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Wireless Transfer of Electricity from Continent to Continent

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Abstract

Author offers collections from his previous research of the revolutionary new ideas: wireless transferring electric energy in long distance – from one continent to other continent through Earth ionosphere and storage the electric energy into ionosphere. Early he also offered the electronic tubes as the method of transportation of electricity into outer space and the electrostatic space 100 km towers for connection to Earth ionosphere.

Early it is offered connection to Earth ionosphere by 100 km solid or inflatable towers. There are difficult for current technology. In given work the research this connection by thin plastic tubes supported in atmosphere by electron gas and electrostatic force. Building this system is cheap and easy for current technology.

The computed project allows estimating the possibility of the suggested method.

Key words: 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. 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]-[15]), the new revolutionary ideas in transferring and storage energy are only in the works [1-6].

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 use of a new linear electrostatic engine suggested in [10] or Magnetic Space Launcher offered in [11]. However, the cheap cable space launch offered by author [12] requires use 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.

The idea of wireless transfer energy through ionosphere was offered and researched by author in [1 - 6]. For connection to Earth ionosphere offered the 100 km solid, inflatable, electrostatic or kinetic towers [7 - 9]. But it is expensive and difficult for current technology.

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 (Fig. 1). The concentration of electrons in this layer reaches 5×10^4 1/cm^3 in daytime and 3.1×10^3 1/cm^3 at night (Fig. 1). 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 (Fig. 2). The cheap optimal inflatable, kinetic, and solid space towers are offered and researched by author in [6-9]. 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.

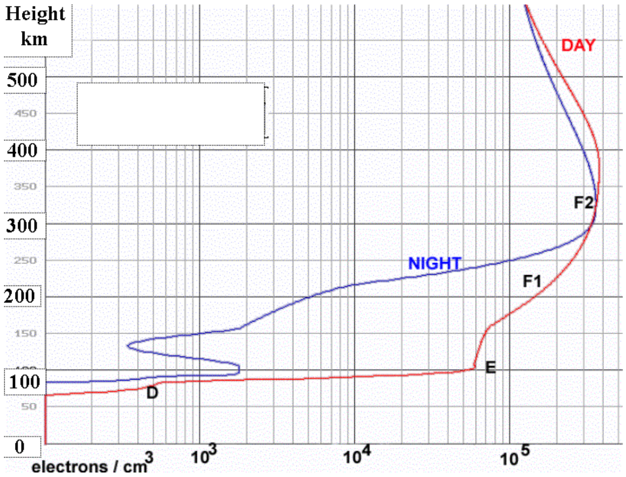

Fig.1. Consentration/cm^3 of electrons (= ions) in Earth's atmosphere in the day and night time in the D, E, F1, and F2 layers of ionosphere.

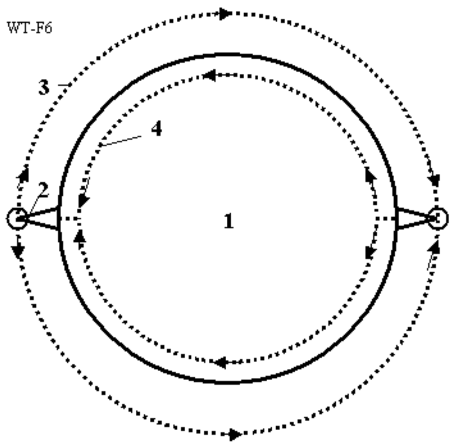

Fig.2. Using the ionosphere as conducting medium for transferring a huge electric energy between continents and as a large storage of the electric energy. Notations: 1 - Earth, 2 - space tower (or electron tube) about 100 km of height, 3 - conducting *E* layer of Earth's ionosphere, 4 - back connection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

However the solid 100 km space towers are very expensive. Main innovation in this work is connection to ionosphere by cheap film tube filled by electron gas.

Electronic tubes

The author's first innovations in electrostatic applications were developed in 1982-1983 [1]-[3]. Later the series articles of this topic were published in [4]-[15]. In particular, in the work [4-5] was developed theory of electronic gas and its application to building (without space flight!) inflatable electrostatic space tower up to the stationary orbit of Earth's satellite (GEO).

In given work this theory applied to special inflatable electronic tubes made from thin insulator film. It is shown the charged tube filled by electron gas is electrically neutral, that can has a high internal pressure of the electron gas.

The main property of AB electronic tube is a very low electric resistance because electrons have small friction on tube wall. (In conventional solid (metal) conductors, the electrons strike against the immobile ions located in the full volume of the conductor.). The abnormally low electric resistance was found along the lateral axis only in nanotubes (they have a tube structure!). In theory, metallic nanotubes can have an electric current density (along the axis) more than 1,000 times greater than metals such as silver and copper. Nanotubes have excellent heat conductivity along axis up 6000 W/m·K. Copper, by contrast, has only 385 W/m·K. The electronic tubes explain why there is this effect. Nanotubes have the tube structure and electrons can free move along axis (they have only a friction on a tube wall).

