SOLAR ELECTRICITY
for military applications

From the May/June 1977 Issue of
SIGNAL Magazine

Reprinted By:

SOLAREX CORPORATION
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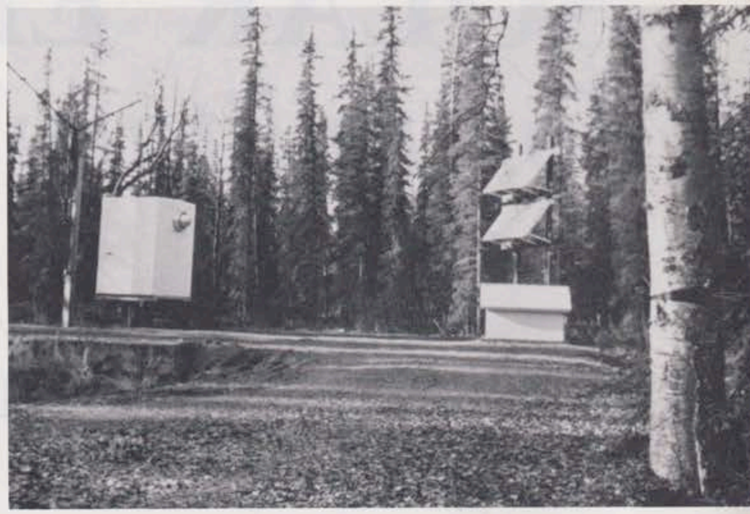
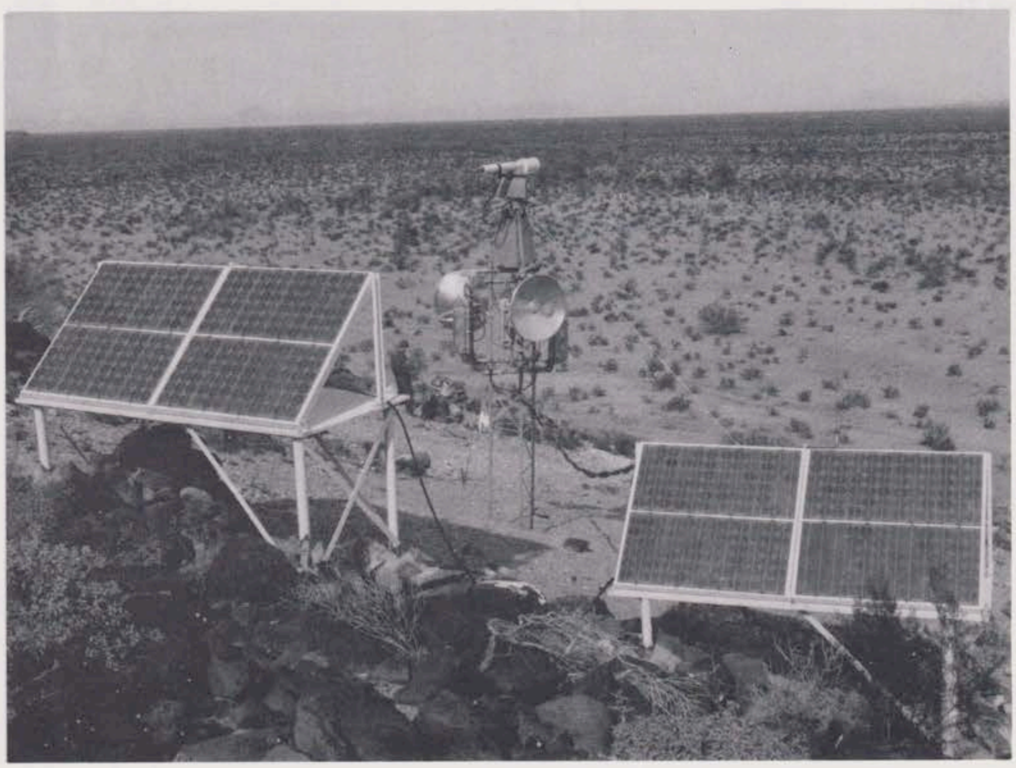
SOLAR *for*



(Left) Foldable solar panel for charging tactical radio batteries. (Above) A 260W (peak) Solarex solar electric system powering a marker beacon for an airport in Kenai, Alaska.



