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Abstract

This paper proposes a new method and transportation system to fly into space, to the Moon, Mars, and other planets. This transportation system uses a mechanical energy transfer and requires only minimal energy so that it provides a "Free Trip" into space. The method uses the rotary and kinetic energy of planets, asteroids, moons, satellites and other natural space bodies.

This paper contains the theory and results of computations for the following projects: 1. Non-Rocket Method for free launch of payload in Space and to other planets. The low cost project will accommodate one hundred thousand tourists annually. 2. Free Trips to the Mars for two thousand annually. 3. Free Trips to the Moon for ten thousand people annually.

The projects use artificial materials like nanotubes and whiskers that have a ratio of tensile strength to density equal 4 million meters. In the future, nanotubes will be produced that can reach a specific stress up 100 millions meter and will significantly improve the parameters of suggested projects.

The author is prepared to discuss the problems with serious organizations that want to research and develop these inventions.

Nomenclature (metric system):

a - relative cross-section area of cable (cable);
a_m - relative cross-section area of Moon cable (cable);
A - cross-section area of cable [m^2];
A_o - initial (near planet) cross-section area of cable [m^2];
C – cost of delivery 1 kg.
C_i – primary cost of installation [$].
D - distance from Earth to Moon [m], D_{min}=356,400 km, D_{max}=406,700 km;
D - specific density of the cable {kg/m^3];
E – delivery energy of 1 kg load mass [j];
g - gravity;
g_o - gravitation at the R_0 [m/s^2]; for Earth g_o=9.81 m/s^2;
g_m - gravitation on Moon surface [m/s^2];
F – force [n];
H – altitude [m];
H - cable tensile stress [n/m^2];

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H_p – perigee altitude [m];
$k = \sigma/\gamma$ – ratio of cable tensile stress to density [nm/kg];
$K = k/10$^7 – coefficient [million meters];
L – annual load [kg];
n – overload;
n– number of working days;
N_eS_e – annual employee salary [$];
M – equalizer mass [kg];
M_a – annual maintenance of installation [$};
M_e – finish mass of an Installation [kg];
M_o – load mass delivered in one day;
r – orbit perigee [m];
R - radius [m];
R_o - radius of planet [m];
R_g - radius of geosynchronous orbit [m];
R_m - radius of Moon [m];
T - orbit period (hours).
v - volume of a cable [m^3];
V_d – delivery speed [km/sec];
V_r – maximum admitted cable speed [m/sec];
V_1 - circulate speed [m/s];
V_2 - escape speed [m/s];
W - mass of a cable [kg];
W_r - relative mass of cable (cable to ship mass);
T - orbit period (hours);
Y – live time [years];
σ - (or H) tensile strength [n/m^2];
ω - angle speed of a planet [rad/sec];
ω_m - angle speed of the Moon [rad/sec].
γ - density of cable [kg/m^3].

Introduction

At present, rockets are used to deliver payloads into Space and to change the trajectory of space ships and probes. This method is very expensive in the requirement of fuel, which limits the feasibility of space stations, interplanetary space ships, and probes. Since 1997 the author has proposed a new revolutionary transport system for (1) delivering payloads and people into space, (2) accelerating a space ship for interplanetary flight, and (3) changing the trajectory of space probes. This method uses a mechanical energy transfer, energy of moved down loads, and the kinetic energy of planets, of natural planet satellites, of asteroids, and other space bodies. The author has not found an analog for this space mechanical energy transfer or similar facilities for transporting a payload to space in literature and patents.

The present method does not require geosynchronous orbit (which is absent from most planets, moons, and asteroids which have a weak gravitation) and instead, uses the kinetic and rotational energy of the space body to modify the trajectory and impart additional speed to the artificial space apparatus. The installation has a cable transport system and counterbalance, which is used for balancing the moving load. The cable is also used for launching or modifying the speed or direction the space vehicle.

Brief history. There are many articles that develop a tether method for a trajectory change of space vehicles [1]-[2] and there is an older idea of a space elevator (see reviews in [4]). In the tether method two artificial bodies are connected by cable. The main problem this method: that requires energy for increasing the rotation of the tether system (motorized tether [2]) is how to rotate it with a flexible cable and what to do with momentum after launch if the tether system is used again, etc. If this system used one time, it is worse then conventional rocket because it losses the second body and requires a large source of energy.

In the suggested method a balance, space vehicle is connected to a natural body (planet, asteroid, moon). The ship gets energy from the natural body and does not have to deal with the natural body in the future.

In the older idea, a space elevator is connected between a geosynchronous space station and the Earth by cable [4]. This cable is used to deliver a payload to the station. The main problems are the very large cable weight and a delivery of the energy for movement of the load container.

The other author non-rocket methods are presented in [3],[8]-[15].

In this suggested transport system the load engine is located on the Earth and transfers energy to the load container and to Space Station with a very simple method (see Project #1, capability is 100,000 tourists in year). The author also found and solved the differential equations of the cable for an equal stress for a complex Earth-Moon gravitation field which allows a decrease the cable weight by several times.

The main difference of the offered method is the use of the planet rotational energy for free trip to another planet, for example, Mars (see the project #2, capability is 2000 men of annually).

In project #3 wit a capability is 10,000 tourists in year, the author suggests the idea to connect Moon and Earth by a load cable. He solves the problem to transfer the energy to load container, finds the cable of equal stress, and shows a possibility of this project in the near future.

Brief Description, Theory, and Computation of Innovations

The objective of these innovations is to: a) provide an inexpensive means to travel to outer space and other planets, b) simplify space transportation technology, and c) eliminate complex hardware. This goal is obtained by new space energy transfer for long distance, by using either engines located on a planet (e.g., the Earth), the rotational energy of a planet (e.g. the Earth, the Mars, etc.), or the kinetic and rotational energy of the natural space bodies (e.g. asteroids, meteorites, comets, planet moons, etc.). Below is the theory and research for three projects, which can be completed in the near future.