More over, the moving electrons produce the magnetic field. The author shows - this magnetic field presses against the electron gas. When this magnetic pressure equals the electrostatic pressure, the electron gas may not remain in contact with the tube walls and their friction losses. The electron tube effectively becomes a superconductor for any surrounding temperature, even higher than room temperature! Author derives conditions for it and shows how we can significantly decrease the electric resistance.

Description, Innovations, and Applications of Electronic tubes.

An electronic AB-Tube is a tube filled by electron gas (fig.3). Electron gas is the lightest gas known in nature, far lighter than hydrogen. Therefore, tubes filled with this gas have the maximum possible lift force in atmosphere (equal essentially to the lift force of vacuum). The applications of electron gas are based on one little-known fact – the electrons located within a cylindrical tube having a positively charged cover (envelope) are in neutral-charge conditions – the total attractive force of the positive envelope plus negative contents equals zero. That means the electrons do not adhere to positive charged tube cover. They will freely fly into an AB-Tube**.** It is known, if the Earth (or other planet) would have, despite the massive pressures there, an empty space in Earth's very core, any matter in this (hypothetical!) cavity would be in a state of weightlessness (free fall). All around, attractions balance, leaving no vector 'down'.

Analogously, that means the AB-Tube is a conductor of electricity. Under electric tension (voltage) the electrons will collectively move without internal friction, with no vector 'down' to the walls, where friction might lie. In contrast to movement of electrons into metal (where moving electrons impact against a motionless ion grate). In the AB-Tube we have only electron friction about the tube wall. This friction is significantly less than the friction electrons would experience against ionic structures—and therefore so is the electrical resistance.

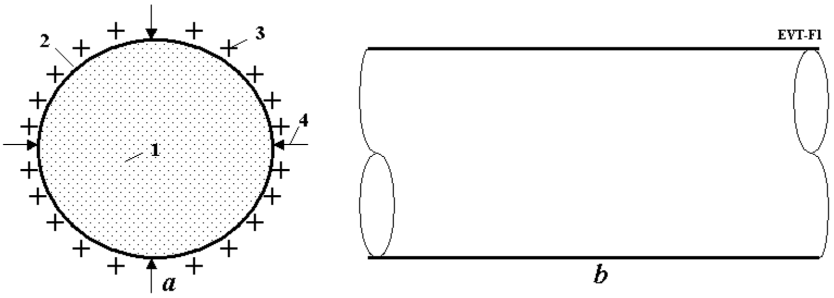

Fig.3. Electronic vacuum AB-Tube**. *a***) Cross-section of tube. ***b***) Side view. *Notation*: 1 – Internal part of tube filled by free electrons; 2 – insulator envelope of tube; 3 – positive charges on the outer surface of envelope (over this may be an additional film-insulator); 4 – atmospheric pressure.

When the density of electron gas equals $n = 1.65\times10^{16}/r$ $1/\mathrm{m}^3$ (where r is radius of tube, m), the electron gas has pressure equals atmospheric pressure 1 atm (see research below). In this case the tube cover may be a very thin—though well-sealed-- insulator film. The outer surface of this film is charged positively by static charges equal the electron charges and AB-Tube is thus an electrically neutral body.

Moreover, when electrons move into the AB-Tube, the electric current produces a magnetic field (fig.4). This magnetic field compresses the electron cord and decreases the contact (and friction, electric resistance) electrons to tube walls. In the theoretical section is received a simple relation between the electric current and linear tube charge when the magnetic pressure equals to electron gas pressure $i = c\tau$ (where i is electric current, A; $c = 3\times10^8$ m/s – is the light speed; τ is tube linear electric charge, C/m). In this case the electron friction equals zero and AB-Tube becomes **superconductive at any outer temperature**. Unfortunately, this condition requests the electron speed equals the light speed. It is, however, no problem to set the electron speed very close to light speed. That means we can make the electric conductivity of AB-Tubes very close to superconductivity almost regardless of the outer temperature.

