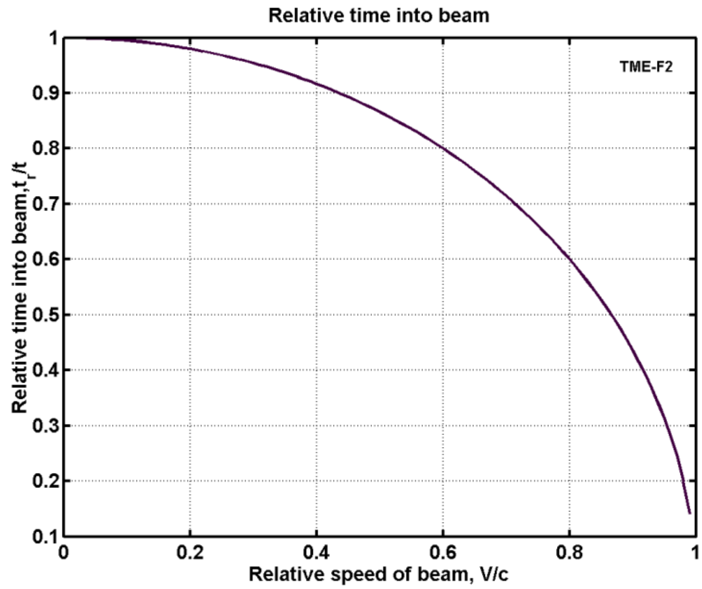

Figure 5. Beam relative time versus beam relative speed for high relativistic beam speed.

2. *The power spent for acceleration plasma beam* in Earth for efficiency = 1 (kinetic power of particle beam) is

$$P_B = \frac{M_0 c^2}{2}\frac{\beta^2}{\sqrt{1-\beta^2}}, \quad \text{or} \quad \text{for} \quad \beta << 1 \quad P_B = \frac{M_0 V^2}{2} \text{ [W/s]} \tag{3}$$

where M_0 is mass flow of beam, kg/s in Earth system of coordinate.

The computations of Eq. (3) for the intervals (0 ÷ 0.1)*c* and (0 ÷ 0.95)*c* are presented in Figures 6, 6a.

The relativistic speed needs very high power in any method because the relativistic beam requires this energy.

3. *The power P_i of dissociation and single ionization* of one nucleon is

$$P_i = 1.6\times10^{-19}\frac{M_0}{m_p n}e_i \quad [J] \quad \text{or} \quad P_i = \frac{M_0}{m_p n}e_i \quad \text{[eV]} \tag{4}$$

where m_p=1.67×10^{-27} kg is mass of proton, *n* is number of nucleon in nucleus, e_i is energy of dissociation, ionization, or molecular breakup respectively. The energy of the first ionization (ion lost one electron) approximately equals from 2 to 14 eV. Magnitudes of this energy for some molecules and ions are in Table No.1.

Table 1. Energy ionization, dissociation, and molecular breakup of some molecules and ions in *eV*

Molecular breakup	$H_2O \to H_2 + O$	2 eV	$CO_2 \to C + O_2$	0.093 eV
Dissociation	$H_2 \to H + H$	4.48 eV	$O_2 \to O + O$	5.1 eV
Ionization	$H \to H^+$	13.6 eV	$H_2 \to H_2^+$	2.65 eV
Ionization	$O_2 \to O_2^+$	6.7 eV		

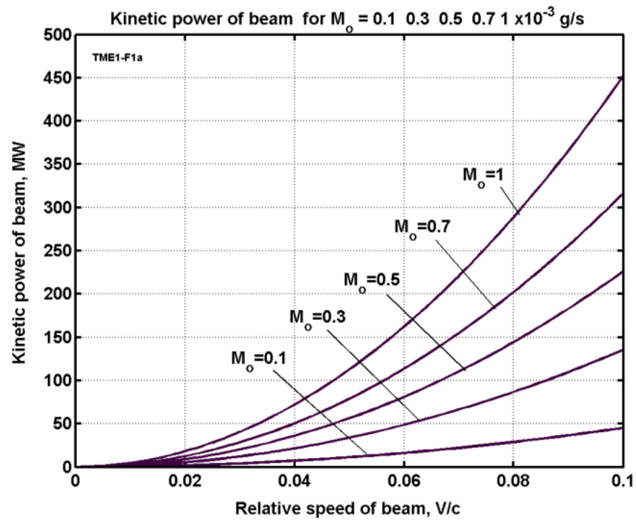

Figure 6. Power for the beam acceleration via beam flow mass and relative beam speed for interval. $(0 \div 0.1)c$

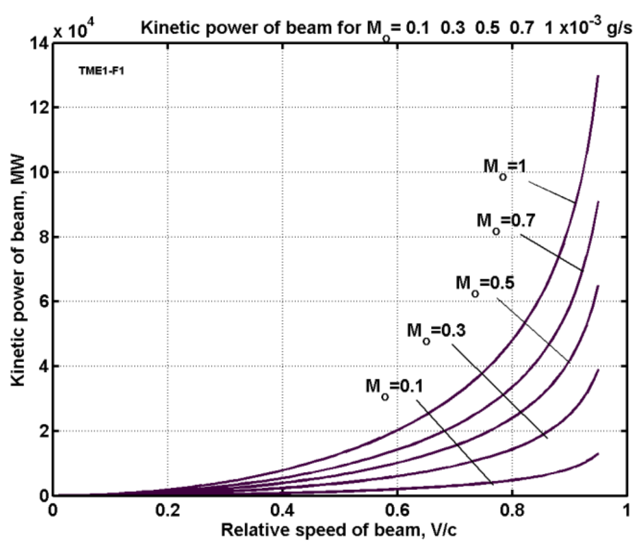

Figure 6a. Power for the beam acceleration via beam flow mass and relative beam speed for interval $(0 \div 0.95)c$.

If speed is relativistic, this energy is small in comparison with kinetic energy of beam. For interplanetary speed (V_S = 8 -15 km/s) the energy of ionization reaches 15 - 50% from kinetic energy of beam. That decreases the coefficient of efficiency launch installation. If we used the heavy ions or a charged matter, the ionization energy decreases but voltage increases. For interplanetary vehicles it is not important because required voltage for low speed are small ($U \approx 5 \div 20$ V).

Figure 7 shows the required energy for different case

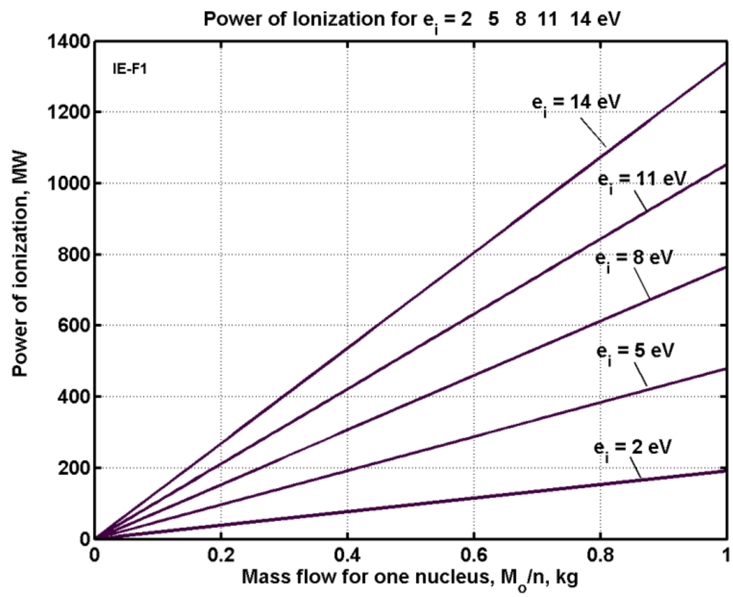

Figure 7. Power of ionization versus mass flow and ionization potencial (Eq. (4)).

4. *The maximal thrust (drag)* from the full reflected one charged plasma beam, for Earth's observer and relativistic speed and non-relativistic speed may be estimated by following equations:

$$T_{max} = 2M(V \mp V_S) \approx \frac{2M_0 c(\beta \mp \beta_S)}{\sqrt{1-\beta^2}}, \quad \text{or for} \quad \beta_S << 1 \quad \text{the thrust is} \quad T_{nax} = \frac{2M_0 c\beta}{\sqrt{1-\beta^2}},$$

$$\text{for} \quad \beta << 1, \quad \beta_S << 1, \quad \text{the thrust is} \quad T_{max} = 2M_0(V - V_S) \qquad (5)$$

Here M is calculated mass of a moving relativistic particle flow, kg/s; M_0 is mass of the particle flow measured by Earth's observer, kg/s.

Note: If the space ship move along the beam in same direction, the thrust is decreased (sign is "-"); if that moves in opposed direction, the drag is increased (sing is "+"). This drag (thrust) is not requested the ship propulsion energy.

Result of computation for intervals $(0 \div 0.1)c$, $(0 \div 0.95)c$, $V_S = 0$ are presented in Figure 8, 8a.

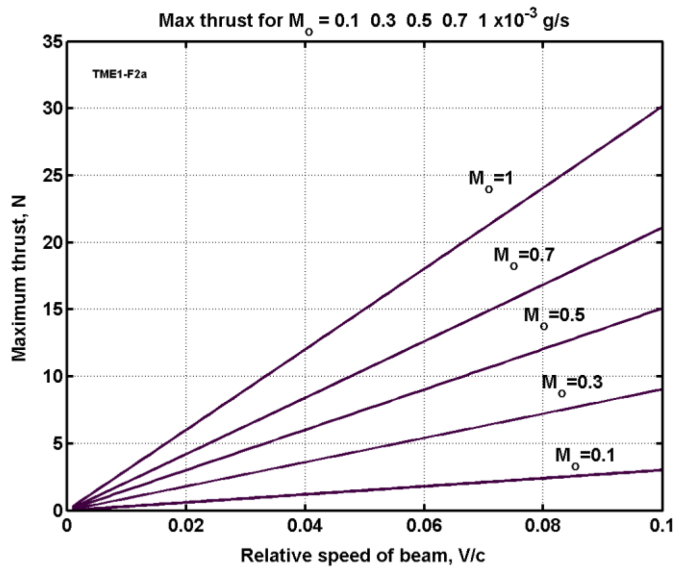

Figure 8. Maximum thrust (drag) is produced by beam in space ship for $V_S = 0$ and the interval $(0 \div 0.1)c$.

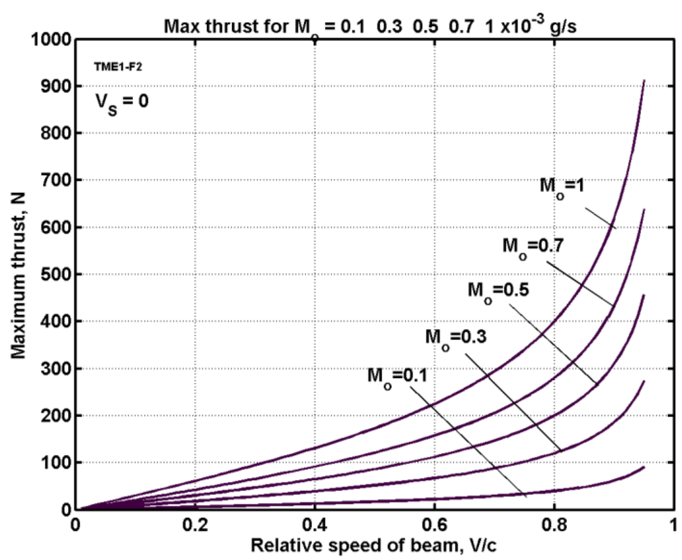

Figure 8a. Maximum thrust (drag) is produced by beam in space ship for $V_S = 0$ and interval $(0 \div 0.95)c$.

5. *The divergence of beam* is a very important magnitude. If divergence is small, we can pass our energy in long distance S:

$$D = \frac{ut'}{Vt} = \frac{u}{c}\frac{\sqrt{1-\beta^2}}{\beta}S, \quad \overline{D} = \frac{D}{S}, \quad S = c\beta t \tag{6}$$

where u is maximal radial speed, m/s; D is maximal radial distance (radius of plasma beam), m; $\overline{D}$ is relative divergence (angle of divergence, $\theta = 2\overline{D}$ radians); t is time of beam moving, s.

The computation of Eq. (6) is shown in Figure 9. We need in small u (ultra-cold plasma) for decreasing of divergence as small as possible (u = 0.01 - 1 m/s). In this case we can transfer energy in the large distance and accelerate a ship for relativistic speed. The plasma is mixture of ions and electrons. If it is low-density, it can exist a long time. The cold plasma can be emitted from solid electrodes.

Note: Equations (2),(6) shows when $V \to c$, then $t' \to 0$ and deviation $D \to 0$. That means the deviation can be small as we want but we need a big power for it.

The corresponding temperature is

$$T_c = \frac{mu^2}{ik}, \tag{7}$$

where m is mass of molecule (ion) [kg]; $m = m_p n$, here m_p=1.67×10 $^{-27}$ is mass of proton, n is number of nucleons into nucleus; i = 3 for single ion (for example O^+), i = 5 for double molecule (for example O_2^+), i = 6 for multi-molecular ions, k = 1.39×10 $^{-23}$ is Boltzmann constant.

For u = 0.1 ÷ 1 m/s the temperature is about 10 $^{-3}$ ^{o}K, the relative divergence is 10 $^{-9}$.

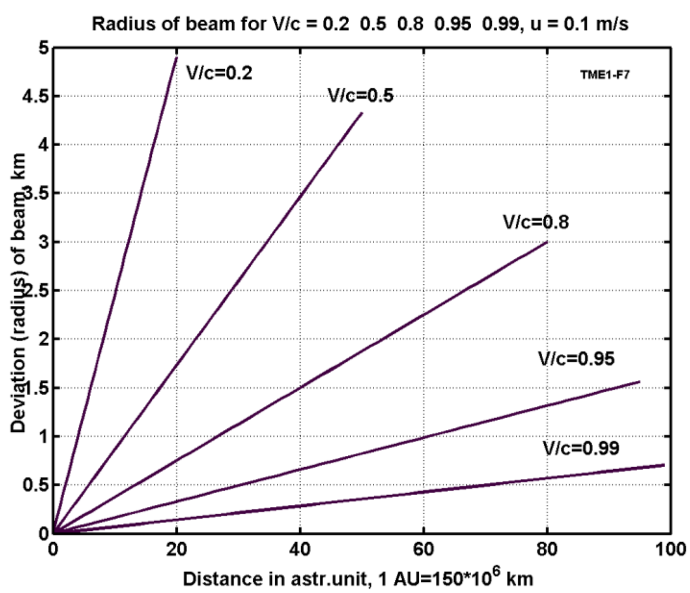

Figure 9. Radius of beam divergence via distance and ratio *V/c*.

6. Accelerate voltage is

$$U = \frac{mV^2}{2q} = \left(\frac{m_p}{q}\right)\frac{nc^2}{2}\frac{\beta^2}{\sqrt{1-\beta^2}} \tag{8}$$

where $q = 1.6\times10^{-19}$ C is electron (ion) charge. The computations are presented in Figure 10, 10a. The need voltage may be reduced in Z times if the ion has Z charges (delete Z electrons from ion).

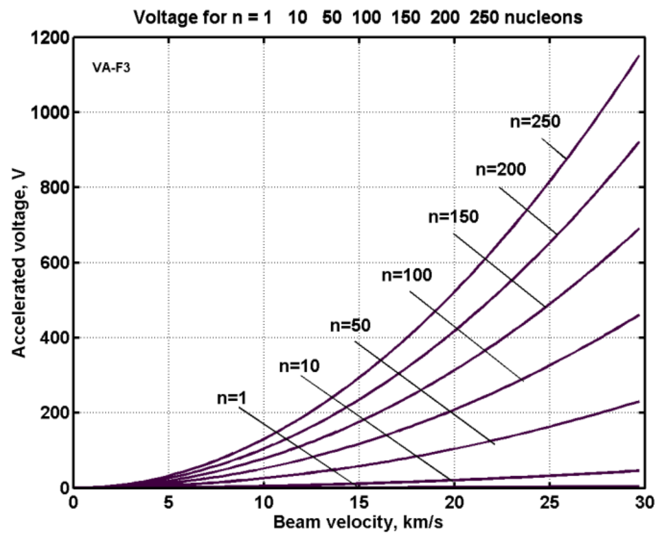

Figure 10. Accelerated voltage versus the coventinal beam speed and number of nucleons.

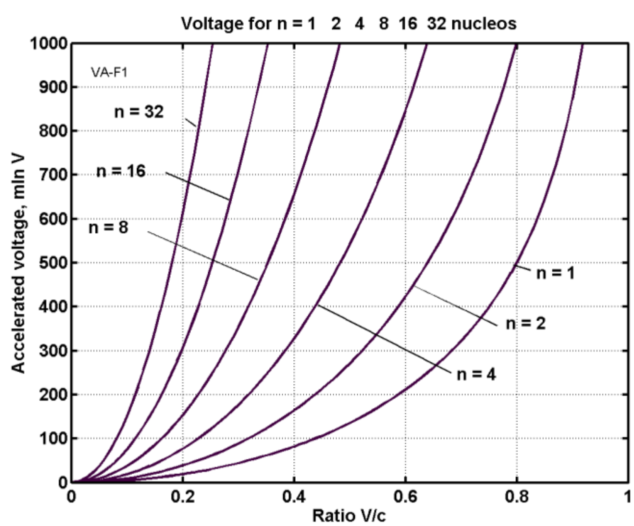

Figure 10a. Accelerated voltage versus a relativistic speed ratio *V/c* and number of nucleons.

7. *The speed V_s and distance of space ship S* can be computed by conventional method (Earth's observer):

$$V_S = at, \quad S = \frac{at^2}{2}, \quad S = \frac{V_S^2}{2a}, \quad a = \frac{T}{M_S}$$

a is ship acceleration, m/s^2. M_s is ship mass, kg, V_S is ship speed measured by Earth's observer, m/s.

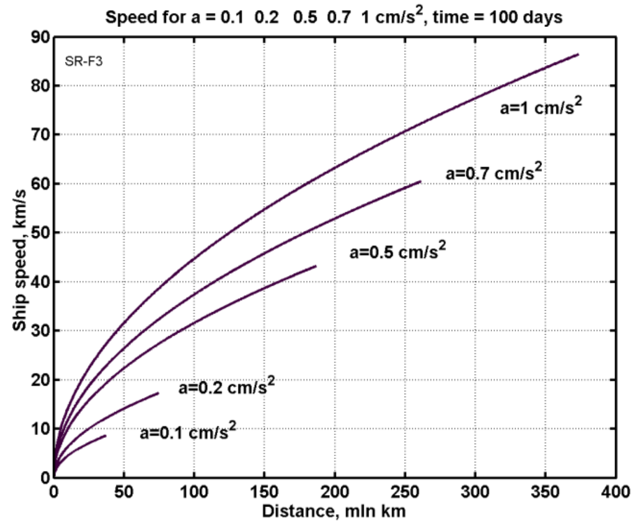

Figure 11. Ship speed for 100-days flight versus distance and ship acceleration.

8. *Relative beam speed* for a ship observer is

$$\beta_{BS} = \frac{\beta \pm \beta_S}{1 + \beta\beta_S} \tag{9}$$

where β, β_S is relative speed of beam and space ship respectively measured by Earth's observer. The sign " -" is used for same direction of speeds.

9. *Loss energy of the beam* in the Earth atmosphere may be estimated by the following way:

$$\tau = \frac{100 H_0 \rho_0 \bar{\rho}(h) \bar{p}(h)}{R_t(U)}, \quad R_t = \frac{m}{m_p} R_t\left(\frac{m_p}{m} U\right) \tag{10}$$

where $H_0 = P_a/\rho = 10^4/1.225 = 8163$ m is thickness (height) of Earth atmosphere having constant density $\rho = 1.225$ kg/m^3, $P_a = 10^4$ kg/m^2 is the atmospheric pressure; $\bar{\rho}(h)$ is relative atmosphere density; $\bar{p}(h)$ is relative atmosphere pressure; R_t is particle track in atmosphere [cm]; *m* is mass of particle, kg; *h* is altitude, m; *U* is beam energy, MeV; ρ_o = 0,001225 g/cm^3 is atmosphere density; 100 is transfer coefficient meter into cm. Magnitudes R_t, $\bar{\rho}(h)$, $\bar{p}(h)$ for proton are given below in Table 2, 3.

Table 2. Value R_t [g/cm^2] versus energy of proton in MeV, [32], p. 953

U MeV	0.1	1	10	50	100	200	300	400	500
R_t g/cm^2	1×10^{-4}	1.09×10^{-2}	$0,99\times10^{-1}$	2.56	8.835	29.64	58.08	93.73	133.3

U	600	700	800	1000	2000	3000	5000	7000	10,000
R_t	176	222	270	370	910	1363	2543	3583	5081

Table 3. Standard Earth atmosphere, [33], p. 261

h km	0	5	10	20	40	60	100
$\bar{\rho}(h)$	1	0.661	0.338	0.072	3.27×10^{-3}	2.71×10^{-4}	4.41×10^{-7}
$\bar{p}(h)$	1	0.533	0.261	0.054	2.92×10^{-3}	8.35×10^{-4}	3.20×10^{-7}

Results of computation Eq. (10) are presented in Figure 12, 12a, 12b.

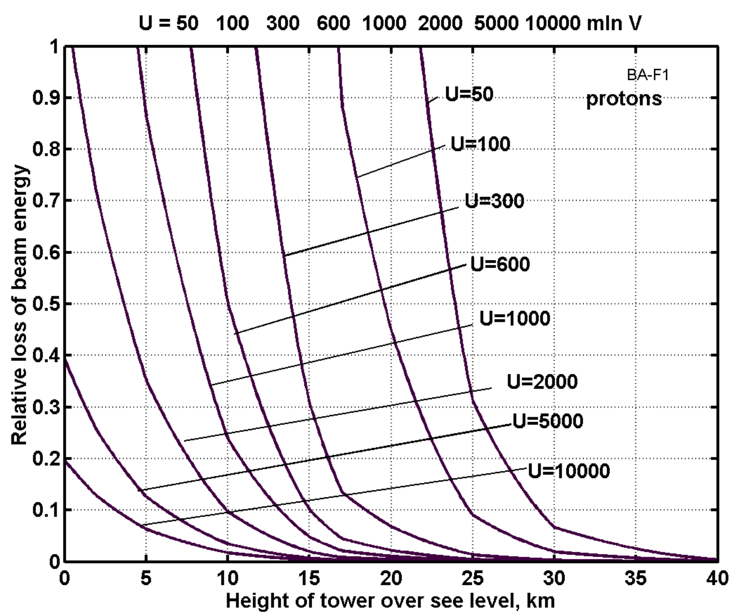

Figure 12. Relative energy loss of the proton particle beam via a tower altitude in Earth atmosphere.

Accelerate voltage *U* are in millions volts.

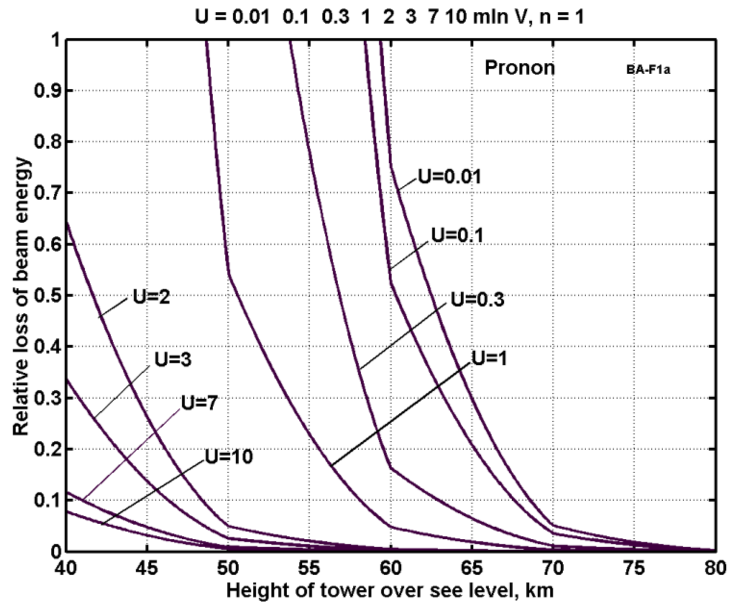

Figure 12a. Relative energy loss of the proton particle beam via a tower altitude in Earth atmosphere.

Accelerate voltage *U* are in millions volts. Angles in curve are result of the linearization data of Table 2, 3.

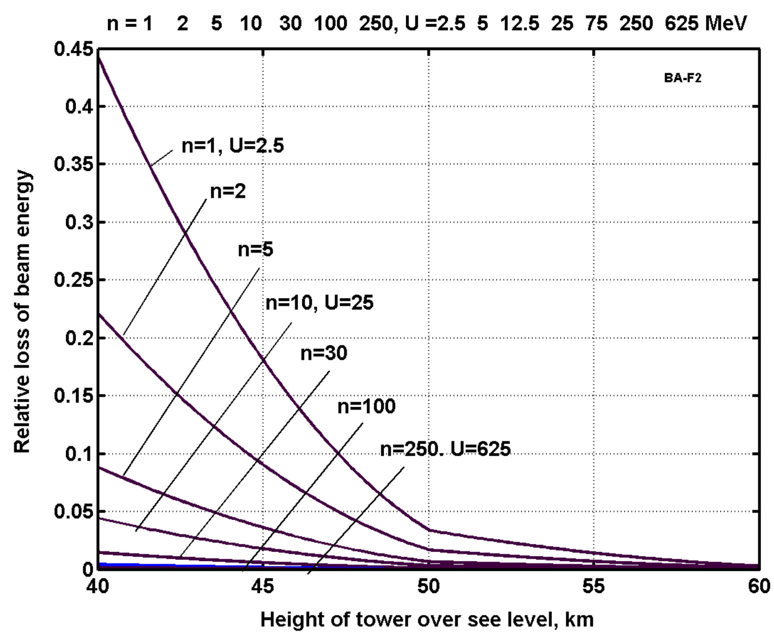

Figure 12b. Relative energy loss of the particle beam via the tower altitude in Earth atmosphere and number n of nucleons in nucleus. Accelerate voltage *U* in millions volts.

Evidently, only high energy particle beam break up the Earth atmosphere. There is no problem if the particle beam starts from a space tower [20], [25] of 40 ÷ 80 km altitude or from the Moon.

Last formula in (10) allows recalculation by the particle track for any atom. For example, we want tocalculate the particle track for oxidizer particle having $m = 16m_p$ and energy 8,000 MeV. We take the R_t from Table 2 for U = 8,000/16 = 500 MeV and multiple by 16. Result R_t = 133×16=2128. The particle track $T_r = R_t/\rho_0$ = 2128/0.001225 =1737142 cm = 17.4 km in the air having density 1.225 kg/m^3. That is enough to break the Earth's atmosphere of the constant density 8.163 km, but the loss of energy will be τ = 8.163/17.4 = 0.47 (47%). The divergence may also be increased by atmosphere. Loss and divergence may be improved is the beam station is located on a mountain or special tower having the height about 40 ÷ 60 km.

9. Multi-reflex launch and landing (Figure2). In a starting or braking period the thrust (braking) can be increasing if we use the multi-reflect method developed in [26]. Multi-reflect in launching does not increased the installation power (thrust is increased by increasing of efficiency), multi-reflex in braking converts the apparatus kinetic energy into the electric energy which can be utilized by apparatus or operated station. The theory of multi-reflection is described below (see also [26]).

Change in beam power. The beam power will be reduced if one (or both) reflector is moved, because the beam speed changes. The total relative loss, q, of the beam energy in one double cycle (when the beam is moved to the reflector and back) is

$$q = (1-2\gamma)(1-2\xi)(1\pm 2v)\varsigma\,, \quad q > 0\,, \qquad (11)$$

where v is the loss (useful work) through relative mirror (lens) movement, $v = V_S/V$, V_S is the relative speed of the electrostatic mirrors (space apparatus)[m/s], V = is the speed of the beam (in system of coordinates connected with an power operating station). We take the "+" when the distance is reduces (braking) and take "– " when the distance is increased (as in launching, a useful work for beam), γ is coefficient reflectivity of electrostatic mirror (the loss of beam energy through the electrostatic reflector); ξ is the loss (attenuation) in the medium (air) (see point 8). If no atmosphere, $\xi = 0$; ς is the loss through beam divergence ($\varsigma = 1$ if $D < D_r$, where D_r is diameter of the electrostatic mirror). For a wire net electrostatic reflector $\gamma \approx 2d_w/l$ where d_w is diameter of wire, l is size of mesh. For example, for the net having a mesh 0.1×0.1 m, the l = 0.1 m and a wire d_w = 0.0001 m, the γ = 0.002.

Multi-reflex light pressure. The beam pressure, T, of two opposed high reflectors after a series of reflections, N, to one another is

$$T(V_S) = T_0 + \frac{2P_B}{V}\sum_{j=1}^{N} q^j(V_S), \quad N(V_S) = \sqrt{\frac{kD_rV}{uS}}. \quad P_B = \frac{M_0V^2}{2}. \quad T_0 = 2M_0(V - V_S) \ge 0 \qquad (12)$$

where S is distance between electrostatic reflectors of the station and ship [m], k = 1 ÷ 1.5 is correction coefficient for the case when $D > D_r$. For primary estimation k = 1.

If V_S is small and V is high, the multi-reflex T may be large. For example, if V_S =10 m/s, V = 30 km/s, S is small, the number of reflection may reach $n \approx$ 30000/10/2 = 1500 times more then regular thrust. That is well for ship trip starting and braking.

Limitation of reflection number. If the reflector is moved away, the maximum number of reflections, N, is limited by $q > 0$, $V_S < 0.5V$ (see Eq. (11)). At ship launch or braking the maximum thrust is limited by a safety acceleration or deceleration.

Coefficient of efficiency. The propulsion efficiency coefficient, η, (without loss for ionization) may be computed using the equation

$$\eta = TV_S / P_B \qquad (13)$$

For full reflection Eq. (13) has the form:

$$\eta = \frac{4(V - V_S)V_S}{V^2}, \quad \eta_{max} = 1 \quad \text{for} \quad V = 2V_S \qquad (14)$$

Computation of launch and landing trajectories computed by the usual method of integration

[illegible] (15)

The results for spaceship having the weight 3 tons and the final speed 12 km/s are presented in Figure 13 - 15.

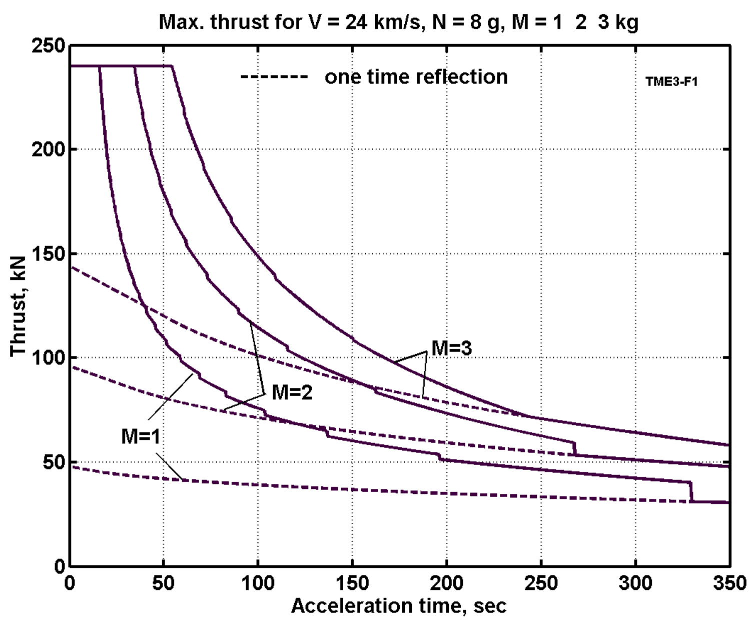

Figure 13. Thrust of the multi-reflection beam and the one time reflection beam versus the flight time and beam flow. Data: $\gamma = 0.002$, $\xi = 0$, $\zeta = 1$, $D_r = 30$ m, $u = 0.1$ m, $V = 25000$ m/s, $M_s = 3000$ kg, acceleration limit $N_g < 8$g, $M_0 = M = 1, 2, 3$ kg/s.

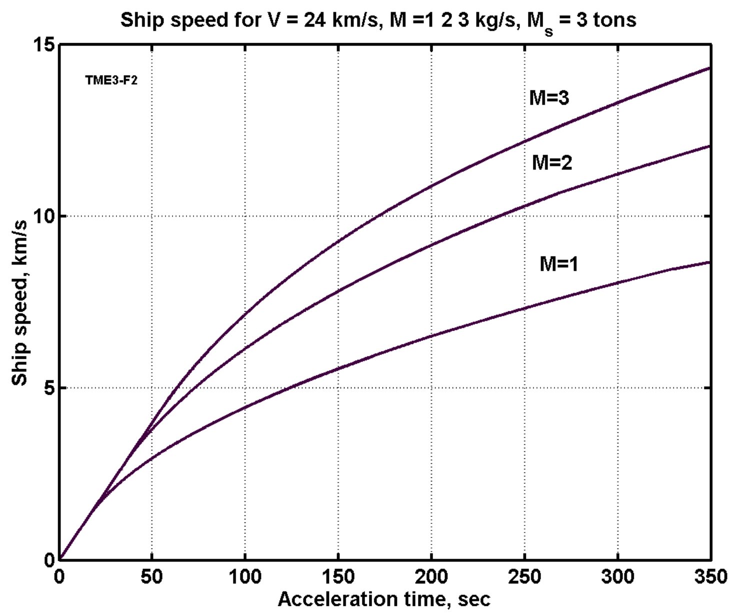

Figure 14. Ship speed versus the flight-time and the beam flow. Data: $\gamma = 0.002$, $\xi = 0$, $\zeta = 1$, $D_r = 30$ m, $u = 0.1$ m, $V = 25000$ m/s, $M_s = 3000$ kg, acceleration limit $N_g < 8$g, $M_0 = M = 1, 2, 3$ kg/s.

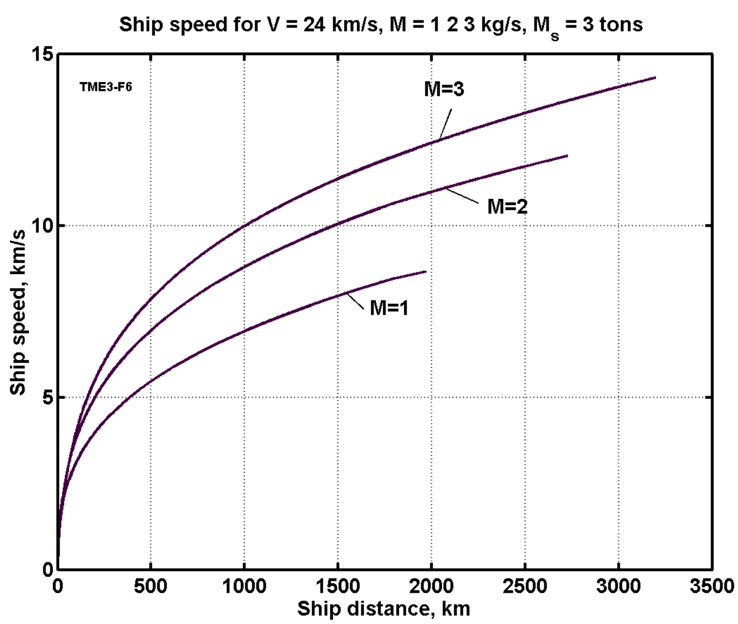

Figure 15. Ship speed versus the distance and the beam flow. Data: flight time $t = 350$ sec., $\gamma = 0.002$, $\xi = 0$, $\zeta = 1$, $D_r = 30$ m, $u = 0.1$ m, $V = 25{,}000$ m/s, $M_s = 3000$ kg, acceleration limit $N_g < 8$g, $M_0 = M = 1, 2, 3$ kg/s.

10. For non-relativistic flight all equations are simplify.

$$T_{\max} = 2M_0(V - V_S), \quad P_B = \frac{M_0 V^2}{2}, \quad D = \frac{u}{V} S = ut, \quad U = \left(\frac{m_p}{q}\right)\frac{nV^2}{2} = \frac{M_0 V^2}{2C} \tag{16}$$

where C is an positive electric charge of M_0.

Typical computations for Earth and interplanetary space vehicles are presented in Figure 16 - 18 (typical probe, Figure 16 and Moon spaceship, Figures 17, 18, - Project 1).

10. Macro-particle beam and projectile. The developed theory may be applied to any macro-particle beam or projectiles. An electrostatic gun may be used for its acceleration [27]. The projectile has a charge which is lost after it exits the gun (charged energy will be returned to installation). There is no big problem with flight through the Earth atmosphere for projectiles. The loss energy is about 10 - 20%, the heat is small if projectile has a sharp tip (see [21], [24]). The ship uses a kinetic energy of projectile and projectile matter as described in [29, 30].

The offered method may be applied variously. We consider only application to interplanetary spaceship and interstellar space probe.

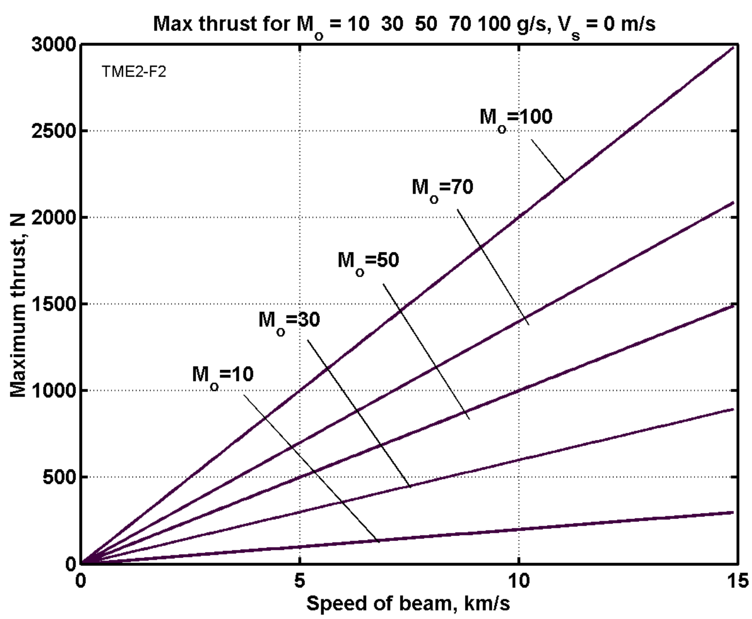

Figure 16. Maximum thrust (drag) versus the particle beam speed and mass flow [g/s] for typical Earth satellite.

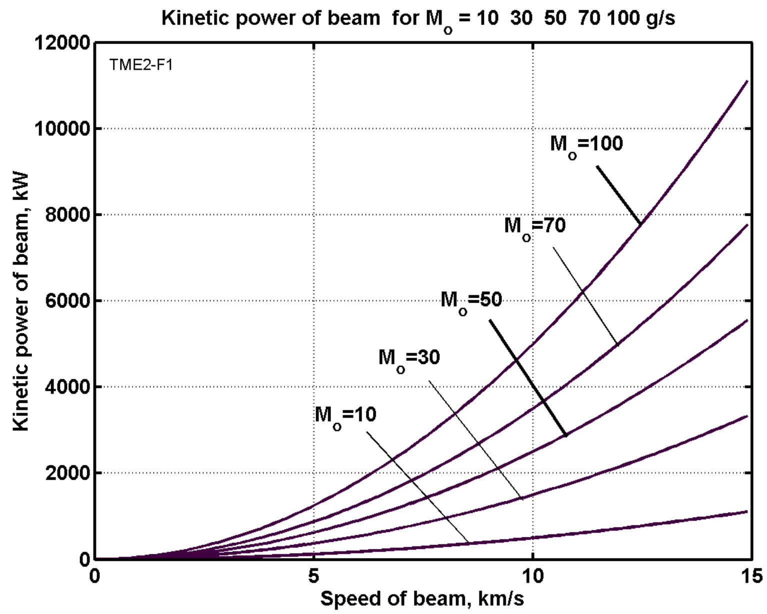

Figure 17. Energy is requested for producing of the beam via the beam speed and mass flow for Moon ship.

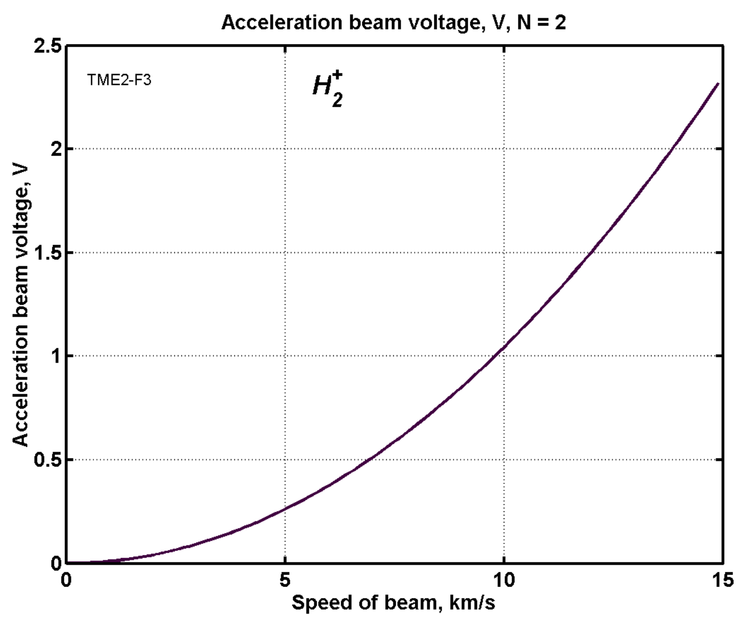

Figure 18. Voltage requited for accelerating of beam via a particles speed. The beam is H_2^+.

PROJECT 1

(Interplanetary Spaceship Having Weight 3 tons and Speed 12 km/s,)

Assume we want to estimate the parameters of an interplanetary manned spaceship for Moon and Mars having weight of 3 tons and a final speed 12 km/s started from Moon, Mars, or Earth's tower having height of 80 km. We use the theory beam reflection, Figs. 16 - 18 and find the estimation time, thrust, speed, distance. The trained astronauts can stand the overload 8g.

The request power for beam flow 1, 2, 3 kg/s are 312, 625, 937 MW respectively. Power for ionization are 127, 254, 391 MW respectively. That is power of a middle electric station.

PROJECT 2

(Interstellar probe having speed 30.000 km/s, weight 100 kg)

Let us assume we want to estimate an interstellar probe which can reach the nearest solar systems. As known they are located about 3 - 4 light years from our Sun. That means the apparatus having speed β_S = 0.1c (V_S = 30,000 km/s) can reach them in 30 - 40 years. Remander, "Voyager-1" was flown for 30+ year, sending information up to present time. But it has speed only 20 km/s and was reached only the boundary of Solar system (about 2 billions km).

Assume, the weight of interstellar probe is 100 kg. If distance of acceleration is S = 3×10^{13} m (200 AU) the acceleration and acceleration time must be

$$a = \frac{V_S^2}{2S} = \frac{9\cdot10^{14}}{2\cdot3\cdot10^{13}} = 15 \ \ m/s^2, \quad t = \frac{V_S}{a} = \frac{3\cdot10^7}{15} = 2\cdot10^6 \sec = 23 \ days .$$

The thrust, requested acceleration energy and power are

$$T = aM_S = 15\cdot100 = 1500 \ N, \quad W = \frac{M_S V_S^2}{2} = \frac{100\cdot9\cdot10^{14}}{2} = 4.5\cdot10^{16} \ \ J, \quad P = \frac{W}{t} = \frac{4.5\cdot10^{16}}{2\cdot10^6} = 22.5 \ \ GW ,$$

The mass of the beam flow, and energy spent by beam station are (Eq. (3),(5))

$$M_0 = \frac{T\sqrt{1-\beta^2}}{2c(\beta-\beta_S)} = \frac{1500\sqrt{1-0.01}}{2\cdot3\cdot10^8(0.1-0.05)} = 5\cdot10^{-5} \ \ kg/s,$$

$$P_B = \frac{M_0 c^2}{2}\frac{\beta^2}{\sqrt{1-\beta^2}} = \frac{5\cdot10^{-5}\cdot9\cdot10^{16}0.01}{2\sqrt{1-0.01}} = 22.5 \ \ \ GW$$

Here $\beta_S = 0 \div 0.1$. We take the average value β_S = 0.05 . Notice that $P_B = P$, that means our installation transfer the station energy to ship with efficiency = 1. Unfortunately, this energy is very high. Tens of electric power stations must accelerate this probe in 23 days. We cannot decrease this amount by any methods because that is a minimum energy required by space probe.

Divergence D for u = 0.01 m/s, voltage U (n =1), and plasma temperature T_p are

$$D = \frac{u}{c}\frac{\sqrt{1-\beta^2}}{\beta}S = \frac{0.01}{3\cdot 10^8}\frac{3\cdot 10^{13}}{0.1} = 10 \quad km, \quad T_p = \frac{mu^2}{ik} = \frac{1,67\cdot 10^{-27}10^{-4}}{3\cdot 1.38\cdot 10^{-23}} = 0.4\cdot 10^{-8} \quad {}^0K,$$

$$U = \left(\frac{m_p}{q}\right)\frac{nc^2}{2}\frac{\beta^2}{\sqrt{1-\beta^2}} = \left(\frac{1.67\cdot 10^{-27}}{1.6\cdot 10^{-19}}\right)\frac{1\cdot 9\cdot 10^{16}}{2}\frac{0.01}{1} = 4.7\cdot 10^6 \quad V.$$

The power of dissociations ($H_2 \to H + H$, 2.2 eV) and ionization ($H \to H^+$, 13,6 eV) are equal

$$E_i = 1.6\cdot 10^{-19}(e_d + e_i)\frac{M_0}{m_p n} = 1.6\cdot 10^{-19}(2.2 + 13.6)\frac{5\cdot 10^{-5}}{1.67\cdot 10^{-27}\cdot 1} = 75.7 \quad kW \, .$$

In given case (comparison with P_B above) this value is small and we can negligee it. But into planetary flight (V≈8 - 30 km/s and large M_0) this energy is essential.

DISCUSSION

In [34] G.A. Landis writes about using particle beams for interstellar flight. The beam is braked by a magnetic sail. Unfortunately, as with most other works in this field, his work also contains only common speculations. No theory, no mathematical models, no computations. More then ten years authors investigate the magnetic sail, but not its theory, no formulas which allows correct calculation or to estimate the magnetic sail drug. More over, the most magseil works contain a common mistake (see Chapter 4 "Electrostatic MagSail"). Landis offered the beam temperature 45 ^{o}K. The theory in this article is shown that this temperature gives the beam divergence which does not allows the interstellar flights. Absolutely unsubstantiated statement that magnetic sail reflects beam in thousands kilometers diameter. The estimations shows for high speed particles especially relativistic particles the affective diameter equals some meters and magnetic field must be powerful. In additional the magnetic sail is impossible at present time: electric ring needs in cryogenic temperature and spaceship must have power cryogenic equipment because the Sun will warm the ring for any heat insulation; for starting the ring needs a power electric station; a special equipment is necessary for displacing the ring of 100 km diameter into space; if the ring temperature exceeds a critical cryogenic temperature in any ring place, the ring explodes. The ring weight is big (22 tons for diameter 100 km), the produced magnetic field is very weak (10^{-6} Tesla). The magnetic sail does not have active control. That means the ship will move in one (non-control) direction and a ship mission will useless. These obvious defects makes impossible the application of the magnetic sail with little or no progress in solution these problems since 1988.

The suggested method does not require a magnetic sail. That used the electrostatic sail [26] and AB-Ramjet engine offered by author early. This sail is light (100 - 300 kg), cheap, and has tens kilometers (hundreds km for low beam density) of the effective radius. For example, for solar wind the magnetic effective radius decreases proportional $1/R^2$ (where R is distance of the sail from the Sun), electrostatic effective radius decreases approximately $1/R$ (see [26]). That is very important advantage.

CONCLUSION

The offered idea and method use the AB-Ramjet engine suggested by author in 1982 [3, 4, 6, 8, 9, 12, 14 - 16, 18] and detail developed in [28]. The installation contains an electrostatic particle collector suggested in 1982 and detail developed in [26, 30]. The propulsion-reflected system is light net from thin wire, which can have a large area (tens km) and allows to control thrust and thrust direction without turning of net (Figure1). This new method uses the ultra-cold full neutral relativistic plasma and having small divergence. The method may be used for acceleration space apparatus (up relativistic speed) for launch and landing Space apparatus to small planets (asteroids, satellites) without atmosphere. For Earth offered method will be efficiency if we built the tower (mast) about 40 ÷ 80 km height [19, 24]. At present time that is the most realistic method for relativistic probe.

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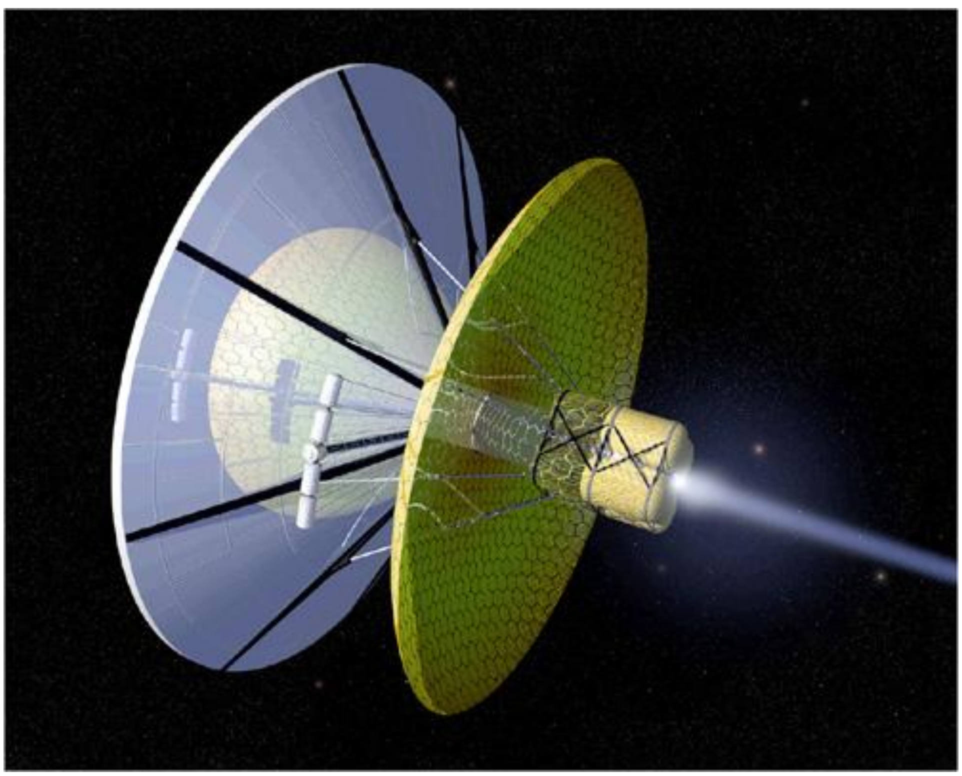
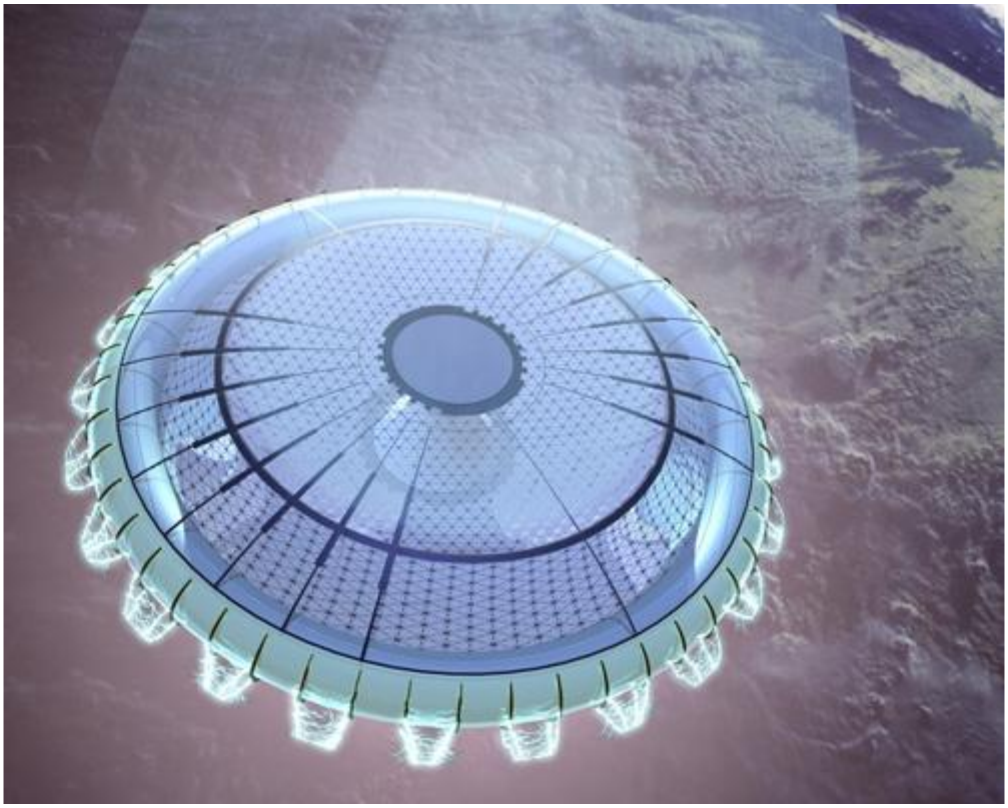
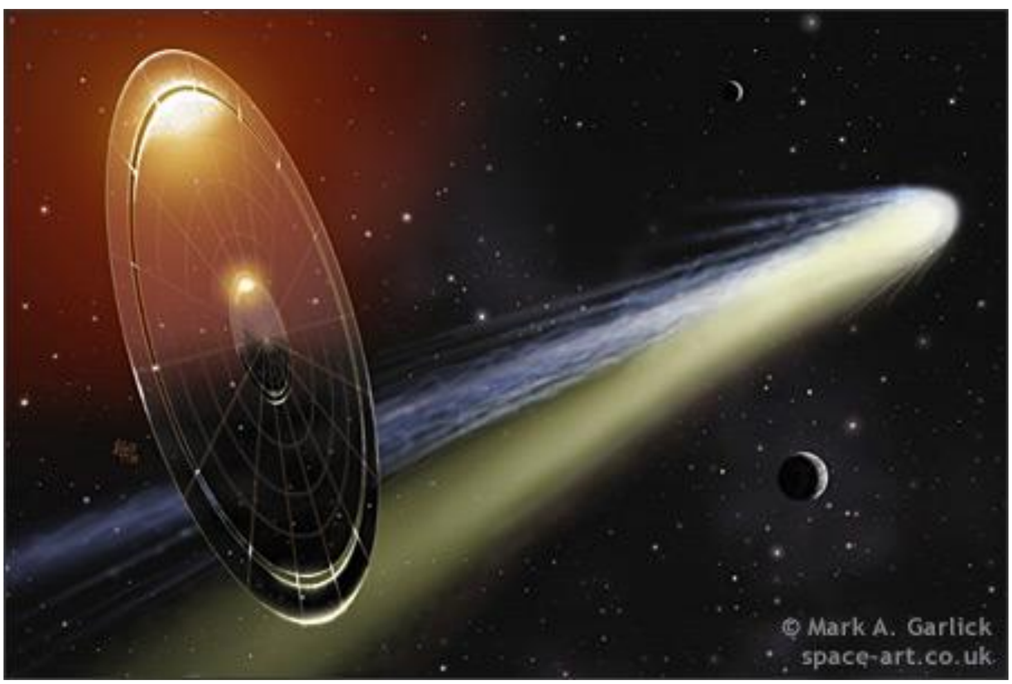
Attachment to Part A, Ch.3. Possible form of Space Ships and Space Stations



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Chapter 4

THEORY OF SPACE MAGNETIC SAIL. SOME COMMON MISTAKES AND ELECTROSTATIC MAGSAIL*

ABSTRACT

The first reports on the "Space Magnetic Sail" concept appeared more 30 years ago. During the period since some hundreds of research and scientific works have been published, including hundreds of research report by professors at major famous universities. The author herein shows that all these works related to Space Magnetic Sail concept are technically incorrect because their authors did not take into consideration that solar wind impinging a MagSail magnetic field creates a particle magnetic field opposed to the MagSail field. In the incorrect works, the particle magnetic field is hundreds times stronger than a MagSail magnetic field. That means all the laborious and costly computations in revealed in such technology discussions are useless: the impractical findings on sail thrust (drag), time of flight within the Solar System and speed of interstellar trips are essentially worthless working data! The author reveals the correct equations for any estimated performance of a Magnetic Sail as well as a new type of Magnetic Sail (without a matter ring).

Keywords: *magnetic sail, theory of MagSail, space magnetic sail, Electrostatic MagSail*.

INTRODUCTION

The idea of utilizing the magnetic field to aggregate matter in space, harnessing a drag from solar wind or receiving a thrust from an Earth- charged particle beam is old. The MagSail is a gigantic (more than 50 -100 km in radius) super-conductive ring located in outer space that produces a magnetic field and reflects the impinging solar wind, or a particle beamed from the Earth. Unfortunately, the currently used theory for computation of drag from solar wind or thrust from particle beam is complex. The magnetic field changes in

* Presented as Bolonkin's paper AIAA-2006-8148 to 14th AIAA/AHI Space Planes and Hypersonic Systems and Technologies Conference, 6 - 9 Nov 2006 National Convention Centre, Canberra, Australia.

widely diapason, every particle moves in its own trajectory and it is exquisitely difficult to accurately estimate a summary drag. Over the years, many space researchers have offered many equations for drag estimation that give remarkably different results. However, no known equations take into proper consideration the magnetic field of particles moved in a ring-shaped magnetic field. These particles create their own magnetic field that is OPPOSED to the MagSail's magnetic field. This magnetic field of charged particles can be stronger—by hundreds times—than a ring field. It can fully deactivate the MagSail magnetic field.

The simplest computation shows a profound mistake in all known works. Some of them presented in [1]-[39].

Take the typical MagSail ring: radius of ring is R = 50 km, electric current I =10^4 A. The intensity H_1 of magnetic field in center of ring is

$$H_1 = \frac{I}{2R} = \frac{10^4}{2\cdot 5\cdot 10^4} = 0.1 \quad \text{A/m}, \qquad (1)$$

This intensity is approximately same of the ring as well as near it. We assume in our subsequent computation that H_1 = constant.

Take the typical solar wind flows into ring at distance from Sun 1 AU (the Earth's orbit about its primary star) with average wind speed V = 400 km/s, and density N = 10^7 1/m^3. The solar wind contains electrons and protons. Within the ring magnetic field they rotate under Lawrence force and produce their own magnetic field that is OPPOSED to the ring magnetic field, decreases it (diamagnetic property), and pumps the ring magnetic energy into energy of its own magnetic field (summary energy is constant). This magnetic field from the rotated electrons (we here neglect the additional magnetic field from the rotated protons) can be estimated by equations (we consider only electrons into the ring):

$$H_2 = \frac{i}{2r}, \quad r = \frac{V}{(q/m_e)B_1}, \quad i = \pi R^2 qNV, \quad B_1 = \mu_0 H_1 \qquad (2)$$

where H_2 is magnetic intensity from rotated solar wind electrons, A/m; r is electron gyro-radius, m; i is electric currency of solar wind electrons, A; V = 400 km/s is average solar wind speed, B_1 is magnetic intensity, T; μ_0 = $4\pi 10^{-7}$ is magnetic constant.

Substituting our values, we received r = 18.2 m; i = 5024 A; H_2 = 276 A/m. The last magnitude shows that the magnetic intensity of solar wind electrons is in 2760 times greater ($H_2 >> H_1$) than the ring magnetic intensity of MagSail! It is correct for any charged beam that interacts with the MagSail. That means all research and computation (without an influence the solar wind or charged beam into MagSail) is wrong and basically worthless for all practical space exploration and exploitation applications.

How can it happen that hundreds of researchers, professors at famous universities, audiences of specialists, members of scientific Conferences and Congresses, editors of scientific journals: "*Journal of Propulsion and Power*", (Editor V. Yang); Journal "*Spacecraft and Rockets*", (Editor V. Zoby), paid so little attention to student-level mistakes in many scientific publications and public presentations to scientific conferences? More over, the director NASA Institute for Advanced Concepts (NIAC) Mr. R. Cassanova awarded (totaling more than $1 million dollars!) to his close associate, professor R.M. Winglee (University of Washington) for pseudo-scientific work about MagSail [1] [#].

It is still happening because popular textbook authors continue to consider the interaction between the strong magnetic field of particle accelerators and small amount of charged particles where we can neglect the influence of charged particles in magnetic field of the accelerator. With MagSail's, we have the opposed situation: the weak ring magnetic field and strong magnetic field of solar sail or charged beam.

THEORY

Below, the author suggests the correct theory of MagSail operation, which takes into consideration the influence of the solar wind flow into the ring magnetic field and allows an estimation of the drag of MagSail.

Let us to take the equations (2) in form:

$$H_1=\frac{I}{R_1},\quad H_2=\frac{i}{2r},\quad r=\frac{V}{(q/m_e)B},\quad R_2=\frac{V}{(q/m_p)B},\quad i=\pi R_3^2 qNV,\quad B=\mu_0(H_1-H \tag{3}$$

where m_p is mass of positive particle, for proton m_p = 1.67×10^{-27}, kg; R_2 is rotate radius of positive particles (protons for Solar Wind), m; R_3 is capture radius of positive particles, m.

Notice particularly the last equation (3). In this equation, the active is summary magnetic intensity B!

For getting the maximum solar wind drag the turn radius of heavy particles must be 90 degrees. Assume $R=R_1=R_2=R_3$. We have 6 equations (3) and 6 unknown values. From set equations (3) we receive the estimation of the radius efficiency R:

$$R^2=\frac{m_e}{\pi q^2 N}\left(\frac{I\,q}{m_p V}-\frac{2}{\mu_0}\right) \tag{4}$$

From (4) we get minimal ring electric currency

$$I\geq\frac{2m_p V}{\mu_0 q} \tag{5}$$

For average solar wind speed V = 400 km/s the minimal ring electric currency is I = 6.65×10^3 A.

[#] Mr. Cassanova invented a new method of legal larceny of government money. He personally awarded taxpayer-funded money grants to his friends, protégés and other useful persons for mere promises of great discoveries and revolutionary developments in future in space sciences. In nine years of NIAC's existence under him, Mr. Cassanova spent in excess of fifty millions dollars of taxpayer money in pseudo-scientific works, but has not presented to the public even one new researched scientific concept. The Scientific Committee of a famous organization, the CAGW (Citizen Against Government Waste), awarded NIAC and Mr. Cassanova pseudo-Nobel prize-2005 and 2006 [42]-[45].

The solar wing drag, *D*, equals approximately

$$D = \pi R^2 m_p N V^2 \qquad (6)$$

Results of computation are presented in figures 1 - 2. Look you attention: for receiving good drag we need in high electric current. For typical current $I = 10^4$ A (I = 10 kA) the efficiency radius *R* and drag *D* are small.

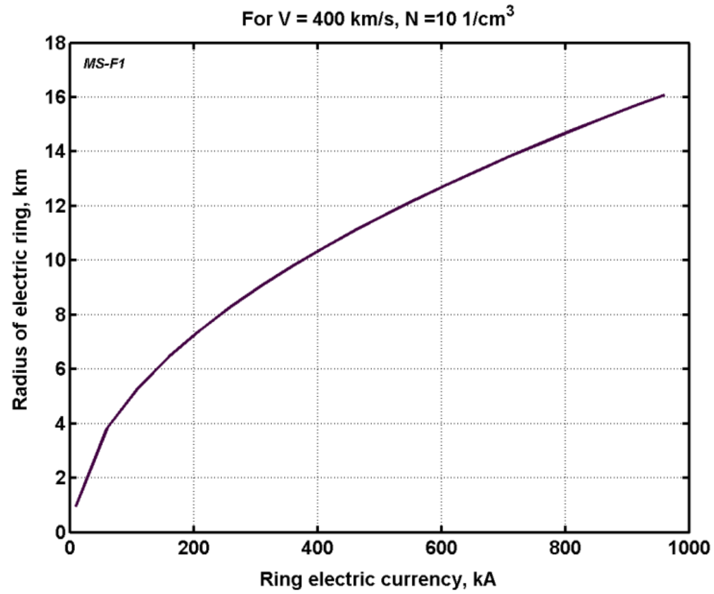

Figure 1. Radius efficiency of MagSail via ring electric current.

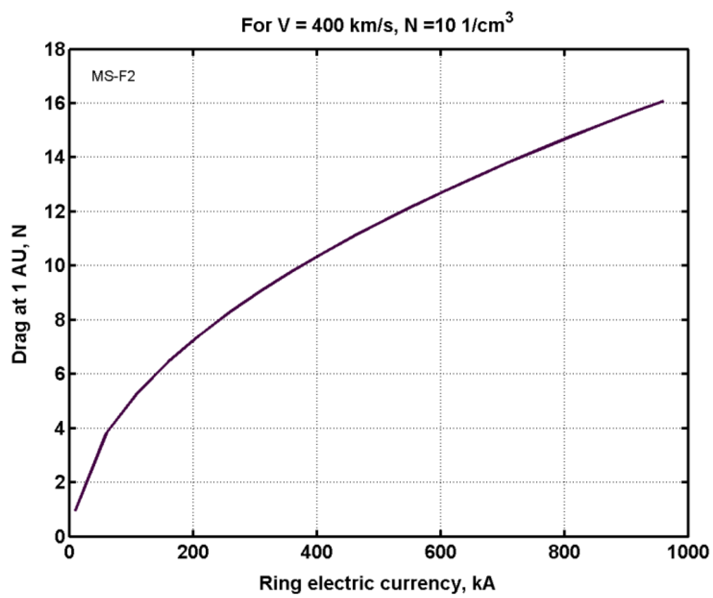

Figure 2. Drag of MagSail via ring electric current at distance from Sun equals 1 Astronomical Unit.

NEW ELECTROSTATIC MAGSAIL (EMS)

The conventional MagSail with super-conductive ring has big drawbacks:

1. It is very difficult to locate gigantic (tens of km radius) ring in outer space.
2. It is difficult to insert a big energy into superconductive ring.
3. Super-conductive ring needs a low temperature to function at all. The Sun heats all bodies in the Solar System to a temperature higher then temperature of super-conductive materials.
4. The super-conductive ring explodes if temperature is decreased over critical value.
5. It is difficult to control the value of MagSail thrust and the thrust direction.

The author offers new Electrostatic MagSail (EMS). The innovation includes the central positive charged small ball and a negative electronic equal density ring rotated around the ball (Figure 3).

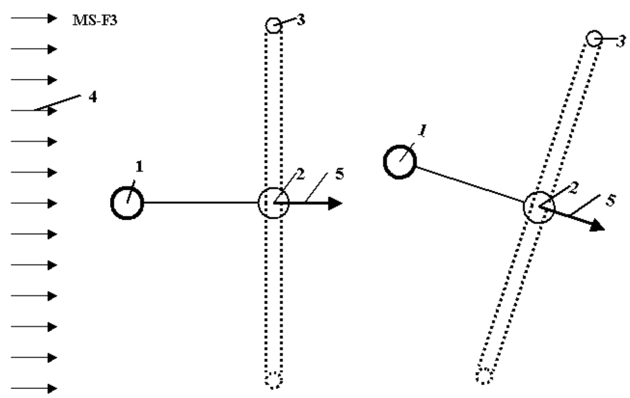

Figure 3. Electrostatic MagSail. *Notations*: 1-Spaceship; 2-Positive charged ball; 3–electrical ring; 4-solar wind; 5-EMS drag. In right side the EMS in turn position.

The suggested EMS has the following significant advantages in comparison with conventional MagSail:

(1) No heavy super-conductive large ring.
(2) No cooling system for ring is required.
(3) Electronic ring is safe.
(4) The thrust (ring radius) easy changes by changing of ball charge.

ELECTROSTATIC MAGSAIL THEORY

Let us consider a method of estimation of electronic ring magnetic intensity in the electronic ring's center [2]. We will take into consideration a repulsion of electrons from electron ring (blocking the ball charge by the electronic ring) and relativistic speed of electrons. We will not take into consideration diamagnetic property of solar wind or charged beam because our purpose here is only to find the magnetic intensity from electronic ring. The blocking the MagSail magnetic field by the particles flow the reader find in previous section (above). We also neglect the radiation of rotary electronic ring because the ring is right circle, has constant density and that does not emit synchronous radiation (this assumption needs further research. Synchronous radiation appears when electrons rotate in outer magnetic field, the electron ring is unclosed or has non-constant density. In our case the ring electric and magnetic fields are constant and not emit energy in outer space).

From equilibrium of the centrifugal and attraction forces we have

$$\frac{MV_e^2}{R} = k\frac{(Q_1 - Q_2)Q_2}{R^2}, \quad M = m_e\frac{Q_2}{q}, \quad Q_1 > Q_2, \tag{7}$$

where M is mass of electron ring, kg; V_e is speed of electrons, m/s; R is ring radius, m; $k = 9\times10^9$ is electrostatic constant; Q_1 is positive charge of the central ball, C; Q_2 is negative charge of the electron ring, C; m_e is mass of electron, kg; $q = 1.6\times10^{-19}$ is electron charge, C.

The best relation between Q_1 and Q_2 is $Q_1 = 2Q_2$. Substitute this value into (7) we receive

$$V_e^2 = k\left(\frac{q}{m_e}\right)\frac{Q_2}{R}, \quad Q_2 = \frac{RV_e^2}{k(q/m_e)}, \quad H = \frac{I}{2R}, \quad I = \frac{Q_2V_e}{2\pi R}, \quad B = \mu_0 H \tag{8}$$

where I is ring electric currency, A; H is magnetic intensity, A/m; B is magnetic intensity, T; $\mu_0 = 4\pi10^{-7}$ is magnetic constant.

Substitute the previous Eqs. (8) in the last equation (8) for B and use the formula for relativistic electron mass

$$B = \frac{\mu_0}{4\pi R}\frac{V_e^3}{k(q/m_e)}, \quad \beta = \frac{V_e}{c}, \quad m_e = \frac{m_{e0}}{\sqrt{1-\beta^2}}, \quad B = \frac{\mu_0 c^3(m_{e0}/q)}{4\pi Rk}\frac{\beta^3}{\sqrt{1-\beta}} \tag{9}$$

where $c = 3\times10^8$ m/s is light speed; $m_{e0} = 9.11\times10^{-31}$ kg is electron mass at $V_e = 0$.

Let us to add formula for estimation charge and radius of ball and substitute the known values into last equation (9). We received the final equations for estimation of MagSail size:

$$B = 1.7\cdot10^{-3}\frac{1}{R}\frac{\beta^3}{\sqrt{1-\beta^2}}, \quad H = \frac{B}{\mu_0} = 1.36\cdot10^3\frac{1}{R}\frac{\beta^3}{\sqrt{1-\beta^2}}, \quad Q_2 = \frac{c^2R}{k(q/m_{e0})}\frac{\beta^2}{\sqrt{1-\beta^2}}, \quad a^2 = \frac{2kQ_2}{E_0} \tag{10}$$

where a is radius of ball, m; E_0 is safety electric intensity at ball surface, V/m.

If the magnetic intensity into ring is constant, we can estimate the energy needed for starting of ring:

$$H = \frac{I}{2R}, \quad \Phi = \mu_0 \frac{I}{2R} S = I L, \quad L = \mu_0 \frac{S}{2R} = \mu_0 \frac{\pi R}{2}, \quad W = \frac{L I^2}{2} \tag{11}$$

where Φ is magnetic flux, Wb: L is ring inductance, Henry; S is ring area, m^2; final equation in (11) W is energy, J. For conventional ring of MagSail having R = 50 km and $I = 10^4$ A the $W = 5\times10^6$ J.

The Eqs. (7) - (11) allow to find magnetic intensity of MagSail for given ring radius and electron speed (without solar wind or plasma beam), charge and radius of ball for given electrostatic ball intensity, energy of rotate ring, but they do not permit to estimate a MagSail drag. We can estimate drag of conventional MagSail (see section above), to compute the drag of electrostatic sail offered by author in [3] Chapter 18, but unfortunately we cannot to estimate for the drag EMS in the time present. The trajectory of charged particle into both field (magnetic and electric) are very complex.

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(Reader can find part of these articles in WEBs: http://Bolonkin.narod.ru/p65.htm, http://arxiv.org, search: Bolonkin, and in the book "*Non-Rocket Space Launch and Flight*", Elsevier, London, 2006, 488 pgs.)

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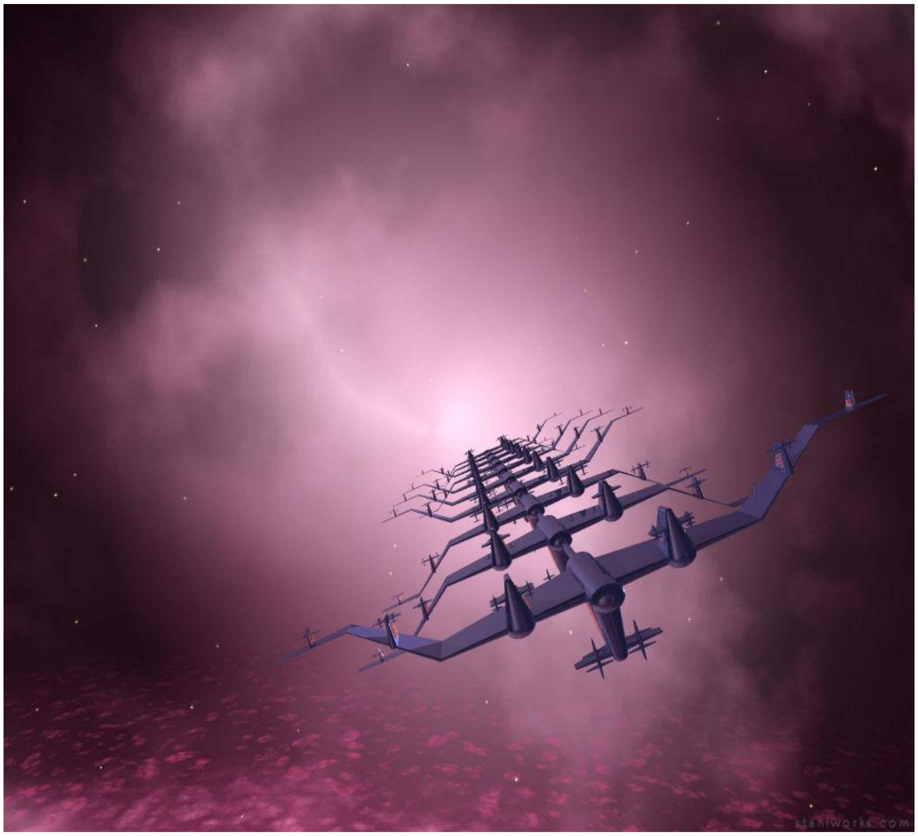
Attachment to Part A, Ch. 4. Possible forms of Space Ships



Chapter 5

HIGH SPEED AB-SOLAR SAIL*

ABSTRACT

The Solar sail is a large thin film used to collect solar light pressure for moving of space apparatus. Unfortunately, the solar radiation pressure is very small about 9 $\mu N/m^2$ at Earth's orbit. However, the light force significantly increases up to 0.2 - 0.35 N/m^2 near the Sun. The author offers his research on a new revolutionary highly reflective solar sail which flyby (after special maneuver) near Sun and attains velocity up to 400 km/sec and reaching far planets of the Solar system in short time or enable flights out of Solar system. New, highly reflective sail-mirror allows avoiding the strong heating of the solar sail. It may be useful for probes close to the Sun and Mercury and Venus.

Keywords: *AB-solar sail, highly reflective solar sail, high speed propulsion.*

1. INTRODUCTION

A solar sail is a thin film reflector that uses solar energy for propulsion. The spacecraft deploys a large, lightweight sail which reflects light from the Sun (or some other source). The radiation pressure on the sail provides thrust by reflecting photons. The solar radiation pressure is very small 6.7 Newtons per gigawatt. That equals 9.12×10^{-6} N/m^2 at Earth's orbit (1 AU - Astronomic Unit = 150 million km) and decreases by the square of the distance from the sun. However, the solar light pressure significently increases near sun and not far above it can reach 0.2 - 0.35 (up o.4 on Solar surfice) N/m^2.

Brief history. The conventional solar sail concept was first proposed by Friedrich Zander in 1924 [1] and gradually refined over the decades. The author proposed innovations and a new design of Solar sail in 1965 [2, 3], and theory was developed in [3] -[6]. Author offers a new revolutionary solar AB-sail. Main particularity this sail is very high reflectivity which allows the AB-sail to come very close to the Sun without great heating and to attain high light force and high speed.

* This work is presented as Bolonkin's paper AIAA-2006-4806 for 42 Joint Propulsion Conference, Sacramento, USA, 9-12 July, 2006.

This innovation allows (main advantages only): 1) to achieve very high speed up 400 km/s; 2) easy to control an amount and direction of thrust without turning a gigantic sail; 3) to utilize the solar sail as a power generator (for example, electricity generator); 4) to use the solar sail for long-distance communication systems.

Short information about Sun. The pressure of light equals $P = 2E/c$ (where E is energy of radiation, c is light speed ($c = 3\times10^8$ m/s)). The solar light energy at Earth's orbit equals 1.4 kW/m^2, but near a solar surface it reaches up to 64×10^3 kW/m^2 (it increases 47 thousand time!). As the result the light pressure jumps up to 0.4 N/m^2. The space apparatus can get significant acceleration (up to 80 m/s^2) and high speed up to 400 - 500 km/s.

Spectrum of Sun is presented in Figure 1. Note, the space mirror (sail) will not heat only if it reflects all solar spectrum (λ = 0.2 ÷ 3 μm, 200 ÷ 3000 nm).

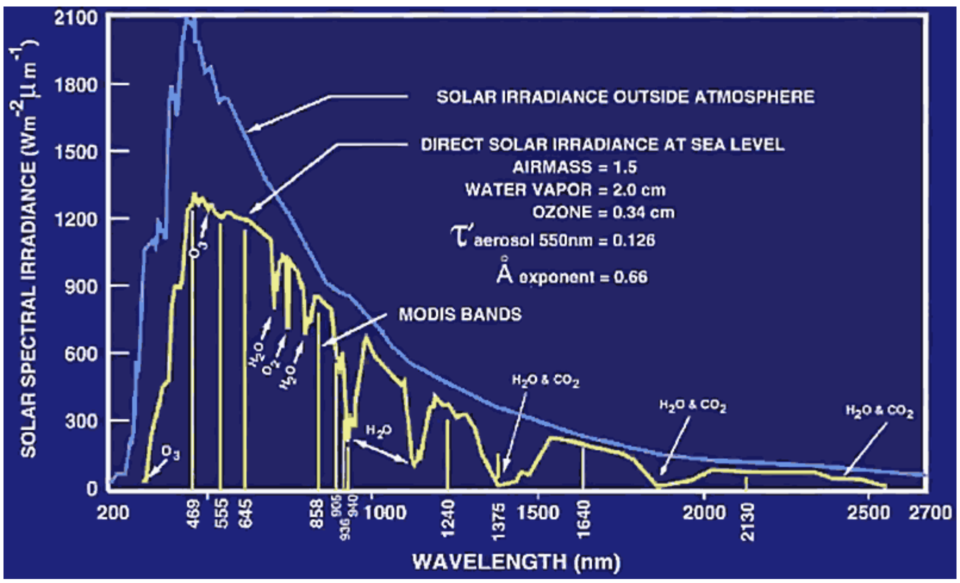


Figure 1. Spectrum of solar radiation. λ is the wavelength [0.2–2.7 μm, 200 ÷ 2700 nm].

2. Description and Innovations

Description. The suggested AB space sail is presented in Figure 2. It consists of: a thin high reflection film (solar sail) supported by an inflatable ring (or other method), space apparatus connected to solar sail, a heat screen defends the apparatus from solar radiation.

The thin film includes millions of very small prisms (angle 45^o, side 3 ÷ 30 μm). The solar light is totally reflected back into the incident medium. This effect is called total internal reflection. Total internal reflection is used in the proposed reflector. As it is shown in [5] Ch.12 the light absorption is very small (10^{-5} ÷10^{-7}) and radiation heating is small (see computation section).

Another possible design for the suggested solar sail is presented in Figure 3. Here solar sail has concave form (or that plate is made like Fresnel mirror).

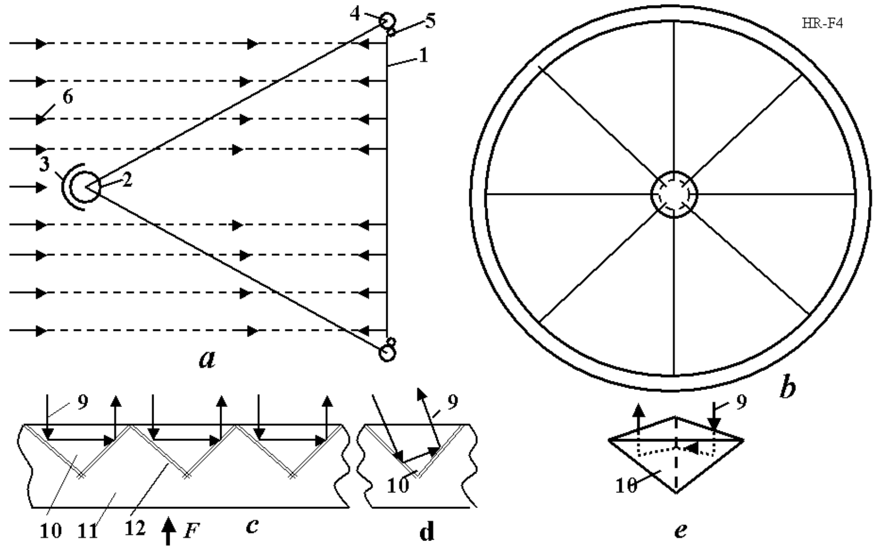


Figure 2. High reflective space AB-sail. (a) Side view of AB-sail; (b) Front view; (c) cross-section of sail surface; (d) case of non-perpendicular solar beam; (e) triangle reflective sell. *Notation*: 1 - thin film high reflective AB-mirror, 2 - space apparatus, 3 - high reflective heat screen (shield) of space apparatus, 4- inflatable support thin film ring, 5 - inflatable strain ring, 6 - solar light, 9 - solar beam, 10 - reflective sell, 11 - substrate, 12 - gap.

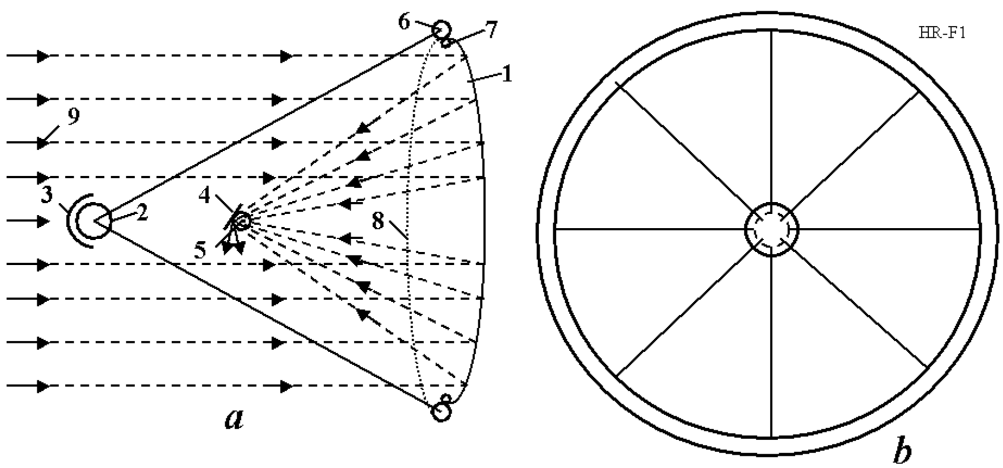


Figure 3. AB highly reflective solar sail with concentrator. (a) side view; (b) front view. *Notation*: 1 - highly reflective AB mirror (it may have a Fresnel form), 2 - space apparatus, 3 - high reflective heat screen, 4 - control mirror, 5 - reflected solar beam, 6 - inflatable support thin film ring, 7 - inflatable strain ring, 8 - thin transparent film, 9 - solar beam.

The sail concentrates solar light on a small control mirror 4. That mirror allows re-directed (reflected) solar beam and to change value and direction of the sail thrust without turning the large solar sail. Between thin films 1, 8 there is a small gas pressure which supports the concave form of reflector 1. Concentration of energy can reach $10^3 \div 10^4$ times, temperature greater than 5000 ^oK. This energy may be very large. For the sail of 200×200 m, at Earth orbit the energy is 5.6×10^4 kW. This energy may be used for apparatus propulsion or other possibilities (see [5]), for example, to generate electricity. The concave reflector may be also utilized for long-distance radio communication.

The trajectory of the high speed solar AB-sail is shown in Figure 4. The sail starts from Earth orbit. Then is accelerated by a solar light to up 11 km/s in opposed direction of Earth moving around Sun and leaves Earth gravitational field. The Earth has a speed about 29 km/s in its around Sun orbit. The sail will be have 29 -11=18 km/s. That is braked and moves to Sun (trajectory 4). Near the Sun the reflector is turned for acceleration to get a high speed (up to 400 km/s) from a powerful solar radiation. The second solar space speed is about 619 km/s. If AB sail makes three small revolutions around Sun, it can then reach speed of a 1000 km/s and leaves the Solar system with a speed about 400 km/s. Suggested highly reflective screen protects the apparatus from an excessive solar heating. Note, the offered AB sail allows also to brake an apparatus very efficiency from high speed to low speed. If we send AB sail to another star, it can brake at that star and became a satellite of the star (or a planet of that solar system).

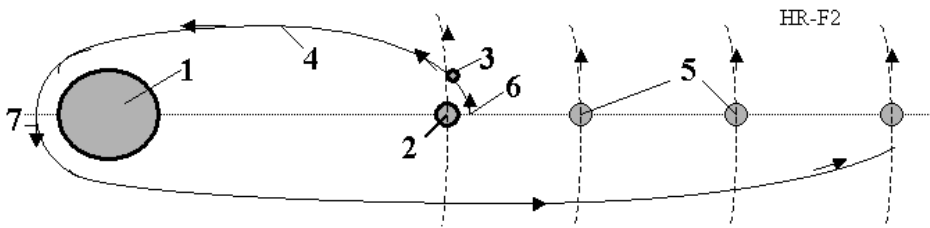


Figure 4. Maneuvers of AB solar sail for reaching a high speed: braking for flyby near Sun, great acceleration from strong solar radiation and flight away to far planets or out of our Solar system. *Notation*: 1 - Sun, 2 - Earth, 3 AB Solar sail, 4 - trajectory of solar sail to Sun, 5 - other planets, 6, 7 - speed of solar sail.

3. Estimation and Computation

1. Light Pressure is Calculated by Equation

$$p=(1+\rho)\frac{E}{c}, \quad \text{for} \quad \rho=1, \quad p=2\frac{E}{c} \tag{1}$$

where p is light pressure, N/m^2; E is energy, J/m^2; $c = 3\times10^8$ m/s is light speed; ρ is reflective coefficient ($\rho = 0 \div 1$). At solar surface $E = 64 \times 103$ kW/m^2 and $p = 0.4$ N/m^2. At Earth's orbit the $E = 1.4$ kW/m^2 and $p = 9$ μN/m^2.

2. Temperature of Sail equals

$$T=100\sqrt[4]{\frac{\gamma E}{c_S(\varepsilon_1+\varepsilon_2)}} \tag{2}$$

where T is temperature, ^oK; E is heat flow, W/m^2; γ is absorption coefficient of light energy, c_S = 5.67 is coefficient, 0 < ε <1 is coefficients of blackness (emissivity) of two sail sides.

In [5] Ch. 12, Annt. #3 it is shown the absorption coefficient may reaches $\gamma = 10^{-7}$ for suggested mirror. If it is taken $\gamma = 10^{-4}$, $\varepsilon_1 = \varepsilon_2 = 0.9$, the sail temperature near the Sun will be about 500 ^oK. That temperature is safe for many dielectric materials. The tangential sail speed in nearest point to Sun reaches 600 km/s and time of AB sail abiding near Sun is only some minutes.

3. Mass of offered solar sail. a) *Estimation of prism mass*. Let us take the prisms having the height δ = 3 μm. That is enough for full reflection 0.9999 of solar spectra radiation (fig.1). The specific density dielectric material of prism is d_1 = 0.8 ÷ 3.5 g/cm^3. The average mass of S = 1 m^2 reflective prism is

$$m_p = (1/3)d_1\delta S = (1/3)\cdot 1.8\cdot 10^3\cdot 3\cdot 10^{-6}\cdot 1 = 1.8\cdot 10^{-3}\ \ kg/m^2 = 1.8\ \ g/m^2 \quad , (3)$$

b) *Estimation of support film mass*. Let us take the support film δ = 1 μm, the specific density of support material is d_2 = 1.8 g/cm^3. The average mass of S = 1 m^2 substrate film is

$$m_f = d_2\delta S = 1.8\cdot 10^3\cdot 1\cdot 10^{-6}\cdot 1 = 1.8\cdot 10^{-3}\ \ kg/m^2 = 1.8\ \ g/m^2 \qquad (4).$$

The total mass of 1 m^2 offered sail is

$$m = m_p + m_f = 1.8 + 1.8 = 3.6\ \ g/m^2 \qquad . \qquad (5)$$

Together with mass of an inflatable ring and filaments connected the sail to apparatus we take the 1 m^2 sail mass m = 5 g/m^2. Then the total mass of S = 200×200 m offered sail is

$$M_S = mS = 0.005\cdot 4\cdot 10^4 = 200\ \ kg. \qquad (6)$$

If apparatus mass is M_a = 100 kg, the total ship mass is $M = M_S + M_a$ = 300 kg.

There are enough of dielectric material (for example, carbonate) which do not change their properties up temperature 600 - 800 C.

4. Trajectory and Speed

The apparatus (sail) radial speed and flight time can be estimated by equations [5] p.322.

$$V^2 = 2as_0^2\left(\frac{1}{s_0} - \frac{1}{s}\right),\quad V_{\max} = \sqrt{2as_0}\,,\quad a = \frac{pA}{M_S + M_a},\quad M_S = Ad,\quad t \approx \frac{s}{V_{\max}} \qquad (7)$$

where: V is radial sail speed, m/s; V_{max} is maximum radial sail speed, m/s; a is initial (maximal) sail acceleration, m/s^2; s is distance of the sail from a Sun center, m; s_0 is minimal distance, m; p = (0.25 ÷ 0.4) is maximal light pressure [Eq.(1)], N/m^2; M_S is mass of sail; A is sail area, m^2; d = (0.001 ÷ 0.005) is specific mass of sail, kg/m^2; t is flight time from Sun to far planets, sec.

For example: If $A = 200\times200 = 4\times10^4$ m^2, d = 0.005 kg/m^2, p = 0.3 N/m^2, M_a= 100 kg, that a = 40 m/s^2. The period of an elliptic rotation of apparatus around Sun or planet may be computed by equation

$$T_1 = \frac{2\pi}{\sqrt{K}} a_1^{3/2}, \quad K = g_0 s_0^2 \tag{8}$$

where T_1 is period of rotation, sec; a_1 is semi-axis of big axis of ellipse, m; g_0 is planet (star) gravitation at distance s_0, m/s^2, (for Sun $K \approx 1.33\times10^{20}$ m^3/s^2; $g_0 \approx 274$ m/s^2; $s_0 \approx 700\times10^6$ m; for Earth $K \approx 4\times10^{14}$ m^3/s^2, $g_0 \approx 9.81$ m/s^2; $s_0 \approx 5.378\times10^6$ m).

Computations are presented in Figure 5 - 7. It can be seen that the AB sail can reach very high speed (up 400 km/s) at distance 10 millions km (< 1 AU) from Sun and a purview of Solar System . The flight time from Sun to the far planets is short time if we use the AB space sail (to Pluto about 150 days). But we must add a time of braking (from 29 km/s to ≈ 1 km/s) and about 65 days moving from Earth orbit to Sun (trajectory 4 in Figure 4).

The main particularity of offered AB-sail-reflector is special layer with very high reflectivity in the full main range of a solar spectrum (Figure1) from 0.1 to 5 μm. That means the temperature of offered sail will be significantly lower then the solar temperature and safe, allowable operating for offered layers and AB-sail-reflector.

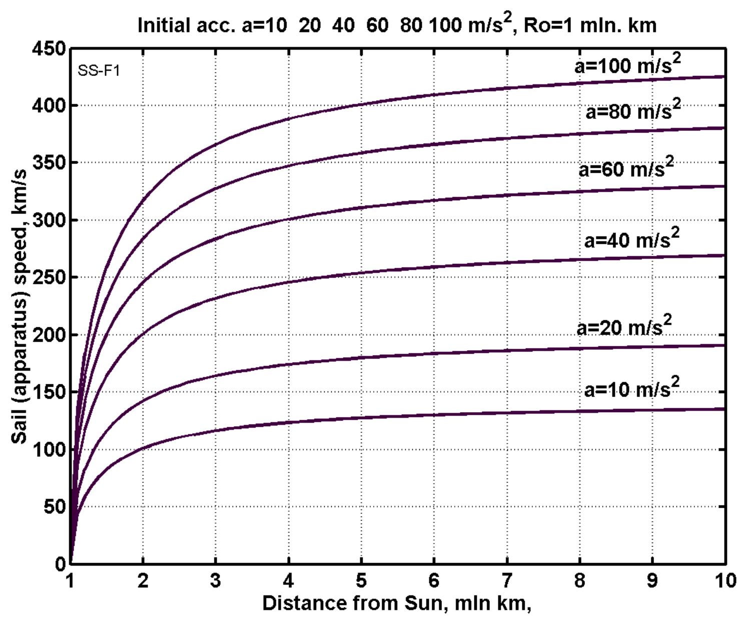


Figure 5. Approximately radial AB-sail speed versus distance from Sun for several initial accelerations a (acceleration at minimum distance from Sun).

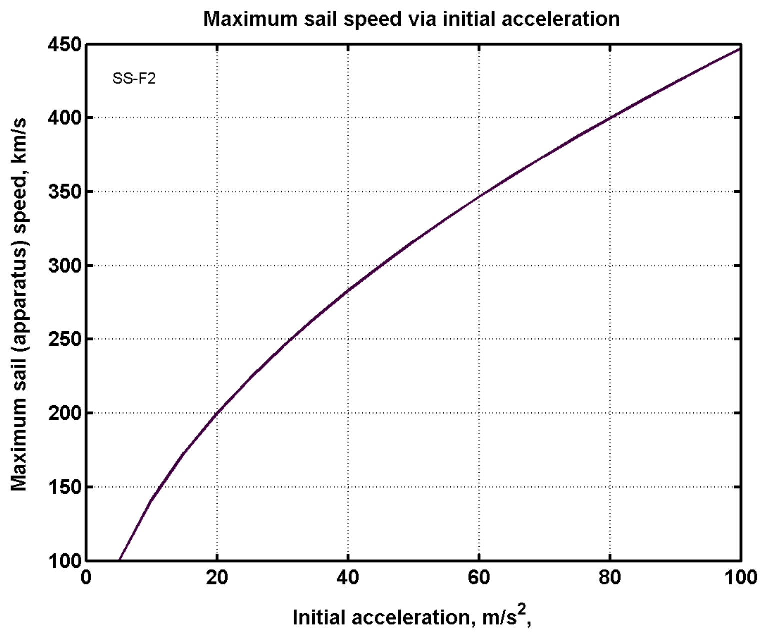


Figure 6. Maximal sail speed versus initial sail acceleration.

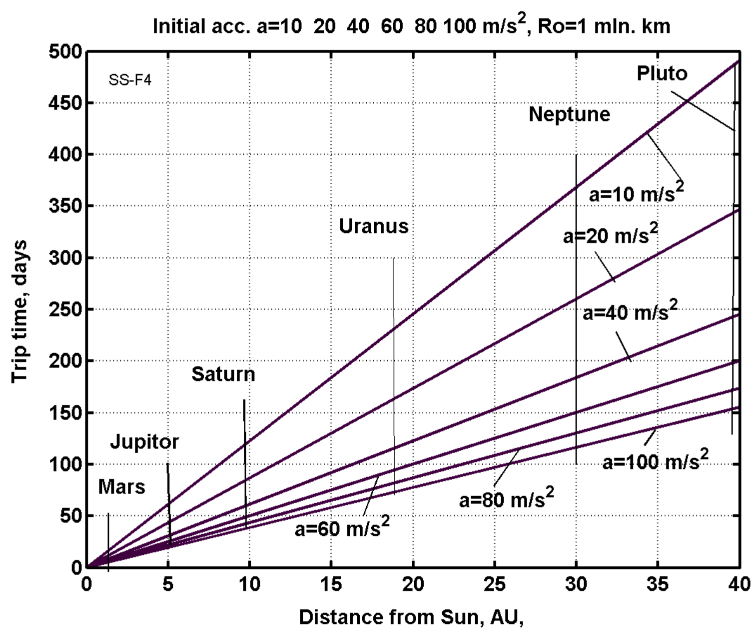


Figure 7. Trip time from Sun to far planets versus a distance from Sun.

The other particularity is special selective coating which has high thermal emissions close to absolute black body in widely range of solar spectrum.

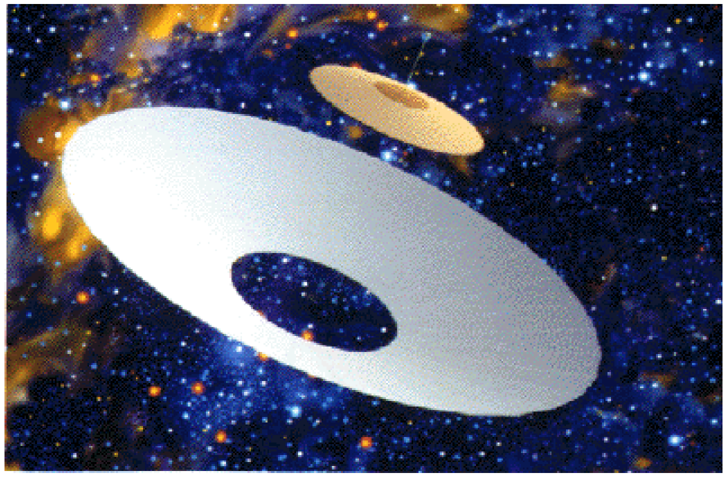


Figure 8. Possible Solar Sail.

DISCUSSION

The conventional mirror or multilayer dielectric mirror [12] is useless in this case. They have a high reflectivity only in narrow range of solar spectrum (Figure 1) and decrease the adsorbed solar energy up 2 - 5%. The solar surface has temperature about 5800 ^{o}K and melts any dielectric layers together with sail-mirror.

CONCLUSION

The suggested new AB sail can fly very close to the Sun's surface and get high speed which is enough for quick flight to far planets and out of our Solar System. Advantages allow: 1) to get very high speed up 400 km/s; 2) easy to control an amount and direction of thrust without turning a gigantic sail; 3) to utilize of the solar sail as a power generator (for example, electricity generator); 4) to use the solar sail for long-distance communication systems.

The same researches were made by author for solar wind sail and other propulsion [7]-[11].

