U.S. Army Prime Power:
A Tradition of Innovation and Excellence

By Chief Warrant Officer 2 Andrew K. Potter

The 249th Engineer Battalion (Prime Power), one of the most unique organizations in the Army, carries on a long and proud tradition of providing excellence in engineering support to the nation. The very motto of Army engineers—Essayons—vividly captures the indomitable can-do spirit of these special soldiers.

The battalion's dual thoroughbred bloodlines trace through many crucial times in the history of our Army. This article is limited in scope and discusses only the unit's Corps of Engineers lineage but does so with full and grateful recognition of the gallant combat and construction ancestry of the unit's highly decorated namesake, the 249th Engineer Combat Battalion. After a long and storied history as a table of distribution and allowances (TDA) organization, today's prime-power battalion activated as a table of organization and equipment (TOE) engineer unit in November 1994 (see article, page 7).

Historical Perspective

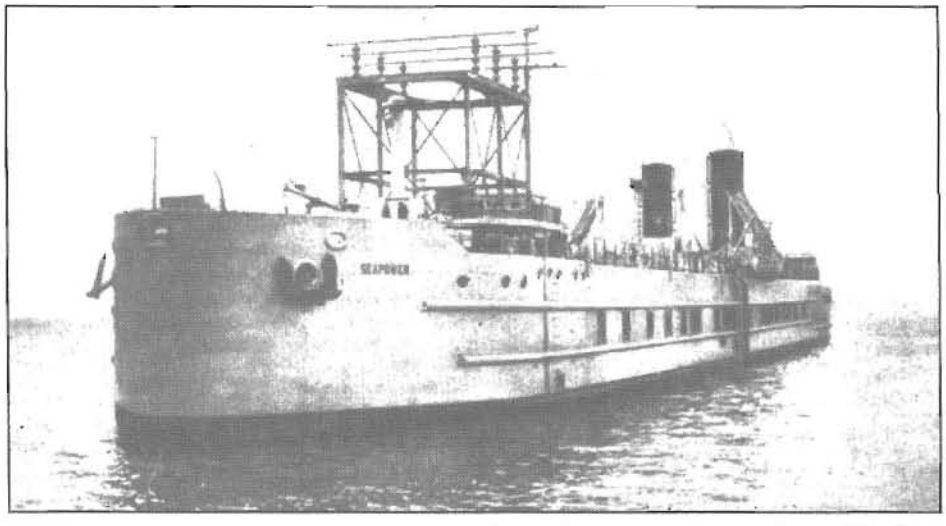
In the 1860s, the Army experimented with methods for protecting American harbors and channels. Torpedoes and mines emerged as the preferred systems, but the underwater firing devices did not always function. The Corps of Engineers perfected reliable, easy-to-maintain electrical firing systems using batteries and small magneto-based generators. Major Henry Abbot discussed the importance of power in his 1876 book *Notes On Electricity*: "The part which electricity now plays...is so important that an accurate knowledge of the leading principles of the science...are indispensable to the engineer officer." [1]

Coastal defense later included huge searchlights, networks of underwater mines and torpedoes, and on-site generators for power. Captain George Anderson, in his 1902 *Handbook for Electricians*, gave timeless maintenance tips: "Prevention is the rule for machinery troubles, not cures."[2] Regarding switch-gear: "No one should be allowed to touch the switchboard unless he is familiar with all circuits connected to it, the strength of main and feeder circuits, and the insulation of each part. Always close a switch deliberately and firmly, while watching the ammeter and voltmeter, and while standing ready to open."[3] This was good advice then and still is today.

World War II brought new challenges. Engineer soldiers used four power barges for on-site electricity, each equipped with a 30-megawatt (mW) generator driven by two marine-type, high-pressure boilers. The barges provided critically needed power to cities whose electrical grids had either been severely damaged or were overloaded by the demands of supporting the Allied ground advance. These one-of-a-kind designs, originally intended for use in the United States to meet anticipated wartime power shortages, saw their first use in the Belgian port city of Antwerp and later in Rotterdam and Manila.

