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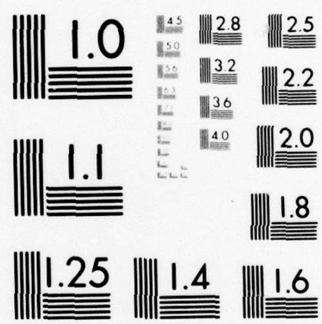

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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE POSSIBILITIES OF SELECTIVE GLASS

by

A. Semenov

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

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By: A. Semenov

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Block	Italic	Transliteration	Block	Italic	Transliteration
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
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
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

THE POSSIBILITIES OF SELECTIVE GLASS

A. Semenov, Engineer

Glass which is coated with a film of tin dioxide passes heat rays primarily in one direction and seems to "seal" the heat in a volume which is limited by such glass. This permitted creating cheap solar heaters and thermoelectric generators without concentrators and without moving parts. The use of selective glass as a coating for hothouses can save one million three hundred thousand rubles per year in fuel alone. The cost of the selective glass with improved technology will be close to the cost of regular glass. Only a little more tin is expended per square meter of surface than for tinning a preserving can.

The simplest device for the direct conversion of solar energy to thermal is the so-called "hot box." It is a wooden box whose bottom is covered within by a thermal-insulating material and a collector - a collector of solar rays - is placed over the insulation. A glass lid is on top. The box is placed in an inclined position with the glass cover toward the south. The sun's rays which have passed through the glass heat the collector which is painted with a dull black paint. The glass lid decreases heat losses from the blowing of the wind, as a result of which the temperature inside the box is 40-50°C higher than the environment. Solar devices for the heating of water in showers and baths evaporators, hotbeds and hothouses, and fruit and vegetable driers operate in accordance with this principle.

However, far from all the energy of the sun's rays is utilized efficiently in these constructions. The glass passes 85% of the solar energy into the "hot box." Heating up, the collector begins to emit infrared rays, that is, to lose the heat which has been obtained. This radiation is reflected back only partially by the glass while a large fraction of it, passing through the transparent cover, is lost irretrievably.

How can we increase the efficiency of this device which is attractive in its simplicity? Associates of the State Scientific Research Power Institute imeni G. M. Krzhizhanovskiy, Candidates of Technical Sciences B. A. Garf, L. V. Gudkov, and A. V. Sheklein, who undertook the solution of this problem came to the conclusion after a number of experiments that the strengthening of the thermal insulation of the walls and bottom of the "hot box" provides no noticeable effect. They tried to reduce the total heat losses through double glass as is done when providing heat insulation of houses in winter. But here, the construction becomes more expensive and heavier and the amount of solar energy which reaches the collector is reduced. It is necessary to force the glass to pass to the collector as much of the sun's rays as possible and, at the same time, to prevent radiation from the collector into the environment. They tried to convert the glass into a "light semiconductor" with the use of films. Antimony film passed the sun's rays well but it reflected the thermal radiation of the collector poorly. The films of nickel and iron, being colored, held back some of the sun's rays. Experiments with an indium film provided encouraging results; such a film was almost transparent for an incident solar flux and, at the same time, a good mirror for the thermal radiation which was departing from the collector. But indium is too expensive. Therefore, the experiments continued. And only after a three-year search did they stop on the use of selective films of tin dioxide. Such a coating is 10 times cheaper than indium and, at the same time, is almost as good as it in effectiveness of reflection. And the tin dioxide films had another advantage of no little significance: the technology for applying them on the glass is relatively simple and has been mastered by industry. A pulverizer is used to spray the molten tin on glass which has first been heated to 400-450°C. Here, the tin dioxide film which is obtained is so thin that such a selective glass cannot be distinguished from regular glass. The cost of the selective glass is presently approximately twice the cost of simple glass but, with improved technology for applying the film, it should be close to the cost of regular glass. The tin itself is relatively cheap and a little more than the tin which is used on a preservative can is expended per square meter. Despite the fact that the tin dioxide film is very thin, it is very strong and resistent.

The selective tin dioxide film deteriorates the passage of direct sun's rays through the glass by only 6% but, in return, it improves by 65% the reflection of the collector's thermal radiation, that is, it serves as a genuine trap! For the employment of a selective tin dioxide film in solar heaters of liquid B. A. Garf, L. V. Gudkov, and A. V. Sheklein were awarded author's certificate No. 282819.

The employment of selective glass for hothouses and seed beds reduces substantially the expenditures on heating them since it reduces the heat losses considerably, especially at night. According to calculations of the "Giproniisel'mash" [All-Union State Institute for the Planning of Scientific Research Institutes and Laboratories of the Academy of Sciences, USSR, and the Academies of Sciences of the Union Republics for Agricultural Machinery] the wide introduction of selective glass for agricultural structures will provide a savings of about one million three hundred thousand rubles per year in fuel alone. In unheated seed beds, during nighttime frost below -5°C plants perish. In seed beds which have been covered by the selective glass a drop in the temperature of the outside air to -12°C holds no terror for plants.

The selective glass permits advancing the boundaries for the raising of heat-loving crops further to the north. It will be possible to obtain early harvest of cucumbers, tomatoes, squash, and lettuce and to place southern flowers in greenhouses to blossom. Hothouses with selective glass are already in operation near Orlov and are providing a tangible economic impact.

Selective films are also being employed in heat exchangers to heat air or gases. The sun's rays, passing through the selective glass, are absorbed by collector plates and heat them. This heat is removed by a flow of gas and subsequently is utilized usefully in vegetable-and fruit driers to heat the premises.