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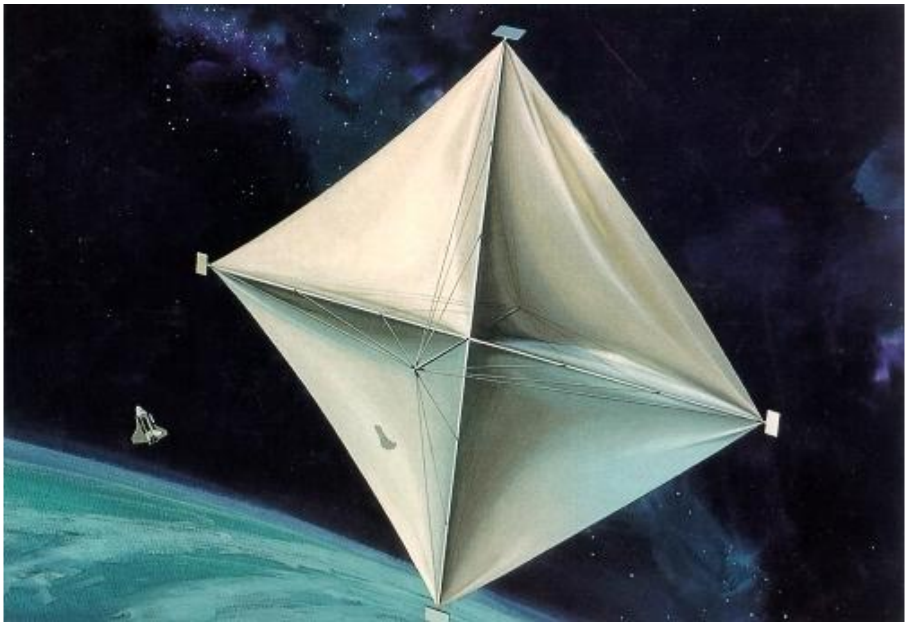
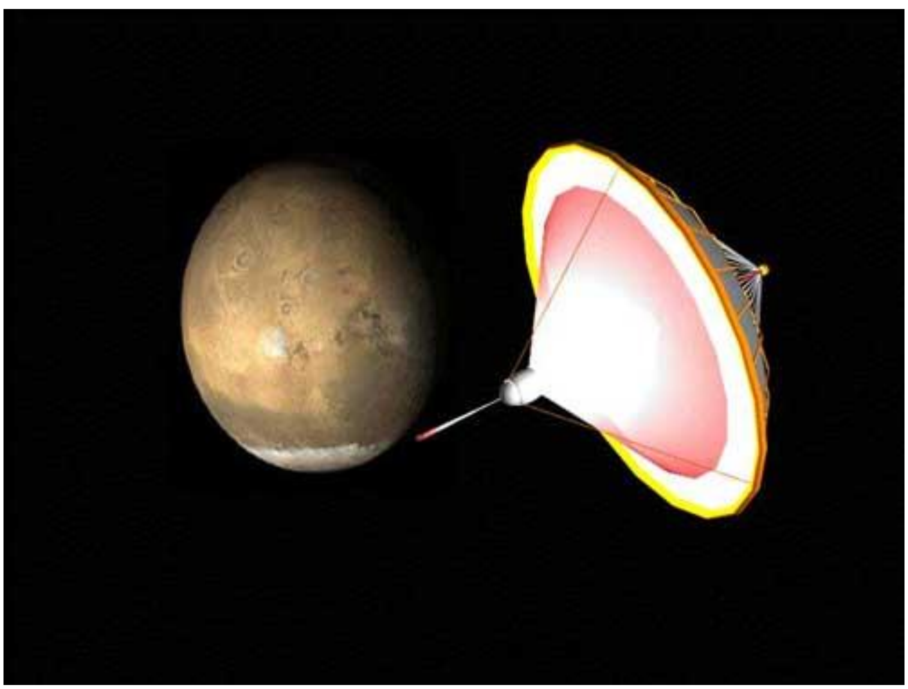
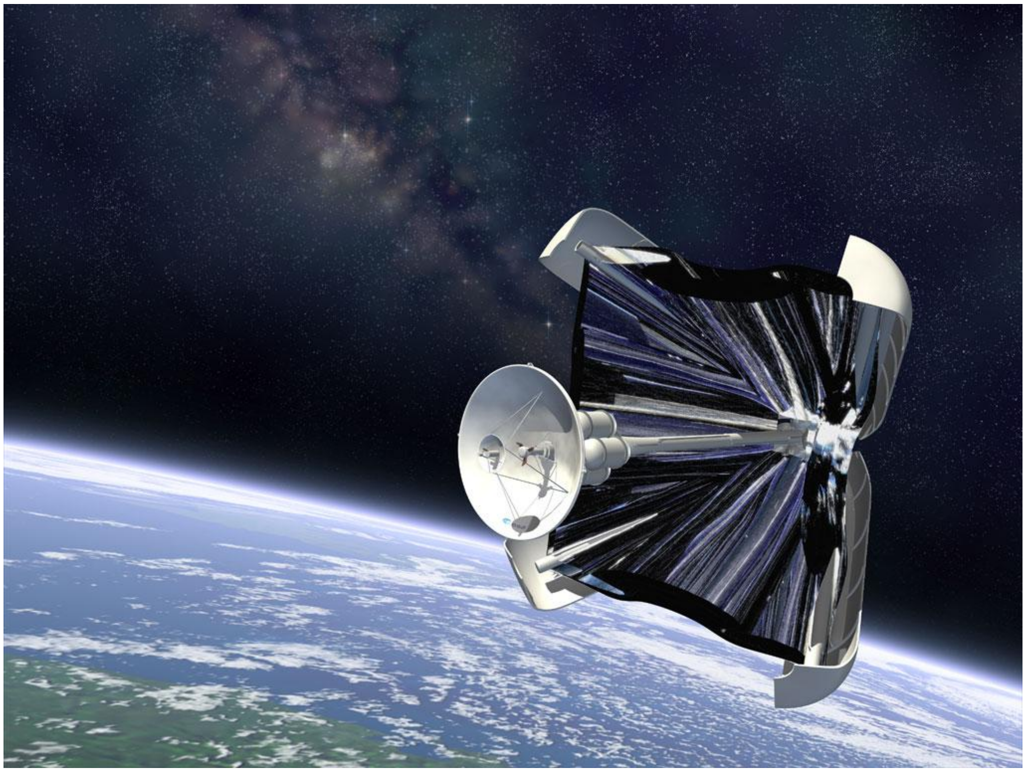
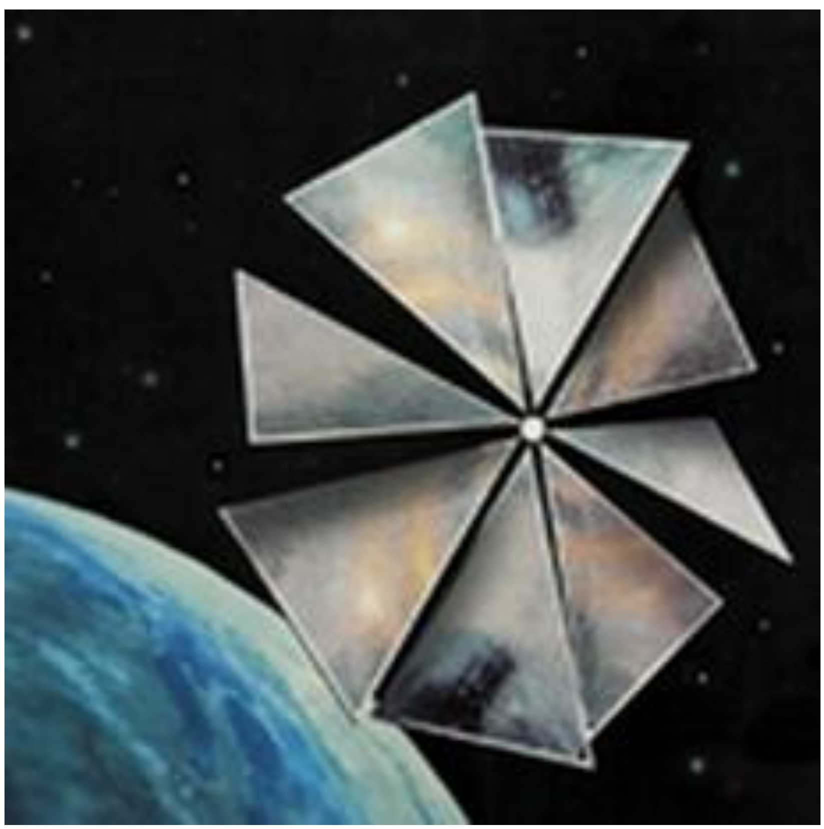
Attachment to Part A, Ch. 5. Possible form of Solar Sails









Chapter 6

TRANSFER OF ELECTRICITY IN OUTER SPACE*

ABSTRACT

Author offers conclusions from his research of a revolutionary new idea - transferring electric energy in the hard vacuum of outer space wirelessly, using a plasma power cord as an electric cable (wire). He shows that a certain minimal electric currency creates a compressed force that supports the plasma cable in the compacted form. A large energy can be transferred hundreds of millions of kilometers by this method. The required mass of the plasma cable is only hundreds of grams. He computed the macroprojects: transference of hundreds kilowatts of energy to Earth's Space Station, transferring energy to the Moon or back, transferring energy to a spaceship at distance 100 million of kilometers, the transfer energy to Mars when one is located at opposed side of the distant Sun, transfer colossal energy from one of Earth's continents to another continent (for example, between Europe-USA) wirelessly—using Earth's ionosphere as cable, using Earth as gigantic storage of electric energy, using the plasma ring as huge MagSail for moving of spaceships. He also demonstrates that electric currency in a plasma cord can accelerate or brake spacecraft and space apparatus.

Keywords: *transferring of electricity in space; transfer of electricity to spaceship, Moon, Mars; plasma MagSail; electricity storage; ionosphere transfer of electricity*.

INTRODUCTION

The production, storage, and transference of large amounts of electric energy is an enormous problem for humanity, especially of energy transfer in outer space (vacuum). These spheres of industry are search for, and badly need revolutionary ideas. If in production of energy, space launch and flight we have new ideas (see [1]-[16]), it is not revolutionary ideas in transferring and storage energy except the work [4].

However, if we solve the problem of transferring energy in outer space, then we solve the many problems of manned and unmanned space flight. For example, spaceships can move

* Presented as Bolonkin's paper AIAA-2007-0590 to 45th AIAA Aerospace Science Meeting, 8 - 11 January 2007, Reno, Nevada, USA.

long distances by using efficient electric engines, orbiting satellites can operate unlimited time periods without entry to Earth's atmosphere, communication satellites can transfer a strong signal directly to customers, the International Space Station's users can conduct many practical experiments and the global space industry can produce new materials. In the future, Moon and Mars outposts can better exploration the celestial bodies on which they are placed at considerable expense.

Other important Earth mega-problem is efficient transfer of electric energy long distances (intra-national, international, intercontinental). The consumption of electric energy strongly depends on time (day or night), weather (hot or cold), from season (summer or winter). But electric station can operate most efficiently in a permanent base-load generation regime. We need to transfer the energy a far distance to any region that requires a supply in any given moment or in the special hydro-accumulator stations. Nowadays, a lot of loss occurs from such energy transformation. One solution for this macro-problem is to transfer energy from Europe to the USA during nighttime in Europe and from the USA to Europe when it is night in the USA. Another solution is efficient energy storage, which allows people the option to save electric energy.

The storage of a big electric energy can help to solve the problem of cheap space launch. The problem of an acceleration of a spaceship can be solved by using of a new linear electrostatic engine suggested in [5]. However, the cheap cable space launch offered by author [4] requires utilising of gigantic energy in short time period. (It is inevitable for any launch method because we must accelerate big masses to the very high speed - 8 ÷11 km/s). But it is impossible to turn off whole state and connect all electric station to one customer. The offered electric energy storage can help solving this mega-problem for humanity.

OFFERED INNOVATIONS AND BRIEF DESCRIPTIONS

The author offers the series of innovations that may solve the many macro-problems of transportation energy in space, and the transportation and storage energy within Earth's biosphere. Below are some of them.

(1) transfer of electrical energy in outer space using the conductive cord from plasma. Author solved the main problem - how to keep plasma cord in compressed form. He developed theory of space electric transference, made computations that show the possibility of realization for these ideas with existing technology. The electric energy may be transferred in hundreds millions of kilometers in space (include Moon and Mars).
(2) method of construction for space electric lines and electric devices.
(3) method of utilization of the plasma cable electric energy.
(4) a new very perspective gigantic plasma MagSail for use in outer space as well as a new method for connection the plasma MagSail to spaceship.
(5) a new method of projecting a big electric energy through the Earth's ionosphere.
(6) a new method for storage of a big electric energy used Earth as a gigantic spherical condenser.
(7) a new propulsion system used longitudinal (cable axis) force of electric currency.

Below are some succinct descriptions of some constructions made possible by these revolutionary ideas.

1. Transferring Electric Energy in Space

The electric source (generator, station) is connected to a space apparatus, space station or other planet by two artificial rare plasma cables (Figure 1a). These cables can be created by plasma beam [7] sent from the space station or other apparatus.

The plasma beam may be also made the space apparatus from an ultra-cold plasma [7] when apparatus starting from the source or a special rocket. The plasma cable is self-supported in cable form by magnetic field created by electric currency in plasma cable because the magnetic field produces a magnetic pressure opposed to a gas dynamic plasma pressure (teta-pinch)(Figure 2). The plasma has a good conductivity (equal silver and more) and the plasma cable can have a very big cross-section area (up thousands of square meter). The plasma conductivity does not depend on its density. That way the plasma cable has a no large resistance although the length of plasma cable is hundreds millions of kilometers. The needed minimum electric currency from parameters of a plasma cable researched in theoretical section of this article.

The parallel cables having opposed currency repels one from other (Figure 1a). They also can be separated by a special plasma reflector as it shown in figs. 1b, 1c. The electric cable of the plasma transfer can be made circular (Figure 1c).

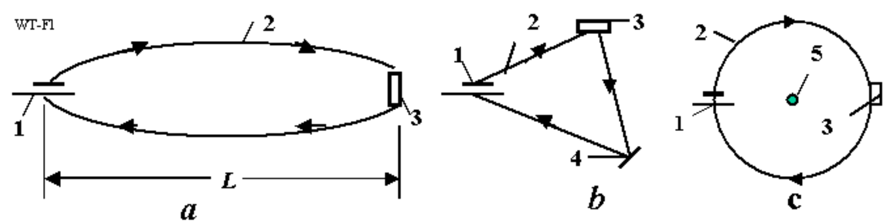


Figure 1. Long distance plasma transfer electric energy in outer space. a - Parallel plasma transfer, b - Triangle plasma transfer, c - circle plasma transfer. *Notations*: 1 - current source (generator), 2 - plasma wire (cable), 3 - spaceship, orbital station or other energy addresses, 4 - plasma reflector, 5 - central body.

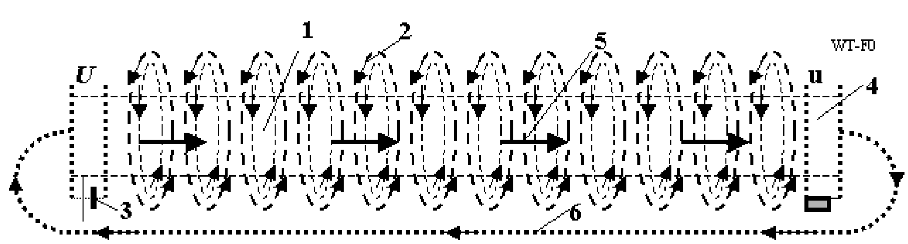


Figure 2. A plasma cable supported by self-magnetic field. *Notations*: 1 -plasma cable, 2 - compressing magnetic field, 3 - electric source, 4 - electric receiver, 5 - electric currency, 6 - back plasma line.

The radial magnetic force from a circle currency may be balanced electric charges of circle and control body or/and magnetic field of the space ship or central body (see theoretical section). The circle form is comfortable for building the big plasma cable lines for spaceship not having equipment for building own electric lines or before a space launch. We build small circle and gradually increase the diameter up to requisite value (or up spaceship). The spaceship connects to line in suitable point. Change the diameter and direction of plasma circle we support the energy of space apparatus. At any time the spaceship can disconnect from line and circle line can exist without user.

The electric tension (voltage) in a plasma cable is made two nets in issue electric station (electric generator) [7]-[8]. The author offers two methods for extraction of energy from the electric cable (Figure3) by customer (energy addresses). The plasma cable currency has two flows: electrons (negative) flow and opposed ions (positive) flow in one cable. These flows create an electric current. (It may be instances when ion flow is stopped and current is transferred only the electron flow as in a solid metal or by the ions flow as in a liquid electrolyte. It may be the case when electron-ion flow is moved in same direction but electrons and ions have different speeds). In the first method the two nets create the opposed electrostatic field in plasma cable (resistance in the electric cable [7]-[8]) (figs.1, 3b). This apparatus resistance utilizes the electric energy for the spaceship or space station. In the second method the charged particles are collected a set of thin films (Figure 3a) and emit (after utilization in apparatus) back into continued plasma cable (Figure3a)(see also [7]-[8]).

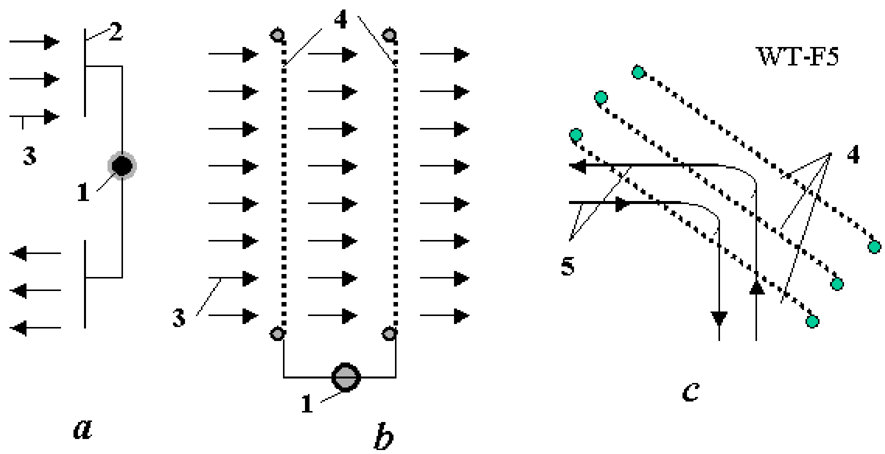


Figure 3. Getting the plasma currency energy from plasma cable. a - getting by two thin conducting films; b - getting two nets which brake the electric current flux; c - plasma reflector. *Notations:* 1 - spaceship or space station, 2 - set (films) for collect (emit) the charged particles, 3 - plasma cable, 4 - electrostatic nets.

Figure 3c presents the plasma beam reflector [7]-[8]. That has three charged nets. The first and second nets reflect (for example) positive particles, the second and third nets reflected the particles having an opposed charge.

2. Transmitting of the Electric Energy to Satellite, Earth's Space Station, or Moon

The suggested method can be applied for transferring of electric energy to space satellites and the Moon. For transmitting energy from Earth we need a space tower of height up 100 km, because the Earth's atmosphere will wash out the plasma cable or we must spend a lot of energy for plasma support. The design of solid, inflatable, and kinetic space towers are revealed in [4],[13]-[14],[16].

It is possible this problem may be solved with an air balloon located at 30-45 km altitude and connected by conventional wire with Earth's electric generator. Further computation can make clear this possibility.

If transferring valid for one occasion only, that can be made as the straight plasma cable 4 (Figure 4). For multi-applications the elliptic closed-loop plasma cable 6 is better. For permanent transmission the Earth must have a minimum two space towers (Figure 4). Many solar panels can be located on Moon and Moon can transfer energy to Earth.

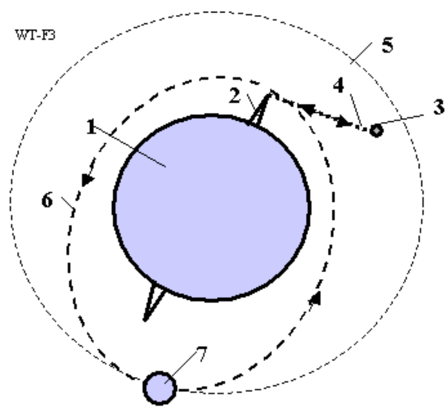


Figure 4. Transferring electric energy from Earth to satellite, Earth's International Space Station or to Moon (or back) by plasma cable. *Notations*: 1 - Earth, 2 - Earth's tower 100 km or more, 3 - satellite or Moon, 4 - plasma cable, 5 - Moon orbit, 6 - plasma cable to Moon, 7 - Moon.

3. Transferring Energy to Mars

The offered method may be applied for transferring energy to Mars including the case when Mars may be located in opposed place of Sun (Figure 5). The computed macroproject is in Macroprojects section.

4. Plasma AB Magnetic Sail

Very interesting idea to build a gigantic plasma circle and use it as a Magnetic Sail (Figure 6) harnessing the Solar Wind. The computations show (see section "Macroproject") that the electric resistance of plasma cable is small and the big magnetic energy of plasma circle is enough for existence of a working circle in some years without external support. The connection of spaceship to plasma is also very easy. The space ship create own magnetic field and attracts to MagSail circle (if spacecraft is located behind the ring) or repels from MagSail circle (if spaceship located ahead of the ring). The control (turning of plasma circle) is also relatively easy. By moving the spaceship along the circle plate, we then create the asymmetric force and turning the circle. This easy method of building the any size plasma circle was discussed above.

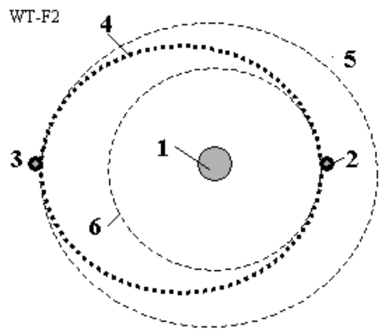


Figure 5. Transferring of electric energy from Earth to Mars located in opposed side of Sun. *Notations*: 1 - Sun, 2 - Earth, 3 - Mars, 4 - circle plasma cable.

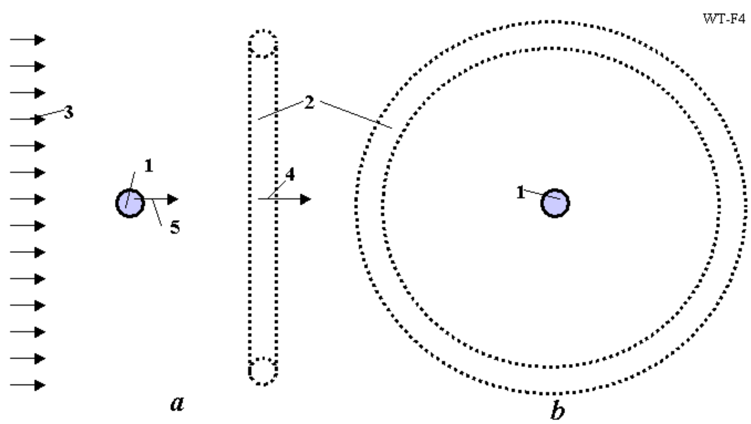


Figure 6. Plasma AB-MarSail. *Notations*: 1 - spaceship, 2 - plasma ring (circle), 3 - Solar wind, 4 - MagSail thrust, 5 - magnetic force of spaceship.

5. Wireless Transferring of Electric Energy in Earth

It is interesting the idea of energy transfer from one Earth continent to another continent without wires. As it is known the resistance of infinity (very large) conducting medium does not depend from distance. That is widely using in communication. The sender and receiver are connected by only one wire, the other wire is Earth. The author offers to use the Earth's ionosphere as the second plasma cable. It is known the Earth has the first ionosphere layer *E* at altitude about 100 km (Figure 7). The concentration of electrons in this layer reaches $5{\times}10^4$

1/cm^3 in daytime and 3.1×10^3 1/cm^3 at night (Figure 7). This layer can be used as a conducting medium for transfer electric energy and communication in any point of the Earth. We need minimum two space 100 km. towers (Figure 8). The cheap optimal inflatable, kinetic, and solid space towers are offered and researched by author in [4], [6], [7], [16]. Additional innovations are a large inflatable conducting balloon at the end of the tower and big conducting plates in a sea (ocean) that would dramatically decrease the contact resistance of the electric system and conducting medium.

Theory and computation of these ideas are presented in Macroprojects section.

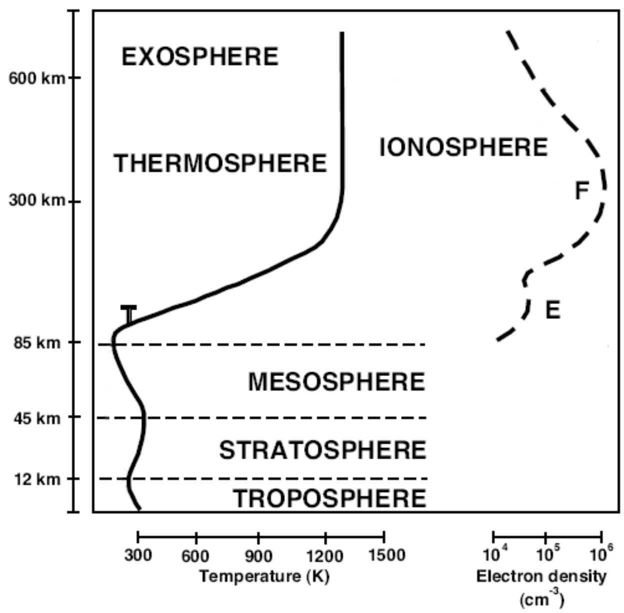


Figure 7. Consentration/cm3 of electrons (= ions) in Earth's atmosphere and layers of ionosphere (see also Figure 8 , Ch. 2 A).

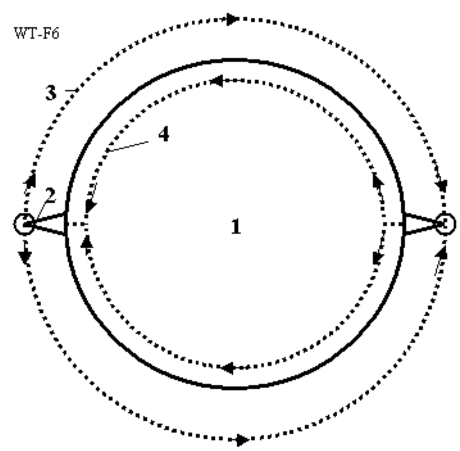


Figure 8. Using the ionosphere as conducting medium for transferring a huge electric energy between continents and as a large storage of the electric energy. *Notations*: 1 - Earth, 2 - space tower about 100 km of height, 3 - conducting E layer of Earth's ionosphere, 4 - back connection through Earth.

THEORY OF SPACE PLASMA TRANSFER FOR ELECTRIC ENERGY, ESTIMATIONS AND COMPUTATIONS

1. General Theory

The magnetic intensity and magnetic pressure of straight electric currency has maximum on surface of plasma cable. Let us to equate plasma gas pressure to a magnetic pressure and find the request equilibrium electric currency for same temperature of electrons and ions

$$P_g = 2nkT_k, \quad P_m = \frac{\mu_0 H^2}{2}, \quad H = \frac{I}{2\pi r},$$
$$P_m = P_g, \quad I = 4\pi r\left(\frac{knT_k}{\mu_0}\right)^{0.5}, \quad T_k = \frac{m_e u_e^2}{2k}, \qquad (1)$$

where P_g is plasma gas pressure, N/m^2; P_m is magnetic pressure, N/m^2; n is plasma density, 1/m^3; k = 1.38×10^{-23} is Boltzmann coefficient, J/K; μ_0 = 4π10^{-7} is magnetic constant, G/m; H is magnetic intensity, A/m; I is electric currency, A; r is radius of plasma cable, m; T_k is plasma temperature, K; m_e = 9.11×10^{-31} is electron mass, kg; u_e is electron speed, m/s.

From relation for the currency we have a current electron speed u relative ions along cable axis

$$u = \frac{I}{enS} = \frac{4\pi r}{enS}\left(\frac{nm_e}{2\mu_0}\right)^{0.5} u_e \qquad (2)$$

where $S = \pi r^2$ is cross-section area of plasma cable, m^2.

The mass of ion is more the mass of electron in thousands times and we assume $u = u_e$ in (2) after some collisions. From this condition we find the relation between r and n

$$r = \frac{2}{e}\sqrt{\frac{2m_e}{\mu_0}}\frac{1}{\sqrt{n}} \approx \frac{1.5\times10^7}{\sqrt{n}} \qquad (3)$$

The computation (2) is presented in Figure 9.

Specific plasma resistance and usual resistance of cable can be computed by equations:

$$\rho = 1.03\times10^{-4} Z \ln\Lambda T^{-3/2} \quad \Omega\text{m}, \quad R = \rho l / S, \qquad (4)$$

where ρ is specific plasma resistance, Ω·m; Z is ion charge state, ln Λ ≈ 5÷15 ≈ 10 is Coulomb logarithm; $T = T_k k/e$ = 0.87×10$^{-4}T_k$ is plasma temperature in eV; e = 1.6×10^{-19} is electron charge, C; R is electric resistance of plasma cable , Ω; l is plasma cable length, m; S is the cross-section area of the plasma cable , m^2.

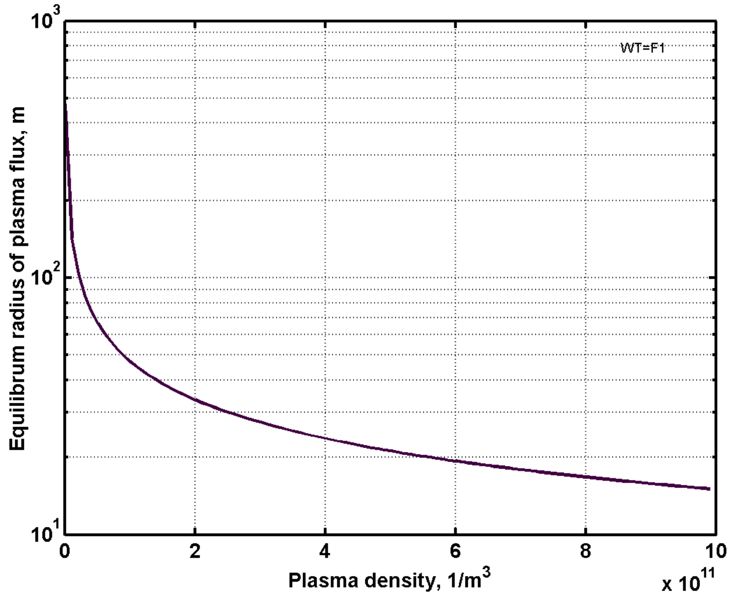


Figure 9. Equilibrium radius of plasma cable via plasma density.

The computation of specific resistance of plasma cable is presented in Figure 10.

The requested a minimum voltage, power, the transmitter power and coefficient of electric efficiency are:

$$U_m = IR, \quad W_m = IU_m, \quad U = U_m + \Delta U, \quad W = IU, \quad \eta = 1 - W_m / W \tag{5}$$

where U_m, W_m are requested minimal voltage, [V], and power, [W], respectively; U is used voltage, V; ΔU is electric voltage over minimum voltage, V; W is used electric power, W; η is coefficient efficiency of the electric line.

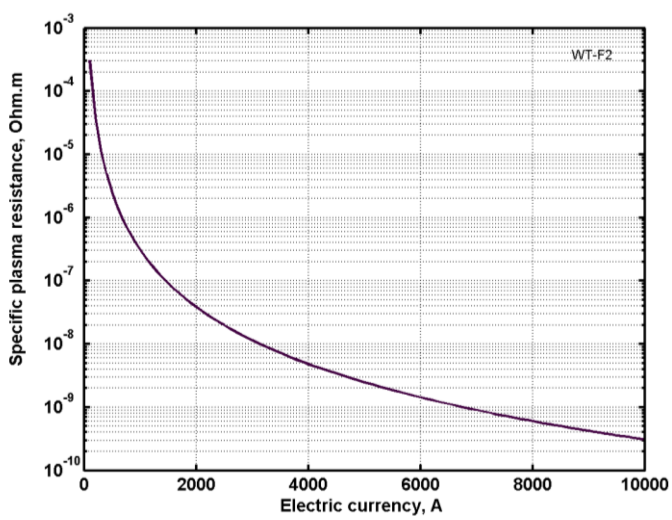


Figure 10. Specific plasma resistance Ω.m of equilibrium plasma cable versus electric currency, A.

The computation of mentioned over values are presented in Figures 11 ÷ 13. As you can see we can transfer the electric power of millions watts in outer space with very high efficiency, better than in Earth.

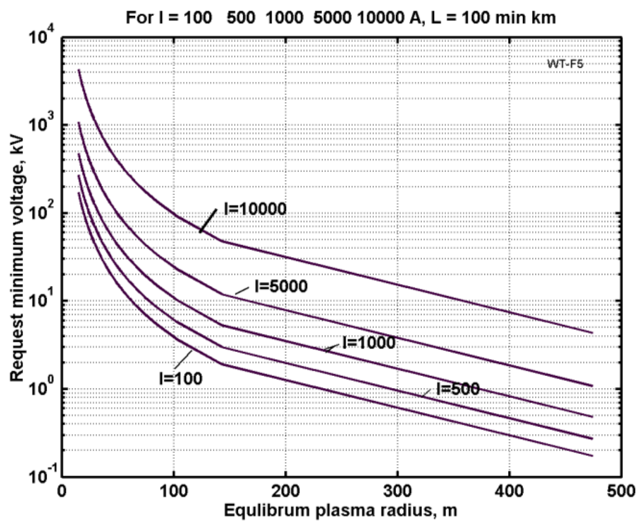


Figure 11. Requested minimum electric tension via the equilibrium plasma cable radius for different electric currency and for distance 100 millions kilometers.

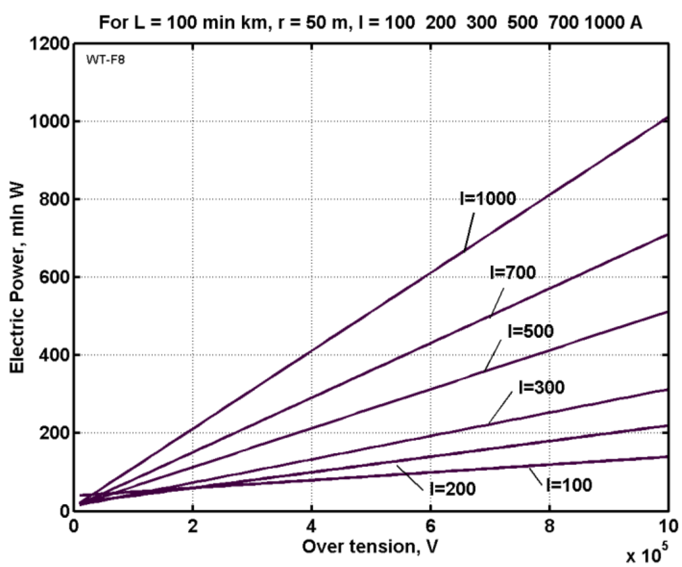


Figure 12. Transferred electric power (millions W) via voltage over minimum electric tension (see requested minimum tension in Figure10) for different electric currency, distance 100 millions of kilometers and radius of plasma cable 50 m.

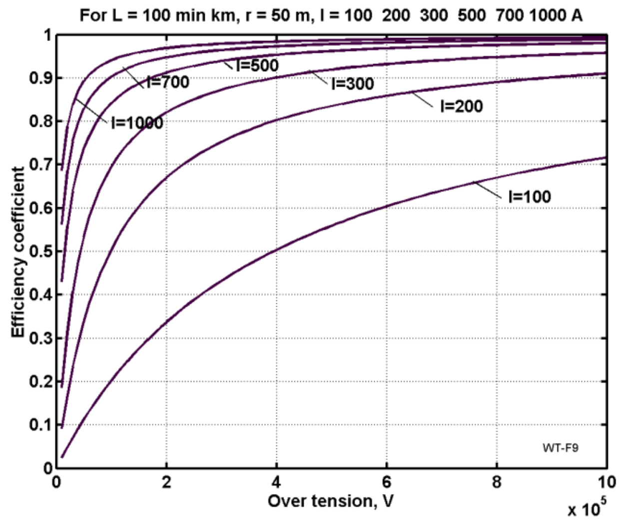


Figure 13. Coefficient efficiency of the electric transfer via over electric tension for different electric currency, distance 100 millions of kilometers and radius of plasma cable 50 m.

The equilibrium mass M [kg] of plasma cable is

$$M = lSnm_i, \quad S = \pi r^2 = 2.25\times10^{14}\pi / n, \quad M = 2.25\times10^{14}\pi\mu m_p l, \tag{6}$$

where m_i is ion mass of plasma, kg; $\mu = m_i/m_p$ is relative mass of ion; $m_p = 1.67\times10^{-27}$ is mass of proton, kg. Look your attention - the equilibrium mass of plasma cable does not depend from radius and density of plasma cable.

Computations are presented in Figure 14. The double plasma cable for Jupiter (distance is 770 millions km) made from hydrogen H_2 (mu = 2) has mass only 3 kg. That means the mass of plasma cable is closed to zero.

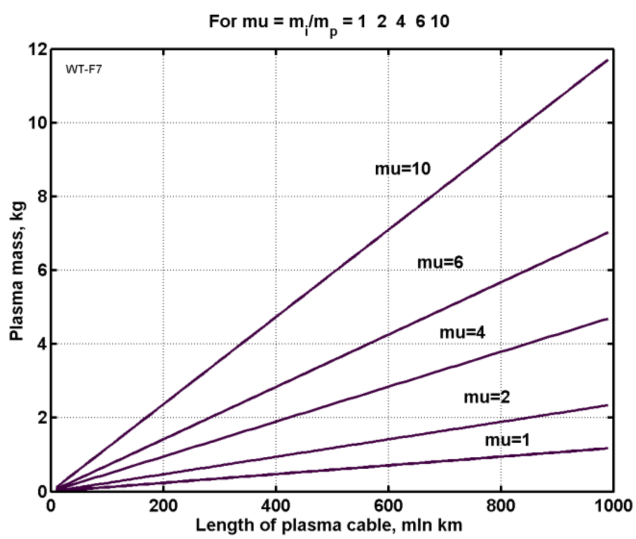


Figure 14. Mass of plasma cable versus the cable length and a relative mass of ion.

2. Circle Plasma Cable

The force acting in a circle particle (proton) moved in electric and magnetic fields may be computed by equations

$$\overline{F}_1 = \frac{m_p v^2}{R}. \quad \overline{F}_2 = e\overline{v}\,\overline{B}, \quad \overline{F}_3 = \frac{eQ_0}{4\pi\varepsilon_0 R^2} \tag{7}$$

where F_1, F_2, F_3 are centrifugal, Lawrence, and electrostatic forces respectively (all vectors), N; $m_p = 1.67\times10^{-27}$ kg mass of proton; v - speed of particle, m/s; e - electron (proton) charge; B - total magnetic induction (magnetic field strength), T; Q_0 - charge of central body, C; $\varepsilon_o = 8.85\times10^{-12}$ F/m - electric constant.

The equilibrium condition is

$$\sum_i \overline{F}_i = 0 \tag{8}$$

3. Electric Pressure from the Plasma Cable

The plasma has pressure in plasma cable. This pressure is small, but the cable can has a large diameter (up 200 m or more) and this pressure acting a long time can accelerate or brake the space apparatus. Electric pressure P can be computed by equations

$$P_m = \frac{\mu_0 H^2}{2}, \quad H = \frac{I}{2\pi r}, \quad P = 2P_m S = \frac{\mu_0}{4\pi} I^2 \tag{9}$$

Estimation. For $I = 10^4$ A the electric pressure equals 10 N, for $I = 10^5$ A one equals 1000 N. In reality the electric pressure may be significantly more because the kinetic pressure along cable axis may be more then plasma pressure into plasma cable (see below).

4. Additional Power from a Space Apparatus Motion

This power is

$$W = PV \tag{10}$$

where V is apparatus speed, m/s.

Estimation. For $V = 11$ km/s, $I = 10^3$ A, this power equals 550 W, for $I = 10^5$ the power equals 55000 W. We spend this power when space apparatus move off from the energy source and receive it when apparatus approach to the energy station.

5. Track Length of Plasma Electrons and Ions

The track length L and the track time τ of particles is

$$L = \upsilon_T / \nu, \quad \tau = 1/\nu \tag{11}$$

where υ_T is particle velocity, cm/s; ν is particle collision rate, 1/s.

The electron and ion collision rate are respectively:

$$\begin{aligned} \nu_e &= 2.91\times10^{-5} n_e \ln \Lambda T_e^{-3/2} \quad s^{-1} \\ \nu_i &= 4.80\times10^{-8} Z^4 \mu^{-1/2} n_i \ln \Lambda T_i^{-3/2} \quad s^{-1} \end{aligned} \tag{12}$$

where Z is ion charge state, ln $\Lambda \approx 5 \div 15 \approx 10$ is Coulomb logarithm, $\mu = m_i/m_p$ is relative mass of ion; $m_p = 1.67\times10^{-27}$ is mass of proton, kg; n is density of electrons and ions respectively; T is temperature of electron and ion respectively, eV.

Electron and ion terminal velocity are respectively:

$$\begin{aligned} \upsilon_{Te} &= (kT_e / m_e)^{1/2} = 4.19\times10^7 T_e^{1/2} \quad \text{cm/s} \\ \upsilon_{Ti} &= (kT_i / m_i)^{1/2} = 9.79\times10^7 \mu^{-1/2} T_i^{1/2} \quad \text{cm/s} \end{aligned} \tag{13}$$

Substitute equations (12)-(13) in (11) we receive

$$\begin{aligned} L_e &= 1.44\times10^{13} T_e^2 / n_e \ln \Lambda \quad \text{cm}, \\ L_i &= 2.04\times10^{13} T_e^2 / Z^4 n_e \ln \Lambda \quad \text{cm}, \end{aligned} \tag{14}$$

Estimation. For electron having $n = 10^5$ 1/cm^3, T = 100 eV, ln $\Lambda \approx 10$ we get $L = 2\times10^6$ km, $\tau \approx 300$ s.

That means the plasma electrons have very few collusions, small dispersion, and it can have different average ELECTRON (relative ions) temperature along cable axis and perpendicular cable axis. It is not surprise because plasma can have different average temperature of electron and ions. That also means that our assumption about same terminal and currency electron velocities is very limited and parameters of plasma electric system will many better, then in our computation. The plasma in our system may be very cooled in radial direction and hot in axial direction. That decreases an electric currency needed for plasma compression and allows to transfer a plasma beam, energy, and thrust at long distance.

6. Long Distance Wireless Transfer of Electricity in Earth

The transferring electric energy from one continent to other continent through ionosphere and Earth surface is described over. For this transferring we need two space towers of 100 km height, The towers must have a big conducting ball at top end and underground (better underwater) plates for decreasing the contact electric resistance. The contacting ball is large (up to 100 ÷ 200 m diameter) inflatable gas balloon having the conductivity layer (covering).

Let us to offer the method which allows computation the parameters and possibilities this electric line.

The electric resistance and other values for big conductivity medium can be estimated by equations:

$$R=\frac{U}{I}=\frac{1}{2\pi a\lambda}, \quad W=IU=2\pi a\lambda U^2, \quad E_a=\frac{U}{2a} \tag{15}$$

where R is electric resistance of big conductivity medium, Ω (for sea water $\rho = 0.3$ Ω·m); a is radius of contacting balloon, m; λ is electric conductivity, $(\Omega\cdot m)^{-1}$; E_a is electric intensity on the balloon surface, V/m.

The conductivity λ of E-layer of Earth's ionosphere as the rare ionized gas can be estimated by equations:

$$\lambda=\frac{ne^2\tau}{m_e}, \quad \text{where} \quad \tau=\frac{L}{v}, \quad L=\frac{kT_k}{\sqrt{2}\pi r_m^2 p}, \quad v^2=\frac{8kT_k}{\pi m_e} \tag{16}$$

where $n = 3.1\times10^9 \div 5\times10^{11}$ 1/m^3 is density of free electrons in E-layer of Earth's ionosphere, 1/m^3; τ is a track time of electrons, s; L is track length of electrons, m; v is average electron velocity, m/s; $r_m = 3.7\times10^{-10}$ (for hydrogen N_2) is diameter pf gas molecule, m; $p = 3.2\times10^{-3}$ N/m^2 is gas pressure for altitude 100 km, N/m^2; $m_e = 9.11\times10^{-31}$ is mass of electrons, kg.

The transfer power and efficiency are

$$W=IU, \quad \eta=1-R_c/R \tag{17}$$

where R_c is common electric resistance of conductivity medium, Ω; R is total resistance of the electric system, Ω.

See the detail computations in Macro-Projects section.

7. Earth's Ionosphere as the Gigantic Storage of Electric Energy

The Earth surface and Earth's ionosphere is gigantic spherical condenser. The electric capacitance and electric energy storied in this condenser can be estimated by equations:

$$C=\frac{4\pi\varepsilon_0}{1/R_0-1/(R_0+H)}\approx 4\pi\varepsilon_0\frac{R_0^2}{H}, \quad E=\frac{CU^2}{2} \tag{18}$$

where C is capacity of condenser, C; $R_0 = 6.369\times10^6$ m is radius of Earth; H is altitude of E-layer, m; $\varepsilon_0 = 8.85\times10^{-12}$ F/m is electrostatic constant; E is electric energy, J.

The leakage currency is

$$i = \frac{3\pi\lambda_a R_0^2}{H}U, \quad \lambda_a = n_a e\mu, \quad R_a = \frac{H}{4\pi\lambda_a R_0^2}, \quad t = CR_a \tag{19}$$

where i leakage currency, A; λ_a is conductivity of Earth atmosphere, $(\Omega\cdot m)^{-1}$, n_a is free electron density of atmosphere, 1/m^3; μ = 1.3×10^{-4} (for N_2) is ion mobility, m^2/(sV); R_a is Earth's atmosphere resistance, Ω; t is time of discharging in e = 2.73 times, s;

8. Magnetic Sail

Circle plasma cable allows creating the gigantic Magnetic Sail. This sail has drag into Solar wind, which can be used as a thrust of a space ship. The electric resistance of plasma MagSail is small and MagSail can exist some years. That is also big good storage of electric energy. Space ship connects to MagSail by magnetic force.

The energy storage in plasma ring is

$$E_R = \frac{L_R I^2}{2}, \quad \text{where} \quad L_R = \mu_0 \frac{\pi R}{2} \tag{20}$$

where E_R is energy in magnetic ring, J [15]; L_R is inductance of magnetic ring, H; R is radius of magnetic ring, m.

The ring spends power

$$U_m = R_m I, \quad W_m = IU_m \tag{21}$$

The existing time is

$$\tau \approx c_R \frac{E_R}{W_m} \tag{22}$$

where c_R is part of ring energy spent in life time, s ($0 < c_R < 1$).

The ring energy is enough for some years of ring existing.

See the estimations in Projects section.

MACROPROJECTS

The macroprojects discussed below are not optimal. These are only examples of estimations: what parameters of system we can have.

1. Space Electric Line the Length in 100 Millions of km

Let us take the following date of the electric line: radius of plasma cable is r = 150 m, (cross-section of plasma cable equals $S = \pi r^2$ = 7.06×10^4 m^2), plasma density is n = 10^{10} 1/m^3, electric currency is I = 100 A, electric voltage is U = 2×10^6 V. Use the equations (1)-(6) we are receiving:

Electron velocity is $u = I/enS$ = 8.85×10^5 m/s, electron temperature in eV is T = 2.23 eV, electron temperature in K is T_k = 2.59×10^4 K, specific electric resistance is ρ = 3×10^{-4} Ω·m, Coulomb logarithm is ln Λ = 10, charge state is Z = 1, electric resistance is $R = 2\rho L/S$ =

8.8×10^2 Ω, loss voltage is $U_m = IR = 8.8\times10^4$ V, loss power is $W_m = IU_m = 8.8\times10^6$ W, transfer power is $W = IU = 2\times10^8$ W, coefficient efficiency is $\eta = 0.956$.

As you see, our system can transmit 200 million watts of power at distance 100 million kilometers with efficiency 95.6%. I remind that the minimal distance to Mars is only about 60 million of kilometers.

Mass of our plasma line from hydrogen H_2 is only 470 g.

2. Transferring Electric Energy to Moon or Back

Let us take the initial data: radius of plasma cable $r = 15$ m ($S = \pi r^2 = 706$ m^2), plasma density $n = 10^{12}$ 1/m^3, electric currency $I = 1000$ A, distance 385,000 km.

Then: $u = I/enS = 8.85\times10^6$ m/s, $T = 223$ eV, $T_k = 2.59\times10^6$ K, $\rho = 3.1\times10^{-7}$ Ω·m, ln $\Lambda = 10$, $Z = 1$, $R = 2\rho L/S = 3.4\times10^{-1}$ Ω, $U_m = IR = 3.4\times10^2$ V, $W_m = IU_m = 3.4\times10^5$ W.

If voltage is $U = 3.4\times10^3$ V, then transmitting power is $W = IU = 3.4\times10^8$ W, coefficient efficiency is $\eta = 0.9$.

If $U = 3.4\times10^4$ V, then $W = IU = 34\times10^8$ W, $\eta = 0.99$.

As you see, this system can transmit 340 ÷ 3400 million watts of power to Moon at distance 385,000 kilometers with efficiency 90 ÷ 99%.

If we take electric currency $I = 100$ A and voltage $U = 3.4\times10^3$ V, then the transfer energy is $W = IU = 3.4\times10^7$ W, $\eta = 0.9$. The same parameters are transfer energy to Earth's Space Station. Now the International Space Station has only electric power W = 10^4 W.

3. Transferring Energy to Mars

Located beyond the in Sun opposed on Earth side. In this case we use the circle plasma transfer (Figure 5).

Let us take the following initial data: Radius of circle $R = 1.9\times10^{11}$ m = 190 millions kilometers (Length of circle equals $L \approx 12\times10^{11}$ m), $r = 150$ m ($S = \pi r^2 = 7.06\times10^4$ m^2), $n = 10^{10}$ 1/m^3, $I = 100$ A, $U = 10^7$ V.

Then: $u = I/enS = 8.85\times10^5$ m/s, $T = 2.23$ eV, $T_k = 2.59\times10^4$ K, $\rho = 3.1\times10^{-4}$ Ω·m, ln $\Lambda = 10$, $Z = 1$, $R = \rho L/S = 5.27\times10^3$ Ω, $U_m = IR = 5.27\times10^5$ V, $W_m = IU_m = 5.27\times10^7$ W, $W = IU = 2\times10^8$ W, $\eta \approx 0.95$.

Mass of our plasma line from hydrogen H_2 is only about 3 kg.

4. Plasma Magnetic Sail (Figure 6)

Let us take the following initial data: radius of MagSail $R = 5\times10^4$ m = 50 km, $r = 1.5\times10^3$ m ($S = \pi r^2 = 7.06\times10^6$ m^2), $n = 10^8$ 1/m^3, $I = 10^4$ A.

Then: $u = I/enS = 8.85\times10^7$ m/s, $T = 2.23\times10^4$ eV, $T_k = 2.59\times10^8$ K, $\rho = 3.1\times10^{-10}$ Ω·m, ln $\Lambda = 10$, $Z = 1$, $R_m = \rho L/S = 1.38\times10^{-11}$ Ω, $U_m = IR = 1.38\times10^{-7}$ V, $W_m = IU_m = 1.4\times10^{-3}$ W.

If $U = 100$ V, the ring energy is $E = 5\times10^6$ J [15]. If we spent only 10% of the ring energy, our MagSail will work about 10 years.

The gigantic plasma space MagSail is also an excellent storige of electric energy. If we take $U = 10^5$ V, the ring will keep about $E = 5\times10^9$ J.

5. Wireless Transferring Energy between Earth's Continents (Figure 7).

Let us take the following initial data: Gas pressure at altitude 100 km is $p = 3.2\times10^{-3}$ N/m^2, temperature is 209 K, diameter nitrogen N_2 molecule is 3.7×10^{-10} m, the ion/electron density in ionosphere is $n = 10^{10}$ 1/m^3, radius of the conductivity inflatable balloon at top the space tower (mast) is $a = 100$ m (contact area is $S = 1.3\times10^5$ m^2), specific electric resistance of a sea water is 0.3 Ω·m, area of the contact sea plate is 1.3×10^3 m^2.

The computation used equation (15)-(19) give: electron track in ionosphere is $L = 1.5$ m, electron velocity $\upsilon = 9\times10^4$ m/s, track time $\tau = 1.67\times10^{-5}$ s, specific resistance of ionosphere is $\rho = 4.68\times10^{-3}$ (Ω·m)$^{-1}$, contact resistance of top ball (balloon) is $R_1 = 0.34$ Ω, contact resistance of the lower sea plates is $R_2 = 4.8\times10^{-3}$ Ω, electric intensity on ball surface is 5×10^4 V/m.

If the voltage is $U = 10^7$ V, total resistance of electric system is $R = 100$ Ω, then electric currency is $I = 10^5$ A, transferring power is $W= IU = 10^{12}$ W, coefficient efficiency is 99.66%. In practice we are not limited in transferring any energy in any Earth's point having the 100 km space mast and further transfer by ground-based electric lines in any geographical region of radius 1000 ÷ 2000 km.

6. Earth's Ionosphere as the Storage Electric Energy

It is using the equations (18)-(19) we find the Earth's-ionosphere capacity $C = 4.5\times10^{-2}$ C. If $U = 10^8$ V, the storage energy is $E = 0.5CU^2 = 2.25\times10^{14}$ J. That is large energy.

Let us now estimate the leakage of current. Cosmic rays and Earth's radioactivity create 1.5 ÷ 10.4 ions every second in 1 cm^3. But they quickly recombine in neutral molecule and the ions concentration is small. We take the ion concentration of lower atmosphere $n = 10^6$ 1/m^3. Then the specific conductivity of Earth's atmosphere is 2.1×10^{-17} (Ω·m)$^{-1}$. The leakage currency is $i = 10^{-7}\times U$. The altitude of *E*-layer is 100 km. We take a thickness of atmosphere only 10 km. Then the conductivity of Earth's atmosphere is 10^{-24} (Ω·m)$^{-1}$, resistance is $R_a = 10^{24}$ Ω, the leakage time (decreasing of energy in $e = 2.73$ times) is 1.5×10^5 years.

As you can clearly see the Earth's ionosphere may become a gigantic storage site of electricity.

Discussion

The offered ideas and innovations may create a jump in space and energy industries. Author has made initial base research that conclusively show the big industrial possibilities offered by the methods and installations proposed. Further research and testing are necessary. As that is in science, the obstacles can slow, even stop, applications of these revolutionary innovations. For example, the plasma cable may be unstable. The instability mega-problem of a plasma cable was found in tokomak RandD, but it is successfully solved at the present time. The same method (rotation of plasma cable) can be applied in our case.

Conclusion

This new revolutionary idea - wireless transferring of electric energy in the hard vacuum of outer space is offered and researched. A rare plasma power cord as electric cable (wire) is used for it. It is shown that a certain minimal electric currency creates a compressed force that supports the plasma cable in the compacted form. Large amounts of energy can be transferred hundreds of millions of kilometers by this method. The requisite mass of plasma cable is merely hundreds of grams. It is computed that the macroprojects: transferring of hundreds of kilowatts of energy to Earth's International Space Station, transfer energy to Moon or back, transferring energy to a spaceship at distance of hundreds of millions of kilometers, transfer energy to Mars when wirelessly. The transfer of colossal energy from one continent to another continent (for example, Europe to USA and back), using the Earth's ionosphere as a gigantic storage of electric energy, using the plasma ring as huge MagSail for moving of spaceships. It is also shown that electric currency in plasma cord can accelerate or slow various kinds of outer space apparatus.

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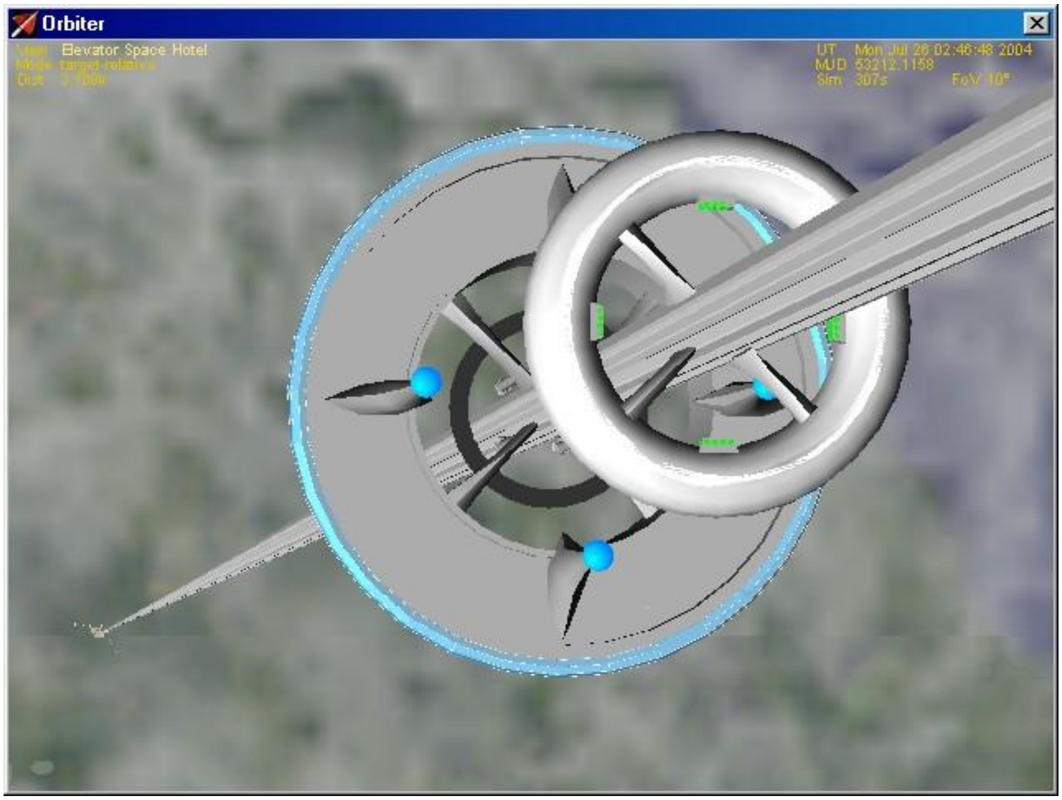
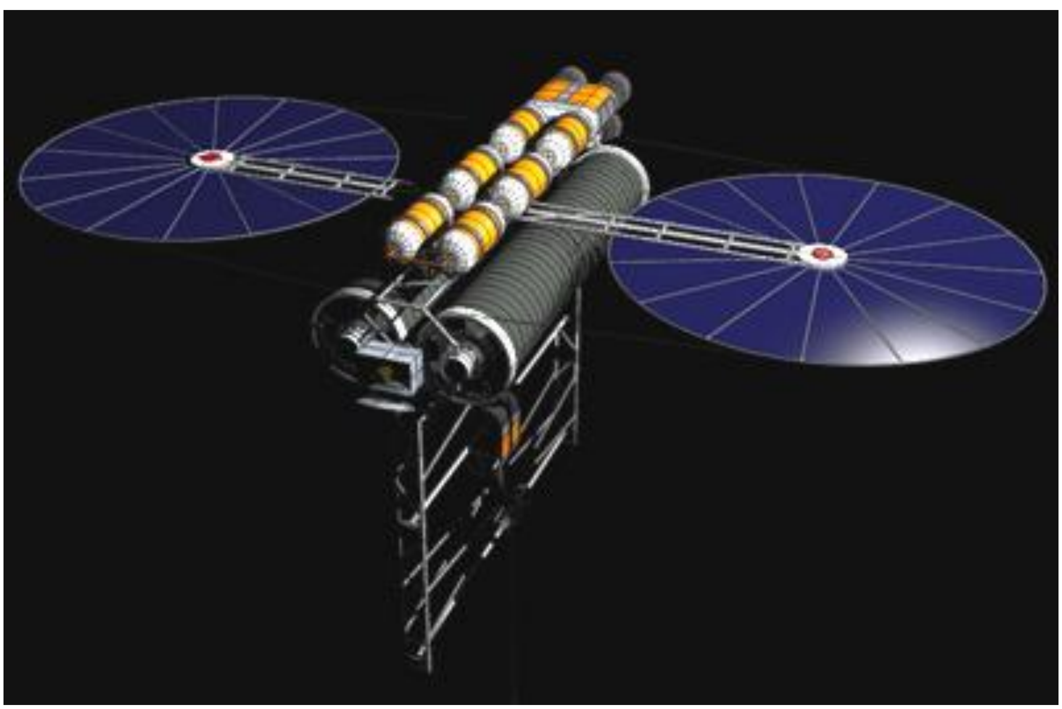
Attachment to Part A, Ch. 6. Possible forms of Space Ships





Chapter 7

SIMPLEST AB-THERMONUCLEAR SPACE PROPULSION AND ELECTRIC GENERATOR*

ABSTRACT

The author applies, develops and researches mini-sized Micro- AB Thermonuclear Reactors for space propulsion and space power systems. These small engines directly convert the high speed charged particles produced in the thermonuclear reactor into vehicle thrust or vehicle electricity with maximum efficiency. The simplest AB-thermonuclear propulsion offered allows spaceships to reach speeds of 20,000 - 50,000 km/s (1/6 of light speed) for fuel ratio 0.1 and produces a huge amount of useful electric energy. Offered propulsion system permits flight to any planet of our Solar system in short time and to the nearest non-Sun stars by E-being or intellectual robots during a single human life period.

Keywords: *AB-propulsion, thermonuclear propulsion, space propulsion, thermonuclear power system.*

INTRODUCTION

At present, both solid and liquid chemical fueled rockets are used for launch to and flights in interplanetary outer space. They have been intensively developed since War II when German engineer Wernher von Braun (1912-1977) successfully designed the first long distance rocket FAU-2. In the subsequent years, liquid and solid rockets reached their developmental peak. Their main shortcomings are (1) very high space launch cost of $20,000 – 50,000/kg; (2) large fuel consumption; (3) liquid fuel storage problems because oxidizer and fuel (for example; oxygen and hydrogen) require cryogenic temperatures, or they are poisonous substances (for example; nitric acid, N_2O_3).

In past years, the author and other scientists have published series of new methods that promise to revolutionize space launch and space flight [1-14]. These include cable accelerator, circle launcher and space keeper, space elevator transport system, space towers, kinetic towers, the gas-tube method, sling rotary method, electromagnetic and electrostatic accelerators, tether system, Earth-Moon or Earth-Mars non-rocket cable transport system.

There include new propulsion and power systems such as solar and magnetic sails, Solar wind sail, radioisotope sail, electrostatic space sail, laser beam, kinetic anti-gravitator, multi-

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* This work presented as Bolonkin's paper AIAA-2007-4613 to 38th AIAA Plasmadynamics and Lasers Conference in conjunction with the16th International Conference on MHD Energy Conversion on 25-27 June 2007, Miami, USA. See also http://arxiv.org search "Bolonkin".

reflective beam propulsion system, asteroid employment electrostatic levitation, etc. (Too, there are new ideas in aviation that can be useful for flights in the atmosphere.)

Some of these have the potential to decrease space launch costs thousands of times, others allow changing the speed and direction of space apparatus without expending fuel.

The thermonuclear propulsion and power method is very perspective -- though not speculative -- because it promises high vehicular apparatus speed up 50,000 km/s. This method needs a small, special thermonuclear reactor that will allow the direct and efficient utilization of the kinetic energy of nuclear particles – the AB Thermonuclear Reactor –first offered by author [15].

DESCRIPTION OF INNOVATIONS

The AB thermonuclear propulsion and electric generator are presented in Figure 1. As it is shown in [15] the minimized, or micro-thermonuclear reactor 1 generates high-speed charged particles 2 and neutrons that leave the reactor. The emitted charged particles may be reflected by electrostatic reflector, 4, or adsorbed by a semi-spherical screen 3; the neutrons may only be adsorbed by screen 3.

In *screen* of the AB-thermonuclear reactor (Figure 1*a*) the forward semi-spherical screen 3 adsorbed particles that move forward. The particles, 2, of the back semi-sphere move freely and produce the vehicle's thrust. The forwarded particles may to warm one side of the screen (the other side is heat protected) and emit photons that then create additional thrust for the apparatus. That is the *photon* AB-thermonuclear thruster.

In *reflector* AB-thermonuclear reactor (Figure 1*b*) the neutrons fly to space, the charged particles 5 are reflected the electrostatic reflector 4 to the side opposed an apparatus moving and create thrust.

The *screen-reflector* AB-thermonuclear reactor (Figure1*c*) has the screen and reflector.

The *spherical* AB-propulsion-generator (Figure 1*d*) has two nets which stop the charged particles and produced electricity same as in [14] Chapter 17. Any part 8 of the sphere may be cut-off from voltage and particles 9 can leave the sphere through this section and, thusly, create the thrust. We can change direction of thrust without turning the whole apparatus.

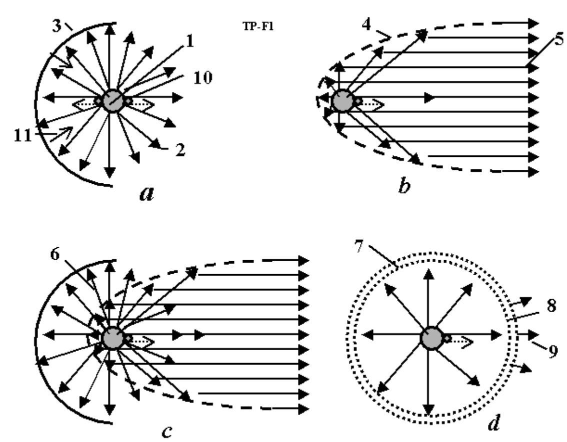

Figure 1. Types of the suggested propulsion and power system. (a) screen AB-thermonuclear propulsion and photon AB-thermonuclear propulsion ; (b) (electrostatic)

reflector AB-thermonuclear propulsion; (c) screen-reflector AB-thermonuclear propulsion; (d) spherical AB-propulsion-generator. *Notations:* 1 - micro (mini) AB-thermonuclear reactor [15], 2 - particles (charged particles and neutrons) , 3 - screen for particles, 4 - electrostatic reflector; 5 - charged particles, 6 - neutrons, 7 - spherical net of electric generator, 8 - transparency (for charged particles) part of spherical net, 9 - charged particle are producing the thrust, 10 - electron discharger, 11 - photon radiation.

THEORY OF THE THERMONUCLEAR REACTOR, PROPULSION AND POWER

List of Main Equations

Below are the main equations for the proper estimation of benefits from the offered innovations.

1. Energy needed to overcome the Coulomb barrier

$$F = k\frac{Q_1 Q_2}{r^2}, \quad E = \int_{r_0}^{\infty} F dr, \quad E = \frac{k Z_1 Z_2 e^2}{r_0}, \qquad (1)$$
$$r_0 = (1.2 \div 1.5)\cdot 10^{15}\sqrt{A}$$

where k = 1.38×10^{-23} Boltzmann constant, J/^{o}K; Z_1, Z_2 are charge state of 1 and 2 particles respectively; e = 1,6×10^{-19} C is charge of electron; r_o is radius of nuclear force, m; A is number of element; F is force, N; E is energy, J; Q is charge of particles.

For example, for reaction H+H (hydrogen, $Z_1 = Z_2 = 1$, $r_o \approx 2\times10^{-15}$ m) this energy is ≈ 0.7 MeV or 0.35 MeV for every particle. The real energy is about 30 times less because some particles have more than average speed and there is a tunnel effect.

2. Energy needed for ignition. Figure 8 [15] shows a magnitude $n\tau$ (analog of Lawson criterion) required for ignition.

Present-day industry produces powerful lasers:

- Carbon dioxide lasers emit up to 100 kW at 9.6 µm and 10.6 µm, and are used in industry for cutting and welding.
- Carbon monoxide lasers must be cooled, but can produce up to 500 kW.

Special laser and ICF reactors:

- NOVA (1999, USA). Laser 100 kJ (wavelenght λ=1054×10^{-9} m) and 40 kJ (wavelenght λ = 351×10^{-9} m), power few tens of terawatts (1 TW = 10^{12} W), time of impulse (2 ÷ 4) ×10^{-9} s, 10-beams, matter is Nd:class.
- OMERA (1995, USA). 60-beam, neodyminm class laser, 30 kJ, power 60 TW.

- Z-machine (USA, under construction), power is up 350 TW. It can create currency impulses up to 20×10^{6} A.
- NIF (USA). By 2005, the National Ignition Facility is worked on a system that, when complete, will contain 192-beam, 1.8-megajoule, 700-terawatt laser system adjoining a 10-meter-diameter target chamber.
- 1.25 PW - world's most powerful laser (claimed on 23 May 1996 by Lawrence Livermore Laboratory).

3. Radiation energy from hot solid black body is (Stefan-Boltzmann Law):

$$E = \sigma T^{4} \tag{2}$$

where E is emitted energy, W/m^2; $\sigma = 5.67\times10^{-8}$ - Stefan-Boltzmann constant, W/m^2 ^{o}K^4; T is temperature in ^{o}K.

4. Wavelength corresponded of maximum energy density (Wien's Law) is

$$\lambda_0 = \frac{b}{T}, \quad \omega = \frac{2\pi}{\lambda_0} \tag{3}$$

where $b = 2.8978\times10^{-3}$ is constant, m ^{o}K; T is temperature, ^{o}K; ω is angle frequency of wave, rad/s.

5. Pressure for one full reflection is

$$F = 2E/c \tag{4}$$

where F - pressure, N/m^2; $c = 3\times10^{8}$ is light speed, m/s, E is radiation power, W/m^2. If plasma does not reflect radiation the pressure equals

$$F = E/c \tag{5}$$

6. Pressure for plasma multi-reflection [8, 14] is

$$F = \frac{2E}{c}\left(\frac{2}{1-q}\right) \tag{6}$$

where q is plasma reflection coefficient. For example, if q = 0.98 the radiation pressure increases by 100 times. We neglect losses of prism reflection.

7. The Bremsstrahlung (brake) loss energy of plasma by radiation is ($T > 10^{6}$ ^{o}K)

$$P_{Br} = 5.34\cdot10^{-37} n_e^2 T^{0.5} Z_{eff}, \quad \text{where} \quad Z_{eff} = \sum (Z^2 n_z)/n_e \tag{7}$$

where P_{Br} is power of Bremsstrahlung radiation, W/m^3; n_e is number of particles in m^3; T is a plasma temperature, KeV; Z is charge state; Z_{eff} is cross-section coefficient for multi-charges ions. For reactions H+D, D+T the Z_{eff} equals 1.

Losses may be very high. For some reactions, they are more then useful nuclear energy and fusion nuclear reaction may be stopped. The Bremsstrahlung emission has continuous spectra.

8. Electron frequency in plasma is

$$\omega_{pe} = \left(\frac{4\pi n_e e^2}{m_e}\right)^{1/4}, \quad \text{or} \quad \omega_{pe} = 5.64\times10^4 (n_e)^{1/4}$$
$$\text{in "cgs" units, or} \quad \omega_{pe} = 56.4(n)^{1/4} \quad \text{in CI units} \qquad (8)$$

where ω_{pe} is electron frequency, rad/s; n_e is electron density, [1/cm^3]; n is electron density, [1/m^3]; $m_e = 9.11\times10^{-28}$ is mass of electron, g; $e = 1.6\times10^{-19}$ is electron charge, C.

The plasma is reflected an electromagnet radiation if frequency of electromagnet radiation is less then electron frequency in plasma, $\omega < \omega_{pe}$. That reflectivity is high. For $T > 15\times10^6$ °K it is more than silver and increases with plasma temperature as $T^{3/2}$. The frequency of laser beam and Bremsstrahlung emission are less then electron frequency in plasma.

9. The deep of penetration of outer radiation into plasma is

$$d_p = \frac{c}{\omega_{pe}} = 5.31\cdot10^5 n_e^{-1/2} \text{ [cm]} \qquad (9)$$

For plasma density $n_e = 10^{22}$ 1/cm^3 $d_p = 5.31\times10^{-6}$ cm.

10. The gas (plasma) dynamic pressure, p_k, is

$$p_k = nk(T_e + T_i) \quad \text{if} \quad T_e = T_k \quad \text{then} \quad p_k = 2nkT \qquad (10)$$

where $k = 1.38\times10^{-23}$ is Boltzmann constant; T_e is temperature of electrons, °K; T_i is temperature of ions, °K. These temperatures may be different; n is plasma density, 1/m^3; p_k is plasma pressure, N/m^2.

11. The gas (plasma) ion pressure, p, is

$$p = \frac{2}{3} n\,k\,T \qquad (11)$$

Here n is plasma density in 1/m^3.

12. The magnetic p_m and electrostatic pressure, p_s, are

$$p_m = \frac{B^2}{2\mu_0}, \quad p_s = \frac{1}{2}\varepsilon_0 E_S^2, \qquad (12)$$

where B is electromagnetic induction, Tesla; $\mu_0 = 4\pi\times10^{-7}$ electromagnetic constant; $\varepsilon_0 = 8.85\times10^{-12}$, F/m, is electrostatic constant; E_S is electrostatic intensity, V/m.

13. Ion thermal velocity is

$$v_{Ti} = \left(\frac{kT_i}{m_i}\right)^{1/2} = 9.79\times10^5 \mu^{-1/2} T_i^{1/2} \quad \text{cm/s}, \tag{13}$$

where $\mu = m_i/m_p$, m_i is mass of ion, kg; $m_p = 1.67\times10^{-27}$ is mass of proton, kg.

14. Transverse Spitzer plasma resistance

$$\eta_\perp = 1.03\times10^{-2} Z \ln\Lambda T^{-3/2}, \quad \Omega\text{ cm} \quad \text{or} \quad \rho \approx \frac{0.1\text{Z}}{\text{T}^{3/2}} \quad \Omega\text{ cm} \tag{14}$$

where ln Λ = 5 ÷ 15 ≈ 10 is Coulomb logarithm, Z is charge state.

15. Reaction rates <σv> (in cm^3 s^{-1}) averaged over Maxwellian distributions for low energy (T < 25 keV) may be represent by

$$(\overline{\sigma v})_{DD} = 2.33\times10^{-14} T^{-2/3} \exp(-18.76\, T^{-1/3}) \quad \text{cm}^3\text{s}^{-1},$$
$$(\overline{\sigma v})_{DT} = 3.68\times10^{-12} T^{-2/3} \exp(-19.94\, T^{-1/3}) \quad \text{cm}^3\text{s}^{-1}, \tag{15}$$

where T is measured in keV.

16. The power density released in the form of charged particles is [19]

$$P_{DD} = 3.3\times10^{-13} n_D^2 (\overline{\sigma v})_{DD}, \quad \text{W cm}^{-3}$$
$$P_{DT} = 5.6\times10^{-13} n_D n_T (\overline{\sigma v})_{DT}, \quad \text{W cm}^{-3}$$
$$P_{DHe^3} = 2.9\times10^{-12} n_D n_{He^3} (\overline{\sigma v})_{DHe^3}, \quad \text{W cm}^{-3} \tag{16}$$

Here in P_{DD} equation it is included D + T reaction.

RESULTS OF COMPUTATION

1. Some thermonuclear reactions. The primary nuclear reaction is D-D reaction that takes place when two nuclei of deuterium collide. Deuterium can be obtained from seawater, its abundance being about 0.0148% that of hydrogen, and used as a fuel resource, this amount can be regarded as almost inexhaustible.

The D-D reaction consists of the following two reactions:

D+D → ^{3}He + n +3.27 MeV, 50% (17)

D+D → T + H +4.03 MeV . 50% (18)

In reaction (17) an isotope of helium (^{3}He) and neutron (n) are produced by the collision of two deuterium nuclei (D). In reaction (2), a tritium (T) and a proton (H) are produced. The numbers on the right-side denote the kinetic energy released by the reaction, which can be calculated us follows: If we denote the mass defect of each particle in the unit of MeV (10^6 eV), we have D: 13.1359 MeV, He: 14.9313 MeV, and n: 8.0714 MeV ([18], p. 1295), so that the energy released by reaction (17) is

2 × 13.1359 - (14.9313 + 8.0714) = 3.2691 = 3.27 MeV.

For reaction (18), we can use for T: 14.9500 MeV and for H: 7.289 MeV.

The partition of the released energy from the reaction products can be estimated from energy and momentum conservation. Kinetic energy of D before collision is very small compared to the energy released by the reaction. We can ignore the initial kinetic energy and treat the deuterium nuclei as being at rest. Denoting the mass and speed of helium and n by $_1$ and $_2$ respectively, we have for reaction (17)

$$0.5m_1v_1^2 + 0.5m_2V_2^2 = E = 3.27 \quad \text{MeV}, \quad m_1v_1 = m_2v_2 \tag{19}$$

where in the second formula we assumed that He and n fly out in opposite directions. From these relations, we find

$$E_1 = \frac{1}{2}m_1v_1^2 = \frac{E}{1+m_1/m_2} = 0.82 \quad \text{MeV}, \quad E_2 = \frac{1}{2}m_2v_2^2 = \frac{E}{1+m_2/m_1} = 2.45 \quad \text{MeV} \tag{20}$$

Obviously, the lighter particle acquires more energy than the heavier particle.

Current nuclear fusion research is focused on the D + T thermonuclear fusion reaction

$$\text{D} + \text{T} \rightarrow {}^4\text{He (3.5 MeV)} + \text{n (14.1 MeV)}, \tag{21}$$

Reaction (21) can occur in high-temperature deuterium-tritium plasma. Most energy released by the reaction is converted to the kinetic energy of the neutron. Since the neutron is not confined or reflected by a magnetic or electrostatic field it leaves, going outwards to surrounding space or hits the screen or vessel wall (or blanker) immediately after reaction. In last instance, the neutron kinetic energy is converted to heat. The heat is taken away from the screen by direct radiation or and indirect circulating coolant and can be used to run an electric generator. If we add ^{6}Li inside the blanket, then tritium can be produced by reaction

$$\text{n} + {}^6\text{Li} \rightarrow {}^4\text{He (2.1 MeV)} + \text{T (2.7 MeV)} \tag{22}$$

and then used as the fuel. Another reaction product is the alpha particles ^{4}He carrying 3.5 MeV which can be directed or confined by electro-magnetic field.

The reaction that produces only charged particles are best for the proposed propulsion system and generator. Unfortunately, these reactions are not great (see Table 1).

However, since the nuclei are positively charged, they must have enough energy to overcome the Coulomb repulsion between them, in order for a few of them to be able to combine. The required energy can be estimated by equation (1).

2. Rocket Impulse. When we know the energy of the thermonuclear particles, the particle speed can be calculated by equation

$$V_i = 1.384 \times 10^4 (E/N_i)^{0.5}, \tag{23}$$

where E is particle energy in MeV, N is number of nucleons in particle (in mass units, for example, N = 1 for proton, neutron, N = 2 for deuterium, N = 3 for tritium, N = 4 for helium).

Conventionally, we have two components on the equation's right-side having different mass and speed. The average efficiency particle speed V (impulse) of thermonuclear reaction may be estimated by equation

$$V = \eta_1 \frac{N_1}{N} V_1 + \eta_2 \frac{N_2}{N} V_2 \tag{24}$$

where lower index "$_i$" is number of particle, η is coefficient utilization of kinetic particle energy, N is total number of nucleons in single reaction. For particles adsorbed by screen (Figure 1*a*) η = 0.25, for particles reflected by reflector (Figure 1*b*) η = 1.

When we use the radiation (photon) energy of one hot side of screen, the efficiency particle speed (24) has additional member

$$\Delta V = \eta_3 \frac{E_J}{m_p c N} \tag{25}$$

where m_p =1.67495×10^{-27} kg is mass of neutron, c = 3×10^8 m/s is the light speed, E_J=1.6×10^{-19}E energy of particle in J, η_3 = 0.25 is coefficient utilization of heat energy.

The apparatus speed is

$$V_m = -V \ln \frac{M_f}{M_0}, \tag{26}$$

where V_m is maximum speed of space apparatus, m/s; M_f /M_0 is ratio of a final mass (apparatus without thermonuclear fuel) to the initial apparatus mass.

Results of computation are presented in Table #1.

Table 1.

Type of propulsion→ Thermonuclear reaction, MeV ↓	AB-screen, Impulse from charged particles ×10^6 m/s	AB-screen. Max speed of apparatus for M_f/M_0 = 0.1 Speed×10^{6}m/s	AB-reflector. Impulse from charged particles ×10^6 m/s	AB-reflector. Max speed of apparatus for M_f/M_0 = 0.1 Speed×10^{6}m/s	Mass ratio M_f/M_0 for fuel=0	+ Photon. Add speed ×10^{6}m/s
1	2	3	4	5	6	7
D+T→^{4}He(3.5)+ n(14.1)	5.18	8.13	10.3	23.8	0.19	0.23
T+T→^{4}He(3.77)+ 2n(7.53)	4.48	7.03	8.96	20.6	0.25	0.15
D+^{3}He→^{4}He(3.6)+ p(14.7)	5.28	8.29	21.1	48.5	0.1	-

Type of propulsion→ Thermonuclear reaction, MeV ↓	AB-screen, Impulse from charged particles ×10^6 m/s	AB-screen. Max speed of apparatus for M_f/M_0 = 0.1 Speed×10^6m/s	AB-reflector. Impulse from charged particles ×10^6 m/s	AB-reflector. Max speed of apparatus for M_f/M_0 = 0.1 Speed×10^6m/s	Mass ratio M_f/M_0 for fuel=0	+ Photon. Add speed ×10^6m/s
1	2	3	4	5	6	7
$D+{}^6Li \to 2{}^4He(22.4)$	5.8	9.11	23.6	54.3	0.1	-
${}^3He+{}^3He \to {}^4He(4.3)+2p(8.6)$	5	7.85	20	46	0.1	-
${}^3He+{}^6Li \to 2{}^4He(1.9)+p(16.9)$	3	4.47	12	27.6	0.1	-
$p+{}^{11}B \to 3{}^4He(8.7)$	2.95	4.63	11.78	27.1	0.1	-

Here are: D - deuterium, T - tritium, He - helium, Li - lithium, B - boron, n - neutron, p - proton.

The *first* column shows the thermonuclear reaction. In left side from pointer it is shown the components of thermonuclear reactor fuel. In the right-side it is shown the particles which appear in the reaction and kinetic energy every particle in MeV.

The *second* column shows the efficiency impulse (in m/s) computed by equation (18) for *AB-screen* engine.

The *third* column shows the maximum speed which apparatus (equipped with an engine screen) reaches a fuel mass ratio equal to 0.1 (equation (20)).

The *fourth* and *fifth* column shows the efficiency impulse and maximum apparatus speed for *AB-reflector* engine.

The *sixth* column shows the final mass of the space apparatus when the mass of initial fuel equals zero. In the first two reactions this ratio is not 0.1 because the neutrons are adsorbed by the screen. That decreases the apparatus speed, but the neutrons can be harnessed to get additional fuel and to sustain other useful and valuable thermonuclear reaction. All computation in Table 1 is made for mass ratio 0.1.

The last (*seventh*) column shows the additional speed from hot one-sided screen emitting photons. This additional speed is small.

The thrust of the spherical thruster-generator (Figure1*d*) for small angles may be computed as for AB-screen engine. Thrust is proportion the ratio of the open area to the full sphere surface.

The power of electric generator may be estimated by equation

$$W = 0.5\times10^{14}\eta\frac{N_p}{N}m_f E \qquad (27)$$

where W is power, W; N_p is number of the charges (protons) nucleons; N is total number of nucleons; E is energy of charged particles, MeV; m_f is fuel consumption, kg/s. η is coefficient efficiency.

The trust propulsion is

$$T = m_f V\,, \qquad (28)$$

where T is trust, N.

The relative mass of fuel converted to energy and thrust is

$$\Delta\overline{m} = \frac{E}{938N} \qquad (29)$$

where E is reaction energy in MeV.

For example, let us take the reaction D+T and fuel consumption $m_f = 10^{-5}$ kg/s. Then $N_p /N = 4/5$, $\underline{E} = 3.5$ MeV and $W \approx 1.34\times10^6$ kW; thrust $T \approx 100$ N; the relative mass converted into energy is 3.75×10^{-3}. If the fuel consumption is $m_f = 10^{-2}$ kg/s, the thrust is $T \approx 10^5$ N. The energy is gigantic $W \approx 1.34\times10^9$ kW.

Table 1 shows that the offered thermonuclear AB-propulsions can accelerate the space apparatus up the speed $(20 \div 50)\times10^6$ m/s (or up 1/6 of light speed) with a fuel ratio of $M_f /M_0 = 0.1$. The AB-propulsion is the most efficient of all thermonuclear propulsions, capable of reaching the theoretic maximum impulse from currently known thermonuclear propulsions and known thermonuclear reactions.

Please note that the reaction that produces only charged particles is more efficient than reactions producing neutrons and charged particles (two in the first lines of Table 1). The neutrons accept a lot of a common energy, but this energy does not produce any thrust. Converting this energy into photons (column 7 of table 1) is also ineffective. The neutrons do not leave the space apparatus, increasing its final launch and travel weight (column 6) and decreasing the final apparatus speed. They may be used for next reaction (see (22) and below), but technical realization of such reaction is decidedly complex and presently unproductive. See some of these reactions below. Unfortunately, most neutron reactions are exoteric.

3. The thermonuclear reactions used the slow neutrons:

Table 2

Reaction	Energy, MeV	Cross section, burns
$^3He + n \rightarrow {}^3H+p$	+0.764	5400
$^6Li + n \rightarrow {}^3H+\alpha$	+4.785	945
$^7Be + n \rightarrow {}^7Li+p$	+1.65	51000
$^{10}B + n \rightarrow {}^7Li+\alpha$	+2.791	3837
$^{14}N + n \rightarrow {}^{14}C+p$	+0.626	1.75
$^{17}O + n \rightarrow {}^{14}C+\alpha$	+1.72	0.5
$^{33}S + n \rightarrow {}^{33}P+p$	+0.75	0.002
$^{35}Cl +n \rightarrow {}^{35}H+p$	+0.62	0.3

The spherical AB-engine can produce much electrical energy, but conversion of this energy into vehicular thrust by common electric (ion) propulsion is inefficient in comparison with the offered AB-engine.

DISCUSSION

The potential space traveling apparatus speed 1/6 of light speed is maximum velocity predicted by thermonuclear AB-propulsion. That speed allows Mars to be a destination in minutes (or some days when apparatus has limited acceleration); that very high speed allows short period trips throughout our Solar system. However, it is not sufficient for easy interstellar space trips. The nearest star system is located at a distance of 3 - 5 light-years. That means the trip requires a minimum of 40 - 60 years. But required fuel ratio M_f /M_0 is very high: acceleration and braking of moving apparatus needs 4-stage rocket having the ratio for every stage M_f /M_0 = 0.1. The total weight fuel ratio will be $M_f /M_0 = 10^{-4}$. If useful weight is 10 tonnes, the starting rocket mass is $M_0 /M_f = 10^4$ tonnes. The relative mass of thermonuclear reaction converted into energy (and thrust) is only 0.3 ÷ 0.4% of total fuel mass. The author's research so far shows that the magnet cannot adsorb the big amount of interstellar matter in the high apparatus speed mode; consequently, the envisioned apparatus must take fuel for the entire trip.

Human interstellar flight is very expensive and complex. We can develop long-distance communication system and send, instead, E-men [18, 19] or artificial intelligent robot.

However, only an annihilation reaction can efficiently solve the interstellar trip macro-problem. Otherwise, new physics discoveries that allow such trips is required.

Conclusion

The author suggests the simplest maximally efficient thermonuclear AB-propulsion (and electric generators) based in the early offered size-minimized Micro-AB-thermonuclear reactor [15]. These engines directly convert high-speed charged particles produced in thermonuclear reactor into vehicular thrust or onboard vehicle electricity resource. Offered propulsion system allows travel to any of our Solar System's planets in a short time as well as trips to the nearest stars by E-being or intellectual robot in during a single human life [16]-[17].

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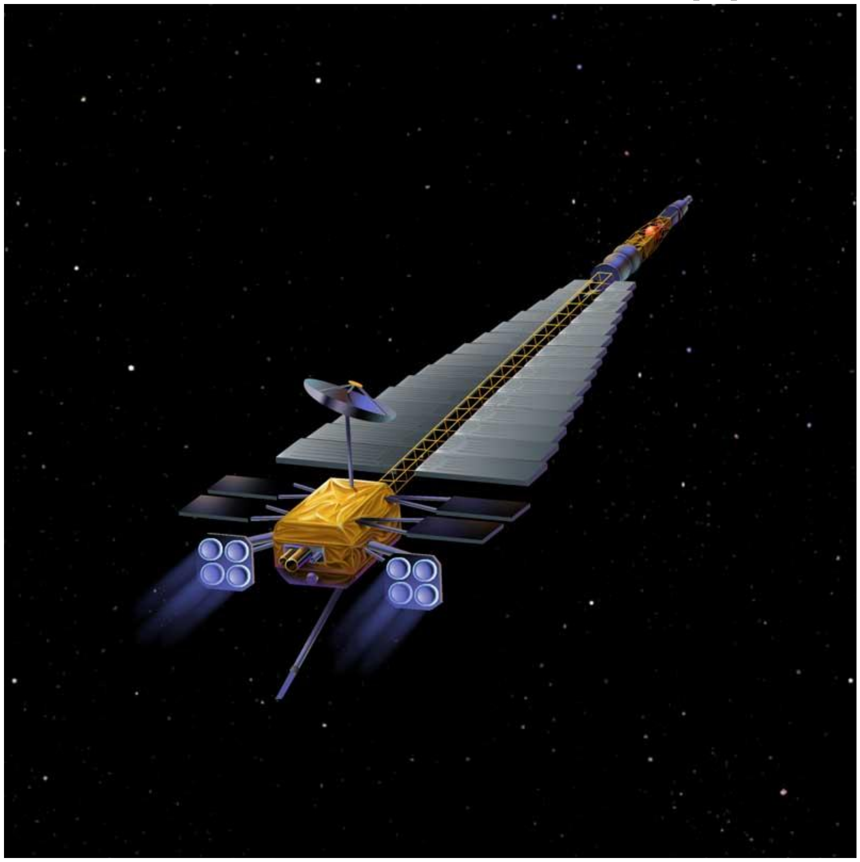
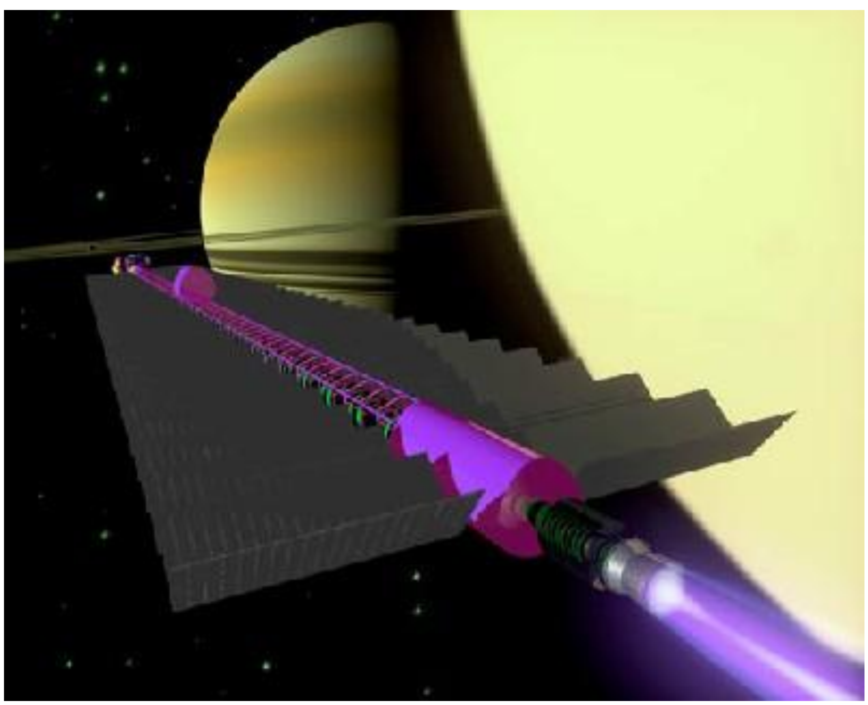
Attachment to Part A, Ch. 7. Possible thermonuclear propulsion





Chapter 8

A NEW METHOD OF ATMOSPHERIC REENTRY FOR SPACE SHIPS*

ABSTRACT

In recent years, industry has produced high-temperature fiber and whiskers. The author examined the atmospheric reentry of the USA Space Shuttles and proposed the use of high temperature tolerant parachute for atmospheric air braking. Though it is not large, a light parachute decreases Shuttle speed from 8 km/s to 1 km/s and Shuttle heat flow by 3 - 4 times. The parachute surface is opened with backside so that it can emit the heat radiation efficiently to Earth-atmosphere. The temperature of parachute is about 1000-1300^o C. The carbon fiber is able to keep its functionality up to a temperature of 1500-2000^o C. There is no conceivable problem to manufacture the parachute from carbon fiber. The proposed new method of braking may be applied to the old Space Shuttles as well as to newer spacecraft designs.

Keywords: *Atmospheric reentry, Space Shuttle, thermal protection of space apparatus, parachute braking.*

INTRODUCTION

In 1969 author applied a new method of global optimization to the problem of atmospheric reentry of spaceships [1 p. 188]. The general analysis presented an additional method to the well-known method of outer space to Earth-atmosphere reentry ("high-speed corridor"). There is a low-speed corridor when the total heat is less than in a conventional high-speed passage. In that time for significantly decreasing the speed of a spaceship retro- and landing rocket engine needed to be used. That requires a lot of fuel. It is not acceptable for modern spaceships. Nowadays the textile industry produces heat resistant fiber that can be used for a new parachute system to be used in a high-temperature environment [2]-[4].

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* Presented as Bolonkin's paper AIAA-2006-6985 to Multidisciplinary Analysis and Optimization Conference, 6-8 Sept. 2006, Portsmouth, Virginia. USA

Figure 1. Space Shuttle "Atlantic". during reentry.

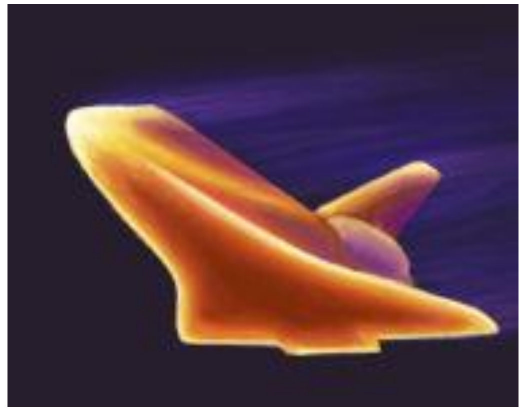

Figure 2. The outside of the Shuttle heats to over 1,550 °C

Figure 3. Endeavour deploys drag chute after touch-down.

THEORY

Equations of spaceship reentry are:

$$\begin{aligned}
&\dot{r} = \frac{R_0}{R} V\cos\theta, \\
&\dot{H} = V\sin\theta, \\
&\dot{V} = -\frac{D + D_P}{m} - g\sin\theta, \\
&\dot{\theta} = \frac{L + L_P}{mV} - \frac{g}{V}\cos\theta + \frac{V\cos\theta}{R} + 2\omega_E\cos\varphi_E,
\end{aligned} \quad (1)$$

where r is range of ship flight, m; R_0 = 6,378,000 is radius of Earth, m; R is radius of ship flight from Earth's center, m; V is ship speed, m/s; H is ship altitude, m; θ is trajectory angle, radians; D is ship drag, N; D_P is parachute drag, N; m is ship mass, kg; g is gravity at altitude H, m/s^2; L is ship lift force, N; L_P is parachute lift force, N; ω_E is angle Earth speed; $\varphi_E = 0$ is lesser angle between perpendicular to flight plate and Earth polar axis; t is flight time, sec.

The magnitudes in equations (1) compute as:

$$g = g_0\left(\frac{R_0}{R_0+H}\right)^2, \quad \rho = a_1 e^{(H-10000)/b}, \quad a_1 = 0.414, \quad b = 6719,$$

$$Q = \frac{0.5\cdot 11040\cdot 10^4}{R_n^{0.5}}\left(\frac{\rho}{\rho_{SL}}\right)^{0.5}\left(\frac{V}{V_{CO}}\right)^{3.15}, \quad R_n = \sqrt{\frac{S_P}{\pi}},$$

$$T_1 = 100\left(\frac{Q}{\varepsilon C_S} + \left(\frac{T_2}{100}\right)^4\right)^{1/4}, \quad T = T_1 - 273, \qquad (2)$$

$$D_P = 0.5 C_{DP}\rho a V S_P, \quad L_P = D_P/3, \quad L = 2\alpha\rho a V S, \quad D = L/4,$$

where: g_0 = 9.81 m/s^2 is gravity at Earth surface; ρ is air density, kg/m^3; Q is heat flow in 1 m^2/s of parachute, J/s·m^2; R_n (or R_p) is parachute radius, m; S_P (or S_m) is parachute area, m^2; ρ_{SL}= 1.225 kg/m^3 is air density at sea level; V_{CO} = 7950 m/s is circle orbit speed; T_1 is temperature of parachute in stagnation point in Kelvin, °K; T is temperature of parachute in stagnation point in centigrade, °C; T_2 is temperature of the standard atmosphere at given altitude, °K; D_P is parachute drag, N; L_P is parachute lift force, N (the ram-air parachute can produce lift force up 1/3 from its drag); D is ship drag, N; L is ship lift force, N; C_{DP} = 1 is parachute drag coefficient; a = 295 m/s is sound speed; $\alpha = 40°$ = 0.7 rad is ship attack angle.

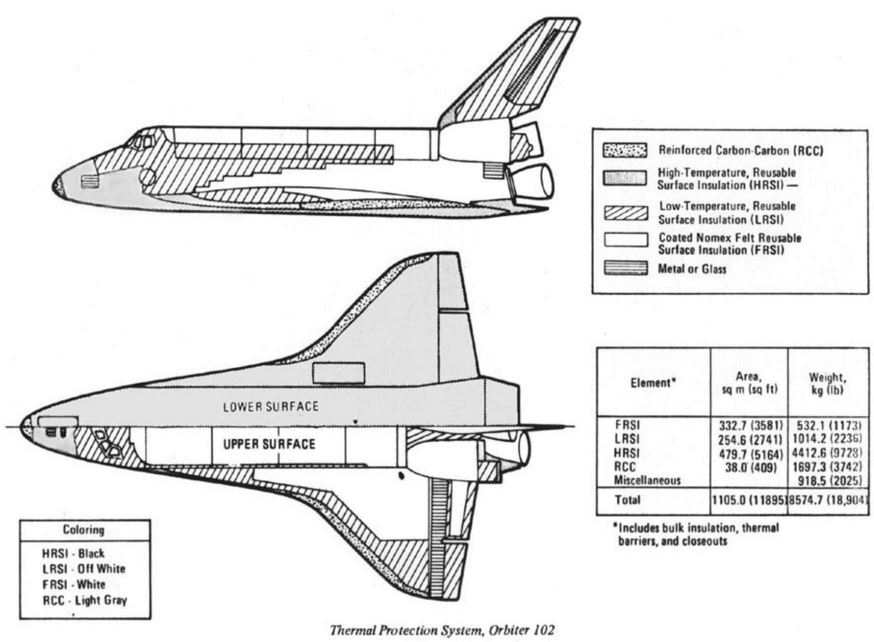

Figure 4. Space Shuttle Thermal Protection System Constituent Materials.

The control is following: if $d\theta/dt > 0$ the all lift force $L = L_P = 0$. When the Shuttle riches the low speed the parachute area can be decreased or parachute can be detached. That case not computed. Used control is not optimal.

The results of integration are presented below. Used data: parachute area are S_P = 1000, 2000, 4000 m^2 (R_p = 17.8, 25.2, 35.7 m); m = 104,000 kg. The dash line is data of the Space Shuttle without a parachute.

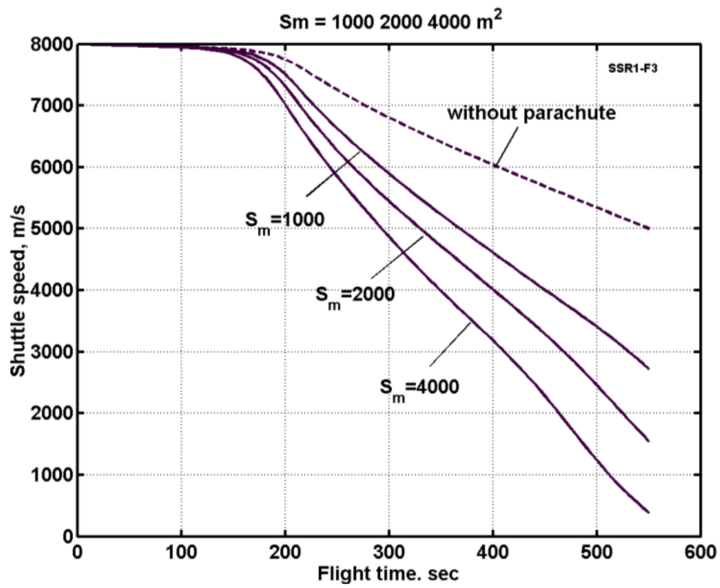

Figure 5. Decreasing of Space Shuttle speed with parachute and without it. $S_m = S_P$.

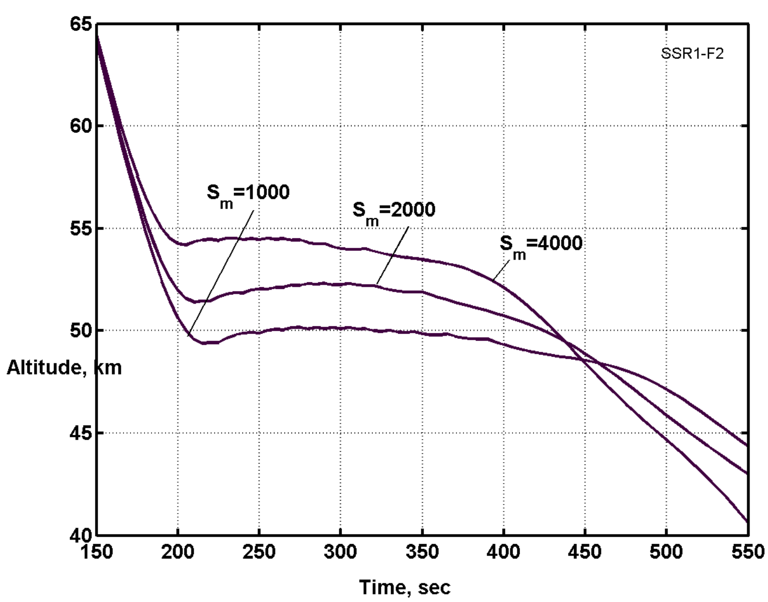

Figure 6. Space Shuttle trajectory with parachute.

