

I. PHYSICAL ELECTRONICS

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A. QUANTITATIVE ANALYSIS OF A PHOTOEMISSIVE SOLAR-ENERGY CONVERTER

An energy converter that depends on photoemission of electrons can best be understood in terms of its component parts. First, the emitter itself should be of a type that has a very high quantum yield. A suitably processed cesium antimonide surface is typical of this class of photoemitters. The emitter must be located in such a manner as to make efficient use of the solar energy received. No useful power output can be expected from this converter unless the electron receiver has a very low work-function. This receiving surface should also have a low photoelectric yield. The converter structure must take on a form that minimizes the amount of light received by the electron collector. The reason for these two requirements is that no matter what the actual configuration is, the minimum useful solar-energy frequency, or the maximum wavelength, will be determined by the sum of the collector work-function and the voltage output. Thus if the output of the device is to be as high as 0.4 volt and the work-function of the receiver as low as 1.2 volts, the longest wavelength in the solar spectrum which could be used is 760 $m\mu$. All of the various configurations of electrodes that have been proposed to meet the requirement that the electrons be collected on a low work-function surface maintained in the dark have additional potential barriers that limit the useful range of solar energy to still shorter wavelengths than this.

A configuration that lends itself to analysis – even though it is by no means practical – is shown in Fig. I-1. Its construction and operation may be described with reference to this figure. The emitter is a semitransparent film of cesium antimonide deposited on a glass surface with transmission far into the ultraviolet. A rectangular set of conducting bars is formed on the emitter surface; each bar is 0.01 inch wide,

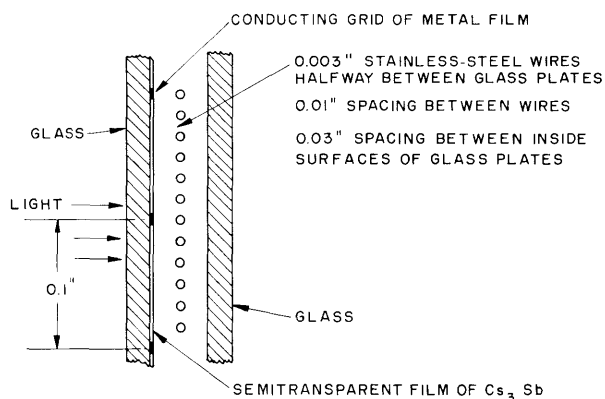


Fig. I-1. A possible configuration for a photoemissive solar-energy converter.

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and the spacing between bars is 0.1 inch. Between this photoemissive surface and another glass wall is a set of stainless steel grid wires, 0.003 inch in diameter and with 0.01-inch spacing from center to center. The spacing between the glass surfaces is 0.03 inch. Even though it would be difficult to accomplish, it is assumed that silver can be deposited by evaporation on the right side of each of the stainless-steel wires. These surfaces are not exposed directly to light. After oxidation this silver film is reacted with cesium, with the idea that it can be made to have a true work-function of 1.2 ev. The exposed side of the stainless steel is assumed to have a work-function of 4.7 ev. Photoelectrons are emitted from the semitransparent film and some of those with high energy can surmount a potential barrier between the grid wires. These electrons are collected on the low work-function side of the wires. After a detailed analysis to establish the distribution of potential in the space between the glass and the wires, a calculation was made to find the current-voltage characteristic that this cell should produce under the most optimistic assumptions that are reasonable. The resulting current-voltage curve is shown in Fig. I-2. Since the power output will be the product of the current and the voltage, the associated power curve is shown in this same figure. The maximum in this curve occurs at 0.3 volt and the power available per square centimeter is $3.7 \mu\text{w}$. The total solar energy received on a surface outside of the earth's atmosphere is taken as 0.135 watt/cm^2 . The conversion efficiency computed for this

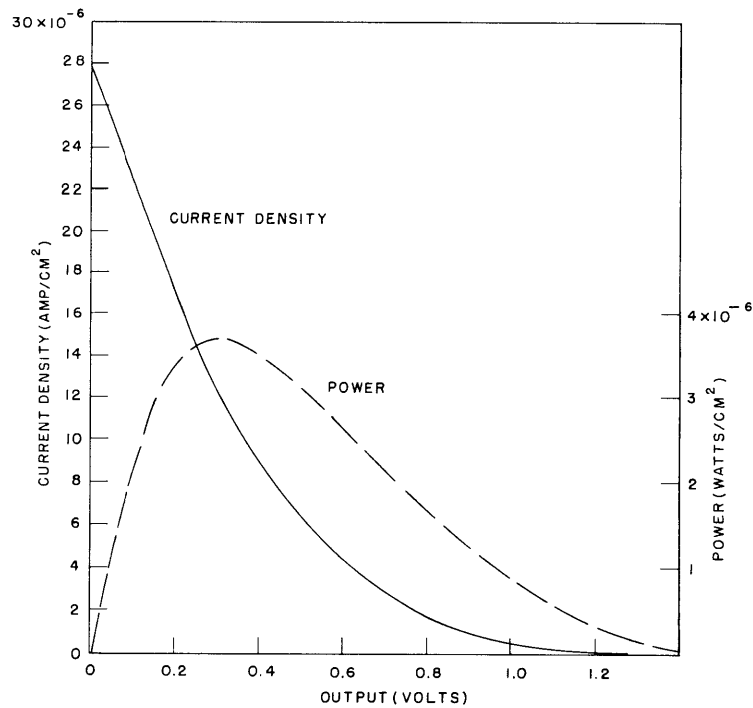


Fig. I-2. Computed voltage-current curve and power output as a function of voltage.

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configuration is therefore 0.0037 per cent.

The electrode configuration shown in Fig. I-1 is not claimed to be the most efficient of all possible configurations. It was used because it contains the essential parts of the device and provides a means for carrying through the calculation of the final volt-current characteristic shown in Fig. I-2. If a number of optimistic assumptions had not been made, the efficiency of this device would have been still lower. It is therefore considered realistic to predict that no photoemissive solar-energy converter is likely to be developed with an efficiency greater than 0.03 per cent.

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