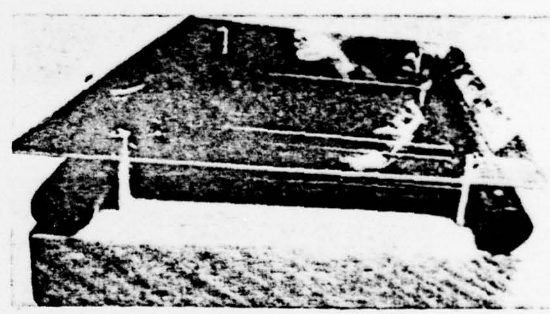
The replacement of regular glass by selective is also effective in continuous-flow heaters of liquids, in showers, and in baths. And if the collector is coated with a dull black paint having a solar radiation absorption factor of more than 90%, its temperature begins to exceed 100°C. Constructing such units in the southern republics, fresh water can be obtained from salt water without any special expenditures.

And now imagine solar electric power plants having concentrators of solar energy. These are rather expensive units in which the mechanism for tracking the sun must be complex. Furthermore, the scheme for the conversion of solar energy to electrical is multi-stage: reflector (concentrator) - boiler - turbine - generator. Recently, devices have appeared which are constructed in accordance with the "hot box" principle for the direct conversion of solar energy to electric - solar thermoelectric generators (STEG). The new thermoelectric generators which have been developed, in particular, in the Power Engineering Institute imeni G. M. Krzhizhanovskiy, in combination with selective glass permit creating small electrical units without a concentrator with a power on the order of one kilowatt. Such STEG's have no moving parts and are very simple to maintain. Furthermore, they are very economical, for they require no energy except the radiant energy of the sun.

The mass production and wide introduction of STEG's with selective glass will provide a simple and reliable source for electric power for expeditions and small non-electrified populated places. It will be very advantageous to use STEG's as power supply sources for mechanisms to lift water from wells on vast pastures of our Central Asian republics.

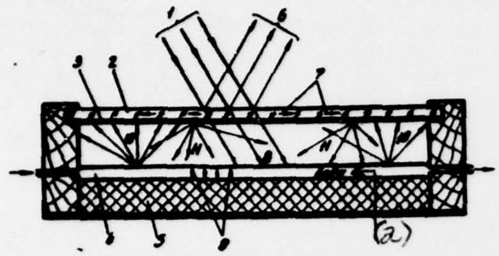
But the employment of selective films on glass is not the limit for increasing the efficiency of a solar unit of the "hot box" type. If we also apply to the glass an anti-reflection coating similar to the one which is applied to the lens of cameras, then the losses of solar energy caused by reflection from the glass will be reduced by approximately half.

Unfortunately, the practical introduction of selective films in the national economy is lagging impermissibly behind the level which has been attained by scientists and inventors.



A model of a helioboiler - a prototype of the giant "heaters" which use solar energy.

Lev Vasil'yevich Gudkov and Andrey Vasil'yevich Sheklein (on the right) are graphically demonstrating the advantages of their invention. Coffee was boiled under a dome of selective glass right on a forest lawn in the Moscow suburbs. The natural source of energy consisted of the still not very "energetic" sun's rays.



Schematic diagram of low-temperature solar power unit: 1 - incident directed radiation of the Sun, 2 - transparent insulation, 3 - selective film, 4 - radiant energy receiver, 5 - thermal insulation, 6 - solar radiation reflected by glass, 7 - solar radiation absorbed by glass, 8 - solar radiation passed through by glass, 9 - energy of solar radiation converted in collector, 10 - thermal radiation of the collector surface (radiation losses), 11 - radiation losses of glass.

Key: (a) water.

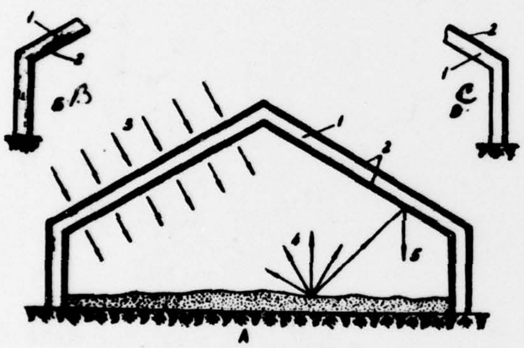
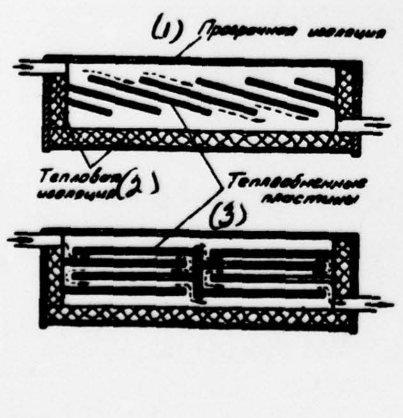


Diagram of cultivation structure with selective-transparent film. Fig. A portrays the glass with 2-sided application of selective film; Figs. B and C - one-sided (internal and external): 1 - glass, 2 - selective film, 3 - incident flux of solar radiation, 4 - thermal radiation of soil and plants, 5 - thermal radiation of the soil reflected by selective film.



Two versions of a solar heat exchanger for the heating of gases.

KEY: (1) Transparent insulation; (2) Thermal insulation; (3) Heat exchanger plates.

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