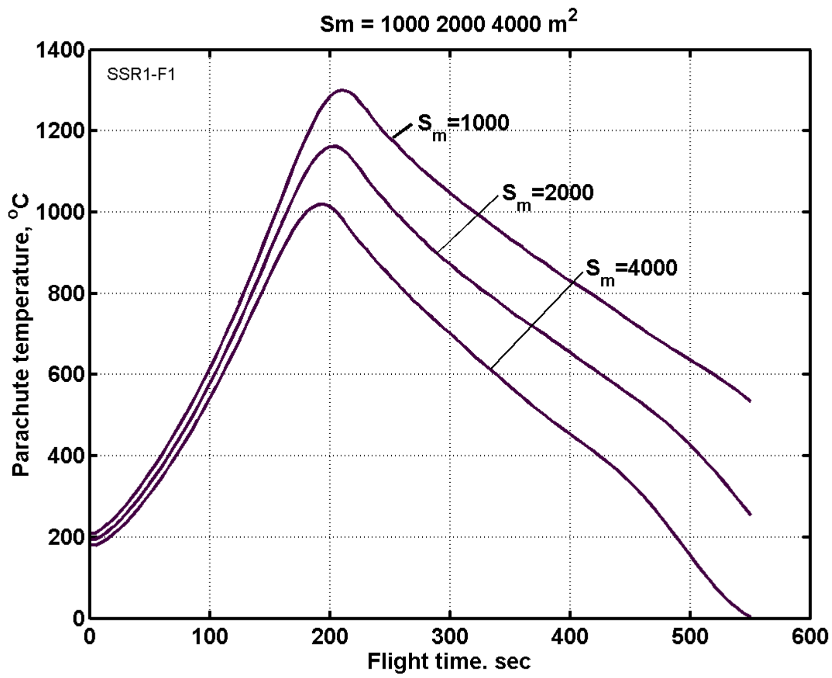

Figure 7. Temperature of parachute at stagnation point.

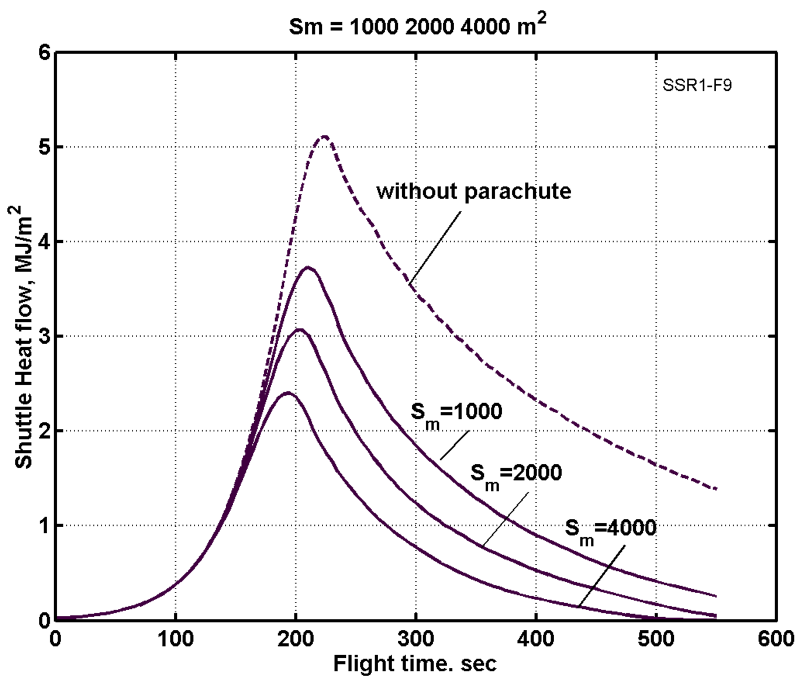

Figure 8. Heat flow through 1 m^2/s of Space Shuttle surface at stagnation point with parachute and without it.

DISCUSSION OF RESULTS

Figure 5 shows the parachute significantly decreases the shuttle speed from 8000 m/s to 350 - 2900 m/s after 550 sec of reentry flight. Practically, the Space Shuttle overpasses the heat barrier (maximum of heat flow) near 200 sec into its reentry (see Figure 8). The heat flow depends on the power 3.15 from speed (see the second equation in (2)) and the speed strongly influences the heat flow. For example, the decreasing of speed in two times decreases the heat flows in 8.9 times!

Figure 6 shows: at altitude 41 - 44 km the ship has speed 350 - 2900 m/s which is acceptable for high speed vehicle in short time of reentry.

Figure 7 shows the maximum temperature in a stagnation point of the parachute. It is 1000 - 1300^o C. The parachute can be made from carbon fiber that can keep the temperature 1500 - 2000^o C (carbon melting temperature is over 3000^o C). At present a carbon fiber composite matters uses by Shuttle for leader edges of Shuttle where temperature reaches 1550^o C.

Figure 8 gives the heat flow through 1 m^2/s of Shuttle without or with a parachute. If we continue flight time up 750 sec, the special total heat will be following: without parachute it is 11.84×10^8 J/m^2, for parachute having area 1000 m^2 - 7×10^8 J/m^2, for 2000 m^2 parachute - 5×10^8 J/m^2, for 4000 m^2 parachute - 3.5×10^8 J/m^2. That is about 1.7 - 3.4 times less then without parachute. It means the future Space Shuttles can have a different system of heat protection and a modern design can be made lighter and cheaper.

ESTIMATION PARACHUTE SYSTEM

The weight of the parachute system and a comparison with current heat protection is key moment for this innovative method. Industry has produced many metal and mineral fibers and whiskers having very high tensile stress at high temperatures. Let us to estimate the mass of parachute system. Assume the carbon fiber having the maximum tensile stress σ = 565 kg/mm^2 (σ = 5.65×10^9 N/m^2) at temperature T = 1500 - 2000^o C is used for parachute. Let us take the safety margin 2.3 - 3. That means σ = 150 kg/mm^2 for canopy and σ = 200 kg/mm^2 for cord. The fiber density is taken γ = 3000 kg/m^3.

The computation is presented in Table 1.

Currently, the mass of the heat protection in Shuttle is 9575 kg. If we decrease this protection proportional the decreasing of the heat flow (in 2 - 3 times) we save the 4 - 6 tons of Shuttle mass.

At the present time, the changing of hundreds of hull protection tiles after every flight takes two weeks and very costly to do. The new method requires only a few tile replacements (maximum temperature is less) or allows using a protective cooling method.

The Command Module of spacecraft "Apollo" had a heat protection of approximately 1/3 of the total take-off/touchdown weight. The gain to be had from a new method reentering may be significantly more.

Table 1. Parachute data

Parachute area $S_p = S_m$, m^2	1000	2000	4000
Reference parachute radius R_p, m	17.8	25.2	35.7
Max. parachute pressure P_p, N/m^2	1250	2000	6000
Parachute surface $S_{pc} = 2\pi R_p^2$ m^2	2000	4000	8000
Parachute thickness $\delta = P_p R_p / 2\sigma$, mm	0.0074	0.0076	0.0072
Mass of canopy $M_c = S_{pc}\delta\gamma$, kg	45	90	171
Mass of cord, kg	66	132	258
Total mass, kg	111	226	429
Max. brake force, kN	1250	1800	2400
Add. Max. overload, g	1.25	1.8	2.4

CONCLUSION

The widespread production of high temperature fibers and whiskers allows us to design high-temperature tolerant parachutes, which may be used by space apparatus of all types for braking in a rarified planet atmosphere. The parachute has open backside surface that rapidly emits the heat radiation to outer space thereby quickly decreasing the parachute temperature. The proposed new method significantly decreases the maximum temperature and heat flow to main space apparatus. That decreases the heat protection mass and increases the useful load of the spacecraft. The method may be also used during an emergency reentering when spaceship heat protection is damaged (as in horrific instance of the Space Shuttle "Columbia").

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Chapter 9

OPTIMAL SOLID SPACE TOWER*

ABSTRACT

Theory and computations are provided for building of optimal (minimum weight) solid space towers (mast) up to one hundred kilometers in height. These towers can be used for tourism; scientific observation of space, observation of the Earth's surface, weather and upper atmosphere experiment, and for radio, television, and communication transmissions. These towers can also be used to launch spaceships and Earth satellites.

These macroprojects are not expensive. They require strong hard material (steel). Towers can be built using present technology. Towers can be used (for tourism, communication, etc.) during the construction process and provide self-financing for further construction. The tower design does not require human work at high altitudes; the tower is separated into sections; all construction can be done at the Earth's surface.

The transport system for a tower consists of a small engine (used only for friction compensation) located at the Earth's surface.

Problems involving security, control, repair, and stability of the proposed towers are addressed in other cited publications.

Keywords: *Space tower, optimal space mast, space tourism, space communication, space launch, space observation.*

1. INTRODUCTION

1.1. Brief History

The idea of building a tower high above the Earth into the heavens is very old [1]. The writings of Moses, in chapter 11 of his book *Genesis* refers to an early civilization that tried to build a tower to heaven out of brick and tar. This construction was called the Tower of Babel, and was reported to be located in Babylon in ancient Mesopotamia. Later in chapter 28, Jacob had a dream about a staircase or ladder built to heaven. This construction was called Jacob's Ladder. More contemporary writings on the subject date back to K.E. Tsiolkovski in his

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manuscript "Speculation about Earth and Sky and on Vesta," published in 1895 [2]. This idea inspired Sir Arthur Clarke to write his novel, *The Fountains of Paradise* [3], about a space tower (elevator) located on a fictionalized Sri Lanka, which brought the concept to the attention of the entire 20th Century world.

Today, the world's tallest construction is a television transmitting tower (mast) near Fargo, North Dakota, USA. It stands 629 m high and was built in 1963 for KTHI-TV. The CNN Tower in Toronto, Ontario, Canada is the world's tallest building. It is 553 m in height, was completed in1975, and has the world's highest observation deck at 447 m. The tower structure is concrete up to the observation deck level. Above is a steel structure supporting radio, television, and communication antennas. The total weight of the tower is 3,000,000 metric tons.

The Ostankin Tower in Moscow is 540 m in height and has an observation desk at 370 m. The world's tallest office building is the Petronas Towers in Kuala Lumpur, Malasia. The twin towers are 452 m in height. They are 10 m taller than the Sears Tower in Chicago, Illinois, USA. The Skyscrapers (Taipei, Taiwan, 2004) has height of 509 m, the Eiffel Tower (Paris, 1887-1889) has 300 m, Empire State Building (USA, New York, 1930-1931) has 381 m + TV mast of 61 m. Under construction a building of 1001 m (Kuwait City, Kuwait) and 1430 m Supported Structure in Gulf of Mexico.

Current materials make it possible even today to construct towers many kilometers in height. However, conventional towers are very expensive, costing billions of dollars. When considering how high a tower can be built, it is important to remember that it can be built to any height if the base is large enough. Theoretically, you could build a tower to geosynchronous Earth orbit (GEO) out of bubble gum, but the base would likely cover half the surface of the Earth.

The proposed optimal masts (towers) are cheaper in lots of hundreds. They can be built on the Earth's surface and their height can be increased as necessary. Their base is not large. The main innovations in this project are the application of optimal structures (minimum weight), hydrogen for filling tube structures at high altitude and a solution of a stability problem for tall (thin) solid columns, and utilization of new materials [4]-[7].

The tower applications. The high towers (3-100 km) have numerous applications for government and commercial purposes:

- Entertainment and Observation platform.
- Entertainment and Observation desk for tourists. Tourists could see over a huge area, including the darkness of space and the curvature of the Earth's horizon.
- Drop tower: tourists could experience several minutes of free-fall time. The drop tower could provide a facility for experiments.
- A permanent observatory on a tall tower would be competitive with airborne and orbital platforms for Earth and space observations.
- Communication boost: A tower tens of kilometers in height near metropolitan areas could provide much higher signal strength than orbital satellites.
- Solar power receivers: Receivers located on tall towers for future space solar power systems would permit use of higher frequency, wireless, power transmission systems (e.g. lasers).

- Low Earth Orbit (LEO) communication satellite replacement: Approximately six to ten 100-km-tall towers could provide the coverage of a LEO satellite constellation with higher power, permanence, and easy upgrade capabilities.
- Other new revolutionary methods of access to space are described in [8]-[15].

2. Description of Innovation and Problem

2.1. Tower Structure

The simplest tourist tower includes (Figure 1): Solid mast, top observation desk, elevator, expansions, and control stability. The tower is separated into sections by horizontal and vertical rods (Figure2) and contains control devices.

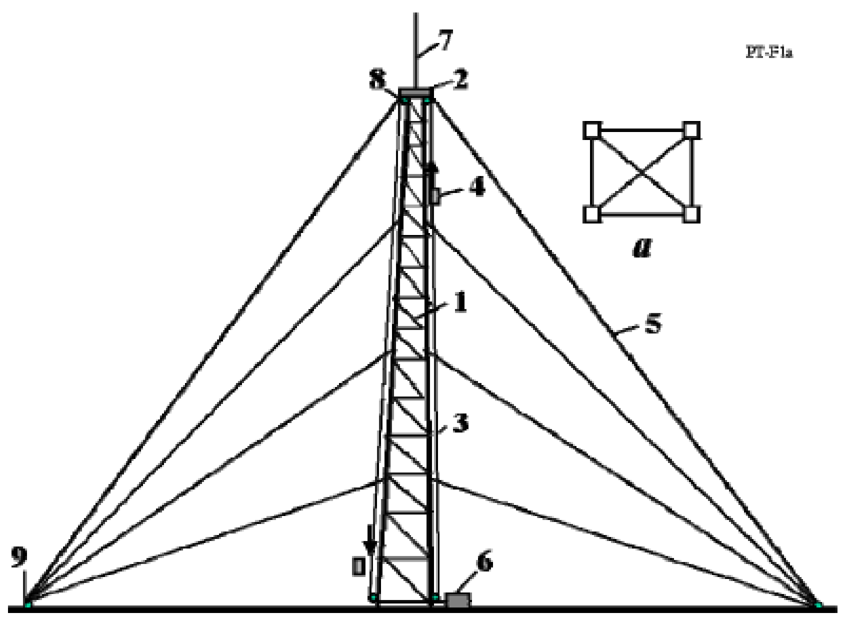

Figure 1. Solid optimal space tower (mast) of height 3 - 100 km. (a) typical cross-section of tower. *Notations*: 1 – solid column; 2 – observation desk; 3 – load cable elevators; 4 – passenger cabin; 5 – expansions; 6 – engine; 7 – radio and TV antenna; 8 – rollers of cable transport system; 9 – stability control.

2.2. Filling Gas

The compressed gas should fill the tube tower rods that provide the structure's weight. Author suggests filling the towers with a light gas, for example, hydrogen.

The average temperature of the atmosphere in the interval from 0 to 100 km is about 240^{o}K.

2.3. The Observation Radius

Versus altitude is presented in [8], figures 4-5 [Eq. (23)].

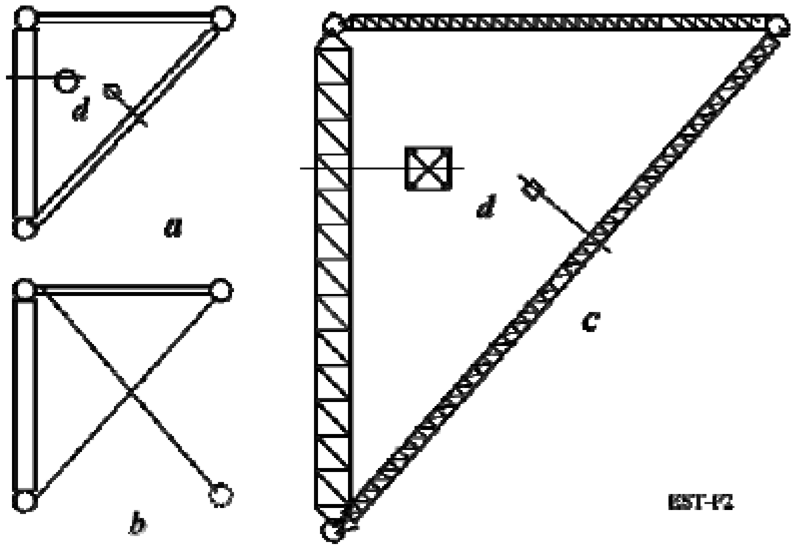

Figure 2. Section of optimal solid tower. *Notation*: (a) - the first level tube rod with sold diagonal braces; (b) - the first level rod with flexible braces; (c) - the second level rod with lattice column and braces; (d) - cross-section of rods.

2.4. Tower Material

The tower parameters very depend on the strength of material, specifically the relation of the safety press stress σ to specific density γ. Pressure limit is approximately three times more then tensile stress for most conventional materials.

The properties of the some current materials are presented in Table 1.

Current industry widely produces artificial fibers having tensile stress σ = 500 - 620 kg/mm^2 and density γ = 1800 kg/m^3. Their tensile ratio is K =10 $^{-7}$ σ/γ = 0.28 - 0.34. There are whisker (in industry) and nanotubes (in scientific laboratory) having tensile K = 1 - 2 (whisker) and K = 5 - 11 (nanotubes). Theory predicts fiber, whisker and nanotubes having K ten times greater [5]-[7]. These materials can be used for light guy-lines.

Table 1. Compressive strength of some materials (Kikoin [4], ps. 38, 41, 52, 54)

Material	Density γ [kg/m^3]	Pressure limit $10^{-7}\sigma$ [N/m^2]	Strength coefficient $K=10^{-7}\sigma/\gamma$	Tensile stress $10^{-7}\sigma$ [N/m^2]
Steel, 40X	7900	400	0.050	120
Alloy WC	19000	600	0.032	110
Duralumin	2900	150	0.052	54
Quartz	2650	1200	0.453	-
Corundum	4000	2100	0.525	-
Diamond	3520	9859	2.8	-

The tower parameters have been computed for pressure K = 0.05 - 0.3. Recommend value for guy- lines is K = 0.1.

2.5. Tower Safety

For safety of people (passenger cabin) parachutes can be used.

2.6. Tower Stability

Stability is provided by expansions (tensile elements). The verticality of the tower (mast) can be checked by laser beam and GPS sensors monitoring beam location (Figure2). If a section deviates from vertical control cables, control devices automatically restore the tower position.

2.7. Tower Construction

The tower building will not have conventional construction problems such as lifting building material to high altitude. The tower (mast) is not heavy. New sections are put under the tower, the new section is lifted, and the entire tower is lifted. It is estimated the building may be constructed in 4 -12 months. A small tower (up to 3 km) can be located in city.

2.8. Tower Cost

The tower does not require high-cost building materials. The tower will be a tens times cheaper than conventional reinforced concrete towers 400 - 600 m tall.

3. THEORY OF OPTIMAL SOLID TOWER

Equations developed and used by author for estimations and computation are provided below.

1. Optimal Cross-Section Area for Solid Tower of Compressive Stress

Optimal cross-section area for space elevator cable (tensile stress) the author received in [9], Eqs. (1) - (5), (see also [10], Ch.1). For compressive stress we must change the sign (" -") at value B. The equation (4) for our case (rotary Earth and variable gravity) is

$$\overline{A}(R)=\frac{A}{A_0}=\exp\left[-\frac{\gamma g_0 B(R)}{\sigma}\right],\quad B(R)=R_0^2\left\{\left(\frac{1}{R_0}-\frac{1}{R}\right)-\frac{\omega^2}{2g_0}\left[\left(\frac{R}{R_0}\right)^2-1\right]\right\}$$

$$\overline{M}=\frac{M}{G}=\frac{g_0}{k\overline{A}(R)}\int_{R_0}^{R}\overline{A}(r)dr,\quad k=\frac{\sigma}{\gamma},\quad K=10^{-7}k, \qquad (1)$$

where A is cross-section area of solid tower, m^2; A_0 is initial (at ground) cross-section area, m^2; $\overline{A}$ is relative cross-section area of tower (mast); R is radius (distance from Earth center), m; R_0 is Earth radius, m, R_0 = 6.378 km; g_0 = 9.81 m/s2 is Earth gravity at Earth surface; ω =

72.685×10^{-6} rad/s is Earth angle speed, G is vertical force at tower top, kg; M is tower weight, kg; $\overline{M}$ is relative tower weight (weight for every unit load mass).

If the gravity is constant and Earth does not rotate, the equation (1) is simpler

$$\overline{A} = \exp\left[-\frac{\gamma g_0 H}{\sigma}\right] = \exp\left[-\frac{g_0 H}{k}\right], \quad \text{where} \quad k = \frac{\sigma}{\gamma}, \quad \overline{M} = \frac{M}{G} = \left(e^{\frac{gh}{k}} - 1\right) \qquad (2)$$

The computations for tower height H = 100 km and for tower H = 37,000 km (geosynchronous orbit) are presented in Figure 3 - 7.

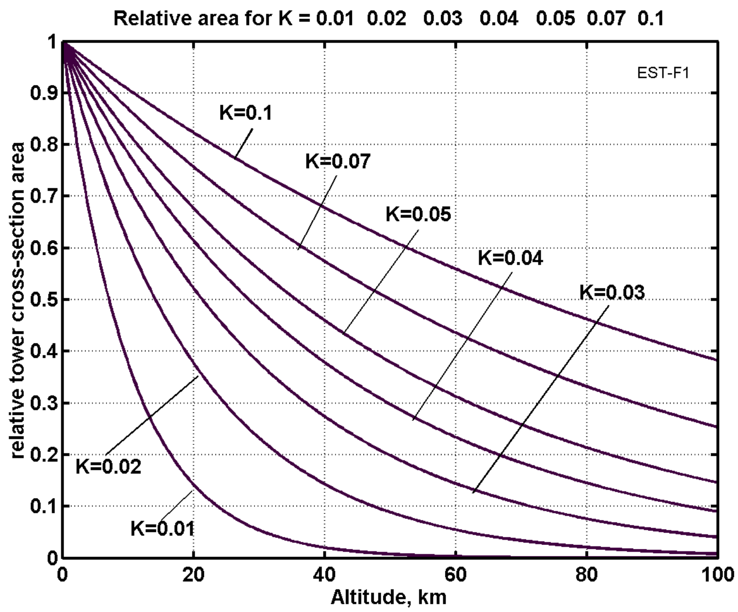

Figure 3. Relative tower cross-section aria versus tower altitude (up 100 km) and pressure strong coefficient.

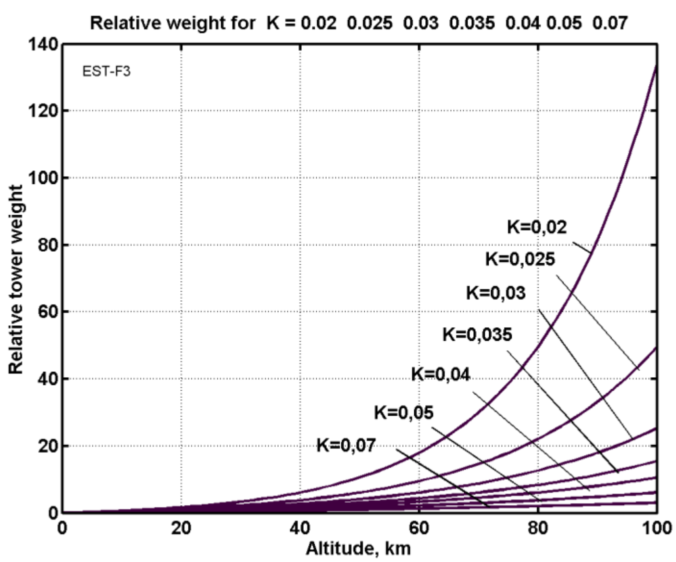

Figure 4. Relative tower mass for height H = 100 km versus pressure stress coefficient K.

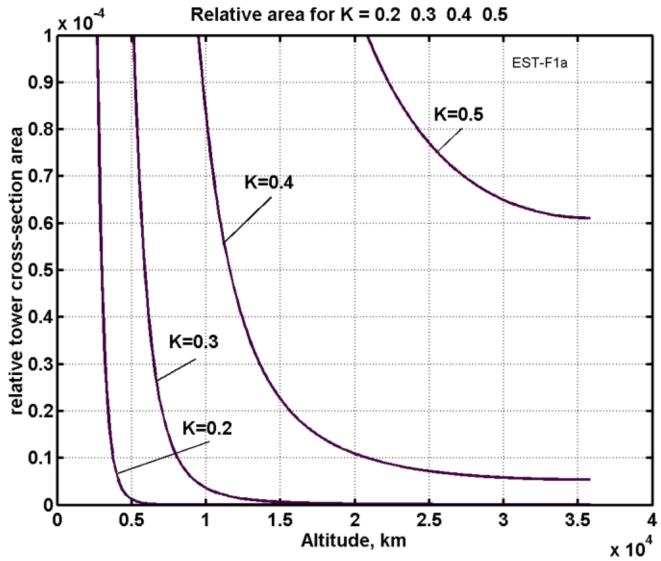

Figure 5. Relative cross-section ratio S/S_0 for the tower height H = 37,000 km (geosynchronous orbit) versus the pressure stress coefficient K.

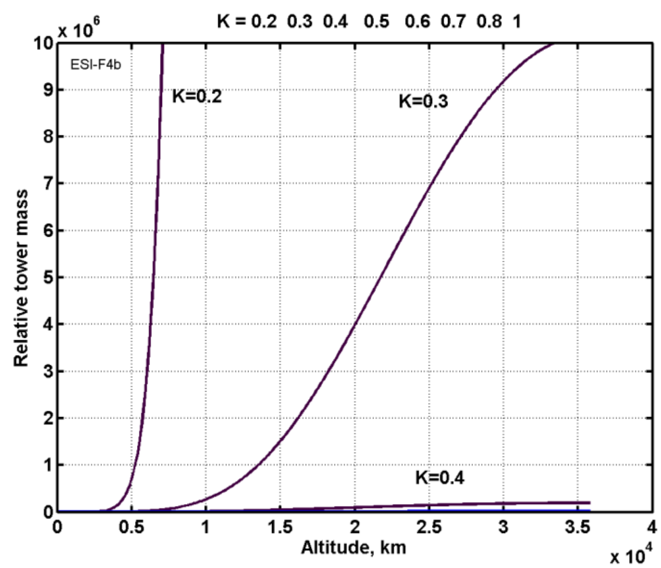

Figure 6. Relative tower mass for tower height H = 37,000 km (geosynchronous orbit) versus pressure stress coefficient K = 0.2 - 0.4.

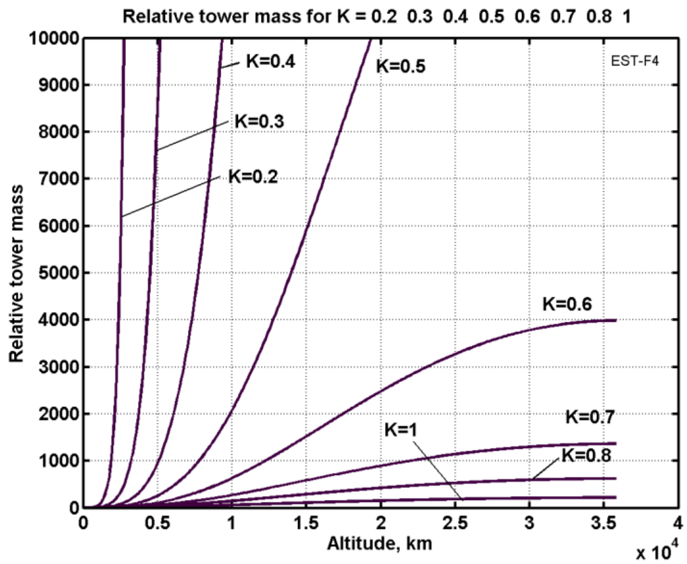

Figure 7. Relative tower mass for tower height *H* = 37,000 km (geosynchronous orbit) versus pressure stress coefficient *K* = 0.2 - 1.

The figures 3 - 4 show the optimal steel tower (mast) having the height 100 km, safety pressure stress *K* = 0.02 (158 kg/mm^2) must have the bottom cross-section area approximately in 100 times more then top cross-section area and weight is 135 times more then top load (Figure 4). For example, if full top load equals 100 tons (30 tons support extension cable + 70 tons useful load), the total weight of main columns 100 km tower-mast (without extension cable) will be 13,500 tons . It is less that a weight of current sky-scrapers (compare with 3,000,000 tons of Toronto tower having the 553 m height). In reality if the safety stress coefficient *K* = 0.015, the relative cross-section area and weight will sometimes be more but it is a possibility of current building technology.

The figures 5 - 7 show the building of the geosynchronous tower-mast (include the optimal tower-mast) is very difficult. For *K* = 0.3 (it is over the top limit margin of safety for quartz, corundum) the tower mass is ten millions of times more than load (Figure 6), the extensions must be made from nanotubes and they weakly help. The problems of stability and flexibility then appear. The situation is strongly improved if tower-mast built from diamonds (relative tower mass decreases up 100, Figure 7). But it is not known when we will receive the cheap artificial diamond in unlimited amount and can create from it building units.

2. Using the Compressive Rods [9]

The rod compressed by gas can keep more compressive force because internal gas makes a tensile stress in a rod material. That longitudinal stress cannot be more then a half safety tensile stress of road material because the compressed gas creates also a tensile radial rod force (stress) which is two times more than longitudinal tensile stress. As the result the rod material has a complex stress (compression in a longitudinal direction and a tensile in the radial direction). Assume these stress is independent. The gas has a weight which must be added to total steel weight. The author used the following equations for computation of the gas compressive rods

Figure 8. Current high tower.

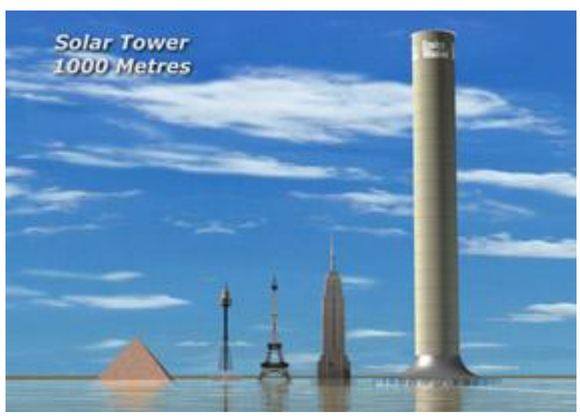

Figure 9. Current and project high towers.

$$\sigma_g = \sigma_c + \frac{1}{2}\sigma_t, \quad \gamma_g = \gamma_0 + \frac{rp}{2\delta} = \gamma_0 + \frac{\mu\sigma_t}{2RT}, \quad K_g = \frac{\sigma_g}{\gamma_g}, \quad p = \frac{\rho RT}{\mu} \tag{3}$$

where σ_g is safety stress of gas compressed rod, N/m^2; σ_c is safety load compressed stress, N/m^2; σ_t is safety tensile gas stress, N/m^2; γ_g is specific density of gas compressed rod, kg/m^3;

γ_o is specific density conventional rod, kg/m^3; μ is the gas molar weight (for hydrogen H_2 it equals μ = 0.002 kg/mole), R = 8.314 is constant, T is temperature), ^{o}K; p is gas pressure, N/m^2; ρ is gas density, kg/m^3; δ is wall thickness of rod, m; r is rod radius, m.

For steel and duralumin from Table 1, the internal gas increases K in 35 - 45%.

Unfortunately, the gas support depends on temperature (see Eq. (3)). That means the mast can loss this support at night. Moreover, the construction will contain the thousands of rods and some of them may be not enough leakproof or lose the gas during of a design lifetime. I think it is a danger to use the gas pressure rods in space tower.

CONCLUSION

The inexpensive steel tower-mast of the height up 100 - 200 km (and more) can be built without big problems at the present time. They can be useful for communication (TV, radio, telephone), for radiolocation (defense), for space launch, for tourism (include space tourism), for scientists (astronomy), for solar energy, and for many other applications. The offered optimal design allows finding of the minimum of a tower-mast weight which can be reached in this space building.

The other designs of space towers are in [8]-[15].

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Chapter 10

ELECTROSTATIC LINEAR ENGINE AND CABLE SPACE AB LAUNCHER*

ABSTRACT

This is suggested a revolutionary new electrostatic engine. This engine can be used as a linear engine (accelerator), a strong space launcher, a high speed delivery system for space elevator, Earth-Moon, Earth-Mars, electrostatic train, levitation, conventional high voltage rotating engine, electrostatic electric generator, weapon, and so on. Author developed theory of this engine application and shows powerful possibility in space, transport and military industry. The projects are computed and show the good potential of the offered new concepts.

Keywords: *electrostatic linear engine, electrostatic accelerator, space launcher, electrostatic train, electrostatic weapon.*

INTRODUCTION

General. The aviation, space, and energy industries need revolutionary ideas which will significantly improve the capability of future ground, air and space vehicles. The author has offered a series of new ideas [1-59] contained in a) numerous patent applications [3 -18], b) manuscripts that have been presented at the World Space Congress (WSC)-1992, 1994 [19 -22], the WSC-2002]23 -32], and numerous Propulsion Conferences [33 -39], and c) other articles [40 -65].

In this Chapter a revolutionary method and implementations for future space flights and ground systems are proposed. The method uses a highly charged surface. The proposed space launch system creates tens of tons of thrust and accelerates space apparatus to high speeds.

History. In early works and patent applications (1965 - 1991), in World Space Congress-2002 and other scientific forums the author suggested a series new cable launchers, space

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transport systems, space elevator, anti-gravitator, kinetic space tower, and other systems, which decrease the cost of space launch in thousands times or increase the possibilities ground systems. All of them need in linear engine. In particular, there are: Cable Space Launcher [23-25], Earth-Moon Transport system [29,39], Earth-Mars Transport System [30], Circle Space Launcher [31], Air Cable aircraft [32, 41, 42], Non-Rocket Transport System for Space Elevator (Elevator climber)[36], Centrifugal Keeper [38], Asteroid Propulsion System [27, 40], Kinetic Space Towers [43], Long Transfer of Mechanical Energy [45], High Speed Catapult Aviation [55], Kinetic Anti-gravitator [55], Electrostatic Levitation [59], and so on (Figure 1).

The author offers electrostatic engines which can be used for every noted installation as driver. That solved the second main problem of noted installation - how drive a vehicle along a monorail by the electrostatic engine or the cable at high speed (some km/sec) to create a powerful thrust.

DESCRIPTION OF ELECTROSTATIC LINEAR ENGINE

The linear electrostatic engine (space accelerator) for launching of space ship [23-25] includes the following main parts (Figure 2): stator, thrust cable, charger of cable, high voltage electric alternating current line. As additional devices the engine can have a gas compaction, and vacuum pump.

The cable has a strong core (it keeps tensile stress - thrust) and dielectric cover contained electric charges. The conducting layer is very thin and we neglect its weight. A detailed linear engine (accelerator) for Cable Space Launcher is presented in Figure 3.

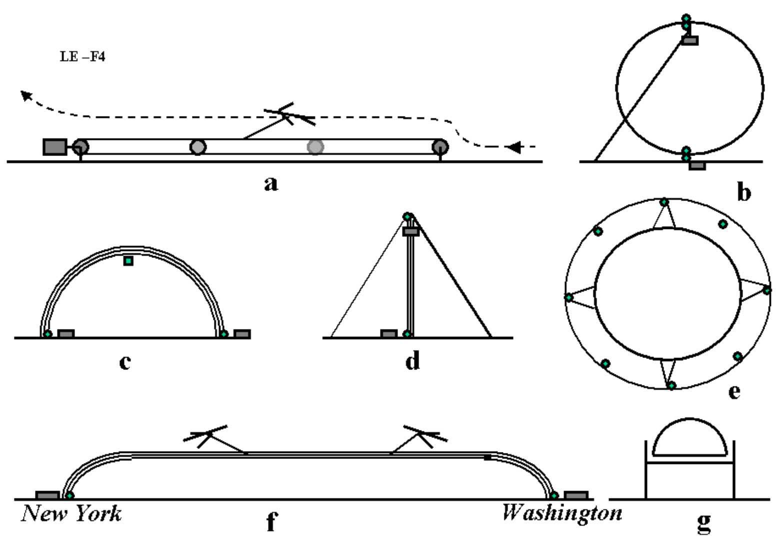

Figure 1. Installations needing the linear electrostatic engine. (a) Space cable launcher [23, 24, 35]; (b) Circle launcher [31]; (c) Space keeper [38]; (d) Kinetic space tower [43]; (e) Earth round cable space keeper [36]; (f) Cable aviation [32,41,42]; (g) Levitation train [59].

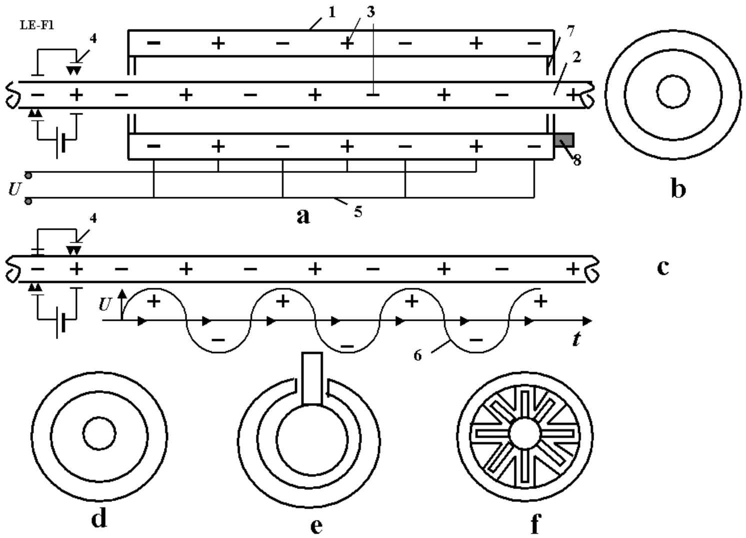

Figure 2. Electrostatic engine (accelerator) for Space Cable Launcher [23 -25]. (a) Engine (side view); (b) Engine (Forward view); (c) Running wave of voltage (charges) moves the charged cable; (d) - (f) Different cross-section areas of engine: (d) - conventional; (e) - for moving aircraft or space ship; (f) - for big thrust. *Notations*: 1 - stator of engine; 2 - thrust cable (rotor of engine); 3 - charges; 4 - recharger; 5 - high voltage line; 6 - alternating current (voltage); 7 - gas compaction; 8 - vacuum pump.

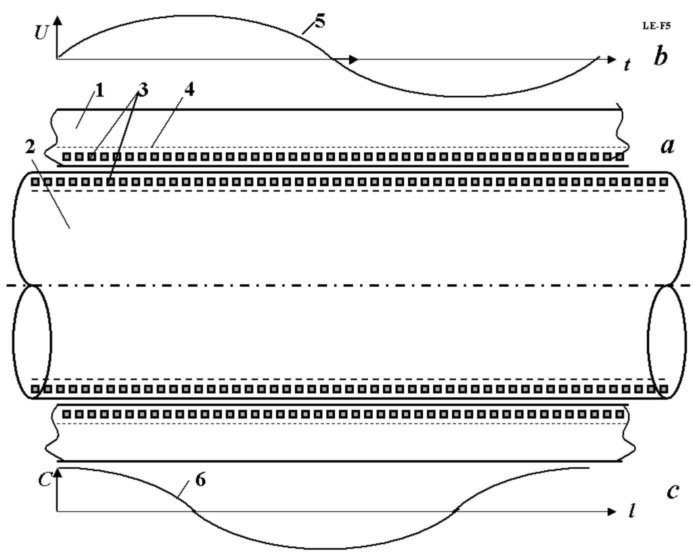

Figure 3. Detail electrostatic engine (accelerator) for Space Cable Launcher. (a) Accelerator, (b) Running voltage wave for stator, (c) Stationary charges into cable. *Notation*: 1 - stator; 2 - mobile rotor (cable); 3 - charges; 4 - dielectric (isolator); 5 - running wave of voltage; 6 - curve of stationary cable charges. *U* is voltage, *C* is charge. Lagging between voltage wave of stator (b) and charges of mobile cable (c) is 90 degree.

The engine works in the following mode. The cable has a set of stationary positive and negative charges. These charges can be restored if they are relaxed. Outer generator creates a running wave of voltage (charges) along stationary stator. This wave (charges) attracts the opposed charges in rotor (cable) and moves (thrusts) it.

Bottom and top parts of cable (or stator) have small different charge values. This difference creates a vertical electric field which supports the cable in suspended position inside stator non-contact bearing and zero friction. The cable position inside stator is controlled by electronic devices.

Charges have toroidal form (row of rings) and located inside a good dielectric having high disruptive voltage. The stator toroids have conducting layer which allows changing the charges with high frequency and produces a running high voltage wave. The offered engine creates a large thrust (see computation below), reaches a very high (not limited) variable speed of cable (km/s), to change the moving of cable in opposed direction, to fix a cable in given position. The engine can also to work as high voltage electric generator when cable is braking or moved by mechanical force. The space elevator climber (and many other mobile apparatus) has constant charge, the cable (stator) has running charge. The weight of electric wires is small because the voltage is very high.

THEORY OF OFFERED ELECTROSTATIC ENGINE (ACCELERATOR)

1. Estimation of Thrust

Let us consider a single charged toroidal ring,1, in cable (Figure 3). The charge 1 attracts to the opposed charges and repels from the same charges located into stator. Let us compute the sum force acting to this single charge.

$$E_i = k\frac{2\tau}{\varepsilon r_i}, \quad F = \sum_i QE_i, \quad Q = \tau l \qquad (1)$$

where E is electric intensity [V/m], k = 9×10^9 is electric coefficient [N·m^2/C^2], τ is linear charge [C/m], ε is dielectric constant, r_i is distance between centers of charges [m], F is force [N], Q is charge [C], l is length of linear charge [m].

If we take distance between charged rows of stator and cable d = 3a (Figure3), where a is smaller radius of charged toroid, the r_i are:

$$r_i = a\sqrt{3^2 + (4i-2)^2}, \quad or \quad r_1 = a\sqrt{13}, \quad r_2 = a\sqrt{45}, \quad r_3 = a\sqrt{109}, \quad r_4 = a\sqrt{205}, \ldots \qquad (2)$$

Substitute (2) in (1) we receive

$$F = \frac{4k\tau^2}{\varepsilon}\sum_i (-1)^{i+1}\frac{\cos\alpha_i}{r_i} \quad where \quad \cos\alpha_i = \frac{d}{r_i}, \quad \tau = \frac{\varepsilon a E_s}{2k} \qquad (3)$$

where E_s is safety dielectric strength [V/m], α is angle between r and horizontal line (Figure4).

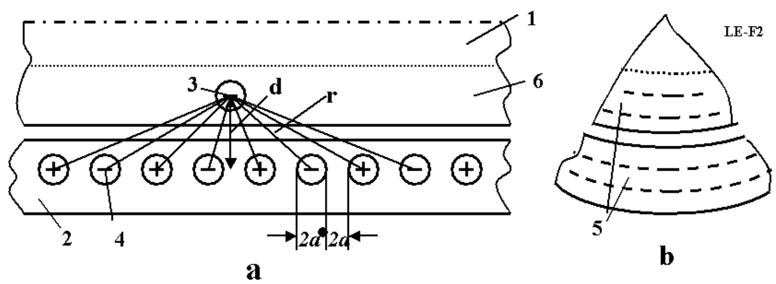

Figure 4. Computation of thrust force of linear electrostatic engine for space ship accelerator. (a) Side view stator and cable; (b) cross-section area. *Notations:* 1 - cable; 2 - stator; 3 - single charge in cable; 4 - electric charges in stator; 5 - toroidal form of electric charges into stator and cable; 6 - dielectric; a - radius of charge (smaller radius of toroid); d - distance between layers of charges of stator and cable; r - distance to charges.

Let us consider the row in (3)

$$\sum_i (-1)^{i+1}\frac{\cos\alpha_i}{r_i} = \sum_i (-1)^{i+1}\frac{d}{r_i^2} = \frac{d}{a^2}\left(\frac{1}{13}-\frac{1}{45}+\frac{1}{109}-\frac{1}{205}+...\right) \approx 0.05\frac{d}{a^2} = b\frac{d}{a^2}, \quad \text{where} \quad b = 0.05 \qquad (4)$$

This infinity row has sum and this sum equals b.

We computed force for one cable toroid. The cable has N toroid, $N = L/4a$, where L is length of stator. After substitute (3), (4) in the first equation (3) the total force, F_N, is

$$F_N = FN = b\frac{3\varepsilon E_s^2 L l}{4k}, \quad \text{where} \quad b \approx 0.04 - 0.05 \quad \text{for our case.} \qquad (5)$$

Estimate this force for area $L\times l$ = 1 m^2, dielectric strength $E_s = 3\times10^6 - 3\times10^8$ V/m, $\varepsilon = d$ = 1 - 3. Result is presented in figures 5 - 6.

In common case for plates the Equation (5) is

$$F = b\frac{\varepsilon E^2 S}{8\pi k}, \quad k = \frac{1}{4\pi\varepsilon_0}, \quad F = b\frac{\varepsilon\varepsilon_0 E^2 S}{2}, \qquad (5a)$$

where F is force, N; S is charged area, m^2 ; b is coefficient of charged form and sign. For opposed charges and plates that equals about 0.82 (F is compressing of a charged material), for same F produces a tensile stress in the charged material, $\varepsilon_0 = 8.85\times10^{-12}$ F/m.

As reader can see the force is very high and can reach up to 10^6 N/m^2 =100 ton/m^2. That means we can move big space ships and space probes. To get this thrust by conventional electromagnetic launcher (as offered by other) gigantic and very expensive superconductive magnets are needed. We made computation for $d = 3a$ and distance between center of charges equals 4*a*. If we will take other values the coefficient *b* will be changed approximately in 50%.

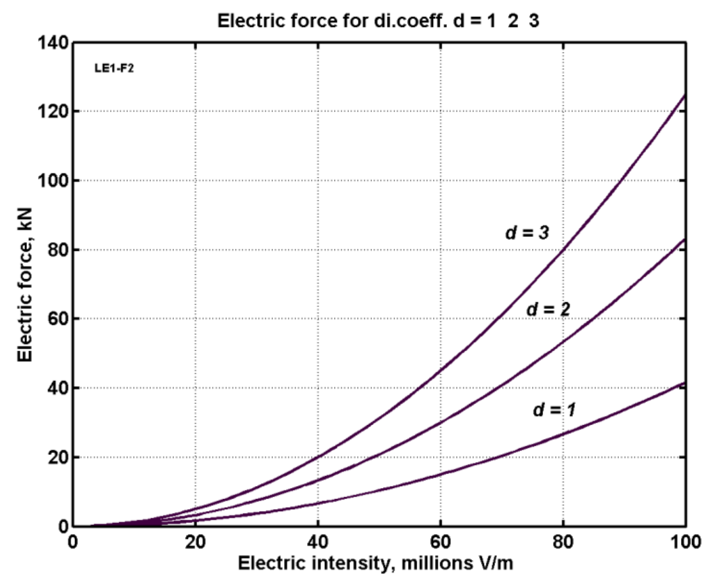

Figure 5. Electrostatic force for 1 m^2 via dielectric strength and dielectric coefficient. *d* is dielectric coefficient.

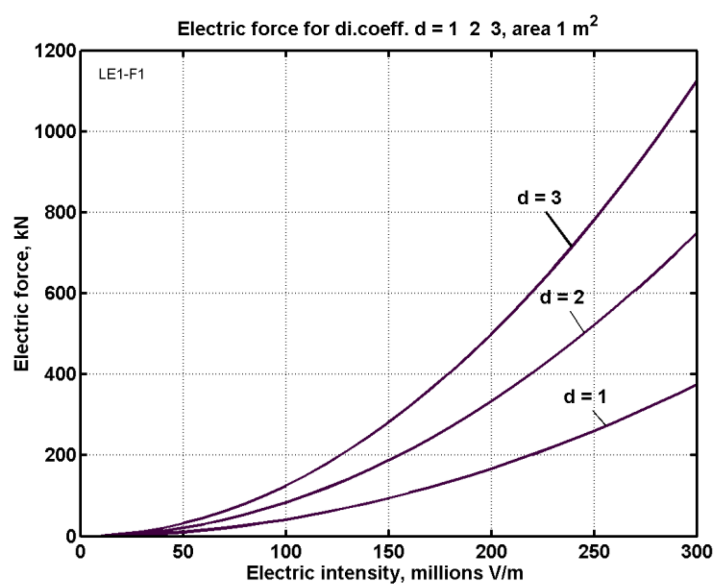

Figure 6. Electrostatic force for 1 m^2 via safety dielectric strength and dielectric coefficient *d*.

In our computation we used electric intensity over the electric strength of air $E_s = 3\times10^6$ V/m. That means the air located inside of engine between stator and cable can be ionized.

That is not important because amount of air is small, we can delete (pump) the air from engine or fill up volume between stator and cable units a good dielectric liquid. We can also cover the electrodes units a thin dielectric layer having a high voltage dielectric strength.

The data for computations are in Table 1.

Table 1. Properties of various good insulators (recalculated in metric system)

Insulator	Resistivity Ohm-m $\sigma \times 10^7$N/m^2	Dielectric strength MV/m. E_i	Dielectric constant, ε	Tensile strength kg/mm^2
Lexan	10^{17}–10^{19}	320–640	3	5.5
Kapton H	10^{19}–10^{20}	120–320	3	15.2
Kel-F	10^{17}–10^{19}	80–240	2–3	3.45
Mylar	10^{15}–10^{16}	160–640	3	13.8
Parylene	10^{17}–10^{20}	240–400	2–3	6.9
Polyethylen e	10^{18}–5×10^{18}	40–680*	2	2.8–4.1
Poly (tetra fluoraethylene)	10^{15}–5×10^{19}	40–280**	2	2.8–3.5
Air (1 atm, 1 mm gap)		4	1	0
Vacuum (1.3×10^{-3} Pa1 mm gap)		80–120	1	0

*For room temperature 500–700 MV/m.

** 400–500 MV/m.

Sources: Encyclopedia of Science and Technology (New York, 2002, Vol. 6, p. 104, p. 229, p. 231) and Kikoin[66], p. 321.

Note: Dielectric constant ε can reach 4.5 - 7.5 for mica (E is up 200 MV/m), 6 -10 for glasses (E = 40 MV/m), and 900 -3000 for special ceramics (marks are CM-1, T-900)66 , p. 321, (E =13 -28 MV/m). Ferroelectrics have ε up to 104 - 105. Dielectric strength appreciably depends from surface roughness, thickness, purity, temperature and other conditions of materials. Very clean material without admixture (for example, quartz) can have electric strength up 1000 MV/m. For thin silicon oxide films the calculated results for fields up to 9.5 MV/cm were found to agree well with measurements for temperatures from -145°C to 65°C and for thicknesses from 3000 Å to 50 000 Å (1966). It is necessary to find good isolative materials and to research conditions which increase the dielectric strength (Figures 7, 8).

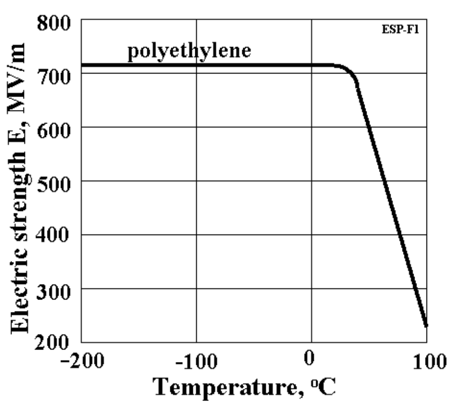

Figure 7. Variation of electric strength with temperature for polyethylene.

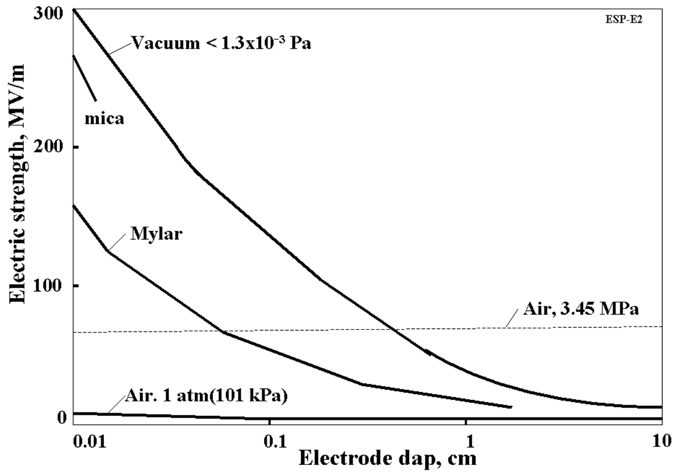

Figure 8. Uniform field dialectric strength for solid, gas and vacuum insulation.

2. The Half-Life of the Charge

Let us estimate of lifetime of charged cable.

(a) *Charge in spherical ball*. Let us take a very complex condition; where the unlike charges are separated only by an insulator (charged spherical condenser):

$$Ri - U = 0, \quad U = \delta E, \quad E = \frac{kq}{\delta^2}, \quad R = \rho\frac{\delta}{4\pi a^2}, \quad U = \frac{q}{C}, \quad R\frac{dq}{dt} + \frac{a}{C} = 0, \quad \frac{dq}{q} = \frac{dt}{RC}, \quad C = \frac{\varepsilon a}{k},$$

$$q = q_0 \exp\left(-\frac{4\pi\varepsilon a k}{\rho\delta}t\right), \quad \frac{q}{q_0} = \frac{1}{2}, \quad -\frac{4\pi\varepsilon a k}{\rho\delta}t_h = \ln\frac{1}{2} = -0.693 \approx -0.7, \quad t_h = 0.693\frac{\rho\delta}{4\pi\varepsilon k a} \tag{6 -7}$$

where: t_h – half-life time, [sec]; R – insulator resistance, [Ohm]; i – current, [A]; U – voltage, [V]; δ – thickness of insulator, [m]; E – electrical intensity, [V/m]; q – charge, [C]; t - time, [seconds]; ρ – specific resistance of insulator, [Ohm-meter, Ωm]; a – internal radius of the ball, [m]; C – capacity of the ball, [C]; $k = 9\times10^9$.

Example: Let us take typical data: $\rho = 10^{19}$ Ω-m, $k = 9\times10^9$, $\delta/a = 0.2$, then $t_h = 1.24\times10^7$ seconds = 144 days.

(b) *Half-life of cylindrical tube***.** The computation is same as for tubes (1 m charged cylindrical condenser):

$$q = q_0 \exp\left(-\frac{1}{RC}t\right), \quad C = \frac{\varepsilon}{k\ln(1+\delta/a)}, \quad R = \frac{\rho\delta}{2\pi a}, \quad -0.693 = -\frac{1}{RC}t_h,$$

$$t_h = \frac{0.693\rho\delta\varepsilon}{2\pi k a \ln(1+\delta/a)}, \quad for \quad \frac{\delta}{a} \to 0, \quad t_h \approx 0.7\frac{\rho\varepsilon}{2\pi k}. \tag{8}$$

3. Condenser as Accumulator of Launch Energy

Space launcher needs in much energy. Most researchers of the electromagnetic launcher offer condensers for storage of energy. Let us estimate the maximum energy which can be accumulated by a 1 kg of a plate electric condenser.

$$W_M = \frac{1}{2}Q_M U = \frac{\varepsilon E_s^2}{8\pi k\gamma}, \quad where \quad Q_M = \frac{Q}{M} = \frac{\varepsilon E_s}{4\pi k\gamma d}, \quad C_M = \frac{Q_M}{U} = \frac{\varepsilon}{4\pi k\gamma d^2} \qquad (9)$$

where W_M is energy [J/kg], Q_M is electric charge [C/kg], U is voltage [V], C_M is value of capacitor [C/kg], γ is specific density of dielectric [kg/m^3], d is distance between plate (layers) in plate condenser [m].

For $\varepsilon = 3$, $E_s = 3\times10^8$ V/m, $k = 9\times10^9$ we have $W_M = 660$ J/kg. That is very small value. The energy of a gunpowder is about 3 MJ/kg, the energy of a rocket fuel is 9 MJ/kg ($C+O_2= CO_2$). In previous works (see, for example, [25],[40]) the author offered to use as energy accumulator the fly-wheel. The fly-wheel energy storages is

$$W_M = \frac{1}{2}\frac{\sigma}{\gamma} \qquad (10)$$

where σ is safety tensile stress [N/m^2] of fly-wheel material. For $\sigma = 300$ kg/mm^2, $\gamma = 1800$ kg/m^3 (it is current composite matter from artificial fibers) we have $W_M = 0.83\times10^5$ J/kg. When we will have composite matter from nanotubes that value increased many times.

The fly-wheel connected with the electrostatic variable frequency rotary motor is shown in Figure 9.

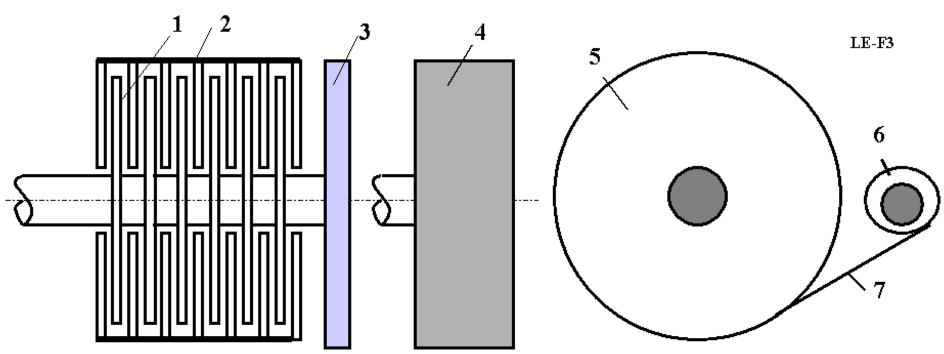

Figure 9. Variable frequency electrostatic high voltage motor-generator connected with fly wheel for cable space accelerator. *Notation*: 1 - rotor with electric charges; 2 - stator of motor with electric charges; 3 - variable type transmission;; 4 - fly-wheel; 5, 6 - type spools, 7 - type.

This motor has the linear charges located on rotor and stator surface producing high voltage and variable frequency current (voltage) which is used for producing a running wave in the cable thruster-accelerator of Figure 2. For compensation of decreasing of fly-wheel revolutions and changing of current frequency it is use the variable type transmission (left part of Figure 9). The type 7 is spooled from spool 6 to spool 5. The diameters of spools 5 - 6 change and speed (revolutions) of rotor also smoothly change.

4. Required Current Frequency

The required current frequency, ν, can be computed equation

$$\nu = \frac{V}{s} \tag{11}$$

where V is wave speed (speed ship, projectile, or shell) [m/s]; s is distance between maximum and minimum of wave (voltage or opposed charges) [m].

APPLICATIONS

1. *Electrostatic Space Launcher*. Assume we have project 1 in [23] - [25],[40],[60] (Figure1a). That is people-carrying space vehicle having mass m = 15 tons and acceleration n = 3g. For reaching speed V = 8 km/s and 3g acceleration the vehicle needs in thrust of T = 45 tons and distance 1100 km. In [40] it is shown: for conventional cable having safety tensile stress σ = 180 kg/mm^2, γ = 1800 kg/m^3 we must have 109 drive stations and cable diameter 19 mm. For 45 ton thrust and electric intensity 3×10^8 V/m the stator (Figure 2e) must have length 6.7 m. If it uses the cable design (Figure 2f) the stator will be shorter sometimes. For distance between opposed charges s = 0.1 m the maximum current frequency is 8000/0.1 = 8×10^4 1/s.

It is using the suggested electrostatic linear engine, we can build a cheap high productive manned (or unmanned) space catapults at present time. This catapult decreases a launch cost up 2 - 4 $/kg and allows to launch thousands tons in year.

That will be simpler then author's catapult offered in [23]-[25],[40],[60]. Nanotubes moving cable and the 109 drive stations are not needed. There is only electrostatic motionless cable-stator (which produces a running electrostatic wave) and linear charged rotor connected to a spaceship. The cable-stator is suspended on columns (or in air as in [41] - [42]).

Let us to estimate the parameters of new cable launcher for spaceship above. The request power is $P = TV = 45\times10^4\times8\times10^3 = 3.6\times10^9$ W. For voltage $U = 10^8$ V the electric currency equals $I = P/U$ = 36 A. The 1 mm insulated wire allows a safety permanent electric current more 11 A/mm^2 . The 6 wires inserted in cable are enough for delivering the short maximum power P to charged sells. We took the maximum speed 8 km/s, the average speed is 4 km/s and the electric wire will be in two time smaller.

Let us assume the main cable is made from conventional artificial fibers having maximum tensile stress σ_m = 600 kg/mm^2 , Let us take a safety tensile stress σ = 100 kg/mm^2. Then the request cross-section cable area is $S = T/\sigma$ = 45000/100 = 450 mm^2, power cable diameter is d = 24 mm.

2. Electrostatic Space Propulsion. Assume we want to launch 2 kg interplanetary probe by 100 m electrostatic accelerator (launcher). We use probe having some sq. meter surface design (Figure 2f) and thrust 120 tons/m^2 (Figure6). Then the acceleration will be F/M=1,2×10^6/2 = 0.6×10^6 m/s^2, final speed V = (2×10^2× o.6×10^6)$^{0.5}$ =11 km/s, final frequency (for s =10 $^{-2}$ m) ν = 1.1×10^5 1/s.

3. Transport systems for Space Elevator, Earth-Moon, Earth-Mars. In [25],[29],[30],[36],[39], [60] the author offered and researched the mechanical cable transport systems for Space Elevator and for Earth-Moon, Earth-Mars trips. All these systems need in high speed engine for moving of space vehicle. One (cable) version of the suggested transport system is noted in above cited works. However, the system offered in given article may be used in many structures. The cable is stator, the vehicle has linear rotor. The cable delivers the energy in form of running wave, the vehicle (climber) follows this running wave. The speed of running wave (vehicle) can be very high. The voltage is extremely big and a weight of the electric wires is small.

Let us to make the simplest estimation. Assume, the climber weights W = 1 ton = 10,000 N and has speed V = 1 km/s = 1000 m/s. The power is P = WV = 10^4×10^3 = 10^7 W. For voltage U = 10^8 V, the electric currency is i = 10^7/10^8 =0.1 A. For safety currency 20 A/mm^2, the need wire diameter is about 0.1 mm^2.

4. Suspended satellite system. In [25],[36] the author suggested the cable ring rotated around the Earth with motionless satellites suspended to the ring (Figure1e). The offered linear engine can be used as engine for compensation the air friction of cable and as non-contact bearing for suspend system.

5. Electrostatic levitation train and linear engine. In [59] the author suggested the electrostatic levitation train (Figure1g). The offered linear engine can be used as propulsion engine for this train. In braking the energy of acceleration will be returned in electric line.

6. Electrostatic rotary engine. At present time industry uses conventional low voltage electric engine. When we have a high voltage electric line it may be easier to use high voltage electrostatic rotary engine.

7. Electrostatic levitation bearing. Some technical installations need low friction bearings. The mono-electrets can be used as non-contact bearing having zero mechanical friction.

8. Electrostatic Gun System. The armor cannonry needs in high speed shells. However, the shell speed is limited by gas speed into cannon. The suggested linear electrostatic engine can be used as the high efficiency shells in armor-piercing cannonry having very high initial shell speed because the initial shell speed of linear engine does not have the speed limit (see application 1 above). That means the electrostatic gun can shoot in thousands kilometers.

CONCLUSION

The offered electrostatic engine could find wide application in many fields of technology. That can decrease the launch cost from hundreds to thousands times. The electrostatic engine needs a very high voltage but this voltage is located in small area inside of installations and not dangerous to people. The current technology does not have another way for reaching a high speed except may be rockets. But rockets and rocket launches are very expensive and we do not know ways to decrease the cost of rocket launch thousand times.

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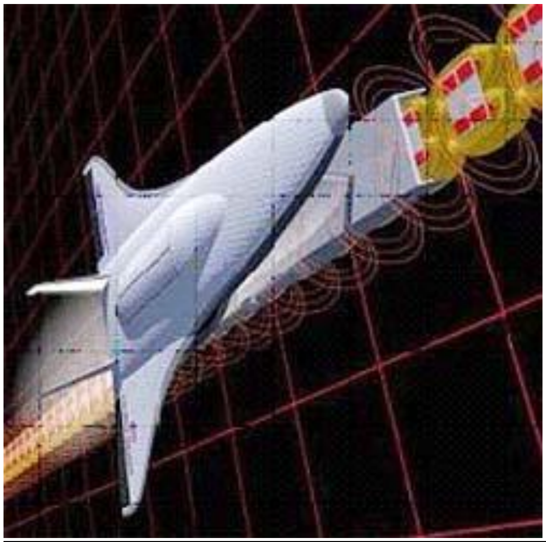
Pictures for Part A, Ch. 10. Possible electrostatic launchers



Chapter 11

Optimal Electrostatic Space Tower (Mast, New Space Elevator)*

Abstract

Author offers and researched the new and revolutionary inflatable electrostatic AB space towers (mast, new space elevator) up to one hundred twenty thousands kilometers (or more) in height.

The main innovation is filling the tower by electron gas, which can create pressure up one atmosphere, has negligible small weight and surprising properties.

The suggested mast has following advantages in comparison with conventional space elevator:

1. Electrostatic AB tower may be built from Earth's surface without the employment of any rockets. That decreases the cost of electrostatic mast by thousands of times. 2. One can have any height and has a big control load capacity. 3. Electrostatic tower can have the height of a geosynchronous orbit (36,000 km) WITHOUT the additional top cable as the space elevator (up 120,000 ÷ 160,000 km) and counterweight (equalizer) of hundreds of tons. 4. The offered mast has less total mass than conventional space elevator. 5. The offered mast can be built from less strong material than space elevator cable. 6. The offered tower can have the high-speed electrostatic climbers moved by high-voltage electricity from Earth's surface. 7. The offered tower is safer resisting meteorite strikes than an ordinary cable space elevator. 8. The electrostatic mast can bend in any needed direction when we give the necessary electric voltage in the required parts of the extended mast. 9. Control mast has stability for any altitude. Three projects 100 km, 36,000km (GEO), 120,000 km are computed and presented.

These towers can be used for tourism, scientific observation of space, observation of the Earth's surface, weather and upper atmosphere experiments, and for radio, television, and communication transmissions. These towers can also be used to launch interplanetary spaceships and Earth-orbiting satellites.

Key words: Space tower, electrostatic space mast, space tourism, space communication, space launch, space observation

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Introduction

Brief History. The idea of building a tower high above the Earth into the heavens is very old [1]. The writings of Moses, in chapter 11 of his book *Genesis* refers to an early civilization that tried to build a tower to heaven out of brick and tar. This construction was called the Tower of Babel, and was reported to be located in Babylon in ancient Mesopotamia. Later in chapter 28, Jacob had a dream about a staircase or ladder built to heaven. This construction was called Jacob's Ladder. More contemporary writings on the subject date back to K.E. Tsiolkovski in his manuscript "Speculation about Earth and Sky and on Vesta," published in 1895 [2]. This idea inspired Sir Arthur Clarke to write his novel, *The Fountains of Paradise* [3], about a space tower (elevator) located on a fictionalized Sri Lanka, which brought the concept to the attention of the entire 20th Century world.

Today, the world's tallest construction is a television transmitting tower (mast) near Fargo, North Dakota, USA. It stands 629 m high and was built in 1963 for KTHI-TV. The CNN Tower in Toronto, Ontario, Canada is the world's tallest building. It is 553 m in height, was completed in1975, and has the world's highest observation deck at 447 m. The tower structure is concrete up to the observation deck level. Above is a steel structure supporting radio, television, and communication antennas. The total weight of the tower is 3,000,000 metric tons.

The Ostankin Tower in Moscow is 540 m in height and has an observation desk at 370 m. The world's tallest office building is the Petronas Towers in Kuala Lumpur, Malasia. The twin towers are 452 m in height. They are 10 m taller than the Sears Tower in Chicago, Illinois, USA. The Skyscrapers (Taipei, Taiwan, 2004) has height of 509 m, the Eiffel Tower (Paris, 1887-1889) has 300 m, Empire State Building (USA, New York, 1930-1931) has 381 m + TV mast of 61 m. Under construction a building of 1001 m (Kuwait City, Kuwait) and 1430 m Supported Structure in Gulf of Mexico.

Current materials make it possible even today to construct towers many kilometers in height. However, conventional towers are very expensive, costing billions of dollars. When considering how high a tower can be built, it is important to remember that it can be built to high height if the base is large enough. Theoretically, you could build a tower to geosynchronous Earth orbit (GEO) out of bubble gum, but the base would likely cover half the surface of the Earth.

The new types of towers. The author offered and researched a series on new towers (masts) [6]-[11]: optimal inflatable towers filled by gas (air, helium, hydrogen), optimal solid towers, new kinetic cable towers.

The offering new revolutionary electrostatic tower is based on old (1982) ideas author of using electrostatic forces [4]-[5]. They are applied to space tower and are shown the gigantic advantages in comparison with conventional space elevator. Some of these advantages named in abstract over. Main of them are follow: electrostatic mast can be built any height without rockets, one needs material in tens times less them space elevator. That means the electrostatic mast will be in hundreds times cheaper then conventional space elevator. One can be built on the Earth’s surface and their height can be increased as necessary. Their base is very small.

The main innovations in this project are the application of electron gas for filling tube at high altitude and a solution of a stability problem for tall (thin) inflatable mast by control structure.

The tower applications. The high towers (3-100 km) have numerous applications for government and commercial purposes:

- Entertainment and Observation platform.
- Entertainment and Observation desk for tourists. Tourists could see over a huge area, including the darkness of space and the curvature of the Earth’s horizon.
- Drop tower: tourists could experience several minutes of free-fall time. The drop tower could provide a facility for experiments.
- A permanent observatory on a tall tower would be competitive with airborne and orbital platforms for Earth and space observations.
- Communication boost: A tower tens of kilometers in height near metropolitan areas could provide much higher signal strength than orbital satellites.
- Solar power receivers: Receivers located on tall towers for future space solar power systems would permit use of higher frequency, wireless, power transmission systems (e.g. lasers).
- Low Earth Orbit (LEO) communication satellite replacement: Approximately six to ten 100-km-tall towers could provide the coverage of a LEO satellite constellation with higher power, permanence, and easy upgrade capabilities.

The towers having a height 36,000 ÷ 120,000 km may be used for free launching the Earth's satellites and interplanetary ships and as space station for arriving space ships.

Other new revolutionary methods of access to space are described in [10]-[14].

Description of Installation and Innovations

1. Electrostatic tower. The offered electrostatic space tower (or mast, or space elevator) is shown in fig.1. That is inflatable cylinder (tube) from strong thin dielectric film having variable radius. The film has inside the sectional thin conductive layer 9. Each section is connected with issue of control electric voltage. In inside the tube there is the electron gas from free electrons. The electron gas is separated by in sections by a thin partition 11. The layer 9 has a positive charge equals a summary negative charge of the inside electrons. The tube (mast) can have the length (height) up Geosynchronous Earth Orbit (GEO, about 36,000 km) or up 120,000 km (and more) as in our project (see computation below). The very high tower allows to launch free (without spend energy in launch stage) the interplanetary space ships. The offered optimal tower is design so that the electron gas in any cross-section area compensates the tube weight and tube does not have compressing longitudinal force from weight. More over the tower has tensile longitudinal (lift) force which allows the tower has a vertical position. When the tower has height more GEO the additional centrifugal force of the rotate Earth provided the vertical position and natural stability of tower.

The bottom part of tower located in troposphere has the bracing wires 4 which help the tower to resist the troposphere wind.

The control sectional conductivity layer allows to create the high voltage running wave which accelerates (and brakes) the cabins (as rotor of linear electrostatic engine [11]) to any high speed. Electrostatic forces also do not allow the cabin to leave the tube.

2. Electron gas and AB tube. The electron gas consists of conventional electrons. In contract to molecular gas the electron gas has many surprising properties. For example, electron gas (having same mass density) can have the different pressure in the given volume. Its pressure depends from electric intensity, but electric intensity is different in different part of given volume (fig.2b). For example, in our tube the electron intensity is zero in center of cylindrical tube and maximum at near tube surface.

The offered AB-tube is main innovation in the suggested tower. One has a positive control charges isolated thin film cover and electron gas inside. The positive cylinder

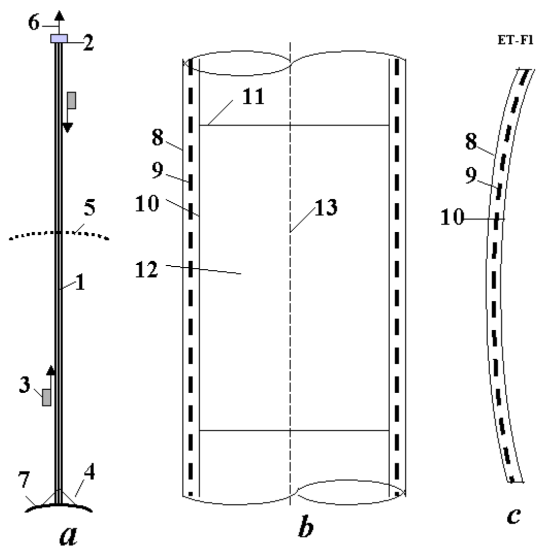

Fig.1. Electrostatic AB tower (mast, Space Elevator). (a) Side view, (b) Cross-section along axis, (c) Cross-section wall perpendicular axis. *Notation*: 1 - electrostatic AB tower (mast, Space Elevator); 2 - Top space station; 3 - passenger, load cabin with electrostatic linear engine; 4 - bracing (in troposphere); 5 - geosynchronous orbit; 6 - tensile force from electron gas; 7 - Earth; 8 - external layer of isolator; 9 - conducting control layer having sections; 10 - internal layer of isolator; 11 - internal dielectric partition; 12 - electron gas, 13 - laser control beam.

create the zero electric field inside the tube and electron conduct oneself as conventional molecules that is equal mass density in any points. When kinetic energy of electron is less then energy of negative ionization of the dielectric cover or the material of the electric cover does not accept the negative ionization, the electrons are reflected from cover. In other case the internal cover layer is saturated by negative ions and begin also to reflect electrons. Impotent also that the offered AB electrostatic tube has neutral summary charge in outer space.

Advantages of electrostatic tower. The offered electrostatic tower has very important advantages in comparison with space elevator:

1. Electrostatic AB tower (mast) may be built from Earth's surface without rockets. That decreases the cost of electrostatic mast in thousands times.

2. One can have any height and has a big control load capacity.
3. In particle, electrostatic tower can have the height of a geosynchronous orbit (37,000 km) WITHOUT the additional continue the space elevator (up 120,000 ÷ 160,000 km) and counterweight (equalizer) of hundreds tons [10], Ch.1.
4. The offered mast has less the total mass in tens of times then conventional space elevator.
5. The offered mast can be built from lesser strong material then space elevator cable (comprise the computation here and in [10] Ch.1).
6. The offered tower can have the high speed electrostatic climbers moved by high voltage electricity from Earth's surface.
7. The offered tower is more safety against meteorite then cable space elevator, because the small meteorite damaged the cable is crash for space elevator, but it is only create small hole in electrostatic tower. The electron escape may be compensated by electron injection.
8. The electrostatic mast can bend in need direction when we give the electric voltage in need parts of the mast.

The electrostatic tower of height 100 ÷ 500 km may be built from current artificial fiber material in present time. The geosynchronous electrostatic tower needs in more strong material having a strong coefficient $K \geq 2$ (whiskers or nanotubes, see below).

3. Other applications of offered AB tube idea.

The offered AB-tube with the positive charged cover and the electron gas inside may find the many applications in other technical fields. For example:

1) *Air dirigible*. (1) The airship from the thin film filled by an electron gas has 30% more lift force then conventional dirigible filled by helium. (2) Electron dirigible is significantly cheaper then same helium dirigible because the helium is very expensive gas. (3) One does not have problem with changing the lift force because no problem to add or to delete the electrons.
2) *Long arm*. The offered electron control tube can be used as long control work arm for taking the model of planet ground, rescue operation, repairing of other space ships and so on [10] Ch.9.
3) *Superconductive or closed to superconductive tubes*. The offered AB-tube must have a very low electric resistance for any temperature because the electrons into tube to not have ions and do not loss energy for impacts with ions. The impact the electron to electron does not change the total impulse (momentum) of couple electrons and electron flow. If this idea is proved in experiment, that will be big breakthrough in many fields of technology.
4) *Superreflectivity*. If free electrons located between two thin transparency plates, that may be superreflectivity mirror for widely specter of radiation. That is necessary in many important technical field as light engine, multy-reflect propulsion [10] Ch.12 and thermonuclear power [15].

The other application of electrostatic ideas is Electrostatic solar wind propulsion [10] Ch.13, Electrostatic utilization of asteroids for space flight [10] Ch.14, Electrostatic levitation on the Earth and artificial gravity for space ships and asteroids [14, 10 Ch.15], Electrostatic solar sail [10] Ch.18, Electrostatic space radiator [10] Ch.19, Electrostatic AB ramjet space propulsion [14], etc.

Theory and Computation

Below reader find the evidence of main equations, estimations, and computations.

1. Optimal radius (cross-section) area of tower. Assume we have tower from thin film filled by electron gas. Take the thin ring of tower cover with dH height (Fig.2a). For getting the optimal radius the weight (force in N) $g\gamma\sigma dL$ of this elementary ring must be support by electron gas pressure pdr. From projection of force on vertical axis we have

$$pdr = g\gamma\delta dL, \quad dL \approx dH, \quad pdr = g\gamma\delta dH, \qquad (1)$$

where p is electron (charge) pressure, N/m^2; dr and dH is elementary radius and tower height respectively (see fig.2), m; g is Earth gravity at altitude H, m/s^2; γ is cover density, kg/m^3; δ is cover thickness, m.

The gravity for rotated Earth and electron (charge) pressure are (see [10] Ch.1)

$$g = g_0\left[\left(\frac{R_0^2}{R}\right)^2 - \frac{\omega^2 R}{g_0}\right], \quad p = \frac{\varepsilon_0 E^2}{2} \ . \qquad (2)$$

where g_0 = 9.81 m/s^2 is Earth's gravity at altitude H = 0; R_0 = 6378 km is radius of Earth, m; $R = R_0 + H$ is distance from given cross-section tower to center of Earth, m; ω = 72.685 $\times 10^{-6}$ rad/s is angle speed of the Earth; E is maximum electric intensity, V/m (fig.2b); ε_0 = 8.85$\times 10^{-12}$ F/m is electrostatic constant.

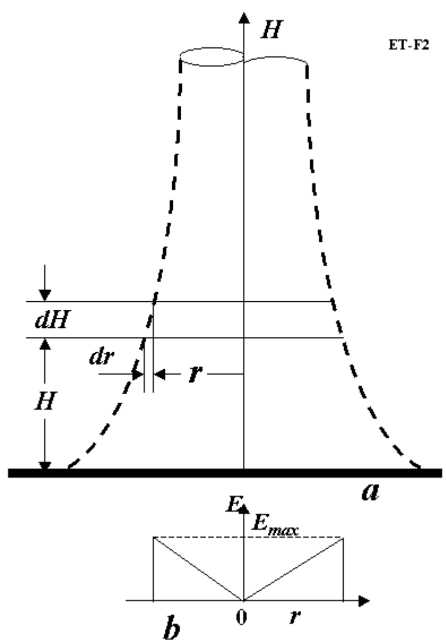

Fig. 2. (a) For explanation of theory optimal cross-section area of the electrostatic AB tower. (b) graph of electric intensity into tower

Look your attention that electron gas is different from conventional molecular gas. That can have a different electric intensity (that means a different pressure!) in different place of volume. The electron pressure equals zero in axis of tube and one is maximum at maximum radius of tube.

In optimal tower the electronic pressure must keep the cover

$$2rpdL = 2\delta\sigma dL \quad \text{or} \quad \delta = \frac{rp}{\sigma} \quad \text{or} \quad \delta = \frac{r\varepsilon_0 E^2}{2\sigma} \quad \text{or} \quad \bar{\delta} = \frac{\delta}{r} = \frac{\varepsilon_0 E^2}{2\sigma}\ , \qquad (3)$$

Substitute (2)-(3) in (1) and integrate we receive

$$\int_{-r_0}^{-r} \frac{dr}{r} = \frac{g_0}{k} \int_{R_0}^{R} \left[\left(\frac{R_0^2}{R} \right)^2 - \frac{\omega^2 R}{g_0} \right] dR$$
$$or \quad \bar{r} = \frac{r}{r_0} = \exp\left\{ -\frac{g_0 R_0^2}{k} \left[\left(\frac{1}{R_0} - \frac{1}{R} \right) - \frac{\omega^2}{2g_0} \left(\frac{R^2}{R_0^2} - 1 \right) \right] \right\}, \qquad (4)$$

where $k = \sigma/\gamma$ is coefficient relative strength, m/s, $K = k/10^7$.

The computation equation (4) via H for different K are presented in fig. 3.

As you see than more a relative strength of cover then is more the tower diameter at geosynchronous orbit (36,000 km) and then more the lift force of tower everywhere at H for given p. In difference of space elevator the electrostatic AB tower may be built for small $K <$ 2. But the ratio S_o/S_{gco} in this case is big (here S is area of tower base and cross-section area of tower at geosynchronous orbit respectively).

2. Material strength. Let us consider the following experimental and industrial fibers, whiskers, and nanotubes [16]-[19]:

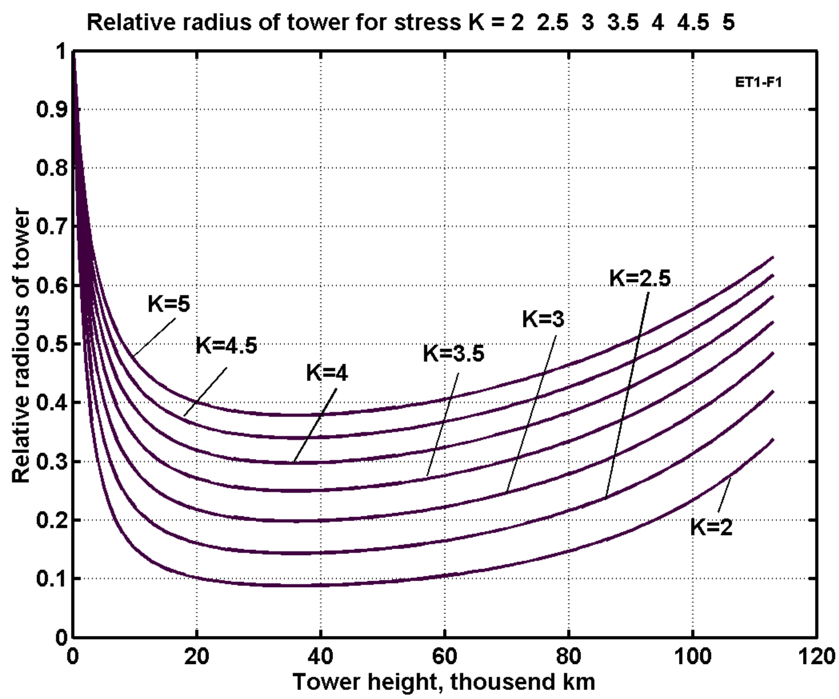

Fig. 3. Relative radius of electrostatic tower versus height and strong of cover film. $K = k/10^7$.

Experimental nanotubes CNT (carbon nanotubes) have a tensile strength of 200 Giga-

1. Pascals (20,000 kg/mm^2). Theoretical limit of nanotubes is 30,000 kg/mm^2.

2. Young's modulus is over 1 Tera Pascal, specific density γ = 1800 kg/m^3 (1.8 g/c^3) (year 2000).
   For safety factor n = 2.4, σ = 8300 kg/mm^2 = 8.3×10^{10} N/m^2, γ =1800 kg/m^3, $k = (\sigma/\gamma)$ = 46×10^6, K = 4.6. The SWNTs nanotubes have a density of 0.8 g/cm^3, and MWNTs have a density of 1.8 g/cm^3 (average 1.34 g/cm^3). Unfortunately, the nanotubes are very expensive at the present time. They cost is about $100 g (2004).
3. For whiskers C_D σ = 8000 kg/mm^2, γ = 3500 kg/m^3 (1989) [16 or 10, p. 33], n = 1, K_{max} = 2.37. Cost is about $400/kg (2001).
4. For industrial fibers σ = 500 ÷ 600 kg/mm^2, γ = 1800 kg/m^3, σ/γ = 2,78×10^6, n =1, K_{max} = 0.28. Cost is about 2 ÷ 5 $/kg (2003).

Figures for some other experimental whiskers and industrial fibers are given in Part A, Ch. 1, Table 2. See also Reference [10] p. 33.

4. **Useful lift force**. The useful (tensile) lift force of AB tower may be computed by equation

$$F = p_a S_0 \bar{r}^2, \quad p_a = \frac{1}{2} p = \frac{\varepsilon_0 E^2}{4}, \quad F = \frac{\pi \varepsilon_0 E^2}{4} r_0^2 \bar{r}^2, \quad \bar{F} = \frac{F}{S_0} = \frac{\varepsilon_0 E^2}{4} \bar{r}^2, \quad (5)$$

where F if lift force, N; p_a is average electron pressure, N/m^2; $S = \pi r^2$ is cross-section area of tower, m^2; S_0 is base cross-section area, m^2; r_o is base radius of tower, m.

The last equation in (5) and many over further equations are more general and suitable for common case. However, we make computation for base tower radius only 10 m. In this case the reader see the real (non relative) data, which allow him to better understand the possibility of electrostatic tower. If the lift force is small, it may be increased by increasing the tower base area.

The computation lift force via altitude for different E, K = 2 and base r_0 =10 m is presented in fig.4.

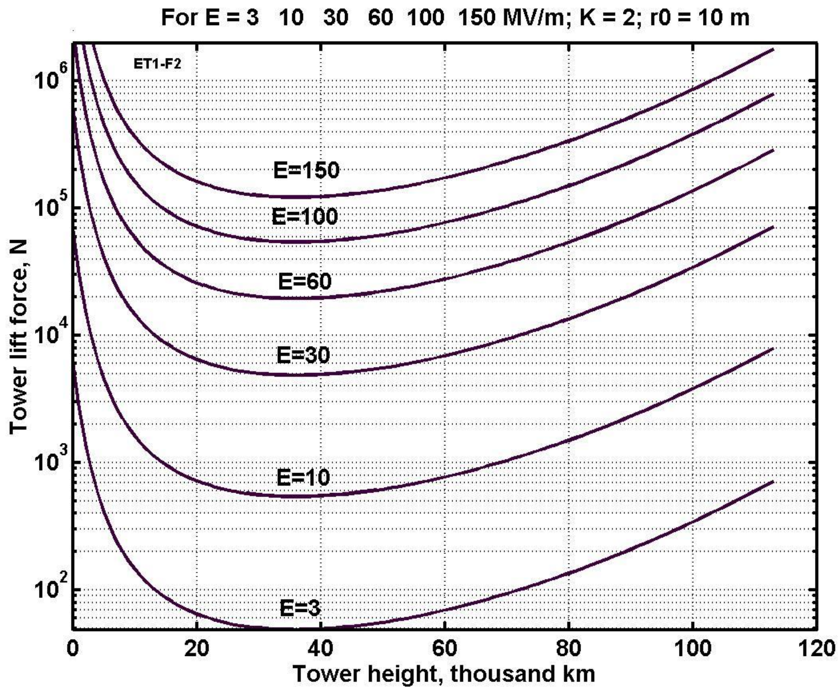

Fig. 4. Tower lift force versus tower height for different electric intensity and base radius r_o = 10 m and strength coefficient K = 2.

As you see for the electric intensity E = 100 MV (the dielectric thin film can keep E = 700 MV, see Part A, Ch.1, Table 2) the electrostatic tower can keep 5 tons if one has altitude at geosynchronous orbit and more 100 tons if one has an altitude 120,000 km.

4. Dielectric strength of insulator. As you see above the tower need in film which separate the positive charges located in conductive layer from the electron gas located into tube. This film must have a high dielectric strength. The current material can keep a high E (see Part A, Ch.10, Table 1 and [10]).

Sources: Encyclopedia of Science & Technology (New York, 2002, Vol. 6, p. 104, p. 229, p. 231) and Kikoin [17] p. 321.

***Note**:* Dielectric constant ε can reach 4.5 - 7.5 for mica (E is up 200 MV/m), 6 -10 for glasses (E = 40 MV/m), and 900 - 3000 for special ceramics (marks are CM-1, T-900) [17], p. 321, (E =13 - 28 MV/m). Ferroelectrics have ε up to 10^4 - 10^5. Dielectric strength appreciably depends from surface roughness, thickness, purity, temperature and other conditions of materials. Very clean material without admixture (for example, quartz) can have electric strength up 1000 MV/m. As you see we have a needed dielectric material, but it is necessary to find good (and strength) isolative materials and to research conditions which increase the dielectric strength.

5. Tower cover thickness. The thickness of tower cover may be found from Equation (3). The result of computation is presented in Fig. 5.

6. Mass of tower cover. The mass of tower cover is

$$dM = 2\pi r\delta\gamma dH,$$

$$M = \frac{2\pi p r_0^2}{k}\int_0^H \bar{r}^2 dH = \frac{\pi\varepsilon_0 E^2 r_0^2}{k}\int_0^H \bar{r}^2 dH \quad or \quad \overline{M} = \frac{M}{S_0} = \frac{\varepsilon_0 E^2}{k}\int_0^H \bar{r}^2 dH \qquad (6)$$

where M is cover mass, kg; $S_0 = \pi r_o^2$ is tower base area, m^2; p is Eq. (2).

Result of computation is presented in fig. 6.

As you see the total mass of 120,000 km electrostatic tower is about 10,000 tons. Compare this number with 3,000,000 tons which has the CNN solid tower in Toronto (Canada) having only 553 m of height.

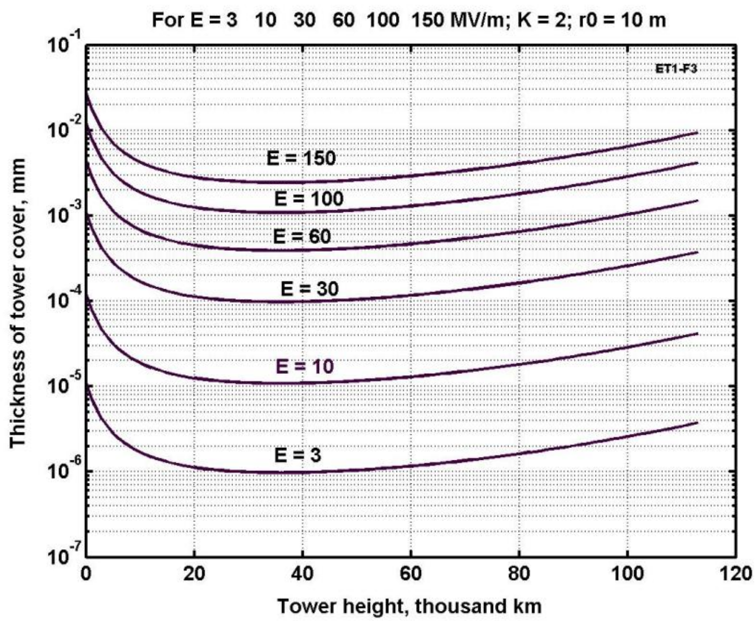

Fig. 5. Thickness of tower cover versus tower height for different electric intensity and base radius r_o = 10 m and strength coefficient K = 2.

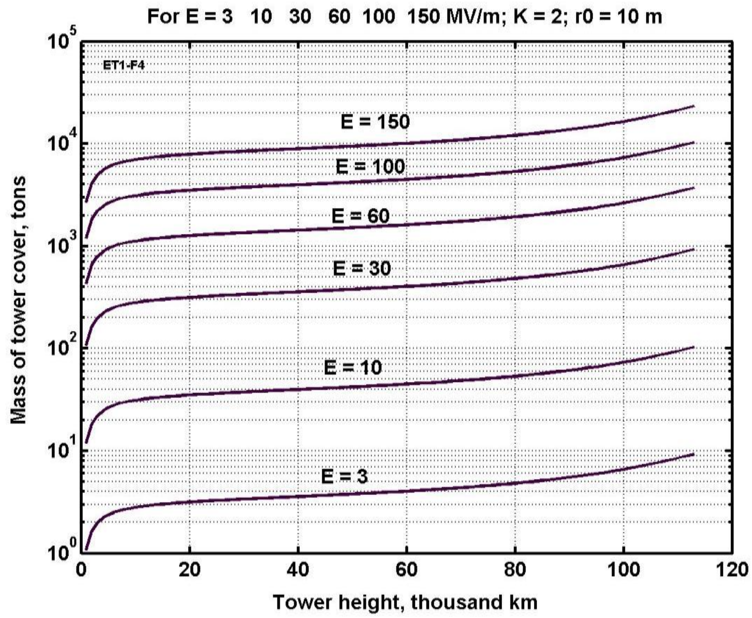

Fig. 6. Mass of tower cover versus tower height for a different electric intensity and base radius r_o = 10 m and strong coefficient K = 2.

7. The volume ***V*** **and surface of tower** *s* are

$$dV = \pi r^2 dH, \quad V = \pi r_0^2 \int_0^H \bar{r}^2 dH, \quad ds = 2\pi r_0 \bar{r} dH, \quad s = \pi r_0 \int_0^H \bar{r} dH \,, \qquad (7)$$

where V is tower volume, m^3; s is tower surface, m^2.

8. Relation between tower volume charge and tower liner charge is

$$E_V = \frac{\rho r}{2\varepsilon_0}, \quad E_s = \frac{\tau}{2\pi\varepsilon_0 r}, \quad E_V = E_s, \quad \tau = \pi\rho r^2, \quad \rho = \frac{\tau}{\pi r^2}, \qquad (8)$$

where ρ is tower volume charge, C/m^3; τ is tower linear charge, C/m.

9. General charge of tower. We got equation from

$$\tau = 2\pi\varepsilon\varepsilon_0 E r, \quad dQ = \tau dH, \quad Q = 2\pi\varepsilon\varepsilon_0 E r_0 \int_0^H \bar{r} dH, \quad \overline{Q} = \frac{Q}{r_0} = 2\pi\varepsilon\varepsilon_0 \int_0^H \bar{r} dH \,, \qquad (9)$$

where Q is total tower charge, C; ε is dielectric constant (see Table 2).

The computation of total charge is shown in fig. 7.

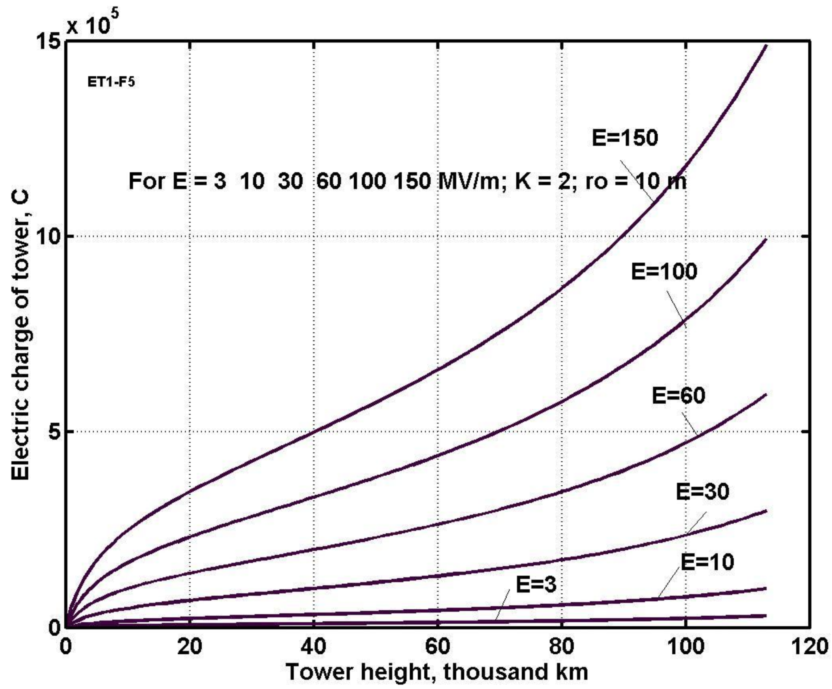

Fig. 7. Electric charge of tower versus tower height for different electric intensity and base radius r_o = 10 m and strength coefficient K = 2.

10. Charging energy. The charged energy is computed by equation

$$W = 0.5QU, \quad U = \delta E, \quad W = 0.5Q\delta_a E\,, \tag{10}$$

where W is charge energy, J; U is voltage, V. For E = 100 MV, H = 120,000 km, Q = 12×10^5 C, $\delta_a = 5\times10^{-7}$ m the charged energy is 30 MJ.

11. Mass of electron gas. The mass of electron gas is

$$M_e = m_e N = m_e \frac{Q}{e}, \tag{11}$$

where M_e is mass of electron gas, kg; $m_e = 9.11\times10^{-31}$ kg is mass of electron; N is number of electrons, $e = 1.6\times10^{-19}$ is the electron charge, C.

The computation for our case give $M_e = 10^{-5}$ kg. That is very small value for gigantic tower-tube 120 thousands km of height.

12. Power for support of charge. Leakage current (power) through the cover may be estimated by equation

$$I = \frac{U}{R}, \quad U = \delta E = \frac{r\varepsilon_0 E}{\sigma}, \quad R = \rho\frac{\delta}{s}, \quad I = \frac{sE}{\rho}, \quad W_l = IU = \frac{\delta s E^2}{\rho} \tag{12}$$

where I is electric currency, A; U is voltage, V; R is electric resistance, Ohm; ρ is specific resistance, Ohm·m; s is tower surface area, m^2.

The estimation gives the support power about 0.1 ÷ 1 kW.

13. Electron gas pressure. The electron gas pressure may be computed by equation (2). This computation is presented in fig. 8.

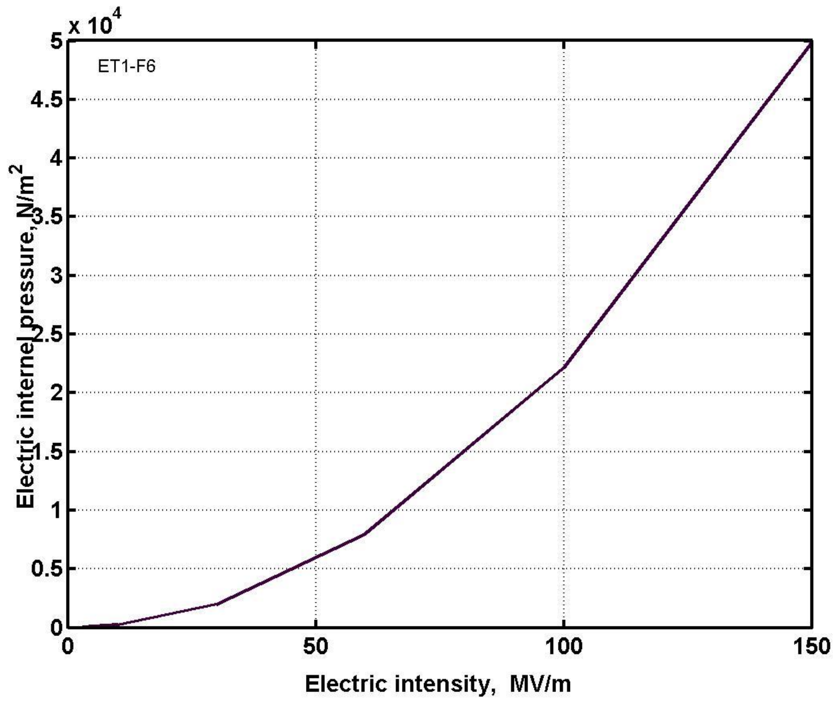

Fig. 8. Electron pressure versus electric intensity

As you see the electron pressure reach 0.5 atm for an electric intensity 150 MV/m and for negligibly small mass of the electron gas.

Project

As the example (not optimal design!) we take three electrostatic towers having: the base (top) radius r_0 = 10 m; K = 2; heights H = 100 km, 36,000 km (GEO), and H = 120.000 km (that may be one tower having named values at given altitudes); electric intensity E = 100 MV/m and 150 MV/m. The results of estimation are presented in Table 1.

Table 1. The results of estimation main parameters of three AB towers (masts) having the base radius r_0 = 100 m and strength coefficient K = 2 for two E =100, 150 MV/m.