1. Free trip to Space (Project #1)

Description. A proposed centrifugal space launcher with a cable transport system is shown in Fig.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 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

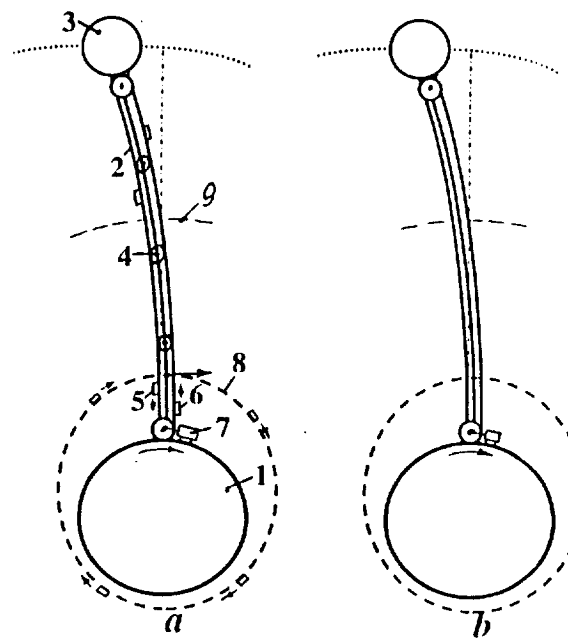

Fig.1a,b. The suggested Space Transport System. Notations: 1 – Rotary planet (for example, the Earth); 2 - suggested Space Transport System ; 3 - equalizer (counterweight); 4 - roller of Transport System; 5 - launch space ship; 6 - a return ship after flight ; 7 – engine of Transport System; 8 – elliptic orbit of tourist vehicles; 9 - Geosynchronous orbit. ***a*** – System for low coefficient ***k***, ***b*** – System for high coefficient ***k***.

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 only the required amount of cable is needed 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 the any conventional motor **located on the planet**. When payloads are not being delivered into the 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.

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 same position (Fig.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 they can connect back to transport system when ship is returned.

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 to the work of descent, except small loss in the upper and lower rollers. The suggested transport system lets us fly into space without spending enormous energy. This is reason why the method and system are named a "Free Trip".

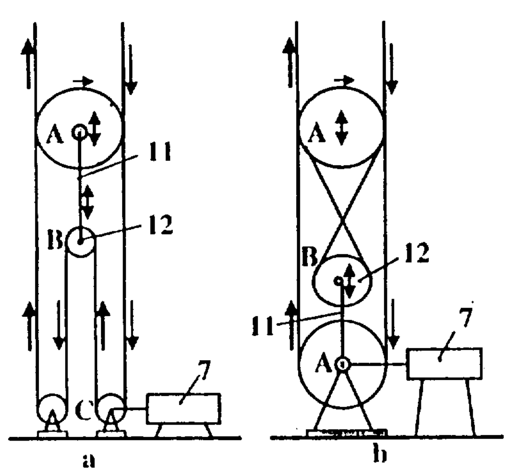

Fig.2a,b. Two mechanisms for changing the rope length in the Transport System (They are same for the space station). Notations: 11 - the rope which is connected axis ***A,B***. This rope can change its length (the distance ***AB***); 12 - additional rollers.

Devices shown on fig.2 are used to change the cable length (or chain length). If the cable material has a very high ratio of an admissible stress/density the chain may be one. The transport system then has only one main cable. This design has many problems, for example, in the transfer of large amounts of energy to the load cabin.

Theory and Computation

(in metric system)

1. The cable of equal stress for planet

The force actives in cable is

$$F=\sigma A=F_o+\int_{R_o}^{R} dG=F_o+\int_{R_o}^{R}\gamma A\,dR\,; \qquad (1)$$

where

$$\gamma=\gamma_o g_o[(R_o/R)^2-\omega^2/g_o]\,. \qquad (2)$$

Let us substitute (2) in (1) and difference to variable upper integral limit, we find the differential equations

$$dA/A=(\gamma_o g_o/\sigma)[(R_o/R)^2-\omega^2/g_o]\,dR. \qquad (3)$$

Solution to equation (3) is

$$a(R)=A/A_o=\exp[\gamma_o g_o B(R)/\sigma]; \qquad (4)$$

$$B(R)=R_o^2\{(1/R_o-1/R)-\omega^2[(R/R_o)^2-1]/2g_o\}.$$

where ***a*** is relative cable area.

The computation for different $K=\sigma/\gamma_o/10^7$ is presented in Fig.3.

As you see for ***K=2*** the cable area change in 11 times, but for very high ***K=30*** only in 1.19 times.

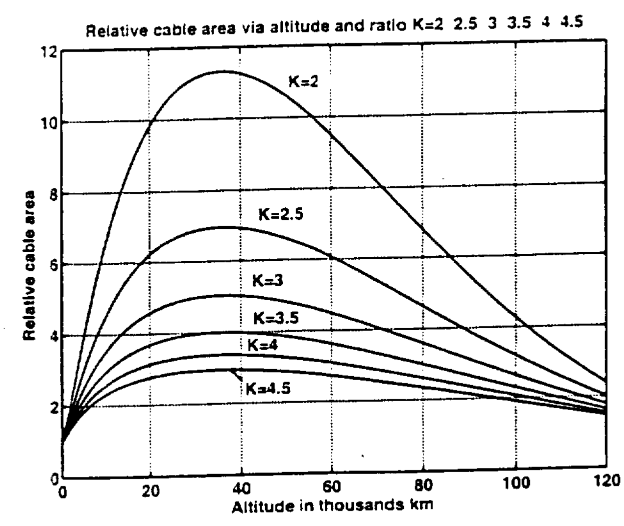

Fig.3. Relative cable area via altitude (in thousands km) for coefficient ***K***=2-4.5 .

