DEPARTMENT OF THE AIR FORCE
NATIONAL AIR & SPACE INTELLIGENCE CENTER (AF ISR AGENCY)
WRIGHT-PATTERSON AFB OHIO

APR 0 2 2014

Colonel Charles E. Hogan II
Vice Commander
National Air and Space Intelligence Center (NASIC)
4180 Watson Way
Wright-Patterson AFB OH 45433-5648

John Greenewald
[redacted]

Dear Mr. Greenewald,

This letter is in reference to your Freedom of Information Act (FOIA) request dated 14 December 2013 for a copy of a document entitled *"Energy From Space" A look At A Problem.* We received your request and assigned case number 2014-01437-F to it.

A review was conducted with the utmost diligence to determine if the record you requested may be released in whole or in part. After reviewing the document it has been determined that some information can be released, but the FOIA requires that other portions be withheld because of personal privacy interests. The denied portions of the document are exempt from public disclosure under United States Code, Title 5, Section 552(b)(6). The unauthorized disclosure of such information would result in a clearly unwarranted invasion of personal privacy, by revealing the identity of personnel assigned to sensitive units.

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Sincerely,

CHARLES E. HOGAN II, Colonel, USAF
Vice Commander

Attachment
Requested Document

FASTC-ID(RS)T-0269-93

FOREIGN AEROSPACE SCIENCE AND TECHNOLOGY CENTER

ENERGY FROM SPACE

A LOOK AT A PROBLEM

by

I. Kurkin, M. Kukolev

HUMAN TRANSLATION

FASTC-ID(RS)T-0269-93 3 June 1993

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ENERGY FROM SPACE
A LOOK AT A PROBLEM

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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
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И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
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К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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Aeronautics and Astronautics

ENERGY FROM SPACE
A LOOK AT A PROBLEM

I. KURKIN, M. KUKOLEV

In the search for an ecologically clean source of energy, people are more often turning their attention to the Sun. As a continuation of discussions begun in our journal (1991 № 3 and 5), we present to our readers a space-based solar electric power station project developed under the direction of Professor D. Sevruka at the Moscow Institute of Aviation [MAI].

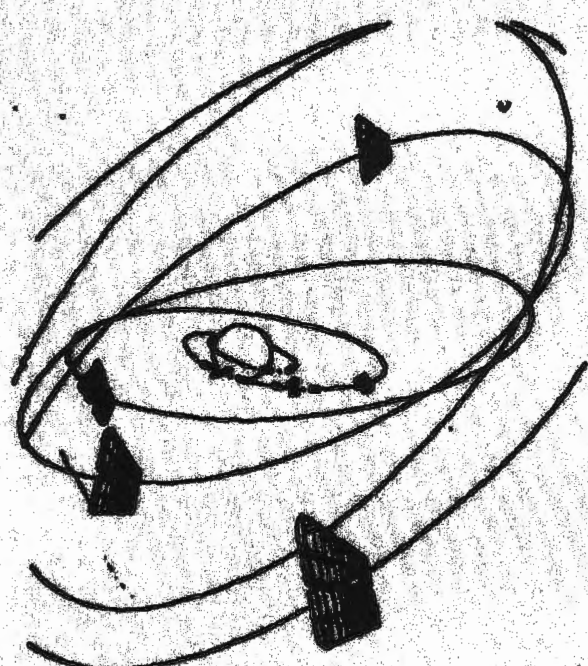

Fig. 1

In 1968, American engineer Paul Glaser published a technical proposal for the creation of a new energy system. The idea was to deploy solar-cell panels in near-Earth orbit to produce electrical energy and to transmit this energy by microwave radiation. After converting this radiation back into electrical energy, it would be used to supply the industrial consumers on Earth.

Since then specialists of different countries have been conducting design studies. An ever increasing number of working and theoretically feasible designs have been developed for the creation of a power system which uses photocells or thermal converters. Both variants work equally well and evidently the final choice in favor of one or the other can be made after experiments have been carried out on low-power model stations under space conditions.

