BEAM-WAVEGUIDE ANTENNA WITH ABERRATION

ANGULAR-SEPARATION COORDINATES

COORDINATES FOR DISPLACEMENTS OF TRANSMITTING FEED

The **Transmitting Feed Is Displaced in X and Y** by amounts needed to point the transmitting beam away from the receiving beam (which coincides with the antenna axis) by angular-separation amounts α and β.

displacement vector chosen so that the direction of the transmitted beam is altered by the small amount needed to make the beam point to the anticipated position of the target at the anticipated time of arrival of the transmitted signal at the target.

The angular and linear coordinates mentioned in the following sentences are defined in the figure. The angular separation between the transmitting and receiving beams is described in terms of the separation angle α and the clock angle β. The transmitting feed is mounted on an X-Y translation table. The problem is to compute the polar coordinates ρ and φ of the amount by which the transmitting feed must be displaced in the X-Y plane to move the direction transmitting beam, away from the direction of the receiving beam, by the amounts of the required angular separation. The problem becomes one of computing the ρ and φ needed to obtain the required α and β. (Then the required X and Y are calculated from ρ and φ by simple trigonometry.)

The algorithm used to control the X-Y table implements a closed-form representation of the coordinates ρ and φ as functions of the coordinates α and β. This representation can be obtained by experimentation and/or physical-optics-based, computational-simulation studies of electromagnetic scattering by the pertinent antenna optics configuration for various combinations of ρ and φ. The representation is of the general form

$$\rho = c_1\alpha + c_2\alpha^2 \text{ and}$$

$$\phi = \phi_F - \beta + \theta_{EL} - \theta_{AZ} - n\pi/2 \text{ radians,}$$

where c_1 and c_2 are coefficients determined by the computational study; f_F is related to the feed position on the floor; θ_{EL} and θ_{AZ} are the elevation and azimuth angles, respectively; and n is one of the integers between −1 and +2, determined through measurements of beam offsets obtained at known feed offsets.

This work was done by Manuel Franco, Stephen Slobin, and Watt Veruttipong of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30534

![JPL logo] # Advanced Rainbow Solar Photovoltaic Arrays

Concentrated sunlight is spectrally dispersed onto adjacent cells with different bandgaps.

NASA's Jet Propulsion Laboratory, Pasadena, California

Photovoltaic arrays of the rainbow type, equipped with light-concentrator and spectral-beam-splitter optics, have been investigated in a continuing effort to develop lightweight, high-efficiency solar electric power sources. This investigation has contributed to a revival of the concept of the rainbow photovoltaic array, which originated in the 1950s but proved unrealistic at that time because the selection of solar photovoltaic cells was too limited. Advances in the art of photovoltaic cells

since that time have rendered the concept more realistic, thereby prompting the present development effort.

A rainbow photovoltaic array comprises side-by-side strings of series-connected photovoltaic cells. The cells in each string have the same bandgap, which differs from the bandgaps of the other strings. Hence, each string operates most efficiently in a unique wavelength band determined by its bandgap. To obtain maximum energy-conversion

efficiency and to minimize the size and weight of the array for a given sunlight-input aperture, the sunlight incident on the aperture is concentrated, then spectrally dispersed onto the photovoltaic-array plane, whereon each string of cells is positioned to intercept the light in its wavelength band of most efficient operation. The number of cells in each string is chosen so that the output potentials of all the strings are the same; this makes it possible to connect the
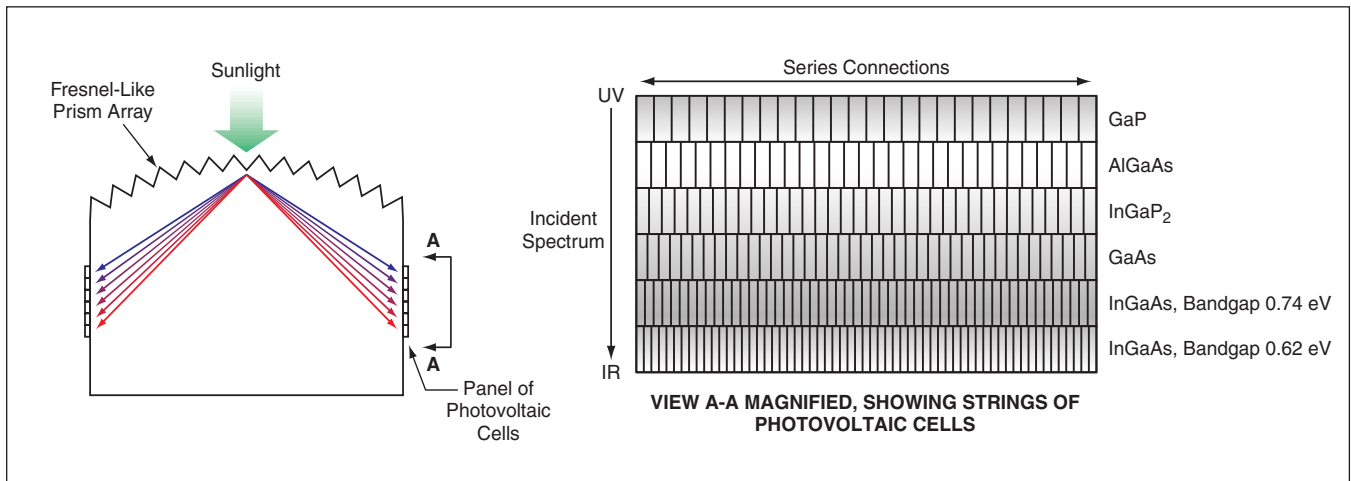
A **Curved Fresnel Prism** would concentrate and spectrally disperse sunlight onto adjacent strings of solar photovoltaic cells, each string optimized for the part of the spectrum incident upon it.

