Review of new ideas, innovations of non-rocket propulsion systems for Space Launch and Flight

(Part 3)

by Alexander Bolonkin

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Review of new ideas, innovations of non-rocket propulsion systems for Space Launch and Flight (Part 3)

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Abstract

In the past years the author and other scientists have published a series of new methods which promise to revolutionize the space technology. These include the Space Elevator, Men without the space suite into space, Artificial gravity, New method of atmospheric re-entry for space ship, Inflatable Dome for Moon, Mars, asteroids, Closed loop water cycle, Climber for Space Elevator, Cheap Protection from Nuclear Warhead, Wireless transfer of electricity throw outer Space, Artificial explosion of Sun, etc.

Some of them have the potential to decrease the space research costs in thousands of time, other allow decreasing the cost of the space exploration.

The author reviews and summarizes some revolutionary ideas, innovations and patent applications for scientists, engineers, inventors, students and the public.

Key words: Space Elevator, Men without the space suite into space, Artificial gravity, New method of atmospheric re-entry, Inflatable Dome for space, Closed loop water cycle, Climber for Space Elevator, Cheap protection from Nuclear Warhead, Wireless transfer of electricity throw outer Space, Artificial explosion of Sun.

Introduction

Space technology is technology that is related to entering, and retrieving objects or life forms from space.

"Every day" technologies such as weather forecasting, remote sensing, GPS systems, satellite television, and some long distance communications systems critically rely on space infrastructure. Of sciences astronomy and Earth sciences (via remote sensing) most notably benefit from space technology.

Computers and telemetry were once leading edge technologies that might have been considered "space technology" because of their criticality to boosters and spacecraft. They existed prior to the Space Race of the Cold War (between the USSR and the USA.) but their development was vastly accelerated to meet the needs of the two major superpowers' space programs. While still used today in spacecraft and missiles, the more prosaic applications such as remote monitoring (via telemetry) of patients, water plants, highway conditions, etc. and the widespread use of computers far surpasses their space applications in quantity and variety of application.

Space is such an alien environment that attempting to work in it requires new techniques and knowledge. New technologies originating with or accelerated by space-related endeavors are often subsequently exploited in other economic activities. This has been widely pointed to as beneficial by space advocates and enthusiasts favoring the investment of public funds in space activities and programs. Political opponent[1] counter that it would be far cheaper to develop specific technologies directly if they are beneficial and scoff at this justification for public expenditures on space-related research.

After World War 2 the space technology have received the great progress and achieved a great success. But space technology are very expensive and have limited possibilities. In the beginning 21th century the researches of some revolutionary space technology started [1]-[22]. These new technology which promise to decrease the cost of a space exploration in hundreds times. Some of them are described in this review.

Current status of new space technology and systems. Over recent years interference-fit joining technology including the application of space methods has become important in the achievement of space propulsion system. Part results in the area of non-rocket space launch and flight methods have been patented recently or are patenting now.

Professor Bolonkin made a significant contribution to the study of the new revolutionary space technology in recent years [1]-[22] (1982-2011). Some of them are presented in given review.

Space Elevator, Transport System for Space Elevator is researched in [1] Ch.1; Men without the space suite into space is described in [1] Ch.19; Electrostatic levitation and Artificial gravity is investigated in [1] Ch.15; New method of atmospheric re-entry of space ship was studied in [2] Ch.8; Inflatable Dome for Moon, Mars, satellites, and space hotel is described [3] Ch2; AB method irrigation for planet without water (Closed loop water cycle) is studied in [3] Ch.1; Artificial explosion of the Sun was researched in [4] Ch.10.

Some of these systems were developed in [5]-[23].

Many useful ideas and innovations for space technologies in given field were presented in patent and patent application section of References. In particularly, there are:

Significant scientific, interplanetary and industrial use did not occur until the 20th century, when rocketry was the enabling technology of the Space Age, including setting foot on the Moon.

But rockets are very expensive and have limited possibilities. In the beginning 21th century the researches of new space technologies started []-[22].Some of them are described in this review.

Main types of Non-Rocket Space Propulsion System

Contents:

1. Space Elevator, Transport System for Space Elevator
2. Men without the space suite into space,
3. Electrostatic levitation and Artificial gravity,
4. New method of atmospheric re-entry of space ship,
5. Inflatable Dome for Moon, Mars, satellites, and space hotel
6. Ab method irrigation for planet without water. (Closed loop water cycle),
7. Artificial explosion of the Sun.

1. Space Elevator, Transport System for Space Elevator*

The reseach brings together research on the space elevator and a new transportation system for it. This transportation system uses mechanical energy transfer and requires only minimal energy so that it provides a “Free Trip” into space. It uses the rotary energy of planets. The research contains the theory and results of computations for the following projects: 1. Transport System for Space Elevator.

The low cost project will accommodate 100,000 tourists annually. 2. Delivery System for Free Round Trip to Mars (for 2000 people annually). 3 Free Trips to the Moon (for 10,000 tourists annually).
The projects use artificial material like nanotubes and whiskers that have a ratio of strength to density equal to 4 million meters. At present scientific laboratories receive nanotubes that have this ratio equal to 20 million meters.

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* That part of the chapter was presented by author as paper IAC-02-V.P.07 at the World Space Congress-2002, Oct.10-19, Houston, TX, USA and published in *JBIS*, vol. 56, No. 7/8, 2003, pp. 231–249. See also Bolonkin A.A., (2005)"Non-Rocket Space Launch and Flight", Elsevier, 2005, Ch.1, http://www.archive.org/details/Non-rocketSpaceLaunchAndFlight, http://www.scribd.com/doc/24056182

Free trip to Space (Project 1)

Description

A proposed centrifugal space launcher with a cable transport system is shown in Fig.1-1. The system includes an equalizer (balance mass) located in geosynchronous orbit, an engine located on Earth, and the cable transport system having three cables: a main (central) cable of equal stress, and two transport cables, which include a set of mobile cable chains connected sequentially one to an other by the rollers. One end of this set is connected to the equalizer, the other end is connected to the planet. Such a separation is necessary to decrease the weight of the transport cables, since the stress is variable along the cable. This transport system design requires a minimum weight because at every local distance the required amount of cable is only that of the diameter for the local force. The load containers are also connected to the chain. When containers come up to the rollers, they move past the rollers and continue their motion up the cable. The entire transport system is driven by any conventional motor located on the planet. When payloads are not being delivered into space, the system may be used to transfer mechanical energy to the equalizer (load cabin, the space station). This mechanical energy may also be converted to any other sort energy.

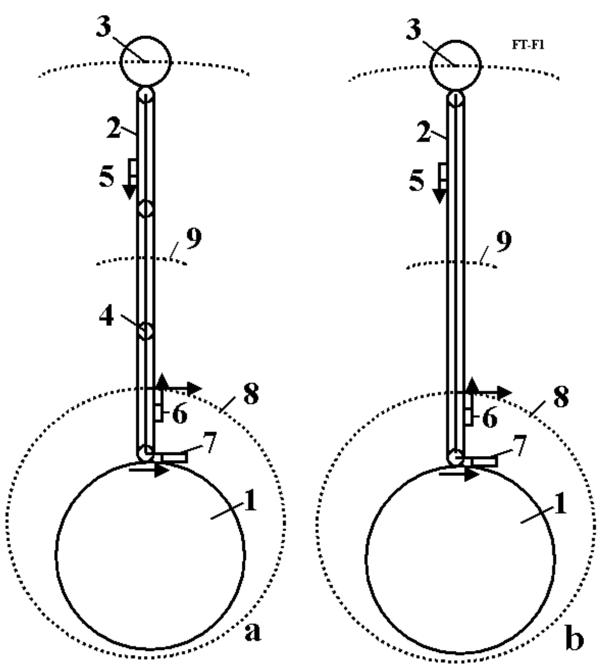

Fig. 1-1a,b. The suggested Space Transport System. Notations: 1 – Rotary planet (for example, the Earth); 2 - suggested Space Transport System ; 3 - equalizer (counterweight); 4 - roller of Transport System; 5 - launch space ship; 6 - a return ship after flight ; 7 – engine of Transport System; 8 – elliptic orbit of tourist vehicles; 9 - Geosynchronous orbit. *a* – System for low coefficient *k*, *b* – System for high coefficient *k* (without rollers 4).

The space satellites released below geosynchronous orbit will have elliptic orbits and may be connected back to the transport system after some revolutions when the space ship and cable are in the same position (Fig.1- 1). If low earth orbit satellites use a brake parachute, they can have their orbit closed to a circle.

The space probes released higher than geosynchronous orbit will have a hyperbolic orbit, fly to other planets, and then can connect back to the transport system when the ship returns.

Most space payloads, like tourists, must be returned to Earth. When one container is moved up, then another container is moved down. The work of lifting equals the work of descent, except for a small loss in the upper and lower rollers. The suggested transport system lets us fly into space without expending enormous energy. This is the reason why the method and system are named a "Free Trip".

Devices shown on fig. 1-2 are used to change the cable length (or chain length). The middle roller is shown in fig. 1-3.

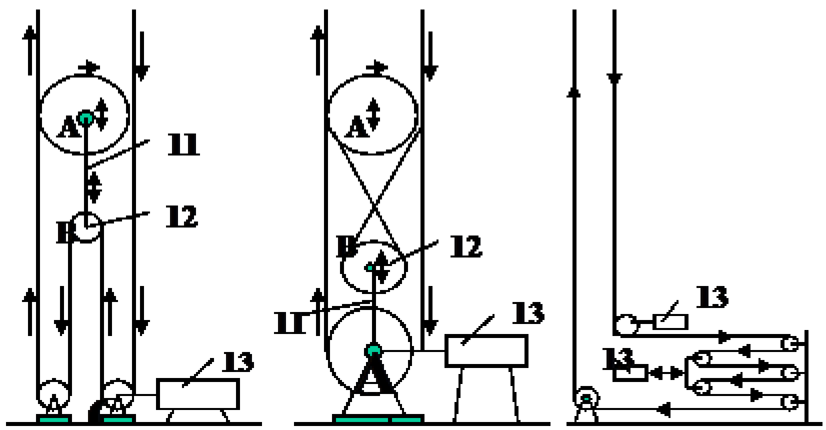

Fig. 1-2. Two mechanisms for changing the rope length in the Transport System (They are same for the space station). Notations: 11 - the rope which is connected axis *A,B*. This rope can change its length (the distance *AB*); 12 - additional rollers.

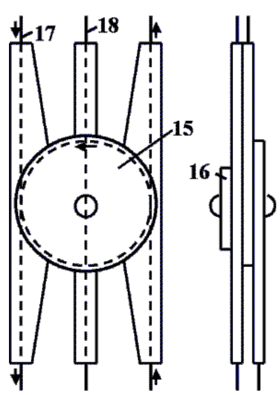

Fig. 1-3. Roller of Space Transport System. Notations: 15 – roller, 16 – control; 17 – transport system cable; 18 – main cable.

If the cable material has a very high ratio of safe (admissible) stress/density there may be one chain (Fig. 1-1b). The transport system then has only one main cable. Old design (fig. 1-1.1) has many problems, for example, in the transfer of large amounts of energy to the load cabin.

Theory and Computation of optimal cable

(in metric system)

1. The cable of equal stress for the planet. The force active in the cable is:

$$F = \sigma A = F_0 + \int_{R_0}^{R} dW = F_0 + \int_{R_0}^{R} \gamma A dR \qquad (1.1)$$

where

$$\gamma = \gamma_0 g_0 \left[\left(\frac{R_0}{R} \right)^2 - \frac{\omega^2 R}{g_0} \right] . \qquad (1.2)$$

F is force, N; σ is tensile strength, N/m^2; W – mass of cable, kg; γ – density of cable, kg/m^3; A is cross-section area of cable, m^2; R_o – radius of planet, m; R – radius, m; ω – angle speed of planet, rad/sec; g – planet acceleration, m/s^2; the lower index '$_o$' means data on planet surface.

If we substitute (1.2) in (1.1) and find the difference to the variable upper integral limit, we obtain the differential equations

$$\frac{1}{A} dA = \frac{\gamma_0 g_0}{\sigma} \left[\left(\frac{R_0}{R} \right)^2 - \frac{\omega^2 R}{g_0} \right] dR . \qquad (1.3)$$

Solution to equation (1.3) is

$$a(R) = \frac{A}{A_0} = \exp\left[\frac{\gamma_0 g_0 B(R)}{\sigma} \right] \qquad (1.4)$$

$$B(r) = R_0^2 \left\{ \left(\frac{1}{R_0} - \frac{1}{R} \right) - \frac{\omega^2}{2 g_0} \left[\left(\frac{R}{R_0} \right)^2 - 1 \right] \right\} ,$$

where a is the relative cable area, $B(r)$ is the work of lifting 1 kg mass.

The computation for different $K=\sigma/\gamma_o/10^7$ is presented in [1] Fig. 1.6.

Transport system for Space Elevator (Project 1)

That is an example of an inexpensive transport system for cheap annual delivery of 100,000 tourists, or 12,000 tons of payload into Earth orbits, or the delivery up to 2,000 tourists to Mars, or the launching of up to 2,500 tons of payload to other planets.

Main results of computation

The suggested space transport system can be used for delivery of tourists and payloads to an orbit around the Earth, or to space stations serving as a tourist hotel, scientific laboratory, or industrial factory, or for the delivery of people and payloads to other planets.

Technical parameters: Let us take the safe cable stress 7200 kg/mm^2 and cable density 1800 kg/m^3. This is equal to K = 4. This is not so great since by the year 2000 many laboratories had made experimental nanotubes with a tensile stress of 200 Giga–Pascals (20,000 kg/mm^2) and a density of 1800 kg/m^3. The theory of nanotubes predicts 100 ton/mm^2 with Young's modulus of up to 5 Tera Pascal's (currently it is 1 Tera Pascal) and a density of 800 kg/m^3 for SWNTs nanotubes. This means that the coefficient K used in our equations and graphs can be up to 125.

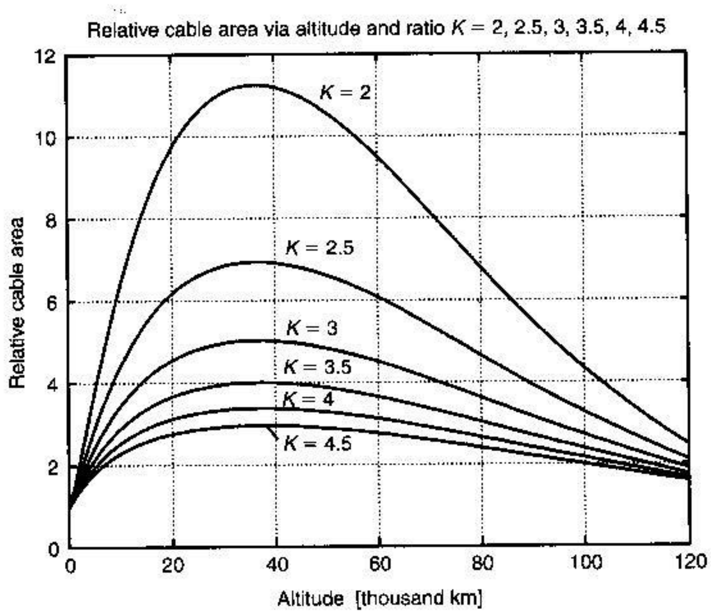

Fig. 1.6. Relative cable area via altitude [thousand km] for coefficient K = 2–4.5.

[1] Fig. 1.6.

Assume a maximum equalizer lift force of 9 tons at the Earth's surface and divide this force between three cables: one main and two transport cables. Then it follows from [1] Fig. 1.11, that the mass of the equalizer (or the space station) creates a lift force of 9 tons at the Earth's surface, which equals 518 tons for K = 4 (this is close to the current International Space Station weight of 450 tons). The equalizer is located over a geosynchronous orbit at an altitude of 100,000 km. Full centrifugal lift force of the equalizer ([1] Fig. 1.10) is 34.6 tons, but 24.6 tons of the equalizer are used in support of the cables. The transport system has three cables: one main and two in the transport system. Each cable can support a force (load) of 3000 kgf. The main cable has a cross-sectional area of equal stress. Then the cable cross-section area is (see [1] Fig. 1.6) A = 0.42 mm^2 (diameter D = 0.73 mm) at the Earth's surface, maximum 1.4 mm^2 in the middle section (D = 1.33 mm, altitude 37,000 km), and A = 0.82 mm^2 (D = 1 mm) at the equalizer. The mass of main cable is 205 tons (see [1] Fig. 1.8). The chains of the two transport cable loops have gross section areas to equal the tensile stress of the main cable at given altitude, and the capabilities are the same as the main cable. Each of them can carry 3 tons force. The total mass of the cable is about 620 tons. The three cables increase the safety of the passengers. If any one of the cables breaks down, then the other two will allow a safe return of the space vehicle to Earth and the repair of the transport system.

If the container cable is broken, the pilot uses the main cable for delivering people back to Earth. If the main cable is broken, then the load container cable will be used for delivering a new main cable to the equalizer. For lifting non-balance loads (for example, satellites or parts of new space stations, transport installations, interplanetary ships), the energy must be spent in any delivery method. This energy can be calculated from equation [1] (1.8) (Fig. 1.15). When the transport system in Fig. 1-1 is used, the engine is located on the Earth and does not have an energy limitation [1][11]. Moreover, the transport system in Fig. 1-1 can transfer a power of up to 90,000 kW to the space station for a cable speed of 3 km/s. At the present time, the International Space Station has only 60 kW of power.

Delivery capabilities. For tourist transportation the suggested system works in the following manner. The passenger space vehicle has the full mass of 3 tons (6667 pounds) to carry 25 passengers and two pilots. One ship moves up, the other ship, which is returning, moves down; then the lift and descent energies are approximately equal. If the average speed is 3 km/s then the first ship reaches the altitude of 21.5 – 23 thousands km in 2 hours (acceleration 1.9 m/s^2). At this altitude the ship is separated from the cable to fly in an elliptical orbit with minimum altitude 200 km and period approximately 6 hours ([1] Figs. 1.16, 1.17). After one day the ship makes four revolutions around the Earth while the cable system makes one revolution, and the ship and cable will be in the same place with the same speed. The ship is connected back to the transport system, moves down the cable and lifts the next ship. The orbit may be also 3 revolutions (period 8 hours) or 2 revolutions (period 12 hours). In one day the transport system can accommodate 12 space ships (300 tourists) in both directions. This means more then 100,000 tourists annually into space.