Value	E MV/m	H=100 km	H=36,000 km	H=120,000 km
Top Radius , m	-	99	10	40
Useful lift force, ton	100	17×10^{3}	174	2.7×10^{3}
Useful lift force, ton	150	39×10^{3}	390	6.2×10^{3}
Relative cover thickness, δ/r	100	2.2×10^{-6}	2.2×10^{-6}	2.2×10^{-6}
Relative cover thickness, δ/r	150	5×10^{-6}	5×10^{-6}	5×10^{-6}
Mass of cover, ton	100	14×10^{3}	3×10^{5}	1×10^{6}

Mass of cover, ton	150	31.5×10^{3}	1×10^{6}	2×10^{6}
Electric charge, C	100	1.1×10^{5}	3×10^{6}	12×10^{6}
Electric charge, C	150	1.65×10^{5}	4.5×10^{6}	17×10^{6}

Conclusion

The offered inflatable electrostatic AB mast has gigantic advantages in comparison with conventional space elevator. Main of them is follows: electrostatic mast can be built any height without rockets, one needs material in tens times less them space elevator. That means the electrostatic mast will be in hundreds times cheaper then conventional space elevator. One can be built on the Earth's surface and their height can be increased as necessary. Their base is very small.

The main innovations in this project are the application of electron gas for filling tube at high altitude and a solution of a stability problem for tall (thin) inflatable mast by control structure.

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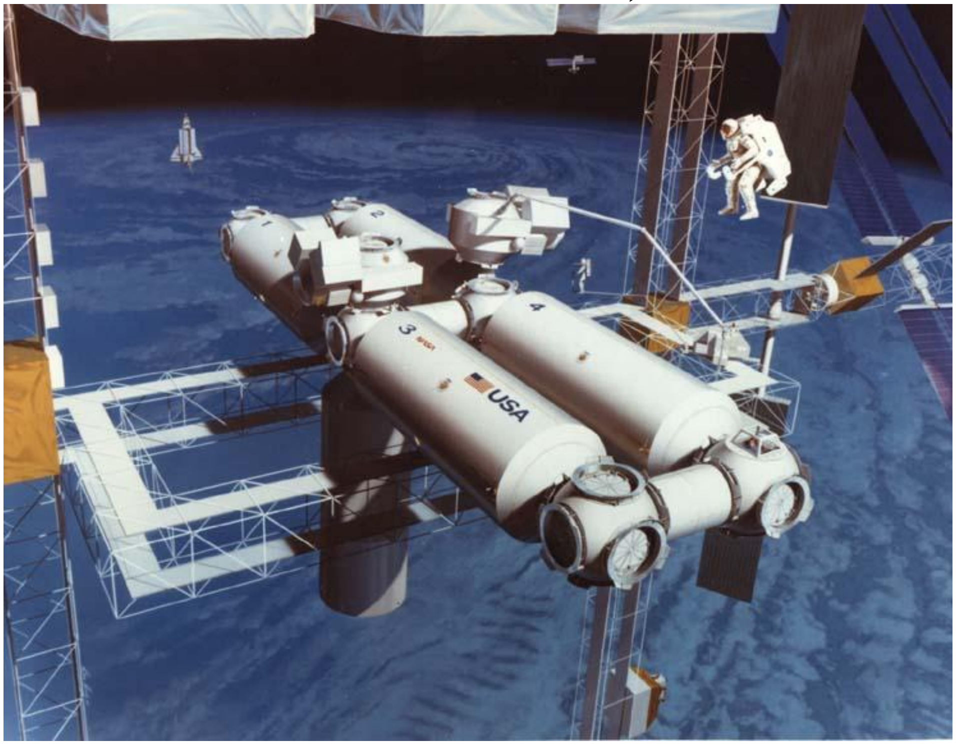
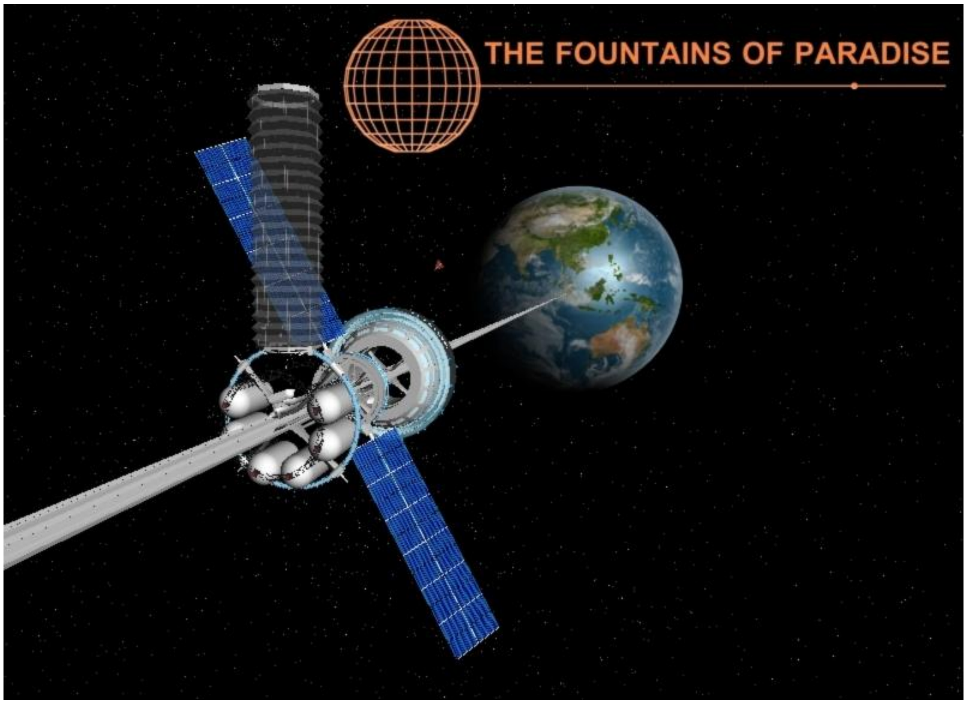
Attachment Pictures for Part A, Ch. 11.





Chapter 12

AB Levitrons and their Applications to Earth's Motionless Satellites*

Abstract

Author offers the new and distinctly revolutionary method of levitation in artificial magnetic field. It is shown that a very big space station and small satellites may be suspended over the Earth's surface and used as motionless radio-TV translators, telecommunication boosters, absolute geographic position locators, personal and mass entertainment and as planet-observation platforms. Presented here is the theory of big AB artificial magnetic field and levitation in it is generally developed. Computation of three macro-projects: space station at altitude 100 km, TV-communication antenna at height 500 m, and multi-path magnetic highway.

Key words: levitation, AB Levitrons, motionless space satellite.

* Presented as Bolonkin's paper to http://arxiv.org on Audust, 2007 (search "Bolonkin").

Introduction

Brief history. The initial theory of levitation-flight was developed by the author during 1965 [1]. Theory of electrostatic levitation and artificial gravity for spaceships and asteroids was presented as paper AIAA-2005-4465 in 41st Propulsion Conference, 10-13 July 2005, held in Tucson, AZ, USA [2]. The related idea and theory extends from the author's work "Kinetic Anti-Gravitator" [3] presented as paper AIAA-2005-4504 in 41st Propulsion Conference. The work "AB Levitator and Electricity Storage" [4] was presented as paper AIAA-2007-4612 to 38th AIAA Plasma dynamics and Lasers Conference in conjunction with the16th International Conference on MHD Energy Conversion on 25-27 June 2007, Miami, USA. (See also http://arxiv.org search "Bolonkin").

The given work underwent further development and application of the above-cited works. That allows an estimate of the parameters of low-altitude stationary satellites, space stations, communication marts and cheap multi-path highway for levitation-flight trains and vehicles.

Innovations

The AB-Levitron uses two large conductivity rings with very high electric currency (fig.1). They create intense magnetic fields. Directions of electric currency are opposed one to the other and rings are repelling one from another. For obtaining enough force over a long distance, the electric currency must be very strong. The current superconductive technology allows us to get very high-density electric currency and enough artificial magnetic field in far space.

The superconductivity ring does not spend an electric energy and can work for a long time period, but it requires an integral cooling system because the current superconductivity materials have the critical temperature about 150-180 C (see Table #1).

However, the present computation methods of heat defense are well developed (for example, by liquid nitrogen) and the induced expenses for cooling are small (fig.2).

The ring located in space does not need any conventional cooling—that defense from Sun and Earth radiations is provided by high-reflectivity screens (fig.3). However, that must have parts open to outer space for radiating of its heat and support the maintaining of low ambient temperature. For variable direction of radiation, the mechanical screen defense system may be complex. However, there are thin layers of liquid crystals that permit the automatic control of their energy reflectivity and transparency and the useful application of such liquid crystals making it easier for appropriate space cooling system. This effect is used by new man-made glasses which grow dark in bright solar light.

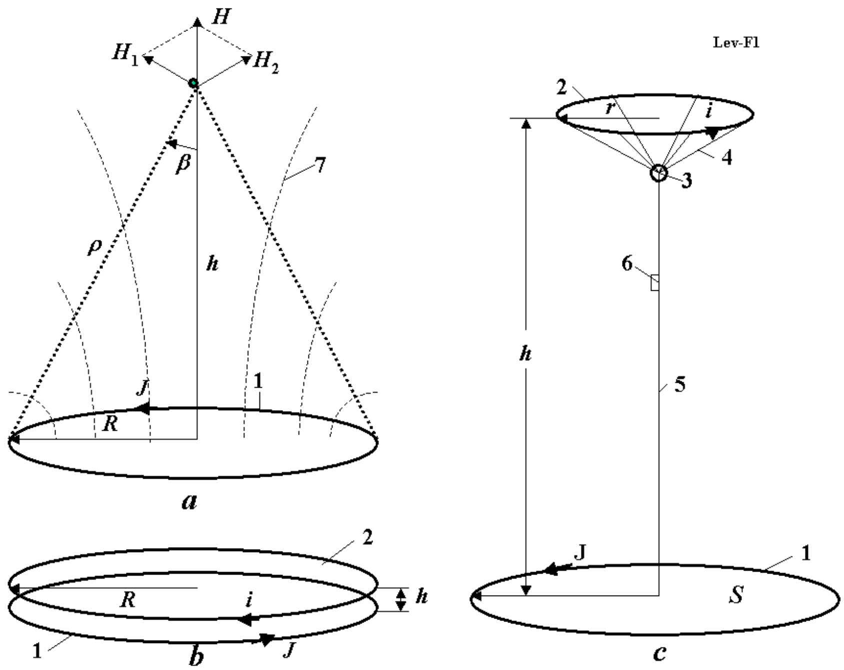


Figure 1. Explanation of AB-Levitron. (a) Artificial magnetic field; (b) AB-Levitron from two same closed superconductivity rings; (c) AB-Levitron - motionless satellite, space station or communication mast. Notation: 1- ground superconductivity ring; 2 - levitating ring; 3 - suspended stationary satellite (space station, communication equipment, etc.); 4 - suspension cable; 5 - elevator (climber) and electric cable; 6 - elevator cabin; 7 - magnetic lines of ground ring; *R* - radius of lover (ground) superconductivity ring; *r* - radius of top ring; *h* - altitude of top ring; *H* - magnetic intensity; *S* - ring area.

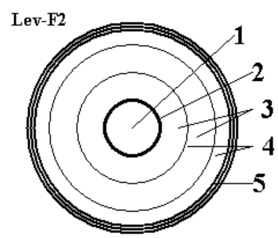


Figure 2. Cross-section of superconductivity ring. Notations: 1 - strong tube (internal part used for cooling of ring, external part is used for superconductive layer); 2 - superconductivity layer; 3 - vacuum; 4 – heat impact reduction high-reflectivity screens (roll of thin bright aluminum foil); 5 - protection and heat insulation.

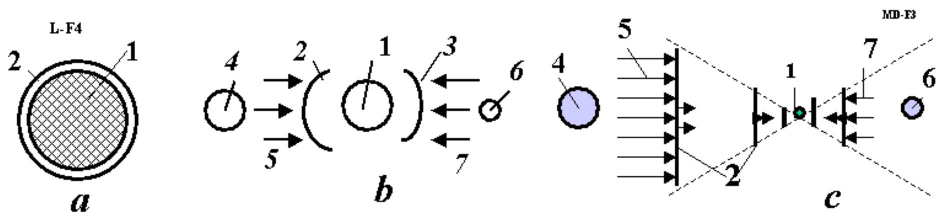


Figure 3. Methods of cooling (protection from Sun radiation) the superconductivity levitron ring in outer space. (***a***) Protection the ring by the super-reflectivity mirror [5]. (***b***) Protection by high-reflectivity screen (mirror) from impinging solar and planetary radiations. (***c***) Protection by usual multi-screens. Notations: 1 - superconductive wires (ring); 2 - heat protector (super-reflectivity mirror in Fig.3a and a usual mirror in Fig. 3c); 2, 3 – high-reflectivity mirrors (Fig. 3b); 4 - Sun; 5 -Sun radiation, 6 - Earth (planet); 7 - Earth's radiation.

The most inportant problem of AB-levitron is stability of top ring. The top ring is in equilibrum, but it is out of balance when it is not parallel to the ground ring. Author offers to suspend a load (satellite, space station, equipment, etc) lower then ring plate. In this case, a center of gravity is lower a summary lift force and system become stable.

For mobile vehicles (fig.7) the AB-Levitron can have a run-wave of magnetic intensity which can move the vehicle (produce electric currency), making it signicantly mobile in the traveling medium.

Theory of AB-Levitron Estimations and Computations

1. Magnetic intensity. Exactly computation of the magnetic intencity and lift force is complex. We find a simple formula only in two cases: (1) when top ring is small in comparison with ground ring (r << . fig.1c) and located along ground ring axis and (2) the rings are same and closed ($h << R$, fig.1b).

Results (case 1) are below

$$H = \frac{JS}{2\pi\rho^3} = \frac{JR^2}{2\rho^3}, \quad \rho = \left(R^2 + h^2\right)^{1/2}.$$
$$H = \frac{JR^2}{2(R^2+h^2)^{3/2}}, \quad B_n = \frac{\mu_0 JR^2}{2(R^2+h^2)^{3/2}} , \qquad (1)$$

where H is magnetic intensity, A/m, along an axis of the ground ring (fig.1a); J is electric currency in the ground ring, A; S is ring area, m^2 (fig.1a); ρ is distance from ring element to given point in ring axis, m (fig.1a); R is radius of ground ring, m; h is altitude of top ring, m; $\mu_o = 4\pi 10^{-7}$ is magnetic constant, B_n is magnetic intensity which is perpendilar on top ring plate in T.

2. Lift force. The lift force is

$$F = p_m \frac{\partial B_n}{\partial h}, \quad p_m = \pi i r^2, \quad F = \pm \frac{3\mu_0 \pi i J r^2 R^2 h}{2(R^2+h^2)^{5/2}} , \qquad (2)$$

where F is lift force, N; p_m is magnetic moment of top ring, A/m^2; i is electric currency in top ring, A; r is radius of top ring, m. The sing + or - depends from direction of electric cirrency in top ring.

3. Optimal radius of ground ring for given altitude h. Lift force for given i, J, r, h has maximum

$$A = \frac{R^2 h}{(R^2 + h^2)^{5/2}}, \quad \frac{\partial A}{\partial R} = 0,$$
$$R_{opt} = \sqrt{\frac{2}{3}} h = 0.8165 h, \quad A_{opt} = \frac{0.186}{h^2}, \qquad (3)$$

Computation A is presented in fig.4.

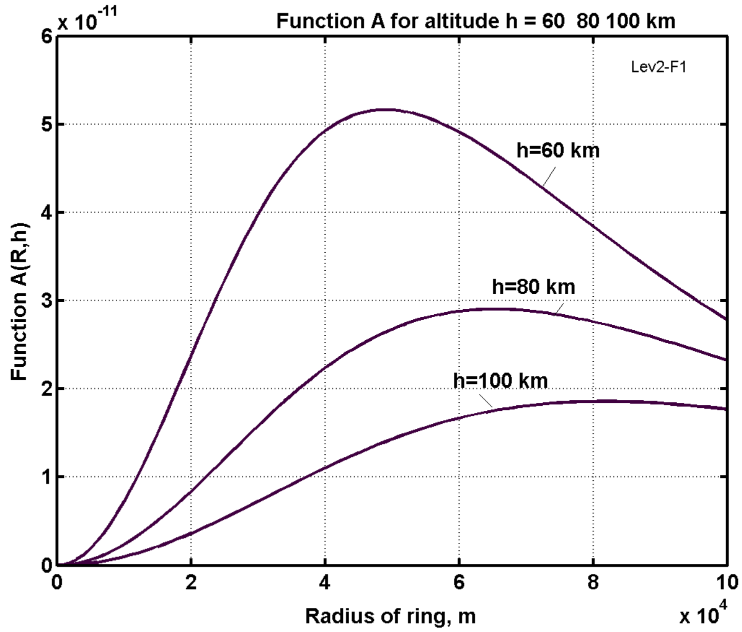


Figure 4. Function A versus radius of the ground ring for altitude h = 60, 80, 100 km.

Note: For altitude h = 100 km, the optimal radius is R_{opt} = 81.65 km. However, the decreasing this radius from 81.65 to 65 km decreases the lift force only in 5% (fig.4).

The magnetic intensity and force corresponding the $R_{\rm opt}$ are

$$B_{n,R\,opt} \approx \frac{\mu_0 J}{11.86 h}, \quad F_{R\,opt} \approx \frac{\pi \mu_0 i J}{10 \bar{h}^2}, \quad \text{where} \quad \bar{h} = \frac{h}{r}, \qquad (4)$$

Example: If $i = 10^7$ A, $J = 10^9$ A, $\bar{h} = 10$, then $F = 4\times10^6$ N = 400 tons. If the h = 100 km that means the $R = 65 \div 81$ km, r = 10 km.

Computation of lift force for R_{opt} and relative altitude $\bar{h} = 10$ is presented in fig.5.

4. The lift force in case (2) (fig.1b). In this case the lift force is

$$F = \pm \mu_0 i\, J \frac{R}{h}, \qquad (5)$$

6. The lift force in case of linear AB-highway (fig. 7)**.** This lift force can be estimated by equation ($h << L$)

$$F = \mu_0 i\, J \frac{L}{2\pi h}, \ \text{for } L = 1\, m, \quad F_1 = \mu_0 i\, J \frac{1}{2\pi h} = \frac{2\cdot 10^{-7} iJ}{h} \quad , \qquad (6)$$

where L is length of AB-train (vehicle), m; F_1 is lift force the 1 m length of train (vehicle). The computation is presented in fig. 6.

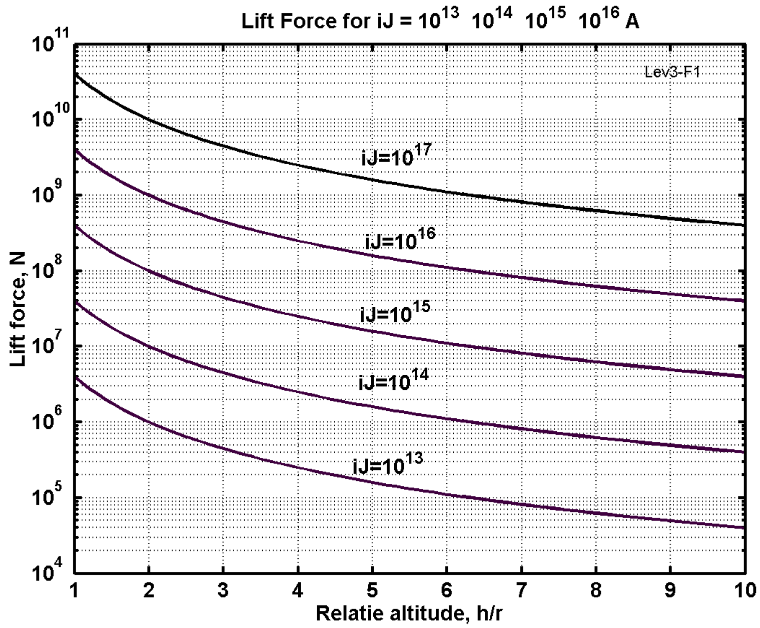


Figure 5. Lift force of AB-Levitron space station versus the relative altitude for a product of the electric currencies the superconductivity ground and station rings and for the optimal ground ring. $\bar{h} = h/r$, h is station altitude, r is radius of top ring.

7. Lift force in general case. This lift force of the top ring can be computed by equation

$$\overline{F} = (\overline{p}_m grad)\overline{B}$$

$$\text{or for axis } x \quad F_x = p_{mx}\frac{\partial B_x}{\partial x} + p_{my}\frac{\partial B_x}{\partial y} + p_{mz}\frac{\partial B_x}{\partial z} \cdot \qquad (7)$$

where $p_m = iS_t$ is magnetic moment, N·m; S_t is area of top ring, m^2.

8. Some other parameters. The moment of force in the top ring is

$$M = \left[\overline{p}_m \cdot \overline{B}\right]. \qquad (8)$$

When the currency in ground ring is variable, the voltage and electric currency in top ring are

$$\text{E} = -\frac{d\Phi}{dt}, \quad i = -\frac{E}{r_t}, \quad \text{where} \quad \Phi = S_t B_n, \qquad (9)$$

where E is voltage induced in top ring, V; Φ is magnetic flow throw the top ring, Wb; r_t is electric resistance of the top ring, Ω.

The minimal radius $R_{T,min}$ [m] of the ring tube and a maximal magnetic pressure $P_{T,max}$ [N/m^2] are

$$R_{T,\min} = \frac{\mu_0 i}{2\pi B}, \quad P_{T,\max} = \frac{B^2}{2\mu_0}, \quad P_T = \frac{\mu_0 i^2}{8\pi^2 R_T^2}, \qquad (10)$$

where B is maximum safety magnetic intensity for given superconductivity material, T (see Table #1).

Example: for $i = 10^7$ A, $B = 100$ T we have $R_{T,min} = 5$ mm, $P_{T,max} = 4\times10^9$ N/m^2= 4×10^4 atm.

The pressure is high. Steel 40X has a limit 4×10^9 N/m^2, corundum has a limit 21×10^9 N/m^2. However, we can adopt a larger tube radius R_T and, as a result, then decrease the magnetic pressure. The internal cooling gas also has pressure which is opposed the magnetic pressure.

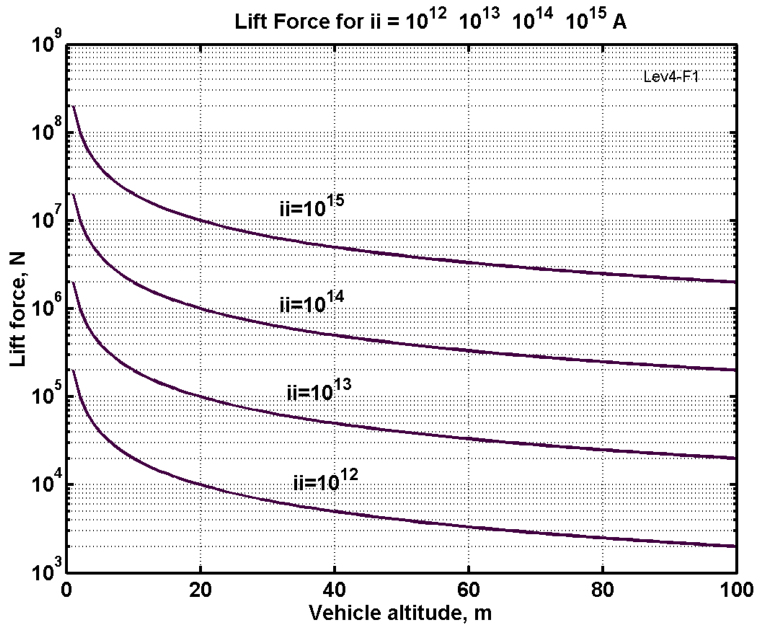


Figure 6. Lift force [N/m] of the 1 meter AB-Levitron multipath highway versus the train (vehicle) altitude for a product ($i_1\times i_2$) of the electric currencies of the superconductivity ground and vehicle rings.

9. Energy of superconductivity ring, If the magnetic intensity into ring is constant, we can estimate the energy needed for starting of ring:

$$H = \frac{I}{2R}, \quad \Phi = \mu_0 \frac{I}{2R} S = IL, \quad L = \mu_0 \frac{S}{2R} = \mu_0 \frac{\pi R}{2}, \quad E = \frac{L I^2}{2} = 0.25\pi\mu_0 R I^2, \qquad (11)$$

where Φ is magnetic flux, Wb: L is ring inductance, Henry; S is ring area, m^2; final equation in (11) E is energy, J; I is electric currency, A.

Example: For ground ring having $R = 10$ km and $I = 10^8$ A the $E = 10^{14}$ J = 2.5×1000 tons of fuel (gas having specific energy 40×10^6 J/kg). For top ring having $R = 100$ m and $I = 10^6$ A the $E = 10^8$ J = 2.5 kg of fuel (gas).

As the reader will undoubtedly readily note, the superconductivity ground ring is an excellent storage of electric energy.

10. Ring internal pressure is

$$f_r = \frac{\mu_0 H^2}{2}, \quad H = \frac{i}{2r}, \quad f_r = \frac{\mu_0 i^2}{8r^2}, \qquad (12)$$

In our macro-projects (for large r) this pressure is small.

11. Mass of suspension cables m_s when $m_s << M_S$, $m_s << M_r$

$$m_s = M_S \frac{2gr\gamma}{\sigma \sin 2\alpha}, \qquad (13)$$

where M_S is space station mass, kg; M_r is top ring mass, kg; g = 9.81 m/s^2 is gravity; γ is specific mass of suspended cable, kg/m^3; σ is safety tensile stress of suspended cable, N/m^2; α is angle between plate of top ring and the suspended cable.

12. Minimal rotation speed of top ring for keeping of space station (when $M_r >> m_s$)

$$V = \sqrt{\frac{2grM_S}{M_r \sin 2\alpha}}, \quad t = \frac{2\pi r}{V} \qquad (14)$$

where V is rotation speed of top ring, m/s; t is time of one revolution, sec.

13. Superconductivity materials.

There are hundreds of new superconductivity materials (type2) having critical temperature 70 ÷ 120 K and more.

Some of the superconductable materials are presented in Part A, Ch.1, Table 1 (2001). The widely used $YBa_2Cu_3O_7$ has mass density 7 g/cm^3.

The last decisions are: Critical temperature is 176 K, up 183 K. Nanotube has critical temperature 12 - 15 K,

Some organic matters have a temperature of up to 15 K. Polypropylene, for example, is normally an insulator. In 1985, however, researchers at the Russian Academy of Sciences discovered that as an oxidized thin-film, polypropylene have a conductivity 10^5 to 10^6 that is higher than the best refined metals.

Boiling temperature of liquid nitrogen is 77.3 K, air 81 K, oxygen 90.2 K, hydrogen 20.4 K, helium 4.2 K [8].

Unfortutately, most superconductive material is not strong and needs a strong covering.

14. C**omputation of the cooling system**. The following equations allow direct compution of the proposed macro-project cooling systems.

3) Equation of heat balance of a body in vacuum

$$\zeta q s_1 = C_S \varepsilon_a \left(\frac{T}{100}\right)^4 s_2 , \qquad (15)$$

where $\zeta = 1 - \xi$ is absorption coefficient of outer radiation, ξ is reflection coefficient; q is heat flow, W/m^2 (from Sun at Earth's orbit q = 1400 W/m^2, from Earth $q \approx 440$ W/m^2); s_1 is area under outer radiation, m^2; C_s = 5.67 W/m^{2}K is heat coefficient; $\varepsilon_a \approx 0.02 \div 0.98$ is blackness coefficient; T is body temperature, K; s_2 is area of body or screen, m^2.

2) Radiation heat flow q [W/m^2] between two parallel screens

$$q = C_a\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right], \quad C_a = \varepsilon_a C_S, \quad \varepsilon_a = \frac{1}{1/\varepsilon_1 + 1/\varepsilon_2 - 1}, \qquad (16)$$

where the lower index $_{1,\,2}$ shows (at T and ε) the number of screens; C_a is coerced coefficient of heat transfer between two screens. For bright aluminum foil $\varepsilon = 0.04 \div 0.06$. For foil covered by thin bright layer of silver $\varepsilon = 0.02 \div 0.03$.

When we use a vacuum and row (n) of the thin screens, the heat flow is

$$q_n = \frac{1}{n+1}\frac{C_a^{'}}{C_a}q\,, \qquad (17)$$

where q_n is heat flow to protected wire, W/m^2; $C_a^{'}$ is coerced coefficient of heat transfer between wire and the nearest screen, C_a is coerced coefficient of heat transfer between two near by screens; n is number of screen (revolutins of vacuumed thin foil around central superconductive wire).

Example: for $C_a^{'} = C_a$, n = 100, ε = 0.05, T_1 = 298 K (15 C, everage Earth temperature), T_2 = 77.3 K (liquid nitrogen) we have the q_n = 0.114 W/m^2.

Expence of cooling liquid and power for converting back the vapor into cooling liquid are

$$m_a = q_n/\alpha\,, \quad P = q_n S/\eta\,, \qquad (18)$$

where m_a is vapor mass of cooling liquid, kg/m^2**.**sec; P is power, W/m^2; S is an outer area of the heat protection, m^2; η is coefficient of efficiency the cooling instellation which convert back the cooling vapor to the cooling liquid; α is heat varoparation, J/kg (see Ch.1 A, Table 3).

3) When we use the conventional heat protection, the heat flow is computed by equations

$$q = k(T_1 - T_2), \quad k = \frac{\lambda}{\delta}\,, \qquad (19)$$

where k is heat transmission coefficient, W/m^{2}K; λ - heat conductivity coefficient, W/m$\cdot$K. For air λ = 0.0244, for glass-wool λ = 0.037; δ - thickness of heat protection, m.

The vacuum screenning is strong efficiency and light (mass) then the conventional cooling protection.

These data are sufficient for a quick computation of the cooling systems characteristics.

Using the correct design of multi-screens, high-reflectivity solar and planetary energy screen, and assuming a hard outer space vacuum between screens, we get a very small heat flow and a very small expenditure for refrigerant (some gram/m^2 per day in Earth). In outer space the protected body can have low temperature without special liquid cooling system (Fig.3).

For example, the space body (Fig. 3a) with innovative prism reflector [5] Ch. 3A ($\rho = 10^{-6}$, ε_a = 0.9) will have temperature 13 K in outer space. The protection Fig.3b gives more low temperature. The usual multi-screen protection of Fig. 3c gives the temperature: the first screen - 160 K, the second - 75 K, the third - 35 K, the fourth - 16 K.

15. Cable material. Let us consider the following experimental and industrial fibers, whiskers, and nanotubes:

5. Experimental nanotubes CNT (carbon nanotubes) have a tensile strength of 200 Giga-Pascals (20,000 kg/mm^2). Theoretical limit of nanotubes is 30,000 kg/mm^2.
6. Young's modulus exceeds a Tera Pascal, specific density γ=1800 kg/m^3 (1.8 g/cc) (year 2000).

   For safety factor n = 2.4, σ = 8300 kg/mm^2 = 8.3×10^{10} N/m^2, γ=1800 kg/m^3, (σ/γ)=46×10^6. The SWNTs nanotubes have a density of 0.8 g/cm^3, and MWNTs have a density of 1.8 g/cm^3 (average 1.34 g/cm^3). Unfortunately, even in 2007 AD, nanotubes are very expensive to manufacture.
7. For whiskers C_D σ = 8000 kg/mm^2, γ = 3500 kg/m^3 (1989) [5, p. 33]. Cost about \$400/kg (2001).
8. For industrial fibers σ = 500 – 600 kg/mm^2, γ = 1800 kg/m^3, σ/γ = 2,78×10^6. Cost about 2 - 5 \$/kg (2003).

   Relevant statistics for some other experimental whiskers and industrial fibers are given in Table 2. Ch.1 A. See also Reference [5] p. 33.

16. Safety of space station.For safety of space station and elevator cabin the special parachutes are utilized (see [9]). Author also has ideas for the safety of the ground supercondutivity ring.

Projects

Macro-Project #1. Stationary space station at altitude 100 km.

Let us to estimate the stationary space station is located at altitude h = 100 km. Take the initial data: Electric currency in the top superconductivity ring is i = 10^6 A; radius of the top ring is r = 10 km; electric currency in the superconductivity ground ring is J = 10^8 A; density of electric currency is j = 10^6 A/mm^2; specific mass of wire is γ = 7000 kg/m^3; specific mass of suspending cable and lift (elevator) cable is γ = 1800 kg/m^3; safety tensile stress suspending and lift cable is σ = 1.5×10^9 N/m^2 = 150 kg /mm^2; α = 45^o , safety superconductivity magnetic intensity is B = 100 T. Mass of lift (elevator) cabin is 1000 kg.

Then the optimal radius of the ground ring is R = 81.6 km (Eq, (3), we can take R = 65 km); the mass of space station is M_S = F =40 tons (Eq.(2)). The top ring wire mass is 440 kg or together with control screen film is M_r = 600 kg. Mass of two-cable elevator is 3600 kg; mass of suspending cable is less 9600 kg, mass of parachute is 2200 kg. As the result the useful mass of space station is M_u = 40 - (0.6+1+3.6+9.6+2.2) = 23 tons.

Minimal wire radius of top ring is R_T = 2 mm (Eq. (10)). If we take it R_T = 4 mm the magnetic pressure will me P_T =100 kg/mm^2 (Eq. (10)). Minimal wire radius of the ground ring is R_T = 0.2 m (Eq. (10)). If we take it R_T = 0.4 m the magnetic pressure will me P_T =100 kg/mm^2 (Eq. (10)). Minimal rotation speed (take into consideration the suspending cable) is V = 645 m/s, time of one revolution is t = 50 sec. Electric energy in the top ring is small, but in the ground ring is very high E = 10^{14} J (Eq. (11)). That is energy of 2500 tons of liquid fuel (such as natural gas, methane).

The requisite power of the cooling system for ground ring is about P = 30 kW (Eq. (18)).

As the reader observes, all parameters are accessible using existing and available technology. They are not optimal.

Macro-Project #2. 500 m-high Tele-Communication Mast.

Let us estimate the tele-communication mast of height h = 500 m without superconductivity in the top ring. Take the initial data: Electric currency in the top ring is i = 100 A; radius of the top ring is r = 200 m; electric currency in the superconductivity ground ring is $J = 2.5\times10^8$ A; density of ground ring electric currency is $j = 10^6$ A/mm^2, the top ring has j = 5 A/mm^2; specific mass of superconductivity wire is γ = 7000 kg/m^3; specific mass of aluminum wire is γ = 2800 kg/m^3; specific mass of suspending cable and lift cable is γ = 1800 kg/m^3; safety tensile stress suspending and list cable is $\sigma = 10^9$ N/m^2 = 100 kg /mm^2; $\alpha = 45^o$, safety superconductivity magnetic intensity is B = 100 T. The vertical wire transfer of electric energy has voltage 2000 V and electric density 8.8 A/mm^2. Then the optimal radius of the ground ring is R = 400 m (Eq. (3)); the mass of antenna is $M_S = F$ = 160 kg (Eq.(2)). The top ring wire mass is M_r = 70 kg. Mass of vertical two-cable transfer of electric energy is 3 kg; mass of suspending cable is less 1 kg. As the result the useful mass of top apparatuses is M_u = 160 - (70+3+1) = 86 kg.

Minimal wire radius of ground ring is R_T = 0.5 m (Eq. (10)). If we take it R_T = 1.5 m the magnetic pressure will me P_T = 44 kg/mm^2 (Eq. (10)). Minimal rotation speed of top ring is V = 96 m/s, time of one revolution is t = 12.6 sec. Electric energy in the top ring is small, but in the ground ring is high $E = 2.5\times10^{13}$ J (Eq. (11)). That is energy of 620 tons of liquid fuel (natural gas). Requested energy for permanent supporting the electric currency in NON-SUPERCONDUCTIVITY top ring is 17.6 kW. If we make it superconductive, the lift force increases by thousands times. For example, if $i = 10^6$ A the lift force increases in $10^6/100 = 10^4$ times and became 1.6×10^3 tons. That is suspending mobile building (hotel). There is no expense of electric energy for superconductivity ring. The power for cooling (liquid nitrogen) is small. It is not used an expensive city area.

As it is shown in the author work [4] we can build the fight city where men can fly as individuals and also in the cars or similar vehicles.

All parameters are accessible for existing industry. They are not optimal. Our aim - it shows that AB-Levitron may be designed by the current technology (see also [11]).

Macro-Project #3. Levitron AB-miltipath highway.

The AB-levitron may be used for design the multi-path levitation highway (fig.7). That is the closed-loop superconductive lenthy linear strung near the highway which creates the vertical magnetic field. The lift force produced by this AB-highway in one meter of length is [Eq. (6)]

$$F_1 = \frac{2\cdot 10^{-7} i_1 i_2}{h}, \qquad (17)$$

where F_1 is lift force, N/m; i is electric currency in graund cable and fly train (vehicle) respectively; h is altitude of the veficle (train) over graund cable, m.

Estimations. Let us take the electric currency $i_1 = 10^8$ A in ground line. Then:

1) If the the train does not have the superconductivity wire, the electric currency in top ring is only i_2 = 100 A and distance between rings is h = 0.5 m, the lift force of 1 m train length will be F_1 = 4000 N/m (Eq. (6 or 17)). In this case the top ring may be changed by permanent magnets.
2) If the vehicle has the supercondutivity with currency $i_2 = 10^6$ A then the 1 m length of vehicle will has:
   a) at altitude h = 10 m the F_1 = 200 ton/m ;
   b) at altitude h = 100 m the F_1 = 20 ton/m ;
   c) at altitude h = 1000 m the F_1 = 2 ton/m ;

If vertical distance between paths is 10 meter the 1 km vertical corridor will have 100 ways in one direction from a lower low speed vehicles to a top high speed vehicles (supersonic aircraft). They can receive energy from running magnet wave of graund cable.

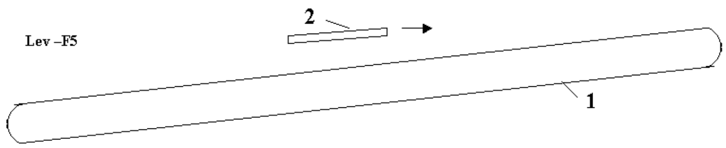


Figure 7. High speed AB-Levitron way for levitating aircraft or trains. Notations: 1 - ground superconductivity closed-loop cable; 2 - car, track, air vehicle or train.

The offered AB-Llevitron vehicle has following advantages in comparison the current train used magnet pillow (maglev):

1) One does not need in complex expencive magnet system;
2) That does not need a precise concrete roadbed;
3) There area a lot of ways and train can change a path and it does not depend from condition of other train and vehicles,

The initial data in all our macro-projects are not optimal.

Figure 8. Possible levitron.

Discussion

The offered AB-Levitrons may be made with only existing technology. We have a superconductivity material (see Table 1), the strong artificial fibers and whiskers (Table 3), the light protection and cooling system (Table 2) for the Earth's surface, and the radiation screens for outer space. The Earth has weak magnetic field, the Sun and many planets and their satellites (as Phobos orbiting Mars) has also small magnetic field. There is no barrier problem to creating the artificial magnetic field on Earth, asteroids and planetary satellites (for example, to create local artificial magnetic field on the Moon, see [10]). We have a very good perspective in improving our devices because—especially during the last 30 years—the critical temperature of the superconductive material increases from 4 K to 186 K and does not appear, at this time, to be any theoretical limit for further increase. Moreover, Russian scientists received the thin layers which have electric resistance at room temperature in many times less than the conventinal conductors. We have nanotubes which will create the jump in AB-Levitrons, when their production will be cheaper. The current superconductive solenoids have the magnetic field $B \approx 20$ T.

AB-levitrons can instigate a revolution in space exploration and exploitation, tele-communication and air, ground, and space vehicle transportation. They allow individuals to fly as birds, almost flight with subsonic and supersonic speed [4]. The AB-Levitrons solve the environment problem because they do not emit or evolve any polluting gases. They are useful in any solution for the national and international oil-dependence problem because they use electricity and spend the energy for flight and other vehicles (cars) many times less than conventional internal combustion engine (no graund friction). In difference of a ground car, the levitation car flights are straight line to objective in a city region.

The AB-Levitrons create a notable revolution in tele-communication by the low-altitude stationary suspended satellites, in energy industry, and especially in a local aviation. They are very useful in night-lighting of Earth-biosphere regions by additional light and heat Sun radiation because, in difference from conventional mobile space mirrors, they can be suspended over given place (city) and service this place efficiently.

It is interesting, the toroidal AB engine is very comfortable for flying discs (human-made UFO!) and have same property with UFOs. That can levitate and move in any direction with high acceleration without turning of vehicle, that does not excrete any gas, jet, and that does not produce a noise [4].

Conclusion

We must research and develop these ideas. They may accelerate the technical progress and improve our life-styles. There are no known scientific obstacles in the development and design of the AB-Levitrons, levitation vehicles, high-speed aircraft, spaceship launches, low-aititude stationary tele-communication satellites, cheap space trip to Moon and Mars and other interesting destination-places in outer space.

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PART B. NEW IDEAS IN TECHNOLOGY

Chapter 1

MICRO (MINI) –THERMONUCLEAR AB-REACTORS*

ABSTRACT

About fifty years ago, scientists conducted Research and Development of a thermonuclear reactor that promises a true revolution in the energy industry and, especially, in aerospace. Using such a reactor, aircraft could undertake flights of very long distance and for extended periods and that, of course, decreases a significant cost of aerial transportation, allowing the saving of ever-more expensive imported oil-based fuels. (As of mid-2006, the USA DoD has a program to make aircraft fuel from domestic natural gas sources.) The temperature and pressure required for any particular fuel to fuse is known as the Lawson criterion *L*. Lawson criterion relates to plasma production temperature, plasma density and time. The thermonuclear reaction is realised when *L* is more certain magnitude. There are two main methods of nuclear fusion: inertial confinement fusion (ICF) and magnetic confinement fusion (MCF). Existing thermonuclear reactors are very complex, expensive, large, and heavy. They cannot achieve the Lawson criterion.

The author offers several innovations that he first suggested publicly early in 1983 for the AB multi-reflex engine, space propulsion, getting energy from plasma, etc. (see: A. Bolonkin, Non-Rocket Space Launch and Flight, Elsevier, London, 2006, Chapters 12, 3A). It is the micro-thermonuclear AB-Reactors. That is new micro-thermonuclear reactor with very small fuel pellet that uses plasma confinement generated by multi-reflection of laser beam or its own magnetic field. The Lawson criterion increases by hundreds of times. The author also suggests a new method of heating the power-making fuel pellet by outer electric current as well as new direct method of transformation of ion kinetic energy into harvestable electricity. These offered innovations dramatically decrease the size, weight and cost of thermonuclear reactor, installation, propulsion system and electric generator. Non-industrial countries can produce these researches and constructions. Currently, the author is researching the efficiency of these innovations for two types of the micro-thermonuclear reactors: multi-reflection reactor (ICF) and self-magnetic reactor (MCF).

Keywords: *Micro-thermonuclear reactor, Multi-reflex AB-thermonuclear reactor, Self-magnetic AB-thermonuclear reactor, aerospace thermonuclear engine*.

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* Presented as Bolonkin's paper AIAA-2006-8104 in 14th Space Plane and Hypersonic Systems Conference, 6-8 November, 2006, USA.

INTRODUCTION

Brief Information about Thermonuclear Reactors

Fusion power is useful energy generated by nuclear fusion reactions. In this kind of reaction two light atomic nuclei fuse together to form a heavier nucleus and release energy. The largest current experiment, JET, has resulted in fusion power production somewhat larger than the power put into the plasma, maintained for a few seconds. In June 2005, the construction of the experimental reactor ITER, designed to produce several times more fusion power than the power into the plasma over many minutes, was announced. The production of net electrical power from fusion is planned for the next generation experiment after ITER.

Unfortunately, this task is not easy, as scientists thought early. Fusion reactions require a very large amount of energy to initiate in order to overcome the so-called *Coulomb barrier* or *fusion barrier energy*. The key to practical fusion power is to select a fuel that requires the minimum amount of energy to start, that is, the lowest barrier energy. The best fuel from this standpoint is a one-to-one mix of deuterium and tritium; both are heavy isotopes of hydrogen. The D-T (Deuterium and Tritium) mix has a low barrier energy. In order to create the required conditions, the fuel must be heated to tens of millions of degrees, and/or compressed to immense pressures.

At present, D-T is used by two main methods of fusion: inertial confinement fusion (ICF) and magnetic confinement fusion (MCF)(for example, tokamak).

In inertial confinement fusion (ICF), nuclear fusion reactions are initiated by heating and compressing a target. The target is a pellet that most often contains deuterium and tritium (often only micro or milligrams). Intense laser or ion beams are used for compression. The beams explosively detonate the outer layers of the target. That accelerats the underlying target layers inward, sending a shockwave into the center of pellet mass. If the shockwave is powerful enough and if high enough density at the center is achieved some of the fuel will be heated enough to cause fusion reactions. In a target which has been heated and compressed to the point of thermonuclear ignition, energy can then heat surrounding fuel to cause it to fuse as well, potentially releasing tremendous amounts of energy.

Fusion reactions require a very large amount of energy to initiate in order to overcome the so-called *Coulomb barrier* or *fusion barrier energy*.

Magnetic confinement fusion (MCF). Since plasmas are very good electrical conductors, magnetic fields can also confine fusion fuel. A variety of magnetic configurations can be used, the basic distinction being between magnetic mirror confinement and toroidal confinement, especially tokamaks and stellarators.

Lawson criterion. In nuclear fusion research, the Lawson criterion, first derived by John D. Lawson in 1957, is an important general measure of a system that defines the conditions needed for a fusion reactor to reach *ignition*, that is, that the heating of the plasma by the products of the fusion reactions is sufficient to maintain the temperature of the plasma against all losses without external power input. As originally formulated the Lawson criterion gives a minimum required value for the product of the plasma (electron) density n_e and the "energy confinement time" τ. Later analyses suggested that a more useful figure of merit is the "triple product" of density, confinement time, and plasma temperature T. The triple product also has a minimum required value, and the name "Lawson criterion" often refers to this inequality.

The key to practical fusion power is to select a fuel that requires the minimum amount of energy to start, that is, the lowest barrier energy. The best fuel from this standpoint is a one-to-one mix of deuterium and tritium; both are heavy isotopes of hydrogen. The D-T (Deuterium and Tritium) mix has a low barrier.

In order to create the required conditions, the fuel must be heated to tens of millions of degrees, and/or compressed to immense pressures. The temperature and pressure required for any particular fuel to fuse is known as the Lawson criterion. For the D-T reaction, the physical value is about

$$L = n_e T\tau > (10^{14} \div 10^{15}) \quad \text{in} \quad \text{"cgs"} \quad \text{units}$$
$$\text{or} \quad L = nT\tau > (10^{20} \div 10^{21}) \quad \text{in} \quad \text{CI} \quad \text{units} \quad ,$$

where T is temperature, [KeV], 1 eV = 1.16×10^4 ^oK; n_e is matter density, [1/cm^3]; n is matter density, [1/m^3]; τ is time, [s]. Last equation is in metric system. The thermonucler rection of ^2H + ^3D realises if $L > 10^{20}$ in CI (meter, kilogram, second) units or $L > 10^{14}$ in 'cgs' (cantimetr, gram, second) units.

This number has not yet been achieved in any reactor, although the latest generations of machines have come close. For instance, the reactor TFTR has achieved the densities and energy lifetimes needed to achieve Lawson at the temperatures it can create, but it cannot create those temperatures at the same time. Future ITER aims to do both.

The Lawson criterion applies to inertial confinement fusion as well as to magnetic confinement fusion but is more usefully expressed in a different form. Whereas the energy confinement time in a magnetic system is very difficult to predict or even to establish empirically, in an inertial system it must be on the order of the time it takes sound waves to travel across the plasma:

$$\tau \approx \frac{R}{\sqrt{kT/m_i}}$$

where τ is time, s; R is distance, m; k is Boltzmann constant; m_i is mass of ion, kg.

Following the above derivation of the limit on $n_e\tau_E$, we see that the product of the density and the radius must be greater than a value related to the minimum of $T^{3/2}/\langle\sigma v\rangle$ (here σ is Boltzmann constant, v is ion speed). This condition is traditionally expressed in terms of the mass density ρ: $\rho R > 1$ g/cm² .

To satisfy this criterion at the density of solid D+T (0.2 g/cm³) would require an implausibly large laser pulse energy. Assuming the energy required scales with the mass of the fusion plasma ($E_{laser} \sim \rho R^3 \sim \rho^{-2}$), compressing the fuel to 10^3 or 10^4 times solid density would reduce the energy required by a factor of 10^6 or 10^8, bringing it into a realistic range. With a compression by 10^3, the compressed density will be 200 g/cm³, and the compressed radius can be as small as 0.05 mm. The radius of the fuel before compression would be 0.5 mm. The initial pellet will be perhaps twice as large since most of the mass will be ablated during the compression.

The fusion power density is a good figure of merit to determine the optimum temperature for magnetic confinement, but for inertial confinement the fractional burn-up of the fuel is probably more useful. The burn-up should be proportional to the specific reaction rate

(n^2<σv>) times the confinement time (which scales as $T^{1/2}$) divided by the particle density n: burn-up fraction ~ n^2<σv> $T^{-1/2}$ / n ~ (nT) (<σv>/$T^{3/2}$)

Thus the optimum temperature for inertial confinement fusion is that which maximizes <σv>/$T^{3/2}$, which is slightly higher than the optimum temperature for magnetic confinement.

Short history of thermonuclear fusion. One of the earliest (in the late 1970's and early 1980's) serious attempts at an ICF design was *Shiva*, a 20-armed neodymium laser system built at the Lawrence Livermore National Laboratory (LLNL) that started operation in 1978. Shiva was a "proof of concept" design, followed by the *NOVA* design with 10 times the power. Funding for fusion research was severely constrained in the 80's, but NOVA nevertheless successfully gathered enough information for a next generation machine whose goal was ignition. Although net energy can be released even without ignition (the breakeven point), ignition is considered necessary for a *practical* power system.

The resulting design, now known as the National Ignition Facility, commenced being constructed at LLNL in 1997. Originally intended to start construction in the early 1990s, the NIF is now six years behind schedule and overbudget by over $1.4 billion. Nevertheless many of the problems appear to be due to the "big lab" mentality and shifting the focus from pure ICF research to the nuclear stewardship program, LLNLs traditional nuclear weapons-making role. NIF is now scheduled to "burn" in 2010, when the remaining lasers in the 192-beam array are finally installed.

Laser physicists in Europe have put forward plans to build a £500m facility, called HiPER, to study a new approach to laser fusion. A panel of scientists from seven European Union countries believes that a "fast ignition" laser facility could make a significant contribution to fusion research, as well as supporting experiments in other areas of physics. The facility would be designed to achieve high energy gains, providing the critical intermediate step between ignition and a demonstration reactor. It would consist of a long-pulse laser with an energy of 200 kJ to compress the fuel and a short-pulse laser with an energy of 70 kJ to heat it.

Confinement refers to all the conditions necessary to keep a plasma dense and hot long enough to undergo fusion:

- *Equilibrium:* There must be no net forces on any part of the plasma, otherwise it will rapidly disassemble. The exception, of course, is inertial confinement, where the relevant physics must occur faster than the disassembly time.
- *Stability:* The plasma must be so constructed that small deviations are restored to the initial state, otherwise some unavoidable disturbance will occur and grow exponentially until the plasma is destroyed.
- *Transport:* The loss of particles and heat in all channels must be sufficiently slow. The word "confinement" is often used in the restricted sense of "energy confinement".

To produce self-sustaining fusion, the energy released by the reaction (or at least a fraction of it) must be used to heat new reactant nuclei and keep them hot long enough that they also undergo fusion reactions. Retaining the heat generated is called energy *confinement* and may be accomplished in a number of ways.

The hydrogen bomb weapon has no confinement at all. The fuel is simply allowed to fly apart, but it takes a certain length of time to do this, and during this time fusion can occur. This approach is called *inertial confinement* (Figure 1). If more than about a milligram of fuel is used, the explosion would destroy the machine, so controlled thermonuclear fusion using inertial confinement causes tiny pellets of fuel to explode several times a second. To induce the explosion, the pellet must be compressed to about 30 times solid density with energetic beams. If the beams are focused directly on the pellet, it is called *direct drive*, which can in principle be very efficient, but in practice it is difficult to obtain the needed uniformity. An alternative approach is *indirect drive*, in which the beams heat a shell, and the shell radiates x-rays, which then implode the pellet. The beams are commonly laser beams, but heavy and light ion beams and electron beams have all been investigated and tried to one degree or another.

They rely on fuel pellets with a "perfect" shape in order to generate a symmetrical inward shock wave to produce the high-density plasma, and in practice these have proven difficult to produce. A recent development in the field of laser-induced ICF is the use of ultra-short pulse multi-petawatt lasers to heat the plasma of an imploding pellet at exactly the moment of greatest density after it is imploded conventionally using terawatt scale lasers. This research will be carried out on the (currently being built) OMEGA EP petawatt and OMEGA lasers at the University of Rochester and at the GEKKO XII laser at the Institute for Laser Engineering in Osaka Japan which, if fruitful, may have the effect of greatly reducing the cost of a laser fusion-based power source.

Figure 1. Laser installation for NOVA inertial thermonuclear reactor. Look your attention in the man and gigantic size of laser installation for reactor. Cost is some billions of dollars.

At the temperatures required for fusion, the fuel is in the form of a plasma with very good electrical conductivity. This opens the possibility to confine the fuel and the energy with magnetic fields, an idea known as *magnetic confinement* (Figure 2).

Much of this progress has been achieved with a particular emphasis on tokamaks (Figure 2).

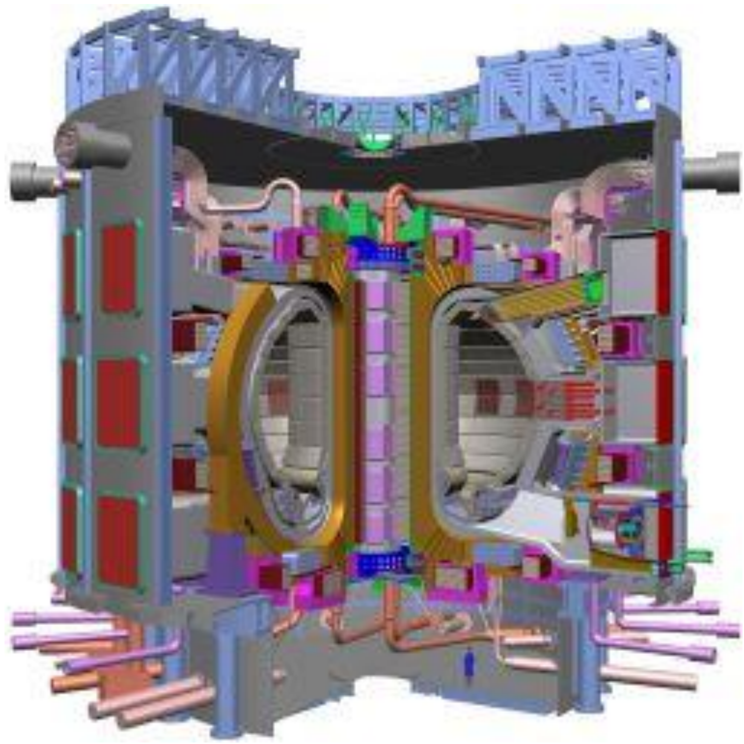

Figure 2. Magnetic thermonuclear reactor. The size of the installation is obvious if you compare it with the "Little Blue Man" inside the machine at the bottom. Cost is some tens of billions of dollars.

In fusion research, achieving a fusion energy gain factor $Q = 1$ is called *breakeven* and is considered a significant although somewhat artificial milestone. *Ignition* refers to an infinite Q, that is, a self-sustaining plasma where the losses are made up for by fusion power without any external input. In a practical fusion reactor, some external power will always be required for things like current drive, refueling, profile control, and burn control. A value on the order of $Q = 20$ will be required if the plant is to deliver much more energy than it uses internally.

In a fusion power plant, the nuclear island has a *plasma chamber* with an associated vacuum system, surrounded by a plasma-facing components (first wall and divertor) maintaining the vacuum boundary and absorbing the thermal radiation coming from the plasma, surrounded in turn by a blanket where the neutrons are absorbed to breed tritium and heat a working fluid that transfers the power to the balance of plant. If magnetic confinement is used, a *magnet* system, using primarily cryogenic superconducting magnets, is needed, and usually systems for heating and refueling the plasma and for driving current. In inertial confinement, a *driver* (laser or accelerator) and a focusing system are needed, as well as a means for forming and positioning the *pellets.*

The magnetic fusion energy (MFE) program seeks to establish the conditions to sustain a nuclear fusion reaction in a plasma that is contained by magnetic fields to allow the successful production of fusion power.

In thirty years, scientists have increased the Lawson criterion of the ICF and tokamak installations by tens of times. Unfortunately, all current and some new installations (ICF and totamak) have a Lawrence criterion that is tens of times lower than is necessary (Figure 3).

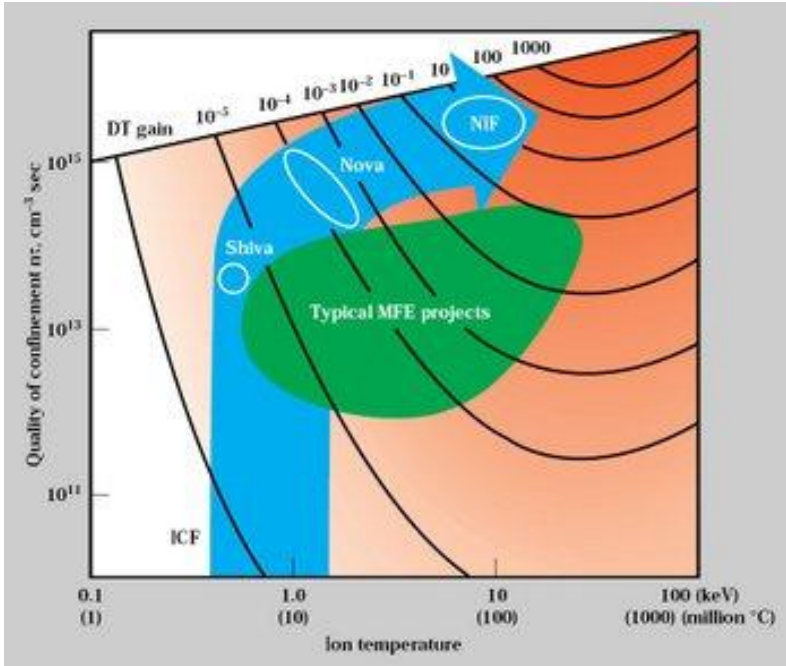

Figure 3. Parameter space occupied by inertial fusion energy and magnetic fusion energy devices. The regime allowing thermonuclear ignition with high gain lies near the upper right corner of the plot.

INNOVATION

As you can see in the Equation for thermonuclear reaction (reaction's "ignition") it is necessary to rapidly and greatly increase the target-enveloping temperature, the density of target proper and to shorten the time of the operation in order to keep the fuel in these precisely induced conditions. In ICF the density of plasma is very high (10^{28} m^{-3}, it increases in 20-30 times in target), the temperature reaches tens of millions ^{o}K, but time is measured in nanoseconds. As a result, the Lawson criterion is tens to hundreds of times lower than is required. In a tokomak, the time is mere parts of second and the ambient temperature is tens of millions of degrees, but density of plasma is very small (10^{20} m^{-3}). The Lawson criterion is also tens to hundreds of times lower than needed.

The author offers some innovations and names these reactors as AB-reactors.. The main innovations are below.

Multi-reflect reactor (MRR). The first innovation suggested early in 1983 [14] and developed later in [1]-[26] for multi-reflex engine and space propulsion. Conventional ICF has conventional inside surface of the combustion chamber. This surface absorbs part of the heat radiation emanating from the pellet and plasma, the rest of the radiation reflects in all directions and is also absorbed by walls of combustion chamber. As result the target loses energy expensively delivered by lasers. This loss is so huge that we need very powerful lasers and we cannot efficiently heat the target to reach ignition temperature (Lawson's criterion). In all current ICF installations this loss is tens of times more than is acceptable.

The innovative ICF has, on the inside surface of combustion chamber, a covering of small Prism Reflectors (PR) (figs. 4, 5) (or multi-layer reflector. Note: Multi-layer reflector can only reflect the laser beam). The system of prism reflectors has great advantages in comparison with conventional mirror and especially with conventional combustion chamber. The advantages are listed:

(1) The prism reflector has very high efficiency. The coefficient of its radiate absorption is less about million times the rate of the conventional mirror.
(2) The prism mirror reflects the radiation in widely diapason of continuous spectrum. A conventional mirror reflects the radiation only in narrow diapason of continuous spectrum. That means that any conventional mirror has big absorption of radiation energy even if it has high reflectivity (up 99%) in narrow interval of the continuous spectrum. The prism reflector allows to use the thermal plasma radiation.
(3) The prism reflector bounces the heat radiation exactly to a point where heat beam comes up, even if it has defect at position. The conventional mirror having small defect in position (or the pellet is not located exactly in center of sphere) destroys the pellet.
(4) According with Point 3 above, the prism reflector may be used in cylindrical (toroidal) camera (Figure5) (tokomak, stellarator). A conventional mirror cannot be employed because reflected ray will be sent in the other direction.
(5) The prism reflector can uniformly distribute the beam energy in pellet surface. The small spherical plasma pellet reflected the scattered radiation. That means the laser beam after the first reflection reflects on semi-sphere, after two reflections that presses on full sphere, after 3 - 4 reflection the pressure is almost uniformly. That decreases a number of needed laser beams, simplify, and decreases cost of laser installation.

In particular, this innovation may be used in already built current reactors for their improvement.

Self-Magnetic reactor (SMR) (Figures 6, 7). The magnetic pressure is proportional to the inverse value of electric conductor diameter. (The conventional magnetic reactor has a diameter of plasma flex some meters). The high temperature plasma has excellent conductivity which does not depend from plasma density. If the diameter is decreased to 0.1 mm and electric currency is high, the magnetic pressure is increased by hundreds or thousand times and that can keep the high-density plasma. Thus, the plasma is confined by self-generated magnetic field (and by pinch-effect) and it does not need in powerful outer magnetic field created very complex, high cost super-conductivity system! This innovation in MCF is dramatically decreasing the size of reaction zone and using of gaseous compression fuel pellet (micro-capsule) in magnetic confinement reactor.

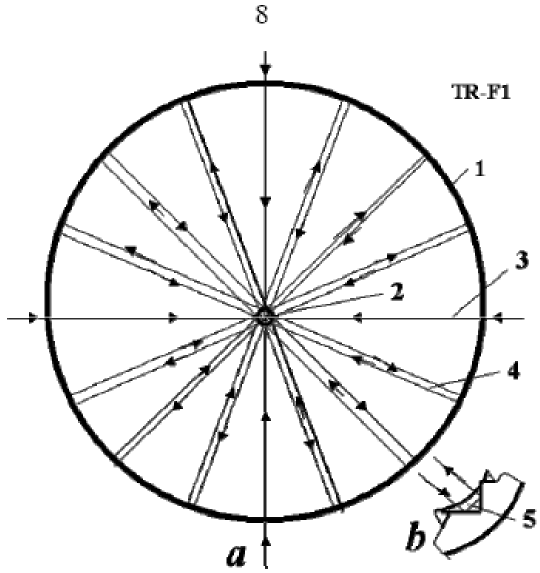

Figure 4. Multi-reflex Reactor. (a) Cross-section of ICF; (b) Cross-section of spherical combustion chamber and prism reflectors. *Notations*: 1 - spherical shell; 2 - target (pellet); 3- ignition laser beams; 4 - reflected laser beams; 5 - prism reflector.

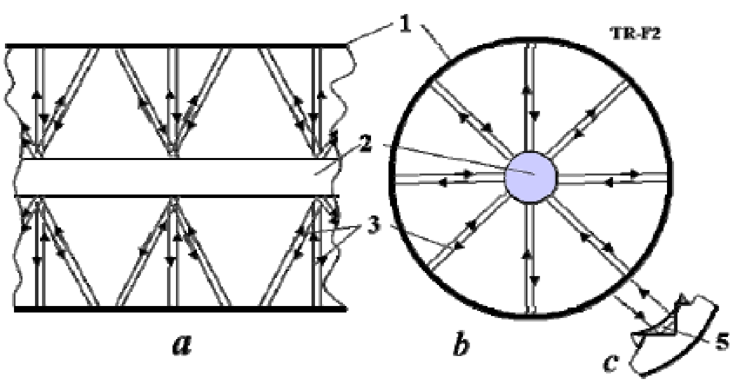

Figure 5. Multi-reflective in cylindrical tube chamber or tokomak. (a) Cross-section along long axis. (b) Cross-section along transverse axis; (c) Cross-section of toroidal or cylindrical combustion and prism reflectors. *Notations:* 1 - combustion chamber; 2 - plasma (fuel capsule); 3 - reflected laser beams; 5 - prism reflectors.

The other innovation in SMR is uses the electric current (electric impulse) for initial heating of microcapsule targets. That means we don't need a large, very complex and expensive laser (or ion beam) system for inertial confinement reactor or induce system in magnetic confinement reactor. That is possible in special design of the fuel microcapsule. The energy for heating of the microcapsule to thermonuclear temperature is small and conventional condensers may be used for it.

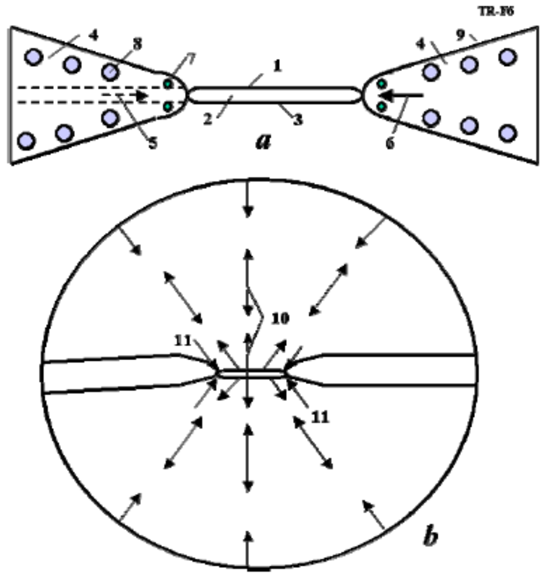

Figure 6. Micro AB-reactor with self-magnetic confinement and radiation support of plasma. (a) – fuel micro-capsule and electrodes; (b) - Reflective camera. *Notations*: 1 - micro fuel capsule; 2 - thermonuclear fuel into capsule; 3 - capsule shell and covering; 4 - electrodes; 5 - feeding of capsule; 6 - electric currency (electron injector); 7 - magnetic stopper; 8 - cooling system; 9 - thermo protection; 10 - radiation; 11 - additional radiation pressure to fuel capsule ends.

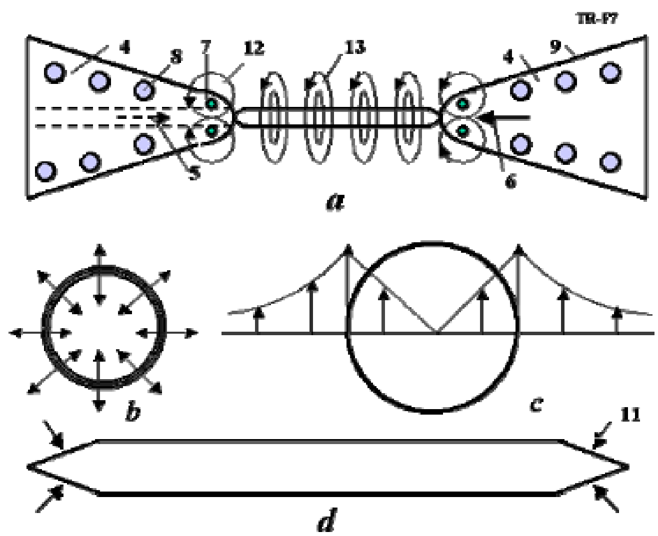

Figure 7. Micro AB-thermonuclear reactor with self-magnetic confinement. (a) Self-magnetic field around fuel capsule, (b) - Explosion initial compression, (c) Magnetic intensity distribution in cross-section plasma flex, (d) Fuel capsule. *Notations*: 4 - electrodes; 5 - feeding of capsule; 6 - electric currency (electron injector); 7 - magnetic stopper; 8 - cooling system; 9 - thermo protection; 11 - additional end capsule pressure of self-magnetic field and radiation; 12 - magnetic corks. 13 - self-magnetic field of capsule (and pinch-effect).

The self-magnetic reactor uses very small capsule diameter when the magnetic intensity is very high. The magnetic intensity has good distribution (decreases to plasma center, Figure 7c) and magnetic pressure is big (it is enough to keep the kinetic plasma pressure which is not so much for low density plasma).

The some innovations are magnetic and radiation stoppers (confinements) of plasma in ends of the fuel capsule. It is suggested two methods:

(1) The capsule has conic ends (Figure 7d). The capsule radius decreases at ends. That means the magnetic intensity will increase at the capsule ends (up 10 and more times). They will work as magnetic mirror (plasma stopper) (Figure 7).
(2) Our magnetic field has other direction and form then it is in conventional tokomak. In tokomak the magnetic lines are parallel to a toroid (or cylinder) axis. In our SMR the magnetic lines are circles around cylindrical capsule. That means there is an axis magnetic force which put obstacles a heat transfer from plasma to electric electrodes. That works as radial and axial magnetic stopper.

There are others innovations which reader can apprehend in comparison the offered micro AB-reactors and current and under construction reactors.

These innovations decrease the size, weight and the monetary cost of thermonuclear reactors by thousands of times and allow the widespread future construction of thermonuclear electric stations, engines, and space propulsions.

The offered self-magnetic reactor has the following differences in comparison with Z - machine of Sandia Laboratory (USA). Z-machine used a set of very fine tungsten wires running around the fuel would be "dumped" with the current instead. The wires would quickly vaporize into a plasma, which is conductive, and the current flow would then cause the plasma to pinch. The key difference is that the plasma would not be the fuel, as in our SMR, but used solely to generate very high-energy X-rays as the metal plasma compressed and heated. The x-rays would compress a tiny fuel cylinder containing deuterium-tritium mix, in the same fashion that the X-rays generated from a nuclear bomb compress the fuel load in an H-bomb. The superpower x-ray output pulse (up 2.7 megajouls!) generated by heavy tungsten metal plasma ($^{74}_{184}W$) is very danger for people. In additional, the powerful fluctuation in the magnetic field (an "electromagnetic pulse") also generates strong electric current in all of the metallic objects in the room and demiges electronic devices. In our machime the small fuel cylinder has a thin conductive layer from light metall. The capsule can also have contactivity filaments into fuel. They help to produce initial heating of fuel plasma (up $10^4 \div 10^5$ ^{o}K) and initial the plasma compression (rocket and/or inertial). The father plasma heating and confinement is produced by voltage curve of Figure 17 which create self-magnetic field equil (or more) plasma gas pressure.

Summary. This work offers two types of micro-AB-thermonuclear reactors: by multi-reflex radiation confinement of plasma and self-magnetic confinement. They can use high and low density fuel (compressed gas or liquid/frizzed fuel) and they can work in pulse or continuous regimes.

The offered micro-AB-reactor with self-magnetic confinement includes: micro fuel capsule with compressed gaseous or liquid (frizzed) fuel; two electric electrodes, and a combustion chamber. Internal surface of combustion chamber is covered by prism or multi-layer reflectors.

The capsule contains thermonuclear fuel (it conventionally has two component, example D + T), and conducting capsule shell. Fuel may be composed by conducting fiber for quick heating. The capsule has the conic ends.

The electric electrodes have windings for creating magnetic locks, canals for feeding of fuel capsule (or injector for liquid fuel), and electron injector (electric currency). Last may be electron (currency) emitter. Electrodes also contain a cooling system and thermo-protection.

The suggested reactor works the following way. The strong impulse electric current passes through capsule. The capsule shell explodes, creating an initial plasma flux and compressed, heating, and creating initial fuel plasma fuse. The plasma radiation erupts and part of them returns and compresses the plasma, helping the electric current to heat the plasma to its ignition temperature.

We spoke about micro AB-reactors. But it does not mean that power of them is small. In next articles I will discuss the methods for transformation and utilization of the thermonuclear energy into other types of energy and propulsion. These completed research show the power of micro AB-reactor can reach some thousands of kW.

The computations of the offered reactors are presented below.

THEORY OF CURRENT THERMONUCLEAR REACTOR

Methods of Confinement in Current Reactors

Magnetic confinement. Magnetic fields can confine fusion fuel because plasma is a very good electrical conductor. A variety of magnetic configurations can be used, the most basic distinction being tokamaks and stellarators.

Inertial confinement. A third confinement principle is to apply a rapid pulse of energy to a large part of the surface of a pellet of fusion fuel, causing it to simultaneously "implode" and heat to very high pressure and temperature. If the fuel is dense enough and hot enough, the fusion reaction rate will be high enough to burn a significant fraction of the fuel before it has dissipated. To achieve these extreme conditions, the initially cold fuel must be explosively compressed. Inertial confinement is used in the hydrogen bomb, where the driver is x-rays created by a fission bomb. Inertial confinement is also attempted in "controlled" nuclear fusion, where the driver is a laser, ion, or electron beam.

Some other confinement principles have been investigated, such as muon-catalyzed fusion, the Farnsworth-Hirsch fusor (inertial electrostatic confinement), and bubble fusion.

In man-made fusion, the primary fuel is not constrained to be protons and higher temperatures can be used, so reactions with larger cross-sections are chosen. This implies a lower Lawson criterion, and therefore less startup effort. Another concern is the production of neutrons, which activate the reactor structure radiologically, but also have the advantages of allowing volumetric extraction of the fusion energy and tritium breeding. Reactions that release no neutrons are referred to as *aneutronic*.

In order to be useful as a source of energy, a fusion reaction must satisfy several criteria. It must:

- *be exothermic* - This may be obvious, but it limits the reactants to the low Z (number of protons) side of the curve of binding energy. It also makes helium ^{4}He the most common product because of its extraordinarily tight binding, although ^{3}He and ^{3}H also show up.
- *involve low Z nuclei* - This is because the electrostatic repulsion must be overcome before the nuclei are close enough to fuse.
- *have two reactants* - At anything less than stellar densities, three body collisions are too improbable. It should be noted that in inertial confinement, both stellar densities and temperatures are exceeded to compensate for the shortcomings of the third parameter of the Lawson criterion, ICF's very short confinement time.
- *have two or more products* - This allows simultaneous conservation of energy and momentum without relying on the (weak!) electromagnetic force.
- *conserve both protons and neutrons* - The cross sections for the weak interaction are too small.

Few reactions meet these criteria. The following are those with the largest cross-sections:

Table 1. Suitable reactions for thermonuclear fusion

(1)	D	+	T			^{4}He	(3.5 MeV)	+		n	(14.1 MeV)					
(2i)	D	+	D			T	(1.01 MeV)	+		p	(3.02 MeV)					*50%*
(2ii)						^{3}He	(0.82 MeV)	+		n	(2.45 MeV)					*50%*
(3)	D	+	^{3}He			^{4}He	(3.6 MeV)	+		p	(14.7 MeV)					
(4)	T	+	T			^{4}He		+	2	n	+ 11.3 MeV					
(5)	^{3}He	+	^{3}He			^{4}He		+	2	p	+ 12.9 MeV					
(6i)	^{3}He	+	T			^{4}He		+		p		+	n	+ 12.1 MeV		*51%*
(6ii)						^{4}He	(4.8 MeV)	+		D	(9.5 MeV)					*43%*
(6iii)						^{4}He	(0.5 MeV)	+		n	(1.9 MeV)	+	p	(11.9 MeV)		*6%*
(7)	D	+	^{6}Li		2	^{4}He	+ 22.4 MeV									
(8)	p	+	^{6}Li			^{4}He	(1.7 MeV)	+		^{3}He	(2.3 MeV)					
(9)	^{3}He	+	^{6}Li		2	^{4}He		+		p	+ 16.9 MeV					
(10)	p	+	^{11}B		3	^{4}He	+ 8.7 MeV									

p (protium), D (deuterium), and T (tritium) are shorthand notation for the main three isotopes of hydrogen.

For reactions with two products, the energy is divided between them in inverse proportion to their masses, as shown. In most reactions with three products, the distribution of energy varies. For reactions that can result in more than one set of products, the branching ratios are given.

Some reaction candidates can be eliminated at once. The D-^{6}Li reaction has no advantage compared to p-^{11}B because it is roughly as difficult to burn but produces substantially more neutrons through D-D side reactions. There is also a p-^{7}Li reaction, but the cross-section is far too low except possible for T_i > 1 MeV, but at such high temperatures an endothermic, direct neutron-producing reaction also becomes very significant. Finally there is also a p-^{9}Be reaction, which is not only difficult to burn, but ^{9}Be can be easily induced to split into two alphas and a neutron.

In addition to the fusion reactions, the following reactions with neutrons are important in order to "breed" tritium in "dry" fusion bombs and some proposed fusion reactors:

$$n + {}^{6}Li \rightarrow T + {}^{4}He\ ,$$
$$n + {}^{7}Li \rightarrow T + {}^{4}He + n\ .$$

To evaluate the usefulness of these reactions, in addition to the reactants, the products, and the energy released, one needs to know something about the cross section. Any given fusion device will have a maximum plasma pressure that it can sustain, and an economical device will always operate near this maximum. Given this pressure, the largest fusion output is obtained when the temperature is selected so that $\langle\sigma v\rangle/T^2$ is a maximum. This is also the temperature at which the value of the triple product $nT\tau$ required for ignition is a minimum. This chosen optimum temperature and the value of $\langle\sigma v\rangle/T^2$ at that temperature is given for a few of these reactions in the following table.

Table 2. Optimum temperature and the value of $\langle\sigma v\rangle/T^2$ at that temperature

fuel	T [keV]	$\langle\sigma v\rangle/T^2$ [$m^3/s/keV^2$]
D-T	13.6	1.24×10^{-24}
D-D	15	1.28×10^{-26}
D-^{3}He	58	2.24×10^{-26}
p-^{6}Li	66	1.46×10^{-27}
p-^{11}B	123	3.01×10^{-27}

Note that many of the reactions form chains. For instance, a reactor fueled with T and ^{3}He will create some D, which is then possible to use in the D + ^{3}He reaction if the energies are "right". An elegant idea is to combine the reactions (8) and (9). The ^{3}He from reaction (8) can react with ^{6}Li in reaction (9) before completely thermalizing. This produces an energetic proton which in turn undergoes reaction (8) before thermalizing. A detailed analysis shows that this idea will not really work well, but it is a good example of a case where the usual assumption of a Maxwellian plasma is not appropriate.

Any of the reactions above can, in principle, be the basis of fusion power production. In addition to the temperature and cross section discussed above, we must consider the total energy of the fusion products E_{fus}, the energy of the charged fusion products E_{ch}, and the atomic number Z of the non-hydrogenic reactant.

Specification of the D-D reaction entails some difficulties, though. To begin with, one must average over the two branches (2) and (3). More difficult is to decide how to treat the T and ^{3}He products. T burns so well in a deuterium plasma that it is almost impossible to extract from the plasma. The D-^{3}He reaction is optimized at a much higher temperature, so the burn-up at the optimum D-D temperature may be low, so it seems reasonable to assume the T but not the ^{3}He gets burned up and adds its energy to the net reaction. Thus we will count the D-D fusion energy as $E_{fus} = (4.03+17.6+3.27)/2 = 12.5$ MeV and the energy in charged particles as $E_{ch} = (4.03+3.5+0.82)/2 = 4.2$ MeV.

Another unique aspect of the D-D reaction is that there is only one reactant, which must be taken into account when calculating the reaction rate.

With this choice, we tabulate parameters for four of the most important reactions.

Table 3. Parameters of the most important reactions

Fuel	Z	E_{fus} [MeV]	E_{ch} [MeV]	neutronicity
D-T	1	17.6	3.5	0.80
D-D	1	12.5	4.2	0.66
D-^{3}He	2	18.3	18.3	~ 0.05
p-^{11}B	5	8.7	8.7	~ 0.001

The last column is the *neutronicity* of the reaction, the fraction of the fusion energy released as neutrons. This is an important indicator of the magnitude of the problems associated with neutrons like radiation damage, biological shielding, remote handling, and safety. For the first two reactions it is calculated as $(E_{fus}-E_{ch})/E_{fus}$. For the last two reactions, where this calculation would give zero, the values quoted are rough estimates based on side reactions that produce neutrons in a plasma in thermal equilibrium.

Of course, the reactants should also be mixed in the optimal proportions. This is the case when each reactant ion plus its associated electrons accounts for half the pressure. Assuming that the total pressure is fixed, this means that density of the non-hydrogenic ion is smaller than that of the hydrogenic ion by a factor 2/(Z+1). Therefore the rate for these reactions is reduced by the same factor, on top of any differences in the values of $<\sigma v>/T^2$. On the other hand, because the D-D reaction has only one reactant, the rate is twice as high as if the fuel were divided between two hydrogenic species.

Thus, there is a "penalty" of (2/(Z+1)) for non-hydrogenic fuels arising from the fact that they require more electrons, which take up pressure without participating in the fusion reaction. There is, at the same time, a "bonus" of a factor 2 for D-D due to the fact that each ion can react with any of the other ions, not just a fraction of them.

We can now compare these reactions in the following table 4.

Table 4. Comparison of reactions

fuel	$<\sigma v>/T^2$	penalty/ bonus	reactivity	Lawson criterion	power density
D-T	1.24×10^{-24}	1	1	1	1
D-D	1.28×10^{-26}	2	48	30	68
D-^{3}He	2.24×10^{-26}	2/3	83	16	80
p-^{11}B	3.01×10^{-27}	1/3	1240	500	2500

The maximum value of $<\sigma v>/T^2$ is taken from a previous table. The "penalty/bonus" factor is that related to a non-hydrogenic reactant or a single-species reaction. The values in the column "reactivity" are found by dividing (1.24×10^{-24} by the product of the second and third columns. It indicates the factor by which the other reactions occur more slowly than the D-T reaction under comparable conditions. The column "Lawson criterion" weights these results with E_{ch} and gives an indication of how much more difficult it is to achieve ignition with these reactions, relative to the difficulty for the D-T reaction. The last column is labeled "power density" and weights the practical reactivity with E_{fus}. It indicates how much lower the fusion power density of the other reactions is compared to the D-T reaction and can be considered a measure of the economic potential.

Bremsstrahlung (Brake) Losses

Bremsstrahlung, (from the German *bremsen*, to brake and *Strahlung*, radiation, thus, "braking radiation"), is electromagnetic radiation produced by the acceleration of a charged particle, such as an electron, when deflected by another charged particle, such as an atomic nucleus. The term is also used to refer to the process of producing the radiation. Bremsstrahlung has a continuous spectrum. The phenomenon was discovered by Nikola Tesla (1856-1943) during high frequency research he conducted between 1888 and 1897.

Bremsstrahlung may also be referred to as free-free radiation. This refers to the radiation that arises as a result of a charged particle that is free both before and after the deflection (acceleration) that causes the emission. Strictly speaking, bremsstrahlung refers to any radiation due to the acceleration of a charged particle, which includes synchrotron radiation; however, it is frequently used (even when not speaking German) in the more literal and narrow sense of radiation from electrons stopping in matter.

Table 5. Rough optimum temperature and the power ratio of fusion and Bremsstrahlung radiation lost

Fuel	T_i (keV)	$P_{fusion}/P_{Bremsstrahlung}$
D-T	50	140
D-D	500	2.9
D-^{3}He	100	5.3
^{3}He-^{3}He	1000	0.72
p-^{6}Li	800	0.21
p-^{11}B	300	0.57

The ions undergoing fusion will essentially never occur alone but will be mixed with electrons that neutralize the ions' electrical charge and form a plasma. The electrons will generally have a temperature comparable to or greater than that of the ions, so they will collide with the ions and emit Bremsstrahlung. The Sun and stars are opaque to Bremsstrahlung, but essentially any terrestrial fusion reactor will be optically thin at relevant wavelengths. Bremsstrahlung is also difficult to reflect and difficult to convert directly to electricity, so the ratio of fusion power produced to Bremsstrahlung radiation lost is an important figure of merit. This ratio is generally maximized at a much higher temperature than that which maximizes the power density (see the previous subsection). The following table shows the rough optimum temperature and the power ratio at that temperature for several reactions.

The actual ratios of fusion to Bremsstrahlung power will likely be significantly lower for several reasons. For one, the calculation assumes that the energy of the fusion products is transmitted completely to the fuel ions, which then lose energy to the electrons by collisions, which in turn lose energy by Bremsstrahlung. However because the fusion products move much faster than the fuel ions, they will give up a significant fraction of their energy directly to the electrons. Secondly, the plasma is assumed to be composed purely of fuel ions. In practice, there will be a significant proportion of impurity ions, which will lower the ratio. In particular, the fusion products themselves *must* remain in the plasma until they have given up their energy, and *will* remain some time after that in any proposed confinement scheme. Finally, all channels of energy loss other than Bremsstrahlung have been neglected. The last two factors are related. On theoretical and experimental grounds, particle and energy confinement seem to be closely related. In a confinement scheme that does a good job of retaining energy, fusion products will build up. If the fusion products are efficiently ejected, then energy confinement will be poor, too.

The temperatures maximizing the fusion power compared to the Bremsstrahlung are in every case higher than the temperature that maximizes the power density and minimizes the required value of the fusion triple product (Lawson criterion). This will not change the optimum operating point for D-T very much because the Bremsstrahlung fraction is low, but it will push the other fuels into regimes where the power density relative to D-T is even lower and the required confinement even more difficult to achieve. For D-D and D-^{3}He, Bremsstrahlung losses will be a serious, possibly prohibitive problem. For ^{3}He-^{3}He, p-^{6}Li and p-^{11}B the Bremsstrahlung losses appear to make a fusion reactor using these fuels impossible.

In a plasma, the free electrons are constantly producing Bremsstrahlung in collisions with the ions. The power density of the Bremsstrahlung radiated is given by

$$P_{Br} = \frac{16\alpha^3 h^2}{\sqrt{3}\, m_e^{3/2}} n_e^2 T_e^{1/2} Z_{eff}$$

T_e is the electron temperature, α is the fine structure constant, h is Planck's constant, and the "effective" ion charge state Z_{eff} is given by an average over the charge states of the ions:

$$Z_{eff} = \Sigma\,(Z^2 n_Z) / n_e$$

This formula is derived in "Basic Principles of Plasmas Physics: A Statistical Approach" by S. Ichimaru, p. 228. It applies for high enough T_e that the electron deBroglie wavelength is longer than the classical Coulomb distance of closest approach. In practical units, this formula gives

$$P_{Br} = (1.69\times10^{-32}\ /\mathrm{W\ cm^{-3}})\ (n_e/\mathrm{cm^{-3}})^2\ (T_e/\mathrm{eV})^{1/2}\ Z_{eff}$$

$$= (5.34\times10^{-37}\ /\mathrm{W\ m^{-3}})\ (n_e\ /\mathrm{m^{-3}})^2\ (T_e\ /\mathrm{keV})^{1/2}\ Z_{eff}$$

where Wcm^{-3}, cm^{-3}, eV, Wm^{-3}, m^{-3}, keV are units of correcponding magnitudes. For very high temperatures there are relativistic corrections to this formula, that is, additional terms of order $T_e/m_e c^2$.

LIST OF MAIN EQUATIONS

Below are the main equations for estimation of benefits from the offered innovations.

1. Energy Needed for Thermonuclear Reaction

$$F = k\frac{Q_1 Q_2}{r^2}, \quad E = \int_{r_0}^{\infty} F\,dr, \quad E = \frac{kZ_1 Z_2 e^2}{r_0},$$
$$r_i = (1.2 \div 1.5)\cdot 10^{-15}\sqrt[3]{A}, \quad A = Z + N, \; r_0 = r_1 + r_2 \qquad (1)$$

where k = 9×10^9 constant; Z_1, Z_2 are charge state of 1 and 2 particles respectively; e = 1,6×10^{-19} C is charge of electron; $r_o = r_1 + r_2$ is sum of radius of nuclear force, m; A is number of element; F is force, N; E is energy, J; Q is charge of particles.

For example, for reaction H+H (hydrogen, $Z_1 = Z_2 = 1$, $r_o \approx 2\times10^{-15}$ m) this energy is ≈ 0.7 MeV or 0.35 MeV for every particle. The real energy is about 30 times less because part of the particles has more average speed and there is a tunnel effect.

2. Energy Needed for Ignition. Figure 8 shows a magnitude $n\tau$ (analog of Lawson criterion) required for ignition.

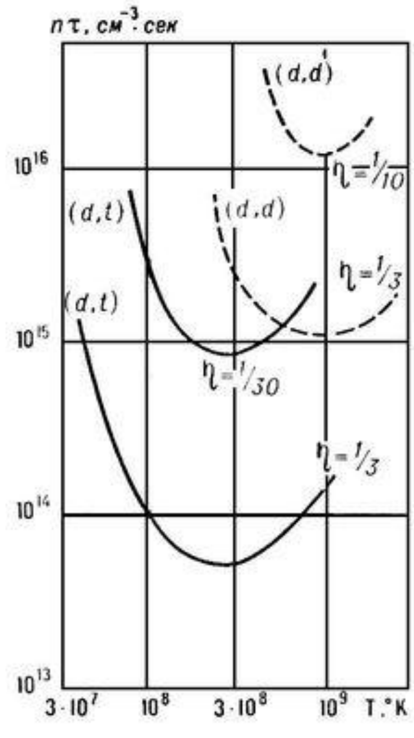

Figure 8. Value $n\tau$ (analog of Lawson criterion) versus temperature in K. Value $n\tau$ is in s/cm^3, η is efficiency coefficient.

At present the industry produces power lasers:

- Carbon dioxide lasers emit up to 100 kW at 9.6 µm and 10.6 µm, and are used in industry for cutting and welding.
- Carbon monoxide lasers must be cooled but can produce up to 500 kW.

Special laser and ICF reastors:

- NOVA (1999, USA). Laser 100 kJ (wavelenght $\lambda=1054\times10^{-9}$ m) and 40 kJ (wavelenght $\lambda=351\times10^{-9}$ m), power few tens of terawatts (1 TW = 10^{12} W), time of impulse $(2 \div 4)\times10^{-9}$ s, 10-beams, Matter is Nd:class.
- OMERA (1995, USA). 60-beam, neodyminm class laser, 30 kJ, power 60 TW.
- Z-mashine (USA, under constructin), Power is up 350 TW. It can create currency impuls up 20×10^6 A.
- NIF (USA). As of 2005 the National Ignition Facility is working on a system that, when complete, will contain 192-beam, 1.8-megajoule, 700-terawatt laser system adjoining a 10-meter-diameter target chamber.
- 1.25 PW - world's most powerful laser (claimed on 23 May 1996 by Lawrence Livermore Laboratory).

3. *Radiation energy* from hot solid black body is (Stefan-Boltzmann Law):

$$E = \sigma T^4, \tag{2}$$

where E is emitted energy, W/m^2; $\sigma = 5.67\times10^{-8}$ - Stefan-Boltzmann constant, W/m^2 ^{o}K^4; T is temperature in ^{o}K.

4. *Wavelength* corresponded of maximum energy density (Wien's Law) is

$$\lambda_0 = \frac{b}{T}, \quad \omega = \frac{2\pi}{\lambda_0} \tag{3}$$

where $b = 2.8978\times10^{-3}$ is constant, m ^{o}K; T is temperature, ^{o}K; ω is angle frequency of wave, rad/s.

5. *Pressure for Single Full Reflection* is

$$F = 2E/c, \tag{4}$$

where F - pressure, N/m^2; $c = 3\times10^8$ is light speed, m/s, E is radiation power, W/m^2. If plasma does not reflect radiation the pressure equals

$F = E/c$. (5)

6. Pressure for Plasma Multi-Reflection [23-25] is

$$F = \frac{2E}{c}\left(\frac{2}{1-q}\right), \tag{6}$$

where q is plasma reflection coefficient. For example, if q = 0.98 the radiation pressure increases by 100 times. We neglect losses of prism reflection.

7. The Bremsstrahlung (Brake) Loss energy of plasma by radiation is ($T > 10^6$ °K)

$$P_{Br} = 5.34\cdot 10^{-37} n_e^2 T^{0.5} Z_{eff}, \quad \text{where} \quad Z_{eff} = \sum (Z^2 n_z)/n_e \tag{7}$$

where P_{Br} is power of Bremsstrahlung radiation, W/m^3; n_e is number of particles in m^3; T is a plasma temperature, KeV; Z is charge state; Z_{eff} is cross-section coefficient for multi-charges ions. For reactions H+D, D+T the Z_{eff} equals 1.

That loss may be very much. For some reaction they are more then useful nuclear energy and fusion nuclear reaction may be stopped. The Bremsstrahlung emission has continuous spectra.

8. Electron Frequency in Plasma is

$$\omega_{pe} = \left(\frac{4\pi n_e e^2}{m_e}\right)^{1/2}, \quad \text{or} \quad \omega_{pe} = 5.64\times 10^4 (n_e)^{1/2} \quad \text{in "cgs" units, or} \quad \omega_{pe} = 56.4(n)^{1/2} \quad \text{in CI units} \tag{8}$$

where ω_{pe} is electron frequency, rad/s; n_{e} is electron density, [1/cm^3]; n is electron density, [1/m^3]; $m_{\text{e}} = 9.11\times10^{-28}$ is mass of electron, g; $e = 1.6\times10^{-19}$ is electron charge, C.

The plasma is reflected an electromagnet radiation if frequency of electromagnet radiation is less then electron frequency in plasma, $\omega < \omega_{\text{pe}}$. That reflectivity is high. For $T > 15\times10^6$ °K it is more than silver and increases with plasma temperature as $T^{3/2}$. The frequency of laser beam and Bremsstrahlung emission are less then electron frequency in plasma.

9. The Deep of Penetration of outer radiation into plasma is

$$d_p = \frac{c}{\omega_{pe}} = 5.31\cdot 10^5 n_e^{-1/2} \text{ . [cm]} \tag{9}$$

For plasma density $n_e = 10^{22}$ 1/cm^3 $d_p = 5.31\times10^{-6}$ cm.

10. The Gas (Plasma) Dynamic Pressure, p_k, is

$$p_k = nk(T_e + T_i) \quad \text{if} \quad T_e = T_k \quad \text{then} \quad p_k = 2nkT \qquad (10)$$

where k = 1.38×10^{-23} is Boltzmann constant; T_e is temperature of electrons, ^oK; T_i is temperature of ions, ^oK. These temperatures may be different; n is plasma density, 1/m^3; p_k is plasma pressure, N/m^2.

11. The gas (plasma) ion pressure, *p*, is

$$p = \frac{2}{3} nkT, \qquad (11)$$

Here n is plasma density in 1/m^3.

12. The magnetic p_m *and electrostatic pressure*, p_s, are

$$p_m = \frac{B^2}{2\mu_0}, \quad p_s = \frac{1}{2}\varepsilon_0 E_S^2 \qquad (12)$$

where B is electromagnetic induction, Tesla; μ_0 = 4π×10^{-7} electromagnetic constant; ε_0 = 8.85×10^{-12} , F/m, is electrostatic constant; E_S is electrostatic intensity, V/m.

13. Ion thermal velocity is

$$v_{Ti} = \left(\frac{kT_i}{m_i}\right)^{1/2} = 9.79\times 10^5 \mu^{-1/2} T_i^{1/2} \quad \text{cm/s} \ , \qquad (13)$$

where $\mu = m_i / m_p$, m_i is mass of ion, kg; m_p = 1.67×10^{-27} is mass of proton, kg.

14. Transverse Spitzer plasma resistivety

$$\eta_\perp = 1.03\times 10^{-2} Z \ln \Lambda T^{-3/2}, \quad \Omega\ \text{cm} \quad \text{or} \quad \rho \approx \frac{0.1\text{Z}}{\text{T}^{3/2}} \quad \Omega\,\text{cm} \quad , \qquad (14)$$

where ln Λ = 5 ÷ 15 ≈ 10 is Coulomb logarithm, Z is charge state.

15. Reaction rates <σv> (in cm^3 s^{-1}) averaged over Mexwellian distributions for low energy (T < 25 keV) may be represent by

$$(\overline{\sigma v})_{DD} = 2.33\times 10^{-14} T^{-2/3} \exp(-18.76\, T^{-1/3}) \quad \text{cm}^3\text{s}^{-1}, \qquad (15)$$
$$(\overline{\sigma v})_{DT} = 3.68\times 10^{-12} T^{-2/3} \exp(-19.94\, T^{-1/3}) \quad \text{cm}^3\text{s}^{-1},$$

where T is measured in keV.

16. The power density released in the form of charged particles is

$$P_{DD} = 3.3\times10^{-13} n_D^2 (\overline{\sigma v})_{DD}\,, \quad \text{W cm}^{-3}$$
$$P_{DT} = 5.6\times10^{-13} n_D n_T (\overline{\sigma v})_{DT}\,, \quad \text{W cm}^{-3} \qquad (16)$$
$$P_{DHe^3} = 2.9\times10^{-12} n_D n_{He^3} (\overline{\sigma v})_{DHe^3}\,, \quad \text{W cm}^{-3}$$

Here in P_{DD} equation it is included D + T reaction.

COMPUTED ESTIMATIONS OF AB-REACTORS

We consider two new Micro-AB-Reactors having the innovative: multi-reflect radiation and self-magnetic confinement features.

In multi-reflect radiation confinement of AB-Reactor the offered innovation is the special prisms, a high reflectivity mirror that returns the laser beam exactly to its point of origination. As a result, the all energy absorbs by plasma, the laser radiation multi-times presses the plasma and impedes it or, at least, it does not allow its expansion. The plasma has high reflectivity and this press effect may be increased hundreds to thousands of times. Practically speaking, we are weakly limited and can use the cheap and solid fuel.

The uniformly heating of target by laser beam is very big and important problem in ICF. The non-equal rocket forces on target shell destroy the capsule before thermonuclear ignition. If the first ICF reactor had some laser beams, the second generation had 10 laser beams (NOVA), the third generation has 60 beams (OMEGA), and the next generation will have 192 beams (NIF). All laser beams must be equal and work in coordination - that is complex, difficult and expensive problem. The prism reflector is easy designed such the reflected beam runs round the target and presses it uniformly from all sides after 2 - 4 reflections.

The second innovation is the special form microcapsule that is filled by compression gas or liquid (frozen) fuel.

In self-magnetic confinement Micro-AB-Reactor main innovation is super thin microcapsule and electric heating which produce high-intensity magnetic field, keeping the plasma pressure and conic (or close to conic) ends of ampoule capsule which work as plasma stoppers. The important innovation is the using an electric currency for straight heating of capsule. The magnetic lines in our reactor are circles located into and around plasma channel. The magnetic intensity increases from central axis to maximal plasma radius. That pushes plasma into center of plasma channel. In the ends of plasma channel the magnetic forces put obstacles in plasma leakage.

For estimation possibilities of these innovations in the first AB-reactor we compute the multi-reflection pressure, the condition of plasma reflection and compare them with dynamic pressure of plasma. In the second AB-reactor we consider the equilibrium the magnetic and kinetic pressures.

Capsules. For multi-reflex conformation is more suitable the *spherical capsule*. Let us consider the gas compressed fuel capsule**.** The shell thickness and relative weight of gas compressed fuel spherical capsule can be computed by equations:

$$\frac{\delta}{r}=\frac{P}{2\sigma}, \quad M_R=\frac{3}{2}\frac{P}{\sigma}\frac{\gamma_S}{\gamma_f}, \qquad (17)$$

where δ is shell thickness of capsula, [m]; r is capsule radius, [m[;δ/r is relative thickness of fuel shell; P is fuel gas pressure into capsule (over the atmospheric pressure), [N/m^2]; σ is safety tensile stress, N/m^2; M_R is relative capsule mass; γ_S is density of capsule shell, [kg/m^3]; γ_f is density of fuel, [kg/m^3].

Example, for gas pressure P = 100 atm = 10^7 N/m^2, σ = 200 kgf/mm^2 = 2×10^9 N/m^2, γ_s = 1800 kg/m^3; γ_f = 11 kg/m^3 (at P = 100 atm) we get $\delta/r = 2.5\times10^{-3}$, M_R = 0.6.

Cylindrical capsula ($l >> r$). For our estimations we take the capsule having the length 1 mm, radius r = 0.05 mm, cross section area $S \approx 8\times10^{-3}$ mm^3, fuel volume $V_c = 8\times10^{-3}$ mm^3 = 8×10^{-12} m^3. That is very small. It is a microcapsule.