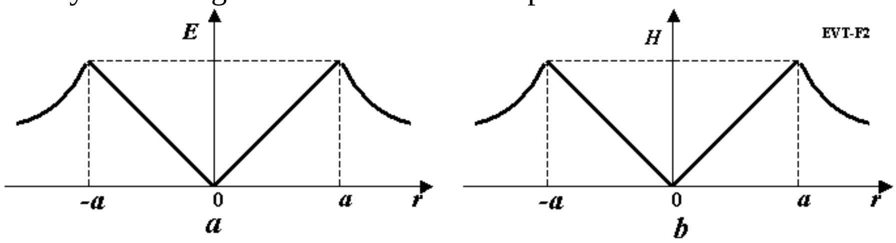

Fig. 4. Electrostatic and magnetic intensity into AB-Tube**.** ***a***) Electrostatic intensity (pressure) via tube radius. ***b***) Magnetic intensity (pressure) from electric current versus rube radius.

Theory of Plasma Transfer for Electric Energy, Estimations and Computations

Long Distance Wireless Transfer of Electricity on Earth.

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

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

The electric resistance and other values for a conductive medium can be estimated by the equations:

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

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

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

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

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 the time of electrons on their track, s; L is the length traversed by electrons on their track, m; v is the average electron velocity, in m/s; $r_m = 3.7\times10^{-10}$ (for hydrogen N_2) is diameter of 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

$$W = IU, \quad \eta = 1 - R_c / R, \qquad (3)$$

where R_c is common electric resistance of conductivity medium, Ω; R is total resistance of the electric system, Ω.
See the detailed computations in the Macro-Projects section.

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:

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

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

$$i = \frac{3\pi\lambda_a R_0^2}{H}U, \quad \lambda_a = n_a e\mu, \quad R_a = \frac{H}{4\pi\lambda_a R_0^2}, \quad t = CR_a, \tag{5}$$

where i leakage currency, A; λ_a is conductivity of Earth atmosphere, $(\Omega\cdot\text{m})^{-1}$, n_a is free electron density of atmosphere, 1/m^3; $\mu = 1.3\times10^{-4}$ (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.

Theory and Computation of Electronic Tube

Below the interested reader may find the evidence of main equations, estimations, and computations.

1. Relation between the linear electric charge of tube and electron gas pressure on tube surface:

$$p = \frac{\varepsilon_0 E^2}{2}, \quad E = k\frac{2\tau}{r}, \quad \varepsilon_0 = \frac{1}{4\pi k}, \quad \tau = \sqrt{\frac{2\pi r p}{k}}, \tag{6}$$

where p is electron pressure, N/m^2; $\varepsilon_0 = 8.85\times10^{-12}$ F/m –electrostatic constant; $k = 9\times10^9$ Nm^2/C^2 is electrostatic constant; E is electric intensity, V/m; τ is linear charges of tube, C/m; r is radius of tube, m.

Example, for atmospheric pressure $p = 10^5$ N/m^2 we receive $E = 1.5\times10^8$ V/m, N/C, the linear charge $\tau = 0.00833r$ C/m.

2. Density of electron (ion) in 1 m^3 in tube.

$$n = \frac{\tau}{\pi r^2 e} = \frac{1}{2\pi ek}\frac{E}{r} = 1.1\cdot10^8\frac{E}{r}, \quad M_e = m_e n, \quad M_i = \mu n_p n, \quad \mu = \frac{m_i}{m_p}, \tag{7}$$

where n is charge (electron or ion) density, 1/m^3; $e = 1.6\times10^{-19}$ C is charge of electron; $m_e = 9.11\times10^{-31}$ is mass of electron, kg; $m_p = 1.67\times10^{-27}$ is mass of proton, kg; M_e is mass density of electron, kg/m^3; M_i is mass density of ion, kg/m^3.

For electron pressure 1 atm the electron density (number particles in m^3) is $n = 1.65\times10^{16}/r$.

3. Electric resistance of AD-tube. We estimate the friction of electron about the tube wall by gas-kinetic theory

$$F_B = \eta_B SV, \quad \eta_B = \frac{1}{6}\rho V, \quad \rho = m_e n, \quad \overline{F} = \frac{F}{S} = \frac{1}{6}m_e nV^2, \quad V = \frac{j}{en} = \frac{i}{en\pi r^2}, \tag{8}$$

where F_B is electron friction , N; η_B is coefficient of friction; S is friction area, m^2; V is electron speed, m/s; ρ is density of electron gas, kg/m^3; $\overline{F}$ is relative electron friction, N/m^2 ; j is current density, A/m^2.

4. Electric loss. The electric loss (power) into tube is

$$P_T = \overline{F}_B SV, \quad S = 2\pi rL, \quad P_T = \frac{1}{3}\pi m_e nrLV^3,$$
$$P_T = \frac{m_e}{3e^3\pi^2}\frac{i^3L}{n^2r^5} = 7.5\cdot10^{24}\frac{i^3L}{n^2r^5} \quad [W], \qquad (9)$$

where P_T is electric loss, W; L is tube length, m; i is electric current, A.