2-3. The mass of the cable ***W*** and a volume ***v*** can be calculated by equations

$$v=A_o\int_{R_o}^{R} a\,dR=(F_o/kg_o)\int_{R_o}^{R} a\,dR;$$

$$W(R)=\gamma_o v=(F_o/k)\int_{R_o}^{R}\exp(\gamma g_o B/\sigma)dR\ ; \qquad (5)$$

The results of the computation of the cable mass for the load mass of 3000 kg (force 3000n) and cable density of 1800 kg/m^3 is presented in Fig.4.

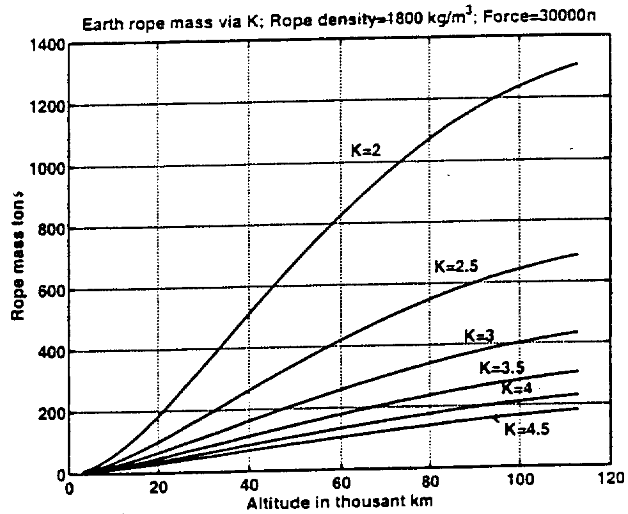

Fig.4. Cable mass in tons via counterweight altitude for Earth surface force of 3 tons, cable density 1800 kg/m^3, and K=2-4.5 .

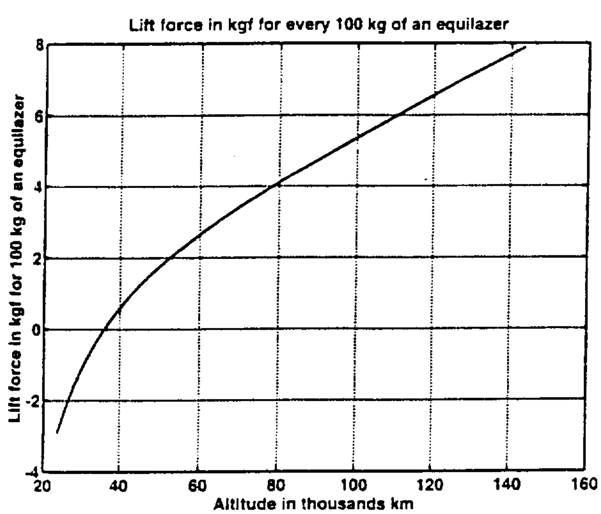

Fig.5. Lift force (in kgf) via altitude (in thousands km) for every 100 kg of a counterweight (equalizer).

4. The lift force of a mass of 1 kg, which is located over geosynchronous orbit and has speed $V>V_1$

$$\Delta F=(\omega^2R/g_o)-(R/R_o)^2 \quad [\text{kgf/kgm}]. \qquad (6)$$

The result of this computation is presented in Fig.5. Every 100 kg of a mass of the equalizer gives 5 kgf of lift force at the altitude 100,000 km.

5. The equalizer mass (counterweight) M for different radius (altitudes) R and K may be computed from the equilibrium equation and (6)

$$F_o a(R) + F_o = M[(\omega^2R/g_o)-(R/R_o)^2],$$
$$M = F_o[a(R)+1]/[(\omega^2R/g_o)-(R/R_o)^2]\ . \qquad (7)$$

Results of this computation are presented on Fig.6. For a lift force 10 tons at Earth (payload of 3000 kg), the equalizer mass is 518 tons for $K=4$ and about 435 tons for $K=10$ at the altitude 100 km.

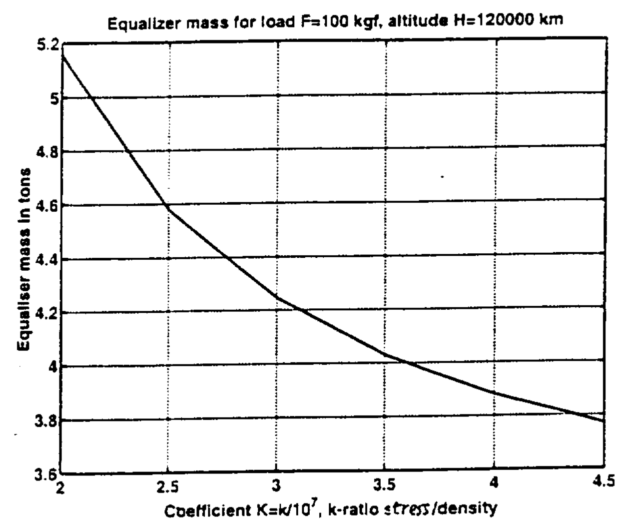

Fig.6. Counterweight for ground force 100 kgf (at Earth surface) via K=2-4.5 . (It is centrifugal force without force, which supports the cable of equal stress).

6. If the balance cabin (load) to be moved down is absent, then the delivery work of 1 kg mass may be computed by equation

$$E(R) = R_o^2\{(1/R_o-1/R)-\omega^2[(R/R_o)^2-1]/2g_o\}. \qquad (8)$$

When a space vehicle (satellite) is disconnected from the transport system before reaching the geosynchronous orbit, an orbit perigee r (perigee altitude H) and period time T can be computed by the equations

$$H = r - R_o,\quad r = uR/[1+u(2-u)]^{1/2},$$
$$T=\pi(r+R)/3600(c)^{0.5}, \qquad (9)$$

where $u=\omega^2R^2/c$, $c=3.986.10^{14}$.