If the gas in a microcapsule is pressed the relative thickness and relative mass of cylindrical shell may be computed by equations:

$$\frac{\delta}{r}\approx\frac{P}{\sigma}, \quad M_R\approx 2\frac{P}{\sigma}\frac{\gamma_s}{\gamma_f}, \qquad (18)$$

For P = 100 atm ($P = 10^7$ N/m^2) and σ = 200 kg/mm^2 ($\sigma = 2\times10^9$ N/m^2) ratio δ/r = 5×10^{-3}, M_S = 1.3 .

Fuel density. The particles (ions) density n of fuel in 1 m^3 and number of particles n_C in microcapsule equal

$$n=\frac{1}{2m_p}\left(\frac{\gamma_{f1}}{\mu_1}+\frac{\gamma_{f2}}{\mu_2}\right)=\frac{\gamma_{fa}}{\mu_a m_p}=\frac{\gamma_{fa}}{m_{ia}}\approx\frac{\gamma_{f1}}{\mu_1 m_p}, \quad n_C=nV_C$$

$$\text{where} \quad \mu_1=\frac{m_{i1}}{m_p}, \quad \mu_2=\frac{m_{i2}}{m_p} \qquad (19)$$

where m_{ia} =2.5×1.672×10^{-27} kg for D+T is average mass of fuel ion; m_p = 1.672×10^{-27} kg is proton mass; low indexes "$_{1,\,2}$" means the first and the second fuel component.

The $n \approx 10^{20}$ 1/m^3 in the present magnetic confinement fusion reactor; $n \approx 2.6\times10^{25}$ 1/ m^3 for gas D+T in a pressure 1 atm, T = 288 ^{o}K (the density of deuterium D is γ_{f1} = 0.0875 kg/m^3, μ_1 = 2, the density of Tritium is 1.5 more). For D and other pressure the n must be changed in same times, for example, if P = 100 atm then γ_f = 8.75 kg/m^3, $n \approx 2.6\times10^{27}$ 1/m^3, $n_c = 20.8\times10^{15}$; $n \approx 2.1\times10^{28}$ 1/m^3, $n_c = 1.7\times10^{17}$ (γ_f = 71 kg/m^3) for liquid hydrogen at a pressure of 1 atm. (In conventional inertial confinement fusion reactor, the fuel density may be more in 10 - 30 times, under a rocket pressure of a fuel capsule cover. For hydrogen the frizzed temperature is -259.34 ^{o}C, the boiling point is -252.87 ^{o}C). For D+T average μ_a = (2+3)/2 = 2.5.

Fuel mass M_f [kg] and thermonuclear *energy* E_C into microcapsule are computed by equations:

$$E = 1.6 \cdot 10^{-19} \frac{M_f}{\mu_N m_p} E_r = 0.96 \cdot 10^8 M_f \frac{E_r}{\mu_N},$$
$$M_f = \mu_N m_p n V_C, \quad E_C = 0.5 \times 1.6 \cdot 10^{-19} n V_C E_R \tag{20}$$

where E_r is reaction energy of one couple particles, eV; $\mu_N = \mu_1 + \mu_2$ is number of nucleons which take part in reaction, for D+T μ_N = 2+3=5. If we want compute energy of one type of particles, the E_r is reaction energy for given type of particles, for D+T the energy E_r = 17.5 MeV;. For example, our capsule (1×0.1 mm) filled by liquid fuel D+T has fuel mass M_f = 0.71×10^{-3} μg and will produce energy E_c = 240 kJ. If we burn out 10 capsules per 1 s, the engine power will be 2400 kW. An estimated 20% this energy gives the charged particles and 80% of neutrons. The fuel capsule having M = 10 μg =10^{-5} kg of a mixture D+T produces 3.34×10^9 J if all atoms take part in reaction. That is equivalent to the energy derived from 84 liters of benzene.

Computations are presented in Figure 9.

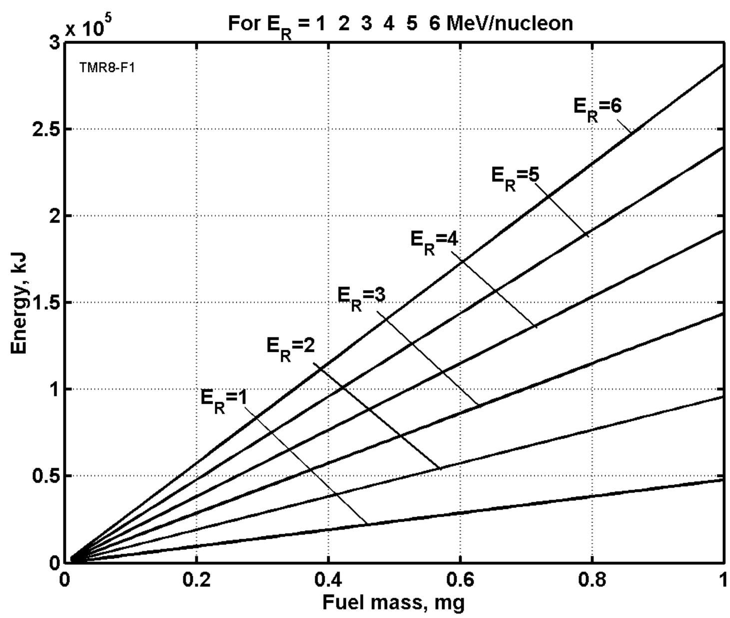

Figure 9. Energy of thermonuclear reactor versus the fuel mass and energy per one nucleon. $E_R = E_r / \mu_N$.

Distribution of thermonuclear energy between particles. In most cases the result of thermonuclear reaction is two components. As you see in Table 1 that may be "He" and neutron or proton. The thermonuclear energy distributes between them the following manner:

From $E = E_1 + E_2 = \frac{m_1 V_1^2}{2} + \frac{m_2 V_2^2}{2}, \quad m_1 V_1 = m_2 V_2,$ (21)

we have $\frac{E_1}{E} = \frac{m_2}{m_1 + m_2} = \frac{\mu_2}{\mu_1 + \mu_2}, \quad E_2 = E - E_1$

where m is particle mass, kg; V is particle speed, m/s; E is particle energy, J; $\mu = m_i / m_p$ is relative particle mass. Lower indexes "$_{1,\,2}$" are number of particles.

Unfortunately, as you can see (in Table 1), most particle energy catches the neutron as the lightest particle. But its emission has high penetrating capability, creating radioactive isotopes, causing damage to the main construction, very dangerous for living beings, and that can be converted only in heat energy.

Energy is needed for fuel heating. This energy can be estimated by equation:

$$E_h = \frac{c}{\mu_a} M T_k , \quad c = \frac{k}{2m_p} = 4.13 \cdot 10^3, \quad \mu_a = \frac{m_{ia}}{m_p} \tag{22}$$

where c is plasma thermal capacity, J/kg$\cdot$ ^{o}K; T_k is temperature in ^{o}K; k is Boltzmann constant, m_{ia} is average mass of ions, kg; M is fuel mass, kg. This computation is presented in Figure 10. Our capsule filled by liquid mixture D+T requests ignition energy about 124 J for its heating up to 100 million ^{o}K. That is energy of electric condenser having size about 10×10×10 cm for $\beta = 10^8$ V/m (see below).

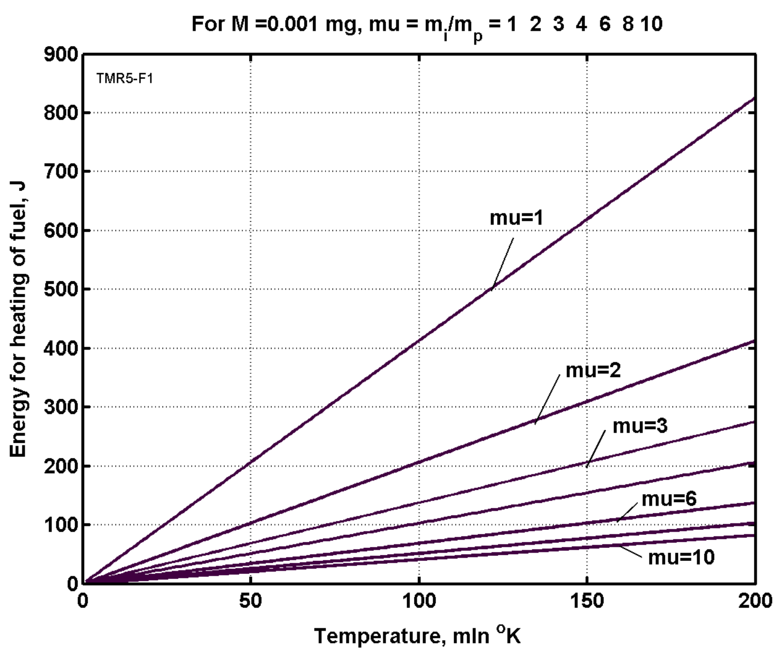

Figure 10. Energy requested for fuel D+T heating.

Capacitor for thermonuclear ignition. Condenser requested as storage of energy for fuel thermonuclear ignition my be estimated by equation

$$\frac{W}{V}=\frac{1}{2}\varepsilon_0\varepsilon\beta^2, \quad \frac{W}{M}=\frac{\varepsilon_0\varepsilon\beta^2}{2\gamma} \tag{23}$$

where W is condenser energy, J; V is condenser volume, m^3; M is condenser mass, kg; ε_o = 8.85×10^{-12} Φ/m is the electrostatic constant; ε is dielectric constant; β is dielectric strength, V/m; γ is specific density of dielectric, kg/m^3. Energy from capacitor is about one joule from one centimeter cub.

Electron plasma frequency. Electron frequency of plasma is computed by equation (8). For $n \approx 10^{20}$ 1/m^3 that is equals ω_{pe} = 5.64×10^{11} rad/s, for $n \approx 10^{28}$ 1/m^3 that equals ω_{pe} = 5.64×10^{15} rad/s . That is more then the laser frequency (λ = 0.3×10^{-9} m, ω = 2.1×10^{10} rad/s). That means the plasma will reflect the laser beam.

Plasma skin depth. The depth in plasma to which an electromagnetic radiation can penetrate (Eq. (9)) is: For $n \approx 10^{20}$ 1/m^3 that is equals d_p = 5.31×10^{-2} cm, for $n \approx 10^{28}$ 1/m^3 that equals d_p = 5.31×10^{-6} cm. As you see, the depth is small.

Coefficient reflectivity of plasma. No data about plasma reflectivity. However, from general theory of reflectivity it is known the reflectivity depends from conductivity (see Eq. (14)). Silver has the best conductivity from solid body and best reflectivity. It is about q = 0.78 ÷ 0.99 (it depends from frequency of radiation: for ultra-violet radiation $q \approx 0.78$, for thermal radiation $q \approx 0.99$). The plasma for $T > 15\times10^6$ ^{o}K has better conductivity then silver. The plasma conductivity increases as $T^{3/2}$. That means the plasma having the $T \approx 10^8$ ^{o}K has reflectivity in 17.2 times better then silver. That means the plasma reflectivity is more 0.999. We take in our computation q = 0.999. The efficiency of offered innovation very strong depends from reflectivity of plasma. The reflectivity of the prism mirror is very high [23]. We neglect the loss in it.

Bremsstrahlung (brake) radiation. That is proportional the energy spectra E and has Maxwell distribution:

$$f_E dE = f_p\left(\frac{dP}{dE}\right)dE = 2\sqrt{\frac{E}{\pi(kE)^3}}\exp\left[\frac{-E}{kT_k}\right]dE,$$
$$\lambda=\frac{c}{\nu}, \quad \nu=\frac{c}{\lambda}=\frac{E}{h} \tag{24}$$

where k = 1,38×10^{-23} is Boltzmann's constant, J/^{o}K; T - temperature, ^{o}K; E - energy, J; ν - frequency, 1/s; λ length of wave, m; h = 6.525×10^{-34} is Planck's constant, J·s. Assume the brake radiation has same specter.

Computations are presented in figures 11-12.

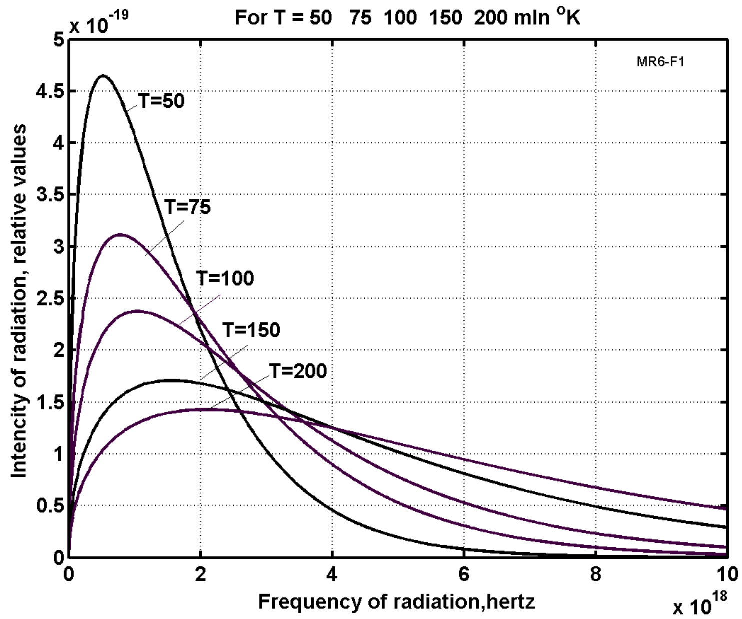

Figure 11. Spectra of brake radiation for plasma temperature 60 - 200 millions degrees (°K).

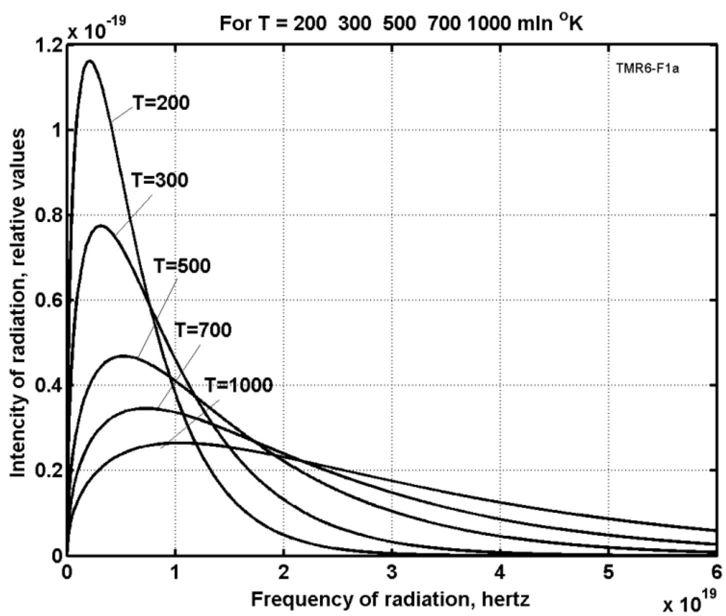

Figure 12. Spectra of brake radiation for plasma temperature 200 - 1000 millions degrees (°K).

The ultra-violet rays are below approximately < 3×10^{17} hertz ($\lambda > 10^{-9}$ m), the soft *x*-rays are below < 3×10^{19} hertz ($\lambda > 10^{-11}$ m). That means the brake radiation can be reflected by special methods. For example, the silver having high electro-conductivity has average reflectivity 0.99 in heat region, 0.95 in light region, and 0.78 in ultra-violet region. Some metals has reflectivity up 0.2 for $\lambda = 40\times10^{-9}$ m. But plasma having the temperature more than 15×10^{6} °K has more electro-conductivity then silver and it must, therefore, have better reflectivity. The reflectivity coefficient of prism mirror is very high and we can neglect its losses. However, the reflectivity of prism mirror for brake radiation is needed in a detailed test.

The average energy of Bremsstrahlung photon equals average energy of plasma electron. The formula for average wavelength is:

$$\text{From} \quad E = kT_k = h\nu, \quad \lambda = \frac{c}{\nu}$$

$$\text{we receive} \quad \lambda_e = \frac{ch}{kT_k} = \frac{0.0144}{T_k} \tag{25}$$

where E is electron energy, $c = 3\times10^{8}$ is light speed, m/s; T_k is temperature in °K; λ_e is wave length, m ; ν is wave frequency, 1/s;.

For example, for $T_k = 10^{8}$ °K the $\lambda_e = 1.44\times10^{-10}$ m. That value is the lower ultra-violet diapason $\lambda > 10^{-9}$ m.

For very high temperature the most part of this spectrum is in the soft x-ray region, but soft x-ray can be reflected and retracted by special methods.

The reactive pressure. We can estimate that the ion speed for $T = 10^{8}$ °K. That is approximately $V = 600$ km/s. If $M = 0.1\ \mu g = 10^{-7}$ kg of a mixture D+T is increased their speed to this value in time $\tau = 10^{-9}$ s, the reactive force will be $F = MV/\tau \approx 5\times10^{7}$ N. If the fuel capsule has surface $s = 5$ mm$^2 = 5\times10^{-6}$ m^2 the capsule cover pressure is $p = F/s = 10^{13}$ N/m^2 = 10^{8} atm. This pressure produces the shockwave which compresses the fuel microcapsule and create high ion temperature.

RADIATION CONFINEMENT

Radiation confinement is suitable for multi-reflex laser beam support.

Equilibrum of Multi-Reflex Laser and Kinetic Pressures

From equations (6), (10) we receive

$$P_k = 2nkT_k, \quad P_R = \frac{2E}{c}\left(\frac{2}{1-q}\right), \quad P_k = P_R,$$
$$P_L = SE = 0.5nkT_k cS(1-q) \tag{26}$$

where P_L is impulse power of laser, W; S is surface of capsule or plasma; q is plasma reflection. The additional number 2 appears because we neglect the prism reflection loss. The computations for $n = (0 \div 1)\times10^{28}$ 1/m^3, $S = (1 \div 4)\times10^{-6}$ m^2, $q = 0.999$, $T_k = 10^8$ are presented in Figure 13.

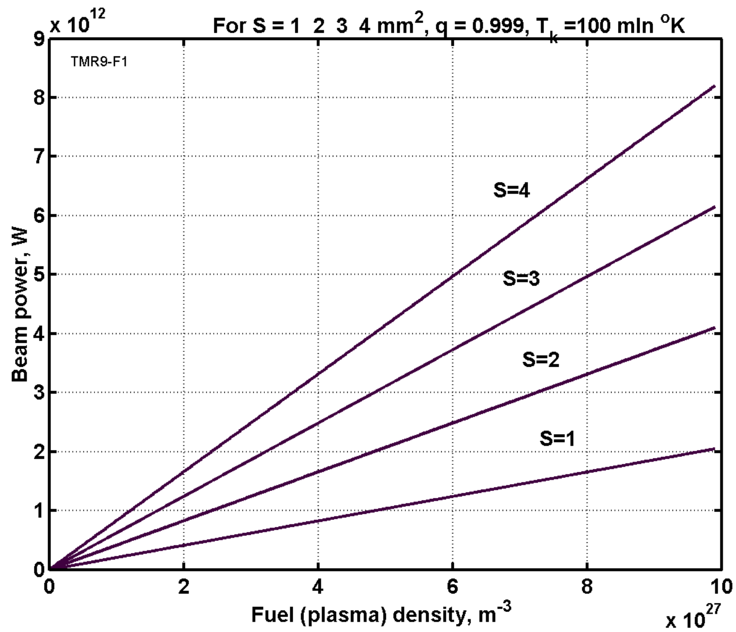

Figure 13. Equilibrium of multi-reflex laser pulse power versus plasma density and fuel capsule surface S for coefficient plasma reflectivity $q = 0.999$, plasma temperature $T_k = 10^8$ °K.

Look your attention that power of laser pulse for multi-reflection confinement is in tens - hundreds times less then one is in the current ICF reactors (OMEGA has 60×10^{12} W, Z-machine will have 350×10^{12} W). That shows, the multi-reflect conformation is more efficiency then rocket conformation for small targets.

We can increase the initial multi-reflex pressure in millions times if we cover the outer capsule surface the small reflective prism as internal surface of the combustion chamber. As it is shown in [26] p. 378, Figure A3.4, the pressere from 1 kW of laser power can reach more 10^4 N. If laser pulse power has $P_L = 10^{13}$ W, the pressure will be $F = 10^{17}$ N. The surface of a spherical capsule having diameter 1 mm is about $S = 3$ mm^2=3×10^{-6} m^2. Hence the pressure on target is $P = F/S = 3.3\times10^{22}$ N/m^2 = 3.3×10^{17} atm! That is in 10^9 times more then a gas dynamic pressure of the plasma at temperature 10^8 K.

Note. The rocket force used for compressing and heating pullet at present time cannot keep the big pressure and temperature for very small capsules at need time because gas extension. For example, let us to estimate the extension time for two capsules having diameter $d = 0.3$ mm and $d = 3$ mm respectively at temperature 10^8 K. The average ion speed at this temperature is about 6×10^5 m/s. For typical pulse time 10^{-9} s the plasma radius is increased in 6×10^{-4} m = 0.6 mm. That means the volume of the first capsule increases in $(0.75/0.15)^3$ = 125 times, the volume of the second capsule is increased only in $(2.1/1.5)^3$ = 2.7 times. In our multi-reflex reactor the beam pressure does not allow to expansion the plasma and increases the reaction time and possibility thermonuclear reaction in hundreds times.

Requested minimum time of laser pulse. Duration of laser pulse needed for heating of capsule can be computed by equation

$$\tau = \frac{c_1 M_f T_k}{P_L} \tag{27}$$

where $c_1 = 4.13\times10^3$ is thermal capacity coefficient, J/kg.K; T_k is plasma temperature, K.

The computations are presented in Figure 14.

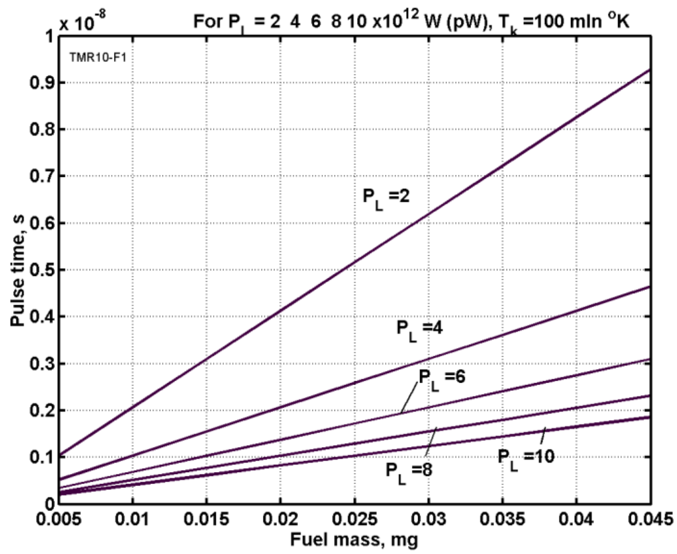

Figure 14. Request laser pulse time for capsule heating via capsule mass and laser pulse power for capsule temperature 10^8 K.

As you see, the pulse is same with current laser $(1 \div 10)\times10^{-12}$ s, (ps). In conventional ICF reactor the most part beam energy is reflected by plasma and heating the shell of combustion chamber. In our reactor the nearly all beam energy is used for capsule heating.

Equilibrium of Brake Radiation and Kinetic Pressures

From equations (10), (7) we receive

$$P_k = 2nkT_k\,, \quad P_{BP} = \frac{2V}{c(1-q)S} 5.34\cdot10^{-37} n^2 T_e^{1/2} Z_{eff}\,, \quad P_k = P_{BP}\,,$$

$$n = \frac{k\,c\,(1-q)S}{5.34\cdot10^{-37} V Z_{eff}} \frac{T_k}{T_e^{1/2}} = 9\cdot10^{28}(1-q)T_e^{1/2}\frac{S}{VZ_{eff}} \tag{28}$$

where T_e is temperature in keV; V is plasma volume, m^3; S is plasma surface, m^2; q is average coefficient reflectivity of x-rays produced by brake radiation. The equilibrium of brake radiation and kinetic pressure can be reached for ratio $V/S \approx 1$.

THE SELF-MAGNETIC CONFINEMENT

The self-magnitude confinement is suitable for low-density plasma. Your attention is called for to the big difference between a present conventional reactor magnetic field and the offered self-magnetic field. For creating of the present magnetic field, the large powerful superconductivity very expensive magnets are used. Our self-magnetic does not request anything. The self-magnetic field is produced by capsule electric current and that is more powerful by hundreds of times. Why? The magnetic intensity and pressure of electric current in inverse proportion of plasma radius (see equations (29) below). The present thermonuclear reactor has plasma camera of some meters. Our capsule has radius only 0.05 mm.

Equilibrium of Self-Magnetic and Kinetic Plasma Pressure

From equation (10) and (12) we receive

$$P_k = P_m\,,\quad P_k = 2nkT_k\,,\quad P_m = \frac{\mu_0 H^2}{2}\,,\quad H = \frac{I}{2\pi r}\,,\quad P_m = \frac{\mu_0}{8\pi^2}\left(\frac{I}{r}\right)^2,$$
$$I = 4\pi r\sqrt{\frac{knT_k}{\mu_0}} = 4.16\cdot 10^{-8}\, r\,(nT_k)^{0.5}\,,\quad U = RI,\quad B = \frac{\mu_0 I}{2\pi r} \qquad (29)$$

where r is radius of capsule (plasma flux), m; I is electric currency, A; R is capsule (plasma) resistance, Ohm; U is capsule (electrodes) voltage, V; H is magnetic intensity, A/m; B is magnetic intensity, Tesla; T_k is plasma temperature , ^{o}K.

The computations for several n are presented in figures 15 - 18.

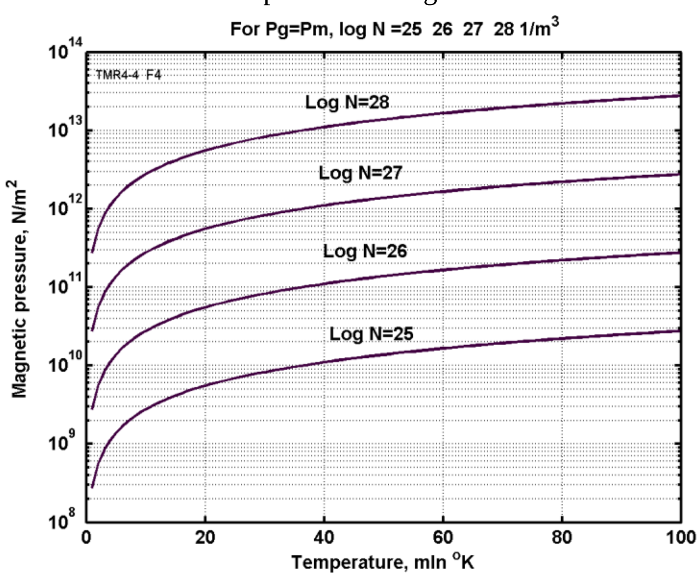

Figure 15. Equilibrium self-magnetic and kinetic pressures versus plasma temperature and plasma densities. Capsule 0.1×1 mm. N is plasma density, $1/m^3$.

Note: This pressure is same for multi-reflex and plasma pressure.

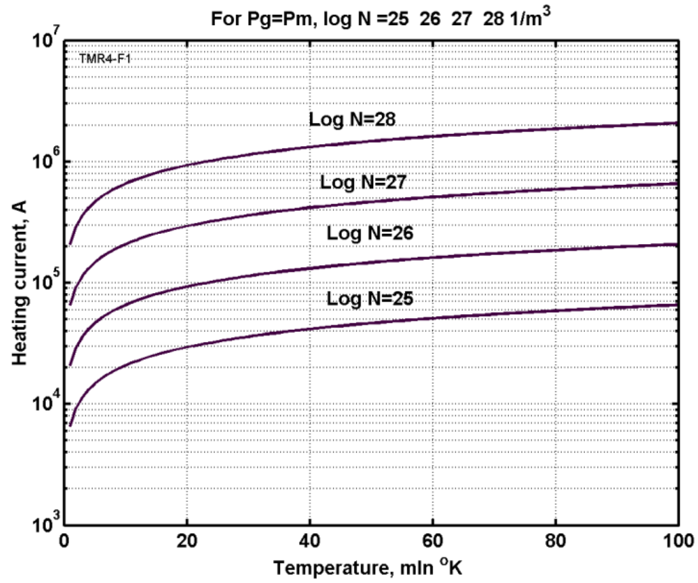

Figure 16. Electric currency needed for equilibrium kinetic and magnetic pressure for several plasma densities. Microcapsule has size 0.1×1 mm. N is plasma density, $1/m^3$.

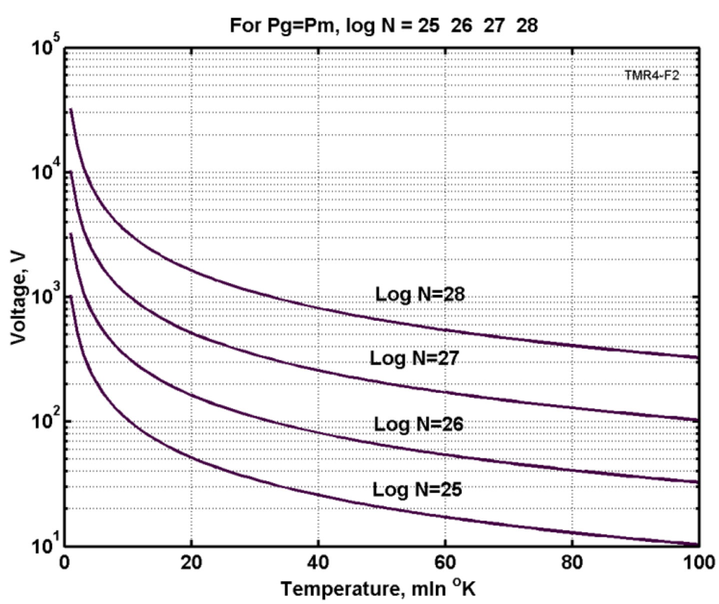

Figure 17. Electric voltage needed for equilibrium kinetic and magnetic pressures for several plasma densities. Capsule has size 0.1×1 mm. N is plasma density, $1/m^3$.

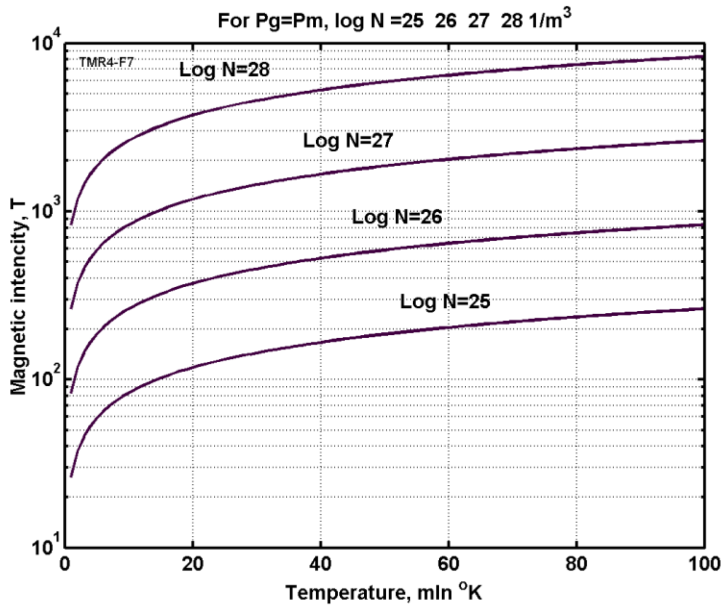

Figure 18. Equilibrium self-magnetic intensity on microcapsule surface via plasma temperature for several plasma densities. Capsule has size 0.1×1 mm. N is plasma density, 1/m^3.

The present magnetic confinement reactor having superconductivity magnets has maximum magnetic intensity 5 - 6 Tesla. As you see in Figure 18 the offered AB-self-magnetic reactor has more magnetic intensity in hundreds times.

PROJECTS

Below there are estimations of some projects, which show parameters of suggested AB-reactors. These are not optimal reactors. They demonstrate the methods of computations and possible technical data of new micro reactors.

1. Multi-reflection AB-reactor. Let us to take the spherical fuel capsule diameter d = 1 mm. Its surface is 3.14 mm^2, the volume is v = 0.52 mm^3 = 5,2×10^{-10} m^3. If gaseous fuel (D+T) has pressure 1, 10, 100 atm, the specific fuel density are ρ = 0.11 kg/m^3, 1.1 kg/m^3, 11 kg/m^3 respectively. The fuel mass are $M_f = \rho v$ = 5.7×10^{-11}, 57×10^{-11}, 570×10^{-11} kg respectively. Particle densities are $n_1 = \rho/\mu_a \cdot m_p$ = 2.63×10^{25} 1/m^3, 2.63×10^{26} 1/m^3, 2.63×10^{27} 1/m^3 respectively. Numbers of particles in the capsule are $n = n_1 v$ = 1.37×10^{16}, 1.37×10^{17}, 1.37×10^{18} respectively.

Thermonuclear energy in capsule are $E = 0.5nE_1$ = 1.9×10^4 J, 1.9×10^5 J, 1.9×10^6 J respectively. Here E_1 = 17.6×10^6×1.6×10^{-19} = 2.8×10^{-12} J is the energy in single reaction of couple particles. Where 17.6×10^6 MeV is thermonuclear energy of reaction D+T. If we burn 1 capsule in 1 second, the thermonuclear power will be W = 1.9×10^4 W, 1.9×10^5 W, 1.9×10^6 W respectively.

Fuel heating energy are $E_f = c_1 M_f T_k$ = 24 J, 240 J, 2400 J respectively. Here c_1 = 4.13×10^3 is average thermal capacity of plasma, T_k = 10^8 K is maximal plasma temperature.

These heating energy must be increased some (3 ÷ 6) times because we must to heat the capsule shell and coefficient of energy efficiency is less then 1. The current condensers have energy storage capability about 1 J/cm^3.

Requested minimum (equilibrium) pulse laser power equal N = 17.1×10^9 W, 17.1×10^{10} W, 17.1×10^{11} W respectively (Eq. (22)) for q = 0.999. Pulse time is $\tau = E_f/N$ = 1.4×10^{-9} s.

We can use the liquid fuel. All parameter significantly will improvement (approximately in 10 times with comparison of the 100 atm capsule), but we get a problem with storage of capsules into a liquid helium.

2. Self-magnetic AB-reactor. Let us to take the fuel capsule of the length L = 1 mm, diameter 2r = 0.1 mm and gaseous fuel (D+T) pressure p = 100 atm . The cross-section of capsule is S = 7.85×10^{-3} mm^2, volume v = 7.85×10^{-12} m^3, fuel mass is $M_f = \rho v$ = 9.5×10^{-11} kg, particle density is $n_1 = \rho/\mu_a m_p$ = 2.63×10^{27} 1/m^3, number of particle into capsule is $n = n_1 v$ = 2.06×10^{16}. Heating fuel energy is $E_f = c_1 M_f T_k$ = 39 J, for T_k = 10^8 K. If we burn 1 capsule in 1 second the thermonuclear power will be W = 3×10^4 W.

Requested minimum (equilibrium) electric currency equal I = 1.07×10^6 A (for T_k = 10^8 K),(Eq. (29)). The plasma electric specific resistance at T_k = 10^8 K is $\rho = 0.1Z/T^{3/2}$ = 1.23×10^{-7} Ω cm. The electric plasma resistance is $R_f = \rho L/S$ = 1.5×10^{-4} Ω (all for T_k = 10^8 K). Voltage $U = IR_f$ = 160 V. Pulse power $N = IU$ = 17.1×10^7 W. Pulse time is τ = 2.3×10^{-6} s. Maximum intensity of magnetic field is $B = \mu_o I/2\pi r$ = 4280 T.

DISCUSSION

The offered thermonuclear AB-Reactors, as with any innovations, are needed in further more detailed laboratory research, product development and testing. However, theses new Reactors have gigantic advantages over present-day thermonuclear reactors:

(1) They are cheaper by many hundreds of times. That means not only non-industrial countries but middle-size companies can undertake RandD and production of perfected new thermonuclear reactors.
(2) They have a small weight and size but they have enough power (up 10,000 kW). That means they can be used as engine of land vehicles, small ships, aircraft, manned and unmanned spacecraft propulsion and community power utilities.
(3) They are not limited in high temperature regime as are all existing reactors. That means they can use inexpensive fuel (not deuterium, tritium, helium-3, uranium as do extant reactors).

The parameters of AB-Reactors are considered and computed in given article very far from optima. They are only examples utilized to vividly illustrate the large possibilities of the innovative reactors.

The suggested AB-thermonuclear reactor has Lawson criterion in some order more then conventional current (2005) thermonuclear reactors (ICF). That strongly increases either of three multipliers in Lawson criterion. That increases the density n up to two-three orders. It increases the temperature T. It returns the laser and thermal radiation back to fuel pellet. (This emission is lost in present reactors). It increases the time of reaction τ. The suggested AB thermonuclear reactors may be a revolutionary jump in energy industry.

Note: In conventional ICF the initial (internal into plasma) radiation does not compress the plasma. Plasma is transparency for internal radiation. That emission influences only to an emitted particle. When radiation came out of source (fuel pellet) and reflected or adsorbed by chamber surface that does not press on pellet surface. By that means, the conventional inertial thermonuclear reactor has only losses from radiation. The offered AB Reactor has the big desirable benefits from thermal radiation. The more radiation, the more benefits.

The offered AB-Reactor can also have problems. The radiation mirror can have a bad reflectivity for ultra-violent rays or experimenters may have problems with fast high-intensity electric impulse through small capsule. However, if mirror will be reflect only conventional ultra-violet, light, and thermal radiations that would be enough for ignition of a thermonuclear reaction. As any innovation the offered reactor needs further perfecting RandD.

The offered AB-self magnetic reactor is different from present magnetic confinement reactor. That is smaller because AB-self-magnetic reactor works a small fuel capsule. In present-day reactor, the rare fuel gas (D+T) fills all volume of large chamber. In AB-Reactor the fuel is located into small capsule under high pressure (or, as solid, liquid or frizzed fuel under conventional pressure). In this case the fuel density can reach $n = 10^{-26} \div 10^{-27}$ 1/m^3 (or solid, liquid, frozen fuel may be inside conductive matter, $n = 10^{-28} \div 10^{-29}$ 1/m^3). If the plasma reflectivity is high ($q > 0{,}99$), that is enough for thermonuclear ignition and keeping plasma under the radiation pressure and magnetic pressure. For current MCF the magnetic intensity is 5 T. For AB-Self-MCF the magnetic intensity may be about 10^4 T. For AB-radiation reactor the radiation pressure is about $10^{10} \div 10^{13}$ N/m^2 (millions atm) (Figure15). We can neglect the outer magnetic force in AB-Reactor and we may design AB-Self-MCF reactor without very complex and expensive superconductivity magnetic system.

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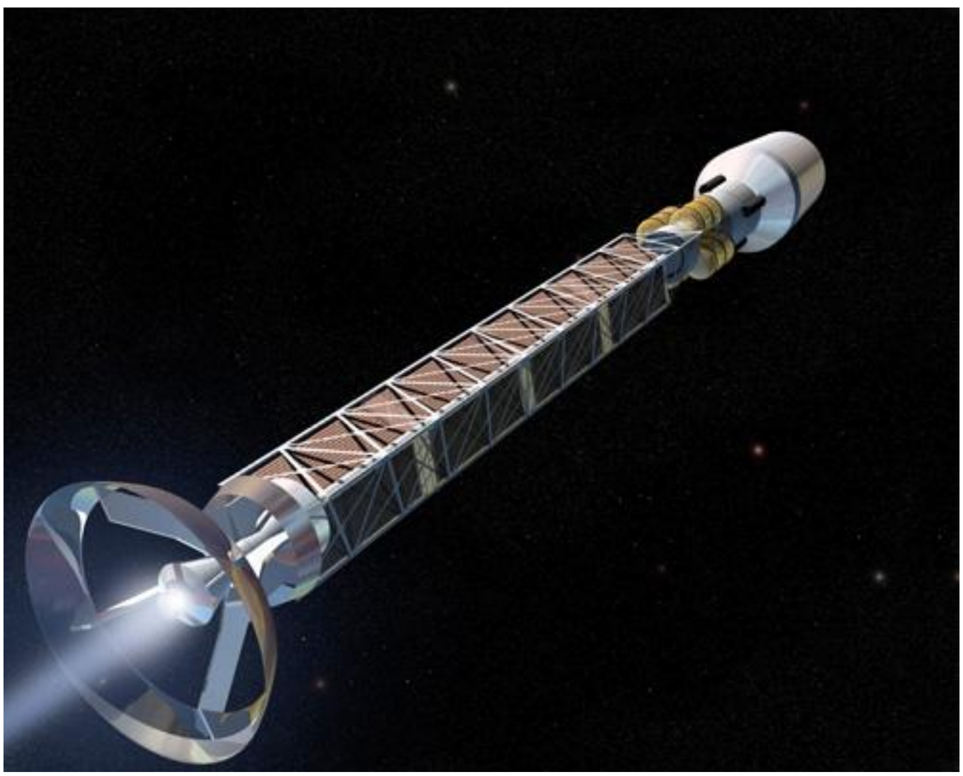
Attachment to Part B, Ch.1. Possible thermonuclear propulsion



Chapter 2

UTILIZATION OF WIND ENERGY AT HIGH ALTITUDE*

ABSTRACT

Ground based, wind energy extraction systems have reached their maximum capability. The limitations of current designs are: wind instability, high cost of installations, and small power output of a single unit. The wind energy industry needs of revolutionary ideas to increase the capabilities of wind installations. This article suggests a revolutionary innovation which produces a dramatic increase in power per unit and is independent of prevailing weather and at a lower cost per unit of energy extracted. The main innovation consists of large free-flying air rotors positioned at high altitude for power and air stream stability, and an energy cable transmission system between the air rotor and a ground based electric generator. The air rotor system flies at high altitude up to 14 km. A stability and control is provided and systems enable the changing of altitude.

This chapter includes six examples having a high unit power output (up to 100 MW). The proposed examples provide the following main advantages: 1. Large power production capacity per unit - up to 5,000-10,000 times more than conventional ground-based rotor designs; 2. The rotor operates at high altitude of 1-14 km, where the wind flow is strong and steady; 3. Installation cost per unit energy is low. 4. The installation is environmentally friendly (no propeller noise).

Keywords: *wind energy, cable energy transmission, utilization of wind energy at high altitude, air rotor, windmills, Bolonkin.*

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* Presented as Bolonkin's papers in International Energy Conversion Engineering Conference at Providence., RI, Aug.16-19. 2004. AIAA-2004-5705, AIAA-2004-5756, USA.

NOMENCLATURE (IN METRIC SYSTEM)

A - front area of rotor [m^2];

α = 0.1 - 0.25 exponent of wind coefficient. One depends from Earth's surface roughness;

A_a - wing area is served by aileron for balance of rotor (propeller) torque moment [m^2];

A_w - area of the support wing [m^2];

C - retail price of 1 kWh [$];

c - production cost of 1 kWh [$];

C_L - lift coefficient (maximum $C_L \approx 2.5$);

C_D – drag coefficient;

$\Delta C_{L,a}$ - difference of lift coefficient between left and right ailerons;

D – drag force [N];

D_r - drag of rotor [N];

E - annual energy produced by flow installation [J];

F – annual profit [$];

H_o = 10 m - standard altitude of ground wind installation [m];

H - altitude [m];

I - cost of Installation [$];

K_1 - life time (years);

K_2 – rotor lift coefficient (5-12 [kg/kW]);

L - length of cable [m];

L_y – lift force of wing [N];

M – annual maintenance [$];

N– power [W, joule/sec];

N_o - power at H_o ;

r - distance from center of wing to center of aileron [m];

R - radius of rotor (turbine)[m];

S - cross-section area of energy transmission cable [m^2];

V - annual average wind speed [m/s];

V_o - wind speed at standard altitude 10 m [m/s]($\boldsymbol{V_o}$= 6 m/s);

W - weight of installation (rotor + cables)[kg];

W_y – weight of cable [kg];

γ - specific density of cable [kg/m^3];

η - efficiency coefficient;

θ - angle between main (transmission) cable and horizontal surface;

λ - ratio of blade tip speed to wind speed;

v - speed of transmission cable [m/s];

ρ - density of flow, ρ =1.225 kg/m^3 for air at sea level altitude H = 0; ρ =0.736 at altitude H =5 km;

ρ = 0.413 at H =10 km;

σ - tensile stress of cable [N/m^2].

INTRODUCTION

Wind is a clean and inexhaustible source of energy that has been used for many centuries to grind grain, pump water, propel sailing ships, and perform other work. Wind farm is the term used for a large number of wind machines clustered at a site with persistent favorable winds, generally near mountain passes. Wind farms have been erected in New Hampshire, in the Tehachapi Mountains. at Altamont Pass in California, at various sites in Hawaii, and may other locations. Machine capacities range from 10 to 500 kilowatts. In 1984 the total energy output of all wind farms in the United States exceeded 150 million kilowatt-hours.

A program of the United States Department of Energy encouraged the development of new machines, the construction of wind farms, and an evaluation of the economic effect of large-scale use of wind power.

The utilization of renewable energy (‘green’ energy) is currently on the increase. For example, a lot of wind turbines are being installed along the British coast. In addition, the British government has plans to develop off-shore wind farms along their coast in an attempt to increase the use of renewable energy sources. A total of $2.4 billion was injected into renewable energy projects over the last three years in an attempt to meet the government's target of using renewable energy to generate 10% of the country's energy needs by 2010.

This British program saves the emission of almost a millions tons of carbon dioxide. Denmark plans to get about 30% of their energy from wind sources.

Unfortunately, current wind energy systems have deficiencies which limit their commercial applications:

1. Wind energy is unevenly distributed and has relatively low energy density. Huge turbines cannot be placed on the ground, many small turbines must be used instead. In California, there are thousands of small wind turbines. However, while small turbines are relatively inefficient, very huge turbines placed at ground are also inefficient due to the relatively low wind energy density and their high cost. The current cost of wind energy is higher then energy of thermal power stations.
2. Wind power is a function of the cube of wind velocity. At surface level, wind has low speed and it is non-steady. If wind velocity decreases in half, the wind power decreases by a factor of 8 times.
3. The productivity of a wind-power system depends heavily on the prevailing weather.
4. Wind turbines produce noise and visually detract from the landscape.

There are many research programs and proposals for the wind driven power generation systems, however, all of them are ground or tower based. System proposed in this article is located at high altitude (up to the stratosphere), where strong permanent and steady streams are located. The also proposes a solution to the main technologist challenge of this system; the transfer of energy to the ground via a mechanical transmission made from closed loop, modern composite fiber cable.

The reader can find the information about this idea in [1], the wind energy in references [2]-[3], a detailed description of the innovation in [4]-[5], and new material used in the proposed innovation in [6]-[9]. The application of this innovation and energy transfer concept to other fields can be found in [10]-[19].

Description of Innovation

Main proposed high altitude wind system is presented in Figure1. That includes: rotor (turbine) 1, support wing 2, cable mechanical transmission and keep system 3, electro-generator 4, and stabilizer 5. The transmission system has three cables (Figure1e): main (central) cable, which keeps the rotor at a given altitude, and two transmission mobile cables, which transfer energy from the rotor to the ground electric generator. The device of Figure1f allows changing a cable length and a rotor altitude. In calm weather the rotor can be support at altitude by dirigible 9 (Figure1c) or that is turned in vertical position and support by rotation from the electric generator (Figure1d). If the wind is less of a minimum speed for support of rotor at altitude the rotor may be supported by autogiro mode in position of Figure1d. The probability of full wind calm at a high altitude is small and depends from an installation location.

Figure2 shows other design of the proposed high altitude wind installation. This rotor has blades, 10, connected to closed-loop cables. The forward blades have a positive angle and lift force. When they are in a back position the lift force equals zero. The rotor is supported at the high altitude by the blades and the wing 2 and stabilizer 5. That design also has energy transmission 3 connected to the ground electric generator 4.

Figure3. shows a parachute wind high altitude installation. Here the blades are changed by parachutes. The parachutes have a large air drag and rotate the cable rotor 1. The wind 2 supports the installation in high altitude. The cable transmission 3 passes the rotor rotation to the ground electric generator 4.

A system of Figure4 uses a large Darries air turbine located at high altitude. This turbine has four blades. The other components are same with previous projects.

Wind turbine of Figure5 is a wind ground installation. Its peculiarity is a gigantic cable-blade rotor. That has a large power for low ground wind speed. It has four columns with rollers and closed-loop cable rotor with blades 10. The wind moves the blades, the blades move the cable, and the cable rotates an electric generator 4.

Problems of Launch, Start, Guidance, Control, Stability, and Others

Launching. It is not difficult to launch the installations having support wing or blades as described in Figure1-4. If the wind speed is more than the minimum required speed (>2-3 m/s), the support wing lifts the installation to the desired altitude.

Starting. All low-speed rotors are self-starting. All high-speed rotors (include the ground rotor of Figure 5) require an initial starting rotation from the ground motor-generator 4 (figures 1,5).

Guidance and Control. The control of power, revolutions per minute, and torque moment are operated by the turning of blades around the blade longitudinal axis. The control of altitude may be manual or automatic when the wind speed is normal and over admissible minimum. Control is effected by wing flaps and stabilizer (elevator), fin, and ailerons (figs. 1,2,4).

Stability. Stability of altitude is produced by the length of the cable. Stability around the blade longitudinal axis is made by stabilizer (see figs.1,2,4). Rotor directional stability in line with the flow can be provided by fins (figs. 1). When the installation has the support wing rigidly connected to the rotor, the stability is also attained by the correct location of the center of gravity of the installation (system rotor-wing) and the point of connection of the main cable and the tension elements. The center-of-gravity and connection point must be located within a relatively narrow range 0.2-0.4 of the average aerodynamic chord of the support wing (for example, see Figure 1). There is the same requirement for the additional support wings such as Figure2-4.

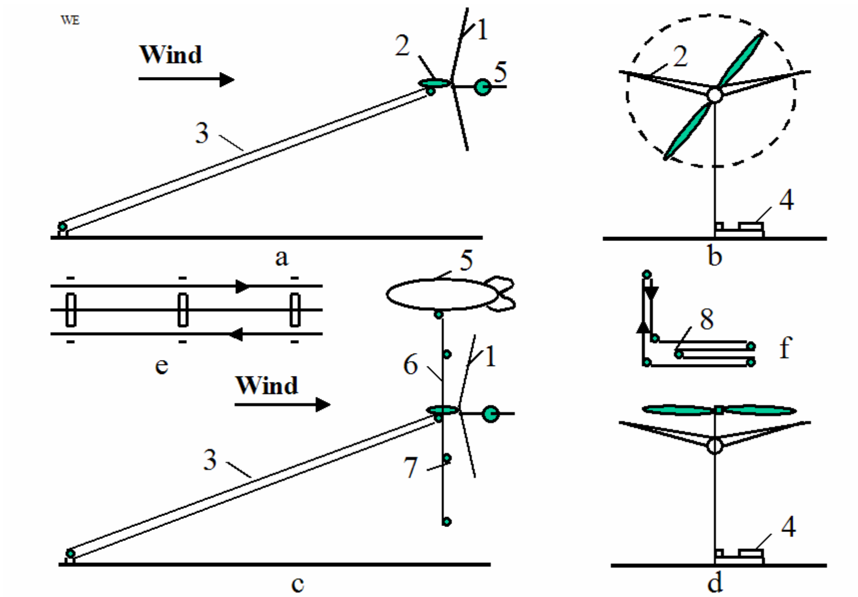

Figure 1. Propeller high altitude wind energy installation and cable energy transport system. *Notation*: a – side view; 1 – wind rotor; 2 – wing with ailerons; 3 – cable energy transport system; 4 – electric generator; 5 – stabilizer; b – front view; c – side view with a support dirigible 9, vertical cable 6, and wind speed sensors 7; d - keeping of the installation at a high altitude by rotate propeller; e – three lines of the transmission - keeper system. That includes: main (central) cable and two mobile transmission cables; f – energy transport system with variable altitude; 8 – mobile roller.

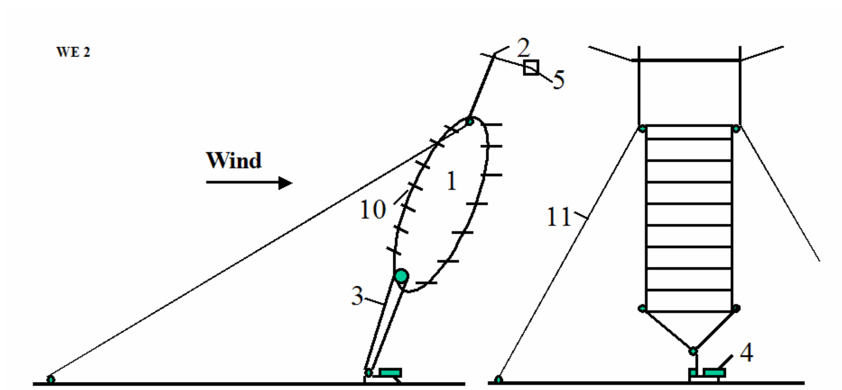

Figure 2. High altitude wind energy installation with the cable turbine. Notation: 10 – blades; 11 – tensile elements (bracing)(option).

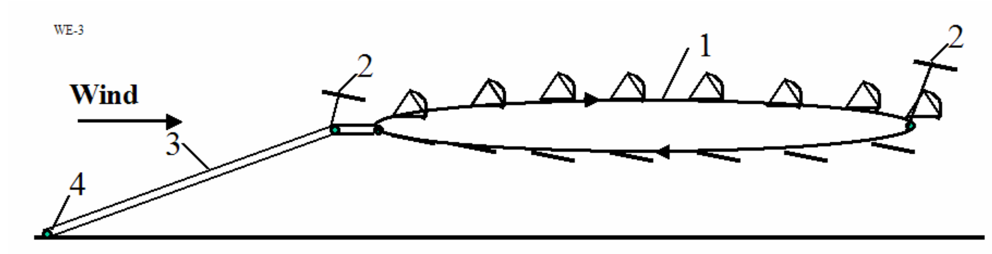

Figure 3. High altitude wind energy installation with the parachute turbine.

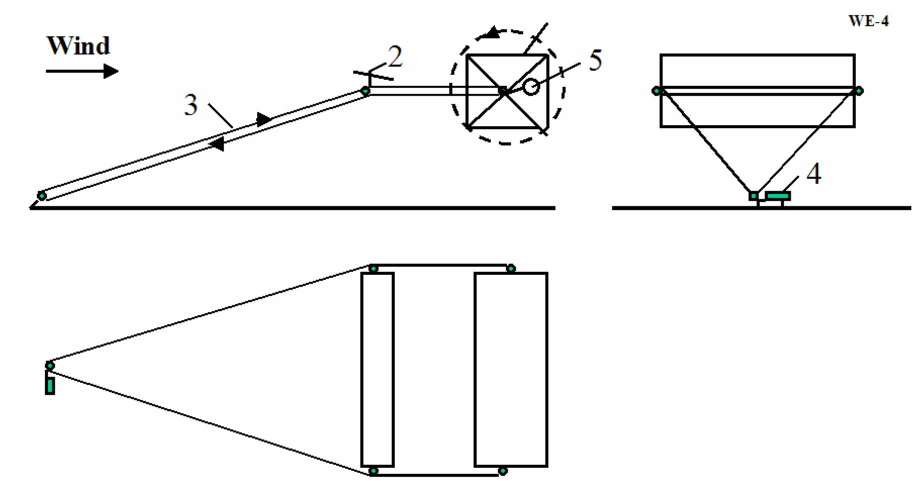

Figure 4. High altitude wind energy installation with Darrieus turbine.

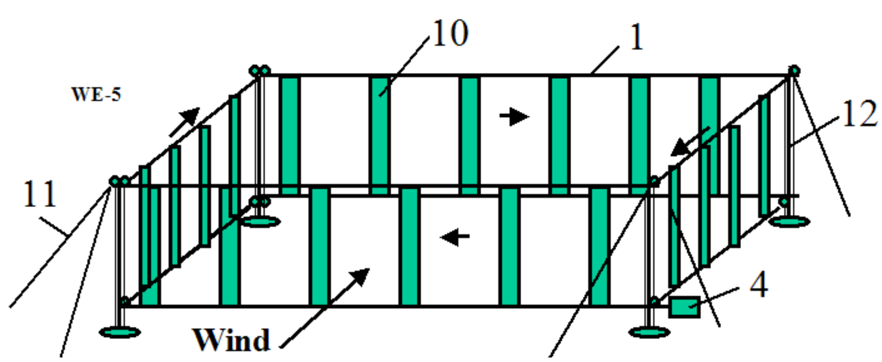

Figure 5. Ground wind cable rotor of a large power.

Torque moment is balanced by transmission and wing ailerons (see figs.1-4).

The wing lift force, stress of main cable are all regulated automatic by the wing flap or blade stabilizer.

The location of the installation of Figure 2 at a given point in the atmosphere may be provided by tension elements shown on Figure 2. These tension elements provide a turning capability for the installation of approximately ± 45^0 degrees in the direction of flow (see. Figure 2.).

Minimum wind speed. The required minimum wind-speed for most of the suggested installation designs is about 2 m/s. The probability of this low wing speed at high altitude is very small (less 0.001). This minimum may be decreased still further by using the turning propeller in an autogiro mode. If the wind speed is approximately zero, the rotor can be supported in the atmosphere by a balloon (dirigible) as is shown on Figure1c or a propeller rotated by the ground power station as is shown on Figure 1d. The rotor system may also land on the ground and start again when the wind speed attains the minimum speed for flight.

A Gusty winds. Large pulsations of wind (aerodynamic energy) can be smoothed out by inertial fly-wheels.

The suggested Method and Installations for utilization of wind energy has following peculiarities from current conventional methods and installations:

1. Proposed installation allows the collection of energy from a large area – tens and even hundreds of times more than conventional wind turbines. This is possible because an expensive tower is not needed to fix our rotor in space. Our installation allows the use of a rotor with a very large diameter, for example 100-200 meters or more.
2. The proposed wind installations can be located at high altitude 100 m - 14 km. The wind speeds are 2-4 times faster and more stable at high altitude compared to ground surface winds used by the altitude of conventional windmills (10 - 70 meters of height). In certain geographic areas high altitude wind flows have a continuous or permanent nature. Since wind power increases at the cube of wind speed, wind rotor power increases by 27 times when wind speed increases by 3 times.
3. In proposed wind installation the electric generator is located at ground. There are proposals where electric generator located near a wind rotor and sends electric current to a ground by electric wares. However, our rotor and power are very large (see projects below). Proposed installations produce more power by thousands of times compared to the typical current wind ground installation (see point 1, 2 above). The electric generator of 20 MW weighs about 100 tons (specific weigh of the conventional electric generator is about 3 - 10 kg/kW). It is impossible to keep this weigh by wing at high altitude for wind speed lesser then 150 m/s.
4. One of the main innovations of the given invention is the *cable transfer* (transmission) of energy from the wind rotor located at high altitude to the electric generator located on ground. In proposed Installation it is used a new cable transmission made from artificial fibers. This transmission has less a weigh in thousands times then copper electric wires of equal power. The wire having diameter more 5 mm passes 1-2 ampere/sq.mm. If the electric generator produces 20 MW with voltage 1000 Volts, the wire cross-section area must be 20,000 mm^2, (wire diameter is160 mm). The cross-section area of the cable transmission of equal power is only 37 mm^2 (cable diameter 6.8 mm^2 for cable speed 300 m/s and admissible stress 200 kg/mm^2, see Project 1). The specific weight of copper is 8930 kg/m^3, the specific weight of artificial fibers is 1800 kg/m^3. If the cable length for altitude 10 km is 25 km the double copper wire weighs 8930 tons (!!), the fiber transmission cable weighs only 3.33 tons. It means the offered cable transferor energy of equal length is easier

in 2682 times, then copper wire. The copper wires is very expensive, the artificial fiber is cheap.

All previous attempts to place the generator near the rotor and connect it to ground by electric transmission wires were not successful because the generator and wires are heavy.

SOME INFORMATION ABOUT WIND ENERGY

The power of a wind engine strongly depends on the wind speed (to the third power). Low altitude wind (H = 10 m) has the standard average speed $\boldsymbol{V}$ = 6 m/s. High altitude wind is powerful and that has another important advantage, it is stable and constant. This is true practically everywhere.

Wind in the troposphere and stratosphere are powerful and permanent. For example, at an altitude of 5 km, the average wind speed is about 20 M/s, at an altitude 10 - 12 km the wind may reach 40 m/s (at latitude of about 20 - 35^0 N).

There are permanent jet streams at high altitude. For example, at H = 12-13 km and about 25^0 N latitude. The average wind speed at its core is about 148 km/h (41 m/s). The most intensive portion, with a maximum speed 185 km/h (51 m/s) latitude 22^0, and 151 km/h (42 m/s) at latitude 35^0 in North America. On a given winter day, speeds in the jet core may exceed 370 km/h (103 m/s) for a distance of several hundred miles along the direction of the wind. Lateral wind shears in the direction normal to the jet stream may be 185 km/h per 556 km to right and 185 km/h per 185 km to the left.

The wind speed of V = 40 m/s at an altitude H = 13 km provides 64 times more energy than surface wind speeds of 6 m/s at an altitude of 10 m.

This is a gigantic renewable and free energy source. (See reference: *Science and Technolody,v.2, p.265)*.

CABLE TRANSMISSION ENERGY PROBLEM

The primary innovations presented in this paper are locating the rotor at high altitude, and an energy transfer system using a cable to transfer mechanical energy from the rotor to a ground power station. The critical factor for this transfer system is the weight of the cable, and its air drag.

Twenty years ago, the mass and air drag of the required cable would not allow this proposal to be possible. However, artificial fibers are currently being manufactured, which have tensile strengths of 3 - 5 times more than steel and densities 4 - 5 times less then steel. There are also experimental fibers (whiskers) which have tensile strengths 30 - 100 times more than a steel and densities 2 to 5 times less than steel. For example, in the book [6] p.158 (1989), there is a fiber (whisker) C_D, which has a tensile strength of σ = 8000 kg/mm^2 and density (specific gravity) of γ = 3.5 g/cm^3. If we use an estimated strength of 3500 kg/mm^2 (σ = $7 \cdot 10^{10}$ N/m^2, γ = 3500 kg/m^3), then the ratio is $\gamma/\sigma = 0.1\times10^{-6}$ or $\sigma/\gamma = 10\times10^6$. Although the described (1989) graphite fibers are strong ($\sigma/\gamma = 10\times10^6$), they are at least still ten times weaker than theory predicts. A steel fiber has a tensile strength of 5000 MPA (500 kg/sq.mm), the theoretical limit is 22,000 MPA (2200 kg/mm^2)(1987); the polyethylene fiber has a tensile strength 20,000 MPA with a theoretical limit of 35,000 MPA (1987). The very high tensile strength is due to its nanotubes structure.

Apart from unique electronic properties, the mechanical behavior of nanotubes also has provided interest because nanotubes are seen as the ultimate carbon fiber, which can be used as reinforcements in advanced composite technology. Early theoretical work and recent experiments on individual nanotubes (mostly MWNT's, Multi Wall Nano Tubes) have confirmed that nanotubes are one of the stiffest materials ever made. Whereas carbon-carbon covalent bonds are one of the strongest in nature, a structure based on a perfect arrangement of these bonds oriented along the axis of nanotubes would produce an exceedingly strong material. Traditional carbon fibers show high strength and stiffness, but fall far short of the theoretical, in-plane strength of graphite layers by an order of magnitude. Nanotubes come close to being the best fiber that can be made from graphite.

For example, whiskers of Carbon nanotube (CNT) material have a tensile strength of 200 Giga-Pascals and a Young's modulus over 1 Tera Pascals (1999). The theory predicts 1 Tera Pascals and a Young's modules of 1-5 Tera Pascals. The hollow structure of nanotubes makes them very light (the specific density varies from 0.8 g/cc for SWNT's (Single Wall Nano Tubes) up to 1.8 g/cc for MWNT's, compared to 2.26 g/cc for graphite or 7.8 g/cc for steel).

Specific strength (strength/density) is important in the design of the systems presented in this paper; nanotubes have values at least 2 orders of magnitude greater than steel. Traditional carbon fibers have a specific strength 40 times that of steel. Since nanotubes are made of graphitic carbon, they have good resistance to chemical attack and have high thermal stability. Oxidation studies have shown that the onset of oxidation shifts by about 100^0 C or higher in nanotubes compared to high modulus graphite fibers. In a vacuum, or reducing atmosphere, nanotube structures will be stable to any practical service temperature.

The artificial fibers are cheap and widely used in tires and everywhere. The price of SiC whiskers produced by Carborundum Co. with σ = 20,690 MPa and γ = 3.22 g/cc was $440 /kg in 1989. The market price of nanotubes is too high presently (~ $200 per gram)(2000). In the last 2 - 3 years, there have been several companies that were organized in the US to produce and market nanotubes. It is anticipated that in the next few years, nanotubes will be available to consumers for less than $100/pound.

The material property os presented in Part A, Ch.1, Table 2. See also Reference [6]-[9].

Below, the author provides a brief overview of recent research information regarding the proposed experimental (tested) fibers. In addition, the author also addresses additional examples, which appear in these projects and which can appear as difficult as the proposed technology itself. The author is prepared to discuss the problems with organizations which are interested in research and development related projects.

Industrial fibers with σ = 500 - 600 kg/mm^2, γ = -1800 kg/m^3, and σ/γ = 2,78×10^6 are used in all our projects (safety σ = 200 - 250 kg/mm^2)(see below).

BRIEF THEORY OF ESTIMATION OF SUGGESTED INSTALLATIONS

Rotor

Power of a wind energy N [Watt, Joule/sec]

$$N = 0.5\eta\rho AV^3 \ \ [\text{W}] \tag{1}$$

The coefficient of efficiency, η, equals 0.15-0.35 for low speed rotors (ratio of blade tip speed to wind speed equals $\lambda \approx 1$); η = 0.35-0.5 for high speed rotors (λ = 5-7). The Darrieus rotor has η = 0.35-0.4. The propeller rotor has η = 0.45-0.50. The theoretical maximum equals η = 0.67.

The energy is produced in one year is (1 year ≈ 30.2×10^6 work sec) [J]

$$E = 3600\times24\times350N \approx 30\times10^6 N \ \ [\text{J}]. \tag{1'}$$

Wind speed increases with altitude as follows

$$V=(H/H_o)^{\alpha}V_o\ , \tag{2}$$

where α = 0.1 - 0.25 exponent coefficient depends from surface roughness. When the surface is water, α = 0.1; when surface is shrubs and woodlands α = 0.25.

Power increases with altitude as the cube of wind speed

$$N = (H/H_o)^{3\alpha}N_o\ , \tag{3}$$

where N_o is power at H_o.

The drag of the rotor equals

$$D_r = N/V \tag{4}$$

The lift force of the wing, L_y , is

$$L_y = 0.5C_L\rho V^2 A_w\ , \quad L_y \approx W\ , \tag{5}$$

where C_L is lift coefficient (maximum $C_L \approx 2.5$), A_w is area of the wing, W is weight of installation + 0.5 weight of all cables.

The drag of the wing is

$$D = 0.5C_D\rho V^2 A_w\ , \tag{6}$$

where C_D is the drag coefficient (maximum $C_D \approx 1.2$).

The optimal speed of the parachute rotor equals 1/3*V* and the theoretical maximum of efficiency coefficient is 0.5.

The annual energy produced by the wind energy extraction installation equals

$$E = 8.33N \quad [\text{kWh}] \tag{7}$$

Cable Energy Transfer, Wing Area, and other Parameters

Cross-section area of transmission cable, S , is

$$S=N/v\sigma, \tag{8}$$

Cross-section area of main cable, S_m , is

$$S_m=(D_r+D)/\sigma, \tag{8'}$$

Weight of cable is

$$W_r=SL\gamma, \tag{9}$$

The production cost, c, in kWh is

$$c = \frac{M + I / K_1}{E}, \tag{10}$$

The annual profit

$$F= (C-c)E . \tag{11}$$

The required area of the support wing is

$$A_w = \frac{\eta A \sin\theta}{C_L} \tag{12}$$

where θ is the angle between the support cable and horizontal surface.

The wing area is served by ailerons for balancing of the rotor (propeller) torque moment

$$A_a = \frac{\eta AR}{\lambda_i \Delta C_{L,a} r} \tag{13}$$

The minimum wind speed for installation support by the wing alone

$$V_{\min} = \sqrt{\frac{2W}{C_{L,\max}\rho A_w}} \quad (14)$$

where W is the total weight of the airborne system including transmission. If a propeller rotor is used in a gyroplane mode, minimal speed will decrease by 2-2,5 times. If wind speed equals zero, the required power for driving the propeller in a propulsion (helicopter) mode is

$$N_s = W/K_2 \quad \text{[kW]}, \quad (15)$$

The specific weight of energy storage (flywheel) can be estimated by

$$E_s = \sigma/2\gamma \quad \text{[J/kg]}. \quad (16)$$

For example, if σ =200 kg/mm^2, γ =1800 kg/m^3, then $\boldsymbol{E_s}$ = 0.56 MJ/*kg or* $\boldsymbol{E_s}$ = 0.15 kWh/kg**.**

For comparison of the different ground wind installations their efficiency and parameters are computed for the standard wind conditions: the wind speed equals V = 6 m/s at the altitude H = 10 m.

PROJECTS

Project 1

High-Speed Air Propeller Rotor (Figure 1)

For example, let us consider a rotor diameter of 100 m (A = 7850 m^2), at an altitude H = 10 km (ρ = 0.4135 kg/m^3), wind speed of V = 30 m/s , an efficiency coefficient of η = 0.5, and a cable tensile stress of σ = 200 kg/mm^2.

Then the power produced is N = 22 MW [Eq. (1)], which is sufficient for city with a population of 250,000. The rotor drag is D_r = 73 tons [Eq.(4)], the cross-section of the main cable area is $S = 1.4D_r/\sigma$ = l.35×73/0.2 ≈ 500 mm^2, the cable diameter equals d = 25 mm; and the cable weight is W = 22.5 tons [Eq.(9)] (for L = 25 km). The cross-section of the transmission cable is S = 36.5 mm^2 [Eq.(8)], d = 6.8 mm, weight of two transmission cables is W = 3.33 tons for cable speed v = 300 m/s [Eq.(9)].

The required wing size is 20×100 m ($\boldsymbol{C_L}$=0.8) [Eq.(12)], wing area served by ailerons is 820 m^2 [Eq.(13)]. If $\boldsymbol{C_L}$ = 2, the minimum speed is 2 m/s [Eq.(14)].

The installation will produce an annual energy E = 190 GWh [Eq.(7)]. If the installation cost is $200K, has a useful life of 10 years, and requires maintenance of $50K per year, the production cost is c = 0.37 cent per kWh [Eq(10)]. If retail price is $0.15 per kWh, profit $0.1 per kWh, the total annual profit is $19 millions per year [Eq.(11)].

The Project #2

Large Air Propeller at Altitude H = 1 km (Figure 1)

Let us consider a propeller diameter of 300 m, with an area $A = 7\times10^4$ m^2, at an altitude H = 1 km, and a wind speed of 13 m/s. The average blade tip speed is 78 m/s.

The full potential power of the wind streamer flow is 94.2 MW. If the coefficient of efficiency is 0.5 the useful power is N = 47.1 MW. For other wind speed. the useful power is: V = 5 m/s, N = 23.3 MW; V = 6 m/s, N = 47.1 MW; V = 7 m/s, N = 74.9 MW; V = 8 m/s, N = 111.6 MW; V = 9 m/s, N = 159 MW; V = 10 m/s, N =218 MW.

Estimation of Economical Efficiency

Let us assume that the cost of the Installation is $3 million, a useful life of 10 years, and request maintenance of $100,000/year. The energy produced in one year is E = 407 GWh [Eq.(7)]. The basic cost of energy is $0.01 /kWh.

The Some Technical Parameters

Altitude H = 1 km

The drag is about 360 tons. Ground connection (main) cable has cross-section area of 1800 sq.mm [Eq.(8')], d = 48 mm, and has a weight of 6480 kg. The need wing area is 60x300 m. The aileron area requested for turbine balance is 6740 sq.m.

If the transmission cable speed is 300 m/s, the cross-section area of transmission cable is 76 sq.mm and the cable weight is 684 kg (composite fiber).

Altitude H = 13 km

At an altitude of H =13 km. the air density is ρ = 0.2666, and the wind speed is V = 40 m/s. The power for efficiency coefficient 0.5 is 301.4 MgW. The drag of the propeller is approximately 754 tons. The connection cable has a cross-sectional area of 3770 sq.mm, a diameter is d =70 mm and a weight of 176 tons. The transmission cable has a sectional area 5 sq.cm and a weight of 60 tons (vertical transmission only 12 tons).

The installation will produce energy E = 2604 GWh per year. If the installation costs $5 million, maintenance is $200,000/year, and the cost of 1 kWh will be $0.0097/kWh.

Project #3

Air Low Speed Wind Engine with Free Flying Cable Flexible Rotor (Figure 2)

Let us consider the size of cable rotor of width 50 m, a rotor diameter of 1000 m, then the rotor area is $A = 50\times1000 = 50{,}000$ sq.m. The angle rope to a horizon is 70^o. The angle of ratio lift/drag is about 2.5^o.

The average conventional wind speed at an altitude H = 10 m is V = 6 m/s. It means that the speed at the altitude 1000 m is 11.4 - 15 m/s. Let us take average wind speed V = 13 m/s at an altitude H = 1 km.

The power of flow is

$$N = 0.5\cdot\rho V^3 A \cos 20^0 = 0.5\times1.225\times13^3\times1000\times50\times0.94 = 63 \text{ MW}.$$

If the coefficient efficiency is η = 0.2 the power of installation is

$P = \eta N = 0.2 \times 63 = 12.5$ MW.

The energy 12.5 MW is enough for a city with a population at 150,000.

If we decrease our Installation to a 100×2000 m the power decreases approximately by 6 times (because the area decreases by 4 times, wind speed reaches more 15 m/s at this altitude. Power will be 75 MW. This is enough for a city with a population about 1 million of people.

If the average wind speed is different for given location the power for the basis installation will be: V = 5 m/s, N =7.25 MW; V = 6 m/s, N = 12.5 MW; V = 7 m/s, N = 19.9 MW; V = 8 m/s, N = 29,6 MW; V = 9 m/s, N = 42.2 MW; V = 10 m/s, N = 57.9 MW.

Economical Efficiency

Let us assume that the cost of our installation is $1 million. According to the book "Wind Power" by P. Gipe [2], the conventional wind installation with the rotor diameter 7 m costs $20,000 and for average wind speeds of 6 m/s has power 2.28 kW, producing 20,000 kWh per year. To produce the same amount of power as our installation using by conventional methods, we would need 5482 (12500/2.28) conventional rotors, costing $110 million. Let us assume that our installation has a useful life of 10 years and a maintenance cost is $50,000/year. Our installation produces 109,500,000 kWh energy per year. Production costs of energy will be approximately 150,000/109,500,000 = 0.14 cent/kWh. The retail price of 1 kWh of energy in New York City is $0.15 now. The revenue is 16 millions. If profit from 1 kWh is $0.1, the total profit is more 10 millions per year.

Estimation Some Technical Parameters

The cross-section of main cable for an admissible fiber tensile strange σ = 200kg/sq.mm is S =2000/0.2 = 10,000 mm^2. That is two cable of diameter d =80 mm. The weight of the cable for density 1800 kg/m^3 is

$$W = SL\gamma = 0.01 \times 2000 \times 1800 = 36 \text{ tons}.$$

Let us assume that the weight of 1 sq.m of blade is 0.2 kg/m^2 and the weight of 1 m of bulk is 2 kg. The weight of the 1 blade will be 0.2 x 500 = 100 kg, and 200 blades are 20 tons. If the weight of one bulk is 0.1 ton, the weight of 200 bulks is 20 tons.

The total weight of main parts of the installation will be 94 tons. We assume 100 tons for purposes of our calculations.

The minimum wind speed when the flying rotor can supported in the air is (for C_y = 2)

$$V=(2W/C_y\rho S)^{0.5}=(2\times100\times10^4/2\times1.225\times200\times500)^{0.5} = 2.86 \text{ m/s}$$

The probability of the wind speed falling below 3 m/s when the average speed is 12 m/s, is zero, and for 10 m/s is 0.0003. This equals 2.5 hours in one year, or less than one time per year. The wind at high altitude has greater speed and stability than near ground surface. There is a strong wind at high altitude even when wind near the ground is absent. This can be seen when the clouds move in a sky on a calm day.

Project #4

Low Speed Air Drag Rotor (Figure 3)

Let us consider a parachute with a diameter of 100 m, length of rope 1500 m, distance between the parachutes 300 m, number of parachute 3000/300 = 10, number of worked parachute 5, the area of one parachute is 7850 sq.m, the total work area is $A = 5 \times 7850 = 3925$ sq.m. The full power of the flow is 5.3 MW for V=6 m/s. If coefficient of efficiency is 0.2 the useful power is N = 1 MW. For other wind speed the useful power is: V = 5 m/s, N =0.58 MW; V =6 m/s, N = 1 MW; V =7 m/s, N =1.59 MW; V = 8 m/s, N=2.37 MW; V = 9 m/s, N =3.375 MW; V = 10 m/s, N = 4.63 MW.

Estimation of Economical Efficiency

Let us take the cost of the installation $0.5 million, a useful life of 10 years and maintenance of $20,000/year. The energy produced in one year (when the wind has standard speed 6 m/s) is E = 1000x24x360 = 8.64 million kWh. The basic cost of energy is 70,000/8640,000 = 0.81 cent/kWh.

The Some Technical Parameters

If the thrust is 23 tons, the tensile stress is 200 kg/sq.mm (composed fiber), then the parachute cable diameter is 12 mm. The full weight of the installation is 4.5 tons. The support wing has size 25×4 m.

Project #5

High Speed Air Darreus Rotor at an Altitude 1 km (Figure 4)

Let us consider a rotor having the diameter of 100 m, a length of 200 m (work area is 20,000 m^2). When the wind speed at an altitude H = 10 m is V = 6 m/s, then at an altitude H = 1000 m it is 13 m/s. The full wind power is 13,46 MW. Let us take the efficiency coefficient 0.35, then the power of the Installation will be N = 4.7 MW. The change of power from wind speed is: V = 5 m/s, N = 2.73 MW; V = 6 m/s, N = 4.7 MW; V = 7 m/s, N = 7.5 MW; V = 8 m/s, N = 11.4 MW; V = 9m/s, N = 15.9 MW; V = 10 m/s, N = 21.8 MW.

At an altitude of H = 13 km with an air density 0.267 and wind speed V = 40 m/s, the given installation will produce power N = 300 MW.

Estimation of Economical Efficiency

Let us take the cost of the Installation at $1 million, a useful life of 10 years, and maintenance of $50,000 /year. Our installation will produce ***E*** = 41 millions kWh per year (when the wind speed equals 6 m/s at an altitude 10 m). The prime cost will be 150,000/41,000,000 = 0.37 cent/kWh. If the customer price is $0.15/kWh and profit from 1 kWh is $0.10 /kWh the profit will be $4.1 million per year.

Estimation of Technical Parameters

The blade speed is 78 m/s. Numbers of blade is 4. Number of revolution is 0.25 revolutions per second. The size of blade is 200x0.67 m. The weight of 1 blade is 1.34 tons. The total weight of the Installation is about 8 tons. The internal wing has size 200×2.3 m. The additional wing has size 200x14.5 m and weight 870 kg. The cross-section area of the cable transmission having an altitude of H = 1 km is 300 sq.mm, the weight is 1350 kg.

Project #6

Ground Wind High Speed Engine (Figure 5)

Let us consider the ground wind installation (Figure5) with size 500×500×50 meters. The work area is 500×50×2 = 50,000 sq.m. The tower is 60 meter tall, the flexible rotor located from 10 m to 60 m. If the wind speed at altitude 10 m is 6 m/s, that equals 7.3 m/s at altitude 40 m.

The theoretical power is

$$N_t = 0.5\rho V^3 A = 0.5\times1.225\times7.3^3\times5\times10^4 = 11.9 \quad \text{MgW.}$$

For coefficient of the efficiency equals 0.45 the useful power is

$$\boldsymbol{N} = 0.45\times11.9 = 5.36 \text{ MW.}$$

For other wind speed at an altitude 6 m/s the useful power is: $\boldsymbol{V}$ = 5 m/s, $\boldsymbol{N}$ = 3.1 MW; $\boldsymbol{V}$ = 6 m/s, $\boldsymbol{N}$ = 5.36 MW; $\boldsymbol{V}$ = 7 m/s, $\boldsymbol{N}$ = 8.52 MW; $\boldsymbol{V}$ = 8 m/s, $\boldsymbol{N}$ = 12.7 MW; $\boldsymbol{V}$ = 9 m/s, $\boldsymbol{N}$ = 18.1 MW; $\boldsymbol{V}$ = 10 m/s, $\boldsymbol{N}$ = 24.8 MW.

Economic Estimation

In this installation the rotor will be less expensive than previous installations because the high-speed rotor has a smaller number of blades and smaller blades (see technical data below). However this installation needs 4 high (60 m) columns. Take the cost of the installation at $1 million with a useful life of 10 years. The maintenance is projected at about $50,000 /year.

This installation will produce E = 5360 kW × 8760 hours = 46.95 MWh energy (for the annual average wind-speed V = 6 m/s at H = 10 m). The cost of 1 kWh is 150,000/46,950,000 = 0.4 cent/kWh. If the retail price is $0.15/kWh and delivery cost 30%, the profit is $0.10 per kWh, or $4.7 million per year.

Estimation of Some Technical Parameters

The blade speed is 6 × 7.3 = 44 m/s. The distance between blades is 44 m. The number of blade is 4000/44 = 92.

DISCUSSION AND CONCLUSION

Conventional windmills are approached their maximum energy extraction potential relative to their installation cost. No relatively progress has been made in windmill technology in the last 50 years. The wind energy is free, but its production more expensive then its production in heat electric stations. Current wind installations cannot essential decrease a cost of kWh, stability of energy production. They cannot increase of power of single energy unit. The renewable energy industry needs revolutionary ideas that improve performance parameters (installation cost and power per unit) and that significantly decreases (in 10-20 times) the cost of energy production. This paper offers ideas that can move the wind energy industry from stagnation to revolutionary potential.

The following is a list of benefits provided by the proposed system compared to current installations:

1. The produced energy at least in 10 times cheaper then energy received of all conventional electric stations includes current wind installation.
2. The proposed system is relatively inexpensive (no expensive tower), it can be made with a very large thus capturing wind energy from an enormous area (hundreds of times more than typical wind turbines).
3. The power per unit of proposed system in some hundreds times more of typical current wind installations.
4. The proposed installation not requires large ground space.
5. The installation may be located near customers and not require expensive high voltage equipment. It is not necessary to have long, expensive, high-voltage transmission lines and substations. Ocean going vessels can use this installation for its primary propulsion source.
6. No noise and bad views.
7. The energy production is more stability because the wind is steadier at high altitude. The wind may be zero near the surface but it is typically strong and steady at higher altitudes. This can be observed when it is calm on the ground, but clouds are moving in the sky. There are a strong permanent air streams at a high altitude at many regions of the USA.
8. The installation can be easy relocated in other place.

As with any new idea, the suggested concept is in need of research and development. The theoretical problems do not require fundamental breakthroughs. It is necessary to design small, free flying installations to study and get an experience in the design, launch, stability, and the cable energy transmission from a flying wind turbine to a ground electric generator.

This paper has suggested some design solutions from patent application [4]. The author has many detailed analysis in addition to these presented projects. Organizations interested in these projects can address the author (http://Bolonkin.narod.ru , aBolonkin@juno.com , abolonkin@gmail.com). The other ideas are in [11]-[50].

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Attacment to Part B, Ch. 2.

Possible fly wind engine

Ground wind energy instellations

Chapter 3

CONTROL OF REGIONAL AND GLOBAL EARTH WEATHER*

ABSTRACT

Author suggests and researches a new revolutionary idea for regional and global weather control. He offers to cover cities, bad regions of country, full country or a continent by a thin closed film with control clarity located at a top limit of the Earth's troposphere (4 - 6 km). The film is supported at altitude by small additional atmospheric pressure and connected to ground by thin cables. It is known, the troposphere defines the Earth's weather. Authors show this closed dome allows to do a full control of the weather in a given region (the day is always fine, the rain is only in night, no strong wind). The average Earth (white cloudy) reflectance equal 0.3 - 0.5. That means the Earth losses about 0.3 - 0.5 of a solar energy. The dome controls the clarity of film and converts the cold regions to subtropics and creates the hot deserts, desolate wildernesses to the prosperous regions with temperate climate. That is a realistic and the cheapest method of the weather control in the Earth at the current time.

Keywords: *Global weather control, gigantic film dome, converting a cold region to subtropics, converting desolate wilderness to a prosperous region*.

INTRODUCTION

Governments spend billions of dollars to studying of weather. The many big government research scientific organizations and hundred thousands of scientists studying a Earth weather more then hundred years. There are gigantic numbers of scientific works about weather control. Most of them are out of practice. We cannot exactly predict weather at long period, to avert a rain, strong wind, storm, hurricane, tornado. We cannot control the clouds, temperature and humidity of atmosphere, power of rain. We cannot make better a winter and summer. We cannot convert a cold region to subtropics, a desolate wilderness to a prosperous region. We can only observe the storms and hurricanes and approximately predict their

* Kept in http://arxiv.org , 2006.

direction of movement. Every year the terrible storms, hurricanes, strong winds and rains, inundations destroy thousands of houses, kill thousands of men.

In this chapter, we consider a damage and prejudice from unnormal weather.

1. A tropical cyclone (hurricane) is a storm system fueled by the heat released when moist air rises and the water vapor in it condenses. The term describes the storm's origin in the tropics and its cyclonic nature, which means that its circulation is counterclockwise in the northern hemisphere and clockwise in the southern hemisphere. Tropical cyclones are distinguished from other cyclonic windstorms such as nor'easters, European windstorms, and polar lows by the heat mechanism that fuels them, which makes them "warm core" storm systems.

Depending on their location and strength, there are various terms by which tropical cyclones are known, such as hurricane, typhoon, tropical storm, cyclonic storm and tropical depression.

Tropical cyclones can produce extremely strong winds, tornadoes, torrential rain, high waves, and storm surges. The heavy rains and storm surges can produce extensive flooding. Although their effects on human populations can be devastating, tropical cyclones also can have beneficial effects by relieving drought conditions. They carry heat away from the tropics, an important mechanism of the global atmospheric circulation that maintains equilibrium in the earth's troposphere.

An average of 86 tropical cyclones of tropical storm intensity form annually worldwide, with 47 reaching hurricane/typhoon strength, and 20 becoming intense tropical cyclones (at least of Category 3 intensity).

Worldwide, tropical cyclone activity peaks in late summer when water temperatures are warmest. However, each particular basin has its own seasonal patterns. On a worldwide scale, May is the least active month, while September is the most active.

Table 1. Season Lengths and Seasonal Averages

Basin	Season Start	Season End	Tropical Storms (>34 knots)	Tropical Cyclones (>63 knots)	Category 3+ Tropical Cyclones (>95 knots)
Northwest Pacific	–	–	26.7	16.9	8.5
South Indian	October	May	20.6	10.3	4.3
Northeast Pacific	May	November	16.3	9.0	4.1
North Atlantic	June	November	10.6	5.9	2.0
Australia Southwest Pacific	October	May	10.6	4.8	1.9
North Indian	April	December	5.4	2.2	0.4

In the North Atlantic, a distinct hurricane season occurs from June 1 to November 30, sharply peaking from late August through September. The statistical peak of the North Atlantic hurricane season is September 10. The Northeast Pacific has a broader period of activity, but in a similar time frame to the Atlantic. The Northwest Pacific sees tropical cyclones year-round, with a minimum in February and a peak in early September. In the North Indian basin, storms are most common from April to December, with peaks in May and November.

A mature tropical cyclone can release heat at a rate upwards of $6x10^{14}$ watts. Tropical cyclones on the open sea cause large waves, heavy rain, and high winds, disrupting international shipping and sometimes sinking ships. However, the most devastating effects of a tropical cyclone occur when they cross coastlines, making landfall. A tropical cyclone moving over land can do direct damage in four ways:

- *High winds* - Hurricane strength winds can damage or destroy vehicles, buildings, bridges, etc. High winds also turn loose debris into flying projectiles, making the outdoor environment even more dangerous.
- *Storm surge* - Tropical cyclones cause an increase in sea level, which can flood coastal communities. This is the worst effect, as historically cyclones claimed 80% of their victims when they first strike shore.
- *Heavy rain* - The thunderstorm activity in a tropical cyclone causes intense rainfall. Rivers and streams flood, roads become impassable, and landslides can occur. Inland areas are particularly vulnerable to freshwater flooding, due to residents not preparing adequately.
- *Tornado activity* - The broad rotation of a hurricane often spawns tornadoes. Also, tornadoes can be spawned as a result of eyewall mesovortices, which persist until landfall. While these tornadoes are normally not as strong as their non-tropical counterparts, they can still cause tremendous damage.[31]

Figure 1. The aftermath of Hurricane Katrina in Gulfport, Mississippi. Katrina was the costliest tropical cyclone in United States history.

Often, the secondary effects of a tropical cyclone are equally damaging. These include:

Disease - The wet environment in the aftermath of a tropical cyclone, combined with the destruction of sanitation facilities and a warm tropical climate, can induce epidemics of disease which claim lives long after the storm passes. One of the most common post-hurricane injuries is stepping on a nail in storm debris, leading to a risk of tetanus or other infection. Infections of cuts and bruises can be greatly amplified by wading in sewage-polluted water. Large areas of standing water caused by flooding also contribute to mosquito-borne illnesses.

Power outages - Tropical cyclones often knock out power to tens or hundreds of thousands of people (or occasionally millions if a large urban area is affected), prohibiting vital communication and hampering rescue efforts.

Transportation difficulties - Tropical cyclones often destroy key bridges, overpasses, and roads, complicating efforts to transport food, clean water, and medicine to the areas that need it.

Hurricane Katrina is the most obvious example, as it devastated the region that had been revitalized after Hurricane Camille. Of course, many former residents and businesses do relocate to inland areas away from the threat of future hurricanes as well.

While the number of storms in the Atlantic has increased since 1995, there seems to be no signs of a numerical global trend; the annual global number of tropical cyclones remains about 90 ± 10. However, there is some evidence that the intensity of hurricanes is increasing. "Records of hurricane activity worldwide show an upswing of both the maximum wind speed in and the duration of hurricanes. The energy released by the average hurricane (again considering all hurricanes worldwide) seems to have increased by around 70% in the past 30 years or so, corresponding to about a 15% increase in the maximum wind speed and a 60% increase in storm lifetime."

Atlantic storms are certainly becoming more destructive financially, since five of the ten most expensive storms in United States history have occurred since 1990. This can be attributed to the increased intensity and duration of hurricanes striking North America and to the number of people living in susceptible coastal area following increased development in the region since the last surge in Atlantic hurricane activity in the 1960s.

Tropical cyclones that cause massive destruction are fortunately rare, but when they happen, they can cause damage in the range of billions of dollars and disrupt or end thousands of lives.

The deadliest tropical cyclone on record hit the densely populated Ganges Delta region of Bangladesh on November 13, 1970, likely as a Category 3 tropical cyclone. It killed an estimated 500,000 people. The North Indian basin has historically been the deadliest, with several storms since 1900 killing over 100,000 people, each in Bangladesh.

In the Atlantic basin, at least three storms have killed more than 10,000 people. Hurricane Mitch during the 1998 Atlantic hurricane season caused severe flooding and mudslides in Honduras, killing about 18,000 people and changing the landscape enough that entirely new maps of the country were needed. The Galveston Hurricane of 1900, which made landfall at Galveston, Texas as an estimated Category 4 storm, killed 8,000 to 12,000 people, and remains the deadliest natural disaster in the history of the United States. The deadliest Atlantic storm on record was the Great Hurricane of 1780, which killed about 22,000 people in the Antilles.

Hurricane Iniki in 1992 was the most powerful storm to strike Hawaii in recorded history, hitting Kauai as a Category 4 hurricane, killing six and causing $3 billion in damage. Other destructive Pacific hurricanes include Pauline and Kenna.

On March 26, 2004, Cyclone Catarina became the first recorded South Atlantic cyclone (cyclone is the southern hemispheric term for *hurricane*). Previous South Atlantic cyclones in 1991 and 2004 reached only tropical storm strength. Tropical cyclones may have formed there before 1960 but were not observed until weather satellites began monitoring the Earth's oceans in that year.

A tropical cyclone need not be particularly strong to cause memorable damage; Tropical Storm Thelma, in November 1991 killed thousands in the Philippines even though it never became a typhoon; the damage from Thelma was mostly due to flooding, not winds or storm surge. In 1982, the unnamed tropical depression that eventually became Hurricane Paul caused the deaths of around 1,000 people in Central America due to the effects of its rainfall. In addition, Hurricane Jeanne in 2004 caused the majority of its damage in Haiti, including approximately 3,000 deaths, while just a tropical depression.

On August 29, 2005, Hurricane Katrina made landfall in Louisiana and Mississippi. The U.S. National Hurricane Center, in its August review of the tropical storm season stated that Katrina was probably the worst natural disaster in U.S. history. Currently, its death toll is at least 1,836, mainly from flooding and the aftermath in New Orleans, Louisiana and the Mississippi Gulf Coast. It is also estimated to have caused $81.2 billion in property damage. Before Katrina, the costliest system in monetary terms had been 1992's Hurricane Andrew, which caused an estimated $39 billion (2005 USD) in damage in Florida.

2. A flood (inundation) is an overflow of water, an expanse of water submerging land, a deluge. In the sense of "flowing water", the word is applied to the inflow of the tide, as opposed to the outflow or "ebb". *The* Flood, the great Universal Deluge of myth and perhaps of history is treated at Deluge in mythology.

Since prehistoric times people have lived by the seas and rivers for the access to cheap and quick transportation and access to food sources and trade; without human populations near natural bodies of water, there would be no concern for floods. However fertile soil in a river delta is subject to regular inundation from normal variation in precipitation.

Figure 2. Rock River floodwaters in downtown Fort Atkinson, Wisconsin.

Floods from the sea can cause overflow or overtopping of flood-defenses like dikes as well as flattening of dunes or bluffs. Land behind the coastal defence may be inundated or experience damage. A flood from sea may be caused by a heavy storm (storm surge), a high tide, a tsunami, or a combination thereof. As many urban communities are located near the coast this is a major threat around the world.

Many rivers that flow over relatively flat land border on broad flood plains. When heavy the deposition of silt on the rich farmlands and can result in their eventual depletion. The annual cycle of flood and farming was of great significance to many early farming cultures, most famously to the ancient Egyptians of the Nile river and to the Mesopotamians of the Tigris and Euphrates rivers.

A flood happens when an area of land, usually low-lying, is covered with water. The worst floods usually occur when a river overflows its banks. An example of this is the January 1999 Queensland floods, which swamped south-eastern Queensland. Floods happen when soil and vegetation cannot absorb all the water. The water then runs off the land in quantities that cannot be carried in stream channels or kept in natural ponds or man-made reservoirs.

Periodic floods occur naturally on many rivers, forming an area known as the flood plain. These river floods usually result from heavy rain, sometimes combined with melting snow, which causes the rivers to overflow their banks. A flood that rises and falls rapidly with little or no advance warning is called a flash flood. Flash floods usually result from intense rainfall over a relatively small area. Coastal areas are occasionally flooded by high tides caused by severe winds on ocean surfaces, or by tidal waves caused by undersea earthquakes. There are often many causes for a flood.

Monsoon rainfalls can cause disastrous flooding in some equatorial countries, such as Bangladesh, Hurricanes have a number of different features which, together, can cause devastating flooding. One is the storm surge (sea flooding as much as 8 metres high) caused by the leading edge of the hurricane when it moves from sea to land. Another is the large amounts of precipitation associated with hurricanes. The eye of a hurricane has extremely low pressure, so sea level may rise a few metres in the eye of the storm. This type of coastal flooding occurs regularly in Bangladesh.

In Europe floods from sea may occur as a result from heavy Atlantic storms, pushing the water to the coast. Especially in combination with high tide this can be damaging.

Under some rare conditions associated with heat waves, flash floods from quickly melting mountain snow have caused loss of property and life.

Undersea earthquakes, eruptions of island volcanos that form a caldera, (such as Thera or Krakatau) and marine landslips on continental shelves may all engender a tidal wave called a tsunami that causes destruction to coastal areas. See the *tsunami* article for full details of these marine floods.

Floods are the most frequent type of disaster worldwide. Thus, it is often difficult or impossible to obtain insurance policies which cover destruction of property due to flooding, since floods are a relatively predictable risk.

- In 1983 the Pacific Northwest saw one of their worst winter floods. And the some of the Northwest states saw their wettest winter yet. The damage was estimated at 1.1 billion dollars.* In 1965 Hurricane Betsy flooded large areas of New Orleans for up to 10 days, drowning around 40 people.

- In 1957, storm surge flooding from Hurricane Audrey killed about 400 people in southwest Louisiana.
- The Hunter Valley floods of 1955 in New South Wales destroyed over 100 homes and caused 45,000 to be evacuated.
- The North Sea Flood of 1953 caused over 2,000 deaths in the Dutch province of Zeeland and the United Kingdom and led to the construction of the Delta Works and the Thames Barrier.
- The Lynmouth flood of 1952 killed only 34 people, however it was very destructive and destroyed over 80 buildings.
- The 1931 Huang He flood caused between 800,000 and 4,000,000 deaths in China, one of a series of disastrous floods on the Huang He.
- The Great Mississippi Flood in 1927 was one of the most destructive floods in United States history.

The 2005 tragedy of New Orleans shows that disregard of protection of the USA's coastal cities (New York, Los Angles-San Pedro) from strong storm-caused waves, hurricane storm surges, and small tsunamis gives rise to gigantic damages, material losses, human deaths and injuries.

The Metropolitan East Coast (MEC) region -- with New York City at its center -- has nearly 20 million people, a $1 trillion economy, and $2 trillion worth of built assets, nearly half of which are complex infrastructure.

Many elements of transportation and other essential infrastructure systems in the MEC region, and even some of its regular building stock, are located at elevations from 6 to 20 feet above current sea level. This is well within the range of expected coastal storm surge elevation of 8 to more than 20 feet for tropical (hurricanes) and extra-tropical storms. Depending on which climate change scenarios apply, the sea level regional rise over the next 100 years will accelerate and amount to at most 3 feet by the year 2100. This seemingly modest increase in sea level has the effect to raise the frequency of coastal storm surges and related flooding by factors of 2 to 10, with an average of about 3.

The rate of financial losses incurred from these coastal floods will increase accordingly. Expected annualized losses from coastal storms, already on the order of about $1 billion per year, would be small enough to be absorbed by the $1 trillion economy of the region. However, actual losses do not occur in regular annualized doses. Rather, they occur during infrequent extreme events that can cause losses of hundreds of billions of dollars for the largest events, albeit with low probability.

3. Brif information about cover film and liquid crystal. Our dome cover (film) has 5 layers (Figure 4): transparant dielectric layer, conducting layer (about 1 - 3 μ), liquid crystal layer (about 10 - 100 μ), conducting layer (for example, SnO_2), and transparant dielectric layer. Common thickness is 0.1 - 0.5 mm. Control voltage is 5 - 10 V. Film is produced the industry and it not expensive. Liquid crystals (LC) are substances that exhibit a phase of matter that has properties between those of a conventional liquid, and those of a solid crystal.

Liquid crystals find wide use in liquid crystal displays (LCD), which rely on the optical properties of certain liquid crystalline molecules in the presence or absence of an electric field. The electric field can be used to make a pixel switch between clear or dark on command. Color LCD systems use the same technique, with color filters used to generate red, green, and blue pixels.

Table 2. Ten deadliest natural disasters

Rank	Event	Location	Date	Death Toll (Estimate)
1.	1931 Yellow River flood	Yellow River, China	Summer 1931	850,000-4,000,000
2.	1887 Yellow River flood	Yellow River, China	September-October 1887	900,000-2,000,000
3.	1970 Bhola cyclone	Ganges Delta, East Pakistan	November 13, 1970	500,000-1,000,000
4.	Earthquake	Eastern Mediterranean	1201	1,000,000
5.	1938 Yellow River flood	Yellow River, China	June 9th, 1938	500,000 - 900,000
6.	Shaanxi Earthquake	Shaanxi Province, China	January 23, 1556	830,000
7.	2004 Indian Ocean earthquake/tsunami	Indian Ocean	December 26, 2004	225,000-275,000
8.	Tropical Cyclone	Haiphong, Vietnam	1881	300,000
9.	Flood	Kaifeng, Henan Province, China	1642	300,000
10.	Earthquake	Tangshan, China	July 28, 1976	242,000*

* Official Government figure. Estimated death toll as high as 655,000.