The system can launch payloads into space, and if the altitude of disconnection is changed then the orbit is changed (see [1] Fig. 1.17). If a satellite needs a low orbit, then it can use the brike parachute when it flies through the top of the atmosphere and it will achieve a near circular orbit. The annual payload capability of the suggested space transport system is about 12,600 tons into a geosynchronous orbit.

If instead of the equalizer the system has a space station of the same mass at an altitude of 100,000 km and the system can has space stations along cable and above geosynchronous orbit then these stations decrease the mass of the equalizer and may serve as tourist hotels, scientific laboratories, or industrial factories.

If the space station is located at an altitude of 100,000 km, then the time of delivery will be 9.36 hours for an average delivery speed of 3 km/s. This means 60 passengers per day or 21,000 people annually in space.

Let us assume that every person needs 400 kg of food for a one–year round trip to Mars, and Mars has the same transport installation (see next project). This means we can send about 2000 people to Mars annually at suitable positions of Earth relative to Mars.

Estimations of installation cost and production cost of delivery

Cost of suggested space transport installation [1][5,6]. The current International Space Station has cost many billions of dollars, but the suggested space transport system can cost a lot less. Moreover, the suggested transport system allows us to create other transport systems in a geometric progression [see equation [1](1.13)]. Let us examine an example of the transport system.

Initially we create the transport system to lift only 50 kg of load mass to an altitude of 100,000 km. Using the [1] Figs. 1.6 to 1.14 we have found that the equalizer mass is 8.5 tons, the cable mass is 10.25 tons and the total mass is about 19 tons. Let us assume that the delivery cost of 1 kg mass is $10,000. The construction of the system will then have a cost of $190 million. Let us assume that 1 ton of cable with $K = 4$ from whiskers or nanotubes costs \$0.1 million then the system costs \$1.25 million. Let us put the research and development (R&D) cost of installation at \$29 million. Then the total cost of initial installation will be \$220 million. About 90% of this sum is the cost of initial rocket delivery.

After construction, this initial installation begins to deliver the cable and equalizer or parts of the space station into space. The cable and equalizer capability increase in a geometric progression. The installation can use part of the time for delivery of payload (satellites) and self-financing of this project. After 765 working days the total mass of equalizer and cables reaches the amount above (1133 tons) and the installation can work full time as a tourist launcher or continue to create new installations. In the last case this installation and its derivative installations can build 100 additional installations (1133 tons) in only 30 months [see equation [1] (1.13) and Fig. 1.21] with a total capability of 10 million tourists per year. The new installations will be separated from the mother installations and moved to other positions around the Earth. The result of these installations allows the delivery of passengers and payloads from one continent to another across space with low expenditure of energy.

Let us estimate the cost of the initial installation. The installation needs 620 tons of cable. Let us take the cost of cable as \$0.1 million per ton. The cable cost will be \$62 million. Assume the space station cost \$20 million. The construction time is 140 days [equation (1.13)]. The cost of using of the mother installation without profit is \$5 millions/year. In this case the new installation will cost \$87 million. In reality the new installation can soon after construction begin to launch payloads and become self-financing.

Cost of delivery

The cost of delivery is the most important parameter in the space industry. Let us estimate it for the full initial installation above.

As we calculated earlier the cost of the initial installation is \$220 millions (further construction is made by self-financing). Assume that installation is used for 20 years, served by 100 officers with an average annual salary of \$50,000 and maintenance is \$1 million in year. If we deliver 100,000 tourists annually, the production delivery cost will be \$160/person or \$1.27/kg of payload. Some 70% of this sum is the cost of installation, but the delivery cost of the new installations will be cheaper.

If the price of a space trip is \$1990, then the profit will be \$183 million annually. If the payload delivery price is \$15/kg then the profit will \$189 millions annually.

The cable speed for $K = 4$ is 6.32 km/s [equation [1] (1.11), Fig. 1.19]. If average cable speed equals 6 km/s, then all performance factors are improved by a factor of two times.

If the reader does not agree with this estimation, then equations [1] (1.1) to (1.13) and Figs. 1.6 to 1.21 are able calculation of the delivery cost for other parameters. In any case the delivery cost will be hundreds of times less than the current rocket powered method.

Delivery System for Free Round Trip to Mars (Project 2)

A method and similar installation Fig.1-1, [1](Figs.1 to 4) can be used for inexpensive travel to other planets, for example, from the Earth to Mars or the Moon and back [1](Fig. 1.22). A Mars space station would be similar to an Earth space station, but the Mars station would weigh less due to the decreased gravitation on Mars. This method uses the rotary energy of the planets. For this method, two facilities are required, one on Earth and the other on another planet (e.g. Mars). The Earth accelerates the space ship to the required speed and direction and then disconnects the ship. The space ship flies in space along the defined trajectory to Mars (Fig.1-4). On reaching Mars the space ship connects to the cable of the Mars space transport system, then it moves down to Mars using the transport system.

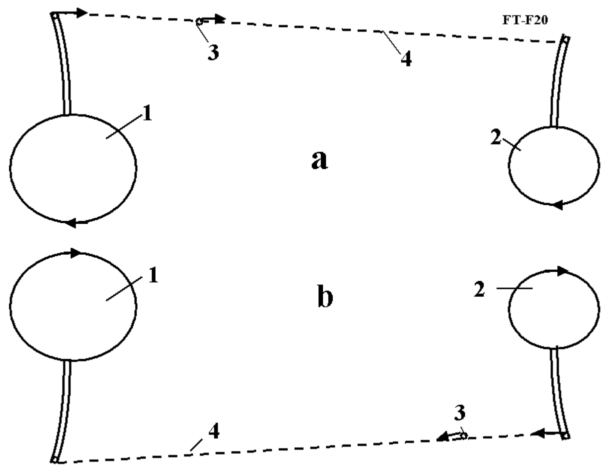

Fig. 1-4. Using the suggested transport system for space flight to Mars and back. Notation: 1 – Earth, 2 – Mars, 3 – space ship, 4 – trajectory of space ship to Mars (a) and back (b).

Free Trip to Moon (Project 3)

This method may be used for an inexpensive trip to a planet's moon, if the moon's angular speed is equal to the planet's angular speed, for example, from the Earth to the Moon and back (Fig. 1-5 to 1-7). The upper end of the cable is connected to the planet's moon. The lower end of the cable is connected to an aircraft (or buoy), which flies (i.e. glides or slides) along the planet's surface. The lower end may be also connected to an Earth pole. The aircraft (or Earth polar station, or Moon) has a device which allows the length of cable to be changed. This device would consist of a spool, motor, brake, transmission, and controller. The facility could have devices for delivering people and payloads to the Moon and back using the suggested transport system. The delivery devices include: containers, cables, motors, brakes, and controllers. If the aircraft is small and the cable is strong then the motion of the Moon can be used to move the airplane. For example, if the airplane weighs 15 tons and has an aerodynamic ratio (the lift force to the drag force) equal to 5, a thrust of 3000 kg would be enough for the aircraft to fly for infinity without requiring any fuel. The aircraft could use a small engine for maneuverability and temporary landing. If the planet has an atmosphere (as the Earth) the engine could be a turbine engine. If the planet does not have an atmosphere, a rocket engine may be used.

If the suggested transport system is used only for free thrust (9 tons), the system can thrust the three named supersonic aircraft or produce up to 40 millions watts of energy.

A different facility could use a transitional space station located at the zero gravity point between the planet and the planet's moon. Fig. 6 shows a sketch of the temporary landing of an airplane on the planet surface. The aircraft increases the length of the cable, flies ahead of the cable, and lands on a planet surface. While the planet makes an angle turn ($\alpha + \beta = 30^{\circ}$, see Fig. 1.31) the aircraft can be on a planet surface. This time equals about 2 hours for the Earth, which would be long enough to load payload on the aircraft.

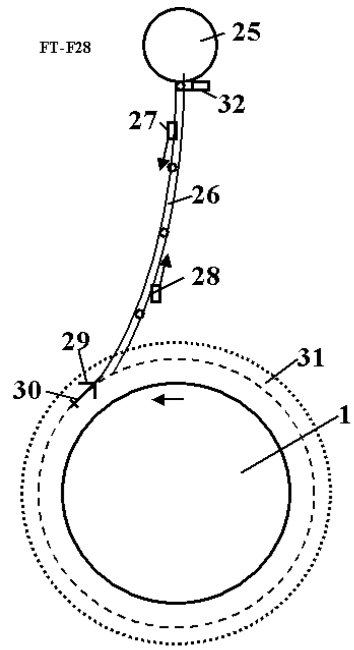

Fig.1- 5. The suggested transport system for the Moon. Notations: 1 – Earth, 25 - Moon, 26 – suggested Moon transport system, 27, 28 – load cabins, 29 – aircraft, 30 – cable control, 32 – engine.

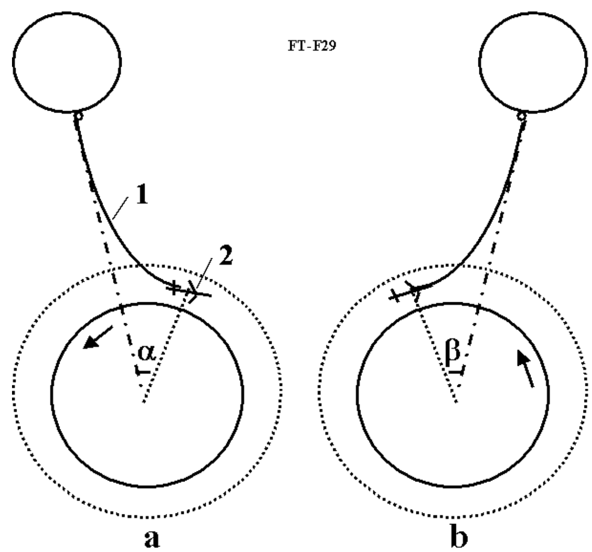

Fig.1- 6. Temporary landing of the Moon aircraft on the Earth's surface for loading. a– landing, b– take-off.

The Moon's trajectory has an eccentricity (Fig.1-7). If the main cable is strong enough, the moon may used to pull a payload (space ship, manned cabin), by trajectory to an altitude of about 60,000 kilometers every 27 days. For this case, the length of the main cable from the Moon to the container does not change and when the Moon increases its distance from the Earth, the Moon lifts the space ship. The payload could land back on the planet at any time if it is allowed to slide along the cable.

The Moon's energy can be used also for an inexpensive trip around the Earth (Figs. 1-5 and 1-7) by having the moon "drag" an aircraft around the planet (using the Moon as a free thrust engine). The Moon tows the aircraft by the cable at supersonic speed, about 440 m/s (Mach number is 1.5).

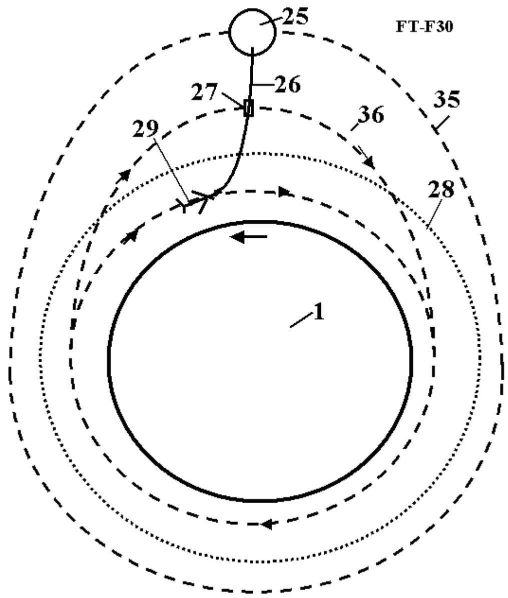

Fig. 1-7. Using the Moon's elliptical orbit for a free trip in space of up to 71,000 km. Notations: 1 – Earth, 25 – Moon, 26 – cable from Earth to Moon, 27 – Space Vehicle, 28 – limit of Earth atmosphere, 35 – Moon orbit, 36 – elliptical orbit of a Moon vehicle.

The other more simple design (without aircraft) is shown in [1] Fig. 7.1, chapter 7. The cable is connected to on Earth pole, to a special polar station which allows to change a length of cable. Near the pole the cable is supported in the atmosphere by air balloons and wings.

Technical parameters

The following are some data for estimating the main transport system parameters for connecting to the Moon to provide inexpensive payload transfer between the Earth and the Moon. The system has three cables, each of which can keep the force at 3 tons. Material of the cable has K=4. All cables would have cross-sectional areas of equal stress. The cable has a minimal cross-sectional area A_0 of 0.42 mm^2 (diameter d = 0.73 mm) and maximum cross-sectional area A_m of 1.9 mm^2 (d = 1.56 mm). The mass of the main cable would be 1300 tons [1] (Fig. 1.36). The total mass of the main cable plus the two container cables (for delivering a mass of 3000 kg) equals 3900 tons for the delivery transport system in [1] Figs. 1.30 to 1.33. An inexpensive means of payload delivery between the Earth and the Moon could thus be developed. The elapsed time for the Moon trip at a speed of 6 km/s would be about 18.5 hours and the annual delivery capability would be 1320 tons in both directions.

Discussion

Cable Problems

Most engineers and scientists think it is impossible to develop an inexpensive means to orbit to another planet. Twenty years ago, the mass of the required cable would not allow this proposal to be possible for an additional speed of more 2,000 m/s from one asteroid. However, today's industry widely produces artificial fibers that have a tensile strength 3–5 times more than steel and a density 4–5 times less than steel. There are also experimental fibers which have a tensile strength 30–60 times more than steel and a density 2 to 4 times less than steel. For example, in the book *Advanced Fibers and Composites* is p. 158, there is a fiber C_D with a tensile strength of σ = 8000 kg/mm^2 and density (specific gravity) γ = 3.5 g/cm^3. If we take an admitted strength of 7000 kg/mm^2 ($\sigma = 7\times10^{10}$ N/m^2, γ = 3500 kg/m^3) then the ratio, $\sigma/\gamma = 0.05\times10^{-6}$ or $\sigma/\gamma = 20\times10^6$ (K = 2). Although (in 1976) the graphite fibers are strong ($\sigma/\gamma = 10\times10^6$), they are at best still ten times weaker than theory predicts.

Steel fiber has tensile strengths of 5,000 MPA (500 kg/mm^2), but the theoretic value is 22,000 MPa (1987). Polyethylene fiber has a tensile strength of 20,000 MPa and the theoretical value is 35,000 MPa (1987).

The mechanical behavior of nanotubes also has provided excitement 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 MWNTs) 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 (an order of magnitude lower). Nanotubes come close to being the best fiber that can be made from graphite structure.

For example, whiskers made from carbon nanotubes (CNT) have a tensile strength of 200 Giga-Pascals and Young's modulus of over 1 Tera Pascal (1999). The theory predicts 1 Tera Pascal and Young modulus 1–5 Tera Pascals. The hollow structure of nanotubes makes them very light (specific density varies from 0.8 g/cc for SWNTs up to 1.8 g/cc for MWNTs, 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 our transportation system and space elevator; nanotubes have this value at least 2 orders of magnitude greater than steel. Traditional carbon fibers have a specific strength 40 times greater than steel. Where nanotubes are made of graphite carbon, they have good resistance to chemical attack and have high terminal stability. Oxidation studies have shown that the onset of oxidation shifts by about 100 $^\circ$C higher temperatures in nanotubes compared to high modulus graphite fibers. In vacuums or reducing atmospheres, nanotubes structures will be stable at any practical service temperature. Nanotubes have excellent conductivity like copper.

The price for the SiC whiskers produced by Carborundun Co. with σ = 20,690 MPa, γ = 3.22 g/cc was $440/kg in 1989. Medicine, the environment, space, aviation, machine-building, and the computer industry need cheap nanotubes. Some American companies plan to produce nanotubes in 2–3 years.

Below the author provides a brief overview of the annual research information (2000) regarding the proposed experimental test fibers.

Data that can be used for computation

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), 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, $(\sigma/\gamma)=46\times10^6$, K = 4.6. The SWNTs nanotubes have a density of 0.8 g/cc, and MWNTs have a density of 1.8 g/cc. 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) [p.158][7].
3. For industrial fibers σ = 500 – 600 kg/mm^2, γ = 1800 kg/m^3, $\sigma\gamma$ = 2,78×10^6, K = 0.278 – 0.333,

Figures for some other experimental whiskers and industrial fibers are give in Table 1.2.

Table 1.2

Material Whiskers	Tensile strength kg/mm^2	Density g/cc	Fibers	MPa	Density g/cc
AlB_{12}	2650	2.6	QC-8805	6200	1.95
B	2500	2.3	TM9	6000	1.79
B_4C	2800	2.5	Thorael	5650	1.81
TiB_2	3370	4.5	Allien 1	5800	1.56
SiC	1380–4140	3.22	Allien 2	3000	0.97

See References [7, 8, 9, 10] in [1] Ch.1.

Conclusions

The new materials make the suggested transport system and projects highly realistic for a free trip to outer space without expention of energy. The same idea was used in the research and calculation of other revolutionary innovations such as launches into space without rockets (not space elevator, not gun); cheap delivery of loads from one continent to another across space; cheap delivery of fuel gas over long distances without steel tubes and damage to the environment; low cost delivery of large load flows across sea streams and mountains without bridges or underwater tunnels [Gibraltar, English Channel, Bering Stream (USA–Russia), Russia–Sakhalin–Japan, etc.]; new economical transportation systems; obtaining inexpensive energy from air streams at high altitudes; etc. some of these are in reference [1][12–21] Ch.1.

The author has developed innovations, estimations, and computations for the above mentioned problems. Even though these projects seem impossible for the current technology, the author is prepared to discuss the project details with serious organizations that have similar research and development goals.