Army Nuclear Power Program

The Corps of Engineers established the Army Nuclear Power Program in the 1950s. The Stationary Medium 1 (SM-1) plant, a 2-mW prototype at Fort Belvoir, Virginia, was the very first nuclear electrical-power plant to be paralleled to a commercial grid. It is commonly thought that the Shippingport, Pennsylvania, plant was first, but the Corps's SM-1 went on-line on 12 April 1957, more than a month before the Shippingport unit.

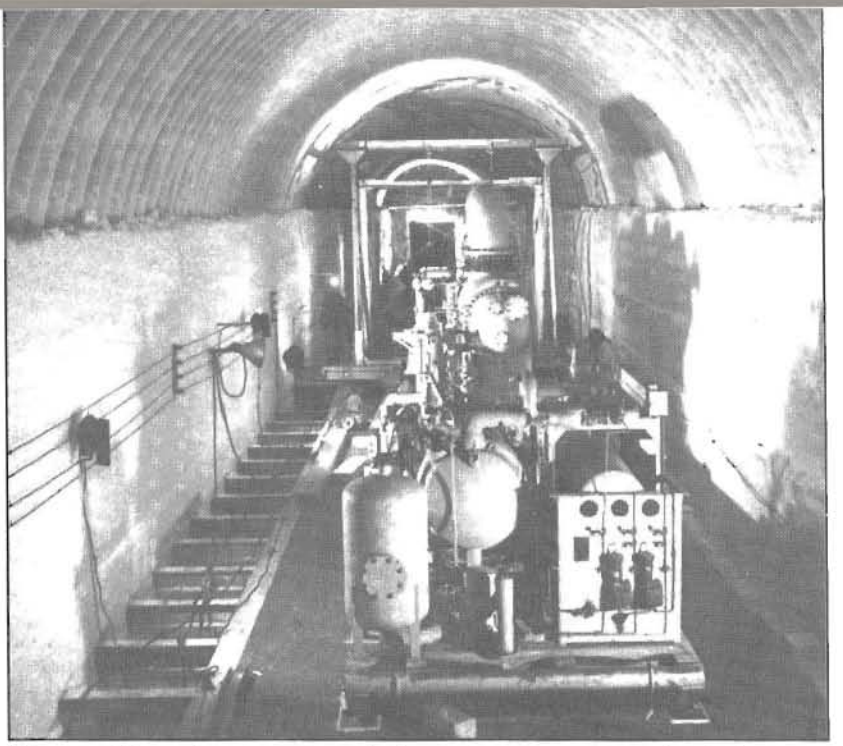


The power barge *Seapower*, one of four unique Corps vessels carrying a 30-mW power plant designed to augment war-damaged electrical grids.

Founders of the Army Nuclear Power Program carefully selected highly qualified officers and enlisted soldiers from the ranks to receive the grueling, year-long, reactor-operator training. The program produced several modular power plants, which were shipped in pieces to remote outposts as a test of the viability of nuclear power for

far-flung military installations. One of these plants generated power from more than 30 feet below the polar ice cap at Camp Century, Greenland, a most unusual Corps outpost just 800 miles from the North Pole.

Army engineers carved Camp Century out of the ice in 1960 to house the Army's Polar Research and Development Center. More than a hundred soldiers and scientists lived and worked in this fascinating tunnel complex. On 12 November 1960, only 77 days after the pieces arrived on station, the compact 2-mW nuclear plant provided power, heat, and fresh water for the city under the ice. Camp Century supported the center until the summer of 1965. Similar plant installations were made in Antarctica, Alaska, Wyoming, and Idaho.[4]



The 2-mW nuclear reactor at Camp Century, Greenland, is home to the Corps's Polar Research and Development Center.