strings together in parallel to maximize the output current of the array.

According to the original rainbow photovoltaic concept, the concentrated sunlight was to be split into multiple beams by use of an array of dichroic filters designed so that each beam would contain light in one of the desired wavelength bands. The concept has since been modified to provide for dispersion of the spectrum by use of adjacent prisms. A proposal for an advanced version calls for a unitary concentrator/spectral-beam-splitter optic in the form of a parabolic curved Fresnel-like prism array with panels of photovoltaic cells on two sides (see figure). The surface supporting the solar cells can be adjusted in length or angle to accommodate the incident spectral pattern.

An unoptimized prototype assembly containing ten adjacent prisms and three photovoltaic cells with different bandgaps ($InGaP_2$, GaAs, and InGaAs) was constructed to demonstrate feasibility. The actual array will consist of a lightweight thin-film silicon layer of prisms curved into a parabolic shape. In an initial test under illumination of 1 sun at zero airmass, the energy-conversion efficiency of the assembly was found to be 20 percent. Further analysis of the data from this test led to a projected energy-conversion efficiency as high as 41 percent for an array of 6 cells or strings (GaP, AlGaAs, $InGaP_2$, GaAs, and two different InGaAs cells or strings).

This work was done by Nick Mardesich and Virgil Shields of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1). NPO-21051*

Metal Side Reflectors for Trapping Light in QWIPs

Quantum efficiency would be increased because light would make multiple passes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Focal-plane arrays of quantum-well infrared photodetectors (QWIPs) equipped with both light-coupling diffraction gratings and metal side reflectors have been proposed, and prototypes are expected to be fabricated soon. The purpose served by the metal side reflectors is to increase quantum efficiency by helping to trap light in the photosensitive material of each pixel.

The reasons for using diffraction gratings were discussed in several prior *NASA Tech Briefs* articles. To recapitulate: In an array of QWIPs, the quantum-well layers are typically oriented parallel to the focal plane and therefore perpendicular or nearly perpendicular to the direction of incidence of infrared light. By virtue of the applicable quantum selection rules, light polarized parallel to the focal plane (as normally incident light is) cannot excite
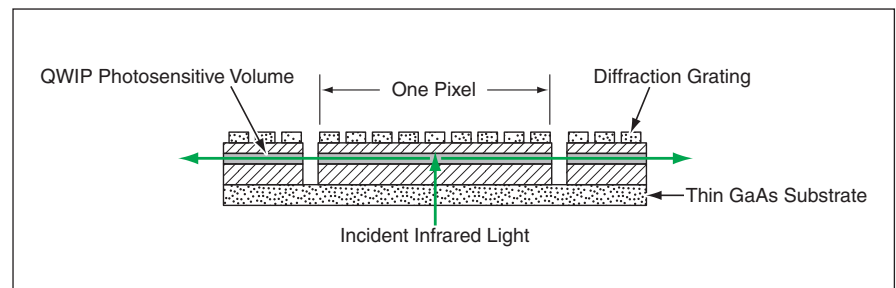

Figure 1. **Light Is Diffracted** almost parallel to the focal plane for maximum quantum efficiency in a QWIP of typical prior design. However, in the absence of reflectors like those shown in Figure 2, much of the diffracted light is lost from the QWIP of a given pixel after a single pass through the photosensitive QWIP volume.

charge carriers and, hence, cannot be detected. Diffraction gratings scatter normally or nearly normally incident light into directions more nearly parallel to the focal plane, so that a significant portion of the light attains a component of polarization normal to the focal plane and, hence, can excite charge carriers. Unfortunately, light scattered in directions parallel or nearly parallel to the focal plane can escape sideways from the QWIP of a given pixel, as illustrated in Figure 1. The escaped light has made only a single pass through the interior photosensitive volume of the QWIP.