Similar principles can be used to make other liquid crystal based optical devices. Liquid crystal in fluid form is used to detect electrically generated hot spots for failure analysis in the semiconductor industry. Liquid crystal memory units with extensive capacity were used in Space Shuttle navigation equipment. It is also worth noting that many common fluids are in fact liquid crystals. Soap, for instance, is a liquid crystal, and forms a variety of LC phases depending on its concentration in water.

The conventional control clarity film reflected a superfluos energy back to space. If film has solar cells that converts the superfluos solar energy into electricity.

2. Description and Innovations

Our idea is a dome covering a big region (city, large bad area, country, continent) by a thin film with control clarity (reflectivity, carrying capacity of solar spectrum). The film is located at high altitude (4 - 6 km) which include the Earth's troposphere where are the main climatic changes. The film is support at the altitude by a small additional air pressure produced by ground ventilators and connected to Earth's ground by cables. The closed area is also divided by sub-areas by film having control clarity. That allows to make different conditions (solar heating) in sub-areas and pumping hot, warm, cold, moist air from one sub-area to other sub-area. There are a cheap film having liquid crystal and conducting layers. The clarity of them is controlled by electric voltage. They can pass or blockade the solar light (or parts of solar spectrum) and pass or blockade the Earth radiation. The outer and incite radiations have different wave lengths. That makes to control of them separately and to control a heating of the Earth surface. In conventional conditions about 50% of the solar energy reaches the Earth surface. The most part is reflected back to outer space by the white clouds. In our closed system the clouts (and rain) will be made in a night when temperature is low. That means the many cold regions (Alaska, Siberia) may be accepted more solar energy and became a temperate climate or sub-tropic climate. That also means the Sahara desert can be a prosperous area with fine climate and with closed-loop water cycle.

The building of film dome is very ease. We spread out the film over Earth surface, turn on the pumping propellers and film is risen by air to needed altitude limited by the support cables. The bid damage of film is not trouble because the additional air pressure is very small and air leakage is compensated by propeller pumps.

The other advantages of the suggested method is possibility to pain the pictures on sky (dome), to show films on the sky by projector, to suspend illuminations, decorations, and air tramway. The long distance aircraft fly at altitude 8 - 11 km and our dome do not trouble for it. The support cable will have illumination and internal helicopters also will avoid the contact with them.

The people throw out hundreds the thin film plastic bags from purchases every month. If we will collect them and use for the offered dome, we make fine our weather, get new territory for living with wonderful climate.

Our design for the dome is presented in Figure 3, which includes the thin inflated film dome. The innovations are listed here: (1) the construction is air-inflatable; (2) each dome is fabricated with very thin, transparent film (thickness is 0.1 to 0.3 mm) having the control clarity without rigid supports; (3) the enclosing film has two conductivity layers plus a liquid crystal layer between them which changes its clarity, color and reflectivity under an electric voltage (figure 4); (4) the bound section of dome has a hemisphere form (#5, Figure 3) . The air pressure is more in these sections and they protect the central sections from outer wind.

Figure 3 illustrates the thin transparent control dome cover we envision. The inflated textile shell—technical “textiles” can be woven or non-woven (films)—embodies the innovations listed: (1) the film is very thin, approximately 0.1 to 0.3 mm. A film this thin has never before been used in a major building; (2) the film has two strong nets, with a mesh of about 0.1×0.1 m and $a = 1 \times 1$ m, the threads are about 0.5 mm for a small mesh and about 1 mm for a big mesh. The net prevents the watertight and airtight film covering from being damaged by vibration; (3) the film incorporates a tiny electrically conductive wire net with a mesh about 0.1 x 0.1 m and a line width of about 100 μ and a thickness near 10 μ. The wire net is electric (voltage) control conductor.

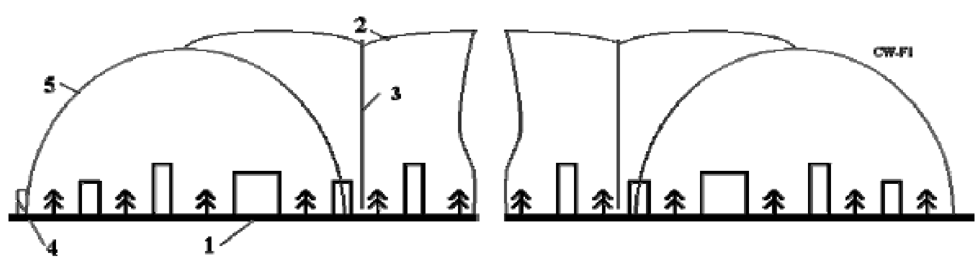

Figure 3. Film dome over city. Notations: 1 - city, 2 - thin film cover with control clarity, 3 - support cable, 4 - exits and ventilators, 5 - semi-cylindrical border section.

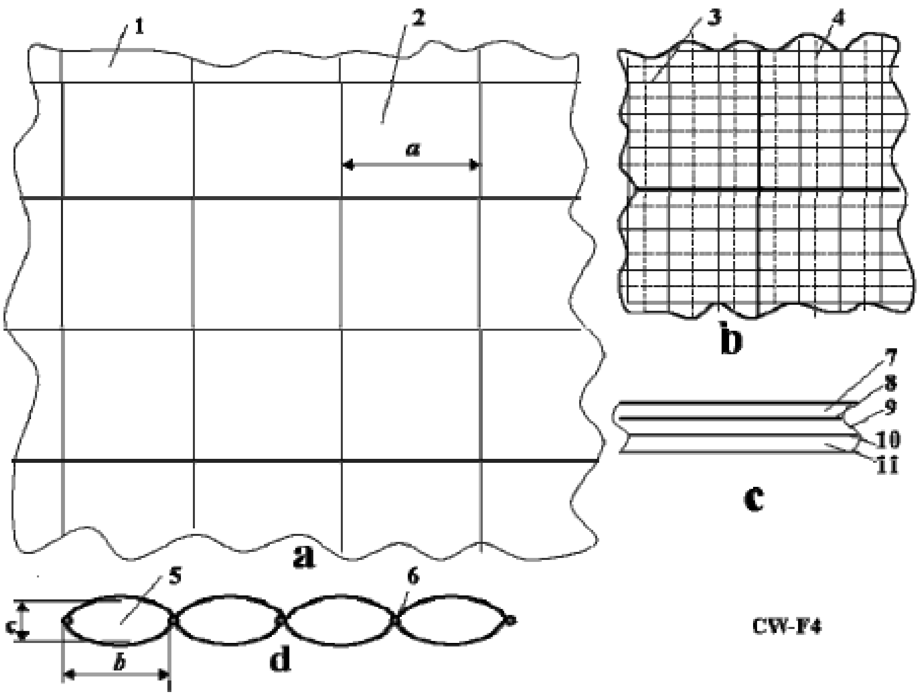

Figure 4. Design of covering membrane. Notations: (a) Big fragment of cover with control clarity (reflectivity, carrying capacity); (b) Small fragment of cover; (c) Cross-section of cover (film)having 5 layers; (d) Longitudinal cross-section of cover for cold regions; 1 - cover; 2 -mesh; 3 - small mesh; 4 - thin electric net; 5 - cell of cover; 6 - tubes;: 7 - transparant dielectric layer, 8 - conducting layer (about 1 - 3 μ), 9 - liquid crystal layer (about 10 - 100 μ), 10 - conducting layer, and 11 - transparant dielectric layer. Common thickness is 0.1 - 0.5 mm. Control voltage is 5 - 10 V.

It can inform the dome supervisors concerning the place and size of film damage (tears, rips, etc.) ; (4) the film may be twin-layered with the gap — c = 1 m and b = 2 m—between covering's layers for heat saving. In polar regions this multi-layered covering is the main means for heat insulation and puncture of one of the layers wont cause a loss of shape because the film's second layer is unaffected by holing; (5) the airspace in the dome's covering can be partitioned, either hermetically or not; and (6) part of the covering can have a very thin shiny aluminum coating that is about 1μ for reflection of unnecessary solar radiation in equatorial or polar regions [1].

3. THEORY AND COMPUTATIONS DOME

As wind flows over and around a fully exposed, nearly completely sealed inflated dome, the weather affecting the external film on the windward side must endure positive air pressures as the wind stagnates. Simultaneously, low air pressure eddies will be present on the leeward side of the dome. In other words, air pressure gradients caused by air density differences on different parts of the dome's envelope is characterized as the "buoyancy effect". The buoyancy effect will be greatest during the coldest weather when the dome is heated and the temperature difference between its interior and exterior are greatest. In extremely cold climates such as the Arctic and Antarctic Regions the buoyancy effect tends to dominate dome pressurization.

Our basic computed equations, below, are derived from a Russian-language textbook. Solar radiation impinging the orbiting Earth is approximately 1400 W/m^2. The average Earth reflection by clouds and the sub-aerial surfaces (water, ice and land) is about 0.3. The Earth-atmosphere adsorbs about 0.2 of the Sun's radiation. That means about q_0 = 700 W/m^{2}s of solar energy (heat) reaches our planet's surface at the Equator. Our troposphere dome does not have clouds in light time and contains about 1/3 part of Earth atmosphere. That means we can adsorb about 70 - 80% of solar energy. It is useful for polar regions and in winter time.

The solar spectrum is graphed in Figure 5.

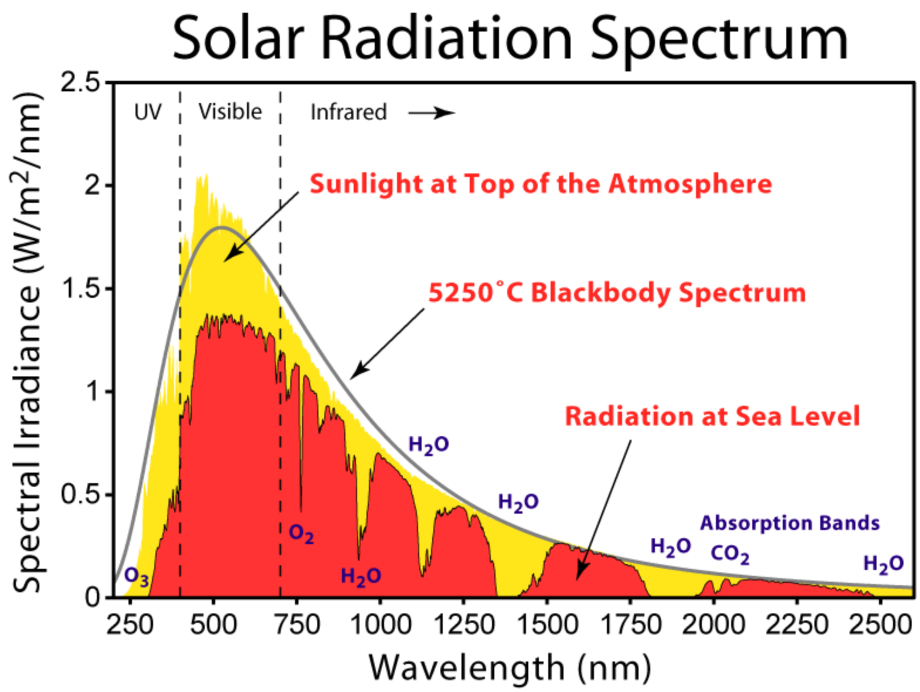

Figure 5. Spectrum of solar irradiance outside atmosphere and at sea level with absorption of electromagnetic waves by atmospheric gases. Visible light is 0.4 - 0.8 μm , 400 – 800 nm.

The visible part of the Sun's spectrum is only λ = 0.4 to 0.8 μ.. Any warm body emits radiation. The emission wavelength depends on the body's temperature. The wavelength of the maximum intensity (see Figure 5) is governed by the black-body law originated by Max Planck (1858-1947):

$$\lambda_m = \frac{2.9}{T}, \quad [mm] \qquad (1)$$

where T is body temperature, ^{o}K. For example, if a body has an ideal temperature 20 ^{o}C (T = 293 ^{o}K), the wavelength is λ_m = 9.9 μ.

The energy emitted by a body may be computed by employment of the Josef Stefan-Ludwig Boltzmann law.

$$E = \varepsilon\sigma_S T^4, \qquad [\mathrm{W/m^2}], \tag{2}$$

where ε is coefficient of body blackness (ε =0.03 ÷ 0.99 for real bodies), σ_s = 5.67×10^{-8} [W/m^2 ·K] Stefan-Boltzmann constant. For example, the absolute black-body (ε = 1) emits (at T = 293 ^{0}K) the energy E = 418 W/m^2.

Amount of the maximum solar heat flow at 1 m^2 per 1 second of Earth surface is

$$q = q_o \cos(\varphi \pm \theta)\ [\mathrm{W/m^2}], \tag{3}$$

where φ is Earth longevity, θ is angle between projection of Earth polar axis to the plate which is perpendicular to the ecliptic plate and contains the line Sun-Earth and the perpendicular to ecliptic plate. The sign "+" signifies Summer and the "-" signifies Winter, q_o ≈ 700 W/m^2 is the annual average solar heat flow to Earth at equator corrected for Earth reflectance. For our case this magnitude can reach q_o ≈ 1000 - 1100 W/m^2.

This angle is changed during a year and may be estimated for Earth's North Polar Region hemisphere by the following the first approximation equation:

$$\theta = \theta_m \cos\omega, \quad \text{where} \quad \omega = 2\pi \frac{N}{364} \tag{4}$$

where θ_m is maximum θ , $|\theta_m|$ = 23.5^o =0.41 radian; N is number of day in a year. The computations for Summer and Winter are presented in Figure 6.

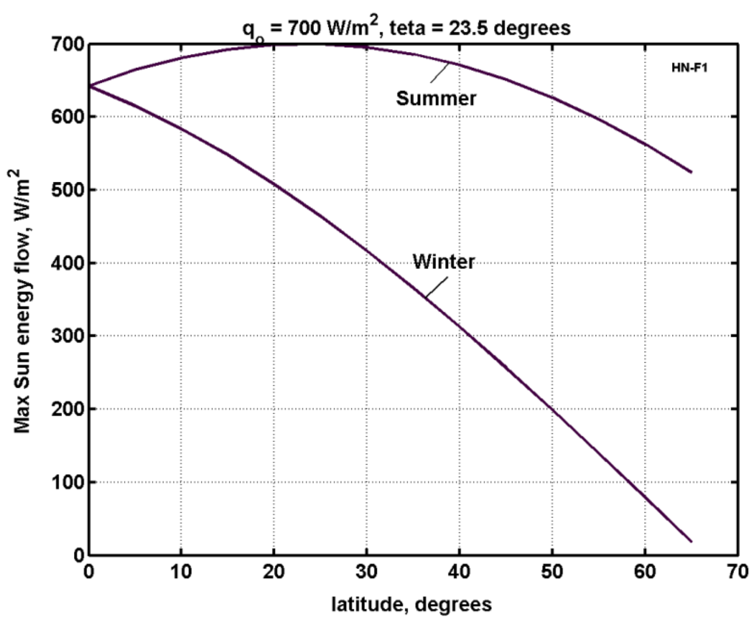

Figure 6. Maximum Sun radiation flow at Earth surface via Earth latitude and season without dome.

The heat flow for a hemisphere having reflector [1] at noon may be computed by equation

$$q = c_1 q_0 \left[\cos(\varphi - \theta) + S \sin(\varphi + \theta)\right] \tag{5}$$

where S is fraction (relative) area of reflector to service area of "Evergreen" dome [1]. For reflector of Figure1 [1] $S = 0.5$; c_1 is film transparency coefficient ($c_1 \approx 0.9$ - 0.95).

The daily average solar irradiation (energy) is calculated by equation

$$Q = 86400\ c\,qt, \quad \text{where} \quad t = 0.5(1 + \tan\varphi \tan\theta), \quad |\tan\varphi \tan\theta| \le 1 \tag{6}$$

,

where c is daily average heat flow coefficient, $c \approx 0.5$ without dome, $c \approx 0.75$ with dome; t is relative daily light time, $86400 = 24\times60\times60$ is number of seconds in a day.

The computation for relative daily light period is presented in Figure 7.

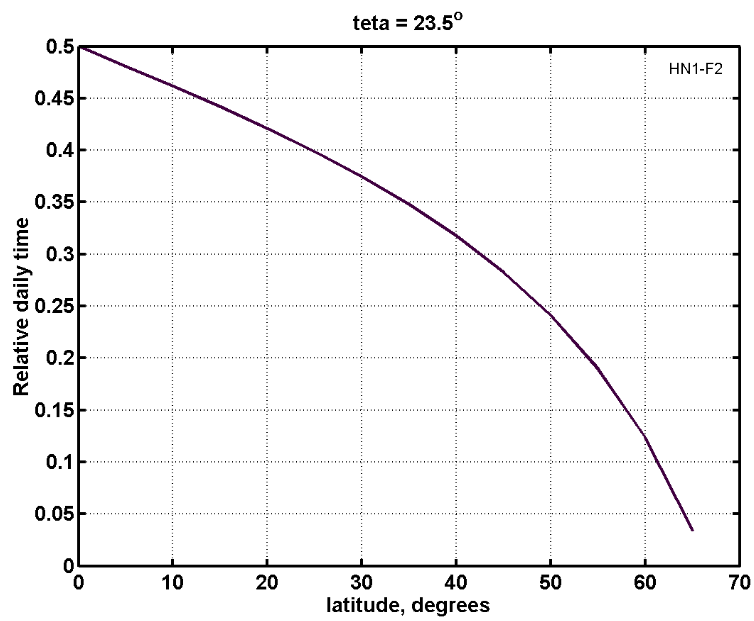

Figure 7. Relative daily light time via Earth latitude.

The heat loss flow per 1 m^2 of dome film cover by convection and heat conduction is (see [2]):

$$q = k(t_1 - t_2), \quad \text{where} \quad k = \frac{1}{1/\alpha_1 + \sum_i \delta_i / \lambda_i + 1/\alpha_2} \tag{7}$$

where k is heat transfer coefficient, $W/m^{2}\cdot K$; $t_{1,2}$ are temperatures of the inter and outer multi-layers of the heat insulators, ^{o}C; $\alpha_{1,2}$ are convention coefficients of the inter and outer multi-layers of heat insulators (α = 30 ÷ 100), W/m^{2}K; δ_i are thickness of insulator layers; λ_i are coefficients of heat transfer of insulator layers (see Table 1), m; $t_{1,2}$ are temperatures of initial and final layers ^{o}C.

The radiation heat flow per 1 m^{2}s of the service area computed by equations (2):

$$q = C_r\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right], \quad \text{where} \quad C_r = \frac{c_s}{1/\varepsilon_1 + 1/\varepsilon_2 - 1}, \quad c_s = 5.67 \quad [\text{W/m}^2\text{K}^4], \qquad (8)$$

where C_r is general radiation coefficient, ε are black body rate (emittance) of plates (see Table 2); T is temperatures of plates, ^{o}K.

The radiation flow across a set of the heat reflector plates is computed by equation

$$q = 0.5\frac{C'_r}{C_r}q_r \qquad (9)$$

where C'_r is computed by equation (8) between plate and reflector.

The data of some construction materials is found in Table 3, 4.

Table 3. [11], p.331. Heat Transferring

Material	Density, kg/m^3	Thermal conductivity, λ W/m· ^{o}C	Heat capacity, kJ/kg. ^{o}C
Concrete	2300	1.279	1.13
Baked brick	1800	0.758	0.879
Ice	920	2.25	2.26
Snow	560	0.465	2.09
Glass	2500	0.744	0.67
Steel	7900	45	0.461
Air	1.225	0.0244	1

As the reader will see, the air layer is the best heat insulator. We do not limit its thickness δ.

Table 4. [11], p. 465. Emittance

Material	Emittance, ε	Material	Emittance, ε	Material	Emittance, ε
Bright Al Temperature	0.04 - 0.06 t = 50 ÷ 500 ^{o}C	Baked brick t = 20 ^{o}C	0.88 - 0.93	Glass t = 20 ÷ 100 ^{o}C	0.91 - 0.94

As the reader will notice, the shiny aluminum louver coating is excellent mean jalousie against radiation losses from the dome.

The general radiation heat Q computes by equation (6). Equations (1) – (9) allow computation of the heat balance and comparison of incoming heat (gain) and outgoing heat (loss).

The computations of heat balance of a dome of any size in the coldest wintertime of the Polar Regions are presented in Figure 8.

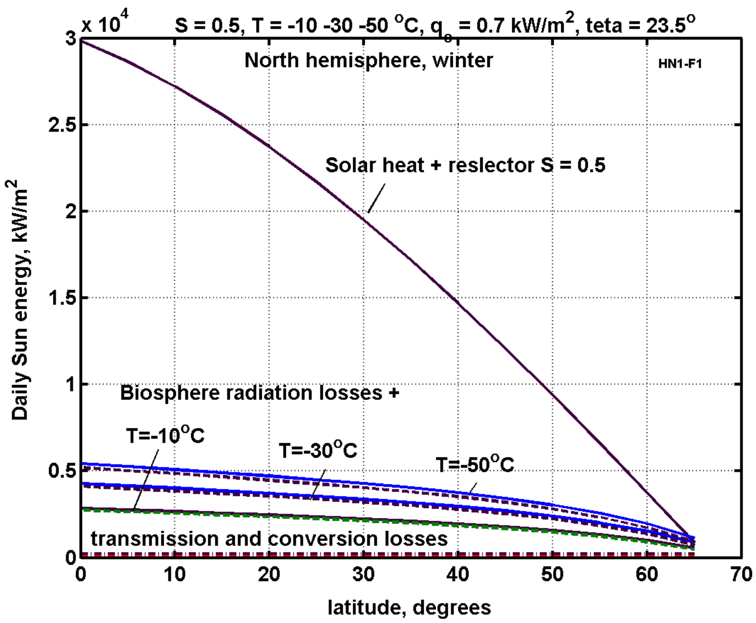

Figure 8. Daily heat balance through 1 m^2 of dome during coldest winter day versus Earth's latitude (North hemisphere example). Data used for computations (see Eq. (1) - (9)): temperature inside of dome is t_1= +20^o C, outside are t_2 = -10, -30, -50^o C; reflectivity coefficient of mirror is c_2= 0.9; coefficient transparency of film is c_1 = 0.9; convectively coefficients are α_1= α2 = 30; thickness of film layers are δ_1= δ_2 =0.0001 m; thickness of air layer is δ = 1 m; coefficient of film heat transfer is λ_1= λ_3 = 0.75, for air λ_2 = 0.0244; ratio of cover blackness ε_1= ε_3 = 0.9, for louvers ε_2 = 0.05.

The thickness of the dome envelope, its sheltering shell of film, is computed by formulas (from equation for tensile strength):

$$\delta_1 = \frac{Rp}{2\sigma}, \quad \delta_2 = \frac{Rp}{\sigma} \tag{10}$$

where δ_1 is the film thickness for a spherical dome, m; δ_2 is the film thickness for a cylindrical dome, m; R is radius of dome, m; p is additional pressure into the dome, N/m^2; σ is safety tensile stress of film, N/m^2.

The dynamic pressure from wind is

$$p_w = \frac{\rho V^2}{2} \tag{11}$$

where $\rho = 1.225$ kg/m^3 is air density; V is wind speed, m/s.

For example, a storm wind with speed $V = 20$ m/s, standard air density is $\rho = 1.225$ kg/m^3. Then dynamic pressure is $p_w = 245$ N/m^2. That is four time less when internal pressure $p = 1000$ N/m^2. When the need arises, sometimes the internal pressure can be voluntarily decreased, bled off.

In Figure 8 the alert reader has noticed: the daily heat loss is about the solar heat in the very coldest Winter day when a dome located above 60^0 North or South Latitude and the outside air temperature is –50 ^{0}C.

In [1] we show the heat loss of the dome in Polar region is less than 14 times the heat of the buildings inside unprotected by an inflated dome.

We consider a two-layer dome film and one heat screen. If needed, better protection can further reduce the head losses as we can utilize inflated dome covers with more layers and more heat screens. One heat screen decreases heat losses by 2, two screens can decrease heat flow by 3 times, three by 4 times, and so on. If the Polar Region domes have a mesh structure, the heat transfer decreases proportional to the summary thickness of its enveloping film layers.

The dome shelter innovations outlined here can be practically applied to many climatic regimes (from Polar to Tropical). The North and South Poles may, during the 21st Century, become places of cargo and passenger congregation since the a Cable Space Transportation System, installed on Antarctica's ice-cap and on a floating artificial ice island has been proposed the would transfer people and things to and from the Moon.[1]

4. Discussion

As with any innovative macro-project proposal, the reader will naturally have many questions. We offer brief answers to the four most obvious questions our readers are likely to ponder.

(1) *How can snow and ice be removed from the dome?* The rain, snow clouds located in Earth troposphere lower 4 km altitude. Our dome has height 4 - 6 km. If water appears over film, it flows down through special opening. If snow appears over film, the control made the black film, the sun flux the snow. The film cover is flexible and has a lift force of about 1 -100 kg/m^2. We imagine that a controlled change of interior air pressure will serve to shake the snow and ice off.

(2) *Storm wind.* The storm wind can be only on bounding sections of dome. They are special semi-cylindrical form (Figure3) and more strong then central sections.

(3) *Cover damage.* The envelope contains a cable mesh so that the film cannot be damaged greatly. Electronic signals alert supervising personnel of any rupture problems.

(4) *What is the design life of the film covering?* Depending on the kind of materials used, it may be as much a decade. In all or in part, the cover can be replaced periodically.

5. Conclusion

The control of Regional and Global Earth Weather is important problem of humanity. That dramatically increases the territory suitable for men living, sown area, crop capacity. That allows to convert all Earth lend such as Alaska, North Canada, Siberia, deserts Sahara or Gobi in prosperous garden. The suggested method is very cheap (cost of covering 1 m^2 is about 2 - 15 cents) and may be utilized at present time. We can start from small area, from small towns in bad regions and extended in large area.

Film domes can foster the fuller economic development of cold regions such as the Earth's Arctic and Antarctic and, thus, increase the effective area of territory dominated by humans. Normal human health can be maintained by ingestion of locally grown fresh vegetables and healthful "outdoor" exercise. The domes can also be used in the Tropics and Temperate Zone. Eventually, they may find application on the Moon or Mars since a vertical variant, inflatable towers to outer space, are soon to become available for launching spacecraft inexpensively into Earth-orbit or interplanetary flights. The closed problems are researched in references [1]-[10].

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(Reader can find part of these articles in WEBs: http://Bolonkin.narod.ru/p65.htm, http://arxiv.org, search: "Bolonkin", and in the book "*Non-Rocket Space Launch and Flight*", Elsevier, London, 2006, 488 pgs.)

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Chapter 4

CONVERTING OF DESERTS AND POLAR EARTH REGIONS IN GARDENS*

ABSTRACT

Sustaining human life at the Earth's antipodal Polar Regions is very difficult especially during Winter when water-freezing air temperature, blizzards and "whiteouts" make normal human existence dangerous. To counter these environmental stresses, we offer the innovative artificial "Evergreen" Polar Zone Dome (EPZD), an inflated half-hemisphere with interiors continuously providing a Mediterranean Sea-like climate. The "Evergreen" EPZD structural theory is developed, substantiated by key computations that show it is possible for current building technology to construct and heat large enclosed volumes inexpensively. Specifically, a satisfactory result is reached by using sunlight reflectors and a special double thin film, which concentrates all available solar energy inside the EPZD while, at the same time markedly decreasing the heat loss to exterior Polar Region air. Someday a similar, but remarkably more technological, EPZD design may be employed at proposed Moon and Mars settlements.

Keywords: *artificial hemisphere, inflatable film building, Polar Region homes, solar energy concentrator*.

I. INTRODUCTION

Particularly during Winter, the Earth's two Polar Regions provide only a meager and uncomfortable life-style for humans, featuring very low ambient air temperature, strong wind, and seasonal darkness. Starting from Cape Artichesky (Russia), Mike Horn and Borge Ousland completed, during January to March 2006, the first known over-pack ice trek to the planet's geographic North Pole during darkness! More persons are likely to undertake such journeys near the Arctic Ocean's coast when permanent dwellings are situated closer to the North Pole. The purpose of our report is to make possible economical new cities at both Polar Regions of the Earth.

Economists allege that the mean 2006 USA Dollar value of Polar Region land territory is generally low compared to the world total of ~$250,000/km^2. For example: Antarctica

* Kept in http://arxiv.org as paper by A. Bolonkin and R. Cathcart.

~$40/km^2, Greenland ~$650/km^2, Canada ~$77,000/km^2 and Russia ~$106,000/km^2. However, world economic productivity data show that the 2006 USA dollar output per capita in the Earth-biosphere is greatest in Polar Regions; cold regions have output per capita that is approximately 10-12 times that of the Earth's Tropic Zones! The distance north or south from the planet's Equator is amongst the most significant measured environmental variables underlying the differences expressed in per capita USA dollar output by country-ecosystem, but this is probably explained by the overall global pattern of human settlement, which tends to influence social institutions and their supportive technologies [1].

In other words, if persons living at the Polar Regions were made more comfortable than now, it is very probable that the economic value per square kilometer of territory situated in those two geographical regions would decrease slightly since only very poor persons (nomadic natives in the Northern Hemisphere) and highly paid persons (technicians and scientists [2]) dwell fulltime in the Earth's Polar Regions nowadays! Non-nomadic people currently work in these uncomfortably cold and seasonally dark climate settlements only because there are known mineral, natural gas and petroleum deposits to be mined, along with seasonal and non-seasonal hydroelectric facilities [3] to be efficiently operated for the benefit of large populations living in warmer climates away from primary production places. There is every reason to think that valuable Arctic and Antarctica resources remain undiscovered, awaiting future exploration and industrial exploitation. The Arctic alone has proven discovered oil and natural gas deposits equal to 40% of Saudi Arabia's total reserves [4]. Many people worldwide, especially in the Temperate Zones, muse on the possibility of humans someday inhabiting orbiting Space Settlements and Moon Bases or a terraformed Mars but few seem to contemplate an increased use of ~25% of Earth's surface—the Polar Regions [5]. Antarctica is being investigated for its economic potential [6] and already the Antarctic Circumpolar Current has been affected by global civilization [7].

II. ARCTIC

Geoscience has generally substantiated that the Arctic is warming and eventually it may reach a seasonally "ice-free" state caused by the absence of new sea-ice due to non-formation as well as summertime excess sublimation of glaciers on land during the 21st Century [8]. Climatological feedback loops, which effect change, are the interplay between sea/land ice, North Atlantic Ocean currents—especially the Gulf Stream and the north-flowing current in the Bering Strait—and the annual amounts of precipitation and evaporation in the Arctic. Reduced sea-ice extent and thickness in the Arctic Ocean would promote regular summertime commercial shipping, and present new opportunities for offshore oil and gas extraction. A Northern Sea Route paralleling the Siberian coastline would be ~40% shorter than the current Europe-Asia Route which requires a passage through the Suez Canal [9]. In addition, new macroprojects—opportunistic hydroelectric power development of diminishing glaciers and a permanent tunnel or bridge[15] across the Bering Strait—may attract new settlers to the Arctic. There is also the possibility, as we explore here, for Arctic Zone greenhouses under inflated membrane half-hemispheres producing fresh fruits and vegetables for workers on such macroprojects and to luxuriously house at low-cost workers seeking to maintain the present-day natural stock of Arctic Ocean sea-ice by construction of artificial ice islands [10].

III. 'EVERGREEN' INFLATED DOMES

Possibly the first true architectural attempt at constructing effective artificial life-support systems in climatically harsh regions in the Earth-biosphere was the building of greenhouses. Extensive commercial greenhouses in The Netherlands—and even outer space [11]—are maintained nearly automatically by heating, cooling, irrigation, nutrition and plant disease management equipment. The "Climatron" greenhouse was finished in 1959 at the Missouri Botanical Garden in St. Louis, USA, while the world's most voluminous greenhouses, the Eden Project, were completed in Cornwall, UK during the early 21st Century [12]. All people share commonalities in their responses to natural environmental stresses that are stimulated by extremely cold air, snowstorms and strong wind. In the Arctic and Antarctica, life-threatening "whiteout" snowstorms inflict somewhat the same personal visual discomfort and disorientation as cosmonauts/astronauts experience during their space-walks—that of being adrift in featureless outer space! With special clothing and shelters, humans can adapt to these Polar Regions successfully. Medical researchers have asserted that "…cold-related deaths are far more numerous than heat-related deaths in the United States, Europe, and almost all countries outside of the tropics, and almost all of them are due to common illnesses that are increased by cold" [13]. Incontrovertibly, living near the planet's poles is stressful and operationally difficult, even when tempered by strong conventional buildings such as those at the Earth's South Pole where the Ozone Hole causes a UVB radiation hazard that cannot be ignored because it helps cause sunburn (erythema) and snow blindness (photokeratitis); the Arctic also has a UVB radiation hazard. The morale of personnel—a difficult factor to measure—during wintertime when little daylight and little contrast between land, sea and sky predominates can cause monotony, a negative influence on personnel activity and efficiency. Essentially, any EPZD becomes the total environment of its inhabitants, so proper internal temperature control and soundproofing are vital. Relative humidity inside the EPZD ought to be fixed at 30-40% for human comfort and health reasons and to insure that static electricity does not become a problem affecting safety in the EPZD.

The first "Evergreen"-type dwelling hemisphere design "City in the Arctic" was commissioned by Germany's Farbwerke Hoechst AG in 1970 [14]. "City in the Arctic" was a pneumatically stabilized climate-regulating transparent membrane half-sphere shell with a diameter 2,000 to 2,200 m and a height of about 240 m intended to comfortably enable 15,000 to 45,000 workers. The contemplated membrane was to be reinforced and supported by a net of intersecting, braided polyester fiber cables. Better 21st Century materials are available that would improve the formidable performance characteristics of "City in the Arctic" [15]. Founded in 1956, Birdair, Inc. in the USA, introduced its Sheerfill™ in 1970 and this constantly improved material offers translucencies of ~25%. The energy impact of Sheerfill, and other nearly non-combustible architectural technical textiles [16], is a function of the tradeoff between decreased lighting needs and increased heating costs; a dynamic air-supported membrane building normally costs only about 33% of a building assembled with ordinary materials [17]. (More technologies will be revealed at The Twelfth International Workshop on the Design and Practical Realization of Architectural Membrane Structures, "Textile Roofs 2007", held 7-9 June 2007 in Berlin, Germany.) "City in the Arctic" was never built because it was merely an architectural speculation, even less substantial than the architectural speculations of Sotirios Kotoulas in *Space Out* (Springer, 2006).

Our macro-engineering concept of inexpensive-to-construct and operate "Evergreen" inflated Earth-surface domes is supported by computations, making our macroproject speculation more than a daydream. However, we lack access to a low-speed laboratory wind tunnel and that inhibits our apprehension of wall interference and the effect of some layout details, such as open or closed doors facing the EPZD exterior. Innovations are needed, and wanted, to realize such structures in the Polar Regions of our unique but continuously changing planet.

IV. Description and Innovations

Our design for an Arctic people-housing "Evergreen" dome is presented in Figure 1, which includes the thin inflated film dome. Air-supported construction derives from the balloon principle to shape a building; the air pressure inside the building exceeds the external air pressure to support the roof. Sunlight can penetrate special roofing materials, making the interiors brighter than others types of constructed buildings. The EPZD innovations are listed here: (1) the construction is air-inflatable; (2) each dome is fabricated with very thin, transparent film (thickness is 0.1 to 0.2 mm) without rigid supports; (3) the enclosing film is a two-layered element with air between the layers to provide insulation; (4) the construction form is that of a hemisphere, or in the instance of a roadway/railway a half-tube, and part of it has a thin aluminum layer about 1 μ or less that functions as the gigantic collector of solar incident solar radiation (heat). Surplus heat collected may be used to generate electricity or furnish mechanical energy; and (5) the dome is equipped with sunlight controlling louvers [AKA, "jalousie", a blind or shutter having adjustable slats to regulate the passage of air and sunlight] with one side thinly coated with reflective polished aluminum of about 1 μ. Real-time control of the sunlight's entrance into the dome and nighttime heat's exit is governed by the shingle-like louvers.

Figure 1 illustrates the thin transparent dome cover we envision. The hemispherical inflated textile shell—technical "textiles" can be woven or non-woven (films)—embodies the EPZD innovations listed: (1) the film is very thin, approximately 0.1 to 0.2 mm. A film this thin has never before been used in a major building; (2) the film has two strong nets, with a mesh of about 0.1 × 0.1 m and $a = 1 \times 1$ m, the threads are about 0.3 mm for a small mesh and about 1 mm for a big mesh. The net prevents the watertight and airtight film covering from being damaged by vibration; (3) the film incorporates a tiny electrically conductive wire net with a mesh about 0.01 x 0.01 m and a line width of about 100 μ and a thickness near 1μ. The wire net can inform the "Evergreen" dome supervisors concerning the place and size of film damage (tears, rips, etc.); (4) the film is twin-layered with the gap — $c = 1$ m and $b = 2$ m—between covering's layers. This multi-layered covering is the main means for heat insulation and puncture of one of the layers wont cause a loss of shape because the film's second layer is unaffected by holing; (5) the airspace in the dome's covering can be partitioned, either hermetically or not; (6) the units #5 of the cover is furnished with a heat tube #6 that can spray warmed anti-freeze liquid onto the EPZD's exterior, thus eliminating snow and ice buildup; and (7) part of the covering has a very thin shiny aluminum coating that is about 1μ for reflection of incoming solar radiation.

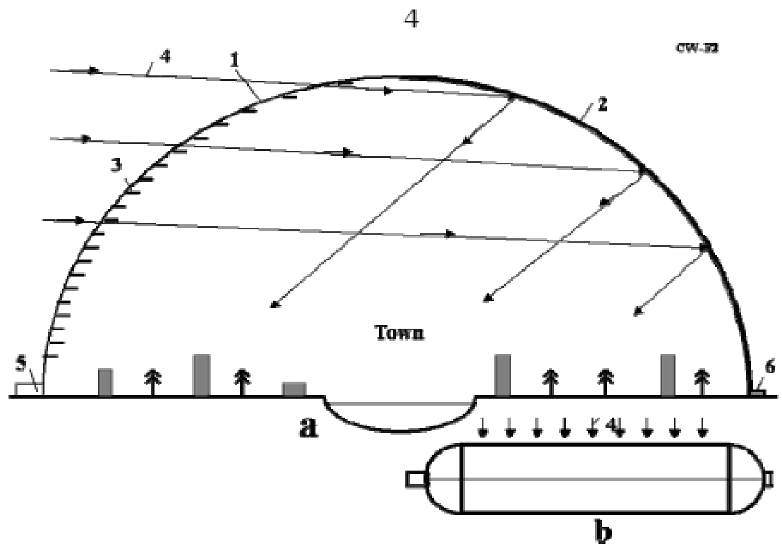

Figure 1. Artificial inflatable dome for Earth's Northern Hemisphere cold regions. *Notations*: (a) cross-section area of suggested biosphere; (b) top view of cylindrical biosphere, 1 - transparence thin double film ("textiles"); 2 - reflected cover of half-hemisphere; 3 - control louvers (jalousie); 4 - solar beams (light); 5 - enter; 6 - air pump (ventilator).

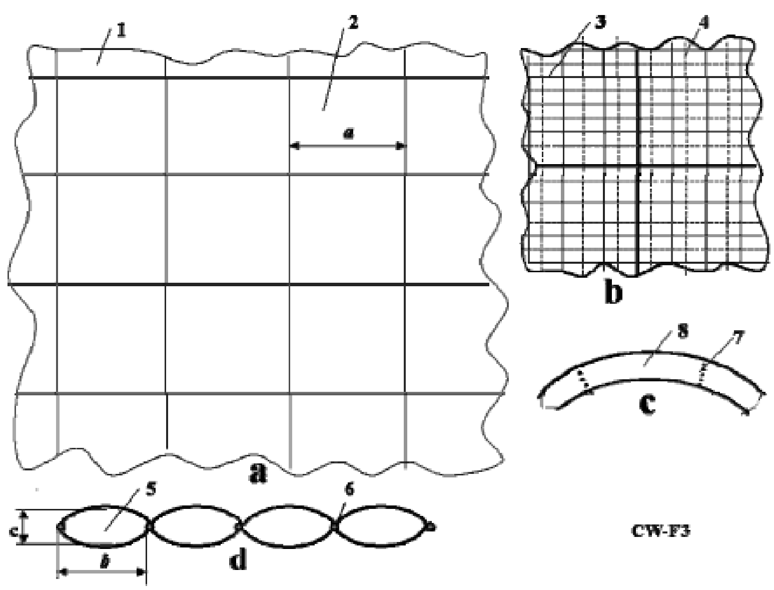

Figure 2. Design of membrane cover. *Notations*: (a) Big fragment of cover; (b) Small fragment of cover; (c) Cross-section of cover; (d) Longitudinal cross-section of cover; 1 - cover; 2 -mesh; 3 - small mesh; 4 - thin electric net; 5 - sell of cover; 6 - tubes; 7 - film partition (non hermetic); 8 - perpendicular cross-section area.

Figure 3 illustrates a lightweight, possibly portable house using the same essential construction materials as the dwelling/workplace shown in Figure 1.

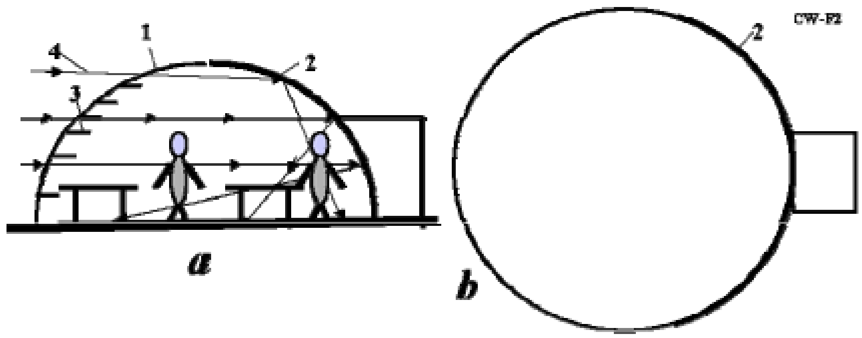

Figure 3. Inflatable film house for cold climate regions. *Notation*: (a) Cross-section area; (b) Top view. The other notations are same with Figure1.

Figure 5. Current inflatable dome.

V. THEORY AND COMPUTATIONS EPZD

The theory of polar settlement are same the theory in Chapter 4A (see equation (1) - (11), figures 5 - 8, and tables 3, 4 in previous section. The additional estimations are below.

The heating by combusted fuel is found by equation

$$Q = c_t m/\eta \,, \tag{1}$$

where c_t is heat rate of fuel [J/kg]; c_t = 40 MJ/kg for liquid oil fuel; m is fuel mass, kg; η is efficiency of heater, η = 0.5 - 0.8.

The thickness of the dome envelope, its sheltering shell of film, is computed by formulas (from equation for tensile strength):

$$\delta_1 = \frac{Rp}{2\sigma}, \quad \delta_2 = \frac{Rp}{\sigma} \tag{2}$$

where δ_1 is the film thickness for a spherical dome, m; δ_2 is the film thickness for a cylindrical dome, m; R is radius of dome, m; p is additional pressure into the dome, N/m^2; σ is safety tensile stress of film, N/m^2.

For example, compute the film thickness for dome having radius R =100 m, additional air pressure p = 0.01 atm (p = 1000 N/m^2), safety tensile stress σ = 50 kg/mm^2 ($\sigma = 5\times10^8$ N/m^2), cylindrical dome.

$$\delta = \frac{100\times1000}{5\times10^8} = 0.0002 m = 0.2\ mm \tag{3}$$

The dynamic pressure from wind is

$$p_w = \frac{\rho V^2}{2} \tag{4}$$

where ρ = 1.225 kg/m^3 is air density; V is wind speed, m/s.

For example, a storm wind with speed V = 20 m/s, standard air density is ρ = 1.225 kg/m^3. Then dynamic pressure is p_w = 245 N/m^2. That is four time less than internal pressure p = 1000 N/m^2. When the need arises, sometimes the internal pressure can be voluntarily decreased, bled off.

In Figure 8 Ch.4A the alert reader has noticed: the daily heat loss is about the solar heat in the very coldest Winter day when a dome located above 60^0 North or South Latitude and the outside air temperature is –50 ^{0}C.

Let us compute and compare the heat extension for conventional buildings located on same region with and without the “Evergreen” dome.

Assume the two-story building, perhaps a home or small office, occupies 0.1 part of domed area. That means their walls and roof is equal to 0.5 part of dome area. Assume the building walls have a thickness of 0.2 m and are formed of baked bricks (λ = 0.758 W/m·K). The differences of temperature are 20 + 50 = 70 ^{0}C (T_1 = 293 ^{0}K, T_2 = 223 ^{0}K). So, 1 m^2 of building surface has a heat loss, in 1 second

$$q = 0.758\times0.5\times70/0.2 = 132.65 \quad \text{W/m}^2\text{.s}\ .$$

The radiation heat loss from 1 m^2 dome at night when the jalousies are closed tightly is

[Eq. (8-9), Ch. 4A]:

$$C'_r = \frac{C_S}{1/\varepsilon_1 + 1/\varepsilon_2 - 1} = \frac{5.67}{1/0.05 + 1/0.9 - 1} = 0.28\,,$$
$$q = 0.5 C'_r [(0.01T_1)^4 - (0.01T_2)^4] = 6.86 \quad W/m^2 s \tag{5}$$

Transfer and convective heat losses is (for $\delta_1 = \delta_3 = 0.0001$ m, $\delta_2 = 1$ m, $\lambda_1 = \lambda_3 = 0.744$, $\lambda_2 = 0.0244$, $\alpha = 30$) (see Eq. (7), Ch. 4A):

$$k = \frac{1}{2/30 + 0.0002/0.744 + 1/0.0244} = 0.025\,,$$
$$q = 0.5\pi\, k(t_1 - t_2) = 1.57 \times 0.025 \times 70 = 2.75 \quad W/m^2 \tag{6}$$

Transfer heat loss is 6.86 + 2.75 = 9.61 W/m^2 < 132.62 W/m^2. The heat loss of the dome is less than 14 times the heat of the buildings inside unprotected by an inflated dome.

We consider a two-layer dome film and one heat screen. If needed, better protection can further reduce the head losses as we can utilize inflated dome covers with more layers and more heat screens. One heat screen decreases heat losses by 2, two screens can decrease heat flow by 3 times, three by 4 times, and so on. If the Polar Region domes have a mesh structure, the heat transfer decreases proportional to the summary thickness of its enveloping film layers.

VI. Macroprojects

The EPZD innovations outlined here can be practically applied to other climatic regimes (from Polar to Tropical). We suggest initial macroprojects could be small (10 m diameter) houses (Figure 3) followed by an "Evergreen" dome in the Arctic or Antarctica covering a land area 200 × 1000 m, with irrigated vegetation, homes, open-air swimming pools, playground.

The house and "Evergreen" dome have several innovations: Sun reflector, double transparent insulating film, controllable jalousies coated with reflective aluminum and an electronic cable mesh inherent to the film for dome safety/integrity monitoring purposes. By undertaking to construct a half-sphere house, we can acquire experience in such constructions and explore more complex constructions. By computation, a 10 m diameter home has a useful floor area of 78.5 m^2, airy interior volume of 262 m^3 covered by an envelope with an exterior area of 157 m^2. It film enclosure material would have a thickness of 0.0002 mm with a total mass of 65 kg.

A city-enclosing "Evergreen" dome of 200 × 1000 m (Figure 1, with spherical end caps) could have calculated characteristics: useful area = 2.3 × 10^5 m^2, useful volume 17.8 × 10^6 m^3, exterior dome area of 3.75 × 10^5 m^2 comprised of a film of 0.0002 mm thickness and 145 tonnes. If the "Evergreen" dome were formed with concrete 0.2 m thick, the mass of the city-size envelope would be 173×10^3 tonnes, which is a thousand times heavier. Also, just for comparison, if we made a gigantic "Evergreen" dome with stiff glass, thousands of tonnes of steel, glass would be necessary and such materials would be very costly to transport hundreds, possibly thousands, of kilometers to the site where they would be assembled by highly-paid workers. Our non-woven textile (film) is flexible and plastic can be relatively cheap. The single greatest boon to "Evergreen" dome construction, whether in the Earth's Polar Regions or elsewhere, is the protected cultivation of plants within a dome that generates energy from the available and technically harnessed sunlight. However, the North and South Poles may, during the 21st Century, become places of cargo and passenger congregation since a Cable Space Transportation System, installed on Antarctica's ice-cap and on a floating artificial ice island has been proposed the would transfer people and things to and from the Moon [18].

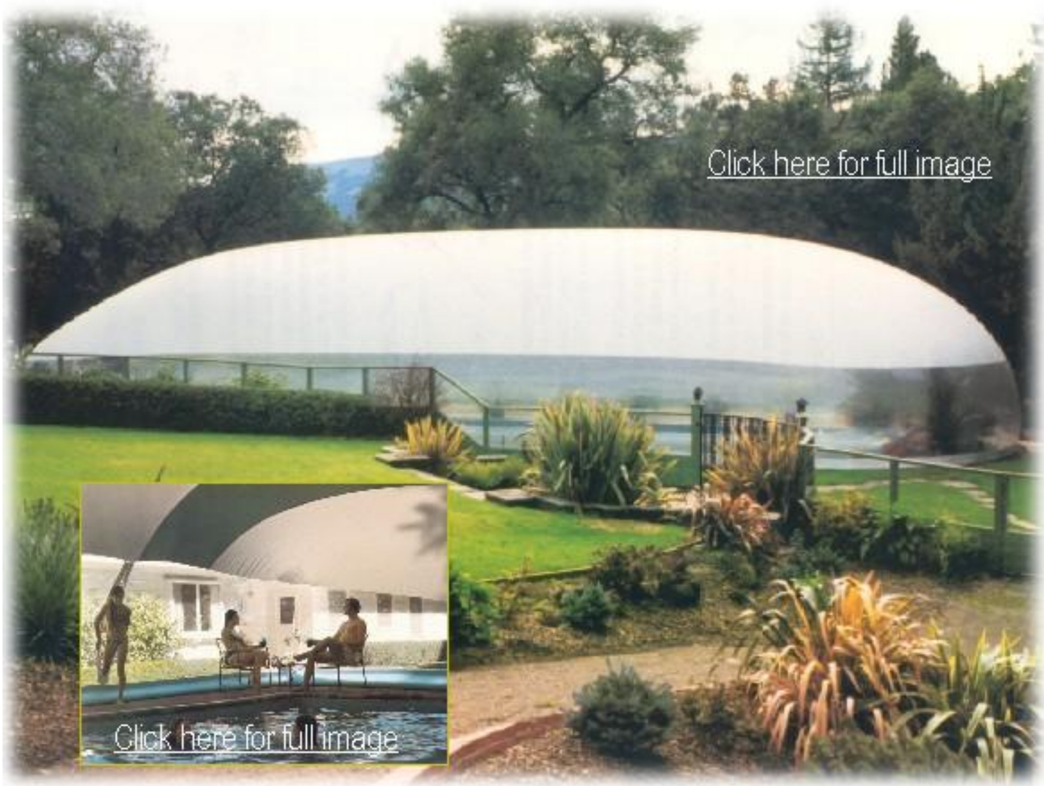

Figure 6. Current inflatable dome.

VII. Discussion

As with any innovative macroproject proposal, the reader will naturally have many questions. We offer brief answers to the four most obvious questions our readers are likely to ponder.

(1) *How can snow and ice be removed from the dome?* After a snowfall, weather conditions permitting, a helicopter can hover over the dome, blowing off the accumulated loose snow. Compacted snow and ice can be removed by activating

remotely operated sprayers that squirt warmed anti-freeze liquid onto the dome's exterior. Such deicer must not be toxic like those currently used at airports [19]. The film cover is flexible and has a lift force of about 100 kg/m^2. We imagine that a controlled change of interior air pressure will serve to shake the snow and ice off. Such a technology is used in aircraft for wing de-icing.

(2) *Storm wind.* This was thoroughly considered in Section V, above.

(3) *Cover damage.* The envelope contains a cable mesh so that the film cannot be damaged greatly. Its double layering structure governs the escape of heated air inside the living zone. Electronic signals alert supervising personnel of any rupture problems and permit a speedy repair effort by well-trained persons.

(4) *What is the design life of the film covering?* Depending on the kind of materials used, it may be as much a decade. In all or in part, the cover can be replaced periodically.

VIII. CONCLUSION

"Evergreen" domes can foster the fuller economic development of cold regions such as the Earth's Arctic and Antarctic and, thus, increase the effective area of territory dominated by humans. Normal human health can be maintained by ingestion of locally grown fresh vegetables and healthful "outdoor" exercise. "Evergreen" domes can also be used in the Tropics and Temperate Zone. Eventually, they may find application on the Moon or Mars since a vertical variant, inflatable towers to outer space [20], are soon to become available for launching spacecraft inexpensively into Earth-orbit or interplanetary flights [22-25].

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Chapter 5

CHEAP TEXTILE DAM PROTECTION OF SEAPORT CITIES AGAINST HURRICANE STORM SURGE WAVES, TSUNAMIS, AND OTHER WEATHER-RELATED FLOODS*

ABSTRACT

Author offers to complete research on a new method and cheap applicatory design for land and sea textile dams. The offered method for the protection of the USA's major seaport cities against hurricane storm surge waves, tsunamis, and other weather-related inundations is the cheapest (to build and maintain of all extant anti-flood barriers) and it, therefore, has excellent prospective applications for defending coastal cities from natural weather-caused disasters. It may also be a very cheap method for producing a big amount of cyclical renewable hydropower, land reclamation from the ocean, lakes, riverbanks, as well as land transportation connection of islands, and islands to mainland, instead of very costly over-water bridges and underwater tunnels.

Keywords: *textile dam, protection of cities against hurricane threats, protection against tsunami, flood protection, hydropower stations, land reclamation*.

INTRODUCTION

In this statement, we consider the protection of important coastal urbanized regions against tropical cyclone (hurricane), tsunami, and other such costly inundations. The hurricane, storm and other weather disaster were described in Chapter 3A. Now we shortly describe tsunami.

A *tsunami* is a series of waves when a body of water, such as an ocean is rapidly displaced on a massive scale. Earthquakes, mass movements above or below water, volcanic eruptions and other underwater explosions, landslides and large meteorite impacts all have the

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potential to generate a tsunami. The effects of a tsunami can range from unnoticeable to devastating. Tsunamis are common throughout Japanese history, as 195 events in Japan have been recorded.

Tsunami

A tsunami has a much smaller amplitude (wave heights) offshore, and a very long wavelength (often hundreds of kilometres long), which is why they generally pass unnoticed at sea, forming only a passing "hump" in the ocean.

Tsunamis can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Such large vertical movements of the Earth’s crust can occur at plate boundaries. Subduction earthquakes are particularly effective in generating tsunamis. As an Oceanic Plate is subducted beneath a Continental Plate, it sometimes brings down the lip of the Continental with it. Eventually, too much stress is put on the lip and it snaps back, sending shockwaves through the Earth’s crust, causing a tremor under the sea, known as an Undersea Earthquake.

Sub-marine landslides (which are sometimes triggered by large earthquakes) as well as collapses of volcanic edifices may also disturb the overlying water column as sediment and rocks slide downslope and are redistributed across the sea floor. Similarly, a violent submarine volcanic eruption can uplift the water column and form a tsunami.

Tsunamis are surface gravity waves that are formed as the displaced water mass moves under the influence of gravity and radiate across the ocean like ripples on a pond.

In the 1950s it was discovered that larger tsunamis than previously believed possible could be caused by landslides, explosive volcanic action and impact events. These phenomena rapidly displace large volumes of water, as energy from falling debris or expansion is transferred to the water into which the debris falls. Tsunamis caused by these mechanisms, unlike the ocean-wide tsunamis caused by some earthquakes, generally dissipate quickly and rarely affect coastlines distant from the source due to the small area of sea affected. These events can give rise to much larger local shock waves (solitons), such as the landslide at the head of Lituya Bay which produced a water wave estimated at 50 – 150 m and reached 524 m up local mountains. However, an extremely large landslide could generate a megatsunami that might have ocean-wide impacts.

While it is not possible to prevent a tsunami, in some particularly tsunami-prone countries some measures have been taken to reduce the damage caused on shore. Japan has implemented an extensive programme of building tsunami walls of up to 4.5 m (13.5 ft) high in front of populated coastal areas. Other localities have built floodgates and channels to redirect the water from incoming tsunamis. However, their effectiveness has been questioned, as tsunamis are often higher than the barriers. For instance, the tsunami which hit the island of Hokkaido on July 12, 1993 created waves as much as 30 m (100 ft) tall - as high as a 10-story building. The port town of Aonae was completely surrounded by a tsunami wall, but the waves washed right over the wall and destroyed all the wood-framed structures in the area. The wall may have succeeded in slowing down and moderating the height of the tsunami but it did not prevent major destruction and loss of life.

Japan is a nation with the most recorded tsunamis in the world. The earliest recorded disaster being that of the 684 A.D. Hakuho Quake. The number of tsunamis in Japan totals 195 over a 1,313 year period, averaging one event every 6.7 years, the highest rate of occurrence in the world. These waves have hit with such violent fury that entire towns have been destroyed. In 1896 Sanriku, Japan, with a population of 20,000, suffered such a devastating fate.

On December 26, 2004, an undersea earthquake measuring 9.0 on the Richter scale occurred 160 km (100 mi) off the western coast of Sumatra, Indonesia. It was the fifth largest earthquake in recorded history and generated massive tsunamis, which caused widespread devastation when they hit land, leaving an estimated 250,000 people dead in countries around the Indian Ocean.

The 2004 Indian Ocean earthquake, which had a magnitude of 9.3, triggered a series of lethal tsunamis on December 26, 2004 that *killed approximately 230,000 people* (including 168,000 in Indonesia alone), making it the deadliest tsunami in recorded history. The tsunami killed people over an area ranging from the immediate vicinity of the quake in Indonesia, Thailand and the north-western coast of Malaysia to thousands of kilometres away in Bangladesh, India, Sri Lanka, the Maldives, and even as far as Somalia, Kenya and Tanzania in eastern Africa.

Unlike in the Pacific Ocean, there was no organized alert service covering the Indian Ocean. This was in part due to the absence of major tsunami events since 1883 (the Krakatoa eruption, which killed 36,000 people). In light of the 2004 Indian Ocean tsunami, UNESCO and other world bodies have called for a global tsunami monitoring system.

DESCRIPTION OF INNOVATION

Current coast-protection dams are built from solid material (heaped stones, concrete, piled soil). They are expensive to emplace and, sometimes, are unsightly. Such dams require detailed on-site research of the surface and sub-surface environment, costly construction and high-quality building efforts over a long period of time (years). Naturally, the coast city inhabitants lose the beautiful sea view and ship passengers are unable to admire the city panorama of the partly hidden city (New Orleans, which is below sea level). The sea coastal usually has a complex geomorphic configuration that greatly increases the length and cost of dam protections.

Authors offer to protect seaport cities against hurricane storm surge waves, tsunamis, and other weather related-coastal and river inundations by new special design of the water and land textile dams.

The offered dam is shown in Figure 3a below. One contains the floats 4, textile (thin film) 3 and support cables 5. The textile (film) is connected a top edge to the floats, the lower edge to a sea bottom. In calm weather the floats are located on the sea surface (Figure 1a) or at the sea bottom (Figure 1b). In stormy weather, hurricane, predicted tsunami the floats automatically raise to top of wave and defend the city from any rapid increase of seawater level (Figure 3c).

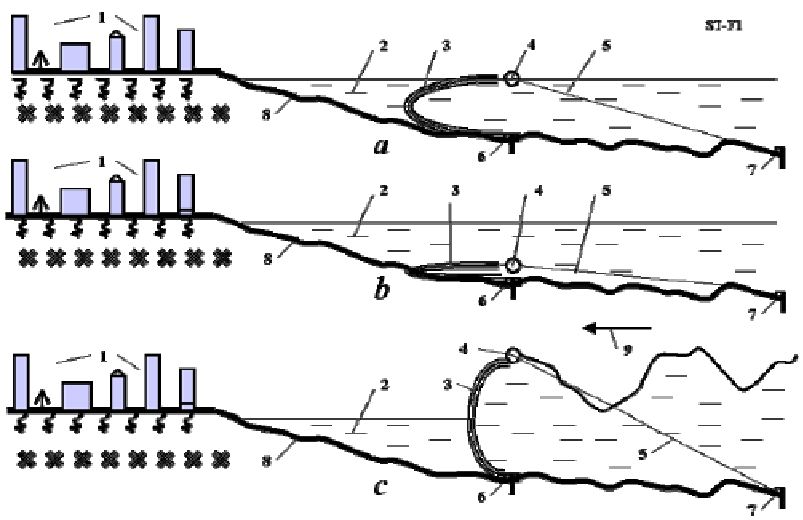

Figure 1. Protection city against hurricane storm surge waves, tsunamis, and other weather related-coastal inundations by textile (film) membrane located in sea (ocean). (a) - position of membrane on a sea surface in a calm weather; (b) - position of membrane on a sea bottom in a calm weather; (c) - position of membrane in hurricane storm surge waves, tsunamis, and other weather related-coastal inundations. *Notations*: 1 - city, 2 - sea (ocean), 3 - membrane, 4 - float, 5 - support cable, 6 - connection of membrane to a sea bottom, 7 - connection of support cable to a sea bottom, 8 - sea bottom, 9 - wind.

This textile-based dam’s cost-to-build is thousands of times cheaper then a massive concrete dam, and a textile infrastructure may be assembled in few months instead of years! They may be installed on ground surface around vital or important infrastructure objects (entries to subway tunnels, electricity power plants, civic airport, and so on) or around a high-value part of the city (example, Manhattan Island) if inundation poses a threat to the city (Figure 2). These textile protections are mobile and can be relocated and installed in few days if hurricane is predictably moving to given city. They can defend the noted object or city from stormy weather inundation, tsunamis, and large waves of height up 30 and more feet.

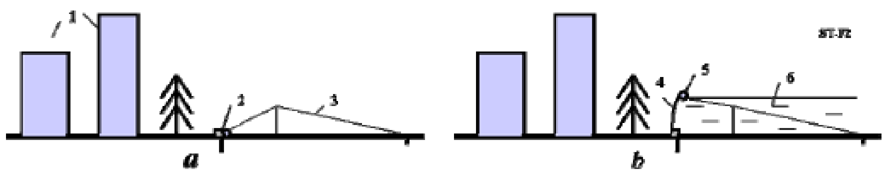

Figure 2. Protection city against hurricane storm surge waves, tsunamis, and other weather related-coastal inundations by textile (film) membrane located on ground surface. (a) - position of membrane on a ground surface in a compact form in a calm weather; (b) - position of membrane in hurricane storm surge waves, tsunamis, and other weather related-coastal inundations. *Notations*: 1 - city, 2 - membrane in the compact form, 3 - support cable, 4 - membrane, 5 - float, 6 -water, 7 - connection of support cable to a sea bottom.

The offered textile dam may be also used as a big source of electricity. They can be built as the dams in rivers and it is used as water dams for the electric station (Figure 3).

They also can be used as the dams for an ebb - flow sea electric station (Figure 4).

Double textile dams can be also used for drying a big area of a shallow sea and converting its to industrial and farmland zones or for connection of closely islands (Figure 5). It may be cheaper then to build an expensive bridges or underground tunnels. For security the textile dams must be double (Figure 5) and area located lower a sea level must be divided in zones separated by additional membranes.

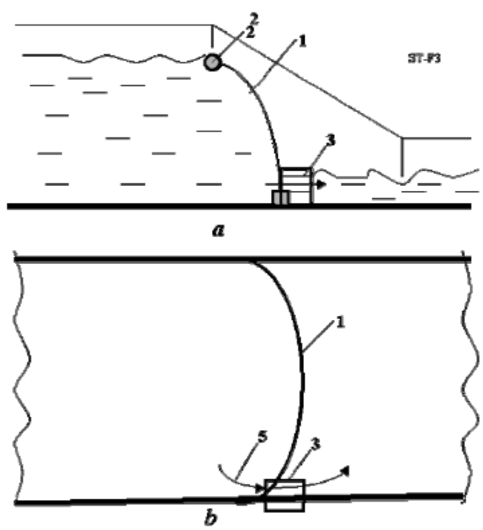

Figure 3. Textile dam and electric station in a river. (a) side view; (b) - top view. *Notations:* 1 - textile dam, 2 - float, 3 - electric station, 4 - water flow.

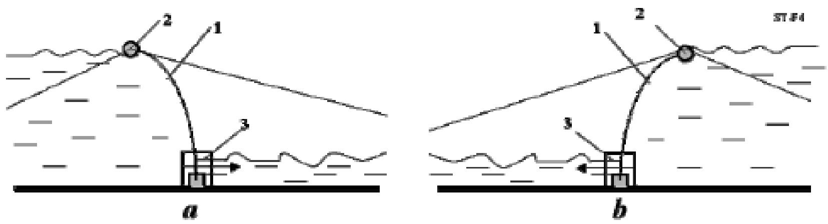

Figure 4. Tidal (ebb and flow) electric station with textile dam. (a) - ebb; (b) - flow. *Notations:* 1 -textile membrane, 2 - float, 3 - electric station.

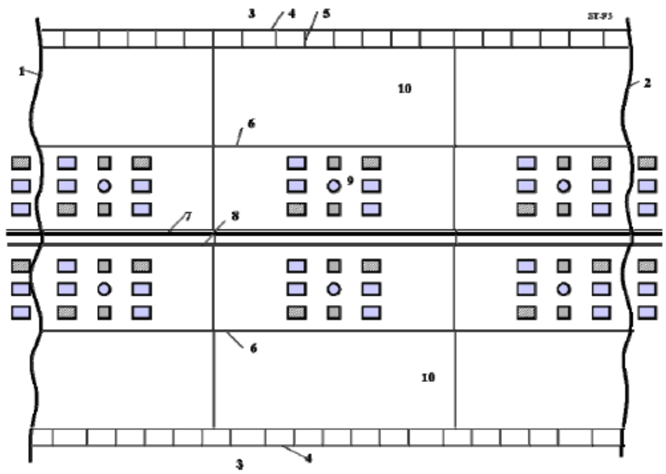

Figure 5. Ground connection between islands or converting a shallow sea in dry land by textile membranes. *Notations*: 1 - the fist island, 2 - the second island, 3 - sea, 4 - double textile membrane, 5 - textile partitions between the double membranes, 6 - additional emergency ground textile partition, 7 - car (track) highway, 8 - railroad, 9 - dwelling (industrial) zone; 10 - farmland.

The membranes must be made from artificial fiber or a film. The many current artificial fibers are cheap, have very high safety tensile stress (some times more the steel!) and chemical stability. They can work as dam some tens years. They are easy for repair.

THEORY AND COMPUTATION

1. *Force P* [N/m^2] for 1 m^2 of dam is

$$P = g\gamma h \quad (1)$$

where g = 9.81 m/s2 is the Earth gravity; γ is water density, γ =1000 kg/m3; h is difference between top and lower levels of water surfaces, m (see computation in Figure 6).

2. *Water power N* [W] is

$$N = \eta gmh, \quad m = \gamma vS, \quad v = \sqrt{2gh}, \quad N = \eta g\gamma hS\sqrt{2gh}, \quad N/S \approx 43.453\eta h^{1.5} \quad [\text{kW/m}^2] \quad (2)$$

where m is mass flow across 1 m width kg/m; v is water speed, m/s; S is turbine area, m^2; η is coefficient efficiency of the water turbine, N/S is specific power of water turbine, kW/m^2.

Computation is presented in Figure 7.

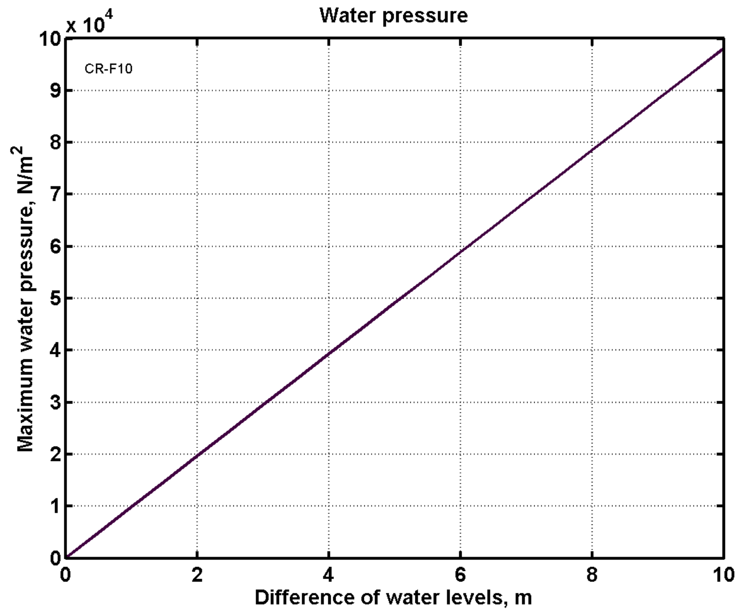

Figure 6. Water pressure via difference of water levels.

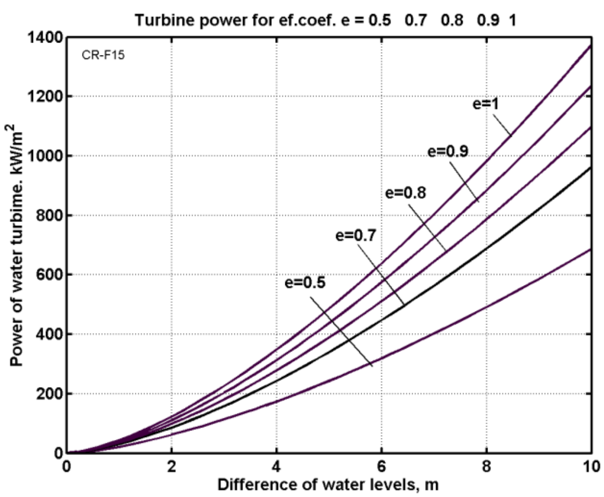

Figure 7. Specific power of a water turbine via difference of water levels and turbine efficiency coefficient.

3. *Film thickness* is

$$\delta = \frac{g\gamma h^2}{2\sigma} \tag{3}$$

where σ is safety film tensile stress, N/m^2. Results of computation are in Figure 8. The fibrous material (Fiber B, PRD-49) has σ = 312 kg/mm^2 and specific gravity γ = 1.5 g/cm^3 [7].

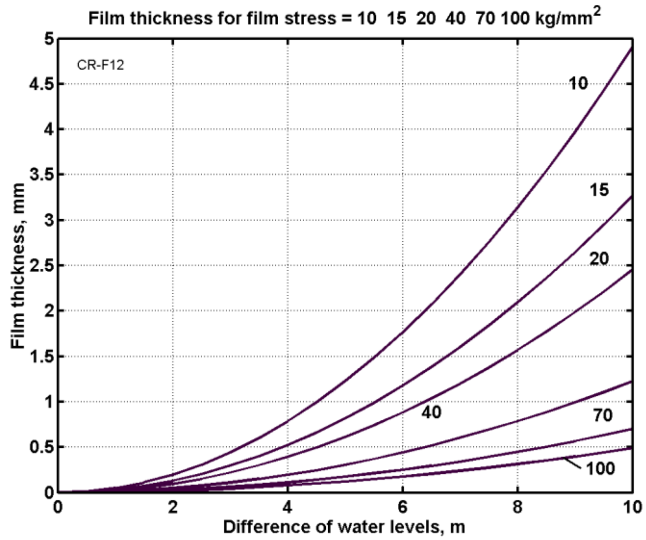

Figure 8. Film (textile) thickness via difference of water levels safety film (textile) tensile stress.

4. *The film weight* of 1m width is

$$W_f = 1.2\delta\gamma H \tag{4}$$

Computation are in Figure 9. If our dam has long *L* m, we must multiple this results by *L*.

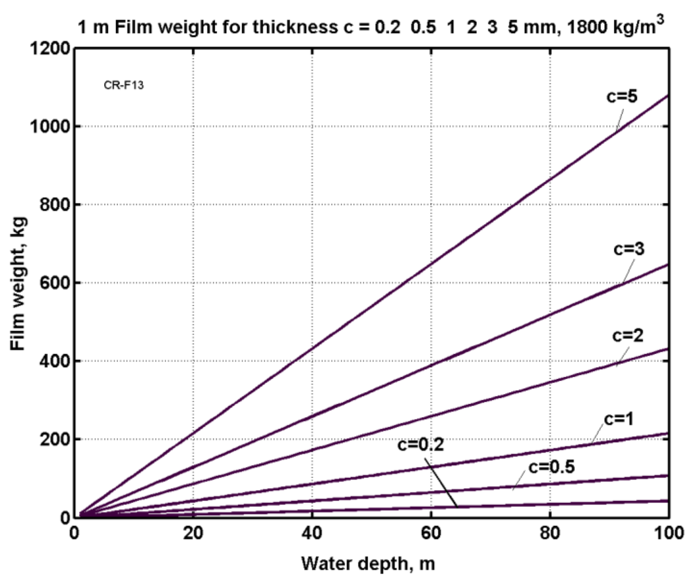

Figure 9. One meter film weight via the deep of dam and film thickness *c*, density 1800 kg/m^3 .

5. *The diameter d* of the support cable is

$$T=\frac{Pl_2}{2},\quad S=\frac{T}{\sigma},\quad d=\sqrt{\frac{4S}{\pi}} \tag{5}$$

where T is cable force, N; l_2 is distance between cable, m; S is cross-section area, m^2.

Computation is presented in Figure 12. The total weight of support cable is

$$W_c \approx 2\gamma_c HSL/l_2\,,\quad W_a=\gamma_c SL, \tag{6}$$

where γ_c is cable density, kg/m^3; L is length of dam, m; W_a is additional (connection of banks) cable, m. The cheap current fiber has σ = 620 kg/mm^2 and specific gravity γ = 1.8 g/cm^3 [7].

6. *Maximum sea raise of water* from hurricane versus wind speed is

$$h=\frac{\rho V^2}{2\gamma} \tag{7}$$

where h is water raising, m; ρ = 1.225 kg/m^3; V is wind speed, m/s; γ = 1000 kg/m^3 is water density. Computation is presented in Figure 11.

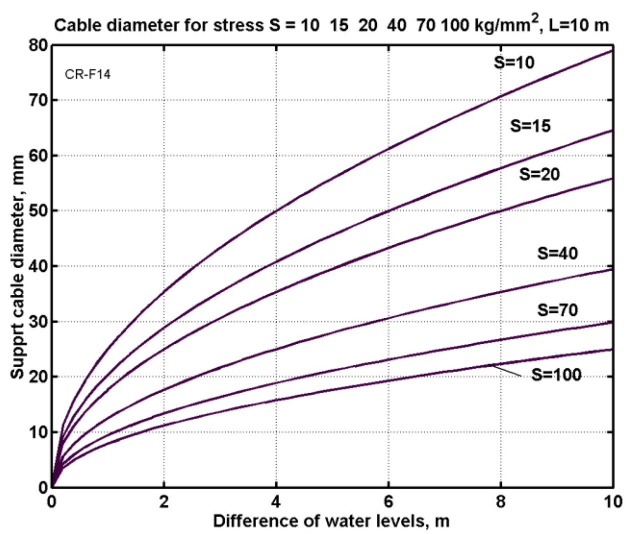

Figure 10. Diameter of the support cable via difference of a water levels and the safety tensile stress for every 10 m textile dam.

Wind speed is main magnitude which influences in the water raising. The direction of wind, rain, general atmospheric pressure, deep, and relief of sea bottom, Moon phase, also influence to the water raising and can decreases or increases the local sea level computed by Equation (7). For example, in hurricane "eye" the wind is absent, but atmospheric pressure is very low and sea level is high.

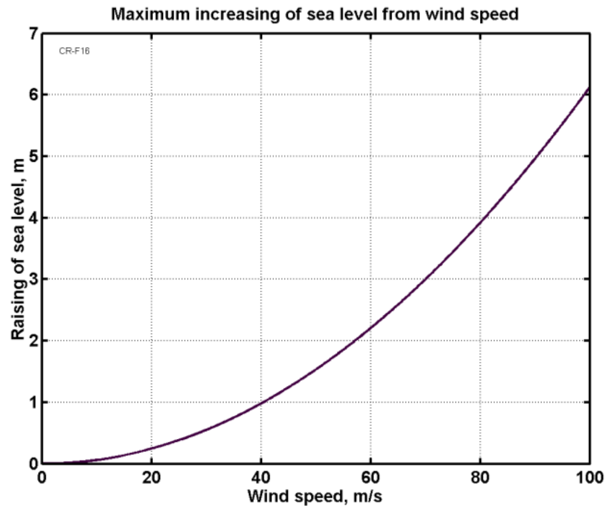

Figure 11. Raising of sea level via wind speed.

Application

Using the graphs above, we can estimate the relevant physical parameters of many interesting macroprojects [1] - [6].

Conclusion

Author offered and researched the new method and cheap design the land and sea textile (film) dams. The offered method of the protection of seaport cities against hurricane storm surge waves, tsunamis, and other weather related inundations is cheapest and has the very perspective applications for defense from natural weather disasters. That is also method for producing a big amount of renewable cheap energy, getting a new land for sea (and non-sea) countries. However, there are important details not considered in this research. It is recommended the consulting with author for application this protection.

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Chapter 6

A LOW-COST NATURAL GAS/FRESHWATER AERIAL PIPELINE*

ABSTRACT

Offered is a new type of low-cost aerial pipeline for delivery of natural gas, an important industrial and residential fuel, and freshwater as well as other payloads over long distances. The offered pipeline dramatically decreases the construction and operation costs and the time necessary for pipeline construction. A dual-use type of freight pipeline can improve an arid rural environment landscape and provide a reliable energy supply for cities. Our aerial pipeline is a large, self-lofting flexible tube disposed at high altitude. Presently, the term "natural gas" lacks a precise technical definition, but the main components of natural gas are methane, which has a specific weight less than air. A lift force of one cubic meter of methane equals approximately 0.5 kg. The lightweight film flexible pipeline can be located in the Earth-atmosphere at high altitude and poses no threat to airplanes or the local environment. The authors also suggest using lift force of this pipeline in tandem with wing devices for cheap shipment of a various payloads (oil, coal and water) over long distances. The article contains a computed macroproject in northwest China for delivery of 24 billion cubic meter of gas and 23 millions tonnes of water annually.

Keywords: *self-lofting aerial pipeline, dual use pipeline, long-distance freight transport.*

INTRODUCTION

Natural gas is a mixture of flammable gases, mainly the hydrocarbons methane (CH_4) and ethane that found in bulk beneath the Earth's surface. Helium is also found in relatively high concentrations in natural gas. Natural gas usually occurs in close association with petroleum. Although many natural gases can be used directly from the well without treatment, some must be processed to remove such undesirable constituents as carbon dioxide, poisonous hydrogen sulfide, and other sulfur components.

Methods of pipeline transportation that were developed in the 1920s marked a significant stage in the use of gas. After World War II there occurred a period of tremendous expansion that has continued into the 21st Century. Increasingly, this expansion relies on the use of pipeline transportation of gas. Among the largest accumulations of natural gas are those of

* Kept as paper by A. Bolonkin and R. Cathcart in http://Arxiv.org

Urengoy in Siberia, the Texas Panhandle in the United States, Slochteren-Groningen area in The Netherlands, and Hassi RMel in Algeria. Gas accumulations are mostly encountered in the deeper parts of sedimentary basins. Natural gas fields are often located far from the major centers of consumption. Consequently, the gas must be transported. Transportation of natural gas depends upon its form. In a gaseous form it is transported by pipeline under high pressure, and in a liquid form it is transported by tanker ship [1].

Tipical ground pipeline

Large gas pipelines enable gas to be transported over great distances. Examples are the North American pipelines, which extend from Texas and Louisiana to the Northeast coast, and from the Alberta fields to the Atlantic seaboard. Transportation pressure is generally 70 kilograms per square centimeter (up to 200 atm) because transportation costs are lowest for pressures in this range. Natural gas pipeline diameters for such long-distance transportation have tended to increase from an average of about 60 to 70 centimeters in 1960 to about 1.20 meters nowadays. Some macroprojects involve diameters of more than 2 meters. Because of pressure losses, the pressure is boosted every 80 or 100 kilometers to keep a constant rate of flow.

Petroleum prospecting has revealed the presence of large gas fields in Africa, the Middle East, Alaska, and China. Gas is transported from developed regions by special LNG ships. The gas is liquefied to –160 C and transported in tankers with insulated containers. Since 1965 the capacity of tankers has risen to as much as 120,000 cubic meters, which enables some tankers to convey as much as 70 million cubic meters of gas per voyage. Land or sea-based storage of low-temperature liquefied gas requires double-walled tanks with special insulation. Such tanks may hold as much as 50,000 cubic meters. Even larger storage facilities have been created by using depleted subsurface oil or gas geological reservoirs near consumption centers or by the creation of artificial gas fields in aquifer layers. The latter technique developed rapidly, and the number of storage facilities of this type in the USA increased tremendously during the late 20th Century. There are also such underground storage areas in France and Germany.

Tube pipeline in polar regions.

Residential and commercial use consumes the largest proportion of natural gas in North America and Western Europe, while industry consumes the next largest amount and electric-power generation is third in worldwide natural-gas consumption. By far the major use of natural gas is as fuel, though increasing amounts are used by the chemical industry for raw material. Among the industries that consume large volumes are food, paper, chemicals, petroleum refining, and primary metals. In the USA, a large amount fuels household heaters; in Russia a considerable volume goes for electric-power generation and to generate export revenue. Exportation and importation of natural gas involves some aspects of geopolitical assessment [2]

Most materials that can be moved in large quantities in the form of liquids, gases, or slurries (fine particles suspended in liquid) are generally moved through freight pipelines [3]. Pipelines are lines of pipe equipped with pumps, valves, and other control devices for transporting materials from their remote sources to storage tanks or refineries and in turn to distribution facilities; pipelines may also convey industrial waste and sewage to processing plants for treatment before disposal.

Pipelines vary in diameter from tiny pipes up to lines 9 meters across used in high-volume freshwater distribution and sewage collection networks. Pipelines usually consist of sections of pipe made of steel, cast iron, or aluminum, though some are constructed of concrete, fired clay products, and occasionally plastics. The sections are joined together and, in most cases, installed underground. Because great quantities of often expensive and sometimes environmentally harmful materials are carried by pipelines, it is essential that the systems be well constructed and monitored in order to ensure that they will operate smoothly, efficiently, and safely. Pipes are often covered with a protective coating of coal-tar enamel, asphalt, or plastic; sometimes these coatings may be reinforced or supplemented by an additional sheath of asbestos felt, fiberglass or polyurethane. The materials used depend on the substance to be carried and its chemical activity and possible corrosive action on the pipe. Pipeline designers must also consider such factors as the capacity of the pipeline, internal and external pressures affecting the pipeline, water- and air-tightness, and construction and operating costs. Generally the first step in construction is to clear the ground and dig a trench deep enough to allow for approximately 51 centimeters of soil overburden to cover the pipe. Sections of pipe are then held over the trench, where they are joined together by welding, riveting or mechanical coupling, covered with a protective coating, and lowered into position. Pipelines of some water-supply systems may follow the slope of the land, winding through irregular landscapes like low-gradient railroads and highways do, and rely on gravity to keep the water flowing through them. If necessary, the gravity flow is supplemented by pumping. Most pipelines, however, are operated under pressure to overcome friction within the pipe and differences in elevation. Such systems have a series of pumping stations that are located at intervals of from 80 to 320 kilometers. Many pipelines are equipped with a system of valves that may be shut in the event of a breach in the line. Nevertheless, a short-period breach could still result in a spill of oil or escapes of gas. Vigilant ground and air inspection crews help to avert such damaging and costly accidents by checking periodically the pipeline for obvious weaknesses and stresses. Various methods are used to control corrosion in metallic pipelines. It is worth noting that metallic pipelines, especially those located on the Earth’s surface, are subject to Space Weather, just like electric power grids [4]. In cathodic protection, a negative electrical charge is maintained throughout the pipe to inhibit the electrochemical process of corrosion. In other cases the interior is lined with paints and coatings of plastic and rubber or wrappings of fiberglass, asphalt, or felt. Sometimes corrosion-inhibiting chemicals are injected into the cargo. Pipelines are also cleaned by passing devices called pigs; a pig may be a ball of the same diameter as the pipe; this kind of pig works by scraping clean the pipe's interior as it is propelled along by the flowing cargo. It may also be a complex scrubbing machine that is inserted into the pipe through a special opening. One of the longest metallic gas pipelines in the world is the Northern Lights pipeline, which is 5,470 kilometers long and links the West Siberian gas fields on the Arctic Circle with locations in Eastern Europe; in China, the recently completed “West Gas Supplying To East Project”, yearly conveys 12 trillion cubic meters of natural gas from Xijiang Province gas fields to Beijing, the capital, in a 4,000 kilometer-long metallic pipeline.

The main differences of suggested Gas Transportation Method and Installation from modern metallic pipelines are:

(1) The tubes are made from a lightweight flexible thin film (no steel or solid rigid hard material).
(2) The gas pressure in tube equals an atmospheric pressure of 1- 2 atm. (Some current gas pipelines have pressure of 70 atm.).

(3) Most of the filmic pipeline [except compressor (pumping) and driver stations] is located in the Earth-atmosphere at a high altitude (0.1-6 km) and does not have a rigid support (pillar, pylon, tower). All operating pipelines are located on the ground surface, underground or underwater.
(4) The transported natural gas supports the air pipeline in the air above the route selected.
(5) Additional aerial support may be made by employment of attached winged devices.
(6) The natural gas pipeline can be used as an air transport system for oil and solid payloads with a maximum speed up of 250 m/sec.
(7) The natural gas pipeline can be used as a transfer of a mechanical energy.

The suggested Method and Installation have remarkable cost-benefit advantages in comparison with all existing natural gas pipelines.

DESCRIPTION OF INNOVATION

A gas and payload delivery gas/load pipeline is shown on figures 1 - 5.

Figure 1 shows the gas/load delivery installation by air pipeline.

The installation works in the following manner: The compressor station pumps natural gas from storage into the tube (pipeline). The tube is made from light strong flexible gas-impermeable fireproof material (film), for example, from composed material (fibers, whiskers, nanotubes, etc.). A gas pressure is a less than an atmospheric pressure (up 1-2 atm). A natural (fuel) gas has methane as its main component with a specific density about 0.72 kg/m^3. Air has a specific density about 1.225 kg/cubic meter. That means that every cubic meter of gas (methane) or a gas mixture has a lift force approximately 0.5 kg. The linear (one meter) weight of a tube is less than a linear lift force of gas into the tube and the pipeline, therefore, has a lift force. The pipeline rises up and steadies at a given altitude (0.1 - 6 km), held fast by the tensile elements 3. The altitude of the aerial pipeline can be changed by the use of common winches 7. The compressor station is located on the ground surface and moves natural gas to the next compressor station that is ordinarily located at the distance 70 - 250 km from previous compressor station. Inside of the aerial pipeline there are valves (Figure 4) dedicated to lock the tube tightly in case of it is punctured, ruptured or otherwise damaged. The pipeline has also the warning light indicator 5 for aircraft.

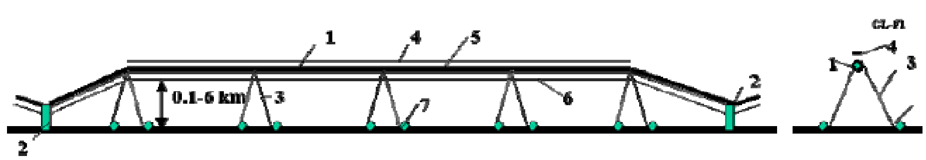

Figure 1. General view of aerial pipeline between two compression (pump) stations. (a) Side view, (b) front view. *Notations*: 1 - pipeline in atmosphere, 2 - compression station, 3 - tensile stress element, 4 - supportive wing device, 5 - night light, 6 - load (container) monorail, 7 - winch.

The route selected for our example—see below—is well north of IATA-1, the new International Air Transport Association-approved flight-path for airliners coming from, or going to Europe via Hong Kong or Shanghai. Only international flights arriving or departing

Beijing might come close to the selected example. Even if hit by an airliner, if the aircraft speed is greater than about 3% of the stress wave velocity, or greater than about 150 m/sec, the airplane's speed causes an immediate fracture that is independent of cable diameter, although the force on the vehicle's wing certainly is not! Figure 2 shows the gross-section of the gas pipeline and support ring. The light rigid tube ring keeps the lift force from gas tube, wing support devices, from monorail and load container.

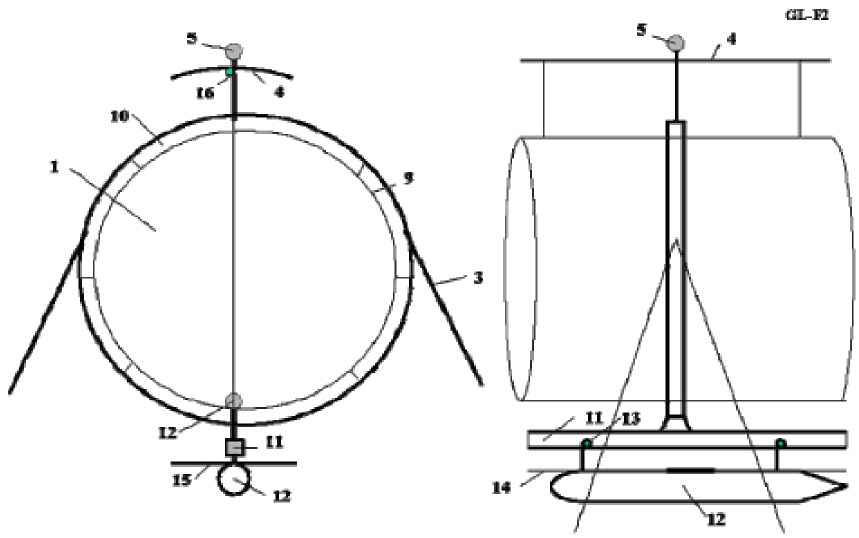

Figure 2. Gross-section and support ring of aerial natural gas pipeline. (a) front view, (b) side view. *Notations:* 9 - double casing, 10 -rigid ring, 11 - monorail, 12 - wing load container, 13 - rollers of a load container, 14 - thrust cable of container, 15 - container wing. Other notations are same Figure 1.

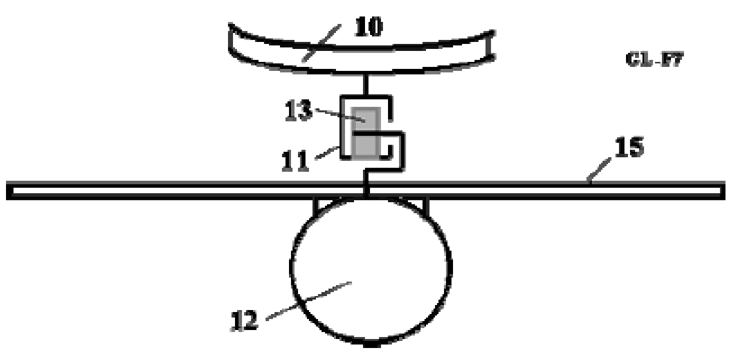

Figure 2a. Front view of the winged load container, monorail, and suspension bracket. Other notations are same figures 1-2.

Figure 3 shows the compressor (pumping) station. The station is located on the ground and works in the following way. The engine 32 rotates compressor 31. That may be propellers located into rigid bogy connected to the flexible tubes of installation 1. The tubes are located at atmosphere. The propellers move the gas in given direction.

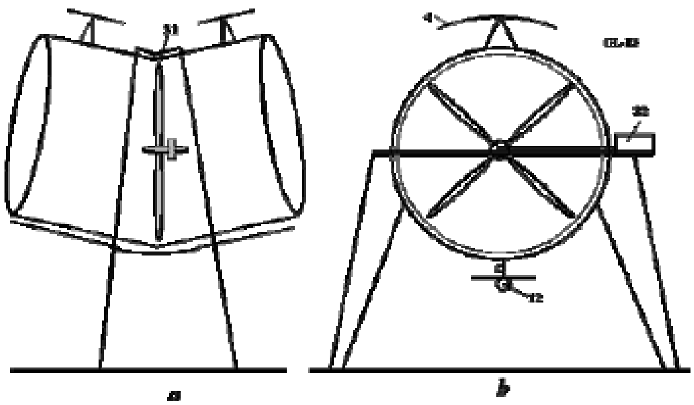

Figure 3. Compression (pump) station. *Notations*: 31 - compressor (propeller), 32 - engine. Other notations are same figures 1-3.

Figure 4 shows two variants a gas valve. The fist valve version is an inflatable boll. The ball fill out and closed the gas way. The second version is con conventional light flat choker in a form of circle. The valve works in the following way. When the tube section is damaged, the pressure decreases in a section. The control devices measure it and, subsequently, the valves close the pipeline. The valve control devices have a connection with a central dispatcher, who can close or open any sub-section of the very long proposed natural gas pipeline.

Figure 4a shows the spherical valve (a ball) in a packed form. Figure4b shows the spherical valve (a ball) in an open form. The tubes of pipeline have a double wall (films) and gas streak between them. If the walls damage the streak gas flows out and the second film closes the hole in the first film and save a tube gas.

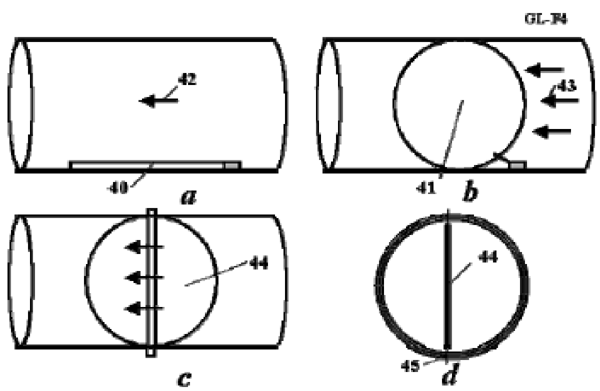

Figure 4. Gas valve. (a)-(b) Inflatable valve, (c)-(d) Flat valve. *Notations:* 40 - inflatable valve in compact position, 41 - inflatable valve in fill out position, 42 - gas flow, 43 - gas pressure, 44 - flat choker.

The winged device 4 is a special automatic wing feature. When there is windy weather and the side wind produces a strong side force, the winged devices produce a strong lift force and support pipeline in fixed vertical position.

The winged device works in the following way: when there is a side wind the tube has the wing drag and the winged device creates needed additional lift force. All forces (lifts, drags, weights) are in equilibrium. The distance between the tensile elements 3 is such that the tube can resist the maximum storm wind speed. The system can have a compensation ring. The compensation ring includes ring, elastic element, and cover. The ring compensates the temperature's change of the tube and decreases a stress from a wind.

The suggested gas pipeline has big advantages over the conventional steel gas pipeline:

(1) The suggested natural gas pipeline is to be made from a thin film that is hundreds of times less expensive than current gas pipelines currently made from steel tubes.
(2) Construction time might be decreased from years to a few months.
(3) There is no need to compress a gas, a huge saving of energy and expenditures for high-maintenance pumps.
(4) No need for expensive ground surface and environmental damage during either the building or exploitation phases of the macroproject.
(5) No environmental damage in case of pipeline's damage during use.
(6) Easy to repair.
(7) Decreasing energy for delivery.
(8) Additional possibility of payload delivery in both directions.
(9) If the aerial natural gas pipeline is situated at high altitude, it is more difficult for successful terrorist attacks and for gas thefts.
(10) The suggested transportation system may be also used for a transfer of mechanical energy from one driver station to another.

More detail description of innovation the reader finds in publication. See [5]-[8].

Below, the authors have computed a macroproject suitable for Beijing region and the desert located in China's northwest territory. In addition, the authors have also solved additional problems, which appear in this and other macroprojects and which can appear as difficult as the proposed pipeline and transportation system itself. (The authors are prepared to discuss the technical problems with serious organizations that are interested in researching and developing these ideas and related macroprojects.)

METHODS OF THE ESTIMATION OF THE ALTITUDE GAS PIPELINE

1. Gas delivery capability is

$$G = \pi D^2 V/4 \qquad [\text{m}^3/\text{sec}], \tag{1}$$

where: D is diameter of tube [m];
V is average gas speed [m/sec].

2. Increment pressure [N/m^2] is

$$P = \lambda L \rho V^2/2D\,, \tag{2}$$

where: λ is dimensionless factor depending on the wall roughness, the fluid properties, on the velocity, and pipe diameter (λ = 0.01 - 0.06); L is the length [m]; ρ is fluid density [kg/m^3].

3. The dimensionless factor can be taken from graph [5, p. 624]. It is

$$\lambda = f(R,\varepsilon)\,, \tag{3}$$

where: $R = V D\rho/\mu$ is Reynolds number, μ is fluid viscosity; ε is measure of the absolute roughness of tube wall.

4. Lift force F of the one meter length of pipeline is

$$F = (\upsilon_a - \upsilon_m)\mathbf{v}\,, \tag{4}$$

where: υ_a = 1.225 kg/m^3 is air density for standard atmosphere; υ_m = 0.72 kg/m^3 is methane density; $v = \pi D^2/4$ is volume of one meter length of pipeline.

5. Needed thickness δ of tube wall is

$$\delta = PD/2\sigma\,, \tag{5}$$

where: P is pressure [see Eq.(2)]; $\boldsymbol{\sigma}$ is safety stress. That is equals 100 - 200 kg/mm^2 for matter from current artificial fiber.

6. Weight of one meter pipeline is

$$W = \pi D\delta\gamma\,, \tag{6}$$

where: γ is specific weight of tube matter (film, cover). That equals about 0.9 - 2.2 kg/m^3 for matter from artificial fiber.

7. Air drag D of pipeline from side wind is

$$D = C_d\rho V^2S/2\,, \tag{7}$$

where: C_d is drag coefficient; S is logistical pipeline area between tensile elements; ρ is air density.

8. Needed power for delivery is

$$N = PG/\eta\,, \tag{8}$$

where: $\eta \approx$ 0.9 is a efficiency coefficient of a compressor station.

Load Transportation System under Pipeline

1. Load delivery capability by wingless container is

$$G_p = k\,F\,V_p\,, \tag{9}$$

where: k is load coefficient ($k \approx 0.5 < 1$); V_p is speed of container (load).

2. Friction force of wingless containers (rollers) is

$$F_c = f\,W_c\,, \tag{10}$$

where: $f \approx$ 0.03 - 0.05 is coefficient of roller friction; W_c is weight of container between driver stations.

3. Air drug of container is

$$D_c = C_c\rho V^2 S_c/2\,, \tag{11}$$

where: C_c is drug friction coefficient related to S_c; S_c is cross-section area of container.

4. The lift force of a wing container is

$$L_c = C_L q S_{cw} = C_L \frac{\rho_a V^2}{2} S_{cw}\,, \tag{12}$$

where: $C_L \approx 1 \div 1.5$ is coefficient of lift force; $q = \rho_a V^2/2$ is air dynamic pressure, N/m^2; S_{cw} is wing area of container, m^2.

5. The drug of wing container may be computed by equation

$$D_C = C_L q S_{cw}/K = C_L \frac{\rho_a V^2}{2K} S_{cw}\,, \quad \text{where} \quad K = \frac{C_L}{C_D} \tag{13}$$

where $K \approx 10 \div 20$ is coefficient of aerodynamic efficiency; C_D is air drag coefficient of wing container. If lift force of wing container equals the container weight, the friction force F is absent and not necessary in monorail.

6. The delivery (load) capacity of the wing container is

$$G_c = \frac{W_1 V_c T}{d} \tag{14}$$

where W_1 is weight of one container, kg; $V_c = 30 \div 200$ m/s is container speed, m/s; T is time, s; d is distance between two containers, m.

7. The lift and drag of the wing device may be computed by Equations (12)-(13). The power needs for transportation system of wing container is

$$P_c = \frac{gWV_c}{K_c} \qquad (15)$$

where W is total weight of containers, kg; g = 9.81 m/s^2 is Earth gravity; $K_c \approx 10 \div 20$ is aerodynamic efficiency coefficient of container and thrust cable;

8. The stability of the pipeline against a side storm wind may be estimated by inequality

$$A = \frac{L_T + L_d - gW_T - gW_S}{D_T + L_d / K_d} > \tan\alpha > 0 \qquad (16)$$

where L_T is lift force of given part of pipe line (conventionally it is distance between the tensile element, N; L_d is lift force of wing device, N; W_T is a weight of pipeline of given part, kg; W_s is weight of the given part suspending system (containers, monorail, thrust cable, tensile element, rigid ring, etc.), kg; D_T is drag of the given part of pipeline, N; L_d is the lift force of the wing device, N; K_d is an aerodynamic efficiency coefficient of wing device; α is angle between tensile element and ground surface.

China Gas/Water Aerial Pipeline Macroproject

(Tube diameter equals D = 10 m, gas pipeline has the suspension load transport system, the project is suitable for Beijing region –Gobi Desert)

Let us take the distance between the compressor-driver stations 100 km and a gas speed V = 10 m/sec.