The Corps's Engineer Reactor Group, as the nuclear program was named, advanced another first with the floating nuclear power station *Sturgis*. The 10-mW pressurized water reactor, mounted on a modified Liberty ship hull, became the first floating plant to regularly supply power to a shore station. It moored from 1968 to 1975 in the Panama Canal Zone, allowing the waters from Gatun Lake to be used for filling locks. The *Sturgis* was on-station during the height of the Vietnam War, allowing more than 2,500 more ships per year to pass through the canal than would have been previously possible.

Prime-Power Battalion

In August 1969, Hurricane Camille struck the Mississippi Gulf Coast with destructive wind gusts in excess of 180 miles per hour and a 23-foot-high storm surge. In the final report on the effects of the storm, the Army Office of Civil Defense noted that "Portable power sources are highly useful in an emer-gency. The operational problems for distributing, installing, and running...emergency power generators have not been solved and merit further study."[5]

On 24 August 1992, the forward edge of Hurricane Andrew reached landfall 25 miles south of Miami. The winds ripped the anemometer off the roof of the National Hurricane Center, with the last recorded speed in excess of 167 miles per hour. In Homestead, 90 percent of the structures collapsed, leaving 50,000 residents with nowhere to live. More than 2 million people lost electricity. Four days later, Florida Power and Light estimated that more than 500,000 were still without power and would remain so for months. On order from President Bush, more than 16,000 soldiers from Fort Bragg, North Carolina; Fort Drum, New York; and other installations deployed to southern Florida. Among them were soldiers of today's 249th Engineer Battalion (Prime Power), the successors to the Engineer Reactor Group. In the first three weeks of that deployment, troops from the 249th installed more than 200 small- and medium-sized generators at critical facilities all across southern Florida, bringing desperately needed on-site power to people in crisis. The Corps of Engineers' tradition of excellent service to the nation continues today.

On-Site Power Needs

Modern military forces depend more and more on reliable, mobile electrical power. Health-service support, automation, communications, and weapons systems all rely heavily on electricity. In the Army, there is a critical gap in the electrical-power continuum between that supplied by small tactical generators (5-kilowatt [kW] to 100-kW) and the option for commercial power. Tactical generators are standard military sets distributed throughout the Army's fighting units, usually configured for multiple voltage and frequency output and ease of portability. The responsibility for setup, installation, and operation rests with the tactical unit.

When soldiers construct or modify large, forward-deployed military installations, tactical generators are often not sufficient to meet the concentrated demands for electrical power. Depending on the area and tactical situation, commercial power may or may not be an option. The 249th produces reliable, utility-grade power to bridge the gap. Headquartered at Fort Belvoir, Virginia, the battalion is comprised of highly trained soldiers who serve as installation specialists, plant operators, and maintenance personnel. Electricity generated by 249th soldiers is used as a supplement to tactical power, as a stand-alone source, or in parallel with a commercial source.

The battalion's primary mission is to generate and distribute prime, utility-grade power in support of warfighting, stability and support, and disaster-relief operations. The secondary mission is to provide advice and technical assistance in all aspects of power systems, with additional responsibilities in maintaining the Army's power-generation war reserves. This broad mission, which encompasses a tremendous range of



A student and instructor carefully check the schematic prints of a system inside a central-control van at the Prime Power School.

logistical and technical challenges, is accomplished through a distinct mix of equipment and people.

Equipment

The standard deployable power plant organic to each of the eight operational platoons around the world consists of four diesel-engine-driven generator sets, each capable of producing 750 kW at 4160 volts. They are in either a wheel-mounted configuration weighing about 25,000 pounds or a skid-mounted set weighing about 40,000 pounds. Both models travel in standard military aircraft, ships, and trucks with no modifications. To distribute the power to users, platoons have trailer-mounted substations complete with metering and switch gear. The four generators are controlled from a single, centralized control and distribution van. These systems are configured into a 2.25-mW (3-mW peak load) plant complete with primary and secondary distribution.