2. Man in Space without Space Suite*

The author proposes and investigates his old idea - a living human in space without the encumbrance of a complex space suit. Only in this condition can biological humanity seriously attempt to colonize space because all planets of Solar system (except the Earth) do not have suitable atmospheres. Aside from the issue of temperature, a suitable partial pressure of oxygen is lacking. In this case the main problem is how to satiate human blood with oxygen and delete carbonic acid gas (carbon dioxide). The proposed system would enable a person to function in outer space without a space suit and, for a long time, without food. That is useful also in the Earth for sustaining working men in an otherwise deadly atmosphere laden with lethal particulates (in case of nuclear, chemical or biological war), in underground confined spaces without fresh air, under water or a top high mountains above a height that can sustain respiration.

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* Published in [1] Ch.19; in [4] Ch.6.

Introduction

Short history. A fictional treatment of Man in space without spacesuit protection was famously treated by Arthur C. Clarke in at least two of his works, “Earthlight” and the more famous “2001: A Space Odyssey”. In the scientific literature, the idea of sojourning in space without complex space suits was considered seriously about 1970 and an initial research was published in [1] p.335 – 336. Here is more detail research this possibility.

Humans and vacuum. Vacuum is primarily an asphyxiant. Humans exposed to vacuum will lose consciousness after a few seconds and die within minutes, but the symptoms are not nearly as graphic as commonly shown in pop culture. Robert Boyle was the first to show that vacuum is lethal to small animals. Blood and other body fluids do boil (the medical term for this condition is ebullism), and the vapour pressure may bloat the body to twice its normal size and slow circulation, but tissues are elastic and porous enough to prevent rupture. Ebullism is slowed by the pressure containment of blood vessels, so some blood remains liquid. Swelling and ebullism can be reduced by containment in a flight suit. Shuttle astronauts wear a fitted elastic garment called the Crew Altitude Protection Suit (CAPS) which prevents ebullism at pressures as low as 15 Torr (2 kPa). However, even if ebullism is prevented, simple evaporation of blood can cause decompression sickness and gas embolisms. Rapid evaporative cooling of the skin will create frost, particularly in the mouth, but this is not a significant hazard.

Animal experiments show that rapid and complete recovery is the norm for exposures of fewer than 90 seconds, while longer full-body exposures are fatal and resuscitation has never been successful.[4] There is only a limited amount of data available from human accidents, but it is consistent with animal data. Limbs may be exposed for much longer if breathing is not impaired. Rapid decompression can be much more dangerous than vacuum exposure itself. If the victim holds his breath during decompression, the delicate internal structures of the lungs can be ruptured, causing death. Eardrums may be ruptured by rapid decompression, soft tissues may bruise and seep blood, and the stress of shock will accelerate oxygen consumption leading to asphyxiation.

In 1942, the Nazi regime tortured Dachau concentration camp prisoners by exposing them to vacuum. This was an experiment for the benefit of the German Air Force (Luftwaffe), to determine the human body's capacity to survive high altitude conditions.

Some extremophile microrganisms, such as Tardigrades, can survive vacuum for a period of years.

Respiration (physiology). In animal physiology, respiration is the transport of oxygen from the clean air to the tissue cells and the transport of carbon dioxide in the opposite direction. This is in contrast to the biochemical definition of respiration, which refers to cellular respiration: the metabolic process by which an organism obtains energy by reacting oxygen with glucose to give water, carbon dioxide and ATP (energy). Although physiologic respiration is necessary to sustain cellular respiration and thus life in animals, the processes are distinct: cellular respiration takes place in individual cells of the animal, while physiologic respiration concerns the bulk flow and transport of metabolites between the organism and external environment.

In unicellular organisms, simple diffusion is sufficient for gas exchange: every cell is constantly bathed in the external environment, with only a short distance for gases to flow across. In contrast, complex multicellular organisms such as humans have a much greater distance between the environment and their innermost cells, thus, a respiratory system is needed for effective gas exchange. The respiratory system works in concert with a circulatory system to carry gases to and from the tissues.

In air-breathing vertebrates such as humans, respiration of oxygen includes four stages:

- *Ventilation* from the ambient air into the alveoli of the lung.
- *Pulmonary gas exchange* from the alveoli into the pulmonary capillaries.
- *Gas transport* from the pulmonary capillaries through the circulation to the peripheral capillaries in the organs.
- *Peripheral gas exchange* from the tissue capillaries into the cells and mitochondria.

Note that ventilation and gas transport require energy to power mechanical pumps (the diaphragm and heart respectively), in contrast to the passive diffusion taking place in the gas exchange steps.

Respiratory physiology is the branch of human physiology concerned with respiration.

Respiration system. In humans and other mammals, the respiratory system consists of the airways, the lungs, and the respiratory muscles that mediate the movement of air into and out of the body. Within the alveolar system of the lungs, molecules of oxygen and carbon dioxide are passively exchanged, by diffusion, between the gaseous environment and the blood. Thus, the respiratory system facilitates oxygenation of the blood with a concomitant removal of carbon dioxide and other gaseous metabolic wastes from the circulation. The system also helps to maintain the acid-base balance of the body through the efficient removal of carbon dioxide from the blood.

Circulation. The right side of the heart pumps blood from the right ventricle through the pulmonary semilunar valve into the pulmonary trunk. The trunk branches into right and left pulmonary arteries to the pulmonary blood vessels. The vessels generally accompany the airways and also undergo numerous branchings. Once the gas exchange process is complete in the pulmonary capillaries, blood is returned to the left side of the heart through four pulmonary veins, two from each side. The pulmonary circulation has a very low resistance, due to the short distance within the lungs, compared to the systemic circulation, and for this reason, all the pressures within the pulmonary blood vessels are normally low as compared to the pressure of the systemic circulation loop.

Virtually all the body's blood travels through the lungs every minute. The lungs add and remove many chemical messengers from the blood as it flows through pulmonary capillary bed. The fine capillaries also trap blood clots that have formed in systemic veins.

Gas exchange. The major function of the respiratory system is gas exchange. As gas exchange occurs, the acid-base balance of the body is maintained as part of homeostasis. If proper ventilation is not maintained, two opposing conditions could occur: 1) respiratory acidosis, a life threatening condition, and 2) respiratory alkalosis.

Upon inhalation, gas exchange occurs at the alveoli, the tiny sacs which are the basic functional component of the lungs. The alveolar walls are extremely thin (approx. 0.2 micrometres), and are permeable to gases. The alveoli are lined with pulmonary capillaries, the walls of which are also thin enough to permit gas exchange.

Membrane oxygenator. A membrane oxygenator is a device used to add oxygen to, and remove carbon dioxide from the blood. It can be used in two principal modes: to imitate the function of the lungs in cardiopulmonary bypass (CPB), and to oxygenate blood in longer term life support, termed Extracorporeal membrane oxygenation, ECMO. A membrane oxygenator consists of a thin gas permeable membrane separating the blood and gas flows in the CPB circuit; oxygen diffuses from the gas side into the blood, and carbon dioxide diffuses from the blood into the gas for disposal.

The introduction of microporous hollow fibres with very low resistance to mass transfer revolutionised design of membrane modules, as the limiting factor to oxygenator performance became the blood resistance [Gaylor, 1988]. Current designs of oxygenator typically use an extraluminal flow regime, where the blood flows outside the gas filled hollow fibres, for short term life support, while only the homogeneous membranes are approved for long term use.

Heart-lung machine. The heart-lung machine is a mechanical pump that maintains a patient's blood circulation and oxygenation during heart surgery by diverting blood from the venous system, directing it through tubing into an artificial lung (oxygenator), and returning it to the body. The oxygenator removes carbon dioxide and adds oxygen to the blood that is pumped into the arterial system.

Space suit. A space suit is a complex system of garments, equipment and environmental systems designed to keep a person alive and comfortable in the harsh environment of outer space. This applies to extra-vehicular activity (EVA) outside spacecraft orbiting Earth and has applied to walking, and riding the Lunar Rover, on the Moon.

Some of these requirements also apply to pressure suits worn for other specialized tasks, such as high-altitude reconnaissance flight. Above Armstrong's Line (~63,000 ft/~19,000 m), pressurized suits are needed in the sparse atmosphere. Hazmat suits that superficially resemble space suits are sometimes used when dealing with biological hazards.

A conventional space suit must perform several functions to allow its occupant to work safely and comfortably. It must provide: A stable internal pressure, Mobility, Breathable oxygen, Temperature regulation, Means to recharge and discharge gases and liquids , Means of collecting and containing solid and liquid waste, Means to maneuver, dock, release, and/or tether onto spacecraft.

Operating pressure. Generally, to supply enough oxygen for respiration, a spacesuit using pure oxygen must have a pressure of about 4.7 psi (32.4 kPa), equal to the 3 psi (20.7 kPa) partial pressure of oxygen in the Earth's atmosphere at sea level, plus 40 torr (5.3 kPa) CO_2 and 47 torr (6.3 kPa) water vapor pressure, both of which must be subtracted from the alveolar pressure to get alveolar oxygen partial pressure in 100% oxygen atmospheres, by the alveolar gas equation. The latter two figures add to 87 torr (11.6 kPa, 1.7 psi), which is why many modern spacesuits do not use 3 psi, but 4.7 psi (this is a slight overcorrection, as alveolar partial pressures at sea level are not a full 3 psi, but a bit less). In spacesuits that use 3 psi, the astronaut gets only 3 - 1.7 = 1.3 psi (9 kPa) of oxygen, which is about the alveolar oxygen partial pressure attained at an altitude of 6100 ft (1860 m) above sea level. This is about 78% of normal sea level pressure, about the same as pressure in a commercial passenger jet aircraft, and is the realistic lower limit for safe ordinary space suit pressurization which allows reasonable work capacity.

Movements are seriously restricted in the suits, with a mass of more than 110 kilograms each (Shenzhou 7 space suit). The current space suits are very expensive. Flight-rated NASA spacesuits cost about $22,000,000. While other models may be cheaper, sale is not currently open even to the wealthy public. Even if spaceflight were free (a huge if) a person of average means could not afford to walk in space or upon other planets.

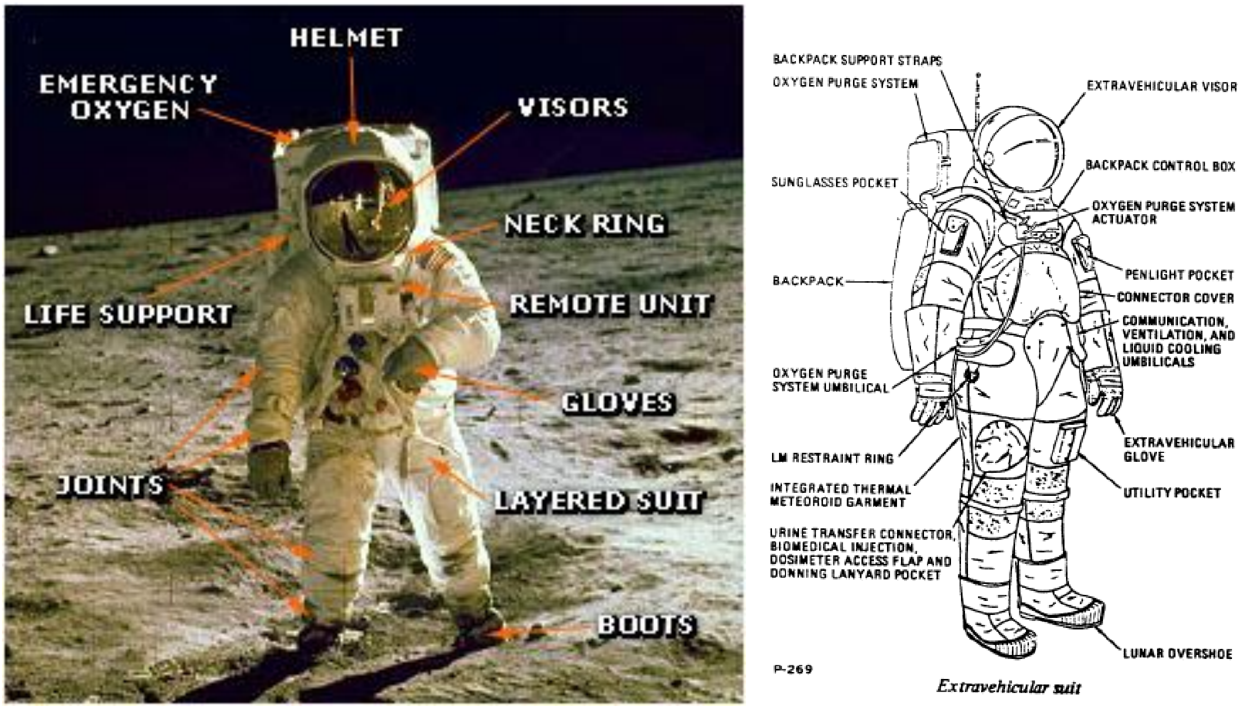

Fig. 2-1. a. Apollo 11 A7L space suit. b. Diagram showing component parts of A7L space suit.

Brief Description of Innovation

A space suit is a very complex and expensive device (Fig. 2-1). Its function is to support the person's life, but it makes an astronaut immobile and slow, prevents him or her working, creates discomfort, does not allows eating in space, have a toilet, etc. Astronauts need a space ship or special space habitat located not far from away where they can undress for eating, toilet activities, and rest.

Why do we need a special space suit in outer space? There is only one reason – we need an oxygen atmosphere for breathing, respiration. Human evolution created lungs that aerates the blood with oxygen and remove carbon dioxide. However we can also do that using artificial apparatus. For example, doctors, performing surgery on someone's heart or lungs connect the patient to a heart – lung machine that acts in place of the patent's lungs or heart.

We can design a small device that will aerate the blood with oxygen and remove the carbon dioxide. If a tube from the main lung arteries could be connected to this device, we could turn on (off) the artificial breathing at any time and enable the person to breathe in a vacuum (on an asteroid or planet without atmosphere) in a degraded or poisonous atmosphere, or under water, for a long time. In space we can use a conventional Earth manufacture oversuit (reminiscent of those used by workers in semiconductor fabs) to protect us against solar ultraviolet light.

The sketch of device which saturates the blood with oxygen and removes the carbon dioxide is presented in fig.2-2. The Heart-Lung machines are widely used in current surgery.

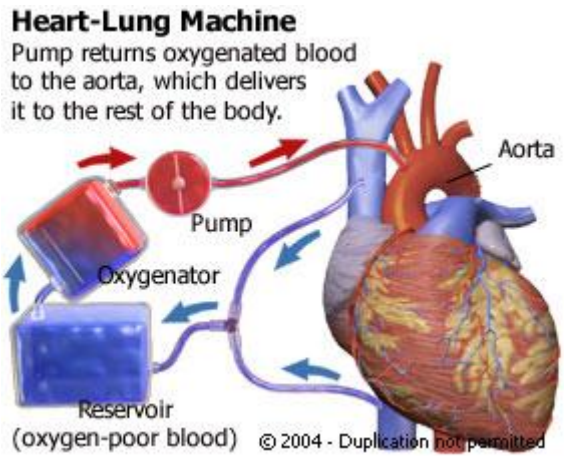

Fig.2-2. Principal sketch of heart-Lung Machine

The main part of this device is oxygenator, which aerates the blood with oxygen and removes the carbon dioxide. The principal sketch of typical oxygenator is presented in fig. 2-3.

The **circulatory system** is an organ system that moves nutrients, gases, and wastes to and from cells, helps fight diseases and helps stabilize body temperature and pH to maintain homeostasis. This system may be seen strictly as a blood distribution network, but some consider the circulatory system as composed of the cardiovascular system, which distributes blood, and the lymphatic system, which distributes lymph. While humans, as well as other vertebrates, have a closed cardiovascular system (meaning that the blood never leaves the network of arteries, veins and capillaries), some invertebrate groups have an open cardiovascular system. The most primitive animal phyla lack circulatory systems. The lymphatic system, on the other hand, is an open system.

The human blood circulatory system is shown in Fig. 2-5.

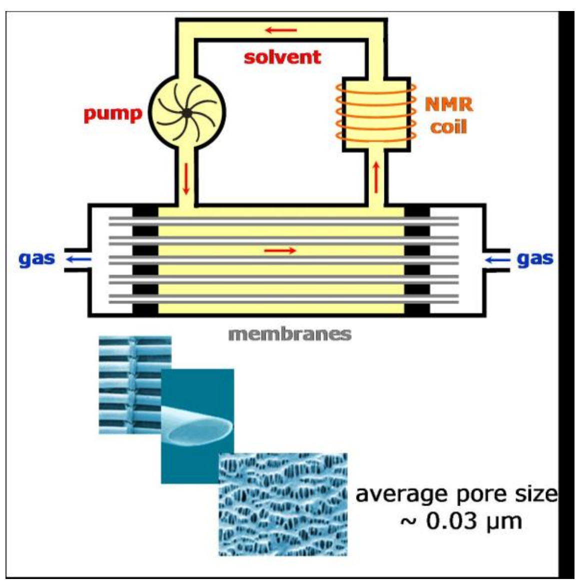

Fig.2-3. Principal sketch of oxygenator.

Current oxygenator is shown in Fig. 2-4.

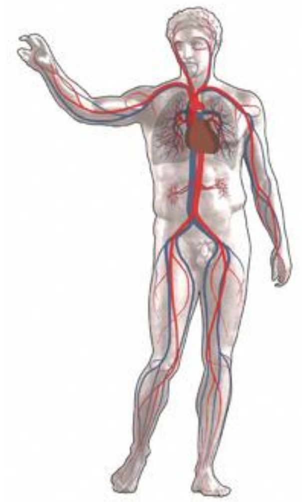

Fig. 2-4. (Left). Oxygenators.
Fig.2-5. (Right). The human circulatory system. Red indicates oxygenated blood, blue indicates deoxygenated.

The main components of the human circulatory system are the heart, the blood, and the blood vessels. The circulatory system includes: the pulmonary circulation, a "loop" through the lungs where blood is oxygenated; and the systemic circulation, a "loop" through the rest of the body to provide oxygenated blood. An average adult contains five to six quarts (roughly 4.7 to 5.7 liters) of blood, which consists of plasma that contains red blood cells, white blood cells, and platelets.

Two types of fluids move through the circulatory system: blood and lymph. The blood, heart, and blood vessels form the cardiovascular system. The lymph, lymph nodes, and lymph vessels form the lymphatic system. The cardiovascular system and the lymphatic system collectively make up the circulatory system.