Let us examine the important problem of choosing an orbit location for the electrical power station. In the opinion of many specialists, it would be best to give preference to the so-called geostationary orbit. With its circular shape and its location at 36,000 km from the Earth's equatorial plane, it possesses valuable properties; In this orbit, since the Earth's days are equal in length to the rotation period of the satellite, the (latter) satellite remains above the same point on the Earth's surface, thus facilitating the energy transmission process. In this case, since the equatorial plane is tilted at an angle of 23.5° to the ecliptic plane, the power station will be continually illuminated by the Sun for practically the whole year (it is in shadow for about 1% of the time).

It has been proposed that the electrical energy produced (with an efficiency greater than 85%) be converted into SHF [microwave] radiation and directed with the help of a focusing transmitting antenna to a surface receiving antenna with a diameter 10 times greater. A frequency of 2450 MHz is optimum from the standpoint of loses occurring during passage through the atmosphere and the dimensions of the transmitting-receiving antennas. This type of radiation is used in both industry and medicine. The field intensity in the center of the SHF-beam will not exceed 230-870 W/m². For comparison, let us point out that solar radiation on the Earth's surface can reach an intensity of nearly 1KW/m². To increase human safety, the receiving antenna is surrounded by a safety zone which prevents unauthorized persons from entering or passing through. In the event of some type of emergency situation, an emergency beam-defocusing system can be activated, decreasing the radiation power to a safe level.

Now let us proceed to a more detailed examination of the projected space power station. This is an installation with a unit which converts thermal solar radiation to electrical current. The light-weight lattice design must provide only that rigidity necessary to maintain its shape within assigned limits.

During the designing of the power station, the goal of specialists of the MAI was to create several base modules with which many problems could be solved. Such an approach makes it possible to decrease the cost of a power station development program and can speed up the program.

Each separate module can be used not only as an integral part of a high-energy power station, but also as a self-contained power plant for a regular satellite or for an orbital station. Figure 2 shows a structural diagram of a 100 KW base module. Its subsystems include: 1 - reflector-concentrator of solar radiation; 2 - radiation receiver with a reconcentration system; 3 - turbo-generator; 4 - radiating cooling unit; 5 - mechanism to deploy and prepare the power module for operation.

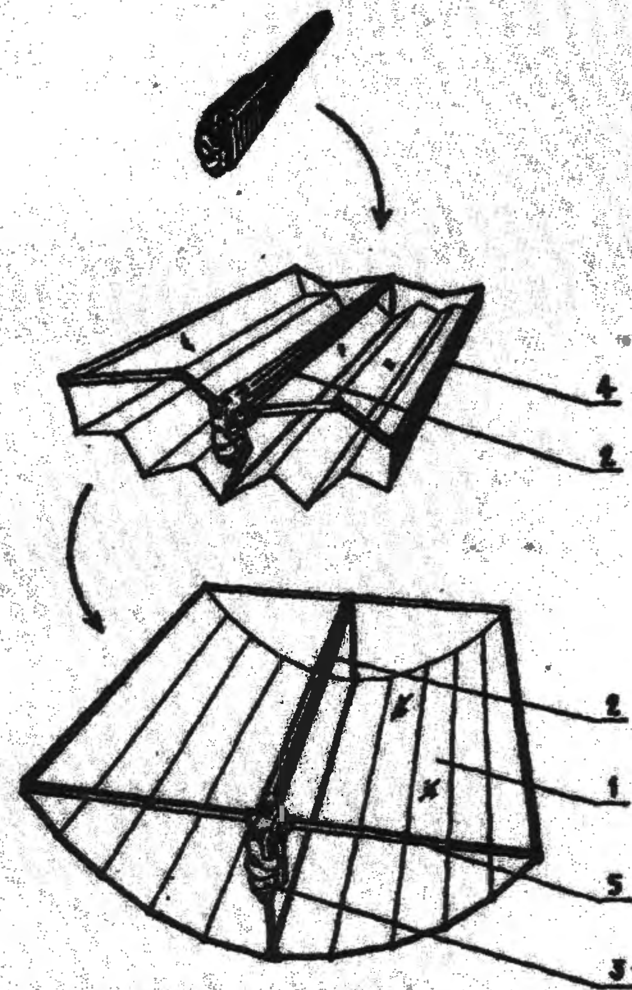

Fig. 2
Drawing by A. Baldenkov

The operating principle of the module is as follows: the mirror concentrates the incoming solar radiation on the heat receiver. The heat-transfer medium flowing through the latter is heated to approximately 830° C and enters the turbine, which rotates the electric generator shaft. After the turbine, the heat-transfer medium is cooled in the radiant cooling unit, proceeds to the compressor, and then returns to the heat receiver.