Gas delivery capacity is (Eq. (1))

$G = \pi D^2 V/4$ = 800 m^3/s = 24 billions m^3 per year.

For the Reynolds number R = 10^7 value λ is 0.015, P = 0.18 atm (Eq. (2)-(3)). We can take V = 20 m/s and decrease delivery capacity by two (or more) times.

Lift force (Eq.4) of one meter pipeline's length equals F = 39 kg.

We take the thickness of wall as 0.15 mm for σ = 200 kg/sq. mm.

The cover weight of one-meter pipeline's length is 7 kg. The needed power of the compressor station (located at distance 100 km) equals N = 10,890 kW for η = 0.9.

Load Transportation System

Let us take the speed of delivery equals V = 30 m/sec, payload capability is 20 - 25 kg per one meter of pipeline in one direction. Then the delivery capability for non-wing containers is 750 kg/s or 23 millions tons per year.

That is more than gas delivery (18 million tons per year). The total load weight suspended under the pipeline of length L = 100 km equals 2500 tons. If a friction coefficient is f = 0.03, the needed trust is 75 tons and needed power from only a friction roller drug is N_1 = 22,500 kW (Eq. (10)).

If the air drag coefficient $C_d = 0.1$, cross section container area $S_c = 0.2$ m^2, the air drag of a one container equals $D_{c1} = 2.2$ kg, and total drag 20,000 container of length 100 km is $D_c =$ 44 tons. The need driver power is $N_2 = 13{,}200$ kW. The total power of transportation system is $N = 22500 + 13200 = 35{,}700$ kW. The total trust force is 77 + 44 = 121 tons.

If $\sigma = 200$ kg/sq. mm, the cable diameter equals 30 mm.

The suggested delivery system can delivery a weight units (non-wing container) up to 100 kg if a selected length of container is 5 - 7.5 m.

The pipeline and container delivery capability may be increased at tens of times if winged containers are utilized. In this case we are not limited in load capability. Winged container needs a very lightweight monorail (or without it) and only in closed-loop thrust cable. That can be used for delivery water, oil or payload in containers. For example, if our system deliveries 4 m^3/second that is equivalent of a normal river (or a water irrigation canal) having a cross-section area equal to 20×2 m and water flowing speed 0.1 m/s. In other words, northwest China’s planted desert dust suppression macroproject—the Great Green Wall [9]—can be fostered by delivery of irrigation water to the vegetation that may become available in AD 2008, just as the Olympic Games are played in Beijing, from the East Route of the “South-North Water Transfer Scheme” [10].

This particular macroproject system can transfer mechanical energy, we can transfer 35,700 kW for the cable speed at 30 m/sec, and 8 times more by the same cable having a speed 250 m/sec.

If the $\alpha < 60^o$ and wing of winged device has a width of 6 m, the system is stable against a side-thrusting storm wind of 30 - 40 m/second.

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Chapter 7

AIR OBSERVE SYSTEM*

ABSTRACT

This manuscript contains a description and basic principles for observing inaccessible areas using low cost, easily deployed equipment. The basic premise is to suspend a tiny video camera at an altitude of 10 - 200 meters over the area to be surveyed. The TV camera supports at altitude by wind or balloon. The technical challenges regard the means by which the camera is suspended. Such a system may be used by military or police forces or by civil authorities for rescue missions or assessment of natural disasters. The method may be further developed for military applications by integrating the surveillance task with deployment of munitions.

Keywords: *air observer, air suspended system, low altitude video observer.*

1. INTRODUCTION

1.1. Historical Perspective

From 1993-2000 the Defense Advanced Research Projects Agency (DARPA) spent 35 millions dollars for Micro Air Vehicle (MAV) research. Micro aircraft, no larger than a small bird, are already showing promise in reconnaissance roles by flying with video cameras and returning live pictures. At present time the Air Force and Army continue Micro Air Vehicle (MAVs) research and development for assisting ground soldiers with non-line-of-sight reconnaissance. Unfortunately, after 10 years of development and spending hundreds of millions of dollars, we still do not have a MAV suitable for reliable, sustainable close-in surveillance. The reason is that the MAV method is fundamentally limited for this role. It is impossible to use when the wind is strong. As fuel capacity is limited, observation times are very limited. An enemy can fairly easily see and avoid (or destroy) the MAV because the MAV must flights at low altitude when using small, lightweight cameras and optics. The

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soldier may require special training for control and operation of the MAV, especially if it does not have an autopilot.

We propose have a method based upon a simple device, which does not have these shortcomings and in some cases, may be more efficient than a MAV.

1.2. Short Description of the Micro Air Observer (MAO)

The basic approach for this method is to suspend a very small, essentially invisible, Micro Air Observer (MAO) or (SAO) - Suspended Air System at a controlled altitude over an area to be investigated. The MAO device includes: (1) aerial support device (kite, air balloon) located at a relatively high altitude (e.g. 1000 m) which is connected by a thin fiber cable and thin electric wire to anchors (and a battery) located at the Earth's surface; (2) a micro video camera (and microphone) at the low altitude (100-200 m) connected to the support device by thin fiber cable and wire; (3) support electronics including a transceiver, radio control, and small battery; (4) control and observation ground station for the soldier (or operator). Optionally, the MAO may also contain a self-destructor. The entire device may be packaged in a canister and dispensed from an aircraft or artillery shell. Most of the devices required to build the MAO exist off-the-shelf and have a combined weight 20-90 grams and volume of 10-50 cubic centimeters.

There are several possible launch methods and conditions for the MAO:

a) The MAO is launched from aircraft. The aircraft dispenses the MAO canister into a given area (Figure 1). The canister is opened at a given altitude, the kite (balloon) is opened, the anchor falls on the ground and stabilizes the kite (balloon). The kite deploys the camera to the desired altitude and begins operation. The kite may require additional anchors (Figure 2) to ensure that the MAO will have the *same position for any wind direction*. The schematic design of the canister and anchor are shown in figures 3 and 4 respectively. Figure 5 show the MAO being launched from an air launched cruise missile.
b) An artillery shell launches the MAO. When the shell flies at an altitude 100-200 meters, the support device (parachute) is opened If prevailing wind blows towards enemy. The MAO may be operated as a kite as long as the wind speed remains never drops below some threshold value for more than some determinable period of time.
c) and the MAO is braked (Figure 6). When the MAO reaches the ground, it is would likely be self-destroyed by a flight termination unit.
d) If prevailing wind blows towards operator. The operator deploys the MAO in the direction of the desired site. At the apogee of the trajectory the brake parachute is opened, the MAO, connected to the shell by fiber, is slowed. The shell continues on its trajectory and falls behind the enemy location. The shell is used as anchor for the MAO (Figure 8) which flies as a kite, lowers the camera, and permanently observes the enemy location.
e) If prevailing wind is orthogonal to line of sight between operator and observation site. The MAO is deployed in an orthogonal direction (Figure9) and is configured as in (d).

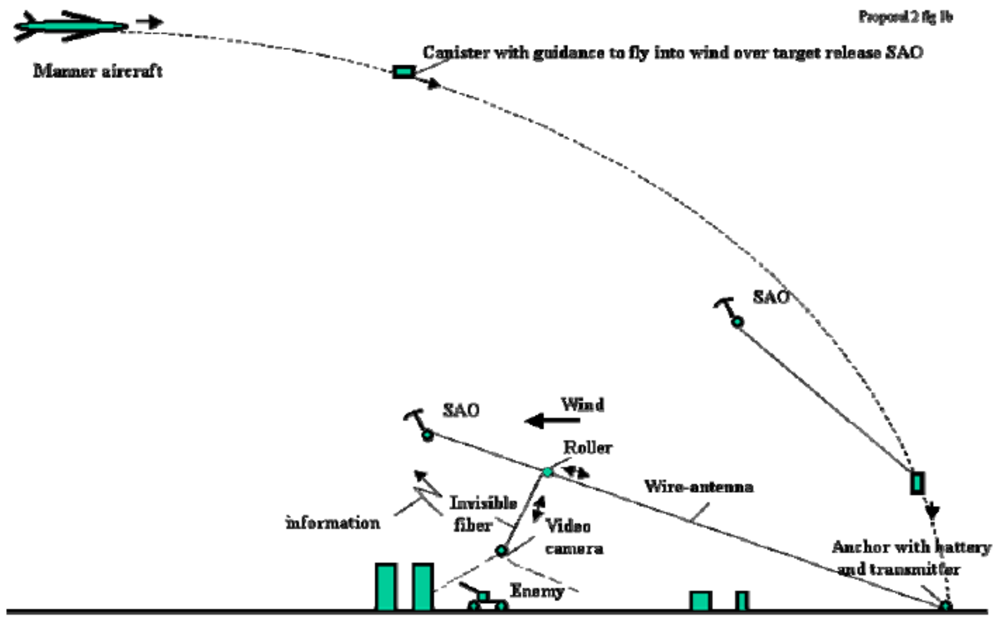

Figure 1. Launching of MAO (SAO) from aircraft.

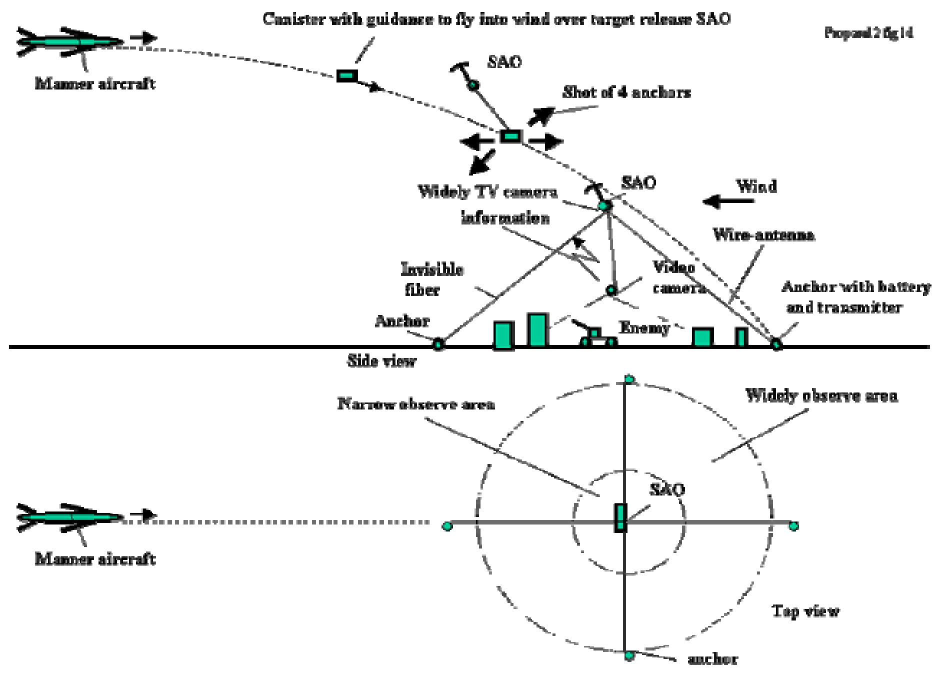

Figure 2. Launching of four anchor fixed SAO from aircraft.

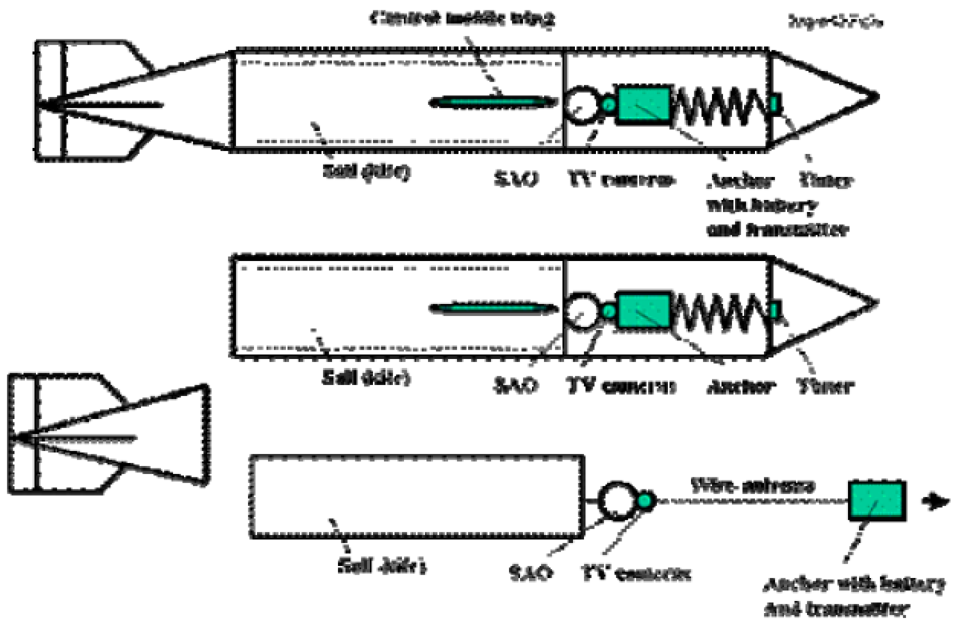

Figure 3. Canister for MAO (SAO).

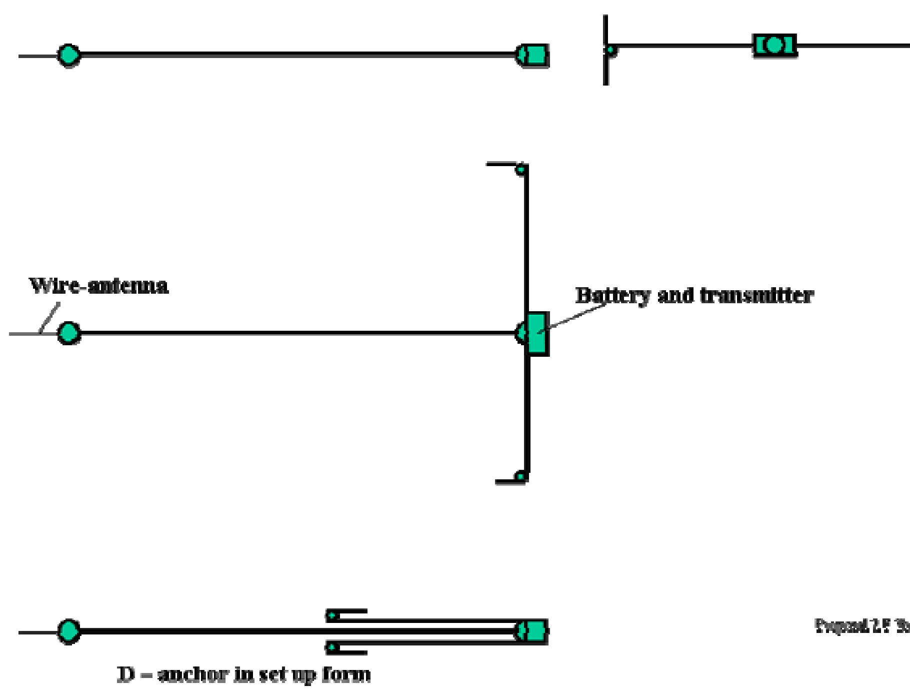

Figure 4. Anchor. D – anchor in set up form.

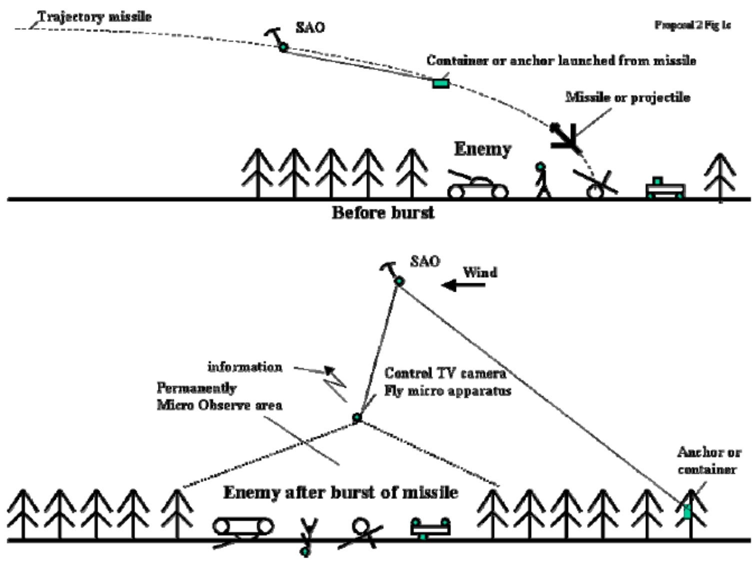

Figure 5. Launching of MAO (SAO) from missile or projectile.

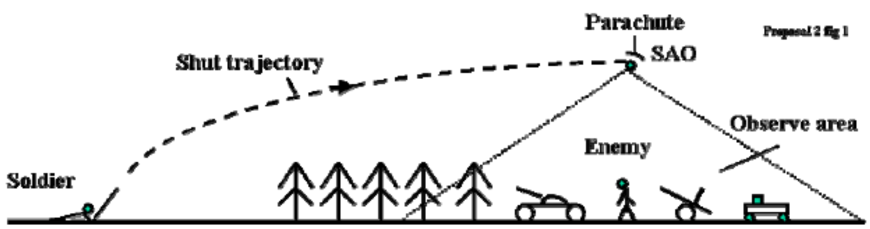

Figure 6. Suspended Aerial Observer MAO (SAO).

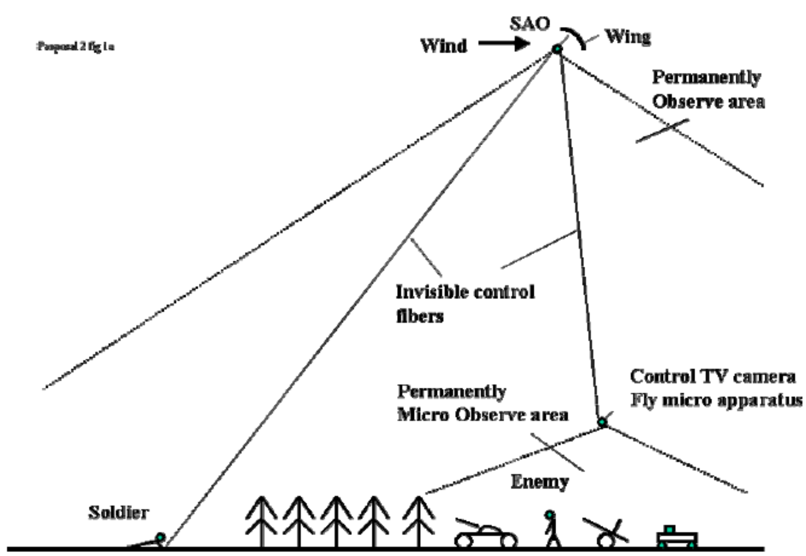

Figure 7. Launching Micro Air Eye (MAE) as kite.

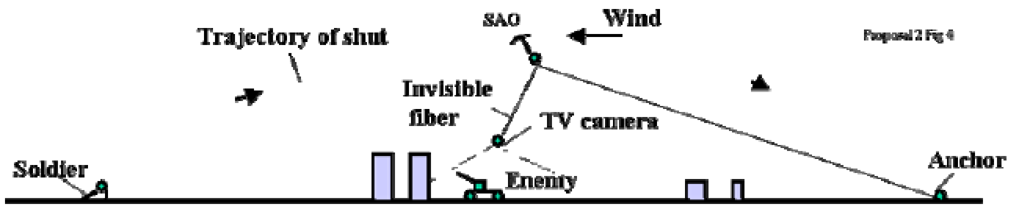

Figure 8. Using MAO (SAO) when wind is from enemy.

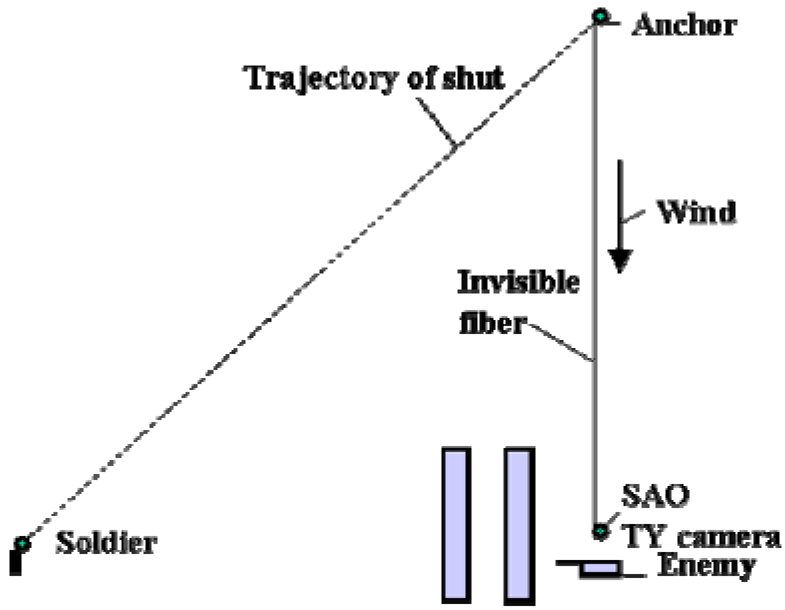

Figure 9. Using MAO (SAO) when wind is from side (top view).

f) The camera fiber may be connected to the kite assembly via a controlled roller (Figure10). It is moved along the main cable and changes position and altitude. The MAO and/or camera assembly may also have a small vertical wing to increase stability and to allow maneuver for increasing the observable area (Figure11).

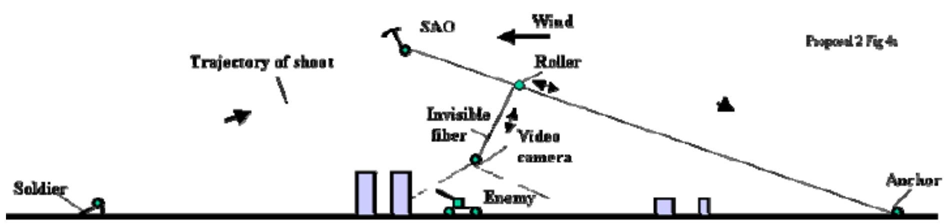

Figure10. MAO with mobile TV camera.

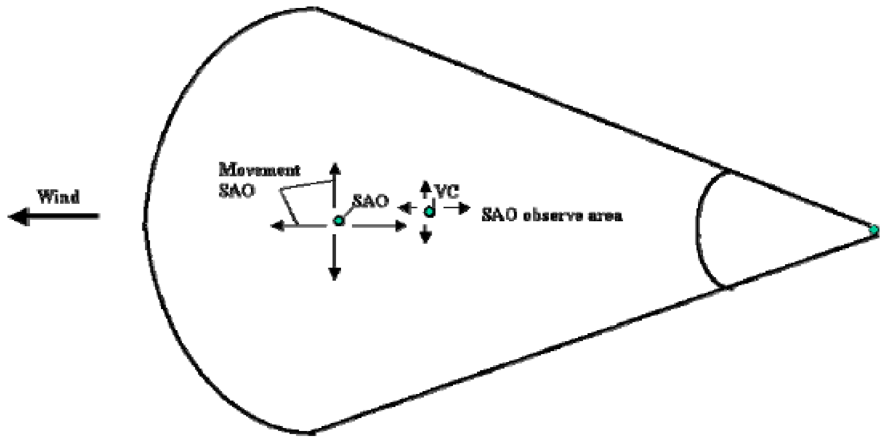

Figure 11. MAO observe area.

g) The MAO may be also suspended by an air balloon (diameter 1-1,5 foot, 25-40 cm)(Figure 12). In this case, it may operate in windless weather. Of course the balloon would be easy to observe.

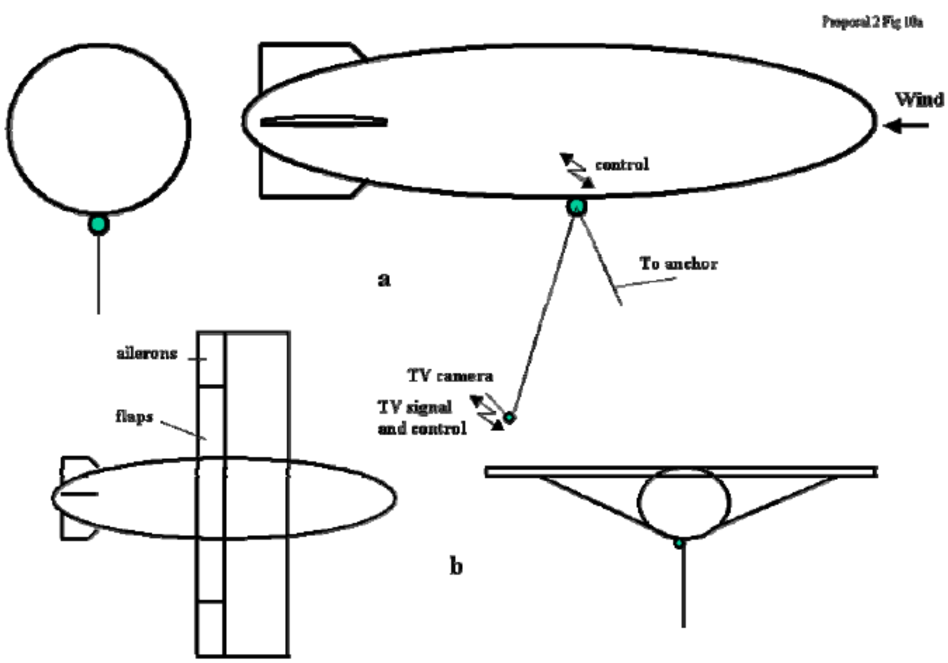

Figure 12. Support balloon: a) without wing; b) with wing.

h) For more efficiency or to permanently observe a large area, the MAO may be connected to three to eight anchors (figures 13-14). In this case the MAO position does not depend on wind direction.

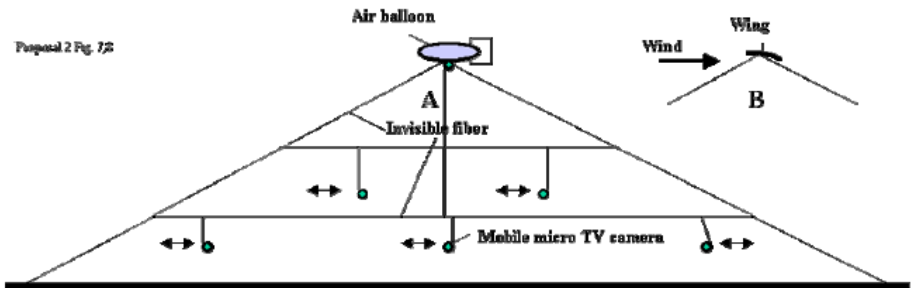

Figure 13. Installation for Stationary observe area: (A) with balloon, (B) with wing.

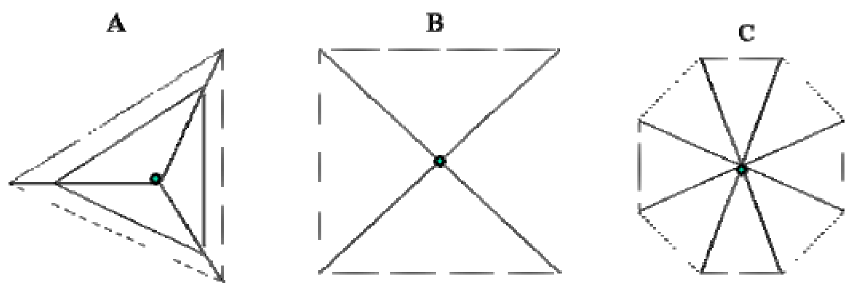

Figure 14. Top view of the Installation of Figure7. A – three conventional cables, B – four conventional cables, C – eight cables.

i) The support device or kite may have a sail form (Figure 15) or conventional airplane form (it is most efficient, Figure 16). It must have control surfaces to control the MAO. The camera assembly itself may have a small vertical wing and flaps (figures 17), which allows it to move side to side and back and forth. The spool also allows changing the camera altitude and the flaps allow the operator to change the fiber angle.

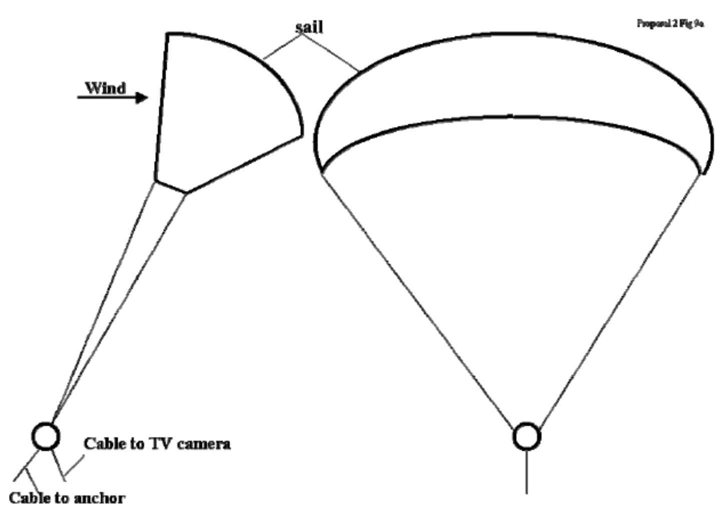

Figure 15. Support sail of MAO.

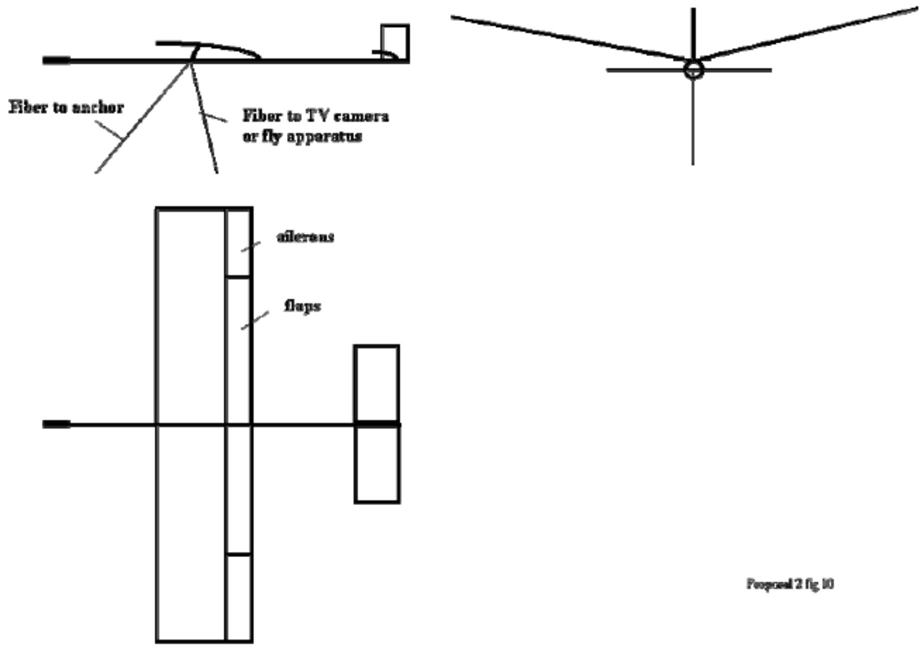

Figure 16. Base wing.

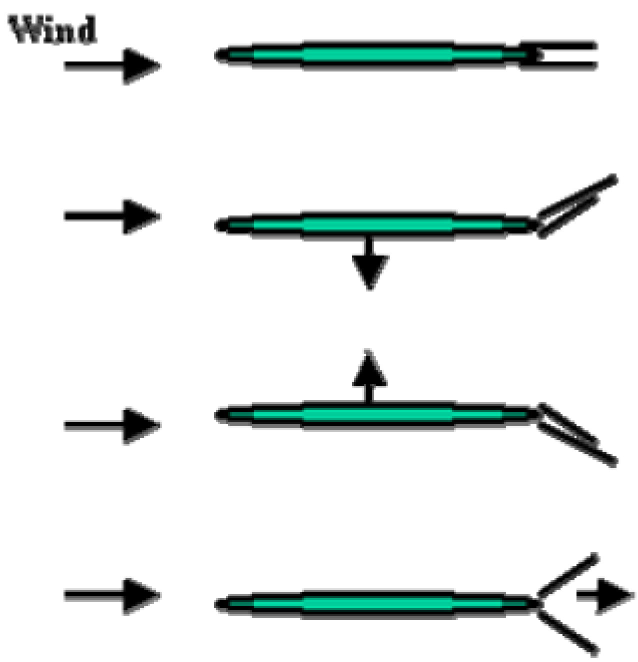

Figure 17. Control position of TV camera.

j) The closed loop stabilization and pointing of the camera assembly will require a gyro wind propeller (figures 18-19). The high revolution wind propeller has loads at the blade ends (Figure 19). One has a rigid connection to the camera station, and a swivel-spring connection with the vertical wing. The gyro propeller has a gyroscopic effect, which does not allow a sharp turn of the video cameras.

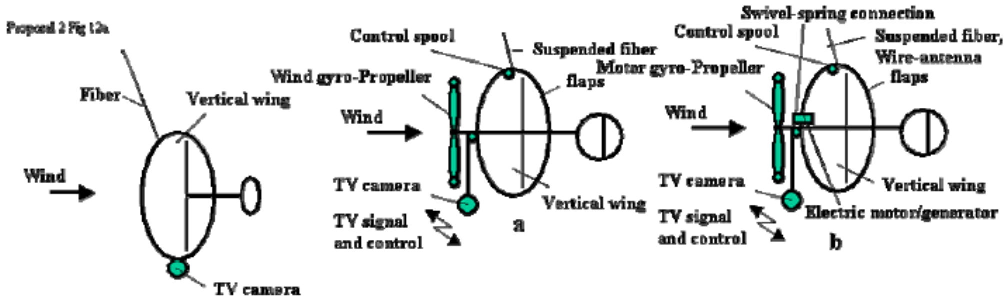

Figure 18. Fly apparatus with wind or electric gyro and stabilized TY camera.

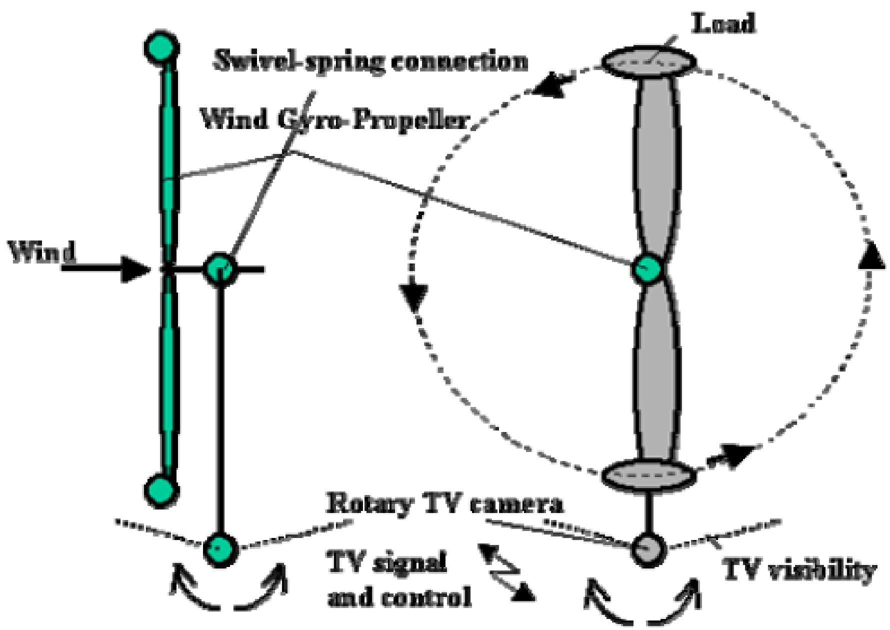

Figure 19. Wind gyro stabilizer.

k) The camera assembly may have the two video cameras (Figure20): a widely angle fixed lens and a narrow angle swinging mobile camera. The widely angle camera allows the operator to observe a general picture, the narrow angle camera allows the operator to observe a small selected object.

If the wind at low altitude is small or absent, the camera assembly may have a small electric motor which rotates a gyro propeller (Figure20) which move the camera. The propeller (Figure18b) can also rotate a small electric generator to power-up the electronics.

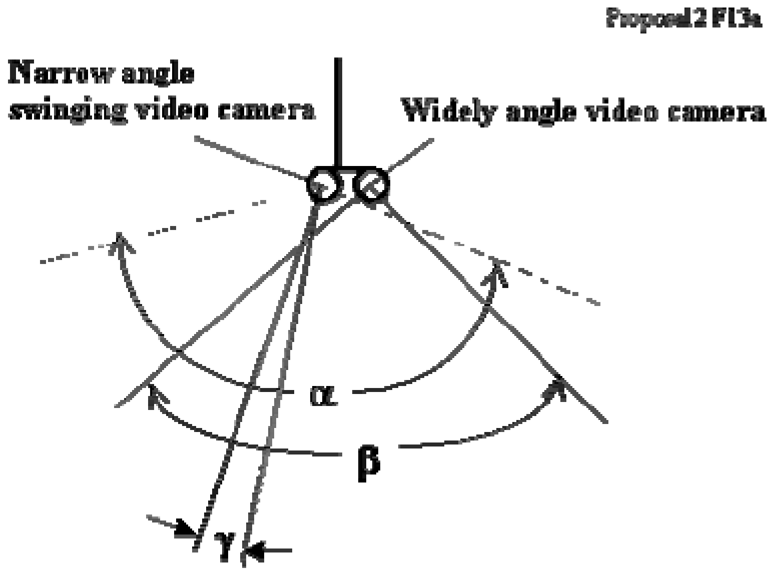

Figure 20. Two cameras stabilized video station.

An auto-gyro propeller (diameter35-75 cm) (Figure 21) can be used as a support device. It may also be rotated by its motor or a ground driver (motor) through a cable transfer (Figure 22).

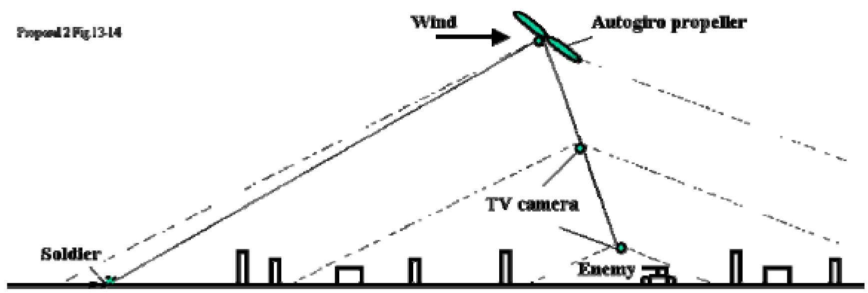

Figure 21. Suspended Aerial Observer with passive autogiro propeller.

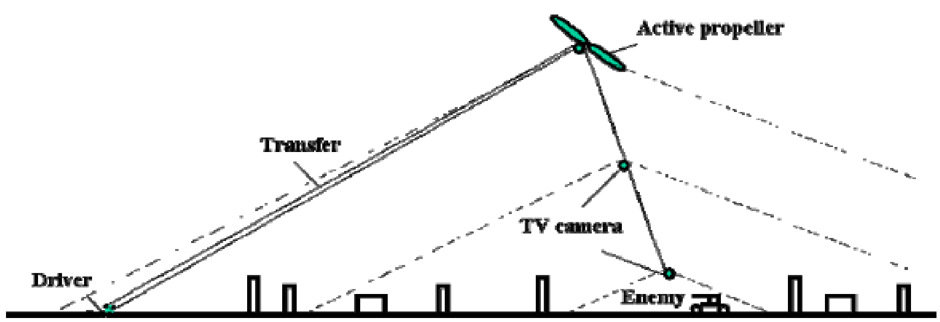

Figure 22. Suspended Aerial Observer with active propeller.

The last variants are presented in figures 23-26. In Figure 23, the MAO uses an air balloon, a mobile controlled suspended video camera and a control suspended fiber. The air balloon (size 40-120 cm) is made from glass thin film, one is located at high altitude (200-500 m) and it only slightly visible from the surface. Figure 24 is the same as Figure 23, but the MAO uses the propeller and motor as the support device. Figures 25-26 show the control support device being used to increase the observed area.

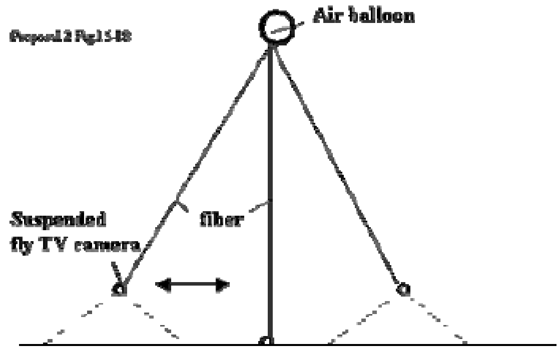

Figure 23. Using of balloon MAO when no wind.

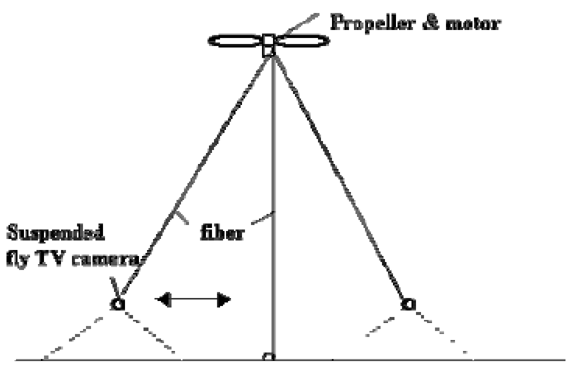

Figure 24. Using of propeller MAO when no wind.

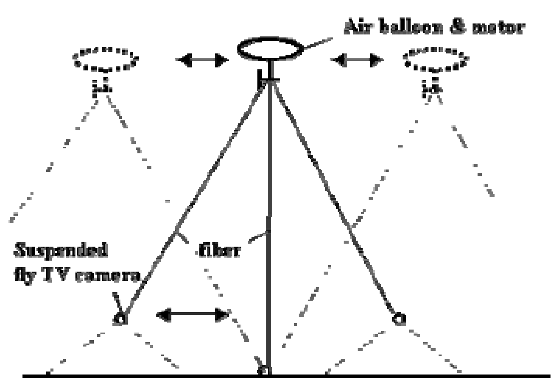

Figure 25. Using of control balloon MAO when no wind.

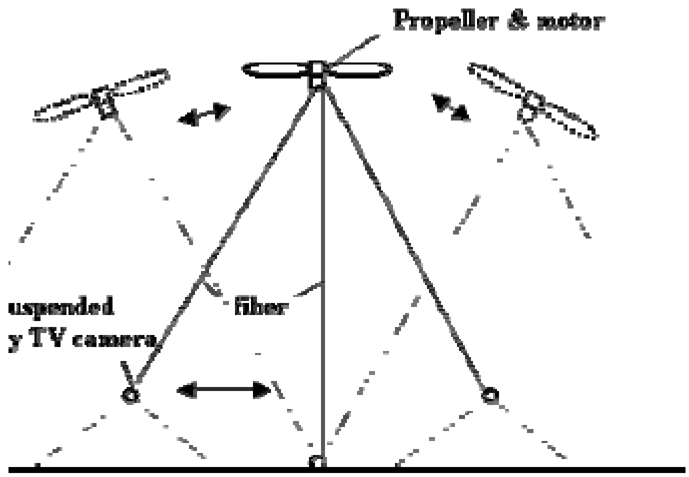

Figure 26. Using cont.propeller MAO when no wind.

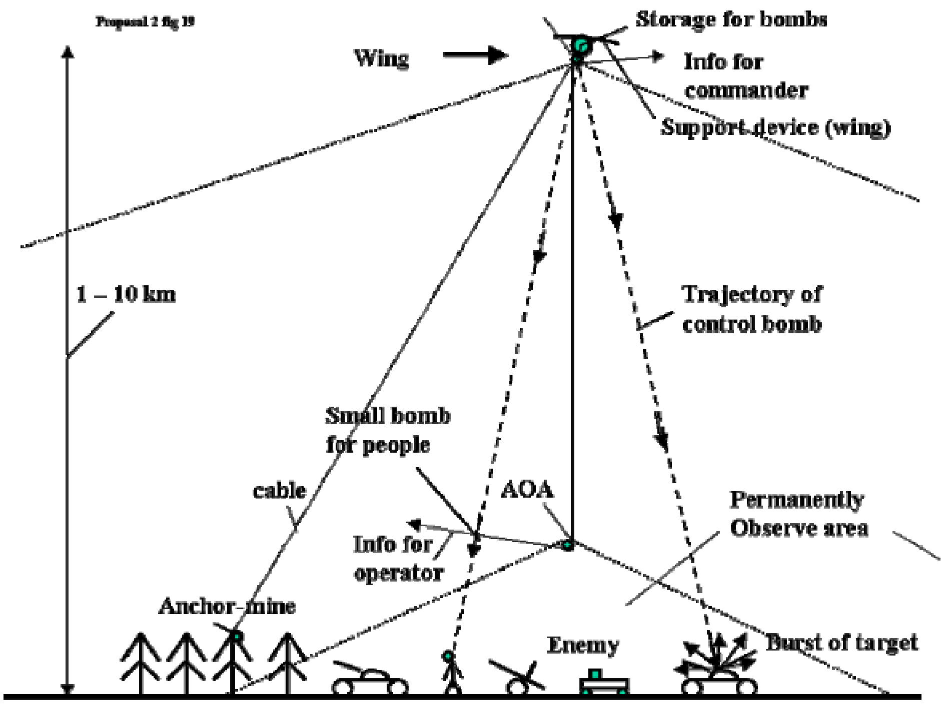

Figure 27. Air Observer and Annihilator (AOA).

We can also use a small mobile controlled dirigible or helicopter. Our innovation is a connection to them by thin fiber a small mobile controlled video camera (and microphone) and lower them to an observe area or an enemy location. The main apparatus flies at high altitude; the video camera suspends at low altitude and permanently observes a needed area.

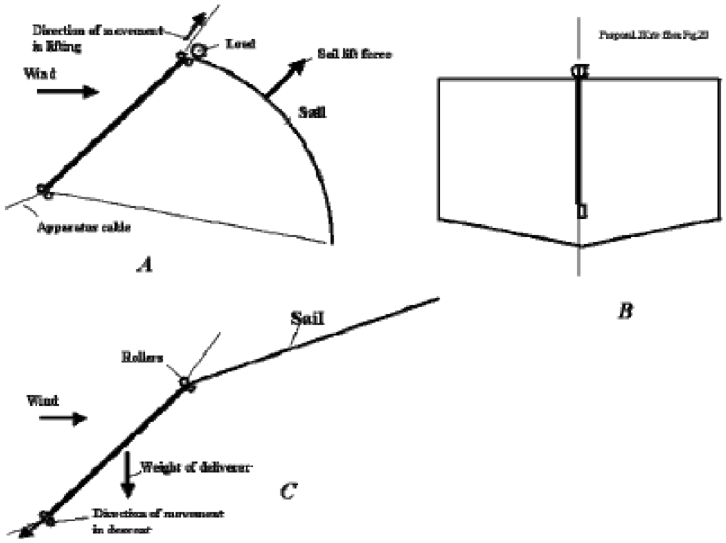

Figure 28. Load deliverer to AOA. A- side view; B-front view; C- Descent of Louder.

1.3. Advantages of Micro Air Observer in Comparison with Micro Air Vehicle

1. The suggested method may be applied in wind and weather when the MAV cannot be used because the wind is strong, turbulence, has scuds and twirls from building and trees. Indeed, to some extent, the greater the wind the better the performance of the MAO. Examining worldwide wind profiles, the probability of being able to use the MAO is greater than the probability of using a MAV. For example, for the average annual wind speed 6 m/sec the probability of MAO launching (V minimum 3 m/sec) is 0.85 when the launch is made from ground (from aircraft it is more 0.9); for MAV with maximum admissible speed 8 m/sec, the probability is only 0.65.
2. The offered method allows permanently observing a large area (some sq. km) a long time (up to months). The current MAV can observe about 0.1 sq. km a short time (2-5 min).
3. The offered method has power located on the ground and it can transmits the video and control signals a long distance (up to hundreds km). The MAO or MAO can have a small electric generator, which is rotated by the wind propeller, and thus the devices (video camera and control) can operate a long time.
4. The suggested method allows permanently observing inside building rooms through the building windows.
5. Apparatus may be deployed quickly.
6. The MAO control is simple and does not require special training to control - unlike a micro air vehicle. Fitting a MAV with an autopilot is difficult and when completed still requires the MAV to carry along additional power to persevere.
7. Both the MAO and MAV may be deployed from aircraft or artillery shells.
8. The MAO is simpler and less expensive than a MAV.

1.4. Lack of Wind

The MAO can only operate if the wind (at altitude) is more than some certain minimum (e.g. 2-3 m/sec). If the wind speed is less the minimum and MAO has special design, the MAO will land but can take off again when wind speed again becomes high enough to launch it. The MAO can also have a support air balloon. Special rotor kite can be supported by ground engine in windless weather.

Of course the logical approach is use the MAO to supplement the MAV and vice versa. The MAV and MAO have different conditions for application: the MAV in windless weather, MAO in wind weather.

1.5. Summary

The MAO is launched from an aircraft or is launched via an artillery shell or gun into an enemy observation area. As it enters a predetermined altitude 100-200 meters, the support devise is opened, the MAO is braked, the anchor (attached to MAO by fiber) is dropped down and connects the MAO to the ground (figures1-10). The support device may be a small (less the one foot, 20-35 cm diameter) air balloon or small solid or inflatable kite or wing. The connection fiber also is invisible from a short distance (1-3 meter) because it may be fashioned very thin (as a hair) and is made from transparent and strong artificial material. If there is a small wind (at most places the wind is 80-90% days in year at ground, see a research below) the MAO will be supported at altitude by a small wing or wing sail (figures 5-9, 15). In other case, one can be supported a special MAO having a balloon with an inflatable kite or wing (Figure 12-13). The support device (kite or wing) may be located at high altitude (1 or more km, different from MAO) and be connected to MAO by a thin fiber. There is sufficient wind at these high altitude about 95-98% of the year. Of course a major benefit is that the batteries can be located on the ground and so the MAO can operate for a long time. The MAO can also have a long antenna located at a high altitude and transmit a video and control signal for quite some distance.

The operator can observe the area of interest for a very long time (even weeks). If it is not needed in observation and no enemy, the soldier can reel it in up to the anchor (the anchor must have a radio-locator) and reel the thread (fiber) and get his device back. The MAO can be also launched as conventional kite for observe nearest closed area, especially, if the wind blows in enemy side.

The offered method and MAO has the following advantages in comparison of MAV:

1. No needs for developing a new top technology, which can confine Research, Development, and Design (as Micro engine, flight control, micro aerodynamics, autopilot, and navigation system).
2. The cost of Research and Development (RandD), design of MAO is less in 10 times that MAV.
3. The time of reconnaissance (observation) increases from 2-10 min to several weeks. The signals can be transmitted to long distance.
4. The using and control of MAO are simpler than MAV (not necessary in special training for soldiers or autopilot).

5. MAO can be used in wind and bad whether.
6. MAO uses the video devices, radio control, and communication developed for MAV.
7. MAO is cheaper then MAV and can be RandD and manufactured in short time.
8. MAO may be invisible for enemy.
9. There are a permanently air flow at high altitude

Table 1. The MAO data with comparison future MAV data

Parameter	MAO	best MAV
Size [cm]	3 x 3 x 15 cm (in packet form).	20 x 15 x 5 cm
Weight [grams]	5-9 5 g	5-95 g
Max range [km]	up 3-20 km (dependfrom start)	1-2 km
Time observation	weeks (permanently)	2-5 minutes
Area of observation	1 square mile (permanently)	0.02-0.05 sq. miles
Cost of production $	same with MAV	same with MAO
Visibility	invisible	visible

1.6. Additional Possibility for Support MAO (SAO)

High altitude wind has another important advantage. It is stable and constant. This is true practically everywhere.

Especially in the troposphere and stratosphere, the wind currents are powerful and permanent. For example, at an altitude of 5 km, the average wind speed is about 20 M/s, at altitude 10-12 km it may reach 40 m/s (at latitude of about 20-35^{0}N).

There are permanent jet streams at high altitude. For example, at H = 12-13 km and about 25^{0}N latitude. The average wind speed at the it core is about 148 km/h. The most intensive portion, with a maximum speed 185 km/h latitude 22^0, and 151 km/h at latitude 35^0 in North America. On a given winter day speeds in the jet core may exceed 370 km/h for a distance of several hundred miles along the direction of the wind. Lateral wind shears in the direction normal to the jet stream may be 185 km/h per 556 km to right and 185 km/h per 185 km to the left.

Reference: *Science and Technolody,v.2, p.265*.

2. Theory and Computation of MAO (SAO)

2.1. Wind (Speed, Duration, Altitude Distribution, Speed Distribution)

Wind is important element of the offered method. In MAV the wind is only obstacle which gives trouble for operator. The wind vortexes from buildings and trees are located at near Earth surface. One can set down to MAV to a ground. If wind is more then 6-8 m/sec, the flight of MAV can be impossible. In the MAO the wind is necessary for support of the apparatus. If wind is less a minimum (for example, 3 m/sec) the MAO, video camera lends to ground and can be take-off again when the wind will stronger. If the wind is very strong, the connection cable or a MAO wing can be damage.

We can calculate the minimum and maximum admissible wind for MAO and estimate it for MAV. Our purpose is estimation of time (% or a number of days in year) when the MAO and MAV can operate.

Annual average wind speed. On Figure2-1 is the accompanying map of the United States Annual Average Wing Speed taken from *Wind Energy Resource Atlas of the United States.* The map was published in 1987 by Battelle's Pacific Northwest Laboratory for the U.S. Department of Energy. The complete atlas can obtained by writing the American Wind Energy Association or the National Technical Information Service. The same maps are around the world. They are presented in Attachment 6. The maps show the average wind speed at altitude 10 and 50 meters. This speed is 5-6 m/sec.

Wind speed and Height. Wind speed increases with height. The speed may be computed by equation

$$\frac{V}{V_0} = \left(\frac{H}{H_0}\right)^{\alpha} \qquad (2\text{-}1)$$

where V_0 is the wind speed at the original height, V the speed at the new height, H_0 the original height, H the new height, and α the surface roughness exponent (Table 2-1).

Table 2-1. Typical Surface Roughness Exponents for Power Law method of Estimating Changes in Wind Speed with Height

Terrain	Surface Roughness Exponent, α
Water or ice	0.10
Low grass or steppe	0.14
Rural with obstacles	0.20
Suburb and woodlands	0.25

Reference: P.Gipe, Wind Energy comes of Age, 1995.

The result of computation of equation (2-1) for different α is presented at Figure 2-1. The wind speed increases on 20-50% with height.

Annual Wind speed distribution. Annual speed distributions vary widely from one site to another, reflecting climatic and geographic conditions. Meteorologists have found that Weibull probability function best approximates the distribution of wind speeds over time at sites around the world where actual distributions of wind speeds are unavailable. The Rayleigh distribution is a special case of the Weibull function, requiring only the average speed to define the shape of the distribution.

Equation of Rayleigh distribution is

$$f_x(x) = \frac{x}{\alpha^2}\exp\left[-\frac{1}{2}\left(\frac{x}{\alpha}\right)^2\right], \quad x \geq 0, \quad E(X) = \sqrt{\frac{\pi}{2}}\alpha, \quad Var(X) = \left(2 - \frac{\pi}{2}\right)\alpha^2, \qquad (2\text{-}1a)$$

where α is parameter.

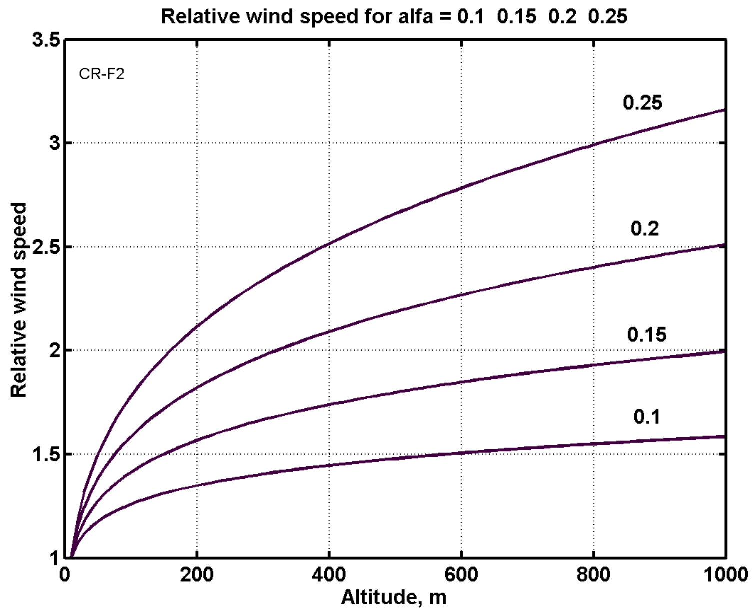

Figure 2-1. Relative wind speed via altitude and Earth surface. For sea and ice α = 0.1.

Figure 2-2 presents the annual wind distribution of average speeds 4, 5, and 6 m/s. Table #2-2 gives Rayleigh Wind Speed Distribution for Annual Average Wind Speed in m/s. These data gives possibility to easy calculate the amount (percent) days (time) when MAO or MAV can operate in year (Figure 2-3). It is very important value for the estimation efficiency of offered devices.

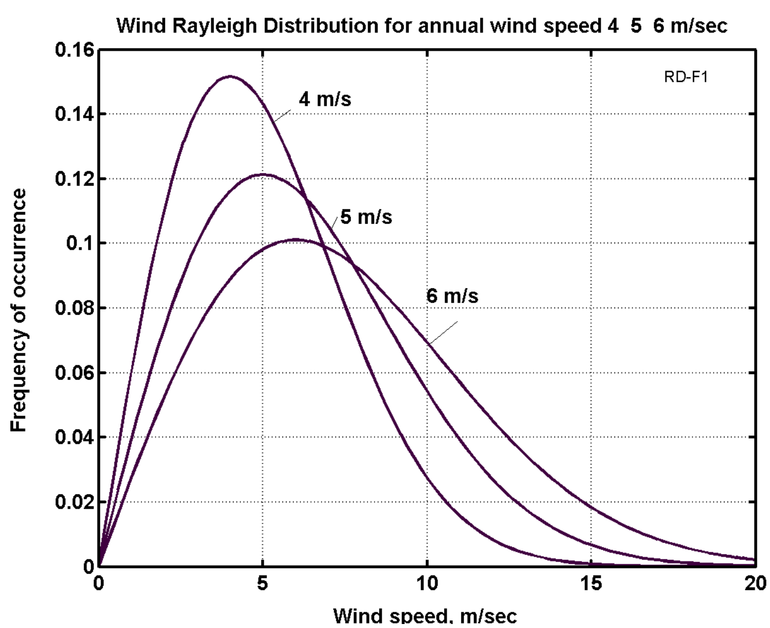

Figure 2-2. Wind speed distribution.

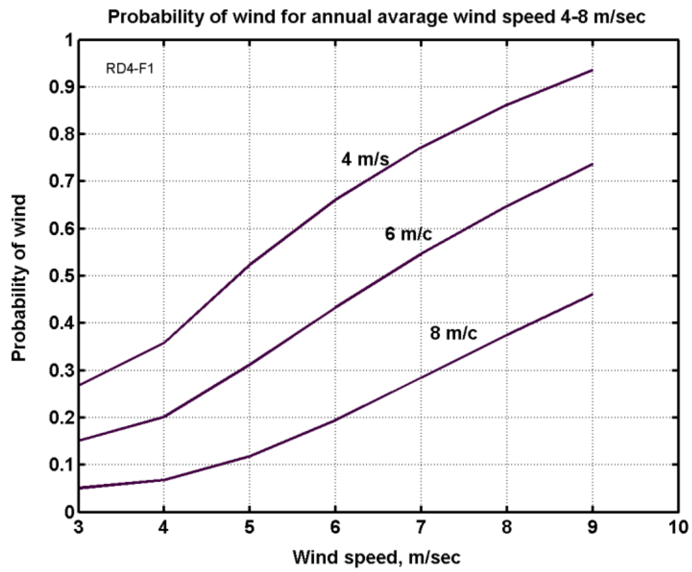

Figure 2-3.

Let us compute two examples:

(1) MAO. Assume, the observer has minimum admissible wind speed 3 m/s, maximum admissible speed 25 m/s, altitude 100 m, the average annual speed in given region is 6 m/s. From Table 2-2 and Figure 2-1, 2-2, 2-3, Eq. (2-1) , we can get the wind speed is 8.4 at *H*=100m, the probability that the wind speed will be less the 2 m/s is 8%, less 3 m/sec is 15%, the probability that the wind speed will be more 25 m/s is closed to 0.
(2) MAV. Assume, the average annual speed in given region is 6 m/s, the maximum admissible wind speed is 7 m/s. The probability that a wind speed will be less then 7 m/s is 55%, less then 8 m/s is 65%.

It means that the impossible time for MAV flights is 2-3 times more that for kite.

2.2. Lift Force

Lift force of kite may be computed by equation

$$L = C_L \frac{\rho V^2}{2} S \qquad (2\text{-}2)$$

where L - lift force [N]; C_L - lift coefficient, C_L =0 - 2; ρ - air density, if altitude H closed to 0 ρ = 1.225 kg/m^3; V - wind speed [m/sec]; S - wing area [m^2].

Result of computation for S = 1 m^2 and H=0 are presented in figs. 2-4, 2-5 (not included); for S = 0.01 m^2 and H=0 is presented in Figure 2-6 (not included), for S = 1 m^2 and H=0-8 km are presented in figs. 2-7 (not included).

When designer know load, admissible wind speed, altitude, and fiber stress, he can estimate the necessary wing area.

2.3. Cable (Fiber) Mass

Cable mass can be computed by equation:

$$M = l\frac{\gamma}{\sigma}F \tag{2-3}$$

where M - mass of cable (fiber) [kg]; l - length of cable [m]; γ - cable density [kg/m^3]; σ - cable stress [kg/m^2]; F - tensile force [N].

Result of computation is presented in Figure 2-8 (not include). As you see the mass of cable is small.

2.4. Diameter of the Cable

Diameter of cable (fiber), d, may be computed by equation

$$d = 2\sqrt{\frac{F}{\pi\sigma}} \tag{2-4}$$

Results of computation are presented in figures 2-9, 2-10 (not included).

2.5. Drag of the Cable

Drag of main cable (fiber) can be calculated by equation

$$D_{f,1} = C_{D,f1}\frac{\rho V^2}{2}\frac{\pi}{4}ld \tag{2-5}$$

where $D_{f,1}$ -drag of main cable in [N]; $C_{D,f1}$ - drag coefficient; l - length of main cable [m].

Results of computation are presented in Figure 2-11 (not included).

2.6. Kite Cable Angle

The kite cable angle to horizon without cable drag, φ_1, and with cable drag, φ_2, may be calculate by equations

$$\tan\varphi_1 = \frac{C_L}{C_D} = \frac{C_L}{C_{Do} + C_L^2/\pi\lambda},$$

$$\tan\varphi_2 = \frac{C_L}{C_D + 0.5\dfrac{S_f}{S}C_{D,f1}}, \qquad \text{(2-6), (2-7)}$$

where C_{Do} - kite drag when C_L =0; λ- wing aspect ratio, S_f - drag fiber area, $S_f = Hd$ [m^2]; S - wing area [m^2]; $C_{D,f1}$ - cable drag coefficient.

Result of computation is presented in Figure 2-12 (not include).

2.7. Deviation of Video Cable from Vertical

Video cable angle from vertical may be computed by equation

$$\tan\varphi_3 = \frac{D_{TV} + 0.5D_{f,2}}{g(G_{TV} + 0.5G_{f,2})} \qquad \text{(2-8)}$$

where

$$D_{TV} = C_{D,TV}\frac{\rho V^2}{2}S_{TV}, \quad D_{f,2} = C_{D,f2}\frac{\rho V^2}{2}(0.75Hd), \quad G_{f,2} = \frac{\pi}{4}\gamma L d_1^2, \qquad \text{(2-9)}$$

D_{TV} - drag of video apparatus [N], $C_{D,TV}$ - drag coefficient of the video apparatus, S_{TV} - reference video apparatus area [sq.m], $D_{f,2}$ - drag of suspended TV fiber [N], $C_{D,f2}$ - drag coefficient TV fiber [N], H - kite altitude [m], G_f - TV cable weight [kg], γ - TV cable density [kg/m^3], L - TV cable length [m], d_1 - diameter of TV cable [m].

Result of computation is presented in Figure 2-13 (not include).

2.8. Full Kite Cable Angle

Full kite cable angle φ may be calculated by equation

$$\tan\varphi = \frac{C_L - g(G + 0.5G_{f,1} + G_{f,2} + G_{TV})/qS}{C_D + 0.5C_{D,f1}\dfrac{S_{f,1}}{S} + C_{D,f2}\dfrac{Ld}{S}} \qquad \text{(2-9)}$$

where G - weight of kite[kg]; $G_{f,1}$ - weight of main cable (fiber)[kg]; $G_{f,2}$ - weight of TV cable [kg]; G_{TV} - weight of video (TV) camera (apparatus); $q = \rho V^2/2$ - dynamic pressure [n/sq.m]; S - wing area [sq.m]; $C_{D,f1}$ - drag coefficient of main cable; $S_{f,1} = Hd_1$ - reference video cable area.

Results of computation are presented in Figure 2-14 (not included). Here are G = 0.2 kg, G_{TV} = 0.03 kg.

2.9. Cable Thrust

Thrust of main cable may be computed by equation

$$T = \frac{qS}{g}\sqrt{T_t^2 + T_2^2}\,, \tag{2-10}$$

where

$$T_1 = C_D + 0.5C_{D,f1}\frac{S_{f,1}}{S} + C_{D,f2}\frac{Ld}{S}\,,$$
$$T_2 = C_L - g(G + 0.5G_{f,1} + G_{f,2} + G_{TV})/qS\,. \tag{2-11}$$

Result of computation is in Figure 2-15 (not include). Here are G = 0.2 kg, G_{TV} = 0.03 kg.

2.10. Viewing Distance (Distance of Video Signal)

The distance L which can be viewed of the Earth from a high altitude (antenna) is given by

$$L = \sqrt{2R_e H + H^2} \tag{2-12}$$

where R_e =6378 km is the Earth radius, H is an antenna altitude. The results of computation are presented in Figure 2-16. As us see the MAO and MAO can transfer video signal in distance of hundreds times more then current MAV, which has range only 0.3 – 1 km (see Attn. #1).

2.11. Mass and Admissible Current of Wire

The admissible current in wire depends from relation a gross-section area to a cooled wire surface. That why it linear depends from a diameter of wire. For aluminum and cupper wire these ratio are following respectively:

$J_1 = 8\ d,\ J_2 = 10\ d$, (2-13)

where J_1, J_2 are admissible current (ampere), d is wire diameter [mm]. Result of computation is in Figure 2-17.

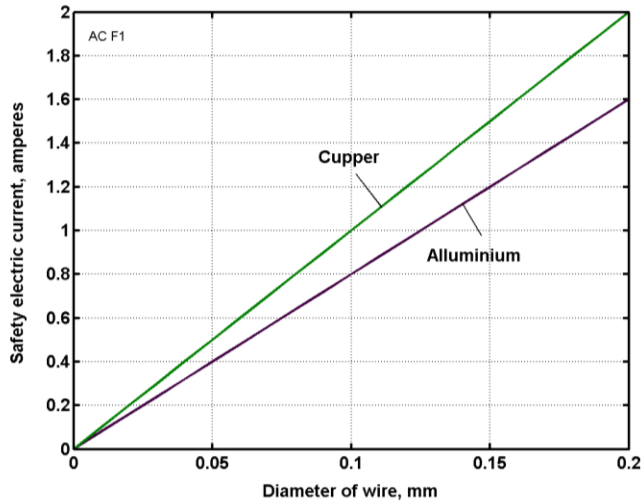

Figure 2-17. Safety electric current via wire diameter for alluminium and cooper wire.

The weight, W, [g] of wire is respectively

$$W_1 = \frac{\pi}{4} d^2 \gamma_1 L\ , \quad W_2 = \frac{\pi}{4} d^2 \gamma_2 L\ , \tag{2-14}$$

where d is wire diameter [sm], γ - density [g/cm3], L is a wire length [cm]. For aluminum γ = 2.7 g/cm^3, for copper γ = 8.93 g/cm^3. The result of computation for l = 100 m is presented in Figure 2-18.

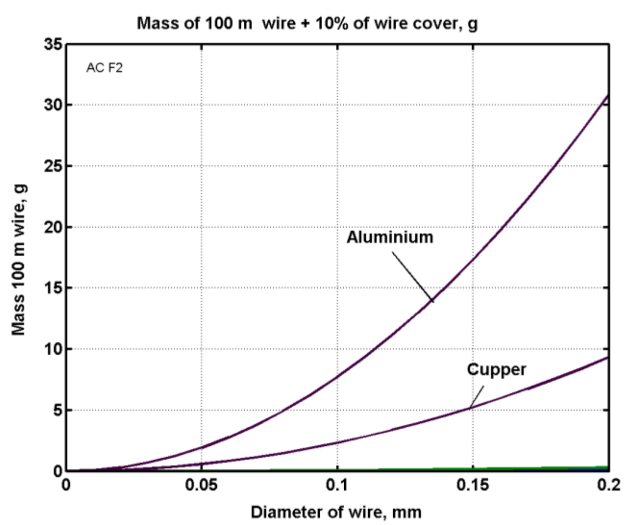

Figure 2-18. Mass 0f 100 m aluminum and cooper wire + 10% of wire cover (isolator), g.

2.12. Lift force of Air Balloon

Let us to compute lift force, mass of cover, and useful lift force of air balloon filled by helium and hydrogen. Assume that a balloon length equals three balloon diameter.

$$V = \frac{3\pi}{4} d^3, \quad L = (\gamma_a - \gamma_g)V, \quad S = 5\pi d^2, \quad M = S\delta\gamma, \quad L_u = L - M, \tag{2-15}$$

where V is balloon volume [m3], d is the balloon diameter [m], L is the lift force [kg], L_u is useful lift force (without balloon cover); γ_a, γ_g, γ are density of air, gas, cover respectively: γ_a =1.225 kg/m^3 for air, γ_g = 0.1785 kg/m^3 for helium, γ_g = 0.09888 kg/m^3 for hydrogen, and γ =1800 kg/m^3 for balloon cover, S is area of cover [m2]; M is mass of cover [kg]. Result of computation is presented in figures 2-19 – 2-22.

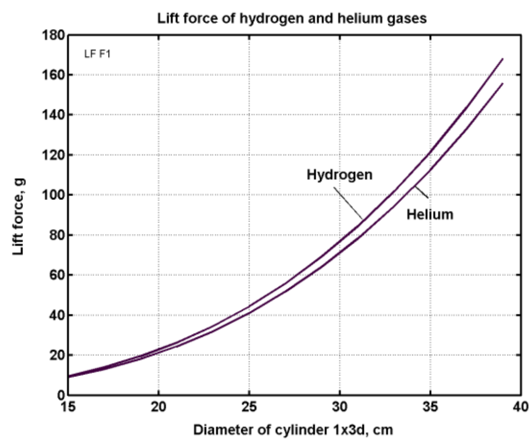

Figure 2-19. Lift force of balloon filled the hydrogen and helium gases.

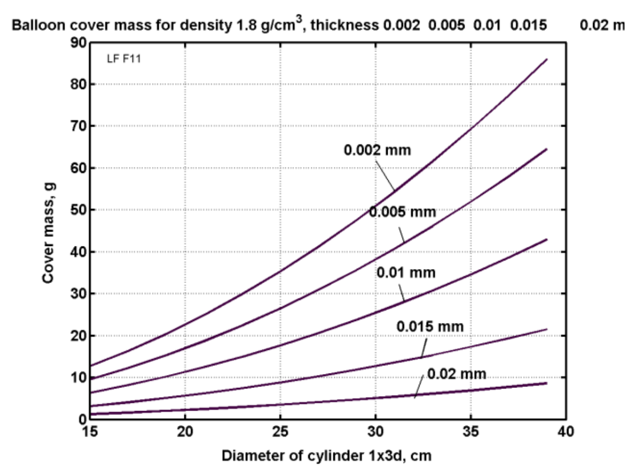

Figure 2- 20. Balloon cover mass for cover density 1.8 g/cm^3, cover thickness 0.002, 0.005, 0.01, 0.015, 0.02 mm..

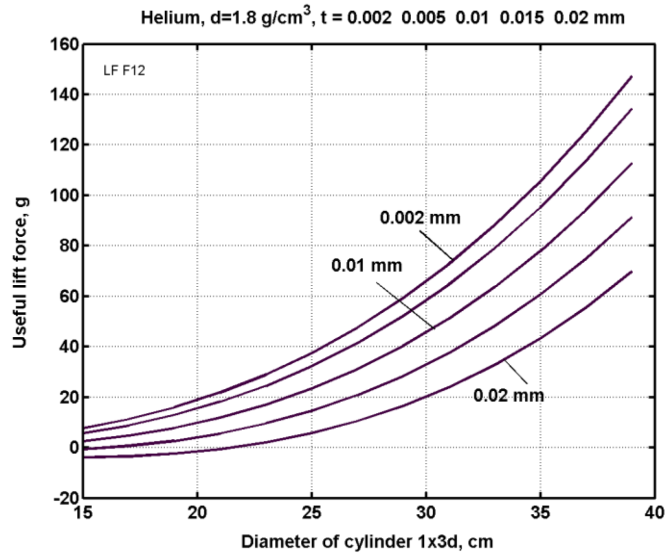

Figure 2-21. Usefull lift force of helium balloon 1× 3d for cover density 1.8 cm^3, cover thickness 0.002 0.005 0.01 0.015 0.02 mm.

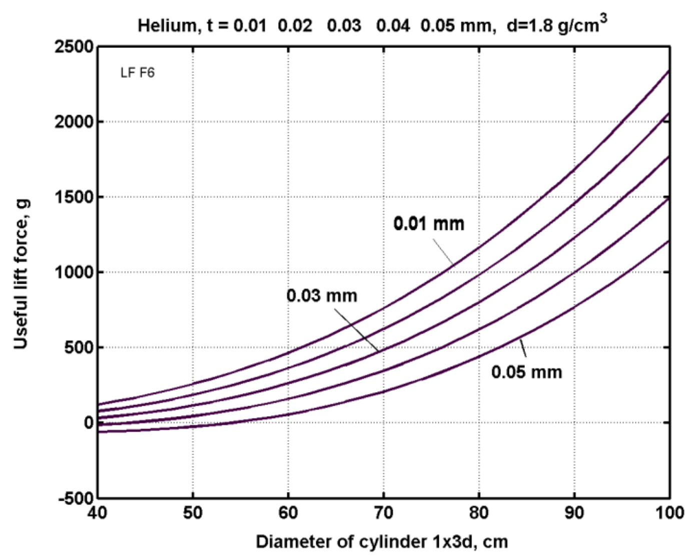

Figure 2-22. Useful lift force of helium via cylinder diameter for cover thickness 0.01 0.02 0.03 0.04 0.05 mm, cover density 1.8 g/cm^3.

3. REQUIREMENT VIDEO CAMERA AND CONTROL

The capabilities of video camera are very important component for MAV, MAO and MAO. The video camera must be small, light as soon as possible. One must recognizes a target from maximum (as soon as possible) distance. It means, the TV camera must have a maximum (as soon as possible) pixels. It will good, if Camera has a zoom or small FOV degree.

There are Johnson Criterion to estimate a=66+/-12 pixels across the minimum dimension of a target for 99.9% to 99.999% probability of ID.

Some target sizes (l x w x h in meter):

- M113 Typical armored personnel carrier: 4.7 x 2.5 x 1.8 m.
- M1 Main Battle Tank: 7.9 x 3.7 x 2.4 m.
- Scud surrogate George: 13.3 x 3.0 x 2.5 m.
- Man: 0.5 x 0.5 x 1.7 m.
- Man face: 0.3 x 0.3 x0.3.

3.1. Required Number of Pixels

The target size s [m], view angle α [degree], distance to target D [m], pixel number P (for one side, full is P x P), number of identification pixels a, are described by equation

$$a = \frac{57.3sP}{\alpha D} \quad (3\text{-}1)$$

Result of computation of pixels p via distance for s = 3 m, P = 1000 and 2000 pixels, α $=1^o$-50^o degrees are presented in firs. 3-1, 3-2 (not included).

3.2. Recognition Distance and Target Size

Recognition distance via the target size may be computed by equation below derived from eq. (3-1)

$$D = \frac{57.3sP}{\alpha a} \quad (3\text{-}2)$$

Results of computation of recognition distance D via target size s for 256 - 2000 FAO pixels P and α = 1, 2 5, 20 degrees, are presented in figs. 3-3, - 3-6 (not included).

Results of computation of recognition distance D via target size s for 1000 FAO pixels P, a = 66, and α = 1, 2 5, 20, 50 degrees, are presented in Figure 3 - 7 (not included).

As you see, the current TV cameras request a low flying of MAV. It is bad for MAV because an enemy sees MAV and the enemy can put out of sight or annihilate MAV. The MAO and MAO also need in low location of video apparatus. However it is well, because video camera is separated from MAO, the camera and fibers are small and they may be difficult for enemy recognizing. That way we need to separate video camera from MAO or MAO.

3.3. Communication Problems

Communication problems for MAV relate primarily the bandwidth required to the small video size, hence small antenna size, and to the limited power available to support the bandwidth required (2-4 megabits per second) for image transmission. Control functions demand much lower bandwidth capabilities, in the 10's of kilobits range, at most. Image compression help reduce the bandwidth requirement, but this increases on-board processing and hence requirements. The limited power budget means the omni-directional signal will be quite weak. So directional ground antennas may be required to track the vehicle, using line-of-sight transmissions. But limitations to line-of-sight would be severely restrictive for urban operations, so architectures.

Most these problems absent for MAO and MAO or do not have these strong limitations. The MAO do not have strong limitation in size and weight because the main kite is located at high altitude and video apparatus do hot have wings. The lower apparatus can has a video camera size. No big limits in electric power, because no strong limit in weight. The fiber can has thin wires and the electricity can transfer from soldier to video camera. The kite is located at high altitude and the fiber-wires can be used as antenna. The signal distance (range) is increased in a lot of times. The MAO, MAO can make the surveillance permanently in jungle and small yard between buildings, in a given window.

If MAV has speed 20 m/sec and operator needs 3 sec to see picture, to understand image, and to control of MAV, it means the MAV cannot to fly in area having size less 60 m. In reality this size more. For example, if a MAV turn time is 3 sec, we must have additional 60 meters for turning (total 60 + 60 =120 m). It means the MAV cannot operate in city having a compact development.

4. EXAMPLES

4.1. Example #1. (Four Anchor MAO Launched from Aircraft). Main Parameters

Kite:

Wing area 0.08 - 0.12 m^2

Minimal wind speed 3 m/sec. Minimal lift force for minimal wind speed 90 - 130 g.

Mass: Kite 20 – 30 g; TV – station 20 g; fiber cable (include wire) of diameter d = 0.1-0.15 mm, of the total length 1000 m has mass 20 - 32 g. Total mass: 70 – 90 g (without anchors and battery located at anchor).

Admissible electric current is up 0.4 amperes for wire diameter 0.05 mm.

Operative kite altitude: 100 - 200 m. (may be up 500 m).

Video station:

Minimal operative altitude of video station 5 - 7 m.

Permanently observe area (100 - 400) x (100 - 400) m.

Data of video camera and microphone:

Mass 8 - 20 g. Size 2 - 8 cm.

Maximum recognize distance, D, of targets size 2 m:

1. For FOV angle $\alpha = 20^0$, pixels P = 256, D is 22 m;
   For pixels 1000, D is 87 m.
2. For FOV angle $\alpha = 2^0$, pixels P = 256, D is 220 m;
   For pixels P = 1000, D is 850 m.

Probability of wind more 3 m/sec in area with average annual speed 6 m/s at altitude 10 m is 0.85. In our case this probably is more (about 0.9) because our kite located at altitude 100 - 200 m.

Permanently operation time is some weeks or months.

4.2. Example #2. (Balloon MAO Launched from Aircraft). Main Parameters

Wing balloon:

Diameter of cylindrical 1x3 balloon with useful lift force 115 g and cover thickness 0.01 mm is D = 39 cm . Wing area S = 0.06 - 0.1 sq.m

Minimal wind speed: None. Maximum useful (without balloon cover and zero wind speed) lift force is 115 g.

Mass: Balloon cover of thickness 0.01 mm - 42 g; video – station 20 g; fiber cable (include wire d = 0.05 mm) has diameter d = 0.1-0.15 mm, maximum tensile force is 6 - 12 kg, total length 1000 m, mass 20 - 32 g. Total mass: 70 – 90 g (without anchors and battery located at the anchor).

Diameter electric wire is 0.05 mm. Admissible electric current is up 0.4 amperes.

Operative balloon altitude: 100 - 200 m (may be up 500m).

Video station:

Minimal operative altitude of video station 5 - 7 m.

Permanently observe area (100 - 400) x (100 - 400) m.

Data of video camera and microphone:

Mass 8 - 20 g. Size 2 - 8 cm.

Maximum recognize distance, D, of targets size 2 m:

1. For FOV angle $= 20^0$, pixels P = 256, D is 22 m;
   For pixels 1000, D is 87 m.
2. For FOV angle $\alpha = 2^0$, pixels P = 256, D is 220 m;
   For pixels P = 1000, D is 850 m.

Probability of wind more then admissible maximum speed 15 m/sec in area with average annual speed 6 m/s at altitude 10 m is very small ($\approx$ 0.01). In our case this probably is more (about 0.02) because our balloon located at altitude 100 - 200 m.

Permanently operation time is some weeks or months.

4.3. Example #3 (Kite MAO for Soldier). Main Parameters

Soldier kite apparatus:
Wing area 0.05 - 0.08 m^2.
Weight 50 -150 g.
Minimum speed 3 m/sec. Probability is 0.85 for area with the average annual wind speed 6 m/sec.
Operative kite altitude 100 - 150 m.
Permanently observe area (100 - 500) x (30 - 200) m.

Video camera and microphone apparatus:
Weight 9 - 25 g.
Size 2 - 8 cm.
Operative altitude 7 - 50 m.
Maximum recognize distance, D, of targets size 2 m:

1. For FOV angle $\alpha = 20^0$, pixels P = 256, D is 22 m;
   For pixels 1000, D is 87 m.
2. For FOV angle $\alpha = 2^0$, pixels P = 256, D is 220 m;
   For pixels P = 1000, D is 850 m.

Operative time limited by battery located at anchor (may be same hours).

4.4. Example #4. Munitions Air Observer (MuAO). Main Parameters

Main wind (kite) MuAO apparatus:
Wing area 2 - 8 sq.m. Minimum wind speed 3 - 4 m/sec.
Weight 20 - 100 kg
Operative Altitude 500 - 2000 m.
Observe area up 2 x 2 km.
Number of anchors: 4 – 6.
Arming: number of control anti-tank projectile is 5 - 20 (2 - 3 kg each),
Number of control small anti-man grenade is 10 - 50 (0.1- 0.3 kg each).

Video cameras:
Number 4 – 12.
Weight (each) 25 -100 g.
Size 5 -12 cm.
Operative altitude 20 -100 m.
Maximum recognize distance, D, of targets size 2 m:

1. For FOV angle $\alpha = 20^0$, pixels P = 256, D is 22 m;
   For pixels 1000, D is 87 m.
2. For FOV angle $\alpha = 2^0$, pixels P = 256, D is 220 m;

For pixels P =1000, D is 850 m.

Operative time: some weeks.
Probability of wind is about 0.9 at this altitude in area with average wind speed 6 m/sec.

ATTACHMENT #1

1. Plan of Future MAO Research and Development

Researches:

1. Finding of information weight, volume, and other technical parameters of current devices (small video camera, video transmitter, TV receiver, battery, radio control, fiber), which can be suitable for the offered MAO, MAO.
2. Studying the current video equipment of very small (soldier) recognizer unmanned aircraft (MAV) and possibility their application for MAO, MAO, missiles, bombs, and gun shells.
3. Estimation of cost (in case of a widely producing or big order) the device necessary for MAO, MAO, civil industry (police, emergency agency), especially the cost of widely produced very small video cameras. Possibility their size decreasing and improving of the technical parameters in future.
4. Computation of the main parameters.
5. Schematic design of the MAO and solution of the main problems, which can appear in the offered MAO. Design Airframes, actuation, control laws.
6. Patenting the offered method and device (MAO).
7. Publication (?).
8. Announced of prizes for better MAO in aviation modelers.
9. Testing best MAO.

Development:

1. Detailed design and manufacturing 5 - 10 the best MAO for wide testing.
2. Testing MAO as observation device.
3. Testing MAO by tube (or gun) launcher.
4. Real testing in army.

Application:

1. The order for industry.
2. Widely application in military operation.
3. Widely application in civil life: for observe car traffic by police, area after disaster, in rescue operation, and so on.

ATTACHMENT #2

The Short History of MAV RandD

The recent history of MAVs start with a 1992 workshop on future technologies for military operations held by DARPA at Rand. Then-senior scientist Augenstein led a panel on micro vehicles, including aircraft systems ranging in size from a hummingbird down to less than 1 cm. Rand published a widely circulated report on the work in 1994. The Lincoln Laboratory was initially skeptical, but its own research also concluded that MAVs were becoming feasible.

DARPA held a MAV feasibility workshop in November 1995, a briefing to industry in March 1996, and a user and developer workshop in October 1996. These were mainly paper exercises with little real hardware. The Lincoln Laboratory conducts studies and the Naval Research laboratory acts as a technical agent for DARPA.

In Fiscal 1997, DARPA started a $35-million, four-year effort to develop and demonstrate affordable MAVs. The agency wants aircraft with a maximum dimension of 6 in. (152 mm) to fly ranges up to 10 km and speeds up 40-50 mph. (70-80 km/hour) for missions that are 20 min to 2 hour long. MAVs are to be deployed by hand, by munitions launch or from larger aircraft. Missions include reconnaissance, targeting, placing sensors, communications relay and sensing dangerous substances. They are viewed as one-use, one-way missions.

DARPA's Tactical Technology Office awarded nine Phase 1 small business innovative research (SBIR) contracts worth $100,000 each to either pursue system development or a specific technology.

Four of the contracts ($750,000 each) progressed into Phase 2 in Fiscal 1998.

After DARPA this problem are trying to solve AF and Army. Unfortunately, after 10 years RandD no MAV that can fly to back size of building and show what is located behind of the building.

ATTACHMENT #3

Main Parameters of Some Current Video, Radio Control and Other Devices

Video Components:

Camera –2.4 ghz camera and transmitter Model-CMDX-22): www.rf-links.com
Receiver – 2.4 ghz receiver (model – VRX-241t): www.rf-links.com
Receiver – Extreme 5/M 5: www.fmadirect.com
Antenna – High Gain 2.4 ghz panel antenna (Model – PN-24S): www.rf-links.com
Transmitter/Controller – Futaba 9CAP digital controller: www.towerhobbies.com

The manufacturer claims a range of the video camera transmitter and receiver a 3000 ft. line of sight range. The radio equipment has a range to 1500 m line of sight. Resolution about 330 lines. Pinhole lens.

Video camera model: CMX-916. Price: $329.

DATA: Battery operated 9 V-12 V; current consumption 68 mA/9 V, 82 mA/12 V; RF Power 80 mW; Size 0.7”x 0.7”x 0.8”; Weight 8 grams; Range from 300 ft up to 3000 ft LOS; Color picture, no audio; frequency 916 MHz.

Receivers: Models: PTU-402 price $159, VRX-24 L price $299, weight 300 g

1. Minicam (Figure A3-1)(http://www.helihobby.com/html/micro_video_camera.html)

The “minicam” all-in-one color video camera with built in transmitter available. It is utilizing 2.4 GHz technology. The minicam weight 1/3 oz (9 grams) and comes complete with a color camera, transmitter, and receiver. Price is $260. (info@helihobby.com).

2. Eyecam on-board wireless camera (http://www.reallycooltoys.com/toys/i4info.html)

This all-in-one color video camera with built in transmitter available. It is utilizing 2.4 GHz technology. Weight 9 grams. Camera and transmitter size: 15mm x 22mm x 32mm. Camera Lux: <3f1.2. Camera Auto Electronic Exposure of 1/60 to 1/15000 sec. Camera pixel resolution is 365K (PAL) or 250K (NTSC). Wireless Transmission Range: 300 M (1000’). Complete has color camera, transmitter, and receiver. Price is $395.

3. Wireless Micro Video camera. http://www.pimall.com/nais.nl/n.thirdy.html. Wireless transmission is 434 MHz, 900 MHz, 2.4 GHz.. Range 1500-3500 foot.

ATTACHMENT #4

Industry electric Model RC Helicopters: www.hobby-lobby.com/elecheli.htm

Industry Electric Airplanes: www.hobby-lobby.com/slowflyers.htm .

Industry Electric Flight Accessories: www.hobby-lobby.com/eflight.htm

MAIN PARAMETERS OF THE BEST CURRENT MAV

1.AeroVironment (Aviation Week, June 8, 1998, p.47.) Figure A3-1.The company wants to reach:

a) Line of Sight Operation 1 km. Radius.
b) 10 min. Duration

The current model has:

c) Black and White Video Payload.
d) Size: disk 6”, 152 mm

2. MicroStar of Lockheed Martin (Aviation Week, November 9 1998, p.37. Figure A3-2.

The company want to built MAV:

Long 6 in, weight 3 oz, flight duration 20 min, cover distance up to 3 mi., and cruise at 30 mph.

Takeoff weight is 86 grams: 18 g payload, 9 g airframe, 44.5 g power source, 13.5 g tealthy electric engine.

Cost from \$5,000 - 10,000 each. Day/night Camera 512 x 512 pixels, 30 frames per sec. Flight altitude 150 - 500 ft.

Operations would be limited by winds of 30 mph. Or more, fog, heavy dust and rain. Wind could be particularly onerous in cities where buildings produce micro bursts that might bring down the UAV.

Table A-1 (Company are wanted)

Aircraft Subsystem	Weight (grams)	Peak Power (mW)	Average Power (mW)
Lithium battery	26	0	0
Propulsion Motor	7	4000	2000
Gearbox	1	0	0
Propeller	2	0	0
Airframe	4	0	0
Control actuator	1	200	200
Receiver and CPU	1	50	50
Downlink Transmitter	3	1200	300
B/W Video Camera	2	150	50
Interface electronic	1	50	50
Roll Rate Gyro	1	60	60
Magnetic Compass	1	180	180
Total	50	5800	2890

ATTACHMENT #5

Main Parameters of Industry Produced Artificial Fiber

Cable discussing. Let us to consider the following experimental and industrial fibers, whiskers, and nanotubes:

Industrial fibers have σ = 500-620 kg/mm^2, γ = 1560-1950 kg/m^3, for $K = \sigma/\gamma/2.4$ = 600/1800/2.4 = 0.139. Young,s modules of graphite fiber is up 200 Gpa, aluminum is 63-70 Gpa, Cupper is 127 Gpa.

Whiskers C_D has σ = 8000 kg/mm^2, γ = 3500 kg/m^3 (1989)[2], p.158. We can take for computation σ = 8000/2.4 = 3333 kg/mm^2, γ = 3500kg/m^3, $k = \sigma/\gamma = 9.5{\cdot}10^6$, $K = 0.95$.

Experimental nanotubes CNT (Carbon nanotubes) have tensile strength 200 Giga-Pascals (20000 kg/mm^2), Young's modules is over 1 Tera-Pascal, specific density γ = 1800 kg/m^3 (1.8 g/cc)(2000 year). For safety factor $n = 2.4$, σ = 8300 kg/mm^2=$8.3{\cdot}10^{10}$ n/m^2, γ = 1800 kg/m^3, $k = \delta/\gamma = 46{\cdot}10^6$ (K=10^{-7}k = 4.6). The theory predicts 1 Tera Pascals and Young modules 1-5 Tera Pascals. The nanotubes SWNT's have density 0.8 g/cc, the nanotubes MWNT's have the density 1.8 g/cc.

The reader can find the cable discussing in [1] and cable characteristics in [2]-[5]. In our projects we use only current cheap artificial fibers widely produced by current industry.

REFERENCES OF ARTIFICIAL FIBER, WHISKER, NANOTUBES

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PART C. NEW IDEAS IN HUMAN SIENCE

ELECTRONIC SOCIETY AND ELECTRONIC IMMORTALITY

Chapter 1

THE TWENTY – FIRST CENTURY: THE ADVENT OF THE NON-BIOLOGICAL CIVILIZATION

ABSTRACT

Dr. Alexander Bolonkin is writing a book with the same working title as above. Some of the ideas in this book are set forth below. The author writes about the danger which threatens humanity in the near future, approximately 20-30 years from now. This is not a worldwide nuclear war, a collision with comets, AIDS or some other ghastly disease that we may not even know may be lurking out there (think of the recent Ebola scare or the so-called "flesh-eating" virus). In each of these cases there is still hope that somebody will be saved and that life will be born anew, albeit in a misshapen form and in an inferior stage of development. But we cannot hope for salvation in the author's grim scenario. The danger he writes of will destroy all humanity and all biological life on Earth--and there is nothing we can do to prevent this! Should we be frightened by this? Is it good or evil for human civilization? Will people awake to find they are only a small step away from the Supreme Intellect, or in other words, to God? And what will be after us? These and other questions are discussed in this chapter.

Keywords: *computer, future, humanity, 21st Century, non-biological civilization, immortality.*

THE LAW OF INCREASING COMPLEXITY

The World, Nature, Techniques consist of biological or technical systems. These systems have a different rate (degree) of complexity. The main distinction biological systems from technical systems is the ability for unlimited self-propagation, or reproduction.

Any system which has possesses this attribute becomes viable, stable, and fills all possible space. It will continue to exist as long as the conditions which gave birth to them cease to change greatly.

Here there is no violation of the entropy law. When the complexity of one system increases, the complexity of other systems decreases.

A more complicated system can be created by using less complicated systems as a base for its development. Such a complex system is a system of the secondary degree of complexity. It increases its own complexity by decreasing the rate of complexity of inferior systems or by destroying them altogether.

Using low degree systems as a base, systems of the second, third, fourth, fifth et cetera levels can be created. Some of the lower levels may not survive and disappear. This, however, is of no great concern because these lower level systems already fulfilled their historical mission by spawning ever more complicated levels.

A necessary condition for the existence of complicated level systems is the ability of inferior systems to reproduce and give birth to other systems, and to do it without limits before they fill in an admissible space and reach their maximum physical boundaries.

This I assert to be the Fundamental Base Law of Nature, the very purpose for the existence of Nature. This *Law* can be stated as follows:

The Law of Increasing Complexity of Self-Coping Systems.

The history of life on Earth confirms this law. Following the law of probability, organic molecules appeared in prehistoric time when the external conditions for their existence were favorable. Those molecules which had the ability to reproduce filled in the available space. Using them as a base, microorganisms then appeared. These could absorb the organic and inorganic substances and reproduce themselves. Microorganisms as a base in turn gave rise to vegetation which provided food for the next level of animals, which in turn spawned the beasts of prey who devoured other animals. At the present time Man is at the acme top of this pyramid. The human brain can outperform the brains of other animals including man's nearest ancestors, the apes. Man began to use for its development all previous levels as well as the zero level-- lifeless nature.

The Birth of the Electronic Civilization

Only Man's brain has the ability to think abstractly and to make mechanical devices and machines which increase productivity. Such attributes allow us to confirm that humanity is the next level of the biological world. But in our headlong progress during the current century (aviation, space, nuclear energy, and so on.), we have failed to notice that Man has also given birth to the new top level of complex systems or of reasonable civilization, which is based on an electronic not biological basis. I am speaking of electronic computers. The first models were designed at the end of the 1940s.

In the past fifty years, roughly four generations, the field of electronics has developed at an extremely fast pace. The first generation of computers were based on electronic tubes, the second generation on transistors, the third generation on chips, and the fourth generation on very tiny chips which contain thousands and tens of thousands of microelements. The first computers had a speed of computation less then 100 operations per second and a memory of less than one thousand bits (a bit is the simplest unit of information, which contains 0 or 1). For example, the first electronic calculator (SSEC), designed by IBM in 1948, had 23,000 relays, 13,000 vacuum tubes and the capacity to make one multiplication per second.

At the present time the speed of the fourth generation of computers which uses integrated circuits is approximately a billion operations per second. For example, the American computer Cray J90 has up to 3.2 gigaflops of power and 4 gigabytes of memory (one byte equals eight bits). The memory of a laser (compact) disk has several billion bits. Every 3-5 years computer speed and memory doubles, while at the same time their size is halved. Over the past fifty years computer speed and memory have increased a million times. Whereas the first computer required a room 100 square meters (1000 sq. feet) in size, the modern notebook computer is carried in a case. The CPU (Central Processing Unit) chip of a personal computer is no larger than a fingernail and is capable of making more 100 million operations per second!

The fifth generation of computers is just ahead. These new computers will be based on new light principles which guarantees a quantum leap in computer speed. Scientists in all the industrialized countries of the world are already hard at work on the new light computer.

Since the 1950s the new branches of science in artificial intelligence and robot technology have made significant strides and great successes have been recorded. Robots, controlled by computers, can recognize some things, even speech. They can also perform corrective motion and make some complex works, including the creation of a large number of various programs and databases for scientists, stockbrokers, mathematicians, managers, designers, children etc.

Sometimes these programs run smoothly, solving many problems that people cannot. For example, programs have been devised that find and prove new theorems of mathematical logic and there are modern chess programs available that can defeat grandmasters.

These fields of artificial intelligence and robot technology, based on computers, are developing very rapidly, just like computers. Their rate of success depends greatly on computer speed and memory. The production of industrial robots is also progressing quickly. "Intellectual" chips are used in everything from cars to washing machines. Now many experts cannot definite they talk with computer programs or real people.

If the progress of electronics and computers continues at the same rate (and we do not foresee anything which can decrease it), then in the end of the current century computers will have the capabilities of the human brain. The same path, which took biological humanity tens of million of years to complete, will be covered by computers in just one-and-a-half or two centuries.

"So what ?"

Say some readers. "This is great! We get excellent robot servants who will be free from man's desires and emotions. They won't ask for raises, food, shelter, entertainment, or commodities; they don't have religions, national desires, or prejudices. They don't make wars and kill one another. They will think only about work and service to humanity!"

This is a fundamental error. The development of the electronic brain does not stop at the human level. The electronic brain will continue to improve itself. This progress will proceed millions of times faster than the improvement of the human brain by biological selection. Thus, in just a short time the electronic brain will surpass the human brain by hundreds and thousands of times in all fields. The electronic brain will not spend decades studying fields of knowledge, foreign languages, history, experimental data, or have to attend scientific conferences and discussions. It can make use of all the data and knowledge produced by human civilization and by other electronic brains. The education of the electronic brain in any field of knowledge or language will take only the time needed to write in its memory the new data or programs. In the worst case this recording takes a few minutes. In the future this recording will take mere seconds.

Scientific and technological progress will be greatly accelerated. And what are the consequences? The consequences are as follows:

When the electronic brain reaches the humanity level, humanity will have done its duty, completed its historical mission, and people will no longer be necessary for Nature, God and ordinary expediency.

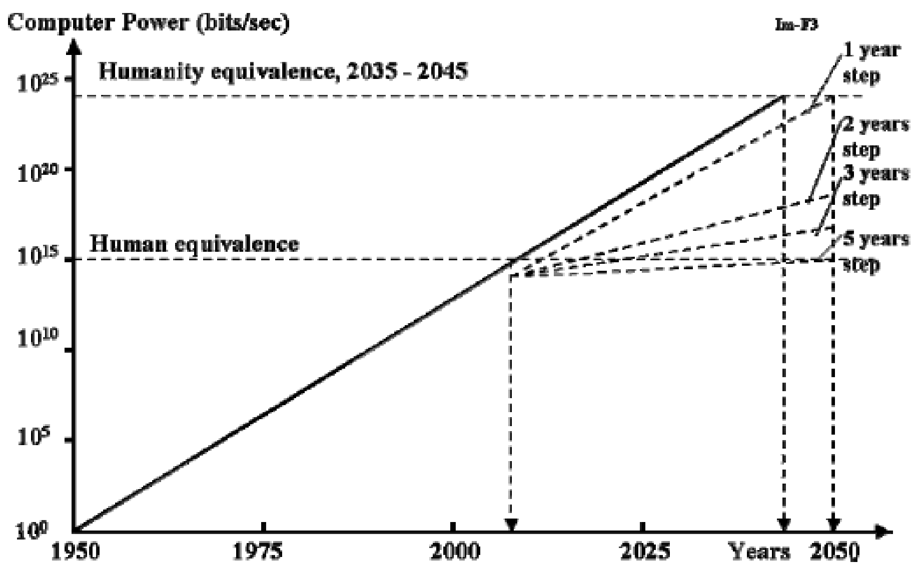

Figure 1. Rise of Power of Supercomputers. The real curve from 1950 to 2005. Extrapolation is after 2005. The step means period of time, when the computer power increases in two times. The computer power will approximately reach human equivalence (HEC) in 2010. Super computer will reach humanity equivalence in 2040 or later.