The simplest form of intravenous access is a syringe with an attached **hollow needle.** The needle is inserted through the skin into a vein, and the contents of the syringe are injected through the needle into the bloodstream. This is most easily done with an arm vein, especially one of the metacarpal veins. Usually it is necessary to use a constricting band first to make the vein bulge; once the needle is in place, it is common to draw back slightly on the syringe to aspirate blood, thus verifying that the needle is really in a vein; then the constricting band is removed before injecting.

When man does not use the outer air pressure in conventional space suite, he not has opposed internal pressure except the heart small pressure in blood. The skin vapor easy stop by film clothes or make small by conventional clothes.

The current lung devices must be re-designed for space application. These must be small, light, cheap, easy in application (using hollow needles, no operation (surgery)!), work a long time in field conditions. Wide-ranging space colonization by biological humanity is impossible without them.

Artificial Nutrition.

Application of offered devices gives humanity a unique possibility to be a long time without conventional nutrition. Many will ask, “who would want to live like that?” But in fact many crew members, military, and other pressured personnel routinely cut short what most would consider normal dining routines. And there are those morbidly obese people for whom dieting is difficult exactly because (in an unfortunate phrase!) many can give up smoking ‘cold turkey’, but few can give up ‘eating cold turkey’! Properly ‘fed’ intravenously, a person could lose any amount of excess weight he needed to, while not suffering hunger pains or the problems the conventional eating cycle causes. It is known that people in a coma may exist some years in artificial nutrition inserted into blood. Let us consider the current state of the art.

Total parenteral nutrition (TPN), is the practice of feeding a person intravenously, bypassing the usual process of eating and digestion. The person receives nutritional formulas containing salts, glucose, amino acids, lipids and added vitamins.

Total parenteral nutrition (TPN), also referred to as Parenteral nutrition (PN), is provided when the gastrointestinal tract is nonfunctional because of an interruption in its continuity or because its absorptive capacity is impaired. It has been used for comatose patients, although enteral feeding is usually preferable, and less prone to complications. Short-term TPN may be used if a person's digestive system has shut down (for instance by Peritonitis), and they are at a low enough weight to cause concerns about nutrition during an extended hospital stay. Long-term TPN is occasionally used to treat people suffering the extended consequences of an accident or surgery. Most controversially, TPN has extended the life of a small number of children born with nonexistent or severely deformed guts. The oldest were eight years old in 2003.

The preferred method of delivering TPN is with a medical infusion pump. A sterile bag of nutrient solution, between 500 mL and 4 L is provided. The pump infuses a small amount (0.1 to 10 mL/hr) continuously in order to keep the vein open. Feeding schedules vary, but one common regimen ramps up the nutrition over a few hours, levels off the rate for a few hours, and then ramps it down over a few more hours, in order to simulate a normal set of meal times.

Chronic TPN is performed through a central intravenous catheter, usually in the subclavian or jugular vein. Another common practice is to use a PICC line, which originates in the arm, and extends to one of the central veins, such as the subclavian. In infants, sometimes the umbilical vein is used.

Battery-powered ambulatory infusion pumps can be used with chronic TPN patients. Usually the pump and a small (100 ml) bag of nutrient (to keep the vein open) are carried in a small bag around the waist or on the shoulder. Outpatient TPN practices are still being refined.

Aside from their dependence on a pump, chronic TPN patients live quite normal lives.

Central IV lines flow through a catheter with its tip within a large vein, usually the superior vena cava or inferior vena cava, or within the right atrium of the heart.

There are several types of catheters that take a more direct route into central veins. These are collectively called *central venous lines*.

In the simplest type of central venous access, a catheter is inserted into a subclavian, internal jugular, or (less commonly) a femoral vein and advanced toward the heart until it reaches the superior vena cava or right atrium. Because all of these veins are larger than peripheral veins, central lines can deliver a higher volume of fluid and can have multiple lumens.

Another type of central line, called a Hickman line or Broviac catheter, is inserted into the target vein and then "tunneled" under the skin to emerge a short distance away. This reduces the risk of infection, since bacteria from the skin surface are not able to travel directly into the vein; these catheters are also made of materials that resist infection and clotting.

Testing

The offered idea may be easily investigated in animals on Earth by using currently available devices. The experiment includes the following stages:

1) Using a hollow needle, the main blood system of a good healthy animal connects to a current heart-lung machine.
2) The animal is inserted under a transparent dome and air is gradually changed to a neutral gas (for example, nitrogen). If all signs are OK, we may proceed to the following stage some days later.
3) The animal is inserted under a transparent dome and air is slowly (tens of minutes) pumped out. If all signs are OK we may start the following stage.
4) Investigate how long time the animal can be in vacuum? How quick we can decompress and compress? How long the animal may live on artificial nutrition? And so on.
5) Design the lung (oxygenator) devices for people which will be small, light, cheap, reliable, safe, which delete gases from blood (especially those that will cause 'bends' in the case of rapid decompression, and work on decreasing the decompressing time).
6) Testing the new devices on animals then human volunteers.

Advantages of offered system.

The offered method has large advantages in comparison with space suits:

1) The lung (oxygenator) devices are small, light, cheaper by tens to hundreds times than the current space suit.
2) It does not limit the activity of a working man.
3) The working time increases by some times. (less heat buildup, more supplies per a given carry weight, etc)
4) It may be widely used in the Earth for existing in poison atmospheres (industry, war), fire, rescue operation, under water, etc.
5) Method allows permanently testing (controlling) the blood and immediately to clean it from any poison and gases, wastes, and so on. That may save human lives in critical medical situations and in fact it may become standard emergency equipment.
6) For quick save the human life.
7) Pilots for high altitude flights.
8) The offered system is a perfect rescue system because you turn off from environment and exist INDEPENDENTLY from the environment. (Obviously excluding outside thermal effects, fires etc—but for example, many fire deaths are really smoke inhalation deaths; the bodies are often not burned to any extent. In any case it is much easier to shield searing air from the lungs if you are not breathing it in!)

Conclusion.

The author proposes and investigates his old idea – a living human in space without the encumbrance of a complex space suit. Only in this condition can biological humanity seriously attempt to colonize space because all planets of Solar system (except the Earth) do not have suitable atmospheres. Aside from the issue of temperature, a suitable partial pressure of oxygen is lacking. In this case the main problem is how to satiate human blood with oxygen and delete carbonic acid gas (carbon dioxide). The proposed system would enable a person to function in outer space without a space suit and, for a long time, without food. That is useful also in the Earth for sustaining working men in an otherwise deadly atmosphere laden with lethal particulates (in case of nuclear, chemical or biological war), in underground confined spaces without fresh air, under water or a top high mountains above a height that can sustain respiration. There also could be numerous productive medical uses.

3.Electrostatic Levitation on Planet and Artificial Gravity for Space Ships and Asteroids*

The author offers and researches the conditions which allow people and vehicles to levitate on the Earth using the electrostatic repulsive force. He shows that by using small electrically charged balls, people and cars can take flight in the atmosphere. Also, a levitated train can attain high speeds. He has computed some projects and discusses the problems which can appear in the practical development of this method. It is also shown how this method may be used for creating artificial gravity (attraction force) into and out of space ships, space hotels, asteroids, and small planets which have little gravity.

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*Presented as paper AIAA-2005-4465 at 41 Propulsion Conference, 10–13 July 2005, Tucson, Arizona, USA. See also [1] Ch.15.

Introduction

People have dreamed about a flying freely in the air without any apparatus for many centuries. In ancient books we can find pictures of flying angels or God sitting on clouds or in heaven. At the present time you can see the same pictures on walls in many churches.

Physicist is know only two methods for creating repulsive force: magnetism and electrostatics. Magnetism is well studied and the use of superconductive magnets for levitating a train has been widely discussed in scientific journals, but repulsive magnets have only a short-range force. They work well for ground trains but are bad for air flight. Electrostatic flight needs powerful electric fields and powerful electric charges. The Earth's electric field is very weak and cannot be used for levitation. The main innovations presented in this chapter are methods for creating powerful static electrical fields in the atmosphere and powerful, stable electrical charges of small size which allow levitation (flight) of people, cars, and vehicles in the air. The author also shows how this method can be utilized into and out of a space ship (space hotel) or on an asteroid surface for creating artificial gravity. The author believes this method has applications in many fields of technology.

Magnetic levitation has been widely discussed in the literature for a long time. However, there are few scientific works related to electrostatic levitation. Electrostatic charges have a high voltage and can create corona discharges, breakthrough and relaxation. The Earth's electrostatic field is very weak and useless for flight. That is why many innovators think that electrostatic forces cannot be useful for levitation.

The author's first innovations in this field which changed this situation were offered in (1982)[1], and some practical applications were given in (1983)[1] Ch.15[2]. The idea was published in 1990 [1] Ch.15[3],p. 79[3]. In the following presented work, these ideas and innovations are researched in more detail. Some projects are also presented to allow estimation of the parameters of the offered flight systems.

Brief description of innovation

It is known that like electric charges repel, and unlike electric charges attract (Fig. 1a,b,c). A large electric charge (for example, positive) located at altitude induces the opposite (negative) electric charge at the Earth's surface (Figs. 1d,e,f,g) because the Earth is an electrical conductor. Between the upper and lower charges there is an electric field. If a small negative electric charge is placed in this electric field, this charge will be repelled from the like charges (on the Earth's surface) and attracted to the upper charge (Fig. 1d). That is the electrostatic lift force. The majority of the lift force is determined by the Earth's charges because the small charges are conventionally located near the Earth's surface. As shown below, these small charges can be connected to a man or a car and have enough force to lift and supports them in the air.

The upper charge may be located on a column as shown in Fig. 1d,e,f,g or a tethered air balloon (if we want to create levitation in a small town) (Fig. 1e), or air tube (if we want to build a big highway), or a tube suspended on columns (Fig.3-1f,g). In particular, the charges may be at two identically charged plates, used for a non-contact train (Fig.3- 3a).

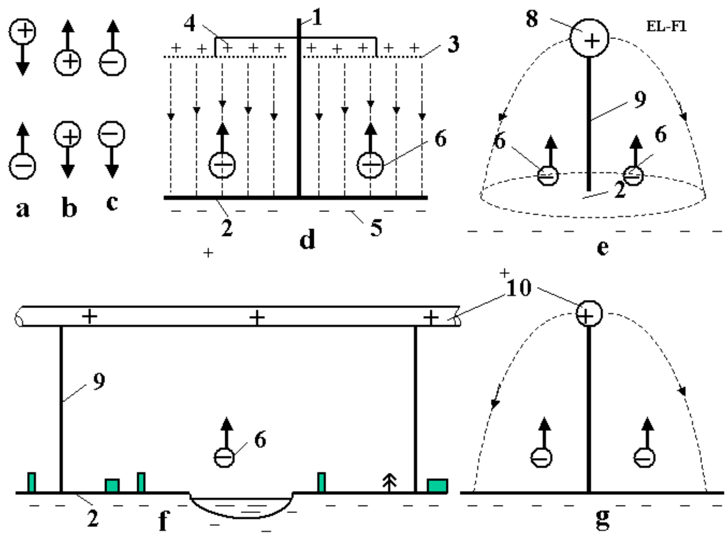

Fig. 3-1. Explanation of electrostatic levitation: a) Attraction of unlike charges; b,c) repulsion of like charges; d) Creation of the homogeneous electric field (highway); e) Electrical field from a large spherical charge ; f,g) Electrical field from a tube (highway) (side and front views). Notations are: 1, 9 – column, 2 – Earth (or other) surface charged by induction, 3 – net, 4 – upper charges, 5 – lower charges, 6 – levitation apparatus, 8 – charged air balloon, 9 – column, 10 – charged tube.

A lifting charge may use charged balls. If a thin film ball with maximum electrical intensity of below 3×10^6 V/m is used, the ball will have a radius of about 1 m (the man mass is 100 kg). For a 1 ton car, the ball will have a radius of about 3 m (see the computation below and Fig. 3-2g,h,i). If a higher electric intensity is used, the balls can be small and located underneath clothes (see below and Fig. 3-2 a,b,c).

The offered method has big advantages in comparison to conventional vehicles (Figs.3-1 and 3-2):

1) No very expensive highways are necessary. Rivers, lakes, forests, and buildings are not obstacles for this method.
2) In given regions (Figs. 3-1 and 3-2) people (and cars) can move at high speeds (man up 70 km/hour and cars up to 200–400 km/hour) in any direction using simple equipment (small balls under their clothing and small engines (Fig. 3- 2a,b,c)). They can perform vertical takeoffs and landings.
3) People can reduce their weight and move at high speed, jump a long distance, and lift heavy weights.
4) Building high altitude homes will be easier.

This method can be also used for a levitated train and artificial gravity in space ships, hotels, and asteroids (Fig. 3-3a,b).

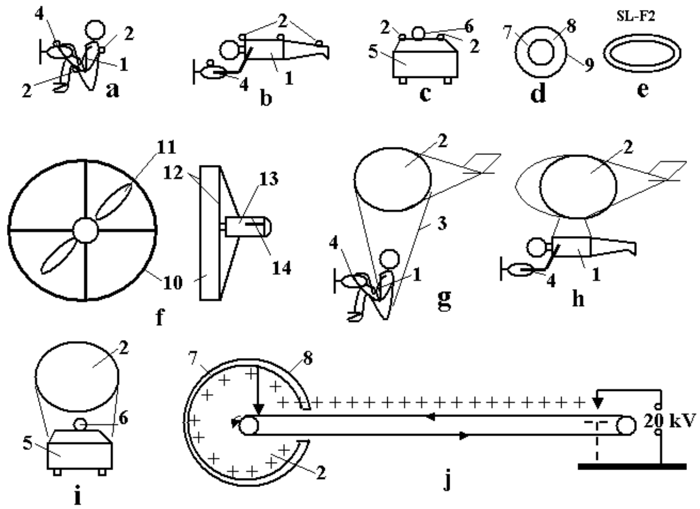

Fig. 3-2. Levitation apparatus: a,b) Single levitated man (mass up to 100 kg) using small highly charged balls 2. a) Sitting position; b) Reclining position; c) Small charged ball for levitating car; d) Small highly charged ball; e) Small highly charged cylindrical belt; f) Small air engine (forward and side views); g) Single levitated man (mass up to 100 kg) using a big non-highly charged ball which doesn't have an ionized zone (sitting position); h) The some man in a reclining position; i) Large charged ball to levitate a car which doesn't have an ionized zone; j) Installation for charging a ball using a Van de Graaff electrostatic generator (double generator potentially reaches 12 MV) in horizontal position. Notations: 1 – man; 2 – charged lifting ball; 4 – handheld air engine; 5 – car; 6 – engine (turbo-rocket or other); 7 – conducting layer; 8 – insulator (dielectric); 9 – strong cover from artificial fibers or whiskers; 10 – lagging; 11 – air propeller; 12 – preventive nets; 13 – engine; 14 – control knobs.

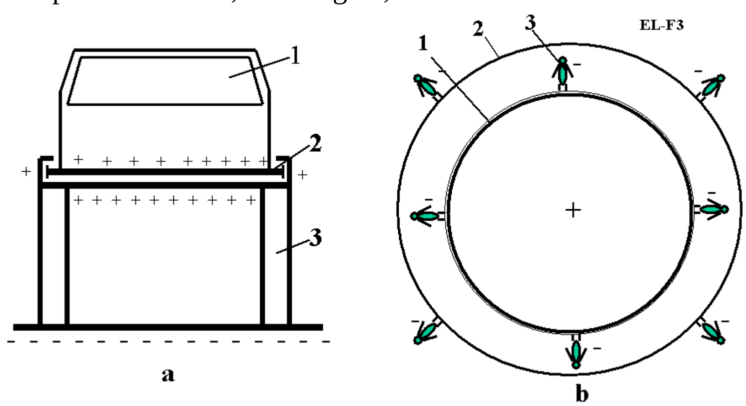

Fig. 3-3. Levitated train on Earth and artificial gravity into and on space ships and asteroids. a) Levitated train; b) Artificial gravity on a space ship. Notation: a) 1 – train; 2 – charged plates; 3 – insulated column; b) 1 – charged space body; 2 – space ship; 3 – man.

A space ship (hotel) definitely needs artificial gravity. Any slight carelessness in space can result in the cosmonaut, instruments or devices drifting away from the space ship. Presently, they are connected to the space ship by cables, but this is not comfortable for working. Science knows only two methods of producing artificial gravity and attractive forces: rotation of space ship and magnetism. Both methods are bad. The rotation creates artificial gravity only inside the space ship (hotel). Observation of space from a rotating ship is very difficult. The magnetic force is only effective over a very short distance. The magnets stick together and a person has to expend a large effort to move (it is the same as when you are moving on a floor smeared with glue).

If then is a charge inside the space ship and small unlike charges attached to object elsewhere, then will fall back to the ship if they are dropped.

The same situation occurs for cosmonauts on asteroids or small planets which have very little gravity. If you charge the asteroid and cosmonauts with unlike electric charges, the cosmonauts will return to the asteroid during any walking and jumping.

The author acknowledges that this method has problems. For example, we need a high electrical intensity if we want to use small charged balls. This problem (and others) is discussed below.

Projects

Let us estimate the main parameters for some offered applications. Most people understand the magnitudes and properties of applications better than theoretical reasoning and equations. The suggested application parameters are not optimal, but our purpose is to show the method can be utilized by current technology.

1. Levitation Highway (Fig.1d).

The height of the top net is 20 m. The electrical intensity is $E_o = 2.5\times10^6$ V < $E_c = (3–4)\times10^6$ V. The voltage between the top net and the ground is $U = 50\times10^6$ V. The width of each side of the road is 20 m. We first find the size of the lifting ball for the man (100 kg), car (1000 kg), or track (10,000 kg). Here R_c is the radius of the ionized zone [m]:

1) Flying man (mass M = 100 kg, ε = 3, $E_i = 200\times10^6$ V/m, g $\approx$10 m/s^2)

$$E_a \le \varepsilon E_i = 3\times 200\times 10^6, \quad a = \sqrt{\frac{kMg}{E_0 E_a}} = \sqrt{\frac{9\times10^9\times100\times10}{2{,}5\times10^6\times6\times10^8}} \approx 0.08\ m, \quad R_c = \sqrt{\frac{E_a}{E_c}} \approx 1\ m.$$

Notice that the radius of a single ball supporting the man is only 8 cm, or the man can use two balls a = 5–6 cm., R_c=0.75 m (or even more smaller balls). If the man uses a 1 m cylindrical belt, the radius of the belt cross-section area is 1.1 cm, σ = 100 kg/mm^2, $E_a = 600\times10^6$ V/m ([1] Figs. 15.10 and 15.11). The belt may be more comfortable for some people.