5. Relative electric loss is

$$\overline{P}_T = \frac{P_T}{P}, \quad P = iU, \quad \overline{P}_T = \frac{m_e}{3\pi^2e^3}\frac{i^2}{n^2r^5}\frac{L}{U} = 7.5\cdot10^{24}\frac{i^2}{n^2r^5}\frac{L}{U} = 7.4\cdot10^{25}\frac{j^2}{n^2r}\frac{L}{U}, \quad (10)$$

Compare the relative loss the offered electric (tube) line and conventional electric long distance line. Assume the electric line have length L = 2000 km, electric voltage $U = 10^6$ V, electric current i = 300 A, atmospheric pressure into tube. For offered line having tube r = 1 m the relative loss equals $\overline{P}_T$ = 0.005. For conventional electric line having cross section copper wire 1 cm^2 the relative loss is $\overline{P}_T$ = 0.105. That is in 21 times more than the offered electric line. The computation of Equation (10) for atmospheric pressure and for ratio L/U = 1 are presented in fig. 5. As you see for electric line L = 1000 km, voltage U = 1 million V, tube radius r = 2.2 m, the electric current i = 50 A, the relative loss of electric power is one/millionth (10^{-6}), (only 50 W for transmitted power 50 millions watt!). For connection Earth's surface with ionosphere we need only 100 km electronic tube ir 100 km electrostatic tower [6].

Moreover, the offered electric line is cheaper by many times, may be levitated into the atmosphere at high altitude, does not need a mast and ground, doesn't require expensive copper, does not allow easy surface access to line tapping thieves who wish to steal the electric energy. And this levitating electric line may be suspended with equal ease over sea as over land.

6. Lift force of tube ($L_{F,1}$, kg/m) and mass of 1 m length of tube (W_1. kg/m) is

$$L_{F,1} = \rho v = \rho\pi r^2, \quad W_1 = 2\pi r^2\gamma\delta, \qquad (11)$$

where ρ is air density, at sea level ρ =1.225 kg/m^3; v is volume of 1 m of tube length, m^3; γ is density of tube envelope, for most plastic γ = 1500 ÷ 1800 kg/m^3; δ is film thickness, m.

Example. For r = 10 m and δ = 0.1 mm, the lift force is 384 kg/m and cover mass is 11.3 kg/m.

7. Artificial fiber and tube (cable) properties [16]-[19]**.** Cheap artificial fibers are currently being manufactured, which have tensile strengths of 3-5 times more than steel and densities 4-5 times less than steel. There are also experimental fibers (whiskers) that have tensile strengths 30-100 times more than steel and densities 2 to 5 times less than steel. For example, in the book [16] 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 ($\sigma = 7\cdot10^{10}$ N/m^2, γ = 3500 kg/m^3), than the ratio is $\gamma/\sigma = 0.1\times10^{-6}$ or $\sigma/\gamma = 10\times10^6$.

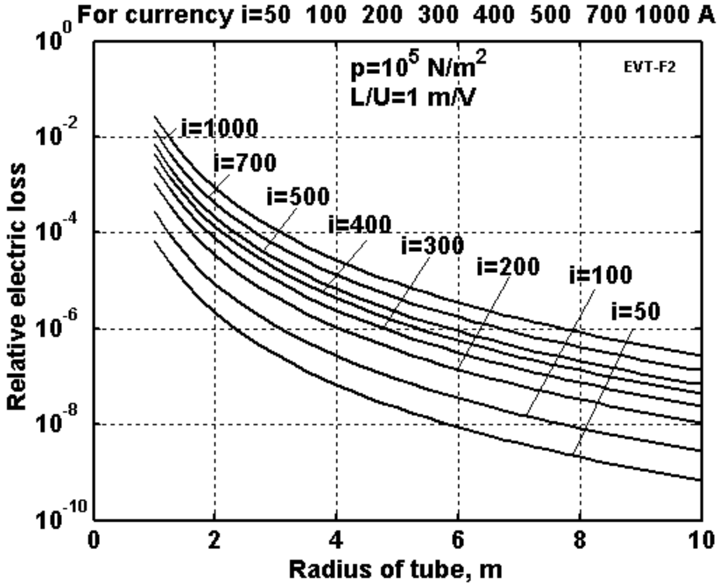

Fig. 5. Relative electric loss via radius of tube for electric **current** $i = 50 \div 1000$ A, the atmospheric pressure into tube and ratio $L/U = 1$.

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); 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 nanotube structure [18].

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). Tensile strength of MWNT's nanotubes reaches 150 GPa.

In 2000, a multi-walled carbon nanotube was tested to have a tensile strength of 63 GPa. Since carbon nanotubes have a low density for a solid of 1.3-1.4 g/cm^3, its specific strength of up to 48,000 kN·m/kg is the best of known materials, compared to high-carbon steel's 154 kN·m/kg.