The result of this computation is presented in Fig.7,8. When this space vehicle has a suitable position (after the return flight), the vehicle can be connected back to the transport system.

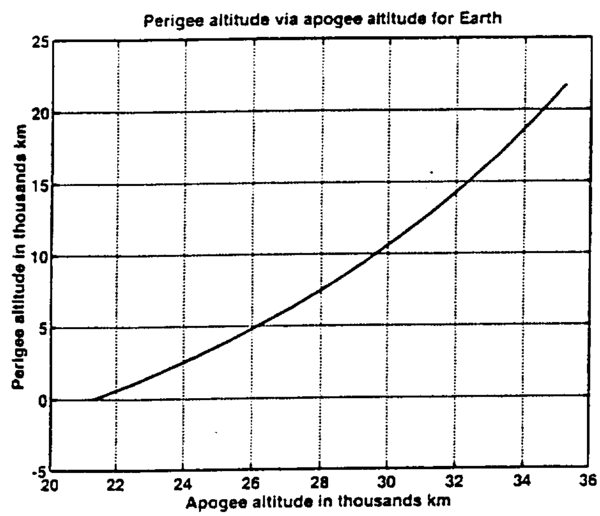

Fig.7. Perigee altitude (in thousands km) via disconnected (apogee) altitude of a space ship.

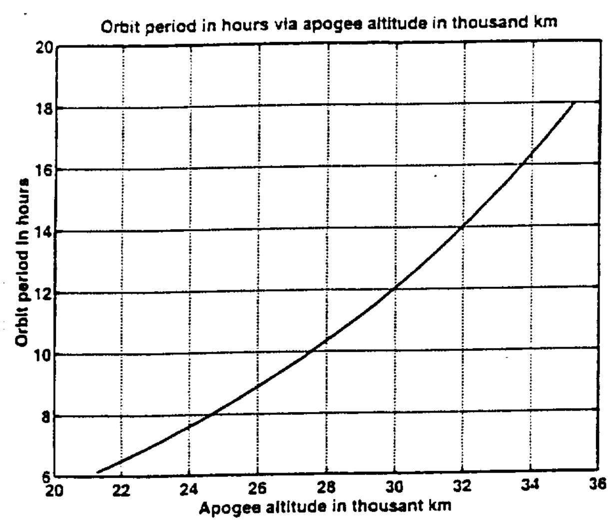

Fig.8. Orbit period (in hours) via apogee altitude (in thousand km).

7. When the space vehicle is disconnected from the transport system higher than the geosynchronous orbit, then the vehicle speed V, the first space speed V_1, the second (escape) space speed V_2 can be computed by formulas

$$V = \omega R, \quad V_1 = 19.976\cdot10^6/R^{1/2}, \quad V_2 = 1.414V_1. \quad (10)$$

Then the result of computation are given in Fig.9. Above the altitude 50,000 km the space vehicle can go into an interplanetary orbit. The necessary speed and direction can be set by a choice the disconnect point and position system in space. Additional speed over the escape velocity may reach 6 km/sec. This is more then enough for a flight to the far planets. When space vehicle returns it can also choose a point in the transport system for connection.

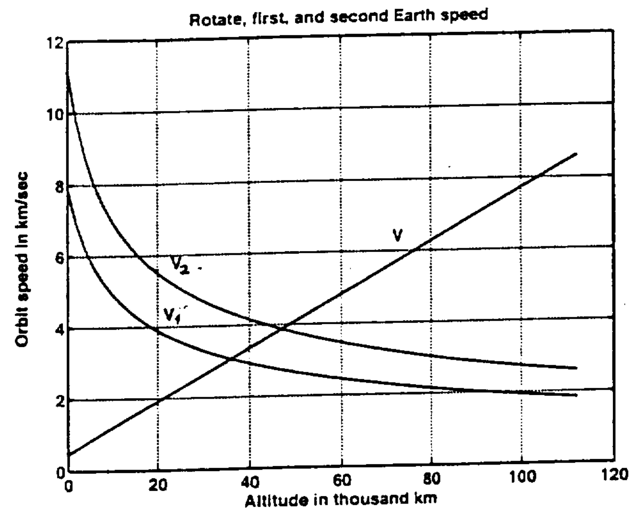

Fig.9. Rotate, first, second Earth speed (in km/sec) via altitude (in thousand km).

8. The maximum admissible cable speed of chains is

$$V_r = (\sigma/\gamma)^{0.5} = (K\cdot10^7)^{0.5} \text{ [m/sec]} \quad (11)$$

Results of this computation are presented in Fig.10.

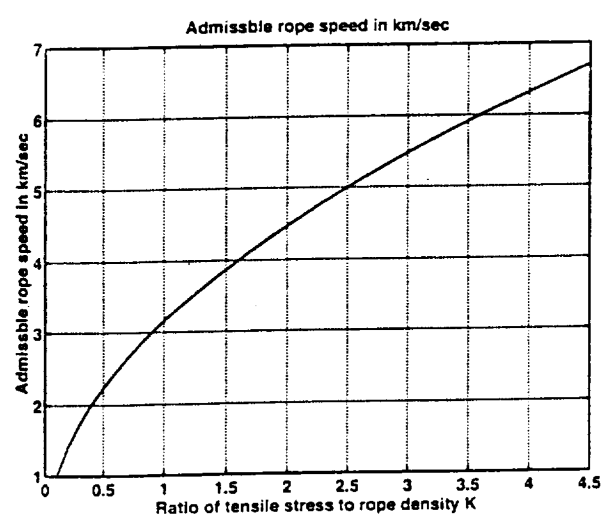

Fig.10. Admissible cable speed (in km/sec) via the ratio of a tensile stress to cable density (coefficient K).