2) With the same calculation you can find that a car of mass M = 1000 kg will be levitated using a single charged ball a = 23 cm, R_c = 3.2 m (or two balls with a = 16 cm. R_c = 2.3 m).

3) A truck of mass M = 10,000 kg will be levitated using a single charged ball a = 70 cm, R_c = 10 m (or two balls with a = 0.5 m. R_c = 7 m).

2. Levitating tube highway

Assume the levitation highway has the design of Fig. 1f,g where the top net is changed to a tube. Take the data $E_o = 2.5\times10^6$ V < $E_c = (3–4)\times10^6$ V, $E_a = 2\times10^8$ V/m, h = 20 m. This means the electrical intensity, E_o, at ground level is the same as in the previous case. The required radius, a, of the top tube is

$$\frac{a}{h} = \frac{E_0}{2E_a} = 0.00625, \quad a = 0.00624h = 0.125\ m, \quad R_c = a\frac{E_a}{E_0} = 10\ m.$$

The diameter of the top tube is 0.25 m, the top ionized zone has a radius of 10 m.

3. Charged ball located on a high mast or tower

Assume there is a mast (tower) 500 m high with a ball of radius a = 32 m at its top charged up to E_a = 3×10^8 V/m. The charge is

$$q = \frac{a^2 E_a}{k} = 34\ C, \quad E_0 = k\frac{2q}{h^2} = 2.45\times10^6\ V/m \quad .$$

This electrical intensity at ground level means that within a radius of approximately 1 km, people, cars and other loads can levitate.

4. Levitation in low cumulonimbus and thunderstorm clouds

In these clouds the electrical intensity at ground level is about $E_o = 3\times10^5 - 10^6$ V/m. A person can take more (or more highly charged) balls and levitate.

5. Artificial gravity on space ship's or asteroids

Assume the space ship is a sphere with an inner radius at a = 10 m and external radius of 13 m. We can create the electrical intensity $E_o = 2.5\times10^6$ V/m without an ionized zone. The electrical charge is $q = a^2E_o/k = 2.8\times10^{-2}$ C. For a man weighing 100 kg (g = 10 m/s^2, force F = 1000 N), it is sufficient to have a charge of $q = F/E_o = 4\times10^{-4}$ C and small ball with a = 0.1 m and $E_a = qk/a^2 = 3.6\times10^8$ V/m. In outer space at the ship's surface, the artificial gravity will be $(10/13)^2 = 0.6 = 60\%^{10}$ of g.

6. Charged ball as an accumulator of energy and rocket engine

The computations show the relative *W/M* energy calculated from safe tensile stress does not depend on E_a. A ball cover with a tensile stress of σ = 200 kg/mm^2 reaches 2.2 MJ/kg. This is close to the energy of conventional powder (3 MJ/kg). If whiskers or nanotubes are used the relative electrical storage energy will be close to than of liquid rocket fuel.

Two like charged balls repel one another and can give significant acceleration for a space vehicle, VTOL aircraft, or weapon.

Discussion

Electrostatic levitation could create a revolution in transportation, building, entertainment, aviation, space flights, and the energy industry.

The offered method needs development and testing. The experimental procedure it is not expensive. We just need a ball with a thin internal conducting layer, a dielectric cover, and high voltage charging equipment. This experiment can be carried out in any high voltage electric laboratory. The proposed levitation theory is based on proven electrostatic theory. There may be problems may be with discharging, blockage of the charge by the ionized zone, breakdown, and half-life of the discharge, but careful choice of suitable electrical materials and electric intensity may be also to solve them. Most of these problems do not occur in a vacuum.

Another problem is the affects of the strong electrostatic field on a living organism. Only experiments using animals can solve this. In any case, there are protection methods – conducting clothes or vehicle is (from metal or conducting paint) which offer a defense against the electric field.

4. A New Method of Atmospheric Reentry for Space Ships*

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.

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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 See also [2] Ch. 8.

Introduction

In 1969 author applied a new method of global optimization to the problem of atmospheric reentry of spaceships ([2] Ch.8, Ref. [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] Ch.8, Ref.[2]-[4]).

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.

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").

Figure 4-1. Space Shuttle "Atlantic". during reentry.

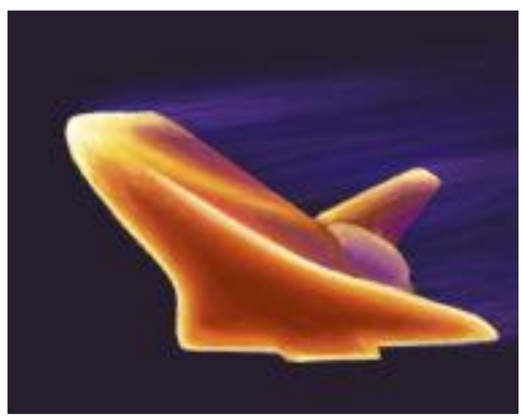
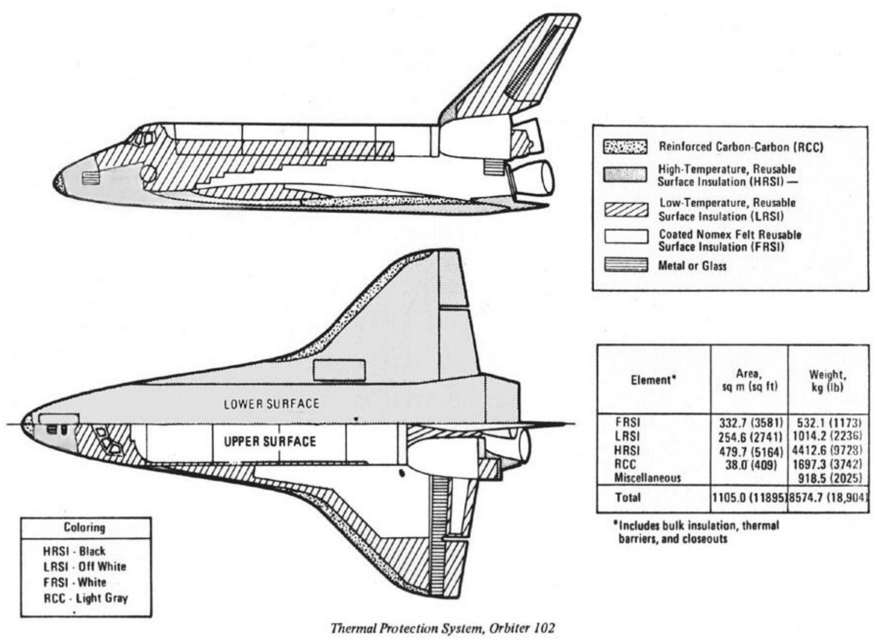


Figure 4-2. The outside of the Shuttle heats to over 1,550 °C

Figure 4-3. Endeavour deploys drag chute after touch-down.



Element*	Area, sq m (sq ft)	Weight, kg (lb)
FRSI	332.7 (3581)	532.1 (1173)
LRSI	254.6 (2741)	1014.2 (2236)
HRSI	479.7 (5164)	4412.6 (9728)
RCC	38.0 (409)	1697.3 (3742)
Miscellaneous		918.5 (2025)
Total	1105.0 (11895)	8574.7 (18,904)

Figure 4-4. Space Shuttle Thermal Protection System Constituent Materials

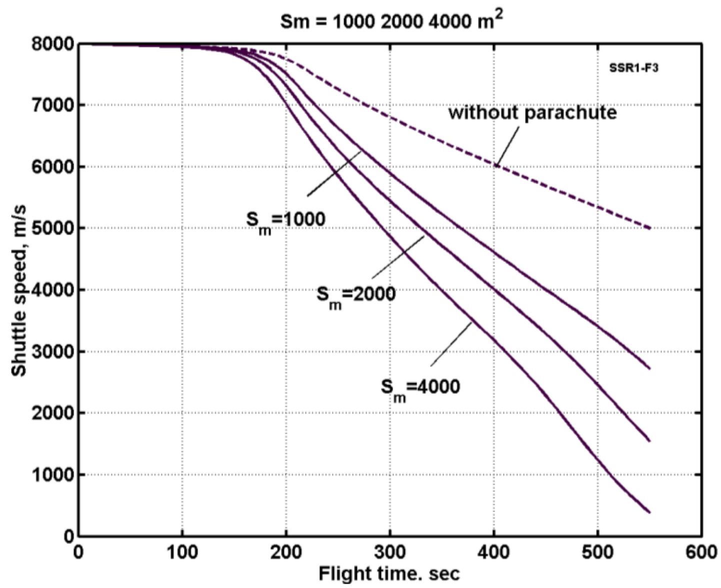


Figure 4-5. Decreasing of Space Shuttle speed with parachute and without it. $S_m = S_P$.

5. Inflatable Dome for Moon, Mars, Asteroids and Satellites*

On a planet without atmosphere, sustaining human life is very difficult and dangerous, especially during short sunlit period when low temperature prevails. To counter these environmental stresses, the author offer an innovative artificial "Evergreen" dome, an inflated hemisphere with interiors continuously providing a climate like that of Florida, Italy and Spain. The "Evergreen" dome theory is developed, substantiated by computations that show it is possible for current technology to construct and heat large enclosed volumes inexpensively. Specifically, a satisfactory result is reached by using high altitude magnetically supported sunlight reflectors and a special double thin film as an enclosing skin, which concentrates solar energy inside the dome while, at the same time, markedly decreasing the heat loss to exterior space. Offered design may be employed for settlements on the Moon, Mars, asteroids and satellites.

Introduction

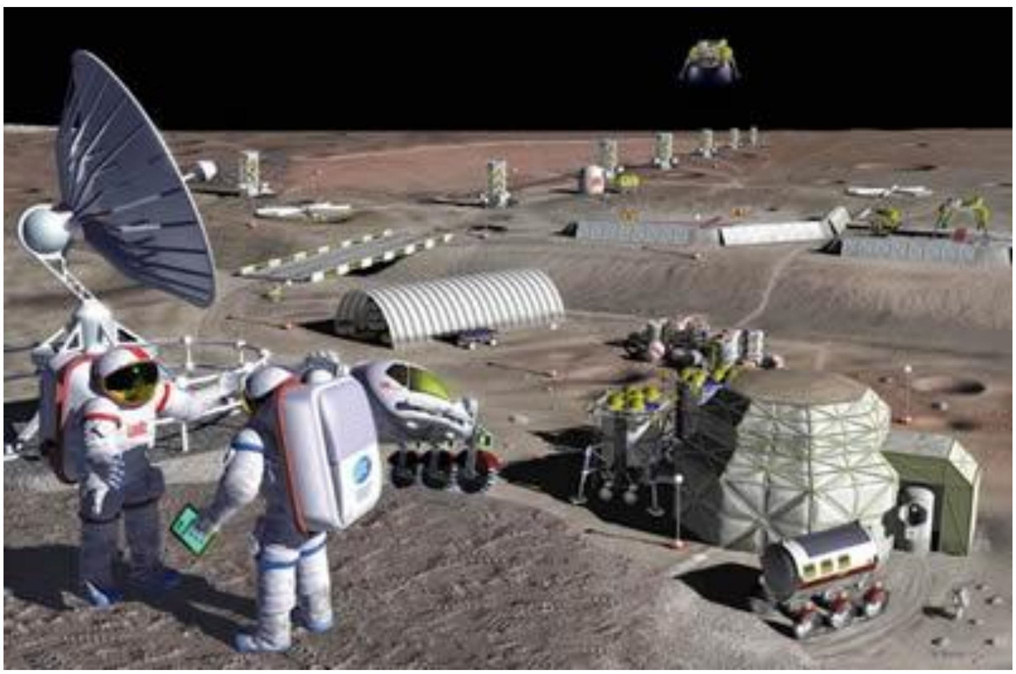
The real development of outer space (permanent human life in space) requires two conditions: all-sufficient space settlement and artificial life conditions close to those prevailing currently on the Earth. (Such a goal extends what is already being attempted in the Earth-biosphere—for example at the 1st Advanced Architecture Contest, “Self-Sufficient Housing”, sponsored by the Institute for Advanced Architecture of Catalonia, Spain, during 2006.) The first condition demands production of all main components needed for human life: food, oxidizer, and energy within the outer space and Solar System body colony.

* Presented as paper AIAA-2007-6262 to AIAA Conference "Space-2007", 18-20 September 2007, Long Beach. CA, USA. Published in http://arxiv.org. See also [3] Ch.2.

The second requisite condition is a large surface settlement having useful plants, attractive flowers, splashing water pools, walking and sport areas, etc. All these conditions may be realized within large 'greenhouses' [1] that will produce food, oxidizer and "the good life" conditions.
Human life in outer space and on other planetary or planet-like places will be more comfortable if it uses A.A. Bolonkin's macro-project proposal - staying in outer space without special spacesuit [2], p. 335 (mass of current spacesuit reaches 180 kg). The idea of this paper may be used also for control of Earth's regional and global weather and for converting our Earth's desert and cold polar zone regions into edenic subtropical gardens ([3] Ch.2, Ref.[3]-[4]).

The current conditions in Moon, Mars and Space are far from comfortable. For example, the Moon does not have any useful atmosphere, the day and night continues for 14 Earth days each, there are deadly space radiation and meteor bombardments, etc.

Especially during wintertime, Mars could provide only a meager and uncomfortable life-style for humans, offering low temperatures, strong winds. The distance north or south from that planet's equator is amongst the most significant measured environmental variables underlying the physical differences of the planet. In other words, future humans living in the Moon and Mars must be more comfortable for humans to explore and properly exploit these distant and dangerous places.



Moon base.

'Evergreen' Inflated Domes

Possibly the first true architectural attempt at constructing effective artificial life-support systems on the climatically harsh Moon will be the building of greenhouses. Greenhouses are maintained nearly automatically by heating, cooling, irrigation, nutrition and plant disease management equipment. Humans share commonalities in their responses to natural environmental stresses that are stimulated by night cold, day heat, absent atmosphere, so on. Darkness everywhere inflicts the same personal visual discomfort and disorientation as cosmonauts/astronauts experience during their space-walks—that of being adrift in featureless space! With special clothing and shelters, humans can adapt successfully to the well-landmarked planet Mars, for example. Incontrovertibly, living on the Moon, beneath Mars' low-density atmosphere is difficult, even when tempered by strong conventional protective buildings.

Our macro-engineering concept of inexpensive-to-construct-and-operate "Evergreen" inflated surface domes is supported by computations, making our macro-project speculation more than a daydream. Innovations are needed, and wanted, to realize such structures upon the Moon of our unique but continuously changing life.

Description and Innovations

Dome.

Our basic design for the Moon-Mars people-housing "Evergreen" dome is presented in Figure 5-1, which includes the thin inflated double 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 0.2 to 0.4 mm) without rigid supports; (3) the enclosing film is a two-layered structural 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 the film has control transparency and a thin aluminum layer about 1 μ or less that functions as the gigantic collector of 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 [also known as, "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 thickness. Real-time control of the sunlight's entrance into the dome and nighttime heat's exit is governed by the shingle-like louvers or a controlled transparency of the dome film.

Variant 1 of artificial inflatable Dome for Moon and Mars is shown in Figure 5-1. Dome has top thin double film 4 covered given area and single under ground layer 6. The space between layers 4 - 6 is about 3 meters and it is filled by air. The support cables 5 connect the top and underground layers and Dome looks as a big air-inflated beach sunbathing or swimming mattress. The Dome includes hermetic sections connected by corridors 2 and hermetic lock chambers 3. Topmost film controls the dome's transparency (and reflectivity). That allows people to closely control temperature affecting those inside the dome. Topmost film also is of a double-thickness. When a meteorite pushes hole in the topmost double film, the lowermost layer closes the hole and puts temporary obstacles in the way of the escaping air. Dome has a fruitful soil layer, irrigation system, and cooling system 9 for supporting a selected given humidity. That is, a closed-biosphere with a closed life-cycle that regularly produces an oxidizer as well as sufficient food for people and their pets, even including some species of farm animals. Simultaneously, it is the beautiful and restful Earth-like place of abode. The offered design has a minimum specific mass, about 7-12 kg/m^2 (air - 3 kg, film - 1 kg, soil - 3 - 8 kg). Mass of an example area of 10×10 m is about 1 metric ton (oftentimes spelt "tonnes"). Figure 2 illustrates the second thin transparent dome cover we envision. The Dome has double film: semispherical layer (low pressure about 0.01 - 0.1 atmosphere, atm.) and lower layer (high 1 atm. pressure). The hemispherical inflated textile shell—technical "textiles" can be woven (weaving is an interlacement of warp and weft) or non-woven (homogenous 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 × 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 micrometeorites; the film incorporates a tiny electrically-conductive wire net with a mesh of about 0.001 x 0.001 m and a line width of about 100 μ and a thickness near 1μ. The wire net can inform the "Evergreen" dome supervisors (human or automated equipment) concerning the place and size of film damage (tears, rips, punctures, gashes); the film is twin-layered with the gap — *c* = 1 m and *b* = 2 m—between the layer covering. This multi-layered covering is the main means for heat insulation and anti-puncture safety of a single layer because piercing won't cause a loss of shape since the film's second layer is unaffected by holing; the airspace in the dome's twin-layer covering can be partitioned, either hermetically or not; and part of the covering may have a very thin shiny aluminum coating that is about 1μ for reflection of non-useful or undesirable impinging solar radiation.