The theory predicts the tensile stress of different types of nanotubes as: Armchair SWNT - 120 GPa, Zigzag SWNT – 94 GPa.

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 (in vacuum up 2800 ^{o}C. in air up 750^{o}C).

In theory, metallic nanotubes can have an electric current density (along axis) more than 1,000 times greater than metals such as silver and copper. Nanotubes have excellent heat conductivity along axis up 6000 W/m·K. Copper, by contrast, has only 385 W/m·K.

About 60 tons/year of nanotubes are produced now (2007). Price is about \$100 - 50,000/kg. Experts predict production of nanotubes on the order of 6000 tons/year and with a price of \$1 – 100/kg to 2012.

Commercial artificial fibers are cheap and widely used in tires and countless other applications. The authors have found only older information about textile fiber for inflatable structures (Harris J.T., Advanced Material and Assembly Methods for Inflatable Structures, AIAA, Paper No. 73-448, 1973). This refers to DuPont textile Fiber **B** and Fiber **PRD-49** for tire cord. They are 6 times strong as steel (psi is 400,000 or 312 kg/mm^2) with a specific gravity of only 1.5. Minimum available yarn size (denier) is 200, tensile module is 8.8×10^6 (**B**) and 20×10^6 (**PRD-49**), and ultimate elongation (percent) is 4 (**B**) and 1.9 (**PRD-49**). Some data are in Table 1.

Table 1. Material properties

Material	Tensile strength	Density g/cm^3	**Fibers**	Tensile strength	Density g/cm^3

Whiskers	kg/mm^2			kg/mm^2	
AlB_{12}	2650	2.6	QC-8805	620	1.95
B	2500	2.3	TM9	600	1.79
B_4C	2800	2.5	Allien 1	580	1.56
TiB_2	3370	4.5	Allien 2	300	0.97
SiC	1380-4140	3.22	Kevlar or Twaron	362	1.44
Material			Dynecta or Spectra	230-350	0.97
Steel prestressing strands	186	7.8	Vectran	283-334	0.97
Steel Piano wire	220-248		E-Glass	347	2.57
Steel A514	76	7.8	S-Glass	471	2.48
Aluminum alloy	45.5	2.7	Basalt fiber	484	2.7
Titanium alloy	90	4.51	Carbon fiber	565	1,75
Polypropylene	2-8	0.91	Carbon nanotubes	6200	1.34

Source: [16]-[19] and Howatsom A.N., Engineering Tables and Data, p.41.

Industrial fibers have up to σ = 500 - 600 kg/mm^2, γ = 1500 -1800 kg/m^3, and σ/γ = 2,78x10^6. But we are projecting use in the present projects the cheapest films and cables applicable (safety σ = 100 - 200 kg/mm^2).

8. Dielectric strength of insulator. As you see above, the tube needs film that separates the positive charges located in conductive layer from the electron gas located in the tube. This film must have a high dielectric strength. The current material can keep a high *E* (see table 2 is taken from [10]).

Table 2. Properties of various good insulators (recalculated in metric system)

Insulator	Resistivity Ohm-m	Dielectric strength, MV/m. E_i	Dielect-riccon-stant, ε
Lexan	10^{17}–10^{19}	320–640	3
Kapton H	10^{19}–10^{20}	120–320	3
Kel-F	10^{17}–10^{19}	80–240	2–3
Mylar	10^{15}–10^{16}	160–640	3
Parylene	10^{17}–10^{20}	240–400	2–3
Polyethylene	10^{18}–5×10^{18}	40–680*	2
Poly (tetra-fluoraethylene)	10^{15}–5×10^{19}	40–280**	2
Air (1 atm, 1 mm gap		4	1
Vacuum (1.3×10^{-3} Pa, 1 mm gap)		80–120	1

*For room temperature 500 – 700 MV/m.
** 400–500 MV/m.

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 the needed dielectric material, but it is necessary to find good (and strong) isolative materials and to research conditions which increase the dielectric strength.

9. Tube cover thickness. The thickness of the tube's cover may be found from Equation

$$\delta = \frac{rp}{\sigma}, \qquad (12)$$

where *p* is electron pressure minus atmospheric pressure, N/m^2. If electron pressure is little more then the atmospheric pressure the tube cover thickness may be very thin.

10. Mass of tube cover. The mass of tube cover is

$$M_1 = \delta\gamma, \quad M = 2\pi r L\gamma\delta, \quad , \tag{13}$$

where M_1 is 1 m^2 cover mass, kg/m^2; M is cover mass, kg.