(Left) Two Solarex 160W (peak) solar arrays operate this TV camera and equipment as part of a Television Optical Scoring System (TOSS) installed at Luke AFB, Ariz.

ELECTRICITY
military applications

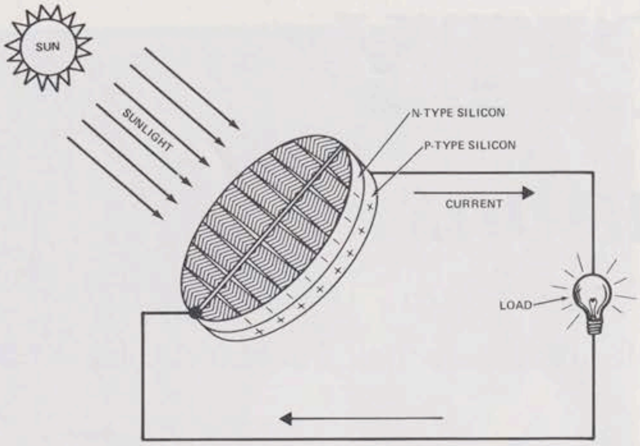
By Ted Blumenstock and Mary Ann Goold

For over fifteen years, space program engineers have successfully used solar cells as an electrical power source for satellites and deep-probe space vehicles. Solarex Corporation of Rockville, Md., has made the transition from space to earth by reducing solar cell prices from as high as \$500/watt to only \$15/watt. A new technology introduced by Solarex has made possible mass production of the most efficient and economical solar cells and solar electric systems available for terrestrial use. Solar electricity is the most effective method of providing continuous power in areas where commercial power is unavailable, too costly, or unreliable. Furthermore, all refueling and maintenance problems associated with conventional engine or thermoelectric generators are eliminated with solar electric generators.

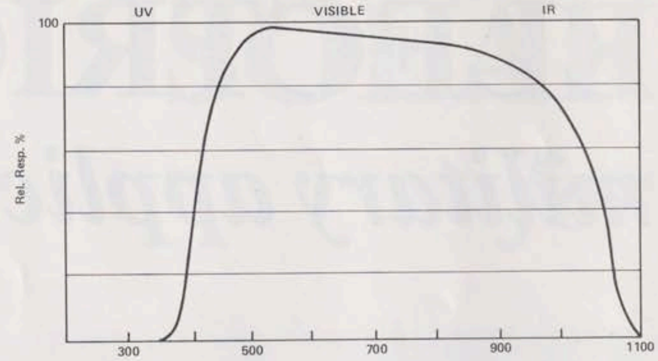
Solar electric systems are being used by the military in a variety of applications. They include:

- Radio/Telephone repeaters
- Mobile communications

(Above) Basic 10W (peak) output solar panel comprised of 3″ diameter Chevron™ silicon solar cells. This Solarex panel is a basic building block for large arrays. (Right) 460W (peak) solar electric system powering microwave and VHF repeaters in the Mojave Desert.



HOW SOLAR CELLS PRODUCE ELECTRICITY



Typical spectral response (Quantum yield) of Solarex solar cells over the wavelength range 300–1100 nanometers.

- Remote security and surveillance—seismic, magnetic, acoustic, infrared, etc.
- Tactical radio battery chargers
- Navigation aids
- Environmental, geological and hydrological data collection platforms
- Range maneuvering and scoring
- Water purification and pumping
- Impressed current cathodic protection
- Railroad signaling

Solarex solar cells are silicon semiconductor devices that employ a natural phenomenon known as the ''photovoltaic effect'' to convert light directly into electricity. Silicon solar cells are today the most widely used and the most economical.