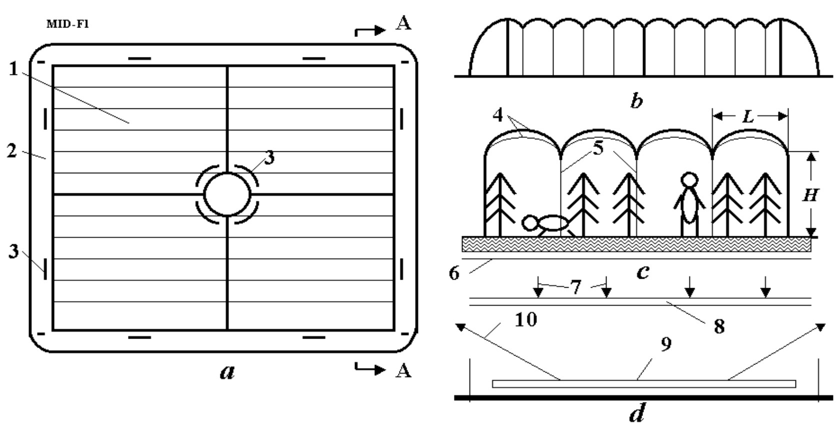


Figure 5-1. Variant 1 of artificial inflatable Dome for Moon and Mars. (a) top view of dome; (b) cross-section AA area of dome; (c) inside of the Dome; (d) Cooling system. Notations: 1 - internal section of Dome; 2 - passages; 3 - doors; 4 - transparence thin double film ("textiles") with control transparency; 5 - support cables; 6 - lower underground film; 7 - solar light; 8 - protection film; 9 - cooling tubes; 10 - radiation of cooling tubes.

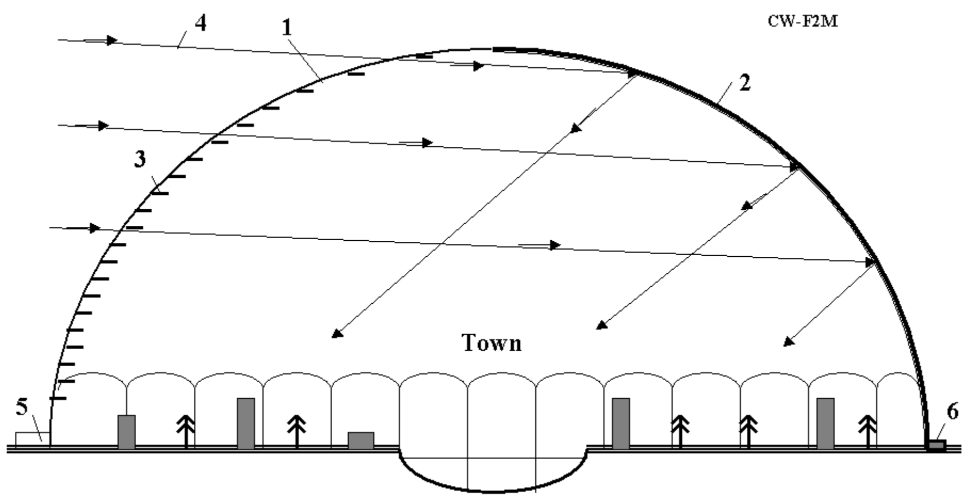


Figure 5-2. Variant 2 of artificial inflatable Dome for Moon and Mars. Notations: 1 - transparent thin double film ("textiles"); 2 - reflected cover of hemisphere; 3 - control louvers (jalousie); 4 - solar beams (light); 5 - enter (dock chamber); 6 - water extractor from air. The lower section has air pressure about 1 atm. The top section has air pressure of 0.01 - 0.1 atm.

Offered inflatable Dome can cover a big region (town) and create beautiful Earth-like conditions on an outer space solid body (Figure 5-4a). In future, the “Evergreen” dome can cover a full planetary surface (Moon, Mars, asteroid) (Figure 5-4b). Same type of domes can cover the Earth's lands, converting them (desert, cool regions) into beautiful gardens with controlled weather and closed material life cycles.

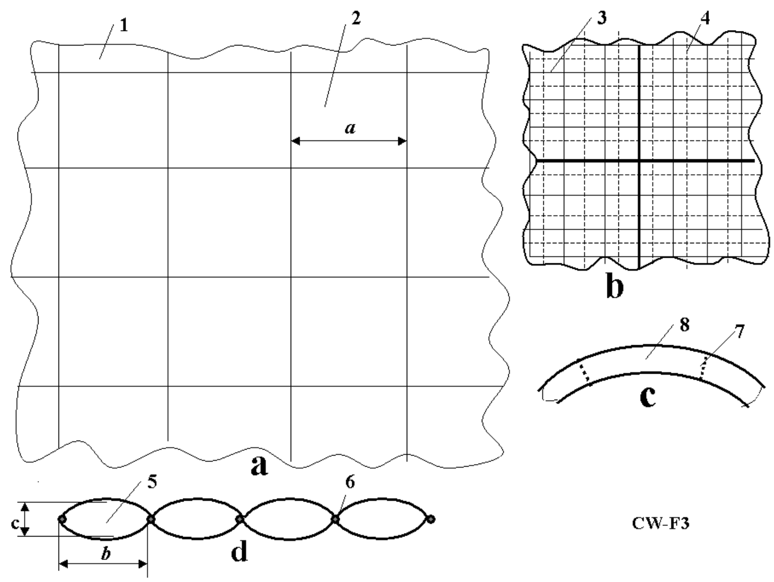


Figure 5-3. Design of “Evergreen” cover. Notations: (a) Big fragment of cover; (b) Small fragment of cover; (c) Cross-section of cover; (d) Longitudinal cross-section of cover; 1 - cover; 2 -mesh; 3 - small mesh; 4 - thin electric net; 5 - sell of cover; 6 - tubes; 7 - film partition (non hermetic); 8 - perpendicular cross-section area.

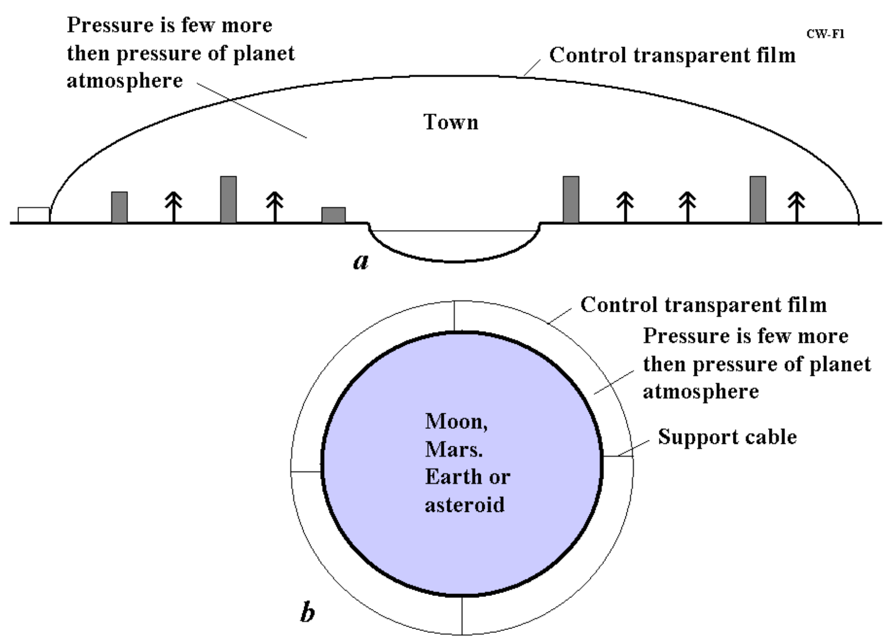


Figure 5-4. (*a*) Inflatable film dome over a single town; (*b*) Inflatable film dome covering a planet (Moon, Mars) and asteroid. Same type of domes can cover the Earth's extreme climate regions and convert them (desert, cool regions) into beautiful gardens with controlled weather and closed life cycles.

Location, Illumination and Defending Human Settlements from Solar Wind and Space Radiation

The Moon makes one revolution in about 29 Earth days. If we want to have conventional Earth artificial day and natural solar lighting, the settlement must locate near one or both of the Moon's poles and have a magnetic control mirror suspended at high altitude in given (stationary) place (Figure 5-5). For building this mirror (reflector) may use idea and theory of magnetic levitation developed by A.A. Bolonkin in [3] Ch.2, Ref.[5]. If reflector is made with variable focus, as in [3] p. 306, Figure 16.3, then it may well be employed as a concentrator of sunlight and be harnessed for energy during "night" (Earth-time).

The second important feature of the offered installation is defense of the settlement from solar wind and all cosmic radiation. It is known that the Earth's magnetic field is a natural defense for living animals, plants and humans against high-energy particles, such as protons, of the solar wind. The artificial magnetic field near Moon settlement is hundreds of times stronger than the Earth's magnetic field. It will help to defend delicate humans. The polar location of the planned settlement also decreases the intensity of the solar wind. Location of human settlement in polar zone(s) Moon craters also decreases the solar wind radiation. People can move to an underground cosmic radiation protective shelter, a dugout or bunker, during periods of high Sun activity (solar flashes, coronal mass ejections).

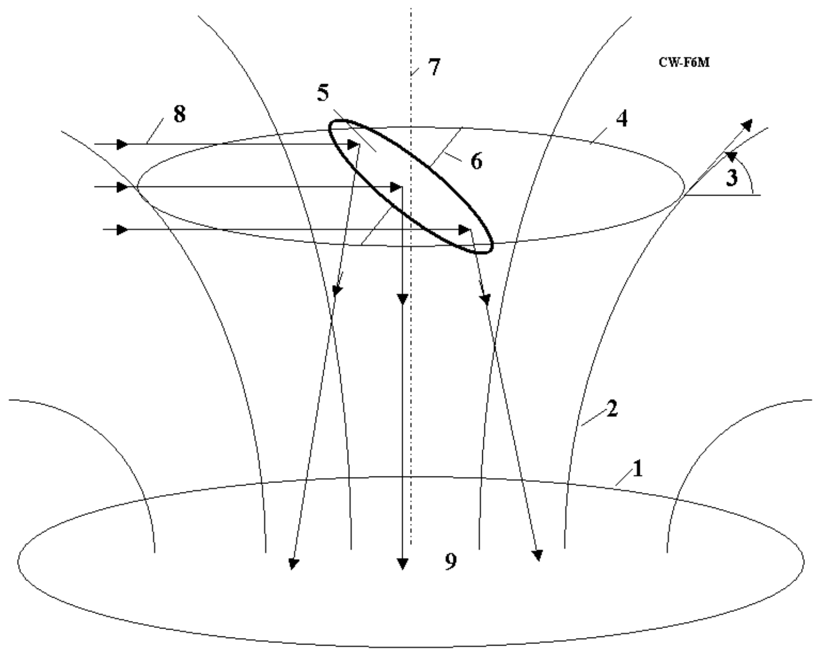


Figure 5-5. Magnetic control mirror is suspended at high altitude over human Moon settlement. Notations: 1 -superconductivity ground ring; 2 - magnetic lines of ground superconductivity ring; 3 -angle (α) between magnetic line of the superconductivity ground ring and horizontal plate (see Eq. (6)); top superconductivity ring for supporting the mirror (reflector) 5; 6 - axis of control reflector (which allows turning of mirror); 7 - vertical axis of the top superconductivity ring; 8 - solar light; 9 – human settlement.

The theory and computation of this installation is in theoretical section, below. The mass of the full reflector (rings, mirror, head screens is about 70 - 80 kg; if the reflector is used also as powerful energy source, then the mass can reach 100 - 120 kg. Note: for lifting, the reflector does not need a rocket. The magnetic force increases near ground (see Eq. (3)). This force lifts the reflector to the

altitude that is required by its usage. The reflector also will be structurally stable because it is located in magnetic hole of a more powerful ground ring magnet.
The artificial magnetic field may be used, too, for free flying of men and vehicles, as it is described in [4]-[5]. If a planet does not have enough gravity, then electrostatic artificial gravity may be used [3], Ch. 15.

The magnetic force lifts the reflector to needed altitude.

Figure 6 illustrates a light-weight, possibly portable house, using the same basic construction materials as the dwelling/workplace.

Inflatable Space Hotel

We live during the 21st Century when Earthly polar tourism is just becoming a scheduled pastime and the world public anticipates outer space tourism. The offered inflatable outer space (satellite) hotel for tourists is shown in Figure 7. That has the common walking area (garden) covered by a film having the controlled transparency (reflectivity), internal sections (living rooms, offices, restaurants, concert hall, storage areas, etc.). Hotel has electrostatic artificial gravity [3], and magnetic field. The electrostatic artificial gravity creates usual Earth environment, the magnetic field allows people to easily fly near the outer space hotel and still be effectively defended from the dangerous, and sometimes even lethal, solar wind.

Hotel has electrostatic artificial gravity and magnetic field that will permit people to freely fly safely near the hotel even when radiation in outer space is closely present and intense.

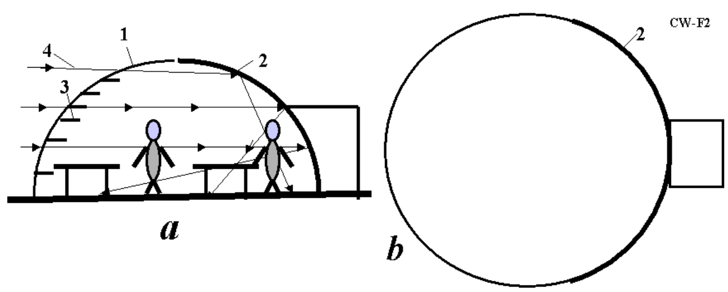


Figure 5-6. Inflatable film house for planet. Notation: (a) Cross-section area; (b) Top view. The other notations are same with Figure 5-2.

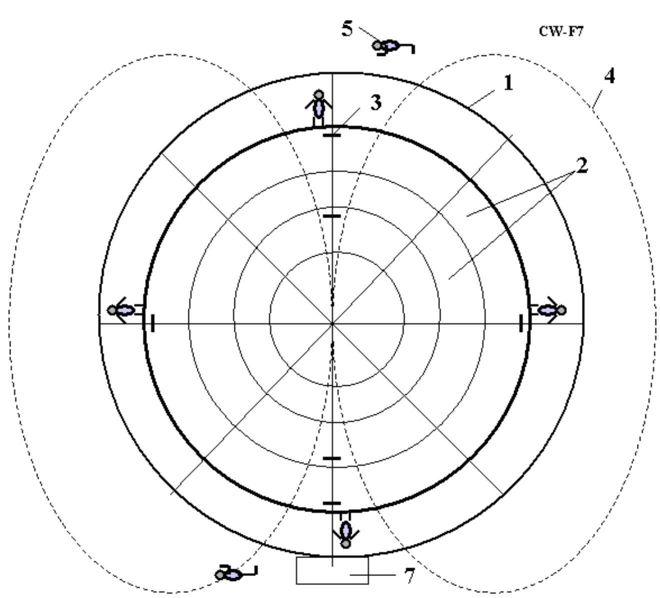


Figure 5-7. Inflatable space (satellite) hotel. Notations: 1 - inflatable hotel (control transparency cover film); 2 - internal sections of hotel (living rooms, offices, café, music hall, storage, etc.); 3 - door and windows in internal sections; 4 - magnetic line; 5 – outer space flying person (within hotel's magnetic field, [5]); 6 - common walking area (garden). 7 - docking chamber.

Visit Outer Space without a Spacesuit.

Current spacesuit designs are very complex and expensive "machines for living". They must, at minimum, unfailingly support human life for some period of time. However, the spacesuit makes a cosmonaut/astronaut barely mobile, slow moving, prevents exertive hard work, creates bodily discomfort such as pain or irritations, disallows meals in outer space, has no toilet, etc. Mass of current spacesuits is about 180 kg. Cosmonauts/Astronauts—these should be combined into "Spationauts" as the 20th Century descriptions were derived from Cold War superpower competition—must have spaceship or special outer space home habitat located not far from where they can undress for eating, toilet, and sleep as well as rest.

Why do humans need the special spacesuit in outer space, or on atmosphere-less bodies of the Solar System? There is only one reason – we need an oxygen atmosphere for breathing, respiration. Human evolution in the Earth-biosphere has created lungs that aerate our blood with oxygen and delete the carbonic acid. However, in a particularly harsh environment, we can do it more easily by artificial apparatus. For example, surgeons when they perform surgery on heart or lungs connect the patient to the apparatus "Heart-lung machine", temporarily stopping the patient's respiration and hear-beat. In [3] at p. 335, it is suggested that a method exists by donating some human blood, with the use of painless suture needles, is possible and that the blood can then be passed through artificial "lungs", just as is done in hospitals today.

We can design a small device that will aerate people's blood with oxygen infusion and delete the carbonic acid. To make offshoots from main lungs arteries to this device, we would turn on/off the artificial breathing at anytime and to be in vacuum (asteroid or planet without atmosphere) or bad or poisonous atmosphere, underwater a long time. In outer space we can be in conventional spacesuit defending the wearer from harmful solar light. Some type of girdle-like total body wrapping is required to keep persons in outer space from expanding explosively.

This idea may be checked with animal experiments in the Earth. We use the current "Heart-Lung" medical apparatus and put an animal under bell glass and remove the air inside the bell jar.
We can add into the blood all appropriate nutrition and, thusly, be without normal eating food for a long period of time; it is widely known that many humans in comas have lived fairly comfortably for many years entirely with artificial nourishment provided by drip injection.

The life possible in outer space without spacesuit will be easier, comfortable and entirely safe.

Macro-Projects

The dome shelter innovations outlined here can be practically applied to many cases and climatic regimes. We suggest initial macro-projects could be small (10 m diameter) houses (Figure 6) followed by an "Evergreen" dome covering a land area 200 m × 1000 m, with irrigated vegetation, homes, open-air swimming pools, playground, "under the stars style" concert hall.

The house and "Evergreen" dome have several innovations: magnetic suspended Sun reflector, double transparent insulating film, controllable jalousies coated with reflective aluminum (or film with transparency control properties and/or structures) 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. Its film enclosure material would have a thickness of 0.0003 m with a total mass of about 100 kg.