11. The volume V and surface of tube s are

$$V = \pi r^2 L, \quad s = 2\pi r L, \tag{14}$$

where V is tube volume, m^3; s is tube surface, m^2.

12. Relation between tube volume charge and tube liner charge for neutral tube is

$$E_V = \frac{\rho r}{2\varepsilon_0}, \quad E_s = \frac{\tau}{2\pi\varepsilon_0 r}, \quad E_V = E_s, \quad \tau = \pi\rho r^2, \quad \rho = \frac{\tau}{\pi r^2}, \tag{15}$$

where ρ is tube volume charge, C/m^3; τ is tube linear charge, C/m.

13. General charge of tube. We got equation from

$$\tau = 2\pi\varepsilon\varepsilon_0 E r, \quad Q = \tau L, \quad Q = 2\pi\varepsilon\varepsilon_0 E r L, \tag{16}$$

where Q is total tube charge, C; ε is dielectric constant (see Table 2).

14. Charging energy. The charged energy is computed by equation

$$W = 0.5QU, \quad U = \delta E, \quad W = 0.5Q\delta E, \tag{17}$$

where W is charge energy, J; U is voltage, V.

15. Mass of electron gas. The mass of electron gas is

$$M_e = m_e N = m_e \frac{Q}{e}, \tag{18}$$

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.

16. Transfer of matter (Matter flow of ion gas). If we change the electron gas by the ion gas, our tube transfer charged matter with very high speed

$$M = M_i \pi r^2 V, \quad M_i = \mu m_p n,$$
$$V = \frac{i}{en\pi r^2}, \quad M = \frac{m_p}{e}\mu = 1.04\cdot10^{-8}\mu i \quad , \tag{19}$$

where M is the mass flow, kg/s; M_i is the gas ion density, kg/m^3; $\mu = m_i/m_p$; V is ions speed, m/s.

Example: We want to transfer to a remote location the nuclear breeder fuel – Uranium-238. (μ = 238) by line having i = 1000 A, r = 1 m, ion gas pressure 1 atm. One day contains 86400 seconds.

The equation (19) gives M = 214 kg/day, speed V = 120 km/s. The AB-tubes are suitable for transferring small amounts of a given matter. For transferring a large mass the diameter of tube and electric current must be larger.

We must also have efficient devices for ionization and utilization of the de-ionization (recombination) energy.

The offered method allows direct conversion of the ionization energy of the electron gas or ion gas to light (for example, by connection between the electron and ion gases).

17. Electron gas pressure. The electron gas pressure may be computed by equation (11). This computation is presented in fig. 6.

As you see the electron pressure reaches 1 atm for an electric intensity 150 MV/m and for negligibly small mass of the electron gas.

18. Power for support of charge. Leakage current (power) through the cover may be estimated by equation

$$I = \frac{U}{R}, \quad U = \delta E = \frac{r\varepsilon_0 E}{\sigma}, \quad R = \rho\frac{\delta}{s}, \quad I = \frac{sE}{\rho}, \quad W_l = IU = \frac{\delta s E^2}{\rho} \quad , \tag{20}$$

where I is electric **current**, A; U is voltage, V; R is electric resistance, Ohm; ρ is specific resistance, Ohm·m; s is tube surface area, m^2.

The estimation gives the support power has small value.

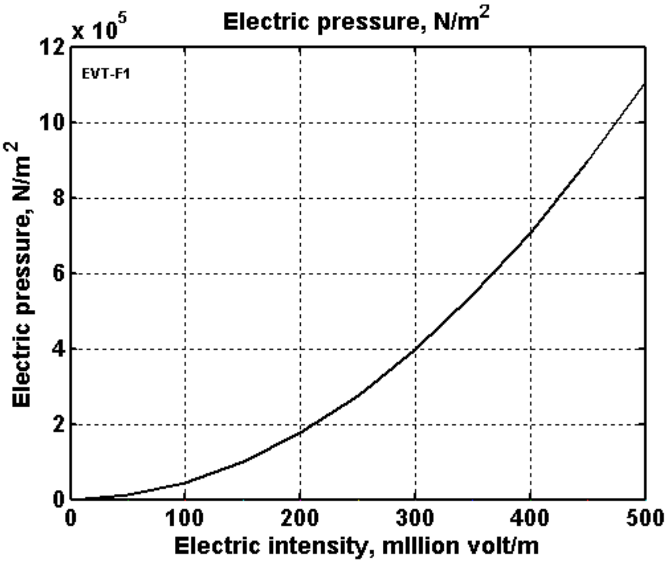

Fig. 6. Electron pressure versus electric intensity

Quasi-superconductivity of AB-Tube.