Other sets in the prime-power inventory include 500-kW, low-voltage, skid-mounted diesels; 1500-kW, skid-mounted diesels; and new 1500-kW International Standards Organization (ISO) container-mounted diesel sets, which are complete with a laptop computer as the remote-control and data-tracking panel. Most of these other sets are managed through the battalion's loan program, through which high-priority government sites borrow assets from the 249th to meet their critical needs. Both parties sign an agreement that the using agency will be responsible for operations and maintenance, while the 249th retains the responsibility for initial installation, training of the operators and maintenance technicians, regular inspections, and on-call assistance.

Soldiers

Soldiers are the key component for success in the 249th. Although equipment is certainly important in accomplishing the mission, without the highly trained, innovative problem solvers who make up this unit, the machinery would be idle. With only about 170 active-duty noncommissioned officers holding this specialized skill, the prime-power field is among the smallest in today's Army.

Imagine an independent group of 14 soldiers, each trained in an intense power-systems course, each constantly immersed in high-voltage safety as a way of life. These people are trained as innovative troubleshooting experts, not just parts changers. They perform both theoretical manipulation of problems and "down-in-the-dirt" practical work. On a job to install a power plant, for example, any member could draw out an accurate one-line diagram, solve and prove the capacity required to meet customer stipulations, and produce a detailed bill of materials and man-hours required. Those same people actively participate in the installation of the plant, providing either mechanical, electrical, or instrumentation systems expertise. They perform quality-control inspections along the way, and when the time comes to put the plant on-line, they analyze the load requirements of the moment and smoothly parallel the required number of units onto the grid. This same group of soldiers also serves as a preventive and predictive maintenance crew.

Does such a group exist? This is but a brief description of a single platoon of the 249th Engineer Battalion (Prime Power). The key component in building such a team is the initial training received by each person vying to become a member of this elite circle.

Prime Power School

Prime-power soldiers come from the active-duty enlisted ranks. Soldiers from any career field may apply, but they must be at least a corporal/specialist (E4). This generally means that they are on their second enlistment, with four to six years in the Army. Entrance requirements are stringent, with high scores required in the standardized tests for math and general technical subjects. Those who are accepted are grouped into classes of about 20, normally with two classes starting each year. They and their families are moved on permanent-change-of-station orders to Fort Belvoir, Virginia. There the soldiers are placed under the charge of the Prime Power School faculty, which consists of both civilian and military instructors.

The training is intense. The course of instruction is 52 weeks long, with eight training hours per day, five days a week. This school grew out of the Army's Engineer Reactor Group program. That tradition of superb technical qualification and rigid standards in power-plant-operations training has not changed. The course is broken into three phases: academics, plant operations, and technical specialty. The homework load averages three hours of work per night. It is one of the longest, most difficult courses in the Army.

During the academic phase, soldiers study mathematics, physics, mechanical and electrical theory, instrumentation and controls, and protective devices. In operator's training, the emphasis is on performance-based evaluation. The various types of sets in the inventory are introduced, and rigorous practical application and testing begins. Several mandatory manual paralleling exercises with both 750-kW and 1500-kW sets present a variety of changing load scenarios. Response time and accuracy of output parameters are tightly graded. Substandard performance in this phase is not taken lightly. A primary job of prime-power soldiers in the field is to operate the power plant. In the specialty phase, soldiers are split into one of three possible tracks: mechanical, electrical, or instrumentation and control. Each of these specialty tracks trains for more than four months in its particular discipline. After the grueling year-long course, soldiers graduate as fully certified, ready-to-work prime-power specialists.

Work in the Field

After finishing the Prime Power School, soldiers report to one of the eight operational platoons. A utilities warrant officer leads each platoon, which is divided into two operational sections, with a further breakdown of the technical specialties. Each platoon has two instrumentation, four mechanical, and six electrical specialists.