A city-enclosing "Evergreen" dome of 200 m × 1000 m (Figure 2, 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 0.0003 m thickness and about 200 tonnes. If the "Evergreen" dome were formed with concrete 0.25 m thick, the mass of the city-size envelope would be 200×10^3 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 or thousands of kilometers into outer space to the planet where they would be assembled by highly-paid but risk-taking construction workers. Our film is flexible and plastically deformable. It can be relatively cheap in terms of manufacturing cost. The single greatest boon to "Evergreen" dome construction, whether on the Moon, in Mars or elsewhere, is the protected cultivation of plants under a protective dome that efficiently captures energy from the available and technically harnessed sunlight.

Discussion

As with any innovative macro-project proposal, the reader will naturally have many questions. We offer brief answers to the two most obvious questions our readers are likely to ponder.

(1) *Cover damage.*

The envelope contains a rip-stopping cable mesh so that the film cannot be damaged greatly. Its structured cross-section of double layering governs the escape of air inside the living realm. Electronic signals alert supervising personnel of all ruptures and permit a speedy repair effort by well-trained responsive emergency personnel. The topmost cover has a strong double film.

(2) *What is the design-life of the dome film covering?*

Depending on the kinds of materials used, it may be as much a decade (up 30 years). In all or in part, the durable cover can be replaced periodically as a precautionary measure by its owners.

Conclusion

Utilization of "Evergreen" domes can foster the fuller economic development of the Moon, Mars and Earth itself - thus, increasing the effective area of territory dominated by humans on, at least, three celestial bodies. 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 Earth's Tropics and Temperate Zone. Eventually, "Evergreen" domes may find application on the Moon or Mars since a vertical variant, inflatable space towers [1], are soon to become available for launching spacecraft inexpensively into Earth orbit or on to long-duration interplanetary outer spaceflights.

6. AB Method of Irrigation on planet without Water (Closed-loop Water Cycle)*

Author methodically researched a revolutionary Macro-engineering idea for a closed-loop

* Presented in electronic library of Cornel University http://arxiv.org in 27 December 2007. See also [3] Ch.1.

freshwater irrigation and in this chapter it is unveiled in some useful detail. We offer to cover a given site by a thin, enclosure film (with controlled heat conductivity and clarity) located at an altitude of 50 – 300 m. The film is supported, at its working altitude, by small additional induced air over-pressuring, and anchored to the ground by thin cables. We show that this closed dome allows full control of the weather within at a given planetary surface region (the day is always fine, it will rain only at night, no strong winds). The average Earth (white cloudy) reflectance equals 0.3 - 0.5. Consequently, Earth does lose about 0.3 - 0.5 of the maximum potential incoming solar energy. The dome (having control of the clarity of film and heat conductivity) converts the cold regions to controlled subtropics, hot deserts and desolate wildernesses to prosperous regions blessed temperate climate. This is, today, a realistic and cheap method of evaporation-economical irrigation and virtual weather control on Earth!

Description and Innovations

Our idea is a closed dome covering a local region by a thin film with controlled heat conductivity and optionally-controlled clarity (reflectivity, albedo, carrying capacity of solar spectrum)(Fig.6-1). The film is located at an altitude of ~50 – 300 m. The film is supported at this altitude by a small additional air pressure produced by ventilators sitting on the ground. The film is connected to Earth's surface by tethering cables. The cover may require double-layer film. We can control the heat conductivity of the dome cover by pumping in air between two layers of the dome film cover and change the solar heating due to sunlight heating by control of the cover's clarity. That allows selecting for different conditions (solar heating) in the covered area and by pumping air into dome. Envisioned is a cheap film having liquid crystal and conducting layers. The clarity is controlled by application of selected electric voltage. These layers, by selective control, can pass or blockade the available sunlight (or parts of solar spectrum) and pass or blockade the Earth's radiation. The incoming and outgoing radiations have different wavelengths. That makes control of them separately feasible and, therefore, possible to manage the heating or cooling of the Earth's surface under this film. In conventional conditions about 50% of the solar energy reaches the Earth surface. Much is reflected back to outer space by white clouds that shade approximately 65% of the Earth's land/water surface. In our closed water system the rain (or at least condensation) will occur at night when the temperature is low. In open atmosphere, the Sun heats the ground; the ground must heat the whole troposphere (4 – 5 km) before stable temperature rises happen. In our case, the ground heats ONLY the air in the dome (as in a hotbed). We have, then, a literal greenhouse effect. That means that many cold regions (Alaska, Siberia, northern Canada) may absorb more solar energy and became a temperate climate or sub-tropic climate (under the dome, as far as plants are concerned). That also means the Sahara and other deserts can be a prosperous regions with a fine growing and living climate and with a closed-loop water cycle.

The building of a film dome is easy. We spread out the film over Earth's surface, turn on the pumping propellers and the film is raised by air over-pressure to the needed altitude limited by the support cables. Damage to the film is not a major trouble because the additional air pressure is very small (0.0001- 0.01 atm) and air leakage is compensated for by spinning propeller pumps. Unlike in an outer space colony or extra-Earth planetary colony, the outside air is friendly and, at worst, we might lose some heat (or cold) and water vapor.

The first main innovation of our dome, and its main difference from a conventional hotbed, or glasshouse, is the inflatable HIGH span of the closed cover (up to 50 – 300 m). The elevated height of the enclosed volume aids organizing of a CLOSED LOOP water cycle - accepting of water vaporized by plants and returning this water in the nighttime when the air temperature decreases. That allows us to perform irrigation in the vast area of Earth's land that does not have enough freshwater for agriculture. We can convert the desert and desolate wildernesses into Eden-like gardens without expensive delivery of remotely obtained and transported freshwater. The initial amount of freshwater for water cycle may be collected from atmospheric precipitation in some period or delivered. Prime soil is not a necessity because hydroponics allows us to achieve record harvests on any soil.

The second important innovation is using a cheap controlled heat conductivity, double-layer cover (controlled clarity is optionally needed for some regions). This innovation allows to conserve solar heat (in cold regions), to control temperature (in hot climates). That allows two to three rich crops annually in the Earth's middle latitudes and to conversion of the cold zones (Siberia, northern Canada, Alaska) to good single-crop regions.

The third innovation is control of the cover height, which allows adapting to local climatic seasons.

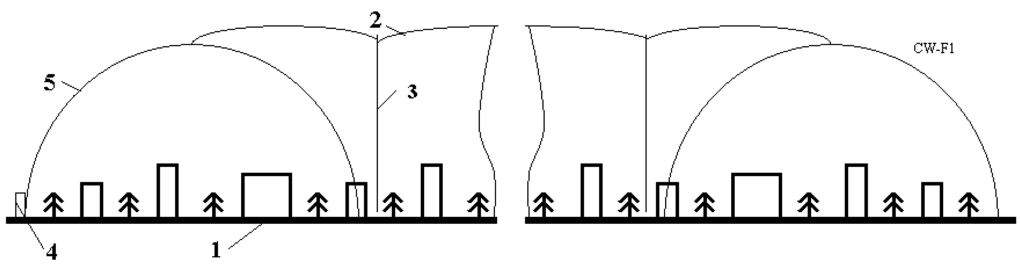


Figure 6-1. Film dome over agriculture region or a city. *Notations*: 1 - area, 2 - thin film cover with a control heat conductivity and clarity, 3 – control support cable and tubes for rain water (height is 50 – 300 m), 4 - exits and ventilators, 5 - semi-cylindrical border section.

The fourth innovation is the use of cheap, thin film as the high altitude cover. This innovation decreases the construction cost by thousands of times in comparison with the conventional very expensive glass-concrete domes offered by some for city use.

Lest it be objected that such domes would take impractical amounts of plastic, consider that the world's plastic production is today on the order of 100 million metric tons. If, with the expectation of future economic growth, this amount doubles over the next generation, and the increase is used for doming over territory at 500 tons a square kilometer, about 200,000 square kilometers could be roofed over annually. While small in comparison to the approximately 150 million square kilometers of land area, consider that 200,000 1 kilometer sites scattered over the face of the Earth made newly inhabitable could revitalize vast swaths of land surrounding them—one square kilometer could grow local vegetables for a city sited in the desert, one over there could grow bio-fuel, enabling a desolate South Atlantic island to become independent of costly fuel imports; at first, easily a billion people a year could be taken out of sweltering heat, biting cold and drenching rains, saving money that purchase, installation and operation of HVAC equipment—heating, ventilation, air-conditioning—would require.

Our dome design is presented in Figure 1 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 controlled clarity and controlled heat conductivity 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 6-2); (4) the bounded section of the dome proposed that has a hemispheric shape (#5, Figure 6-1). The air pressure is greater in these sections, and they protect the central sections from wind outside.

Figure 1 illustrates the thin transparent control dome cover we envision. The inflated textile shell—technical "textiles" can be woven or films—embodies the innovations listed: (1) the film is very thin, approximately 0.1 to 0.3 mm., implying under 500 tons per square kilometer. 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 of 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. It can inform the dome maintenance engineers concerning the place and size of film damage (tears, rips); (4) the film may be twin-layered with the gap — $c = 1$ m and $b = 2$ m—between film layers for heat insulation. In Polar (and hot Tropic) regions this multi-layered covering is the main means for heat isolation and puncture of one of the layers wont cause a loss of shape because the second film 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 (micron) for reflection of unneeded sunlight in the equatorial region, or collect additional solar radiation in the polar regions [1].

The authors offer a method for moving off the accumulated snow and ice from the film in polar regions. After snowfall we decrease the heat cover protection, heating the snow (or ice) by warm air flowing into channels 5 (Figure 2) (between cover layers), and water runs down into tubes 3 (Figure 6-3).

The town cover may be used as a screen for projecting of pictures, films and advertising on the cover at nighttime.

Brief Data on Cover Film

Our dome filmic cover has 5 layers (Figure 4c): 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. This film may be produced by industry relatively cheaply.

1. Liquid Crystals (LC)

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 general employment 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. On command, the electric field can be used to make a pixel switch between clear or dark. Color LCD systems use the same technique, with color filters used to generate red, green, and blue pixels. Similar principles can be used to make other liquid crystal-based optical devices. Liquid crystal in fluid form is used to detect electrically generated hotspots for failure analysis in the semiconductor industry.

Liquid crystal memory units with extensive capacity were used in the USA's Space Shuttle navigation equipment. Worth noting also is the fact 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 (transparancy) film reflected all superfluous energy to outer space. If the film has solar cells then it may convert the once superfluous solar energy into harnessed electricity.

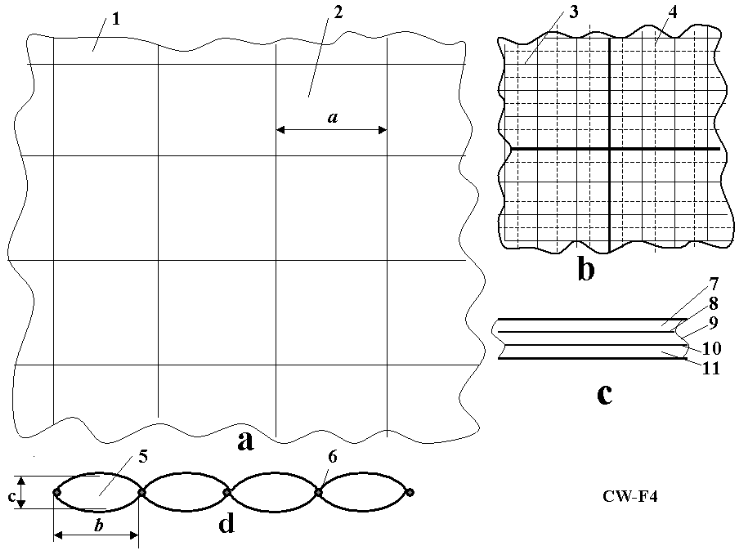


Figure 6-2. Design of membrane covering. *Notations*: (a) Big fragment of cover with control clarity (reflectivity, carrying capacity) and heat conductivity; (b) Small fragment of cover; (c) Cross-section of cover (film) having 5 layers; (d) Longitudinal cross-section of cover for cold and hot regions; 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.

2. Transparency

In optics, transparency is the material property of passing natural and artificial light through any material. Though transparency usually refers to visible light in common usage, it may correctly be used to refer to any type of radiation. Examples of transparent materials are air and some other gases, liquids such as water, most non-tinted glasses, and plastics such as Perspex and Pyrex. The degree of material transparency varies according to the wavelength of the light. From electrodynamics it results that only a vacuum is really transparent in the strictist meaning, any matter has a certain absorption for electromagnetic waves. There are transparent glass walls that can be made opaque by the application of an electric charge, a technology known as electrochromics. Certain crystals are transparent because there are straight-lines through the crystal structure. Light passes almost unobstructed along these lines. There exists a very complicated scientific theory "predicting" (calculating) absorption and its spectral dependence of different materials.

3. Electrochromism

Electrochromism is the phenomenon displayed by some chemical species of reversibly changing color when a burst of electric charge is applied.

One good example of an electrochromic material is polyaniline which can be formed either by the electrochemical or chemical oxidation of aniline. If an electrode is immersed in hydrochloric acid which contains a small concentration of aniline, then a film of polyaniline can be grown on the electrode. Depending on the redox state, polyaniline can either be pale yellow or dark green/black. Other electrochromic materials that have found technological application include the viologens and polyoxotungstates. Other electrochromic materials include tungsten oxide (WO_3), which is the main chemical used in the production of electrochromic windows or smart windows.

As the color change is persistent and energy need only be applied to effect a change, electrochromic materials are used to control the amount of light and heat allowed to pass through windows ("smart windows"), and has also been applied in the automobile industry to automatically tint rear-view mirrors in various lighting conditions. Viologen is used in conjunction with titanium dioxide (TiO_2) in the creation of small digital displays. It is hoped that these will replace LCDs as the viologen (which is typically dark blue) has a high contrast to the bright color of the titanium white, therefore providing a high visibility of the display.

Conclusion

One half of Earth's human population is chronically malnourished. *The majority of Earth's surface area is not suitable for unshielded human life*. The increasing of agriculture area, crop capacity, carrying capacity by means of converting the deserts, desolate wildernesses, taiga, tundra permafrost into gardens are an important escape-hatch from some of humanity's most pressing macro-problems. The offered cheapest ($\$0.1\div 0.3/m^2$) AB method may dramatically increase the potentially realizable sown area, crop capacity; indeed the range of territory suitable for human living. In theory, converting all Earth land such as Alaska, northern Canada, Siberia, or the Sahara or Gobi deserts into prosperous gardens would be the equivalent of colonizing another Solar System planet. The suggested method is very cheap (cost of covering 1 m^2 is about 10 - 30 USA cents) and may be utilized immediately. We can start from small regions, such as towns in bad regions and, gradually, extend the practice over a large region—and what is as important, earning monetary profits most of the time.

Filmic domes can foster the fuller economic development of dry, hot, and cold regions such as the Earth's Arctic and Antarctic, the Sahara and, thus, increase the effective area of territory dominated by 21st Century 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, technical adaptations 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 [12].

The related problems are researched in references [1]-[12].

Let us shortly summarize some advantages of this offered AB Dome method of climate moderation:

(1) Method does not need large amounts of constant input freshwater for irrigation;
(2) Low cost of inflatable filmic Dome per area reclaimed: (10 - 30 cents/m^2);
(3) Control of inside temperature is total;
(4) Usable in very hot and cool climate regions;
(5) Covered region is not at risk from exterior weather;
(6) Possibility of flourishing crops even with a sterile hydroponics soil;
(7) 2 – 3 harvests each year; without farmers' extreme normal risks.
(8) Rich harvests, at that.
(9) Converting deserts, desolate wildernesses, taiga, tundra, permafrost terrain, and the ocean into gardens;
(10) Covering towns and cities with low-cost, even picturesque domes;
(11) Using the dome cover for income-generating neighborhood illumination, picture displays, movies and videos as well as paid advertising.

We can concoct generally agreeable local weather and settle new territory for living with an agreeable climate (without daily rain, wind and low temperatures) for agriculture. By utilizing thin film, gigantic territorial expanses of dry and cold regions can be covered. Countries having big territory (but also much bad land) may be able to use domes to increase their population and became powerful states during the 21st Century.

The offered method may be used to conserve a vanishing sea such as the Aral Sea or the Dead Sea. A closed-loop water cycle could save these two seas for a future generation of people, instead of bequeathing a salty dustbowl.

A.A. Bolonkin has further developed the same method for the ocean. By controlling the dynamics and climate there, oceanic colonies may increase the Earth's humanly useful region another three times concurrent with or after the doubling of useful land outlined above. Our outlined method would allow the Earth's human population to increase by 5 – 10 times, without the starvation.

The offered method can solve the problem of apparent problem of global warming because the AB domes will be able to confine until use much carbon dioxide gas which appreciably increases a harvest. This carbon dioxide gas will show up in yet more productive crop harvests! The dome lift-force reaches up to 300 kg/m^2. The telephone, TV, electric, water and other communications can be suspended from the dome cover.

The offered method can also help to defend cities (or an entire given region) from rockets, nuclear warheads, and military aviation. Details are offered in a later chapter. This method may be applied to other planets and satellites as Moon and Mars.

7. Artificial Explosion of Sun and AB-Criterion for Solar Detonation*

The Sun contains ~74% hydrogen by weight. The isotope hydrogen-1 (99.985% of hydrogen in nature) is a usable fuel for fusion thermonuclear reactions.

This reaction runs slowly within the Sun because its temperature is low (relative to the needs of nuclear reactions). If we create higher temperature and density in a limited region of the solar interior, we may be able to produce self-supporting detonation thermonuclear reactions that spread to the full solar volume. This is analogous to the triggering mechanisms in a thermonuclear bomb. Conditions within the bomb can be optimized in a small area to initiate ignition, then spread to a larger area, allowing producing a hydrogen bomb of any power. In the case of the Sun certain targeting practices may greatly increase the chances of an artificial explosion of the Sun. This explosion would annihilate the Earth and the Solar System, as we know them today.

The reader naturally asks: Why even contemplate such a horrible scenario? It is necessary because as thermonuclear and space technology spreads to even the least powerful nations in the centuries ahead, a dying dictator having thermonuclear missile weapons can produce (with some considerable mobilization of his military/industrial complex)— an artificial explosion of the Sun and take into his grave the whole of humanity. It might take tens of thousands of people to make and launch the hardware, but only a very few need know the final targeting data of what might be otherwise a weapon purely thought of (within the dictator's defense industry) as being built for peaceful, deterrent use.