9. The delivery cost of 1 kg load is (Fig.11)

$$C = (C_i/Y + N_e S_e + M_a)/V_d/3\,, \qquad (12)$$

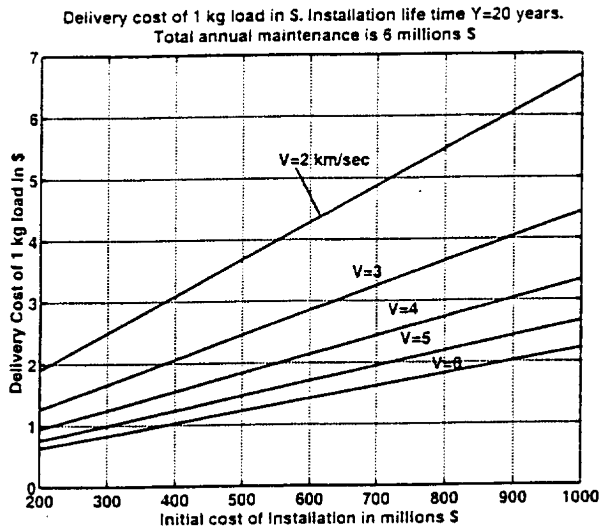

Fig.11. Delivery cost of 1 kg of load (in \$) via an initial cost of Installation (in million \$) for a delivery speed V=2-6 km/sec, for life time 20 years, total annual salary 5 millions, maintenance 1 million (in \$ of USA).

10. The increase of the space Installation mass is a geometric progression

$$n = 1 + \ln(M_i/M_o)/\ln\,[(M_o + M_g)/M_o\,]\,, \quad (13)$$

where: n - number of working days; (Fig.12).

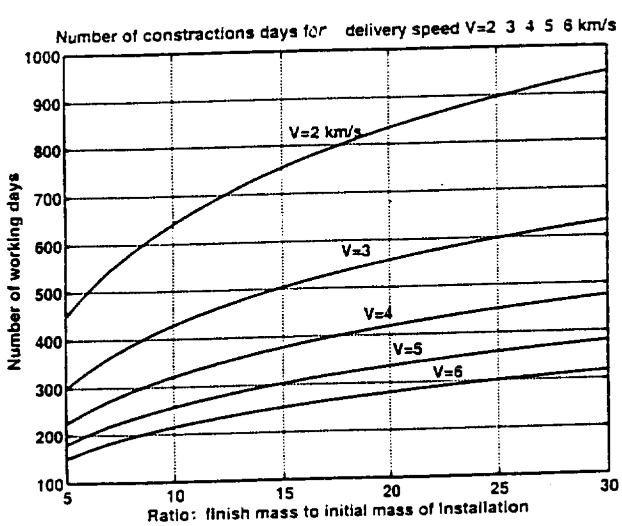

Fig.12, Number of working days via a ratio of a finish mass to an initial mass of the installation for delivery speed V=2-6 km/sec.

Project 1.

Example of an inexpensive transport system for cheap annually 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, industrial factory, or for the delivery people and payloads to other planets.

Technical parameters: Let us take the admissible cable stress 7200 kg/mm^2 and cable density 1800 kg/m^3. It is equal K=4. This is not so great since by the year 2000 many laboratories have made experimental nanotubes that have 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 a Young's modules up 5 Tera Pascal (now it is 1 Tera Pascal) and a density of 800 kg/m^3 for SWNT's nanotubes. This means that the coefficient K used in our equations and graphics can be up to 125.

Assume the maximum equalizer lift force of 9 tons at Earth surface and divide this force between three cables: one main and two transport cables. Then it follows from Fig.6, that the mass of the equalizer (or the space station), creates a lift force of 9 tons at the Earth surface, that equals 518 tons for K=4 (this is close to the current International Space Station weighting 450 tons). The equalizer is located over a geosynchronous orbit at an altitude of 100,000 km. Full centrifugal lift force of the equalizer is (Fig.5) is 34.6 tons, but 24.6 tons of the equalizer is spent on support of 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 Fig.3) A = 0.42 mm^2 (diameter D = 0.73 mm) at Earth's surface, maximum 1.4 mm^2 in middle section (D = 1.33 mm, altitude 37,000 km), and A = 0.82 mm^2 (D = 1 mm) about at equalizer. The mass of main cable is 205 tons (see Fig.4). The chains of the two transport cables loops have the 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 cableis 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 a people to the 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), then energy must be spent in any delivery method. This energy can be calculated from Eq.(8). When the transport system of Fig. 1 is used, the engine is located on the Earth and does not have an energy limitation. Moreover, the transport system Fig.1 can transfer a power up to 90,000 kW to the space station for a cable speed 3 km/sec. At present time, the International Space Station has only 60 kW of power.

Delivery capabilities. For the tourists transportation the suggested system works in the following manner. The passenger space vehicle has the full mass 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/sec then the first ship reaches the altitude of 21.5 - 23 thousands km in 2 hours (acceleration 1.9 m/sec^2). At this altitude the ship is separated from cable to fly in an elliptic orbit with minimum altitude 200 km and period approximately 6 hours (Figs.14-15). After one day the ship makes four revolutions around the Earth while the cable system makes one revolution and ship and cable will be in 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 accomadate 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, if it changes the altitude of disconnection then orbit is changed (see Fig.1). If a satellite needs a low orbit, then the satellite can use the break parachute when it flies through the top of the atmosphere and the satellite 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 thousands 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 a tourist hotels, scientific laboratories, industrial factories.

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

Let us assume that every man needs 400 kg of food for one year round trip to Mars and Mars has same transport installation (see next project). It means we can send about 2000 people to Mars annually in suitable position Earth-Mars.