Silicon Solar Cells

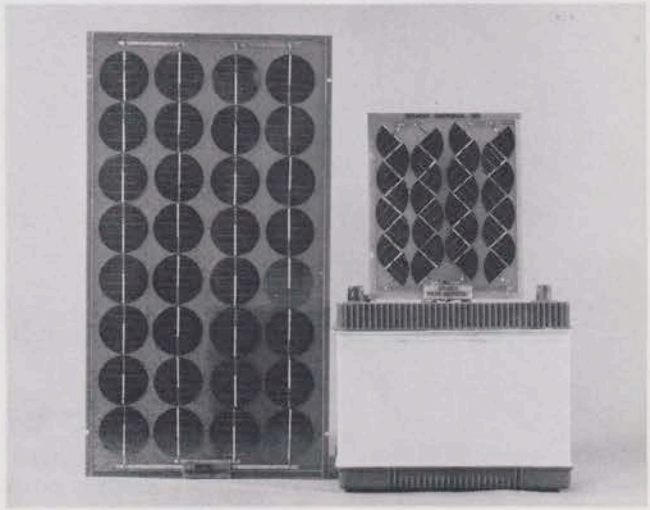
Silicon solar cells are made by doping pure, cylindrical silicon crystals with other chemical elements. When phosphorus is added during the growth of the crystal, the silicon develops negative (n) charge carriers (electrons). When boron is added positive (p) charge carriers (holes) appear. The crystal cylinders are then sliced into wafers. High temperature diffusion of phosphorus into a boron doped silicon creates an n-type to p-type junction and a built-in field.

When the diffused silicon slice is illuminated, incoming units of light energy (photons) are absorbed by the electrons within the silicon wafer. This creates negative charges which are attracted to the p-type. A photocurrent flows, voltage develops, and electricity is produced. Thus, a power source is created: a photovoltaic generator or solar cell.

The amount of electrical power delivered by solar cells depends on their size and efficiency. Solarex silicon solar cells are the largest, the most efficient and the most economical in use today. Chevron™ is the collective name given these Solarex solar cells because of their unique patented current collecting pattern. Normal Solarex production cells are 2 1/4″, 3″, and 4″ in diameter. They are up to 15 per cent efficient as compared to others with efficiencies of 10–12 per cent. Efficiencies of nearly 20 per cent have been reached in Solarex laboratories. Recently, the company introduced a large area, high efficiency 5 × 5cm rectangular solar cell. When these cells are used in terrestrial solar panels, it is possible to provide at least 12 per cent overall conversion efficiency with peak power density as high as $120W/m^2$, about twice the power density now being produced.

All solar cells, when exposed to light, produce about the same voltage (approximately 0.5V). However, the amount of current varies with the light intensity and the surface area of the solar cell. Solar cells are responsive to a broad range of light energy in the spectrum, from ultraviolet through the visible to the infrared. Therefore, they produce energy whenever there is light, even on heavily overcast days or in ordinary room light (tungsten or fluorescent).

Temperature also affects solar cell output. Using a temperature of 25°C ± 3°C as a standard test condition, the output voltage of each cell varies inversely with temperature about 2mV/°C. Power output follows the voltage characteristics but changes only about 0.3 per cent/°C because of the compensating effect of current which varies directly with temperature. A typical silicon solar cell delivers maximum power at approximate-



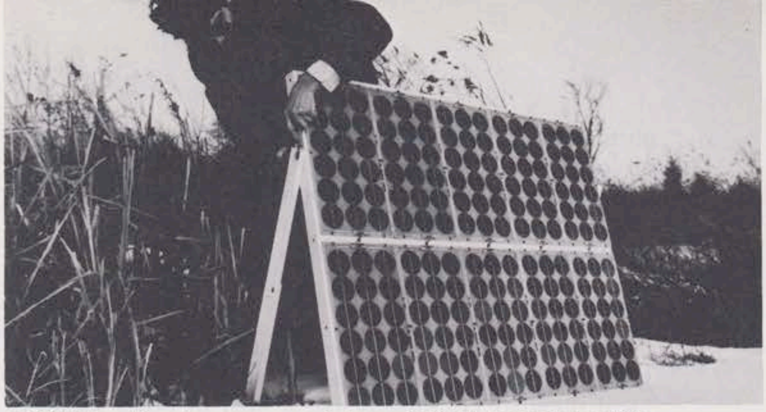
The charging of a 12V lead-acid battery requires at least 30 solar cells connected in series. Solarex typically uses 32 cells. The Type 280 Unipanel™ consists of 32 2-1/4″ diameter round cells and delivers 8.5W (peak). The Type 220 Unipanel consists of 32 quarter sections of the same solar cell and delivers in excess of 2W (peak).

ly .45V. Therefore, to be capable of charging batteries, a solar panel must contain numerous solar cells connected in series. For example, the charging of a 12V lead-acid battery requires at least 30 cells connected in series. For such applications Solarex typically uses 32 cells. The 32-cell arrangement will provide maximum charging power in the 13–14V region required for charging a 12V lead-acid battery. The size of the individual cells in the panel determines the current. For example, the Solarex type 280 Unipanel[TM] (solar panel) consists of 32 2-1/4″ diameter round Chevron cells and delivers 8.5 Watts (peak). The type 220 Unipanel consists of 32 quarter sections of the same solar cell, has one quarter of the area of the type 280 Unipanel, and delivers in excess of 2 Watts (peak).