From this basic structure, many different teams of people are built depending on the mission. On large power-plant-installation jobs, one or two entire platoons may deploy initially to handle the first surge of work. Once complete, an operations and maintenance crew of perhaps only eight or nine soldiers may remain. Technical assistance or survey missions may require only one or two soldiers. Disaster relief might take the entire battalion, as was the case in 1992. In two short months during the summer and autumn of that year, two hurricanes and one typhoon (Andrew, Iniki, and Omar) sent the entire battalion to Florida, Louisiana, Hawaii, and Guam. The unit was stretched so thin that the battalion command graduated an in-session class of students two weeks early and deployed them directly to disaster-ravaged areas.

Technical Assistance

The broadest part of the prime-power battalion's mission statement is to "provide advice and technical assistance in all aspects of power systems." Each platoon has the skills and equipment to do just that. In addition to installing and operating any variation of the basic 3-mW plant, platoons carry out a tremendous range of testing, survey, and quality-assurance missions. A few examples are infrared surveys, high-voltage cable splicing and testing, overhead and underground distribution, power-factor-correction studies, substation maintenance, and protective-relay/circuit-breaker testing. The battalion also provides rapid-response support to victims of hurricanes, floods, and ice storms. Again, the key to success in all these missions is the soldier who makes all the systems work reliably, safely, and efficiently.

Innovative troubleshooting is the hallmark of technical assistance provided by prime-power soldiers. As an example, on a spring 1996 mission to provide power on an isolated grid to Soto Cano Air Base, Honduras, our platoon (which was stationed at Fort Leonard Wood, Missouri, at the time) walked into an interesting technical challenge. For the previous month, daily lunchtime outages plagued the 3.75-mW plant due to a fault somewhere in the 20 or so miles of 23-kV distribution. Our crew was technically responsible only for the installed power plant, but two of us were assigned as quality-assurance representatives for the electrical portion of the base main-tenance contract. The instructions from the colonel were clear: Fix this problem of daily outages, and do it now.

The faults were happening around the same time every day, with a tremendous surge visible on the plant metering just before the relays tripped out on instantaneous overcurrent. With no power-line monitors available and the maintenance contractor unable to provide much historical data, we pored over the distribution plans for likely suspects. Three branch circuits looked interesting, with big refrigeration and industrial laundry loads. With those three circuits isolated, however, the very same surge blasted our plant off-line the following day. We were certain that we had a high-resistance fault somewhere, only showing its ugly face when a decent-sized current was drawn across it. An infrared survey of the entire system that night showed no major problems. Crossing our fingers the next day, we increased the trip values on our plant overcurrent relays, hoping to send enough current down the line just long enough to blow something up. No luck—it just took a little longer to go out on overcurrent. We set the trip windows back to normal.

Because the fault was making it all the way back to the plant, we requested all distribution-system-fuse data from the contractor, which came through in the late afternoon of the second day. Normal high-voltage fuse protection should be in the range of 150 to 200 percent of full-load current values. The fuses for the five main feeders on base, however, were sized at more than 600 percent of full-load current, and the branch circuit fuses were sized between 500 and 1500 percent of full-load current. There was no coordination to the protection at all. We directed that the main feeder fuses be reduced to 200 percent of full-load current. The following day one of the main feeder fuses blew instead of our power plant taking that awful surge.

The rest of the third day, we had the contractor reduce all branch circuit fusing to 125 percent of full-load current. In some cases, due to lack of proper fuse sizes, the branch fusing went below 100 percent. Although this risked a few nuisance blows, it was certainly better than losing the entire base. On the fourth day, a single fuse at the main fuel-distribution point blew. The contractor replaced one transformer in the three-phase bank and our problem went away. We had no way to push enough current through the transformer on the bench to truly test it but, from the end result, it was pretty clear that a high-resistance fault had developed internally. This fault was only showing when one of the big pump-house motors turned on. Sure enough, the tankers that distributed diesel fuel around the base almost always went to the fuel point between 1100 and 1400 hours, and each day one or more of those motors kicked on to level out the belowground fuel tanks. We wrote up a procedure for protective coordination, made several strong recommendations for in-depth available fault current and full protective studies, and closed the book on a problem solved. We spent the rest of our three months in Honduras enjoying both the warm weather and operations shifts that were relatively free of outages.