Estimations of Installation Cost and Production cost of delivery. Cost of suggested Space Transport Installation. The current International Space Station has cost some billions dollars. The suggested space transport system can cost a lot less. Moreover, the suggested transport system allow us to create the other transport system in a geometric progression [see Eq.(13)]. Let us examine an example of the transport system.

At first, we create the transport system for lifting only 50 kg of load mass to an altitude of 100,000 km. Using the figs.4-12 we found that the equalizer mass is 8.5 tons, the cable mass is 10.25 tons and total mass is about 19 tons. Let us assume that delivery cost of 1 kg mass is $10,000. The construction of the system will have a cost of $190 million. Let us assume that one ton of cable with K=4 from whiskers or nanotubes cost $0.1 million then it costs $1.25 million. Let us put a research and development (R&D) 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 space station into space. It increases the cable and equalizer capability in a geometric progression. The Installation can use a 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 reach the amount above (1133 tons) and the installation can work full time as a tourist launcher or continue to create new installations. In last case this installation and children installations can build 100 additional installations (1133 tons) in only 30 months [see Eq. (13) and Fig.12] with total capability 10 millions 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 installation allows the delivery of passengers and payloads from one continent to another across the space with low expenditure of energy.

Let us to estimate the cost the initial installation. The installation needs 620 tons of cable. Let us take the cost cable $0.1 million per one ton. The cable cost will be $62 million. Assume the space station cost $20 million. The construction time is 140 days [Eq.(13)]. The cost for 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 space industry. Let us to estimate it for the full initial installation above.

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

If the price of space trip is $1990, then the profit is $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/sec [Eq.(11), Fig.10]. If average cable speed equals 6 km/sec, then all performance factors are improved by a factor of two times.

If reader does not agree with this estimation, then Equations (1)-(13) and figs. 4-12 allow calculating the delivery cost for other parameters. In any case the delivery cost will be in hundreds times less then by the current rocket powered method.

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

A method and similar installation (Figs.1-2) can be used for inexpensive travel to other planets, for example, from the Earth to Mars or the Moon and back (fig. 13). 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 the Earth and 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.13). Upon reaching Mars the space ship connects to the cable of the Mars space transport system. Then the ship moves down to Mars using the transport system.

The inverse of the process is used for the return trip. If two ships are used for descent and lifting payloads (Fig.1), energy will only be required to overcome the small amount of friction losses in the lift transmission. The way back is the same. The Mars space ship chooses a cable disconnect point with a suitable speed and direction or a connect-disconnect in a special arrive-departure port.

Technical parameters of Mars transport system. The equations (1)-(13) may be used for estimation main parameters of mars transport system. These computations are presented on Figs. (14)-(18). If we want to accept Earth space ships of 3 tons mass, then the parameters of Mars transport system will be K=4, three cables, and an equalizer altitude of 50 thousand km.

Equalizer mass is 94.7 tons. The total cable mass is 51 tons. Cross-section area of one cable is 0.158 mm^2 (diameter D=0.45 mm) at Mars surface, D=0.5 mm at altitude 20,000 km, and D=0.47mm at altitude 50.000 km.

For construction on Mars we need to deliver only the cables. The equalizer can be made from local Mars material, for example, stones. Delivery capability is about 1000 tons, or 2000 men annually.

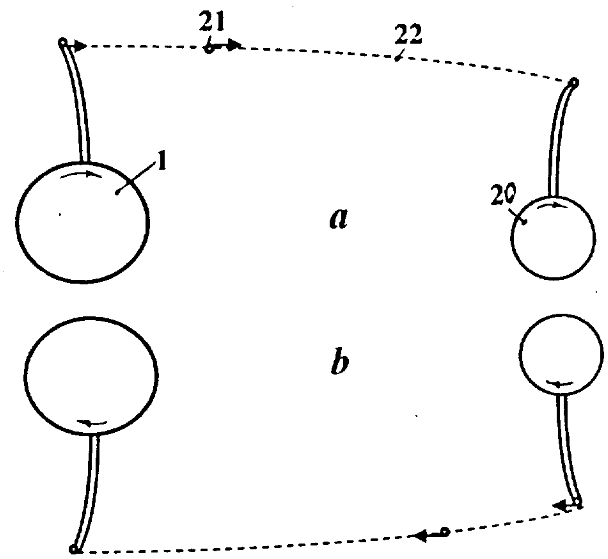

Fig.13. Using the suggested Transport System for space flight to Mars and back. 1-Earth, 20 - Mars, 21 - space ship, 22 - trajectory of space ship to Mars (a) and back (b).

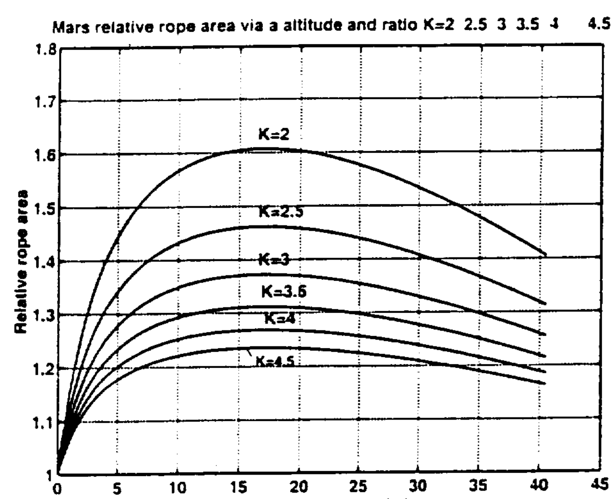

Fig.14. Mars relative cable area via altitude and coefficient K=2-4.5.