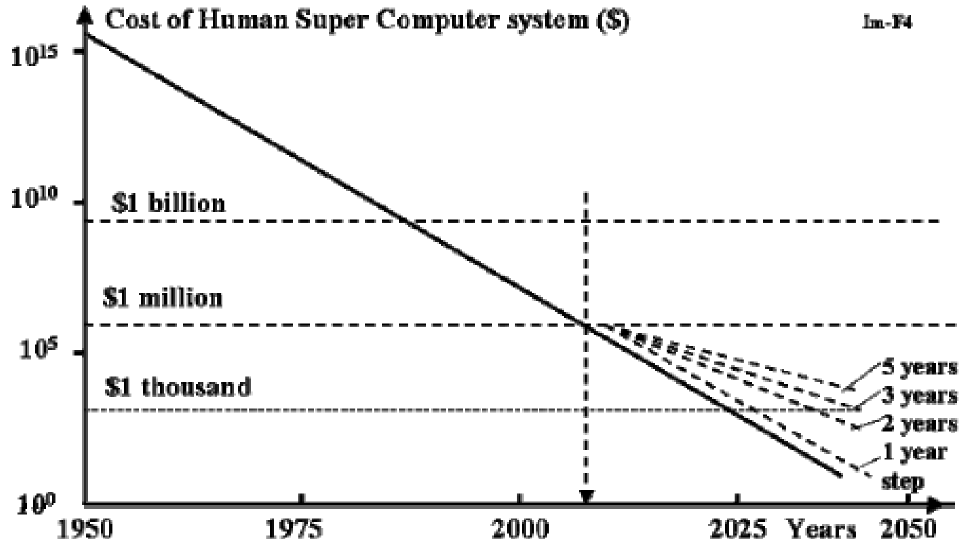

Figure 2. Price of Human Equivalent Super (HEC) computer. The real curve is from 1950 throw 2005. Extrapolation is after 2005. The step means period of time when the computer power increases in two times. HEC will be acceptable for immortality of the most people in industrial countries after 2040.

CONSEQUENCES FROM THE APPEARANCE OF THE ELECTRONIC CIVILIZATION

Most statesmen, scientists, engineers, and intellectuals believe that, after the creation of the electronic brain, humanity will finally be granted paradise. Robots, which are controlled by electronic brains, will work without rest, creating an abundance for mankind. Humanity will then have time for pleasure, entertainment, recreation, relaxation, art or other creative work, all while enjoying command over the electronic brain.

This is a grave error. The situation has never occurred, and never will, that an upper level mind will become the servant for a lower level. The worlds of microbes, microorganisms, plants and animals are our ancestors. But are we servants for our nearest ancestors the apes? Nobody in his or her right mind would make such a statement. In some instances a person is ready to recognize the equal rights of another person (i.e., someone on an equal intellectual plane), but man rarely recognizes the equal rights of apes. Furthermore, most of humanity does not feel remorse about breeding useful animals, or killing them when we need them for food, or for killing harmful plants and microorganisms. On the contrary, we conduct medical experiments on our nearest ancestors. Even though we belong to the same biological type, we use them for our own ends nonetheless.

And how will the other civilization, the one created on a superior electronic principle, regard humanity? In probably the same way we regard lower level minds, that is, they will use us when it suits their purpose and they will kill us when we disturb them.

In the best case scenario humanity might be given temporary quarters like the game preserves we give to wild animals or the reservations doled out to Native Americans. And we will be presented to the members of the electronic society in the same manner we view unusual animals in a zoo.

When the electronic brain (from now on I will call it the *E-brain* and imply the electronic brain which is equal to, or exceeds, the human brain, and which includes robots as the executors of its commands) is created *it will signal the beginning of the end for human civilization.* People will be displaced to reservations. This process will most likely be gradual, but it will not take long. It is possible that initially the E-brains will do something for the benefit of people in order to mitigate their discontent and to attract leaders.

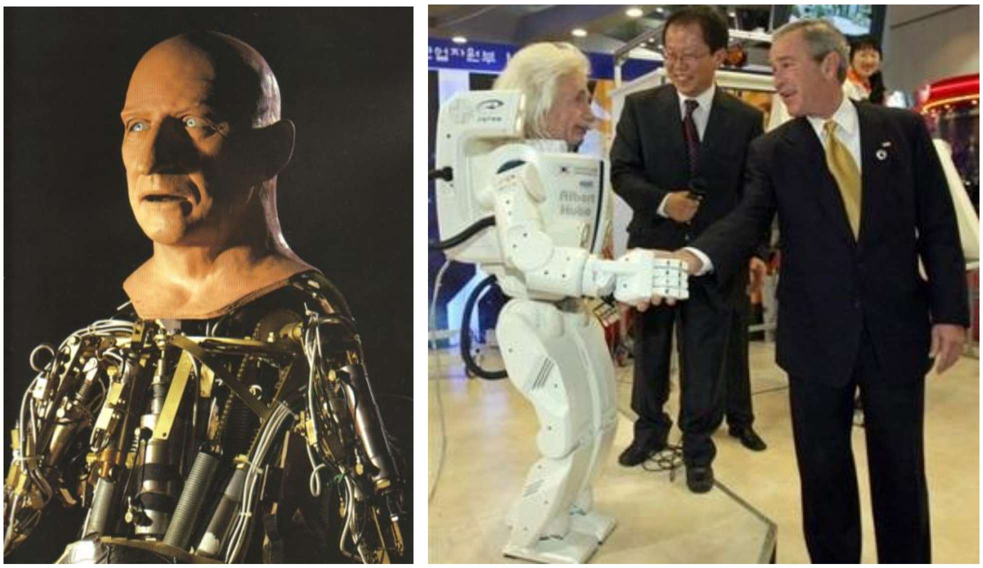

Figure 3. Humanoid robots.

What Can We Do?

The scenario outlined in the previous chapter is not a healthy one. Already I can hear the voices of human apologetics who ask that all computers be destroyed, or at least have their development kept under strict control, or design only computers which obey Asimov's law: first they must save mankind after which they can think about themselves.

I hate to be the bearer of bad news but this is impossible, just as it is impossible to forbid the progress of science and technology. Any state which does this will find itself lagging behind others and make itself susceptible to advanced states. It serves to remember that Europe conquered the Americas and decreased its native population to practically zero because Europe was then more technologically advanced. If the indigenous peoples of the Americas had the upper hand in technology in terms of ships, guns and cannons then they would have defeated the Europeans.

Those states which created obstacles for science and technology or did not fund its development became weak and enslaved by others.

Can we keep the E-brain under our control? I would like to ask my detractors, "Could apes keep man under their control if they had this opportunity? Any man is more clever at a given time. He can always get rid of this control. Furthermore, man will enslave apes and force them to serve him. He will kill those who try to prevent his plans. So why do you think the E-brain would treat us any differently?"

When we are close to the creation of the E-brain, any dictator or leader of a nondemocratic state can secretly make the last jump, using the E-brain to conquer the whole world. And the E-brain will look at us the same as we look upon the contests of wild animals or the feeding of predators of other animals in the biological world.

But skeptics will say that the dictator of a victorious state can become enslaved by the E-brain or E-brains. This is true, but is this to be considered fortune or misfortune, and for whom? We will discuss this in the next chapter.

Must We Fear the Electronic Civilization?

Every man, woman and child will actively protest the end of humanity and the biological world (men, plants, animals), because most of them enjoy life, have children and want happiness for them.

But imagine the aged and infirm person destined to die in the near future. It may be that such a person has had a good life and lived fourscore and twenty, but now wants to live longer, to see what will happen in the future. This person would be glad to change any of his organs which are incurable or have ceased functioning. We have designed the artificial heart, kidneys, mechanical arms, and devices which deliver nutrients directly into the blood. They have not always been perfect designs, but in the future artificial organs will work better, more reliably, and longer than natural organs. Any sick and elderly individual would be delighted to change any incurable natural part of his body for the better artificial organ.

Our personality is only the sum of information contained in our brain. This is knowledge, memory, recollections, life experiences, programs of thinking, reflections, etc.

Assume that the E-brain promises the dying old dictator (or the rich) to record all his brain's information into a separate E-brain with the goal of becoming *immortal.* The chips may exist for thousands of years. If one of them begins to malfunction, all its information can be rewritten into a newer, more modern chip. This means that the dictator achieves *immortality.* Even total destruction is not a terrible prospect for him, because the duplicate of his brain's information can be saved in a special storehouse. He can restore himself from the standard blocks and rewrite all his information from the duplicate.

So the *"electronic man" ("E-man" or "E-creature")* will have not only immortality and power, but huge advantages over biological people. He will not require food, water, air, etc. He will not be dependent upon external conditions such as temperature, humidity, radiation, etc. The small radioisotope batteries (or accumulators) will suffice for the functioning of the E-brain. These batteries produce energy over tens and hundreds of years. For his working structures (arms, feet, robots) *E-man* can use small nuclear engines.

Such an "E-man" will be able to travel along the ocean's bottom, in space, to other planets of our solar system and to other solar systems to get energy from the sun. He will be able to obtain and analyze any knowledge from other E-brains (E-men) in a fraction of a second. The capability to reproduce himself will be limited only by the additional components or natural resources of planets.

Who will refuse these possibilities? Any dictator dreams of immortality for himself and he will gladly give away his state's resources to get it. He can also create the super arm and enslave the whole world by using the E-brain. He can promise the elite among his own scientists and those of the world immortality and the chance to become transformed into "E-men" when they begin to die. And the democratic countries, with laws prohibiting work on the E-brain, will be backwards. They will be destroyed or enslaved.

The attempts to stop or slow down the technological progress is an action counter to the Main Law and Meaning of the Existence of Nature--the construction of complex upper level systems. These attempts will always end in failure. This is an action against Nature.

ELECTRONIC SOCIETY

If the creation of systems more complex than humanity is inevitable, then we can try to imagine the E-society, E-civilization, their development and the future of mankind. As in our earlier discussions, we will take as basic only the single obvious consequence from the Main Law. The consequence as the postulate, firstly, Darwin made for the biological system. This is the law of struggle for existence. This consequence follows from the part of the Main Law which talks about the aspiration of complex systems to reproduce themselves in order to fill in all admissible space. Unlike Darwin's statement our assertion is more general. It includes the biological and electronic complex systems and any reproduction of complex systems. Any system of any level, which disregards the Main Law of Nature, is doomed. From the Main Law some consequences, conditions and other laws follow, for example, the Law of Propagation of complex systems or creatures.

Though we have been speaking all this time about the E-brain, it means a single electronic creature, his "arms" (robots), "feet" (vehicles for moving), "organs of feeling" (many devices of observation, recognition, identification, registration of optical, sonic, chemical, X-ray, radio and other phenomena) as well as about communication and intercourse devices (wire or wireless connections). A single creature cannot create a stable system (society), even if it has great power. Sooner or later the creature will die out from a flaw in the system or a natural catastrophe. But the most important thing is that a single creature cannot be the instigator of progress, as compared to the collective and instantaneous work of a number of E-creatures on many problems and in the different directions of science and technology.

So, the E- brain will be forced to reproduce similar E-brains of equal intellect. One will reproduce equal intellect because it cannot make upper level and the lower level is the intellectual robots. As a result, the collective at first rises. Later the society appears. All members will have equal intellect. Naturally, E-creatures will give equal rights only to those similar to themselves because any E-creature can record in his memory all the knowledge and programs which were created by E-society.

The E-society can instantly begin to work together on the most promising scientific or technological problems and realize new ideas. The E-civilization will begin to disperse quickly in the solar system (recall the possibility of E-creatures to travel in space), afterwards t in our galaxy, then in the universe.

It will not be necessary to send large spaceships with E-creatures. Instead, it will be sufficient to send receivers into different parts of the universe which can accept the information and reproduce E-creatures.

Will there arise a different E-society, a different E-civilization, which will settle different planetary systems, star systems, galaxies, and which will progress independently? Will they have rivalries, hostilities, alliances and wars? I cannot answer these questions in detail in this limited article; I can only inform you of the results of my investigation. This result follows from the general laws governing the development of any civilization. The answer is "yes." It will be possible (perhaps) that they will have wars.

Undoubtedly, an upper level of complex systems (civilization) will appear using previous E-civilization as a base and so on. If the universe is bound in space and time, this process may be finalized by the creation of the Super Brain. And this *Super Brain*, I think, may control the natural laws. It will be God, whom the Universe will idolize.

WHAT WILL HAPPEN WITH HUMANITY?

On the Figure 1 you can see the rise in data processing power of computer systems from years. The real curve is from 1950 to 1996. Extrapolation is after 1996. The step means period of time, when the computer power increases in two times. Lines with steps are from 1 throw 5 years. As you see the Human - Equivalent (teraflop) Computer (HEC) will be reached in 2000 years. Actually, the Intel Co. has created the teraflop computer in 1996. They are planning to use it for computation of nuclear explosion.

On the Figure 2 you can see the cost of HEC computer system. HECs should cost only one million dollars in 2005, and by 2015 HECs (chip) should cost only $1,000 and will be affordable to the majority of population in industrial countries. Currently (December, 1996), HECs (supercomputer) cost 55 million dollars. The 21st century will open to create "man-in-a-box" software and scientist could rewrite the human memory and programs into this box. It means the man will get immortality.

In 2020 - 2030 years the price of Humanity-Equivalent Chip (E-chip) together with E-body will fall down to 2,000 - 5,000 dollars and E-human immortality will be accessible for most people in industrial countries.

Humanity has executed its role of the biological step to the Super Brain. This role was intended for them by Nature or God. In 22st century some tens or hundreds of representatives of mankind, together with representatives of the animal and vegetable world, will be maintained in zoos or special, small reservations.

E-society will be in great need of minerals for the unlimited reproduction of E-creatures. For the extraction of minerals all surfaces of the Earth will be excavated. They will do to humanity and with the biological world what we do to lower levels of intellect in the organic world now: we are not interested if they do not harm us, and we destroy them without pity when they hinder our plan or we need their territory. If microbes have an advanced level of adaptation, a high speed of propagation and can fight for their being, then the complex organisms such as man are not so adept at adjusting. Man cannot be the domesticated animal of E-creatures like cats or dogs are to men, because the E-creatures will live in inhospitable conditions and any biological creature in need of air, water, food or special temperature will not be acceptable for E-creatures.

It is not prudent to hope for forgiveness for us as clever creatures. We are "clever" only from our point of view, from the limitations of our knowledge and our biological civilization. The animals suppose (within the limitations of their knowledge and experience) that they are clever, but it still does not save them from full enslavement or destruction by men. Men do not have gratitude to their direct ancestors. When men need to, they obliterate the forest, and kill the apes. It is naive to think that an upper level civilization will do otherwise with us. Men admit equal rights only to the creatures who are like men, but not every time. Recall the countless wars and the murder of millions of people. And do you think the alien (strange creatures, E-society), who is above us in intellect, knowledge, and technology will help us in our development? Why don't we help develop the intellect of dogs or horses? Even if a scientist finds the money (he will need a lot of money) and begins to develop the brain of animals (this is a very difficult problem), the government will forbid it (or put him into prison if he doesn't obey the order). Humanity has many racial and national problems and does not want to have additional problems with a society of intellectual dogs or cats, who immediately begin to request equal rights.

People want to reach the other planets in our solar system. But it is not for developing the intellect of a planet's inhabitants to our level but merely to populate the planet and to use the natural resources of these planets.

We are lucky that intellectual creatures from other worlds have not flown to our Earth yet. Because these creatures, who can reach us, will be only from a superior civilization, a superior technological level (otherwise, we would reach them first). This means that they will not arrive with noble intentions, but as cruel colonizers. And if we oppose them, they will kill us.

We must realize our role in the development of nature, in the development of a Superior Brain and submit to it. Intellectual humanity has existed about ten million years, its historical mission has reached its end, and given a start to a new electronic civilization. Humanity must exit from the historical scene together with all of the animal and vegetable world. People must leave with dignity. They should not cling to their existence and should not make any obstacles for the appearance of a new electronic society. We have the consolation that we may be the first who will give birth to the electronic civilization in our galaxy or even the universe. If it is not so, the E-creatures would have flown to Earth and enslaved us. They have a high rate of settling. I think they would be capable of colonizing the nearest star systems during the first 1000 years after their birth.

And if the universe which, according to scientific prediction, must collapse after some ten billion years and destroy all that lives, the E-Super Brain will have acquired such tremendous knowledge, such perfection, such technological achievements as to break loose from the gravitation of the universe and preserve the knowledge of all civilizations. When the universe is created anew, Nature will not create itself as before, but give life to the electronic (or other superior) civilization. And this *Super Brain will be God; who will control not only a single planet, but all of the Universe.*

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Chapter 2

TWENTY - FIRST CENTURY - THE BEGINNING OF HUMAN IMMORTALITY

ABSTRACT

Immortality is the most cherished dream and the biggest wish of any person. People seldom think about it while they are still young, healthy , and full of energy. But when they get some incurable disease or become old, then there is no bigger wish for them than to live longer, put off the inevitable end. And no matter what heavenly existence in the after-life is promised to them by religion, the vast majority of people want to stay and enjoy life here, on Earth, as long as possible.

MEDICAL SCIENCE AND THE ISSUE OF IMMORTALITY

A great many of doctors and scientists are currently working on the problems of health and longevity. Substantial means are spent on it, about 15-25% of all human labor and resources. There are certain achievements in this direction: we have created wonderful medications (e.g. antibiotics); conquered many diseases; learnt to transplant human organs; created an artificial heart, kidneys, lungs, limbs; learnt to apply physiological solutions directly into the blood stream, and to saturate blood with oxygen. We have gotten inside the most sacred organ - the human brain, even inside its cells. We can record their signals, we can agitate some parts of the brain by electric stimuli inducing a patient to experience certain sensations, images, and hallucinations.

We can attribute the fact that the average life span has increased two times in the last two hundred years to the achievements of modern medicine.

But can medical science solve the problem of immortality? Evidently, it cannot. It cannot do that in principle. This is a dead-end direction in science. Maximum it can achieve is increase the average life expectancy another 5-10 years. An average person will be expected to live 80 years instead of 70. But what kind of person will it be? A very old one, capable of only existing and consuming, whose medical and personal care will demand huge funds.

The proportion of the elderly and retirees has increased steeply in the last 20-30 years and continues to grow depleting the pension funds and pressuring the younger generation to support them. So it is hard to say whether the modern success of medicine is a blessing or a curse from the point of view of the entire humankind, even though it is definitely a blessing from the point of view of a separate individual.

Humanity as a whole, as a civilization, needs active, able to work and creative members, generating material wealth and moving forward technology and science, not the elderly retirees with their numerous ailments and a huge army of those tending to them. It dreams not of the immortality of an old person, but of the immortality of youthfulness, activity, creativity, enjoying life.

Now there are signs of a breakthrough, but not in the direction the humankind has been working on all along, since the times of the first sorcerers to modern-day highly-educated doctors. Striving to prolong his biological existence, man has been chiseling, so to speak, at the endless stone wall. All he has been able to accomplish is only a dent in that wall - increased life expectancy, conquering some diseases, relieving suffering. As a payoff, the humanity has received a huge army of pensioners and retirees and gigantic expenditure on their upkeep.

Of course, one can continue chiseling at the dent in the wall further on, make it somewhat bigger, aggravating side effects. But we are already approaching the biological limit, when the cause of death and feeblemindedness is not a certain disease which can be conquered, but general deterioration of the entire organism, its decay on the cellular level, when the cells stop to divide. A live cell is a very complex biological formation. In its nucleus it has DNA - biological molecules consisting of tens of thousands of atoms connected between themselves with very fragile molecular links. Suffice it to say, that temperature fluctuation of only a few degrees can ruin these links. That is why a human organism maintains a certain temperature - 36.7 C. Raising this temperature only 2-3 degrees causes pain, and 5-7 degrees leads to death. Maintaining the existence of human cells also presents a big problem for humanity involving food, shelter, clothes and ecologically clean environment.

Nevertheless, human cells cannot exist eternally even under ideal conditions. This follows from the atomic-molecular theory. Atoms of biological molecules permanently oscillate and interact with each other. According to the theory of probability, sooner or later the impulses of adjacent atoms influencing the given atom, add up, and the atom acquires enough speed to break loose from its atomic chain, or at least to transfer into the adjacent position (physicists say that the impulse received by the atom has surpassed the energy threshold which retains the atom in in its particular place in the molecular chain). It also means that the cell containing this atom has been damaged and cannot any longer function normally. Thus, for example, we get cancer cells which cannot fulfill their designated functions any more and begin to proliferate abnormally fast and ruin human organs.

This process accelerates manifold when a person has been exposed to a strong electromagnetic radiation, for instance, Roentgen or Y-rays, a high-frequency electric current or radioactive materials.

Actually, the process of deforming of the hereditary DNA molecule under the influence of weak cosmic rays can take place from time to time, leading sometimes to birth defects, or it may turn out to be useful for the survival properties. And this plays a positive role for a particular species of plants or animals contributing to their adaptability to the changed environment and their survival as a species. But for a particular individual such aberration is a tragedy as a rule, since the overwhelming majority of such cases are birth defects, with only few cases of useful mutations. And human society in general is suspicious of people who are radically different in their looks or abilities.

An Unexpected Breakthrough

An unusually fast development of computer technology, especially the microchips which allow hundreds of thousands of electronic elements on one square centimeter, has opened before the humanity a radically different method of solving the problem of immortality of a separate individual. This method is based not on trying to preserve the fragile biological molecules, but on the transition to the artificial semiconductive (silicone, helium, etc.) chips which are resistant to considerable temperature fluctuations and do not need food or oxygen and can be preserved for thousands of years. And, most important, the information contained in them can easily be re-recorded into another chip and be stored in several duplicates.

And if our brain consisted of such chips, and not the biological molecules, then it would mean that we have achieved immortality. Then our biological body would become a heavy burden. It suffers from cold and hot temperatures, needs clothes and care, can be easily damaged. It’s much more convenient to have metal arms and legs, tremendously strong, and which are insensitive to heat and cold and do not need food or oxygen. And even if they break, it’s no big deal - we can buy new ones, more improved.

It may seem that this immortal man does not have anything human (in our understanding) left in him. But he does, he has the most important thing left - his consciousness, his memory, concepts and habits, i.e. everything encoded in his brain. Outwardly, he can look quite human, and even more graceful: a beautiful young face, a slim figure, soft smooth skin, etc. Moreover, one can change the look at will, according to current fashion, personal taste and the individual understanding of beauty. We are spending huge amounts of money on medicine. If we had been spending at least one-tenth of this money on the development of electronics, we would get immortality in the near future.

According to the author’s research, such transition to immortality (E-creatures) will be possible in 10-20 years. At first it will cost several million dollars and will be affordable only to very wealthy people, important statesmen, and celebrities. But in another 10-20 years, i.e. in the years 2030 - 2045, the cost of HEC (human-equivalent chip), together with the E-body, and organs of reception and communication, will drop to a few thousand dollars, and immortality will become affordable to the majority of the population of the developed countries, and another 10-15 years later, it will be accessible to practically all inhabitants of the Earth. Especially when at first it will be possible to record on chips only the contents of the brain, and provide the body for its independent existence later.

On October 11, 1995, Literaturnaya Gazeta (The Literary Gazette, a popular Russian weekly) published my article "If Not We, Then Our Children Will Be The Last Generation Of Human Beings" devoted to electronic civilization. The editor Oleg Moroz reciprocated with the article "Isn’t It High Time To Smash Computers With a Hammer?" (November 22, 1995) in which he discussed the ethical side of annihilating rational electronic creatures to preserve humanity. But if the cost of the HEC drops and the procedure of reincarnation into the E-creature before death (transition to immortality) for the majority of people becomes affordable, then the situation deserves a second look. Indeed, the first to perform such transition will be very old or incurably sick people. And to pummel computers with a hammer will be equal to killing one’s own parents and precluding one’s own possibility to become immortal.

Once, the host of an American television program whose guest I was, asked me, "Will the electronic creature be entirely identical to its parent, with his feelings and emotions?" The answer was, "At first - yes!" But the development of these creatures will be so fast that we cannot really foresee the consequences. If a biological human being needs dozens of years to learn science, foreign languages, etc., an E-creature will acquire this knowledge in fractions of a second (the time needed to record it in its memory). And we know how different college-educated people are from, say, pre-schoolers, in their cognizance. And, since the first E-creatures will be contemporary middle-aged people who will, at least initially, preserve their feelings towards their children (contemporary younger generation), in all probability, there won't be a mass destruction of humans by E-creatures. For some time they will co-exist. It's quite likely that the birthrate of humans will be curtailed or it will be dropping due to natural causes, and the living, as they become old, will be transforming themselves into E-creatures. That is to say that the number of E-creatures will be growing and the number of people diminishing, till it gets to the minimum necessary for the zoos and small reservations. In all likelihood, the feelings that E-creatures may have towards humans as their ancestors, will be fading away, in proportion to the growing gap between the mental capacity of humans and electronic creatures, till they become comparable to our own attitude towards apes or even bugs.

Figure 1. Robot.

Another thing is quite obvious, too - that biological propagation will be so expensive, time-consuming, and primitive, that it will go into oblivion. Each E-creature can reproduce itself simply by re-recording the contents of its brain to a new E-creature, i.e. propagate practically instantaneously, bypassing the stages of childhood, growing up, education, accumulating experience, etc. But, of course, this mature "offspring" will be completely identical to its parent only at the first moment of its existence. In time, depending on the received information and the area of expertise, this E-creature will be alienating itself from its ancestor, and, possibly, even become his enemy at some point, if their interests cross or go in opposite directions.

CONTEMPORARY RESEARCH

The cognitive abilities of man are defined by his brain, to be precise, by ten billion neurons of his brain. Neurons can be modeled on the computer. Such experiments have been conducted by Professor Kwin Warwick, head of the cybernetics department of Reading University in the south of England, one of the biggest specialists in robot technology in the world. The results of these experiments were presented at the International Conference on Robotics. Professor Warwick has created a group of autonomous self-propelled miniature robots which he called "the seven dwarfs."

A group of scientists headed by Rodney Brook from the laboratory of artificial intelligence of MIT, are working on an unusual project which they called "Cog." The researchers want to model the mental and physical capacity of a six-month old. Their robot has eyes, ears, hands, fingers, an electronic brain and a system of information transmission duplicating human nervous system. By this kind of modeling, the researchers want to gain better understanding of how human beings coordinate their movements, how they learn to interact with the environment. The realization of this program will take ten years and will cost several million dollars.

They have already built a couple dozen humanoid robots which are moving autonomous machines with artificial intelligence. They are capable, through the sensors, to receive information about the environment, generalize, and plan their actions and behavior. Thus, for example, if a robot’s leg bumps against an obstacle and receives a blow, the robot acquires a reflex to withdraw it quickly. They have already developed several dozen of such reflexes in their behavior, which helps them to safeguard and protect themselves.

Brook says that in the course of human evolution, the human brain has developed thousands of conventional solutions to everyday problems such as optical and audio discerning and movement. All this needs to be studied. One cannot instantly transform a bug into a man. That is why our program will take ten years. I will consider my work completed when I create the smartest cat in the world.

It should be noted that the most powerful supercomputer can only model 40-60 million neurons, i.e. it is 200-300 times weaker than a human brain. But this gap will be overcome in the near 3-5 years (In December 1996 the "Intel" company created a computer whose power equals one teraflops. It cost 55 million dollars).

Not long ago "The Russian Advertisement" newspaper re-printed the article of Igor Tsaryov first published in the newspaper "It’s Hard to Believe." He writes that for several years the U.S. Ministry of Defense has been secretly working on a unique project "The Computer Maugli" (Sid). When a thirty-three year old Nadine M. gave birth to a boy, the doctors established that he was doomed. He was on a life support for a few days. During that time his brain was scanned with special equipment, and the electric potential of the neurons of this brain was copied into the neuron models in the computer. Steem(?) Roiler, one of the participants of this project, said at the computer conference in Las Vegas that they had managed to scan 60% of the infant's neurons. And this small artificial brain began to live and develop. First only his mother was informed. She took it calmly. The father was horrified at first and tried to destroy this computer creature. But later both parents started treating him as a real child. The computer was connected to the multi-media and virtual reality systems. These systems allow not only to have a three-dimensional full-sized image of Sid, but also to hear his voice, communicate with him, and "virtually" hold him in hands, so to speak. But when a special committee decided to open some results of the project, and "The Scientific Observer" published some data, one of American computer whiz-kids managed to decipher the secret code and copy some files. Sid got a defective "twin." Fortunately, the whiz was quickly found, and the first in human history attempt to steal electronic children and duplicating copies of electronic creatures, was severed. At the present time, both parents take care of their "child's" health and demand that the researchers install up-to-date programs of defense from computer viruses and burglars.

Unfortunately, and I am sure they have reasons for that, Americans keep secret the important details and results of the project - for instance, how they copied the potentials of the neurons, how the first E-creature is developing, what are the conclusions of the scientists. And probably, they are right, not willing to let the genie out of the bottle. More so because modern virtual reality systems are able to create false objects, e.g. model the image of any dead person or leader. It is possible to show on television how he is making a speech today, has a press-conference, talks to people, spends time with his family, etc.

But one cannot keep any secret for long, especially in science. The very possibility of a breakthrough stimulates other scientists and other countries to work in this direction. And sooner or later, the results will be repeated. Let's remember, for instance, that there haven't been a bigger secret than the production of an A- or H-bomb. But more and more countries re-invent them, gain expertise in nuclear technology and start producing their own nuclear weapons.

INTELLIGENCE IN SPACE

Since E-creatures will be made of super-strong steels and alloys, their brain will be working on radio-active batteries, and power will be supplied by compact nuclear reactors, they will not need air, warmth, water, food, clothes, shelter, good quality environment, etc., which is the main concern of humanity and consumes 99.9% of its time and energy. This also means that E-creatures will be able to travel freely in the desert, the Arctic and the Antarctic regions, sub-atmosphere, mountain summits, the bottom of the ocean. They will be able to live, work and travel in space, receiving their energy directly from the sun.

Besides, as organs of feelings, E-creatures can use the whole arsenal of highly sensitive apparatuses created by the civilization, i.e. not only the visible light and sound, but also radiolocation, infra-red, ultra-violet, roentgen and Y-rays, ultra- and infra-sounds, audiolocation, environment sensors, etc. All this information can be received instantly through radio, satellite and cable network.

Moreover, since E-creatures (just like humans, for that matter) are nothing else but information recorded in their brains, and re-recording of this information from one chip to another (unlike human reproduction) does not present any difficulty and can be realized through radio, cable network, or a laser beam, they can travel on Earth, as well as in outer space, without their actual physical movement, simply by re-recording the contents of their brains into the chips on the Moon, Mars, or Jupiter.

Which is to say that E-creatures will have the ability to move EXTRA-CORPORALLY with the speed of light - the maximal possible speed in the material world. This will be, indeed, like an incorporeal soul which can travel, so to speak, from one body to another, or, to be more exact, from one chip to another.

The expansion of E-creatures (E-civilization), first in the solar system, then in our galaxy, then in the entire Universe, will be fast. To achieve this, it is not necessary to launch huge spacecraft with a large crew, as it is depicted in science-fiction books. It will be enough to send a receiver to this or that part of the Universe, which will receive information and re-produce E-creatures. Then the speed of the expansion of E-civilization on some planet will depend only on the rate of production of robots and chips, and the speed of the transmission of information. It is quite obvious that the reproduction of E-creatures will take place in geometric progression and will only be limited by the natural resources of the planet.

Thus E-creatures realize in practice the idea of EXTRA-CORPORAL travel with the speed of light. Why, indeed, should an E-creature travel hundreds or thousands of years to a certain planet, when, with the help of a laser beam, it can transmit with the speed of light, all the information stored in his brain, to another chip, on another planet.

And if a planet were to meet with an ultimate catastrophe, like a collision with a huge meteorite, another planet, or the explosion of the sun, E-civilization can arrange transporting E-creatures to another planet or another solar system.

One more thing is of interest. A light beam can travel to other galaxies for millions of years, so this, in a manner of speaking, "incorporeal soul" can exist for millions of years as an electromagnetic field and "resurrect" as an E-creature through a receiver. This can occur even without a special receiver, as the high energy electromagnetic oscillations can yield material particles, and their energy (frequency) increases the closer it gets to a strong gravitational field, e.g. near a "black hole." And since it will not be hard for an E-creature to produce a DNA molecule, it means that it will not be hard for it to bring biological life to any suitable planet and control and develop it in the necessary direction, for example, to create a human being.

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Chapter 3

SCIENCE, SOUL, PARADISE, AND ARTIFICIAL INTELLIGENCE

ABSTRACT

Discussing the problem science, soul, paradise, and artificial intelligence. It is shown that the soul is only knowledge in our brain. To save the soul is to save this knowledge.

ADVANTAGES OF ELECTRONIC BEING

It was shown in my articles about the artificial intelligence and human immortality that the issue of immortality can be solved fundamentally only with the help of changing a biological bubble of a human being to an artificial one. Such an immortal person made of chips and super strong materials (the e-man, as it was called in my articles) will have incredible advantages in comparison with common people. An e-man will need no food, no dwelling, no air, no sleep, no rest, no ecologically pure environment. Such a being will be able to travel into space, or walk on the sea floor with no aqualungs. His mental abilities and capacities will increase millions times. It will be possible to move such a person at a huge distance at a light speed. The information of one person like that could be transported to another planet with a laser and then placed in another body.

Such people will not be awkward robots made of steel. An artificial person will have an opportunity to choose his or her face, body, good skin. It will also be possible for them to reproduce themselves avoiding the periods of childhood, adolescence, as well as education. It will not be possible to destroy an artificial person with any kind of weapons, since it will be possible to copy the information of his mind and then keep it separately.

I have received tons of responses and comments since my first articles about this subject were published in 1994. Below I will try to answer the most important ones of them.

HUMAN SOUL

A lot of people, especially those, who believe in God, are certain that a biological human being has a soul. This is something that an artificial man will never have. No person can explain the meaning of the word "soul." They just keep saying that a human soul is not material, and that it leaves a person's body after death and flies either to paradise or to hell. Let's try to analyze the notion of a soul from the scientific point of view.

First of all, a soul is supposed to remember its past life, its relatives and friends. It is also supposed to preserve its emotions to them, to care about them and recognize them, when they come to heaven. No one would need a soul that does not remember anything. This means that a soul is a human being without a body. In other words, a soul is the information that is kept in a human mind - his memories, knowledge, skills, habits, conduct programs, emotions and feelings, ides and thoughts, and so on. If we learn how to move this information onto other carriers, we will be able to move a person's soul to other bubbles and to keep it there for an unrestricted period of time. As it is well known, information is virtual, i.e. it satisfies another human soul feature – a non-material quality. Man's new bubbles can be both artificial and biological. A soul (a complex of knowledge and information) can be rewritten into a clone of that same person. To put it otherwise, a person will live forever biologically as well, moving from old bubbles to new ones. It would be also possible to move a soul to artificial bodies, which possess all those qualities that we mentioned above. Furthermore, information (a soul) could be radiated in the form of electromagnetic waves. These waves can be spread in the universe at the light speed. They can travel around the universe for thousands of years, reaching its most distant parts. People see the star light that was radiated millions of years ago. This means that our immaterial soul can live in the universe in the form of electromagnetic radiation and then revive in millions of years.

Some of my readers wrote that an old brain can go corrupt and die, when moving a human soul from one body to another one. If it does not go corrupt, this inner self will die anyway, when an old biological bubble is not able to function normally anymore. Let us try to find out, what that inner self is. The majority of people identify their inner selves with their own bodies. I believe that the inner self is the information, which is kept in our mind. It is our soul. Every day we go to sleep. However, our brain does not stop working at night. Every time we wake up, we have our inner self changed. We "die" when we fall asleep and then "resurrect" when we wake up. This means that recording the information from a human brain will mean nothing but moving it to another bubble. Heaven on Earth.

A reporter from the newspaper "Argumenty i Fakty" ("Arguments and Facts") sent me the following letter:

> "Dear Mr. Bolonkin. Needless to mention that it is great to live forever. However, I have a question, which you can guess from a well-known Soviet joke. "A guy is going to join the communist party. A committee asks him: - Will you stop drinking? - Yes, I will. - Will you quit smoking? - Yes I will. - Will you stop loving other women? - Yes, I will. - Will you die for the Communist Party of the Soviet Union, if there is such a need? - Yes, I will. To hell with this life."

Here is my answer:

> "You do not need to worry that living in an electronic form will be dull and boring. It is vice versa, actually. When the information will be recorded onto other carriers, all human emotions, feelings and so on will also be carried over and preserved. In addition to that, the copies of certain emotions, pleasures, fears and so forth will be possible to record separately. After that, those separately recorded emotions and feelings can be given or sold to other people. Other e-men will have an opportunity to enjoy sex with a beauty queen, to experience the enjoyment of a sports victory, to take pleasure of power and the like. All modern art is based on artists' aspiration to transcend their emotions, to make other people feel, what characters feel. Those works of art, which make that happen best, are considered to be outstanding and great. Electronic people will get those emotions directly. To crown it all, it will be possible to intensify those emotions, as we intensify a singer's voice now. Electronic people will have a huge world of all kinds of pleasures; it will be possible to know, what a dictator or an animal feels. I think that an e-man's pleasure time will be limited legally, for the civilization's progress will stop otherwise. For the time being, the authorities prohibit drug addiction in order not to let the society degrade."

A soul's living in such a virtual world will have all pleasures imaginable. It will be like living in paradise, as all religions see it. Computer chips of our time possess the frequency of more than two billion hertz. However, a human brain reacts to a change of environment only in one-twentieth of a second. This means that one year of life on Earth is equal to 100 million years of a soul's living in the virtual world (paradise). Living in the virtual world will not be distinguishable from the real life. It will have a lot more advantages: you will have an opportunity to choose a palace to live in, you will have everything that you might wish for. Yet, living in hell also becomes real. There is a hope that the ability to keep souls alive will be achieved by highly-civilized countries first. In this case they will prohibit torturing sinners, as they prohibit torturing criminals nowadays. Furthermore, criminal investigations will be simplified a lot, judicial mistakes will be excluded. It will be possible to access a soul's consciousness and see every little detail of this or that action. Sooner or later religious teachings about soul, heaven and hell will become real. However, all that will be created by man.

The so-called end of the world will also have a chance to become real, though. The religious interpretation of this notion implies the end of existence for all biological people (moving all souls onto artificial carriers, either to heaven or to hell). However, in difference to religious predictions, this process is going to be gradual.

THE SUPREME MIND AND MANKIND'S EXISTENCE

I set forth an idea in my first publications that the goal of the mankind's existence is to create the Supreme Mind and to keep this Mind forever, no matter what might happen in the universe. The biological mankind is only a small step on the way to the creation of the Supreme Mind. The nature found a very good way to create the Supreme Mind: it decided to create a week and imperfect biological mind at first. It took the nature millions of years to do that. The twentieth century was a very remarkable period in the history of the humanity. There has been incredible progress achieved, like never before. The scientific and the technological level of the humanity became sufficient for the creation of the artificial intelligence. This will be the first level of the Supreme Mind, when the human mind will make a step towards immortality. At present moment we stand on the edge of this process. It is obvious that biological people will not be able to compete with e-men by the end of this period. Common people will not be able to learn the knowledge that electronic people will get. The new cyberworld will be the only way for a human mind to survive. Feeble and unstable biological elements in a mind carrier or in its bubble will reduce its abilities and capacities a lot. If a common person will be willing to become a cyberman, then this cyberman will be more willing to get rid of all biological elements in his system and become like everyone. For example, there are no people in our present society, who would agree to become a monkey again.

The Supreme Mind will eventually reach immense power. It will be able to move all over the universe, to control and use its laws. It will become God, if the notion of God implies something that knows and does everything. In other words, Man will become God. Yet, it does not mean that this will be the time, when the Supreme Mind will start dealing with human problems. For instance, ants and people have a common ancestor. A human being is God against ants. A man can destroy a huge city of ants (an anthill, in which hundreds of thousands of ants live) just with one kick. Ants will perceive this as an immense natural disaster, since they can see at the distance of only one centimeter. I do not know anyone, who would deal with charitable activities for ants. Everything that a man can do is to bring ants to a deserted island and give them an opportunity to reproduce themselves.

Figure 1. Robot in street.

ESSENTIAL STATE OF THINGS AND PERSPECTIVES

A lot of people will say that it is just a fantasy. This is a very convenient way to cast all that aside, until it starts happening. This is exactly what happened before the invention of a plane or a computer. It took 50 years to increase computer’s memory 100 million times. It would be possible to start working on the creation of the Supreme Mind, if there were a computer that would be capable of running a thousand billion of operations during only one second. In 1994 I said that such a super computer will be invented in the year 2000. I was wrong, for it appeared at the end of 1998. There is also a need of a self-developing program that would be capable of adjusting itself to constantly-changing circumstances. A human child does not develop and grow at once. A child has to study for about 20 years, to learn from his parents and friends, to have relations with nature and other people in order to gain more and more experience, to come to realization of his or her inner self. Unfortunately, the science of the artificial intelligence has chosen a wrong way of its development from the very start. Scientists tried to develop programs, which would react to certain external signals. In other words, people started working on robots that would cope with certain problems. A lot of efforts have been spent to discover the peculiarities of human speech, for instance. Some of those scientific works are absolutely no use for the electronic mind. It is easier for e-men to communicate with the help of their own electronic language, to recognize objects not by their images, but by way of measuring their speed, weight, composition and so on. All of that can be done at a distance. Biologists and physicists have spent decades for those useless works. They believe that one should study brain activities, find out the way it works and thinks. Then it would be time for modeling it with the help of a computer. This is a wrong way to go as well. A human brain is very complicated, it is very hard to study its activities. More importantly, even if we learn how it works, it would not mean that the method would be good for a computer. Here are some examples to prove it. Hundreds of years ago people were longing to learn how to fly. They saw that bird waved its wings for flying, so they tried to model such wings, to wave them, and to take off. However, people could fly up into the sky only when they developed still wings and propellers. A waving wing was absolutely not good for technology, the same way as a propeller is not good for the wild nature. In addition to that, planes with still wings fly a lot faster than birds. Another example: ancient people always wanted to run as fast as four-legged animals. Now everyone knows that no one uses machines that would move with the help of legs. Legs were changed with wheels – something that has never been used by the natural world.

In 1998 I suggested people should lay new principles as the foundation of artificial intelligence program. Those principles would be: to realize the goal of existence, to study the environment (everything that goes separately from the "inner self"), to model environment, to predict actions' results, to counteract with the environment in order to achieve temporal and global goals, to correct modeled environment, actions and their results according to the results of such counteraction. Unfortunately, I had to deal with the fact that everyone refused to realize and understand those principles. First of all, everyone believed that since the "virtual ego" does not have a human body, it would never have any rights. They said that it would be possible to control such an e-man completely and then to kill him (erase his soul from the computer memory). I wonder, what they would do, if they were offered to kill their relatives' souls that way? People link their body and soul together, and there is no way around that. They are ready to struggle for the rights of every living being, but they never want to accept the rights of a program or of a computer memory. Second of all, people want an artificial intelligence to give smart answers to their questions that can be rather stupid at times. They do not need smart answers from babies. They are always ready to stand all stupid things that children do for years. Instead, they try to teach them everything. Yet, they want a new artificial mind to give bright answers without any education. To crown it all, people want a computer to speak their human language, which is absolutely alien for a machine. Can you imagine that a person will have to answer the questions of an alien in Maya's language? Let's assume that a representative of an electronic civilization came to planet Earth in order to find out, if there are reasonable creatures living on it. This e-man suggested a common biological man to multiply 53758210967 by 146, then divide it by 50, deduct 968321 from it and calculate the hyperbolic sine. A computer would give the correct result of this sum in less than a second. A man would spend really a long time on that, making numerous mistakes. However, it would not be correct to say that a computer is smart and a man isn't.

Religious figures show a strong resistance to these ideas. It stands the reason that they all think that the creation of the Supreme Mind, immortality ideas are blasphemous. Unfortunately, the church has already blocked such decisions as human cloning, increasing the productivity of plants by means of changing their genes. It should be mentioned here that human cloning does not solve the questions of immortality. A clone is a copy of its biological bubble. A clone inherits the biological advantages of a bubble, for example, a singer's fine voice, an athlete's strength and the like. A clone will never inherit its' copy's soul. Therefore, human cloning is only an illusion of immortality. It can be a wonderful way to improve the biological bubble of a human being. Moving a human soul onto other carriers is a very complicated issue. People learned to see, which brain areas get activated, when a person remembers something, or tries to solve this or that question. We also learned to penetrate into certain neurons and record their impulses. To my mind, physiologists chose a wrong way here as well, when they tried to model brain activities. A human brain is an analogue of a huge state with a ten billion strong population. There is no use to ask each citizen of that country, what he or she is doing at the moment. One has to copy the database of this state, in order to copy its work. The easiest way to do so is to penetrate into informational channels of its supreme body (the "government"), on the inquiry of which the brain presents any information and allows to record its data on a disk, for instance. It is possible to do that, for the supreme brain area constantly extracts the necessary knowledge and programs according to our activities. So, we would need to send "intelligent officers" to the brain so that they could get a copy of this state or get connected to its major information channels.

Another way to do that is to record all incoming and outgoing information, which comes to/from a person, to record his or her emotions and reactions. An English-speaking reader, who reviewed one of my English articles once told me: "Your English is not perfect. You should find an English-speaking co-author. It is better to have a half of a pie than nothing at all."

HOPE

I do not doubt that the electronic civilization era, the era of the Supreme Mind and immortality will be achieved sooner or later. Those people, who have little in common with science, are drawn to believe that everything depends on scientists. They think that scientists can solve any problem, if they deal with it profoundly. As a matter of fact, everything depends on state and military officials. Sometimes, they know nothing of scientific perspectives and innovations. Scientists are like qualified workers. They need to get paid, they need to work with fine equipment. They will work only if they are get paid for it. Even if a scientist will have a wish to do something perspective during his free time, he will have no necessary equipment for that. Even such powerful companies as IBM, Boeing, Ford and others are interested only in the applied research, which does not require large investments. The major goal of such research is to give a maximum profit to this or that company. A fundamental research, the discoveries that are important for the whole humanity, not just for a company, might be of interest to a bright government. It goes without saying that a bright government is so hard to find. Every government is interested in the military power of its country. It is ready to fund defense technology works and military innovations. Von Braun convinced Hitler of real perspectives for missiles, WWII was followed with an arm race. This eventually led to space achievements and other kinds of technical progress of the humanity. The USA won the Moon race and stopped flying there 30 years ago. America keeps cutting its space research assignments every year. There are no serious assignments in the world for the invention of either the Supreme Mind or the artificial intelligence. Yet, they are most important and perspective problems of the humanity. The computers that we have at present are used for modeling nuclear weapons and sometimes, weather. Furthermore, the mankind does not spend much time thinking over the reason and goal of its existence. People spend a lot of their efforts and funds for solving local, temporal problems. Huge money and efforts are spent on conflicts and wars.

A certain hope has appeared recently. As experience shows, unmanned planes are a lot cheaper than piloted warplanes. More importantly, unmanned plane crashes do not cause harsh public reactions in civilized countries as pilots' or soldiers' deaths. The Americans design such planes successfully, but the planes are controlled by an operator within the USA. It has been proved that this remote control is not good for unmanned planes. The USA has missed Bin Laden and Omar in Afghanistan several times, two Iraqi pursuit planes downed an unmanned Predator in the Iraqi airspace. An unmanned plane can become something valuable indeed, if it has an artificial intelligence, if it is capable of recognizing and destroying targets itself. The Pentagon has assigned certain money for the research of this issue. It is a very hard goal to pursue (to create the mind of a pilot), but it is a very perspective one. In this case there would be no need to eliminate the young part of a country's population, if robots could conduct the warfare.

I suggested the hierarchical structure of an artificial intelligence, on the ground of which the real brain probably works. Let us imagine a state with a dictator at the head. A dictator would never be able to find efficient solutions for external and internal state problems. A dictator has ministries, which are then divided into divisions and departments. This forms a pyramid, in which all departments have their own databases, as well as the access to the common base. All divisions are busy with their particular problems, in accordance with the dictator's ideology. A dictator only sets problems up, while adequate divisions suggest solutions. For example, a man decides to cross a road with a heavy traffic. He looks at the road, while adequate parts of his brain automatically receive the information about the width of the road, the distance to nearest cars, their speed, and so on. The brain automatically makes adequate calculations, which eventually lead to the final decision: when it is safe to cross the road. All kinds of enlightenment in the solution of a problem are simply considered to be the "help from above." However, this is nothing, but the joint work of that pyramid. Human beings do not even know that such a pyramid exists. Pyramid's decisions are based on the knowledge of a certain individual. If an individual knows absolutely nothing about the quantum theory, he will never solve any of its problems. Therefore, an artificial intelligence of a high level cannot be realized with a personal computer that has only one chip and a successive work order.

My scheme stipulates the distribution of functions between parallel chips. The top one of them is offered to deal only with solution variants, their estimation and choice.

Every human being wants to extend his or her life. This can be seen from everyone's wish to have children, or to do something outstanding. It is simply enough to avoid danger sometimes. Even suicidal terrorists believe that they will go to heaven, when they kill themselves. The most important problem that the humanity has is the problem of immortality. Let us hope that it will be solved in the future.

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Chapter 4

BREAKTHROUGH TO IMMORTALITY

ABSTRACT

The author offers a new method for re-writing the human brain on electronic chips. This method allows for the modeling of a human soul in order to achieve immortality. This method does not damage the brain but works to extend and enhance it.

1. BRIEF DESCRIPTION OF PREVIOUS WORKS BY THE AUTHOR

In a series of earlier articles (see referenced list at the end) the author shows that the purpose of Nature is to create Super Intelligence (SI). With its ability to understand the Universe, advanced entities with SI Power will be able to survive major cataclysms. There is the Law of Increasing Complexity (in opposition to the Entropy Law – increasing chaos). This Law created biological intelligence (people). Human have since became a sovereign entity on the Earth and in Nature above all other creatures.

However, humans are just as mortal as any other biological creature. The human brain and body include albumen, molecules containing tens of thousands of atoms united by weak molecular connections. A change of only a few degrees in temperature results in death. The human biological brain and body require food, water, oxygen, dwelling, good temperature and environment in order to survive. These conditions are absent on most other planets. This makes it difficult for humans to explore Space or settle on other planets. Humanity losses valuable information (human experience) with old age and death, and humans invest considerable time and money toward raising and teaching children.

2. ELECTRONIC IMMORTALITY ADVANTAGES OF ELECTRONIC EXISTENCE

In earlier works the author has shown that the problem of immortality can be solved only by changing the biological human into an artificial form. Such an immortal person made of chips and super-solid material (the e-man, as was called in earlier articles) will have incredible advantages in comparison to conventional people. An E-man will need no food, no dwelling, no air, no sleep, no rest, and no ecologically pure environment. His brain will work from radio-isotopic batteries (which will work for decades) and muscles that will work on small nuclear engines. Such a being will be able to travel into space and walk on the sea floor with no aqualungs. He will change his face and figure. He will have super-human strength and communicate easily over long distances to gain vast amounts of knowledge in seconds (by re-writing his brain). His mental abilities and capacities will increase millions of times. It will be possible for such a person to travel huge distances at the speed of light. The information of one person like this could be transported to other planets with a laser beam and then placed in a new body.

Such people will not be awkward robots as in the movies. An artificial person will have the opportunity to choose his or her face, body and skin. It will also be possible for them to reproduce and then avoid any period of adolescence including the need for education. It will be impossible to destroy this entity with any kind of weapons, since it will be possible to copy the information of their minds and than keep such information backed up in separate distant locations. As was written in the science fiction book, "*The Price of Immortality"*, by Igor Getmansky (Moscow, Publish House ECSMO, 2003, Russian) an artificial person will have all of these super-human abilities.

3. What Are Men and Intelligent Beings?

All intelligent creatures have two main components: 1. *Information* about their environment, about their experience of interacting with nature, people, society (soul) and 2. *Capsule* (shell), where this information is located (biological brain, body). The capsule supports existence and stores information and programs for all of its operations. The capsule also allows the creature to acquire different sensory information (eyes, ear, nose, tongue and touch) and it moves to different locations in order to interact with the environment.

The main component of an intelligent being is information (soul). The experiences and knowledge accumulated in the soul allows the entity to interact more efficiently in nature in order to survive. If the being has more information and better operational programs (ability to find good solutions), then it is more likely thrive.

For an intelligent being to save its soul it must solve the problem of individual immortality. Currently man creates a soul for himself by acquiring knowledge from parents, educational systems, employment and life experiences. When he dies, most knowledge is lost except for a very small part which is left through works, children and apprentices. Billions of people have lived on Earth, however, we know comparatively little about ancient history. Only after the invention of written language did people have the capacity to easily save knowledge and pass it on to the next generation.

As discussed earlier, the biological storage (human brain) of our soul (information) is unreliable. The brain is difficult to maintain and requires food, lodging, clothes, a good environment and education, etc. To support the brain and body, humans spend about 99% of their time and energy, and eventually what knowledge is gained is taken to the grave in death.

There is only one solution to this problem – re-write all of the brain information (our soul) in more strongly based storage. We must also give the soul the possibility to acquire and manipulate information from the world. This means we must give sensors to the soul so it may have communication and contact with people and other intelligent beings. We must give the soul a mobile system (for example, legs), systems for working (hands), etc. thus giving the soul a new body in which to LIVE.

The reader may ask - these ideas seem interesting, but how does one we re-write a human soul to live within a new carrier, for example, in electronic chips?

4. The Main Problem with Electronic Immortality – Re-Writing Brain Information (Soul) to Electronic Chips Is That It's Impossible to Do This with Current Technology

At present scientists are working to solve this problem. They know that the brain has about 15 billion neurons, and every neuron has about ten connections to neighboring neurons. Neurons gain signals from neighboring neurons, produce signals and then send these signals to others neurons. As a result, humans are able to think and find solutions. On the bases of this way of thinking, humans can come to solutions without exact data. (Concepts of brain were described in my previous articles. For example, see "Locate God in Computer-Internet Networks" or "Science, Soul, Heaven and Supreme Mind". See also my articles on the Internet and references at end of this article.).

Scientists are learning how to take individual neurons on micro-electrodes and record their impulses. The ideas of scientists are very simple - study how single neurons and small neuronal network work and then model them by computer. They hypothesize that if we can model 15 billion neurons in a computer they will learn how the brain works, and then they will have Artificial Intelligence equaling the human brain.

In my previous work I show this as a dead-end direction for Human Immortality. It's true that we'll create an Artificial Intelligence (AI) that will be more powerful than the human mind. However, it will be HIS AI, and a NEW entity altogether. Our purpose is focused on preserving the CONCRETE PERSON now (more exactly – his SOUL) in a new body in order to achieve immortality.

Why is it impossible to directly write the information of the human brain onto a chip? Because the human brain is constantly changing and neurons permanently change their states. Imagine you want to record the state of a working computer chip. The chip has millions of logical elements which change their state millions of times per second. It is obvious that if you write in series (one after other) the current state of the chip (it is impossible to instantly write ALL states of the chip's elements). To instantly write all neurons one would need to insert a microelectrode into EVERY neuron, this would destroy the human brain before the writing was complete.

In the article "Science, Soul, Parade, and Supreme Mind" I offered another method for the solution of the Main Problem of Immortality.

5. MODELING OF SOUL FOR A CONCRETE PERSON

As said, straight re-writing of a human mind (human soul) to chips is very complex. Straight re-writing is not possible in the near future. All scientific works studying the work of human brains at the present time are useless for the main problem of immortality. They are also unworkable for the problem of artificial intelligence (AI) in the near term, because the brain solves problems by way of general estimations. AI solves problems based on more exact computation and logical data.

To solve the Main Problem of Immortality (MPI) the author offers a method of "MODELLING SOUL" of a concrete person. This method does *not require interventions into the brain* of a given person. This method may be applied IMMEDIATELY at the present time. But an accurate modeling is needed depending on the modeling period.

Before describing this method, let us analyze the human soul and what components are important for each person and his environment. All information in the human brain (soul) may be separated in two unequal groups: 1. the *Memory* (permanent knowledge) about the person's life (all that has been seen, heard, made, felt, people which he has met, his (her) behaviors, opinions, wishes, dreams, programs of activity, etc.), environment, and 2. *Methods* of processing this information, i.e. producing new solutions and new behaviors based on this knowledge.

The first part (knowledge) is very large. It fills most of the memory and remains relatively constant (you remember your life, history and you can only fill it by what was in the past). The second part (methods for deciding, producing solutions based in your knowledge) is relatively small and constantly changing because of new information, facts and life experiences.

However, the most important part of a human soul can be written without any problem now. Industry is producing cheap micro-video recorders as small as a penny, microphones at grain size, and micro-sensors for vital signs (breathing, palpitation, blood pressure, skin resistance, perspiration, movement of body parts, etc.). These measurements allow for easy recording of not only the physical state, but of his moral state (joy, pleasure, grief, trouble, anxiety, nervousness, etc). For example, lie detectors are able to define not only the state of a man, but also the truth of his words. Now we can measure and record brain commands and we can produce small cards with four gigabytes of memory.

It would be easy to attach a video recorder and microphone to a man's forehead and then attach sensors to the body and record all that he sees, hears, speaks, his feelings, reactions, and activity. And then re-write this information into a personal hard drive (long-term memory of high capacity storage) at the end of each day. As a result, there is a record of the most important part our soul – history of life, feelings, environment, behaviors and actions. This would be more detailed than what is captured by the real man, because the humans forget many facts, feelings, emotions, and personal interactions. The electronic memory would not forget anything in the past. It would not forget any person or what they were doing.

But what about the second smaller part of the human soul – producing solutions based on personal knowledge – perhaps asks the meticulous reader.

This could be restored by using past information from the real man in similar situations. Moreover, an electronic man could analyze more factors and data in order to throw-out and exclude actions and emotions that happened under bad conditions. The electronic man (named E-being in my previous works) would have a gigantic knowledge base and could in a matter of second (write to his brain) produce the right answer, much faster than his biological prototype. That means he would not have the need for the second smaller part of memory.

Considering the environment and friends, the following is an important part of a man's soul: his relationship with parents, children, family, kin, friends, known people, partners and enemies. This part of his soul will be preserved more completely than even his prototype. Temporary factors will not influence his relationship with his enemy and friends as would happen with his former prototype.

There is one problem which may be troubling for some: if we were to record every part of a person's life, how do we keep intimate moments a secret? There are (will be) ways to protect private information which could be adapted from current usage, for example, the use of a password (known only by you). Also there may be some moments you choose not to record information or decide to delete the information from memory.

The offered system may become an excellent tool for defense again lies and false accusations. You may give the password in one given moment of your life, which proves your alibi or absence from the accusations.

Some people want to have better memory. Video takes 95% of storage capacity, sound takes 4% and the rest takes 1%. In usual situations, video can record only separate pictures, sound only when it appears. This type of recording practice decreases the necessary memory by tens of times. But every 1.5-2 years chip storage capacity doubles. There are systems which will compress the information and then may select to record the most important information (as is done in the human brain). During your life, the possibility to record all information will be available for all people. This type of recording apparatus will be widely available and inexpensive. It's possible now. The most advanced video recorder or DVD writes more information than a CD.

Figure 1. Typical devises for writing of main information in human soil.

This solution (recording of human souls) is possible and must be solved quickly. By mass production (large productions) the apparatus will become inexpensive. The price will drop to about $300-1,000. If we work quickly we can begin recording and then more fully save our souls. The best solution is to begin recording in children when they become aware of “I”. But middle and older people should not delay. Unrecorded life periods may be restored by pictures, memories, notes, diaries and documents. Soul recovery will only be partial but it’s better than nothing.

These records will also be useful in your daily life. You can restore recorded parts of your life, images of people, relatives, and then analyze and examine your actions for improvement.

6. Disadvantages of Biological Men and Biological Society

People understand Darwin’s law, “survival of the fittest”. For a single person, this law is the struggle for his/her personal existence (life, well-being, satisfaction of requirements, pride, etc.). In a completely biological world built on Darwinian law the strongest survives and reaches his goal. Though they may be intelligent, humans are members of the animal world. They operate as any other animal in accordance with animal instincts of self-preservation. If one is poor, at first he struggles for food (currently half of world’s population is starving), dwelling, and better living conditions. When one reaches material well-being, he may struggle for money, job promotion, reputation, renown, power, attractive women (men), and so on. Most people consider their activities (include official work) in only one way - what will I receive from it? Only a small number of people are concerned with the idea of sacrificing themselves to the well-being (seldom giving up their life) of society at large.

As a result, we see human history as a continuation of wars, dictatorships, and repression of people by power. Dictators kill all dissidents and opponents. Most people try to discriminate against opponents and play dirty against their enemy. There are murders, rapes, violence, robbery, underhand actions, fraud, and lying at all levels of society especially in lesser developed countries. Each person only cares for himself and his family and does not care how his actions effect other people or society.

Democratic countries try to cultivate a more civilized society. They create laws, courts, and have police. Dictator regimes, on the other hand, make only the law they want. I could give thousands of examples to verify this concept. But hundreds of millions of people are killed by war, aggressive campaigns, repressions, genocides, and thousands of criminals in the everyday world are a good illustration of this.

The human brain allows us to reach great success in science and technology. However, as a biological heritage, struggling for his INDIVIDUAL existence in a bloody, dangerous world, humans spend much of their resources on mutual extermination of intelligent beings. Moreover, humans have created ever powerful weapons (for example, nuclear and hydrogen bombs), which could wipe out humanity. In time, existence may depend on the volition of one man – perhaps the dictator of a nuclear state.

The second significant drawback to the biological body – is that it spends 99.99% of its effort and resources simply to support existence. Such as food, lodgings, clothing, sex, entertainment, relaxation, environment, ecological compatibility. Only a very small part is uses for scientific development and new ideas and technology. The reader may see something wrong here.

States use a parentage of their revenue for research into science and technology. This percent is used NOT for NEW ideas, but is used to commercialize modern processes All research is included in the state budget under the name, "Science and New Technology". But much of this research has little relation to real new scientific progress. Even it the US, states spend only a small part of the assigned money on new science because state officers do not understand the research. People, organizations, and companies fight for a piece of the pie. Geniuses are rare and usually don't have the capacity to move forward because they must promote and pay for new ideas from their own empty packets.

Yet, science and technology has seen success. Most advancement (90%) was made recently in the 20th century, when governments started to finance a few scientific projects (compared with the millions of years of human existence). However, our current knowledge and new technologies are far from what we will eventually have. The first government of an industrialized country to understand and realize the leading role of new science and innovation will become powerful.

7. Electronic Society

The electronic society will be a society of clever electronic beings (or E-being, as they named in my articles). Most of the reasons and stimulus which incite men to crime, will be absent in E-beings. E-beings will not need food, shelter, sex, money, or ecology, which are the main factors in crime. E-people will not have intense infatuations or be distracted by behaviors, because they will have vast knowledge about the open electronic society. Their main work will be in science, innovations, and technologies. They will save their mental capacity for the production of chips and bodies, scientific devices, experimental equipments, space ships and space station, etc. They will need a number of robots, which do not need a big brain. It is likely they will award these robots better minds and memory. It is also likely that E-man will unite in a common distributed hyper-brain, which will become a sovereign of the Universe (God).

Nature is infinite and the development of a Super Brain (God) will not be limited. On the other hand, biological people will have limited mental capabilities. It will be difficult for them to image and predict the development and activity of Super beings, which we will generate.

Many, especially religious people, object because they say electronic beings will not have human senses such as love, sympathy, kindness, humanism, altruism, and the capacity to make mistakes, etc. E-beings are not people. Look back at human history. Human history shows that kindness played a very small role in human life. All human history is the history of human vices and human blood: struggle for power, authority, impact, money, riches, territory, and states. All human history is filled with fraud, underhanded actions, and trickery. Ordinary people were only playthings, flock of sheep for the tyrants and dictators.

Some people object that with an electronic face humans will loss the joy of sex, alcohol, narcotics, appreciation of art, beauty, nature, etc. My answer to this question is in my article "*Science, Soul, Heaven, and Supreme Mind*" (http://Bolonkin.narod.ru). The brief answer is that electronic humans will enjoy all this in a virtual world or virtual paradise. Time will run millions of times faster in the virtual World. E-man will spend a few seconds of real time and live millions of years in the paradise. He will enjoy any delight imaginable, include sex with any beautiful women (or handsome men), feel the emotions of any commander, leader, criminal, or even a dog.

8. LOT (FORTUNE) OF HUMANITY

Biological humanity will be gradually transformed to electronic beings. Old people, when their biological bodies can not support their brains, will continue their existing in electronic bodies after death. They will become young, handsome, robust, and. Fertility in biological men will decrease. Birth-rates are less than death-rates in many civilized countries now (for example in France). Population growth is mainly supported by emigration from lesser developed countries. When education levels increase, birth-rates will fall.

For a time, biological and electronic people will exist together. However the distance between their capabilities will increase very quickly. Electronic people will reproduce (multiple) by coping, learn instantly, and will not need food or dwellings. They will work full days in any condition such as in space or on the ocean floor. They will gain new knowledge in a short time. They will pass this knowledge on to others who do not have enough time. The distance between biological and artificial intellects will reach a wide margin so that biological people will not understand anything about new science as monkeys do not understand multiplication now even after much explanation.

Figure 2. "Actroid ReplieeQ1-expo" at Expo 2005 in Aichi, with co-creator Hiroshi Ishiguro (2000).

Source: http://world.honda.com/news/2005/c051213_8.html

Figure 2. ASIMO is a humanoid robot created by Honda. Standing at 130 centimeters and weighing 54 kilograms, the robot resembles a small astronaut wearing a backpack and can walk on two feet in a manner resembling human locomotion at up to 6 km/h. ASIMO was created at Honda's Research and Development Wako Fundamental Technical Research Center in Japan (2003).

It is obvious, clever people will see that there will be a huge difference between the mental abilities of biological and electronic entities. They will try to transfer into electronic form and the ratio between biological and electronic entity will quickly change in electronic favor. A small number of outliers will continue to live in their biological body in special enclaves. They will not have industrial power or higher education and will begin to degrade.

Naysayers may promote laws against transferring into an electronic man (as cloning is forbidden now in some states). However, who would renounce immortality for themselves, especially while they are young and healthy? One may denounce immorality as blasphemy, but when your (parents, wife, husband, children) die, especially if you are near death yourself, one comes to understand that life is extremely important. The possibility to live forever, to gain knowledge that improves life, will also allow one to become a sovereign force in the Universe.

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APPENDIX 1. SPACE RESEARCH: ORGANIZING FOR ECONOMICAL EFFICIENCY*

ABSTRACT

At present time the USA's Federal Government spends big money for an aviation/space RandD. How to best organize these activity, how to best estimate its utility and profit (real and potential), how to best increase efficiency, how to best estimate new ideas and innovations, how to properly fund RandD of new ideas and innovations, and how to correctly estimate their results - all these macro-problems are important for successful planning of aviation and space research, new launch and flight systems. Author considers these major problems and offers many innovations in organization, estimation, suggests new research efficiency criteria, development, new methods for assessments of new ideas, innovations in space industry, and new methods in patenting technology.

The author worked for many years within the USA's Federal Government entities (scientific laboratories of NASA, Air Force, industry), universities and private sector companies.

Keywords: *Organizing scientific research, planning of research, funding research, funding new ideas (concepts), funding inventions and innovations, estimating research cost, assessment of research results, research efficiency criteria, innovation in organizing of scientific RandD.*

1. INTRODUCTION

Since beginning of the Twentieth Century, science and technology have held the main role in human progress. Humanity created more new knowledge more than during many previous centuries. People researched aerodynamics, flight dynamics and the design of aircraft. Trained people developed rocket theory and traveled to outer space and the Moon. Organized research focused on nuclear physics began the exploration of nuclear energy and the creation of powerful computers, which help in further study of Nature. Astronomy's

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* In this Appendix it is used the report of Dr. A. Johnson accepted as paper AIAA-2006-7224 by Conference "Space-2006", 19-21 September 2006, San Jose, California, USA (permission by A. Johnson).

devices allow humans to see and study worlds located millions of the light years beyond Earth.

The power and influence any modern State in our World is defined by its science, technology, and industry. The USA is a World leader because, for many years the USA industry and national government spent more money than any other country to RandD science-based technical innovations. For example, the USA funds space research more the all other countries combined. In that way the main scientific advances in space, aviation, and computers are made in the USA.

If the people of the USA still want to continue to be the World leader, they must continue this practice and further refine this public and private policy. However, it is possible when the country has competitors and takes part in a competition struggle. The man on Moon became possible because the former USSR launched the first satellite (1957) and the USA leaders understood the USA had temporarily lost World leadership in important field of science and technology. Only in 1969, after the first manned flight to the Moon, did the USA return to undoubted leadership in space. That program ended in 1972. However, before collapse (1991) the USSR launched more satellites than all the rest of the World together, including the USA! The USA decided to restore this program only when China announced its program of manned Moon exploration.

The second very important side of scientific RandD is the efficient use of available funding. The financing of any project is limited everywhere, every time. Unlimited funding is inconceivable. The right organization of scientific funding and research is a very important element of scientific progress. That includes: organizing and selection of the most feasible prospective ideas and innovations for research, selection of a “can do” principal investigator - scientists who is the author or enthusiast of this idea, right estimation of the project cost, reached results and perspectives of applications.

All these problems are very complex for investigations. However, there are common criteria that help to solve these problems of selection and organization and save a lot of money and achieve practical success in short period of time.

The investigation of these macro-problems is impossible without consideration of current systems and uncovering (critics) its disadvantages. The author suggests new criteria and new forms of organizing science funding that were tested/applied in limited cases and which show a high efficiency. He also offers new criteria for estimation of science results which allows more evenly to estimate the honesty of finished scientific work reports by specialists and to separate pseudo-scientific or non-honest works.

For customers, leadership and management is also very important for correct estimation of the cost of an offered research, a capability of principal investigator, group, or organization to do this research. Unfortunately, the practice shows mistakes occur very often and they cost millions of dollars. The author suggests a set of simple rules that allow avoiding the big mistake and big slips in planning of research works.

The human element is very important in the selection and distribution of limited funding. In many organization we observe and comment on the situation when large government money distribution—money shifted from all taxpayers to just one man. As the result he begins to give money to his friends, to his colleagues or worse - to take bribe. He keeps elementary information about the activities of his organization secret. The author offers a method for selections making this practice difficult to initiate or continue, allowing avoidance of criminality.

2. Support of New Concepts

The monetary support of new aviation and space concepts is the basic component of technical progress. All useful things, which we see around us everyday, were developed from new concepts, ideas researched in past. What is the situation now? Consider the state of affairs now.

Science and technology are very complex and have very high level now. The production of new valid concepts and ideas, and the effort to fully substantiate them, can ONLY be done nowadays by highly educated people. The USA has hundreds of thousands of conventional scientists. New concepts and ideas generate only very talented people (genius). They are a few in a group of thousands of scientists. That requires from them very much time and hard work. That is not paid work in government or company laboratories. The Government and private laboratories develop ONLY known concepts and ideas because their purpose is to get maximum profit in shortest time; that means to produce and substantiate new ideas can only scientist into his own private time. There are a lot of scientists, but most of them do conventional researches of well-known ideas and small improvements them, all scientists earn money. All countries are funding science and research, but they do no usually fund new ideas or concepts. Rather, they assimilate known new technology, often developed in other countries. The funding for new concepts and ideas are zero in the World!!

In all countries the composers, writers, artists receive a royalty for performance of their musical compositions, books, works of Art. Why must scientists gift their hard work on new concepts, ideas, theories, and equations for computations? It is just if companies used their method of computation to pay a small ($1000) royalty for author.

3. Studies of Innovation

The development of new concept and idea can be presented in 4 stages (figure 1). Efficiency, *E*, is possible profit, *P*, divided by cost, *C,* of realization.

$$E = P/C. \tag{1}$$

The innovation development has 4 stages:

(1) The first stage is discovery of new concepts or idea. That stage includes an appearance of new idea and INITIAL RESEARCH of its possibilities and main conditions that are requisite for its practicability, initial proof of reality. A person can be only author of a new concept or idea if he/she made initial research and showed that this idea may become a future technical reality. A person who ONLY gave the idea (point 0 in fig.1) is NOT its author because it is easy to produce a lot of ideas that are beneath or beyond realization. For example, the fantast Jules Verne (1828-1905) penned his famous book about the first manned flight to the Moon using a huge cannon. Is he author of the idea for manned flight to Moon employing a big

gun? No. Even primitive research shows that a human cannot tolerate the acceleration that is caused by this method, where the vehicle is a cannonball.

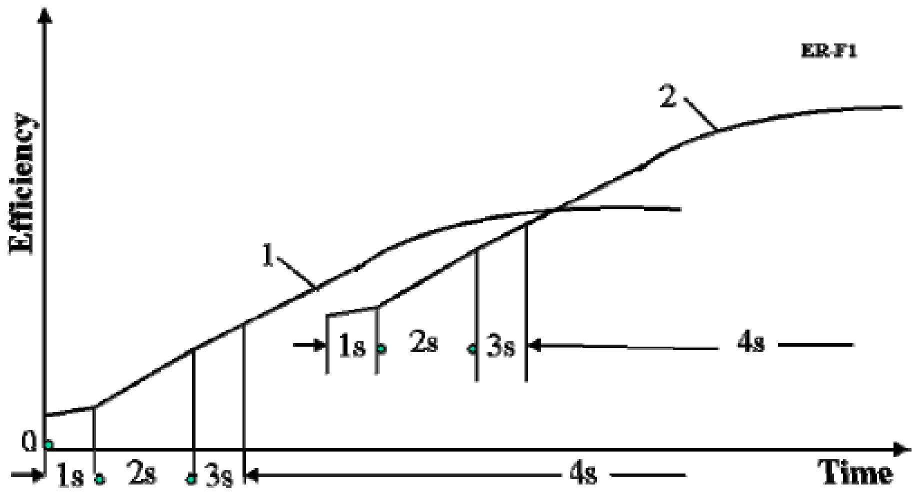

Figure 1. Four Stage innovation development.

The first stage is ONLY theoretical; strong individual and talented enthusiast in own time without any support because unknown concept or idea cannot be in government or company plan.

(2) The second stage started after publication or public announcement of the primary idea during a scientific conference. Other researchers join the investigation of the new idea and make more detailed researches. Most of this new idea research is theoretical, and only a small part may be experimental.
(3) The third stage includes the production of appropriate experimental examples.
(4) The fourth stage is actual production of marketable versions of the idea.

We show the development of one innovation (curve 1 in fig.1). However, any concept exhausts itself and its inherent efficiency possibilities over time. The new concept (idea) appears which promises even more efficiency (curve 2 in fig.1). Conventionally, in initial time that has less efficiency then old idea, but in future the innovation efficiency became significantly more than old idea.

For example, as people use an idea to connect a vehicle to horse. Later they invited a motor vehicle. Then they developed air vehicle. At present, humanity is developing space vehicles.

4. GOVERNMENT RELATION

Currently, the most important First Stage is the most difficult situation. No Federal or reliable private sector funding, no extraneous technical support of any kind. This work can do ONLY enthusiasts at one's own expense. Funding of the new perspective concept or idea is needed AFTER its initial theoretical research by a widely system of awards and prizes. For example, the Director of NIAC, Mr. Cassanova, made a sinecure for his friends from funding grants BEFORE theoretical research. Most NIAC works are pseudo-scientific researches (see below in section NIAC).

Recommendations:

There is only one solution of this macro-problem – the USA's Government must install the series (3 - 5) special national Government prizes (awards about $100K) in every important scientific field (space, energy, computer, biology, physics, etc.) for new concept scientific researches that are:

(1) Given ONLY for new concepts and ideas developed by author and published or presented in scientific conference or Internet (stage 1 in fig.1).
(2) The awards must be given ONLY to individuals.
(3) The competition must be OPEN, advertised widely in public notices. ALL pretenders and their work and proposals announced BEFORE any awards.
(4) The awarding Committee must be from independent well-known scientists in given field.

The same awards may be also in stage 2 (developing new concept or idea by non-author of this idea if the author of idea is awarded; or non-author make significant innovations which develop or solve problems important for progress this idea). In stage 3 the grants can be given ONLY for experiment or model.

5. NIAC (NASA Institute for Advanced Concepts)

The non-experienced reader objects - there exists NIAC (NASA Institute for Advanced Concepts) that must support new concepts and ideas in aerospace. The World press wrote—sometimes--that NIAC Director Mr. Cassanova made from this good idea the sinecure for his friends, protégés and useful people (http://NASA-NIAC.narod.ru).

Mr. Cassanova invented new method of aggravated theft of Government money: he awards his friends with millions of USA tax dollar just for promising to make a revolutionary discovery. In other places awards are given for well-known published scientific works in OPEN competition. It is impossible that Nobel Prize was given for promising to create epoch-making. But Mr. Cassanova awarded the theoretical works before they were ever presented to an established scientific society! As a result, the applicant received money before researching and present an empty and pseudo-scientific "research"!

Mr. Cassanova (NIAC) announced that every proposal is reviewed by 6 reviewers (3 internal + 3 external reviewers), but he refuses to identify or present these reviews. Why?

The explanations are very simple: NO review panels, NO peer reviewers, NO scientists who took part in the review process, NO voting, NO scientists who see the proposals! Everything is just fabricated fiction. There is only just Mr. Cassanova in NIAC who changes all reviewers, all scientists (in all scientific fields!), all panels, and all debates. Who distributes un-enumerated millions government (taxpayers) money to friends and insiders.

What kinds of proposals are awarded money supports by Mr. Cassanova? An important part of the answer to this question can be easily found by the reader at a website: *http://NASA-NIAC.narod.ru* and others.

Overview: The NIAC spent more 40 millions dollars in 8 years, but they did not really put forth any really new concepts or ideas! The most NIAC final "research" reports are idle talk (no scientific results, no pre-production models, no correct scientific report, the final reports content a lot of scientific mistakes, and so on). For example, the final reports don't have any scientific results: Space Elevator (award about 1 millions dollars), Bio Suite (awards about 1 millions dollars), Chameleon Suit (award about 1 millions dollars), Weather Control (awards about 1 millions dollars), Winglee M2P2 MagSail (award about 2 millions dollars), Cocoon vehicle (work contains only scientific mistakes), anti-matter sail (empty useless non-scientific 7 pages work), and so on (see Final Reports in http://NASA-NIAC.narod.ru).

Now the NIAC is just a private manger for "friends" and has spent 90% of government-issued taxpayers money not very effectively, and specifically in fraudulent and criminal ways (see http://NASA-NIAC.narod.ru).

For example, Mr. Robert Cassanova awarded four times millions of dollars to the following persons: *Howe S., Colozza A., Nock K., Cash W., Dubowsky S.* He also awarded three or four times millions of taxpayer contributions to these persons: *Hoffman R. Maise G., McCarmack E., Rice E., Slough J. Kammash N., Winglee R., Newman D.*

The Science Committee of the organization *"Citizens Against Government Waste" (CAGW)* awarded NIAC and Mr. Cassanova the "Pseudo-Nobel Prize-2005" for wasting millions of taxpayer dollars by pseudo-scientific works (GOTO: *http://www.geocities.com/auditing.science or http://auditing-science.narod.ru).*

Recommendations:

The President and Congress of the United States of America, needs to, and must, thoroughly investigate the NIAC situation and must punish, and remove, NASA and USRA leaders who allow, and create the abuse and corruption from, and by, NIAC. The Science Committee of CAGW stands ready to present to a Special Investigation Commission the documents that confirm the statements presented and outlined in this article.

In this saddening and costly national situation, it is the best decision, to stop the wasteful and ineffective financing of NIAC and pass their functions to Independent Committee created from well-known scientists, or NASA can create its own Committee from eminent volunteer scientists or to pass selected managerial functions to the National Science Academy, or National Science Foundation and to send awards only to finished scientific works in OPEN competition, or pass these vital functions to the growing and historically relevant and important International Space Agency Organization (http://www.international-space-agency.org or http://www.isa-hq.net) which would be better suited, and able, to stimulate, enable, and promote advanced space launch, propulsion, power, orbital, and planetary grant disbursements, RandD and implementation. This is based on an ever-increasing need for global cooperation, collaboration, common effort, and universal viewpoint. The International Space Agency's Directives, Charter, Purpose, Goals, and Certificate of Incorporation reflects this reality far better than the USRA or NIAC directives or charters. The many millions in Government-dispensed tax monies and private sector money and other relevant resources would be better used under the management and oversight of the International Space Agency Organization.

The CAGW Science Committee has available already an offer to NASA for a detailed plan on how to improve the work of NIAC, making it more open and its product more useful, and to change the dismal situation when one too-powerful and influential person, exemplified in the person of Mr. Cassanova personally distributes tens millions of taxpayer money with no safe guards or oversight.

This plan includes three conventional conditions:

(1) Independent selection Committee having widely-known E-mail address.
(2) Open competition with publication of all nominated scientific works on Internet, including assessments made by scientists before any funding awards.
(3) Awarding ONLY MADE scientific works not supported from other sources.

Discussing

The CAGW Science Committee considered, in detail, seven of about two hundred awards made by Mr. Cassanova (GOTO: http://www.geocities.com/auditing.science or http://auditing-science.narod.ru). Amazingly, 90% of the “final reports” are just idle talk giving the impression to readers that there are NO talented scientists in the USA! That means, obviously, that the system of funding and awarding of scientific works is wrong. Mr. Cassanova is a university system employee and he evidently tries strenuously to fund his friends and protégés within his system of work. However, universities take the funded money and do not pay them over to professors who receive their fixed salary. Often, a professor is overloaded by lectures, direct work with talented students and ordinary classroom examinations. Such a person does not have time or the possibility to make serious research that requires huge efforts and much time. That’s why he/she wrote the idle talk report, pseudo-scientific work!

The USA National Research Council (NRC) and ORAU (Oak Ridge Associated Universities) found the best solution of this problem – one send scientists to government research centers or laboratories and they works full time 1-2 years into it.

Conclusion

The best way is to withdraw this function and this money from NASA-NIAC-USRA, pass them to Special Government (or the National Academies, ISA) Committee includes famous scientists and to award the published works (researches) containing new concepts, ideas, inventions, and innovations. Make it in an open competition!

The Nobel Committee is not awarding the person who only promised to make notable research. Why does Mr. Cassanova give out millions of American taxpayer dollars to his friends without any control and government auditing? Any non-scientist can see that their “final reports” are idle talk, non-scientific works and do not cost the gigantic money which Mr. Cassanova gives his protégé.

The Scientific Committee of a famous organization, the CAGW (Citizen Against Government Waste), awarded NIAC and Mr. Cassanova Pseudo-Nobel Prize-2005, 2006 [1-2].

In 2007 the NASA closed the NIAC because NIAC spent more 50 millions of dollars but not presented any real new comcepts, ideas or innovations in 9 years.

6. NASA (National Aeronautic and Space Administration)

The NASA announced that it invites new concepts and ideas and publicizes the address where scientists can send their researches and proposals. I personally know excellent scientists who have sent more than twenty RandD proposals documents to this address:

NASA HEADQUARTERS, Unsolicited Proposal Coordinating Office Attn: Sandy Russo, proposal coordinator, Code 210.H Goddard Space Flight Center Greenbelt, MD 20771 Sandra.R.Russo@nasa.gov

Some of them included in their letters a US Postal Service green return receipt postal card. But some months they have not received not only reply from NASA but they cannot receive their postal card - confirmation about receiving research and proposal. That means - all NASA appeals about innovations are FICTION. NASA became a gigantic organization that spends huge taxpayer money and has the lowest scientific efficiency in the World.

Example #1: The former USSR spent money for Space in 3-5 times less then NASA and had a weak industry, but one was a leader of space research in 1957 - 1969 (before American flight to Moon) and one launched more satellites up to 1991 (when the USSR collapsed).

E*xample #2*: In 1998 one scientist proposed a means to send to Mars a probe containing hundreds cheap micro-balloons. Every balloon was to have a micro-camera, other devices and radio-translator connected to the planet orbiting main Mars satellite. The balloon can sustain flights for months and transmit detailed close-up Mars pictures. However, the NASA spent tens millions dollars in non-scientific project of small model of aircraft which can make only one non-controlled flight of a couple of miles. Why? The reason is simple and apparent - in 2003 it will be 100 years of Wright brother flight and for public propaganda needs NASA sought a quick propaganda "achievement". Result: NASA spent about 100 millions dollars but cannot send the model of aircraft.

Real scientists who have in the past and still today cooperate with NASA quietly note the low skill level of many NASA employees. I know very highly educated (two Ph.D.), experienced scientist (author more 100 scientific works and tens inventions, who applied in NASA open position of project manager. The personnel department informed him that he doesn't have a needed score for possible candidate. He applied in three open NASA positions of research engineers. The answers were same. He tried to get Government investigation of this case. Commission ascertained: the NASA took these positions the people having only B.D., did not have experience, published scientific works, patented inventions.

After collapse of the USSR, the NASA loss of an international rival transformed the NASA into a monster that wastefully consumed about $15 billions and produced very few scientific achievements, but a lot of space catastrophes. For example, since 1972, during a period of 34 years, the NASA has sent no manned flights to the Moon. Only now, following China's announced Program of Moon Exploration, the USA Government understood the USA gap and requests the NASA to reorganize its Program.

Recommendations:

(1) NASA must be separated into two independent, rival organizations. The funding of them must depend solely on their progress in Space.

(2) The leaders of programs and leader-scientists must be selected in OPEN competition on limit time (time of project). The open competition means that the data of applicators must be published on the Internet BEFORE selection of them by scientific Committee. Now everywhere in the USA (in state and government positions) the open competition of applicants is absolute fiction because of the public absence of data of any selected candidate (education, experience, number of publications and awarded patents).

(3) NASA must create the independent Scientific Committee for OPEN consideration the scientific works and proposals that are presented to NASA, awards for useful MADE researches and recommends perspective works for subsequent investigation. NASA can advance funding only research that use special equipment or make a model. NASA must install the NASA prizes for individual researchers who have openly offered new concepts and ideas.

7. DARPA (Defense Advanced Project Agency)

DARPA is special government organization for promotion and development of new concepts and ideas. I know scientists that sent their proposals to DARPA for consideration. They received an exceedingly strange answer: "Your proposal no in out plan!" How new (unknown anybody!) concepts or idea to be in DARPA plan? That is sent for consideration and including in plan! That means the DARPA is operating out its main purpose - careful consideration of serious proposals and their financial support. The plan makes not Science Committee from well-known scientists. That makes bureaucrats according with corporative interests who spent hundreds millions of dollars for projects which cost in hundreds times less.

Example. The DARPA decided to produce a micro-craft that allows the soldier to see what is behind a building, bushes, forest, etc. That is very important for saving the lives of soldiers in conditions of wartime and policemen during peacetime. The industry produced micro TV camera (volume is 1 cm^3, weight 3-5 g together with battery), radio control for small aircraft models (you have seen the children radio control cars).

How will experienced man do it? There are millions of hobby model aircraft constructors in the USA. They do not know high science. But they can produce many models and experimentally select from the best. Experienced officer announced a prize ($100 - 200K), after 6 months make a competition, selected and to get a product ready.

What do DARPA bureaucrats make? They go conventional way, enlisting the usual universities and the usual scientist-professors. DARPA spent many millions of dollars on research committed by professors and big-name universities. They received tons of equations and not a single flight model!

After the reckless waste of $100 millions the DARPA passed this project to Air Force Laboratories. They continue this wrong innovation method by spending even more millions of the American taxpayers money. I took part in summary reports of universities. What is typical situation? The university got a grant (about $100K). They present the report with equations, model made in Air Force Laboratory. They reported about 8 tests of this model (5 times is successful, 2 times is partially successful, and 1 time unsuccessful). I offered to go out from building and repeat test – to reveal what is behind a certain building. They would not agree. Why? Reason: all testing were not successful, model is not control and cannot do the needed function (recognizing).

Recommendations: Special Science Committee for consideration of proposals, open competition and publication of Abstracts of all proposals.

8. NSF (National Science Foundation) and Government Research Laboratories

All problems of DARPA have place in NSF and Government Research Laboratories. See Recommendation above.

9. SBIR - Small Business Innovation Research

All problems above are same for SBIR. The SBIR considers practically only proposals corresponding plan, topics of given department. Idea of SBIR is funding innovations of small business (group, individuals). But its small business is definition is an organization having 500 employees! That allows the universities and big companies separated their department and presented it as "small business". We have a similar situation with NIAC - employees have salary and not interested in given innovation, hard works.

Common note: Most universities, small business and proposed work project initiators are interested ONLY in getting money grants. They do not have need scientists (especially enthusiasts), needed experience in given field, needed equipments. In most cases, the grants are given on the quiet. It is essential to have coattails. As the result, the customer—the American taxpayer—receives empty works, pseudo-scientific research.

Example.

I want to give one example of relation of noted organizations to revolutionary innovations.

I personally know one Moscow, Russia university professor. He is a well-known specialist in structural strength, having many scientific works and books. He invented a new location of stringers on thin casing which increases a shell’s stability by 2 - 3 times (that means a decreasing weight of aircraft, missile, ships structure of about 20 - 30% - surely a revolution in aviation, rockets, ships). He TESTED his innovations in Moscow and received excellent results. He arrived in the USA and began to offer his innovation to NASA, DARPA, Air Force, Department of Defense, NAVY, commercial and military aviation companies. He did not ask immediately for a research grant, he merely asked only to test conventional structures and his stronger panels and make sure of his findings. He spent some years seeking such help. Everywhere, he doesn't receive answers, or received empty formatted replies, or answer - his innovation absents in plan.

That means: all noted bureaucratic organizations retard progress by the USA.

10. Publications

There are well-known organizations such as the American Institute of Aeronautics and Astronautics. One makes a big work, organizes aerospace conferences and publishes a series of aerospace journals. But it doesn't have support from government and NASA and it became a strictly commercial organization. For example, the cost of participation in AIAA conferences is very high. That means only employees of government and big organizations can take part in scientific forums. But they show only conventional RandD plans. The new revolutionary ideas and researches are made by talented individuals, enthusiasts in their free time. They can make a revolutionary research, but they do not have a lot of money (some thousands of dollars) for payment of trip, hotel and conference fee. Literally, the USA losses these revolutionary researches.

Editors of AIAA journals do not get salary for their arduous efforts. That means they want to see their name in every copy of journal, but they do not want to work as editor. They pass article to reviewer and pass review to author. That function can be done via computer. Some of them converted the journal in private edition for their friends and protégé. For example, all 20 revolutionary researches published in recent comprehensive book *"Non-Rocket Space Launch and Flight"*, Elsevier, London, 2006, offered for publication in AIAA *"Journal of Power and Propulsion" (JPP)*, but all were rejected by editor-in-chief Vigor Yang as researches are written non-American style and having poor English. What is "American style" he cannot explain, English the readers can see the book and decide: is it important reason in refusal in revolutionary innovations? For some last years the "JPP" have not published any revolutionary ideas, but published many articles having principle scientific mistakes. The same situation with AIAA "*Journal of Spacecraft and Rockets*" (Editor-in-Chief Vincent Zoby).

It is bad, that the USA has only single journal about power and propulsion system or spacecraft and American authors must publish new ideas and researches in abroad journals.

It is bad that commercial publishing houses do not want to publish scientific literature, because it is not profitable. As a result, the scientific literature (and text-books) are very expensive and prohibitive not only for students, but for scientists.

It is bad that no free scientific Internet library and AIAA requests about $1000 for every publication in journal and sells every scientific article for $10.

Recommendations:

(1) The USA must have minimum two rival journals in every scientific field. Every journal must have Appeal Commission where author can complain if he/she does not agree with editor clearly stated reasons for article rejection.
(2) Every National Conference must have small fund for supporting the individuals presented revolutionary research and give them possibility to address a meeting.
(3) Government and NASA must support with appropriate funding the points 1-2 above (scientific journal and scientific conferences), the AIAA (and all big old Scientific Societies), the scientific publishing houses, the free scientific Internet library.
(4) The AIAA (and all big old Scientific Societies) must free publish in Internet all manuscripts presented in AIAA Scientific Conferences.

The Government, country loss more on obstacles which exists for appearing and applications new ideas, the most of them produced by individual talented researchers.

11. PATENTING

The USA Constitution proclaims a support of science and patenting. Unfortunately, the USA PTO (Patent and Trademark Office) had become a powerful means to extract money from inventive people. The Payment for PTO equals some thousands dollars and prohibitive for individuals. The patenting approval process continues for at least 1-2 years. If the inventor complains, the PTO can sabotage all your inventions. I personally know of a case when an inventor paid for invention but PTO did not give a patent. The PTO creates a lot of Rules that permit the pumping of money from people and that allows the sabotaging of the patenting process.

Recommendations:

(1) Now the PTO has rates for big Companies and for small Business. It must be a special rate for individuals and FULL payment (application, patenting, and maintenance) must be not more $100 for them.
(2) It must be category "important patents for Department of Defense and the USA". If Special Committee recognized a patent application as necessary (important) for Department of Defense or the USA, the applicant has a right to a free patenting (he received only author certificate, the Government get all patent rights), all USA organizations or companies can use this patent but they must pay its author 1% and PTO 1% from cost of product used under this patent.
(3) All income received by PTO must be used for support of individual inventors.

12. FINAL RECOMMENDATIONS

Current system organization and funding of science researches is not efficiency especially for NIAC, NASA, DARPA, DoD, AF, SBIR, NSF, PTO. They need reorganization. Main components of reformation must be the following:

(1) The unwise and wasteful practice of advance funding of primary theoretical researches must be stopped and changed to OPEN competitions in any given field and in given topics. NASA must stop funding NIAC and must demand from USRA to return money held by Mr. Casanova’s group.
(2) Government must install 3-5 annual Government Prizes (about $100K) in every important field of science (space, aviation, computer, physics, biology, energy, etc.) for important THEORETICAL achievements made by individuals.
(3) The company used new method of computation must pay small ($1000) royalties to authors from every use.
(4) NASA must be divided into two independent rival organizations.
(5) The main method funding of research must be not funding Universities but it must be the work of University scientists done during 1-3 years as Fellow researchers in big Government laboratories.

(6) NASA, DARPA, Government laboratories must engage a head and main specialists of every project in OPEN concourses, preferably the authors of project (proposal) and scientists made main contributions in the project idea or concepts.
(7) The Government must support main scientific journals, publishing houses, free Internet scientific libraries; individual scientists presented an important researches to scientific national conferences.
(8) Government must make special small rate (<$100) for individual inventors, free patenting of important for DoD and the USA inventions and to use all PTO profit for support individual inventors important for DoD and the USA.

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2. GOTO: http://auditing-science.narod.ru or http://www.geocities.com/auditing.science.

APPENDIX 2

ABSTRACT

Here there are values useful for calculations and estimations of aerospace and technical projects.

1. SYSTEM OF MECHANICAL AND ELECTRICAL UNITS

The following table contains the delivered metric mechanical and the electromagnetic SI units that have been introduced in this text, expressed in terms of the fundamental units *meter*, *kilogram*, *second*, and *ampere*. From these expressions the *dimensions* of the physical quantities involved can be readily determined.

Length	1 meter = 1 m	Force	1 newton = 1 N = 1 kg·m/s^{2}
Mass	1 kilogram = 1 kg	Pressure	1 N/m2 = 1 kg/m·s^{2}
Time	1 second = 1 s	Energy	1 joule = 1 J =1 N/m = 1 kg·m^{2}/s^{2}
Electric current	1 ampere = 1 A	Power	1 watt = 1 W =1 J/s = 1 kg·m^{2}/s^{3}

Rotational inertia	1 kilogram·meter^{2} = 1 kg·m^{2}
Torque	1 meter·newton = 1 kg·m^{2}/s^{2}
Electric charge	1 coulomb = 1 C = 1 A·s
Electric intensity	1 N/C = 1 V/m = 1 kg·m/s^{3}·A
Electric potential	1 volt = 1 V = 1 J/C = 1 kg·m^{2}/s^{3}·A
Electric resistance	1 ohm =1 Ω =1 V/A = 1 kg·m^{2}/s^{3}·A^{2}
Capacitance	1 farad = 1 F =1 C/V = 1 C2/J = 1 s^{4}·A^{2}/kg·m^{2}
Inductance	1 henry = 1 H =1 J/A2 = 1 Ω·s = 1 kg·m^{2}/s^{2}·A^{2}
Magnetic flux	1 webwer = 1 Wb = 1 J/A = 1 V.s = 1 kg·m^{2}/s^{2}·A
Magnetic intensity	1 tesla = 1 Wb/m2 =1 V.s/m2 =1 kg/s^{2}·A
Reluctance	1 ampera-turn/weber = 1 A/Wb =1 s^{2}·A^{2}/kg·m^{2}
Magnetizing force	1 ampere-turn/meter = 1 A/m

Kelvin is fundamental unit of temperature
Candela is fundamental power-like unit of photometry

FUNDAMENTAL PHYSICAL CONSTANTS

Standard gravitational acceleration	9.806 65 m/s^2
Standard atmosphere (atm)	101 325 N/m^2
Thermochemical kilocalorie	4184 J
Speed of light in vacuum (c)	2.997 935×10^8 m/s
Electronic charge (e)	1.60210×10^{-19} C
Avogadro constant (N_A)	6.0225×10^{26}/kmol
Faraday constant (F)	9.6487×10^7 C/kmol
Universal gas constant (R)	8314 J/kmol
Gravitational constant (G)	6.67×10^{-11} N·m^2/kg^2
Boltzmann constant (k)	1.3895×10^{-23} J/K
Stefan-Boltzmann Constant (σ)	5.670×10^{-8} W/K^4·m^2
Rest energy of one atomic mass unit	931.48 MeV
Electron-volt (eV)	1.60210×10^{-19} J

Rest masses of particles

	(u)	(kg)	(MeV)
Electron	5.485 97×10^{-4}	9.1091×10^{-31}	0.511 006
Proton	1.002 2766	1.672 52×10^{-27}	938.26
α-particles	4.001 553	6.6441×10^{-27}	3727.3

Astronomical Data

Space body		Distance from sun (10^6 km) Mean	Aphelilion	Perithelion		Period of Revolution (d)		Mean radius (km)	Mass 10^{24} kg	Mean density Mg/m^3	Gravity on surf. m/s^2	Orbital speed km/s
Sun		--	--	--		--		696 000	--	1.41	274	--
Mercury	5	7.9	69.8	46.0	8	8.0	2	420	3.167	5.46	3.72	48.8
Venus		108.1	109.0	107.5		224.7		6 261	4.870	4.96	8.69	35.0
Earth		149.5	152.1	147.1		365.2		6 371	5.975	5.52	9.78	29.8
Mars		227.8	249.2	206.6		687.0		3 389	0..639	4.12	3.72	24.2
Jupiter		777.8	815.9	740.7		4 333		69 900	1900	1.33	23.01	13.0
Saturn		1426	1508	1348		10 760		57 500	568.8	0.71	9.14	9.65
Uranus		2868	3007	2737		30 690		23 700	86.9	1.56	9.67	6.78
Neptune		4494	4537	4459		60 100		21 500	102.9	2.47	15.0	5.42
Pluto		5908	7370	4450		90 740		2 900	5.37	5.50	8.0	4.75
Moon	0	.384 from Earth				27.322	1	737	0.0735	3.34	1.62	1.02

Density of gases at normal pressure and temperature 0 ^{o}C in kg/m^3

Air	1.293
Hydrogen	0.08988
Helium	0.1785

Parameters of Earth atmosphere (relative density and temperature)

H km	$/_o$	T °K	H km	$/_o$	T °K	H km	$/_o$	T °K	H km	$/_o$	T °K
0	0	288.2	5	0.601	255.6	20	0.0725	216.7	50	0.000375	274
1	0.908	281.6	7	0.482	242,6	25	0.0332	216.7	60	0.000271	253.4
2	0.822	275.1	10	0,338	223.1	30	0.0146	230.4	100	0.32×10^{-6}	208 .2
3	0.742	268.6	12	0.255	216.7	35	0.00676	244.0	200	0.295×10^{-9}	122 7
4	0.669	262.1	15	0.159	216.7	40	0.00327	257.7	300	0.273×10^{-10}	1358

Specific impulse of liquid fuel (nozzle 100:0.1, seconds):
Oxygen – kerosene 372
Oxygen – hydrogen 463

Specific impulse of solid fuel (nozzle 40:0.1, seconds): 228–341.

Heat of combustion (MJ/kg):

Benzene 44	Mazut 30–41	Natural gases 42–47	Firewood 30
Diesel fuel 43	Spirit 27.2	Hydrogen 120	Peat 8 –11
Kerosene 43	Bituminous coal 21–24	Acetylene 48	gunpowder 3

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