Disaster Relief

The 249th is an integral part of the federal response plan to disasters. Under the direction of the Federal Emergency Management Agency, the Corps of Engineers has the lead for the public utilities and civil-works emergency-support function. The Corps often tasks the 249th to install temporary emergency power.

Disaster relief is among the most challenging, interesting, dangerous, and rewarding work performed by prime-power soldiers. Working safely is always at the front of your mind as you deal with fallen lines, overturned pad-mount transformers, the constant danger of back feeds from hurriedly connected small generators, wet ground, and unstable structures.

There is tremendous psychological stress imposed on everyone working in an area torn apart by natural disaster, and soldiers from the 249th are no exception. The pressures of working long hours with few breaks, constant short-fuse missions, the frustration of wanting to help everyone all at once, and the reality of seeing the lives of other humans torn apart all combine to weigh heavily on soldiers working to help.

As a specific operational example, prime-power soldiers installed over 200 small- and medium-sized generators during the six-week deployment to southern Florida following Hurricane Andrew. These generators, ranging in size from 10 to 750 kW, were put into operation at many critical facilities, such as police stations, hospitals, feeding centers, radio stations, schools, emergency shelters, supply distribution points, fire stations, medical and dental clinics, homes for the elderly, telephone-switching centers, pharmacies, and water-lift stations. In recent years, troops from the battalion have swiftly deployed on dozens of such humanitarian-relief missions following hurricanes, typhoons, floods, and severe ice storms.

The technical challenges of disaster relief are many. The job for prime-power soldiers consists primarily of assessing critical facilities for power needs and then installing the proper generator. Of course, things are not always that easy. Often, the critical facility identified for assessment consists of only half a building, along with half a distribution system, or a tent city with no distribution network at all.

Few street signs and landmarks remain after a major hurricane or typhoon. On our very first Hurricane Andrew assessment mission in Homestead, Florida, we drove right past the city. What we saw on the ground defies description – but it didn't look like a place where people had ever lived or worked. Bringing help to areas such as that is indeed satisfying work.

Some samples of my own thoughts during disaster relief are: *Can we rebuild that panel using #2 wire and tape? Is that half-overturned pad-mount hot? Do I hear a little 1.5-kW set running? Am I glad we have these police escorts; this traffic is unbelievable. Is there a back-feed through any of those wires laying on the ground? How can we possibly get a good ground for our generator anywhere in this muck that used to be a parking lot? How did half of a utility pole wind up in the attic of a community center? You know, lying on my back inside this switch-gear, in the middle of the night, with a wrench on this energized bus-bar, sweat pouring off me...is a really bad time to wonder when I last had my gloves certified. If we install a trailer-mounted set here, will it be stolen during the night? Why does this cell phone always cut out just when operations is telling our flying carpet where to go next? How did one crew use an entire case of electrical tape in half a day? Are we even at the right building?*

The Future

Major Henry Abbot, Corps of Engineers officer of the late 1800s, said in his *Notes on Electricity*, "The word electricity is used to designate a force that produces a class of natural phenomena of which the explanation is still shrouded in mystery."[6] True enough, but Corps of Engineers soldiers have made a proud tradition of removing some of that mystery, consistently generating reliable on-site electricity for Army commanders.

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and provides the information to the ESF3 cell. The cell then coordinates for installing generators at the assessed sites.