Whereas under terrestrial conditions the unused heat can be removed rather effectively by convection into the air or by the injection of a cooling liquid or gas, in space this is possible only by thermal radiation from the surface of the heated material. It is for this reason that one of the main elements is the so-called radiant cooling unit, which consists of a surface of a light highly heat-conductive material with tubing arranged in a specific order. The tubing carries the heat-transfer medium from the turbo-generator. The heat-transfer medium imparts heat to the structural elements, which then dissipate it into surrounding space. An argon-xenon gas mixture has been proposed as the heat-transfer medium.

The reflecting surface of the concentrator consists of a thin layer of silver, aluminum, or gold. Silver has the best reflectivity - 96%. Aluminum trails (silver) by only 4%. Without adopting special measures, this coating would quickly loses its properties under space conditions. Consequently the efficiency of the plant would fall as would generated electrical power. For protection the reflecting surface is covered with a thin transparent film, for example SiO_2 or Al_2O_3.

Electric rocket engines are used for precise orientation of the reflector on the sun - a necessary condition of assuring effective operation.

The radiant cooling unit is located on the back side relative to the Sun which allows it to always be in shadow, thereby facilitating the problem of releasing unused heat. To decrease the overall mass of the apparatus, the concentrator and radiant cooling unit were combined. Any adverse mutual effect is eliminated by proper organization of the movement of thermal fluxes.

The reflector of the solar power plant should ideally have the shape of a paraboloid of rotation which will give it the best energy characteristics. However, in the course of the studies, taking into consideration the requirements for simplicity of production, compactness in the stowed position during delivery to orbit, and also the convenience of overall layout, the selection settled on a cylinder of parabolic cross section with a reconcentrator.

In this case, with the help of the launch vehicle "Energiya", in one launch a plant with a total power of 6 MW would be delivered into baseline orbit. There the container with its complex modules is partially exposed, and the extended modules begin to power the ion or plasma engines. The energy unit begins to accelerate on its own in a spiral around the Earth (Fig. 1). Upon reaching the operating orbit altitude, all structures are finally deployed, and this new energy unit links up with the electric power station platform.

With the help of this type of power station it is possible to attain an efficiency in the conversion of solar radiation to electric current of up to 29%. Considering that the overall efficiency of the transmission route of electrical energy from orbit to consumer on Earth is 70%, we get the following ratio: the solar radiation falling on each square meter of the reflector-concentrator gives 280 W of electrical energy to the surface consumer. If the power of the space system is 6 MW, then we will get 4.2 MW of electrical energy.

It is possible that, having seen these figures, the skeptically inclined reader will say: "Even the replacement of nuclear power stations by solar-powered space stations would require a great number of rocket launches, which would not be without risk to the Earth's atmosphere! Isn't it better to perfect terrestrial atomic stations or work at improving the efficiency of the thermal stations?"

Without criticizing such methods of energy development, we would like to note that the plan presented to our reader makes it possible not only to solve the problem of the "energy famine" of the Earth's inhabitants, but also to lay a foundation for removing harmful industries into space and for utilizing space resources. Transporting all of the plant components from Earth to orbit is only necessary in the beginning phase. With the gradual development of plants in orbit and on the moon, these power stations can be built in space from materials extracted from celestial bodies.

In turn it will become possible to create space settlements, an idea already proposed by K. Tsiolkovskiy. At present an American professor, J. O'neal, is conducting research on this problem. His studies suggest that with the use of solar energy, even during the present technological times, the construction of artificial settlements in space will make it possible to remove almost all industry from the surface of the Earth is less than 100 years. Naturally, the requirement for electric power on Earth will decrease and our air and water will begin to gradually regain their purity.

Thus, providing Earth with power from space will be a necessary step on the path to human development.

The authors request that any honoraria be transferred to the Aerospace Development Fund (ADF) "Onward to Mars!"