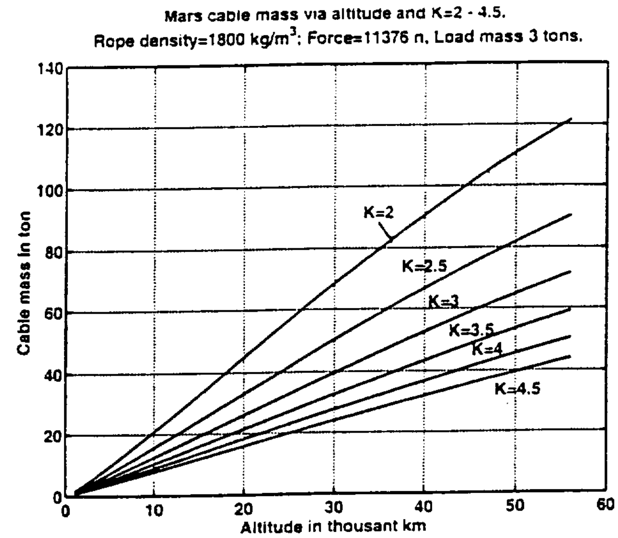

Fig.15. Mars cable mass via altitude (in thousands km), a cable density 1800 kg/m^3 and a load mass of 3 tons.

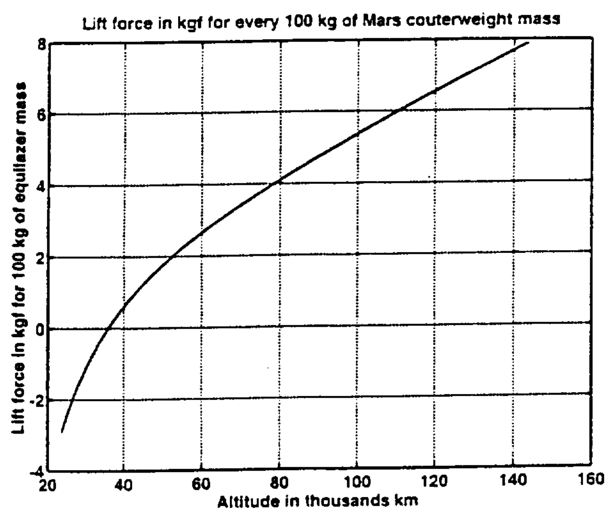

Fig.16. Lift force (in kgf) via altitude (in thousand km) for every 100 kg of Mars equalizer mass.

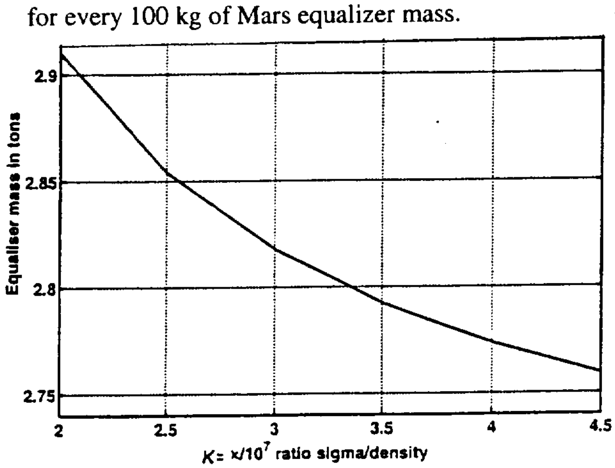

Fig.17. Mars counterweight mass (in tons) via the coefficient K = 2-4.5 for altitude 50,000 km and the force 100 kgf.

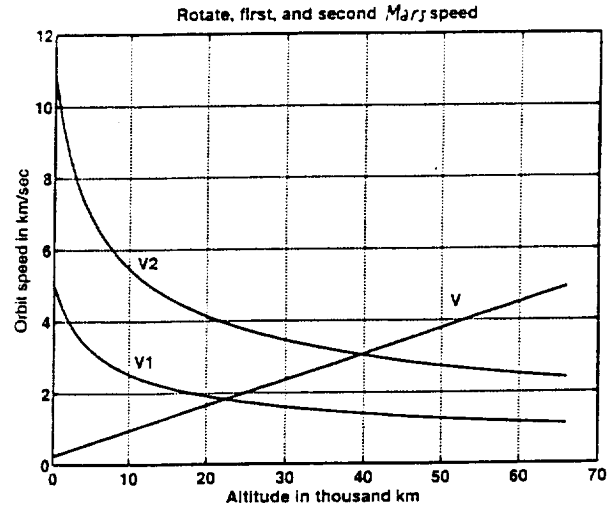

Fig.18. Rotate, first, and second Mars speed via altitude (in thousand km).

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.19). 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 Pole), which flies (i.e. glides or slides) along the planet's surface. The aircraft (or Moon) has a device, which allows the length of cable to be changed. The 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:

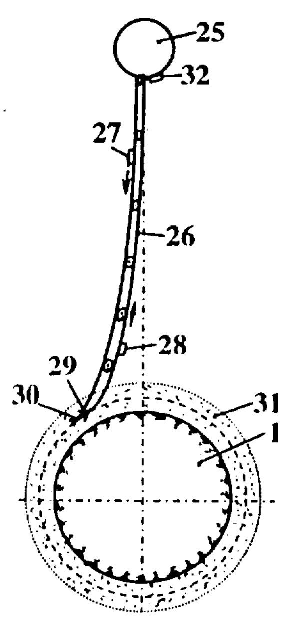

Fig.19. The suggested Transport System for Moon. Notations: 25-Moon, 26 – suggested Moon Transport

System, 27,28 - load cabins, 29 - aircraft, 30 - cable control, 32 - engine.