The proposed AB-Tube may become what we may term 'quasi-superconductive' when magnetic pressure equals electrostatic pressure. In this case electrons cannot contact with the tube wall, do not experience resistance friction and the AB-Tube thus experiences this 'quasi-superconductivity'.
Let us to get this condition:

$$P_e = \frac{\varepsilon_0 E^2}{2}, \quad P_m = \frac{B^2}{2\mu_0}, \quad P_e = P_m, \quad c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}, \quad E = cB \ , \qquad (21)$$

where P_e is electronic pressure, N/m^2; P_m is magnetic pressure, N/m^2; B is magnetic intensity, T; E is electric intensity, V/m; c is light speed, $c = 3\times10^8$ m/s; ε_0, $\mu_0 = 4\pi\times10^{-7}$ are electrostatic and magnetic constants. The relation $E = cB$ is important result and condition of tube superconductivity. For electron pressure into tube 1 atm, the $E = 1.5\times10^8$ V/m (see above) and B = 0.5 T.

From Eq. (21) we receive the relation between the electric current and the tube charge for AB-Tube 'quasi-superconductivity' as

$$E = cB, \quad E = \frac{1}{2\pi\varepsilon_0}\frac{\tau}{r}, \quad B = \frac{\mu_0 i}{2\pi r}, \quad i = c\tau \quad , \qquad (22)$$

where i is electric current, A; τ is liner charge of tube, C/m.

For electron pressure equals 1 atm and r = 1m the linear tube charge is τ = 0.00833 C/m (see above) and the request electric current is $i = 2.5\times10^6$ A (j = 0.8 A/m^2). For r = 0.1 m the current equals $i = 2.5\times10^5$ A. And for r = 0.01 m the current equals $i = 2.5\times10^4$ A.

Unfortunately, the requested electron speed (for true and full normal temperature 'superconductivity') equals light speed c.

$$V = \frac{j}{en} = \frac{i}{en\pi r^2} = \frac{c\tau}{en\pi r^2} = \frac{c\tau}{\tau} = c \ , \qquad (23)$$

That means we cannot exactly reach it, but we can came very close and we can have very low electric resistance of AB-Tube.

Information about high speed of electron and ion beam. Here $\gamma = (1-\beta^2)^{-1/2}$ is the relativistic scaling factor, $\beta = v/c$, v is relative system speed; quantities in analytic formulas are expressed in SI or cgs units, as indicated; in numerical formulas I is in amperes (A), B is in gauss (G, 1 T = 10^4 G), electron linear density N is in cm^{-1}, temperature, voltage, and energy are in MeV, $\beta_z = v_z/c$, and k is Boltzmann's constant.

If the system is moved only along axis x, the Lorentz transformation are (" ' " is marked mobile system):

$$t' = \gamma\left(t - \frac{vx}{c^2}\right), \quad x' = \gamma(x - vt), \quad y' = y, \quad z' = z,$$
$$w' = \frac{w - v}{1 - wv/c^2}, \quad M = \gamma m, \quad \vec{p} = M\vec{v}, \quad \vec{f} = \frac{d\vec{p}}{dt}, \tag{24}$$

where t is time, s; w is speed into systems, m/s, v is system speed, m/s, M is relativistic mass, kg; p is momentum, f is force, N.

For computation electrostatic and magnetic fields about light speed are useful the equations of relativistic theory (Lorenz's Equations, In the immobile system (market "$_1$")) the electric field is directed along axis y, the magnetic field is directed along axis z)):

$$E_x = E_{1x}, \qquad H_x = H_{1x},$$
$$\sqrt{1-\beta^2}E_y = E_{1y} - vB_{1z}, \quad \sqrt{1-\beta^2}H_y = H_{1y} + vD_{1z}, \tag{25}$$
$$\sqrt{1-\beta^2}E_z = E_{1z} + vB_{1y}, \quad \sqrt{1-\beta^2}H_z = H_{1z} - vD_{1y},$$

where lower index "$_1$" means the immobile system coordinate, E is electric intensity, V/m; H is magnetic intensity, A/m; v is speed of mobile system coordinate along axis x, m/s; D is electric displacement. C/m^2; $\beta = v/c$ is relative speed one system about the other.