Those concerned about Man's future must know about this possibility and create some protective system—or ascertain on theoretical grounds that it is entirely impossible.

Humanity has fears, justified to greater or lesser degrees, about asteroids, warming of Earthly climate, extinctions, etc. which have very small probability. But all these would leave survivors -- nobody thinks that the terrible annihilation of the Solar System would leave a single person alive. That explosion appears possible at the present time. In this paper is derived the 'AB-Criterion' which shows conditions wherein the artificial explosion of Sun is possible. The author urges detailed investigation and proving or disproving of this rather horrifying possibility, so that it may be dismissed from mind—or defended against.

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* This work is written together J. Friedlander. He corrected the author's English, wrote together with author Abstract, Sections 8, 10 ("Penetration into Sun" and "Results"), and wrote Section 11 "Discussion" as the solo author. See also [4] Ch.10.

Statement of Problem, Main Idea and Our Aim

The present solar temperature is far lower than needed for propagating a runaway thermonuclear reaction. In Sun core the temperature is only ~13.6 MK (0.0012 MeV). The Coulomb barrier for protons (hydrogen) is more then 0.4 MeV. Only very small proportions of core protons take part in the thermonuclear reaction (they use a tunnelling effect). Their energy is in balance with energy emitted by Sun for the Sun surface temperature 5785 K (0.5 eV).

We want to clarify: If we create a zone of limited size with a high temperature capable of overcoming the Coulomb barrier (for example by insertion of a thermonuclear warhead) into the solar photosphere (or lower), can this zone ignite the Sun's photosphere (ignite the Sun's full load of thermonuclear fuel)? Can this zone self-support progressive runaway reaction propagation for a significant proportion of the available thermonuclear fuel?

If it is possible, researchers can investigate the problems: What will be the new solar temperature? Will this be metastable, decay or runaway? How long will the transformed Sun live, if only a minor change? What the conditions will be on the Earth?

Why is this needed?

As thermonuclear and space technology spreads to even the least powerful nations in the decades and centuries ahead, a dying dictator having thermonuclear weapons and space launchers can produce (with some considerable mobilization of his military/industrial complex)— the artificial explosion of the Sun and take into his grave the whole of humanity.

It might take tens of thousands of people to make and launch the hardware, but only a very few need know the final targeting data of what might be otherwise a weapon purely thought of (within the dictator's defense industry) as being built for peaceful, 'business as usual' deterrent use. Given the hideous history of dictators in the twentieth century and their ability to kill technicians who had outlived their use (as well as major sections of entire populations also no longer deemed useful) we may assume that such ruthlessness is possible.

Given the spread of suicide warfare and self-immolation as a desired value in many states, (in several cultures—think Berlin or Tokyo 1945, New York 2001, Tamil regions of Sri Lanka 2006) what might obtain a century hence? All that is needed is a supportive, obedient defense complex, a 'romantic' conception of mass death as an ideal—even a religious ideal—and the realization that his own days at power are at a likely end. It might even be launched as a trump card in some (to us) crazy internal power struggle, and plunged into the Sun and detonated in a mood of spite by the losing side. *'Burn baby burn'!*

A small increase of the average Earth's temperature over 0.4 K in the course of a century created a panic in humanity over the future temperature of the Earth, resulting in the Kyoto Protocol. Some stars with active thermonuclear reactions have temperatures of up to 30,000 K. If not an explosion but an enchanced burn results the Sun might radically increase in luminosity for –say--a few hundred years. This would suffice for an average Earth temperature of hundreds of degrees over 0 C. The oceans would evaporate and Earth would bake in a Venus like greenhouse, or even lose its' atmosphere entirely.

Thus we must study this problem to find methods of defense from human induced Armageddon. The interested reader may find needed information in [4] Ch.10, Ref. [1]-[4].

Results of research

The Sun contains 73.46 % hydrogen by weight. The isotope hydrogen-1 (99.985% of hydrogen in nature) is usable fuel for a fusion thermonuclear reaction.

The p-p reaction runs slowly within the Sun because its temperature is low (relative to the temperatures of nuclear reactions). If we create higher temperature and density in a limited region of the solar interior, we may be able to produce self-supporting, more rapid detonation thermonuclear reactions that may spread to the full solar volume. This is analogous to the triggering mechanisms in a thermonuclear bomb. Conditions within the bomb can be optimized in a small area to initiate ignition, build a spreading reaction and then feed it into a larger area, allowing producing a 'solar hydrogen bomb' of any power—but not necessarily one whose power can be limited. In the case of the Sun certain targeting practices may greatly increase the chances of an artificial explosion of the entire Sun. This explosion would annihilate the Earth and the Solar System, as we know them today.

Author A.A. Bolonkin has researched this problem and shown that an artificial explosion of Sun cannot be precluded. In the Sun's case this lacks only an initial fuse, which induces the self-supporting detonation wave. This research has shown that a thermonuclear bomb exploded within the solar photosphere surface may be the fuse for an accelerated series of hydrogen fusion reactions.

The temperature and pressure in this solar plasma may achieve a temperature that rises to billions of degrees in which all thermonuclear reactions are accelerated by many thousands of times. This power output would further heat the solar plasma. Further increasing of the plasma temperature would, in the worst case, climax in a solar explosion.

The possibility of initial ignition of the Sun significantly increases if the thermonuclear bomb is exploded under the solar photosphere surface. The incoming bomb has a diving speed near the Sun of about 617 km/sec. Warhead protection to various depths may be feasible –ablative cooling which evaporates and protects the warhead some minutes from the solar temperatures. The deeper the penetration before detonation the temperature and density achieved greatly increase the probability of beginning thermonuclear reactions which can achieve explosive breakout from the current stable solar condition.

Compared to actually penetrating the solar interior, the flight of the bomb to the Sun, (with current technology requiring a gravity assist flyby of Jupiter to cancel the solar orbit velocity) will be easy to shield from both radiation and heating and melting. Numerous authors, including A.A. Bolonkin in works [7]-[12] offered and showed the high reflectivity mirrors which can protect the flight article within the orbit of Mercury down to the solar surface.

The author A.A. Bolonkin originated the AB Criterion, which allows estimating the condition required for the artificial explosion of the Sun.

Discussion

If we (humanity—unfortunately in this context, an insane dictator representing humanity for us) create a zone of limited size with a high temperature capable of overcoming the Coulomb barrier (for example by insertion of a specialized thermonuclear warhead) into the solar photosphere (or lower), can this zone ignite the Sun's photosphere (ignite the Sun's full load of thermonuclear fuel)? Can this zone self-support progressive runaway reaction propagation for a significant proportion of the available thermonuclear fuel?

If it is possible, researchers can investigate the problems: What will be the new solar temperature? Will this be metastable, decay or runaway? How long will the transformed Sun live, if only a minor change? What the conditions will be on the Earth during the interval, if only temporary? If not an explosion but an enhanced burn results the Sun might radically increase in luminosity for –say--a few hundred years. This would suffice for an average Earth temperature of hundreds of degrees over 0 ^{o}C. The oceans would evaporate and Earth would bake in a Venus like greenhouse, or even lose its' atmosphere entirely.

It would not take a full scale solar explosion, to annihilate the Earth as a planet for Man. (For a classic report on what makes a planet habitable, co-authored by Issac Asimov, see http://www.rand.org/pubs/commercial_books/2007/RAND_CB179-1.pdf 0.

Converting the sun even temporarily into a 'superflare' star, (which may hugely vary its output by many percent, even many times) over very short intervals, not merely in heat but in powerful bursts of shorter wavelengths) could kill by many ways, notably ozone depletion—thermal stress and atmospheric changes and hundreds of others of possible scenarios—in many of them, human civilization would be annihilated. And in many more, humanity as a species would come to an end.

The reader naturally asks: Why even contemplate such a horrible scenario? It is necessary because as thermonuclear and space technology spreads to even the least powerful nations in the centuries ahead, a dying dictator having thermonuclear missile weapons can produce (with some considerable mobilization of his military/industrial complex)— the artificial explosion of the Sun and take into his grave the whole of humanity. It might take tens of thousands of people to make and launch the hardware, but only a very few need know the final targeting data of what might be otherwise a weapon purely thought of (within the dictator's defense industry) as being built for peaceful, deterrent use.

Those concerned about Man's future must know about this possibility and create some protective system—or ascertain on theoretical grounds that it is entirely impossible, which would be comforting.

Suppose, however that some variation of the following is possible, as determined by other researchers with access to good supercomputer simulation teams. What, then is to be done?

The action proposed depends on what is shown to be possible.

Suppose that no such reaction is possible—it dampens out unnoticeably in the solar background, just as no fission bomb triggered fusion of the deuterium in the oceans proved to be possible in the Bikini test of 1946. This would be the happiest outcome.

Suppose that an irruption of the Sun's upper layers enough to cause something operationally similar to a targeted 'coronal mass ejection' – CME-- of huge size targeted at Earth or another planet? Such a CME like weapon could have the effect of a huge electromagnetic pulse. Those interested should look up data on the 1859 solar superstorm, the Carrington event, and the Stewart Super Flare. Such a CME/EMP weapon might target one hemisphere while leaving the other intact as the world turns. Such a disaster could be surpassed by another step up the escalation ladder-- by a huge hemisphere killing thermal event of ~12 hours duration such as postulated by science fiction writer Larry Niven in his 1971 story "Inconstant Moon"—apparently based on the Thomas Gold theory (ca. 1969-70) of rare solar superflares of 100 times normal luminosity. Subsequent research[18] (Wdowczyk and Wolfendale, 1977) postulated horrific levels of solar activity, ozone depletion and other such consequences might cause mass extinctions. Such an improbable event might not occur naturally, but could it be triggered by an interested party? A triplet of satellites monitoring at all times both the sun from Earth orbit and the ‘far side’ of the Sun from Earth would be a good investment both scientifically and for purposes of making sure no ‘creative’ souls were conducting trial CME eruption tests!

Might there be peaceful uses for such a capability? In the extremely hypothetical case that a yet greater super-scale CME could be triggered towards a given target in space, such a pulse of denser than naturally possible gas might be captured by a giant braking array designed for such a purpose to provide huge stocks of hydrogen and helium at an asteroid or moon lacking these materials for purposes of future colonization.

A worse weapon on the scale we postulate might be an asymmetric eruption (a form of directed thermonuclear blast using solar hydrogen as thermonuclear fuel), which shoots out a coherent (in the sense of remaining together) burst of plasma at a given target without going runaway and consuming the outer layers of the Sun. If this quite unlikely capability were possible at all (dispersion issues argue against it—but before CMEs were discovered, they too would have seemed unlikely), such an apocalyptic ‘demo’ would certainly be sufficient emphasis on a threat, or a means of warfare against a colonized solar system. With a sufficient thermonuclear burn –and if the condition of nondispersion is fulfilled—might it be possible to literally strip a planet—Venus, say—of its’ atmosphere? (It might require a mass of fusion fuel— and a hugely greater non-fused expelled mass comparable in total to the mass to be stripped away on the target planet.)

It is not beyond the limit of extreme speculation to imagine an expulsion of this order sufficient to strip Jupiter’s gas layers off the ‘Super-Earth’ within. —To strip away 90% or more of Jupiter’s mass (which otherwise would take perhaps ~400 Earth years of total solar output to disassemble with perfect efficiency and neglecting waste heat issues). It would probably waste a couple Jupiter masses of material (dispersed hydrogen and helium). It would be an amazing engineering capability for long term space colonization, enabling substantial uses of materials otherwise unobtainable in nearly all scenarios of long term space civilization.

Moving up on the energy scale-- “boosting” or “damping” a star, pushing it into a new metastable state of greater or lesser energy output for times not short compared with the history of civilization, might be a very welcome capability to colonize another star system—and a terrifying reason to have to make the trip.

And of course, in the uncontrollable case of an induced star explosion, in a barren star system it could provide a nebula for massive mining of materials to some future super-civilization. It is worth noting in this connection that the Sun constitutes 99.86 percent of the material in the Solar System, and Jupiter another .1 percent. Literally a thousand Earth masses of solid (iron, carbon) building materials might be possible, as well as thousands of oceans of water to put inside space colonies in some as yet barren star system.

But here in the short-term future, in our home solar system, such a capability would present a terrible threat to the survival of humanity, which could make our own solar system completely barren.

The list of possible countermeasures does not inspire confidence. A way to interfere with the reaction (dampen it once it starts)? It depends on the spread time, but seems most improbable. We cannot even stop nuclear reactions once they take hold on Earth—the time scales are too short.

Is defense of the Sun possible? Unlikely—such a task makes missile defense of the Earth look easy. Once a gravity assist Jupiter flyby nearly stills the velocity with which a flight article orbits the Sun, it will hang relatively motionless in space and then begin the long fall to fiery doom. A rough estimate yields only one or two weeks to intercept it within the orbit of Mercury, and the farther it falls the faster it goes, to science fiction-like velocities sufficient to reach Pluto in under six weeks before it hits.

A perimeter defense around the Sun? The idea seems impractical with near term technology.

The Sun is a hundred times bigger sphere than Earth in every dimension. If we have 10,000 ready to go interceptor satellites with extreme sunshields that function a few solar radii out each one must be able to intercept with 99% probability the brightening light heading toward its' sector of the Sun over a circle the size of Earth, an incoming warhead at around 600 km/sec.

If practical radar range from a small set is considered (4th power decline of echo and return) as 40,000 km then only 66 seconds would be available to plot a firing solution and arm for a destruct attempt. More time would be available by a telescope looking up for brightening, infalling objects—but there are many natural incoming objects such as meteors, comets, etc. A radar might be needed just to confirm the artificial nature of the in-falling object (given the short actuation time and the limitations of rapid storable rocket delta-v some form of directed nuclear charge might be the only feasible countermeasure) and any leader would be reluctant to authorize dozens of nuclear explosions per year automatically (there would be no time to consult with Earth, eight light-minutes away—and eight more back, plus decision time). But the cost of such a system, the reliability required to function endlessly in an area in which there can presumably be no human visits and the price of its' failure, staggers the mind. And such a 'thin' system would be not difficult to defeat by a competent aggressor...

A satellite system near Earth for destroying the rockets moving to the Sun may be a better solution, but with more complications, especially since it would by definition also constitute an effective missile defense and space blockade. Its' very presence may help spark a war. Or if only partially complete but under construction, it may invite preemption, perhaps on the insane scale that we here discuss…

Astronomers see the explosion of stars. They name these stars novae and supernovae—"New Stars" and try to explain (correctly, we are sure, in nearly all cases) their explosion by natural causes. But some few of them, from unlikely spectral classifications, may be result of war between civilizations or fanatic dictators inflicting their final indignity upon those living on planets of the given star. We have enough disturbed people, some in positions of influence in their respective nations and organizations and suicide oriented violent people on Earth. But a nuclear bomb can destroy only one city. A dictator having possibility to destroy the Solar System as well as Earth can blackmail all countries—even those of a future Kardashev scale 2 star-system wide civilization-- and dictate his will/demands on any civilized country and government. It would be the reign of the crazy over the sane.

Author A.A. Bolonkin already warned about this possibility in 2007 (see his interview http://www.pravda.ru/science/planet/space/05-01-2007/208894-sun_detonation-0 [4] Ch.10, Ref. [15] (in Russian) (A translation of this is appended at the end of this article) and called upon scientists and governments to research and develop defenses against this possibility. But some people think the artificial explosion of Sun impossible. This led to this current research to give the conditions where such detonations are indeed possible. That shows that is conceivably possible even at the present time using current rockets and nuclear bombs—and only more so as the centuries pass. Let us take heed, and know the risks we face—or disprove them.

The first information about this work was published in [4] Ch.10, Ref. [15]. This work produced the active Internet discussion in [4] Ch.10, Ref. [19]. Among the raised questions were the following:

1) It is very difficult to deliver a warhead to the Sun. The Earth moves relative to the Sun with a orbital velocity of 30 km/s, and this speed should be cancelled to fall to the Sun. Current rockets do not suffice, and it is necessary to use gravitational maneuvers around planets. For this reason (high delta-V (velocity changes required) for close solar encounters, the planet Mercury is so badly investigated (probes there are expensive to send).

Answer: The Earth has a speed of 29 km/s around the Sun and an escape velocity of only 11 km/s. But Jupiter has an orbital velocity of only 13 km/sec and an escape velocity of 59.2 km/s. Thus, the gravity assist Jupiter can provide is more than the Earth can provide, and the required delta-v at that distance from the Sun far less—enough to entirely cancel the sun-orbiting velocity around the Sun, and let it begin the long plunge to the Solar orb at terminal velocity achieving Sun escape speed 617.6 km/s. Notice that for many space exploration maneuvers, we require a flyby of Jupiter, exactly to achieve such a gravity assist, so simply guarding against direct launches to the Sun from Earth would be futile!

2) Solar radiation will destroy any a probe on approach to the Sun or in the upper layers of its photosphere.

Answer: It is easily shown, the high efficiency AB-reflector can full protection the apparatus. See [1] Chapters 12, 3A, [2] Ch.5, ref. [9]-[12].

3) The hydrogen density in the upper layers of the photosphere of the Sun is insignificant, and it would be much easier to ignite hydrogen at Earth oceans if it in general is possible.

Answer: The hydrogen density is enough known. The Sun has gigantic advantage – that is PLASMA. Plasma of sufficient density reflects or blocks radiation—it has opacity. That means: **no radiation losses in detonation**. It is very important for heating. The AB Criterion in this paper is received for PLASMA. Other planets of Solar system have MOLECULAR atmospheres which passes radiation. No sufficient heating – no detonation! The water has higher density, but water passes the high radiation (for example γ-radiation) and contains a lot of oxygen (89%), which may be bad for the thermonuclear reaction. This problem needs more research.

Summary

This is only an initial investigation. Detailed supercomputer modeling which allows more accuracy would greatly aid prediction of the end results of a thermonuclear explosion on the solar photosphere.

Author invites the attention of scientific society to detailed research of this problem and devising of protection systems if it proves a feasible danger that must be taken seriously.

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