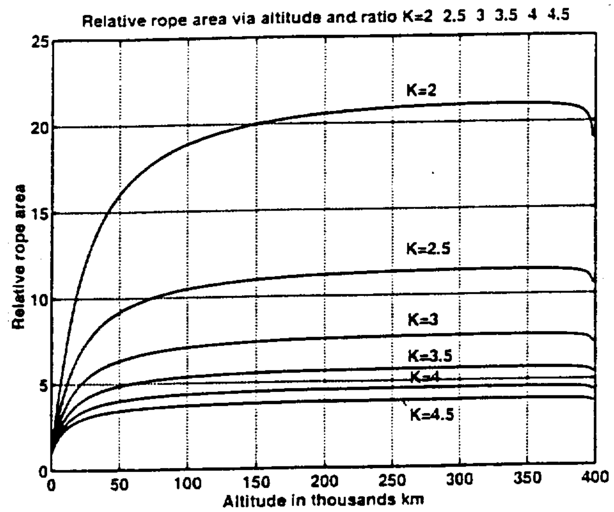

Fig.20. Relative cable area via a maximum altitude to the Moon (up 400,000km) and the coefficient K=2 - 4.5

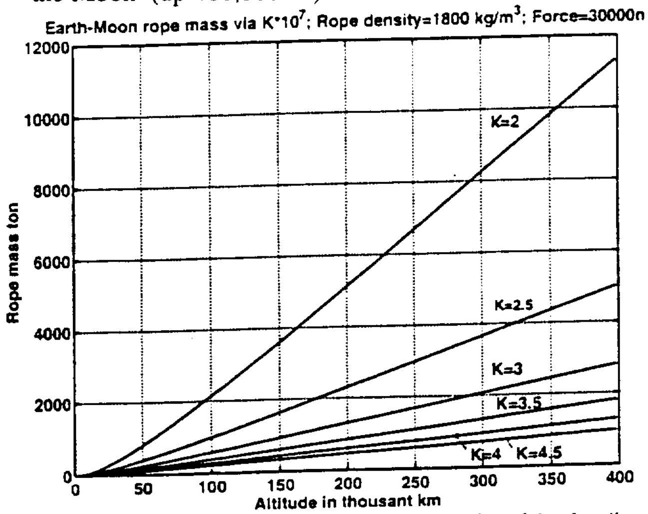

Fig.21. The Earth-Moon cable mass via altitude (in thousands km) for cable density 1800 kg/m^3, delivery mass 3 tons, and the coefficient K=2-4.5.

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 (see enclosed project #3), if the airplane weighs 15 tons and has an aerodynamic ratio (the lift force to the drag force) equal 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 thrusts the three named supersonic aircraft or produces up to 40 millions watt energy.

A different facility could use a transitional space station located at the zero gravity point between the planet and the planet's moon. The airplane can temporary land 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 ($\alpha+\beta=30^0$ degrees) 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.

The Moon's trajectory has an eccentricity. If the main cable is strong enough, the moon may used to pull a payload (space ship, man cabine), 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 Moon to 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 of the Earth (Figs.19) by having the moon "drag" an aircraft around the planet (using the Moon as free thrust engine). The Moon tows the aircraft by the cable at supersonic speed, about 440 m/s (Max Number is 1.5).

Theory of Equal Stress Cable from Earth to Moon

1. The equation of the equal stress cable from the Earth to the Moon may be written and solved same way as the equation (1). The result is below

$$a_m(R)=A/A_o=\exp[g_oB(R)/k]; \qquad (14)$$

where

$$B(R)=R_o-R_o^2/R-g_mR_m^2[1/(D-R)-1/(D-R_o)]/g_o - \omega_m^2(R^2-R_o^2)/2g_o$$

2. The mass of cable is

$$W=(F_o/k)\int_{R_o}^{R} a_m dR \ . \qquad (15)$$

The figs.20-21 represent the computation for maximum distance from Earth to Moon.

Technical parameters of Project 3. Free Trips to the Moon. The following is 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. Every cable can keep the force 3 tons. Material of cable has K=4. All cables would have cross-sectional areas of an **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 (Fig.21). The total mass of the main cable plus the two container cables (for delivering a mass 3000 kg) equals 3900 tons for the delivery transport system

Fig.19. An inexpensive means of the payload delivery between the Earth and the Moon could be developed. An elapsed time for the Moon trip at a speed of 6 km/sec would be about 18.5 hours. The annual delivery capably is 1320 tons in both directions.

Data for computation

Let us to consider the following experimental and industrial fibers, whiskers, and nanotubes [5]-[7]:

1. Experimental nanotubes CNT (Carbon nanotubes) has tensile strength 200 Giga-Pascals (20000 kg/sq.mm), Young's modules is over 1 Tera Pascal, specific density γ=1800 kg/m^3 (1.8 g/cc)(2000 year).

   For safety factor n=2.4, σ=8300 kg/mm^2=8.3x10^{10} n/m^2, γ=1800 kg/m^3, (σ/γ)=46x10^6, K=4.6. The nanotubes SWNT's has density 0.8 g/cc, the nanotubes MWNT's has the density 1.8 g/cc. Whiskers C_D has σ=8000 kg/mm^2, γ=3500 kg/m^3 (1989)[7,p.158]. About 300 kg nanotubes will be produce at the USA in 2002 (See Ch.&Eng. 9/8/01).
2. Industrial fibers have σ=500 - 600 kg/mm^2, γ=1800 kg/m^3, σ/γ=2,78x10^6, K=0.278 – 0.333,

Conclusion

The new materials makes the suggested transport system and projects highly realistic for a free trip to outer space without spending of energy. The same idea was used in the research and calculation of another revolutionary innovations such as: launches to Space without rockets (not space elevator, not gun); cheap delivery of loads from one continent to another across space; cheap delivery of fuel gas on long distance without steel tubes and damage of 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; getting a inexpensive energy from air streams at high altitudes; etc.

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

Patent Applications are 09/789,959 of 02/23/01; 09/873,985 of 6/4/01; 09/893,060 of 6/28/01; 09/946,497 of 9/6/01; 09/974,670 of 10/11/01; 09/978,507 of 10/18/01.

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