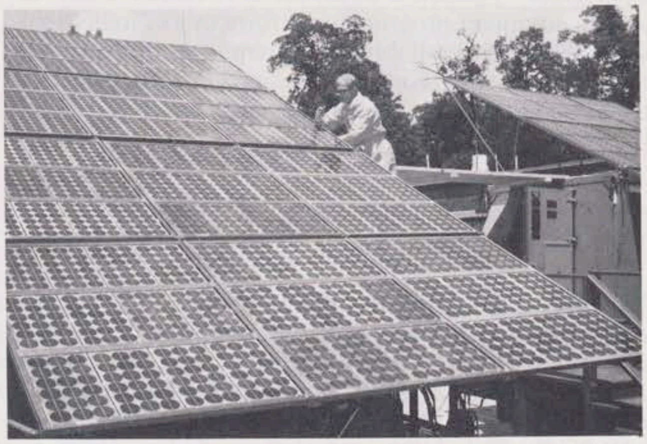
Solar Panels and Arrays.

A Solarex Unipanel consists of a number of interconnected cells, generally mounted on a fiberglass board and fully encapsulated in clear, stabilized, silicone rubber. These durable materials provide a sealed, highly transparent, weather resistant package to protect the solar cells' metal electrodes and all interconnections from corrosion. Even the external connecting wires are typically Teflon (Reg. TM DuPont) insulated. There are no exposed metal terminals.

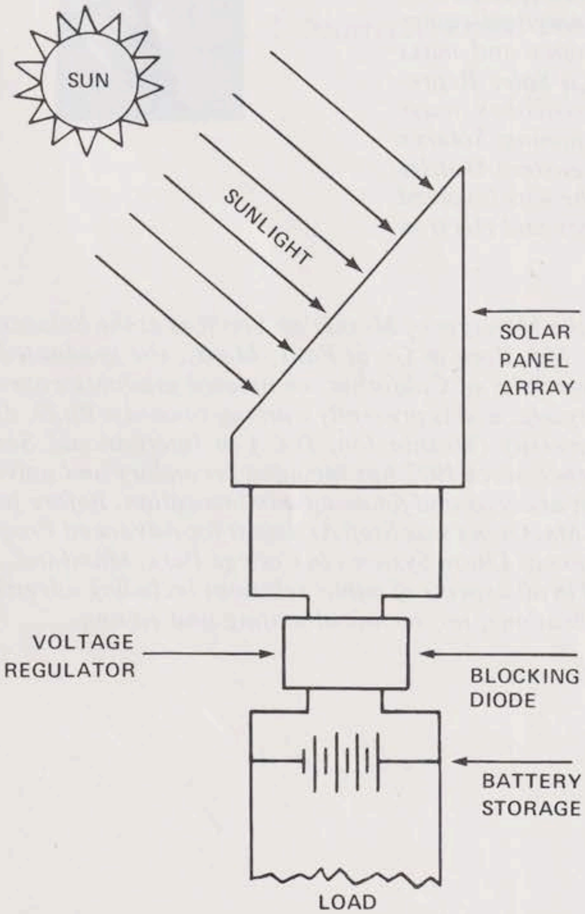
For special environmental conditions, the Unipanel surface may include tough, transparent cover materials such Lexan (Reg. TM General Electric) or Plexiglas (Reg. TM Rohm & Haas). Glass covers are also used. Once constructed, the Solarex Unipanel may be used individually or in arrays for solar electric generator systems.



100W (peak) solar array consisting of 10 Solarex Type 785 Unipanels being installed on site.



Van-mounted Solarex array for a telephone communications system. The solar array delivers over 2.5KW (peak). Storage batteries are also provided for periods of darkness.



