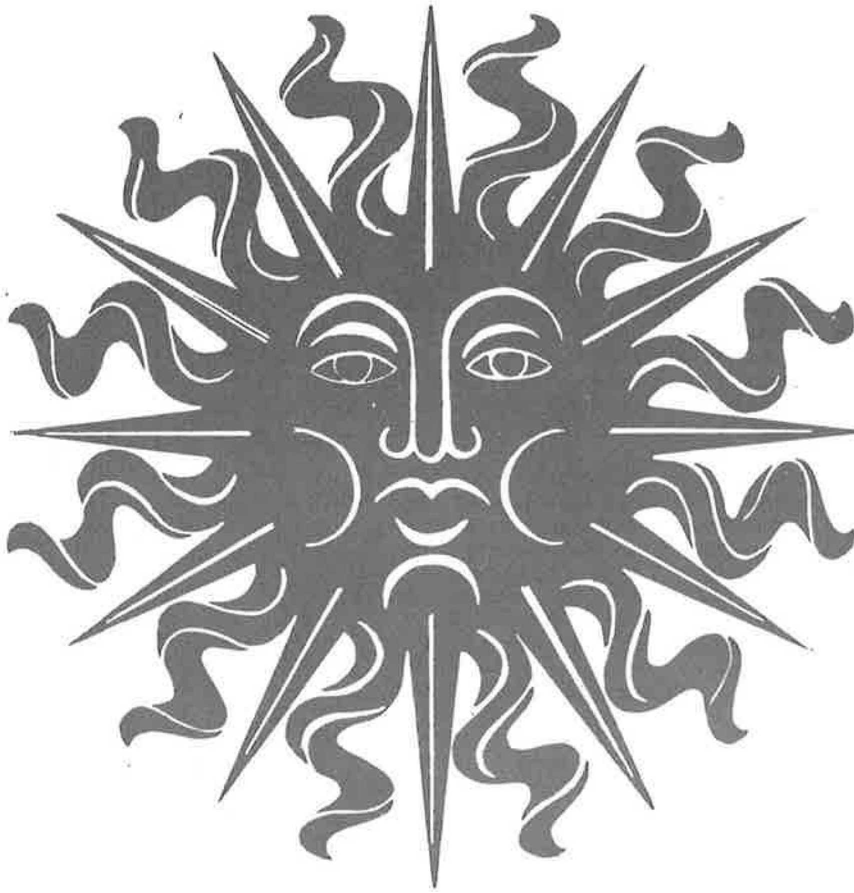

Demonstration Project In Washington: Solar Power Protects Bridge Deck

During the last 6 months, the sunshine that has bathed the scenery of Washington, D.C., has also been used to protect the bridge deck of a structure on the George Washington Memorial Parkway, which parallels the Potomac River close to the city. A solar electric power system mounted between the lanes of the Dead Run Bridge is supplying electrical power to operate a cathodic protection system to control corrosion of the reinforcing steel in the bridge deck.

The National Park Service and Region 15 of the Federal Highway Administration cooperated in the installation of the solar panel, which cost $4620, as opposed to $13 954 for commercial electricity. The $9334 savings in initial installation was the prime reason for using solar power; however, the additional savings of no monthly service charge as well as better uses of natural resources were contributing factors.

Cathodic protection has been used for many years to control the corrosion of buried pipelines and structures in saltwater environments. In the past, the use of cathodic protection in highway-related corrosion problems has been mainly to protect piers, pilings, and other underground and underwater installations. Recently, cathodic systems have been installed on several bridge decks to protect the reinforcing steel.

Corrosion of the reinforcing steel is caused by the penetration of deicing salts, which eliminate the protection normally provided by the alkaline content of the concrete. When this protection is removed, an electrical current flows from the surface of the steel through the concrete by means of the moisture in the concrete to another location on the steel. Corrosion begins in the area from which the current leaves the steel. (That area is called the anode, and the area where the current enters the steel is called the cathode.) When the flow of current stops, the corrosion stops.

Cathodic protection involves the external application of a direct current to the surface of the top mat of steel in sufficient amounts to overcome the internal current flow between the anode and cathode. A sacrificial anode is provided, and is allowed to corrode. The reinforcing steel then becomes a noncorroding current-receiving cathode.

The solar electric power system is essentially a power source composed of a solar panel array, a battery, and blocking diodes. Electricity is produced in the solar array, stored in a battery, and supplied to the cathodic protection system on demand. The blocking diodes are used to prevent the discharge of the battery through the solar panels at night.

The solar panel was mounted on a 7-meter (23.5-foot) diameter mast set into the ground below the bridge. The

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1 Facing south for the maximum exposure to sunlight, the collector has a design output of 33 amperes.

2 The solar collector is mounted on a 7-meter pole between the lanes of the George Washington Parkway near Washington, D.C.

top of the mast was 1.8 meters (6 feet) above the level of of the roadway.

To meet a particular power requirement, a solar electric system must be individually designed for that particular application and location, taking into consideration a host of factors including the amount of sunshine in that location at different times of the day and seasons of the year and local weather conditions.

Designers using historical weather data for the Washington, D.C., area determined that the solar installation required for the cathodic protection installation would have to provide a peak current output of 33 amperes. This would allow the daily current needs to be met, both for the cathodic protection current of 6 amperes and the expected "on" time of the solar array. The size of the storage battery was designed on the basis of a period of 2 weeks as the maximum time in the Washington, D.C., area in which there is no effective sunlight. This required a storage capacity of 2016 ampere-hours (6 amperes x 168 hours/week x 2 weeks).