Relativistic electron gyroradius [22]:

$$r_e = \frac{mc^2}{eB}(\gamma^2 - 1)^{1/2} \ (\text{cgs}) = 1.70\cdot 10^3(\gamma^2-1)^{1/2}B^{-1} \quad \text{cm}. \tag{26}$$

Relativistic electron energy:

$$W = mc^2\gamma = 0.511\gamma \quad \text{MeV}. \tag{27}$$

Bennett pinch condition:

$$I^2 = 2Nk(T_e + T_i)c^2 \ (cgs) = 3.20\cdot 10^{-4}N(T_e + T_i) \quad \text{A}^2. \tag{28}$$

Alfven-Lawson limit:

$$I_A = (mc^3/e)\beta_z\gamma \quad (cgs) = (4\pi mc/\mu_0 e)\beta_z\gamma \quad (SI) = 1.70\cdot 10^4\beta_z\gamma \quad \text{A}. \tag{29}$$

The ratio of net current to I_A is

$$\frac{I}{I_A} = \frac{\nu}{\gamma}. \tag{30}$$

Here $\nu = Nr_e$ is the Budker number, where $r_e = e^2/mc^2 = 2.82\cdot 10^{-13}$ cm is the classical electron radius. Beam electron number density is

$$n_b = 2.08\cdot 10^8 J\beta^{-1} \quad \text{cm}^{-3}, \tag{31}$$

where J is the current density in A cm^{-2}. For a uniform beam of radius a (in cm):

$$n_b = 6.63\cdot 10^7 Ia^{-2}\beta^{-1} \quad \text{cm}^{-3} \tag{32}$$

and

$$\frac{2r_e}{a} = \frac{\nu}{\gamma}, \tag{33}$$

Child's law: nonrelativistic space-charge-limited current density between parallel plates with voltage drop V (in MV) and separation d (in cm) is

$$J = 2.34\cdot 10^3 V^{3/2}d^{-2} \quad \text{A cm}^{-2} \tag{34}$$

The condition for a longitudinal magnetic field B_z to suppress filamentation in a beam of current density J (in A cm^{-2}) is

$$B_z > 47\beta_z(\gamma J)^{1/2} \quad \text{G}. \tag{35}$$

Kinetic energy necessary to accelerate a particle is

$$K = (\gamma - 1)mc^2. \tag{36}$$

The de Broglie wavelength of particle is $\lambda = h/p$, where $h = 6.6262\times 10^{-34}$ J·s is Planck constant, p is particle momentum. Classical radius of electron is 2.8179×10^{-15} m.

Macroprojects

Wireless transferring energy between Earth's continents (Fig. 2). 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 (1)-(2) and (15)-(17) [4] gives: 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%. That is power 1000 powerful electric plants, having power one billion watts. 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.

Earth's ionosphere as the storage electric energy. It is using the equations (18)-(19) [4]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. About 20 of 100 tons rocket may be launched to space in 100 km orbit. This energy are produced a powerful electric plant in one day.

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.

The electric resistance of electronic tube is small.

Discussing

The offered ideas and innovations may create a jump in space and energy industries. Author has made initial base researches that conclusively show the big industrial possibilities offered by the methods and installations proposed.

The offered inflatable electrostatic AB tube has indisputably remarkable operational advantages in comparison with the conventional electric lines. AB-tube may be also used for transfer electricity in long distance without using ionosphere.

The main innovations and applications of AB-Tubes are:

1. Transferring electric energy in a long distance (up 10,000 km) with a small electric loss.
2. ‘Quasi-superconductivity’. The offered AB-Tube may have a very low electric resistance for any temperature because the electrons in the tube do not have ions and do not lose energy by 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.
3. Cheap electric lines suspended in high altitude (because the AB-Tube can have lift force in atmosphere and do not need ground mounted electric masts and other support structures)
4. The big diameter AB-Tubes (including the electric lines for internal power can be used as tramway for transportation .
5. AB-Tube s can be used as vacuum tubes for an exit from the Earth’s surface to outer space (out from Earth’s atmosphere). That may be used by an Earth telescope for observation of sky

without atmosphere hindrances, or sending of a plasma beam to space ships without atmosphere hindrances [12-14].

6. Transfer of electric energy from continent to continent through the Earth's ionosphere [4-5].
7. Inserting an anti-gravitator cable into a vacuum-enclosing AB-Tube for near-complete elimination of air friction [4-5]. Same application for transmission of mechanical energy for long distances with minimum friction and losses. [4-5].
8. Increasing in some times the range of a conventional gun. They can shoot through the vacuum tube (up 4-6 km) and projectile will fly in the rare atmosphere where air drag is small.
9. Transfer of matter a long distance with high speed (including in outer space, see other of author's works).
10. Interesting uses in nuclear and high energy physics engineering (inventions).

The offered electronic gas may be used as filling gas for air balloons, dirigibles, energy storage, submarines, electricity-charge devices (see also [4]-[15]).

Further research and testing are necessary. As that is in science, the obstacles can slow, even stop, applications of these revolutionary innovations.

Summary

This new revolutionary idea - wireless transferring of electric energy in long distance through the ionosphere or by the electronic tubes 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 many thousands of kilometers by this method. The requisite mass of plasma cable is merely hundreds of grams. It is computed that the macroproject: 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 [1]-[21].

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