Solar electricity is produced by the solar panel array, stored in rechargeable batteries and supplied to a load on demand.

A solar electric generator is an independent power source composed of a solar panel array, an electrical storage device and associated power conditioning circuitry. Electricity is produced in the solar panel array, stored (usually in batteries) and supplied to a load on demand.

Solarex has developed a special power conditioner called the Powermizer[TM], specifically developed for solar electric generators. The Powermizer is designed to prevent overcharging of storage batteries after having reached full charge. At the same time the Powermizer conserves solar electric power during the charging process and prevents discharge of the batteries during periods of darkness.

To be harmonious with the solar panels, storage batteries with a high charging efficiency and long life should be used in solar electric systems. Several battery manufacturers offer lead-acid storage batteries that are easily charged at more than 95 per cent efficiency and can last for up to 15 years.

Solar electric generator systems are designed to provide unattended, continuous and maintenance-free power in all kinds of temperature and environmental conditions. For example, Solarex systems are operating in Alaska, the deserts of the Middle East and offshore in the Gulf of Mexico.

Solar panels and arrays are typically mounted on anodized aluminum frames with enamel painted surfaces for maximum resistance to corrosion, high strength-to-weight ratio and reasonable cost. They may be transported easily by helicopter and installed quickly on-site on any choice of frame or structural member. Moreover, for tactical military applications, visual detectability can be reduced by camouflaging the solar cell arrays which are also absolutely quiet.

Reliability

Since the amount of sunshine available varies with geographical location, time of day, season of the year, local weather conditions and a host of other factors, solar electric systems must be individually designed for a particular application and location. Solarex has developed a computer program to perform this systems analysis quickly and reliably. A system is modeled month after month with considerable accuracy before purchase and installation, providing confidence in reliable, unattended operation. Trade-offs in the system are computed, such as between the sizes of panel arrays and storage batteries. With this data in hand, choices are easily made for array size and storage capacity for the specific application.

It is no wonder that the armed forces has so widely accepted the new technology of solar electricity. The reliability and cost effectiveness of solar electric systems are being demonstrated time and again. Solar systems are absolutely quiet and pollution-free. The use of solar energy to convert light directly into electricity reduces the usual logistical burdens associated with conventional power systems as there are no maintenance or fuel requirements. If your equipment can operate from batteries, it can be powered by solar cells!

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Theodore Blumenstock is the Director of Marketing and Sales of Solarex Corporation in Rockville, Md. Born in New York City, he received his B.S. degree in Mechanical Engineering from the University of Wisconsin in 1958. After a brief work period with Procter and Gamble in Cincinnati, Ohio, he served three years in the U.S. Army as an Armor Officer and helicopter pilot. Upon completion of his military tour, he worked in the field of patent law in various capacities and concurrently obtained an L.L.B. from George Washington University in 1966. However, a new career in technical sales was begun in 1967. His sales experience started with Picker X-Ray Corporation as a representative for x-ray analytical equipment which included such products as electron microscopes and mass spectrometers. In July of 1970, Mr. Blumenstock became a Sales Representative of AEI Scientific Apparatus, Inc., marketing microscopes, mass spectrometers and photoelectron spectrometers. Before joining Solarex Corporation in June 1975, Mr. Blumenstock was the Southeastern District Sales Manager for Etec Corporation for two years where he was involved in the sales and marketing of scanning electron microscopes and electron probe microanalyzers.

Mary Ann Goold is the Manager of Marketing Services at the Solarex Corporation, Rockville, Md. Born in Great Falls, Mont., she graduated with honors from the University of California, completed graduate courses at the University of Virginia, and is presently working toward a Ph.D. degree from American University (Washington, D.C.) in International Service. Professional experience since 1972 has included secondary and university instruction, research analysis and financial administration. Before joining Solarex in January, Ms. Goold was Staff Assistant for Advanced Programs at Amecom, a Division of Litton Systems in College Park, Maryland. Presently she is involved in all aspects of public relations including advertising, promotion and publications, ie., technical writing and editing.

Reprinted from SIGNAL, May/June, 1977
Official Journal, Armed Forces Communications and Electronics Association
5205 Leesburg Pike
Falls Church, Virginia 22041