In most instances, the 249th is the disaster effort's "reconnaissance element" that determines the routes for transporting the generators to the desired facilities. Hurricanes, floods, tornadoes, and earthquakes tend to make road routes and critical facilities difficult to identify, and often the existing damage slows the relief effort. In most cases, local governments have difficulties with identifying their electrical needs and critical facilities *after* a disaster strikes.

The Los Alamos National Laboratory in New Mexico is developing an Internet-based computer-simulation model to help decision makers during natural disasters. The Corps of Engineers' South Pacific Division's emergency-operations planners invited the A Company commander to provide an "emergency-power perspective" to the development of the simulation model.

The current model simulates the effects an earthquake would have on the Los Angeles Basin's power grid. The Web-based model will contain damage estimates from potential earthquakes; mission, operational modes, and general information about the stakeholders; and an interactive Web site where stakeholders can coordinate planning issues. By using a predictive model, decision makers can identify the potential damage an earthquake will present to the power grid. With this information, planners can identify which critical facilities will be without power and for what duration.

Currently, city planners have identified more than 50 critical facilities in the greater Los Angeles area, which include command-and-control centers, hospitals, and water-treatment plants. The 249th is working with the Corps of Engineers to develop an earthquake-disaster scenario to test the simulation model and train its soldiers on disaster-relief operations in an urban environment. By training for disaster relief using the latest simulation models, the 249th can ensure that its stakeholders will have electrical power at critical facilities in the event of future earthquakes or other natural disasters.

Remaining Relevant

A Company will continue to seek training opportunities with the joint, civilian, and academic communities that tie into the company's three distinct missions. As the Army transforms into Force XXI, the 249th Engineer Battalion (Prime Power) will remain relevant by addressing the electrical needs of the Army and the nation. A Company trains with the Federal Emergency Management Agency and the civilian side of the U.S. Army Corps of Engineers for emergency-power disaster-relief missions. The company also provides support to joint-task-force headquarters such as Joint Task Force Pacific Command for Exercise Cobra Gold in Thailand and to Joint Task Force Bravo for border-patrol missions. The company deploys annually to Korea to provide its technical expertise to the Eighth United States Army for the joint and combined exercises on the peninsula.

A Company is one of only two multicomponent companies in the Army; the other is B Company, its sister unit at Fort Bragg, North Carolina. The 249th is a model for the Army's future force structure, where both strong technical and tactical expertise at the individual and collective levels are necessary for mission success. The 249th Engineer Battalion (Prime Power) stands ready to accept the twenty-first century's challenges for the country and abroad.

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The Army's electrical needs will continue to grow. The trend is toward more mobile weapons systems and vehicles. The electrical sources to supply those systems will become more mobile as well (see article, page 7.) Whether produced with diesel engines, gas turbines, fuel-cell devices, nuclear power, or some other new technology, increasing amounts of electrical power will be consumed in the Army of tomorrow. The 249th Engineer Battalion (Prime Power) will be there, trained and ready to provide support anytime, anyplace. Responsive, respected, and reliable prime-power soldiers will continue to produce utility-grade power and provide that all-important, in-person technical assistance to support the Army mission.

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Endnotes:

[1] Major Henry Abbot, *Notes on Electricity (In Its Applications to Submarine Mining)*, Torpedo School Battalion Press, (Sergeant Carmichael, Printer), December 1876, Chapter 1.

[2] Captain George Anderson, *Handbook for Electricians in the Operation and Care of Electrical Machinery and Apparatus*, D. Van Nostrand Company, New York, New York, 1902, p. 5.

[3] Anderson, p. 64.

[4] Army Office of Civil Defense, "The Effects of Hurricane Camille on Industry, Public Utilities, and Public Works Operations," URS Research, San Mateo, California, 1970, p. 73.

[5] Charles Daugherty, *City Under the Ice: The Story of Camp Century*, MacMillan, New York, New York, 1963.

[6] Abbot, Chapter 1.