The solar array consists of 10 panels connected in parallel to produce the peak current of 33 amperes at 2.4 volts. The cells in each panel are connected in a series-parallel combination to produce 3.3 amperes at 2.4 volts. Silicon circular cells 76.2 millimeters (3 inches) in diameter and coated with a thin oxide are covered with a protective coating.

The panel was installed on the mast at an angle of approximately 45 degrees, with the possibility that the angle would have to be changed if snow or ice accumulated on its surface during the winter. Rainwater keeps the solar cell surfaces clean in normal use.

A lead-calcium storage battery, rated at 2016 ampere-hours and weighing 167.8 kilograms (370 pounds) was selected for the system. According to an FHWA spokesman, the only maintenance needed is the addition of water every 2 to 3 years. The expected life is 10 to 20 years. The most critical item in the design was selecting the correct wire size to connect the solar array to the battery. Because of the total cable length of 18.3 meters (60 feet) and because of the high current supplied to the battery from the solar cells, any resistence in the wire would create a severe voltage drop. A size O wire was used to minimize this voltage drop.

What did it cost? The expense can be divided into three areas, as follows:

Item	Cost ($)	Cost/ Peak Watt ($)
Solar panel array	2540	32
Lead-calcium battery	305	4
Installation of solar array	1775	22
Total	4620	58

The cost of the solar panel array included the solar panel, the protective cover, the metal frame with adjustable leg assemblies, a wiring junction box, and blocking diodes with a current meter. The protective cover of the silicon cells, an option, amounted to $1.25 of the cost per peak watt. A local electrician and neon sign contractor suppied the labor, equipment, and materials for the installation of the solar array. Region 15 personnel made the wiring hookups, which were not included in the cost.

Basically, the solar cells use a natural phenomenon known as the photovoltaic effect to convert light energy directly into direct current. Silicon, the second most abundant element on earth, is the primary material used for solar cells. Although other semiconductor materials, such as cadmium sulfide, are also being used, the cathodic protection system used silicon. The manufacture of such a solar cell begins with a wafer of almost pure silicon. Since pure silicon is a poor electrical conductor, impurities are added to make it conduct either negative charges (electrons) or positive charges (holes). Sunlight is absorbed by electrons within the silicon wafer or solar cell. This creates both negatively charged electrons and positively charged holes. The negative charges are attracted to the N-type silicon and the positive charges to the P-type. Thus, an electric current starts to flow and voltage develops.

FHWA researchers point out that, because of its solid state construction, a solar array has a high potential for a reliable and long operational life. If repair is necessary, it can be done with minimal effort.

Because the power output of solar cells increases when temperatures are lowered, solar cells can perform well in extreme cold climates. Solar power produces no adverse environmental effect. At a mounting angle of 45 degrees, and with the protective cover, the solar cells are virtually bulletproof.

So far, the peak current generated by the solar array has been 27 amperes. FHWA points out that this was not under ideal conditions. There have been few clear days in Washington since the array was installed on June 25, 1976. An interesting finding has been the amount of power generated in the early morning. The sun at 9:00 a.m. has been supplying 15 to 20 amperes, causing researchers to believe that the total output per day may finally be higher than originally expected.

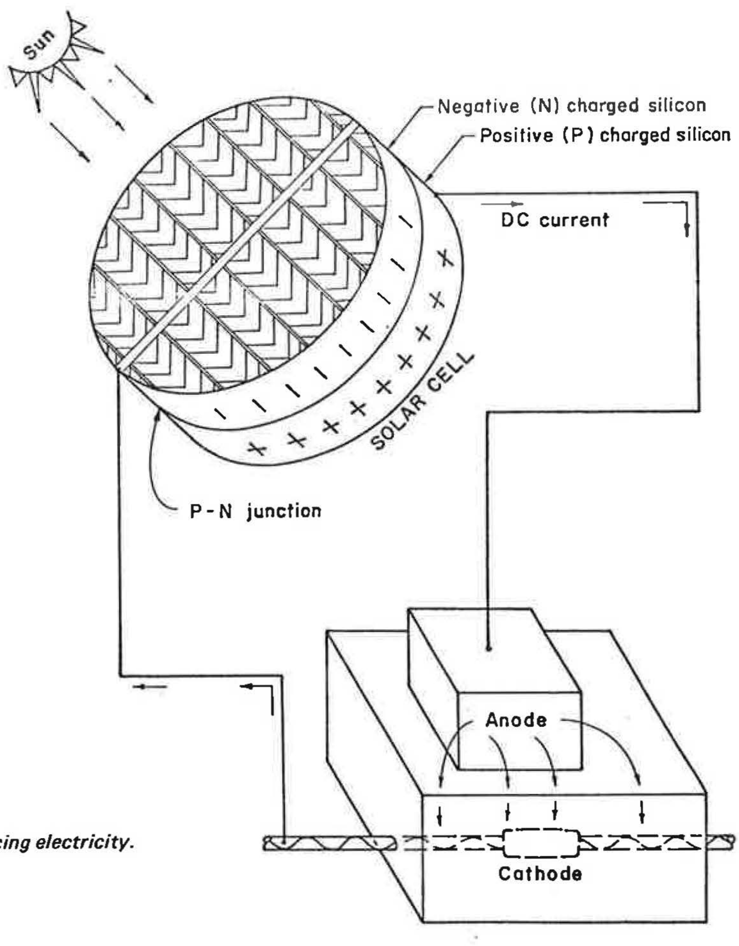

Figure 1. Solar cell producing electricity.