Liquid Fuse to Smart Grid
A Century of Innovation
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When S&C Electric Company previewed a radical new product called IntelliRupter® PulseCloser at an industry trade show in 2006, the competition said it couldn’t be done . . .
Over the next three years, more than a dozen teams of S&C engineers, software developers, and manufacturing experts turned IntelliRupter from raw concept to finished product. Now—with utilities installing hundreds of the devices on their systems—IntelliRupter is helping define the emerging “Smart Grid.”

IntelliRupter continues a tradition of technical breakthroughs that began in 1909 when the company founders, Edmund O. Schweitzer and Nicholas J. Conrad, developed a “liquid fuse” to interrupt high-voltage short circuits. In the 1940s, S&C’s engineers conceived the Aldutirupter® Switch, which confined the high-voltage arc to an enclosed interrupter where it can’t cause a fire. In the 1960s, there was Circuit-Switcher, another game changer that “couldn’t be done” . . . until S&C did it. Most recently, IntelliRupter and other innovations use electronics and software to do things that were once considered impossible.

S&C employs 1,700 people at its Chicago headquarters and 200 more in other U.S. locations. It has subsidiaries in Canada, Brazil, China, Mexico, and Europe. Small, nimble, and employee-owned, S&C is a global leader in power systems technologies.

“There aren’t very many companies around that could have pulled this off,” said S&C President and CEO John Estey, when the first IntelliRupter was shipped.
The Smart Grid heals itself, and here too, S&C is a leader. IntelliRupter® PulseClosers, combined with the IntelliTEAM SG® Automatic Restoration System, communicate with each other and make operating decisions that keep the lights on. And S&C’s TripSaver™ Dropout Recloser replaces old-fashioned fuses or reclosers with an intelligent device that reduces the need to send out line crews.

To connect wind farms to the grid, S&C’s power quality teams build the PureWave DSTATCOM®, a truck-sized device that rides the alternating-current waveform and injects current exactly as needed to maintain a steady power factor. S&C’s Smart Grid SMS™ Storage Management System captures energy when demand is low, stores it in 80-ton arrays of sodium-sulfur batteries, and returns it to the grid during periods of peak demand.

Developing the future

**TripSaver™ Dropout Recloser** is ideally suited for lateral circuits that frequently experience momentary faults. TripSaver eliminates the permanent outages that result when lateral fuses operate in response to these momentary faults.

**Smart Grid SMS™ Storage Management System** allows better utilization of renewable energy such as wind power. It offers megawatt-hours of energy storage for Smart Grid applications, permitting this power to be dispatched when it’s needed.
IntelliRupter® PulseCloser is a breakthrough in overhead distribution system protection. It's a unique alternative to conventional reclosers. IntelliRupter was designed from the ground up to accommodate advanced distribution automation functions.

PureWave DSTATCOM® Distributed Static Compensator is specifically designed to address voltage regulation and power factor issues. It supports dynamic power factor requirements or system voltage during normal operation, and compensates for voltage sags which can cause wind turbines to trip off-line.

S&C was founded in 1911 as Schweitzer & Conrad, Inc. Its mission was to help utilities protect their systems from short circuits. That role continues today, but now S&C's products use sensors, relays, and microprocessors to identify circuit disruptions and respond so quickly that many users don't even see a blink in the lights.

How S&C grew from a one-person shop into a global enterprise is a story of innovation, manufacturing prowess, and testing ingenuity. It is a story of survival . . . from paying back an initial $1,000 loan, to making it through the Great Depression and World War II. Most of all, it is about opportunities captured—from the first decades of a brand-new industry to today's digital revolution.
Dawn of the electric age

In the early 1900s, as consumers embraced electric lights and appliances, utilities installed larger generators and stepped up distribution voltages to reduce power losses. But early high-voltage fuses often weren’t up to the task. They didn’t operate reliably, sometimes resulting in fires and explosions. After one such fire in 1909 at Commonwealth Edison’s Fisk Generating Station in Chicago, the utility gave two of its top engineers an assignment: Find a better way to interrupt short circuits.

Nicholas Conrad, then 27, and Edmund Schweitzer, 20 years older, got to tinkering and soon invented something completely new: a spring-loaded fusible element inside a glass tube filled with arc-extinguishing liquid. When short-circuit current melted the element, the spring stretched out the arc, which was “quenched” in the liquid.

It was a breakthrough idea . . . and they knew it. Conrad began making Liquid Fuses on his home workbench, selling them to Commonwealth Edison for $1.25 each. Soon other customers were placing orders. The two men borrowed $1,000 in 1911 and formed Schweitzer & Conrad, Inc.

At first, a single employee named Ed Toman did all the assembly. But orders kept growing.

In 1915, Schweitzer and Conrad invested $30,000 to build a factory on Ravenswood Avenue, on Chicago’s North Side. The following year, Conrad quit his Commonwealth Edison job to devote full-time to the enterprise . . . a decision Schweitzer thought was too risky. By the mid-1920s, 110 employees worked in the noisy shop that smelled of solder. August Cherrie was one of them, earning 58 cents an hour as he filled and sealed 100 fuses a day.
Competing in a crowded field of equipment suppliers, the company distinguished itself with high-quality manufacturing and a steady stream of new devices: choke coils and lightning arresters, many sizes of fuses, even a giant Pantograph Switch that could close into a live circuit at 138,000 volts. Deploying new technologies five to ten years before the competition became an S&C hallmark.

“They’re not copycats,” said Edgar Kobak, who in 1918 sold Nicholas Conrad the company’s first ad in *Electrical World* magazine.

Being a leader came with risks: S&C had to invest heavily in research, constantly upgrade manufacturing, and stand behind its products when something went wrong. The first such problem came in the 1920s when utility crews found corrosion and leakage at the solder seal of older fuses. Conrad assigned the problem to Sigurd “Sig” Lindell, a young engineer who would later become Vice President for Research and Engineering.

After inspecting the corroded fuses and testing various possible solutions, Lindell’s team finally got the results they wanted with a new non-solder design. Conrad then offered customers free replacements for their existing fuses.
Nicholas J. Conrad was a restless and driven man, rarely satisfied with current technologies or how they were being applied. He constantly talked about new product ideas and personally earned 49 patents. But that fertile mind was also prone to dejection, and in 1930 Conrad’s poor health forced him to sell out to a motor control manufacturer, Cutler-Hammer. The company name didn’t change, and most of the staff stayed on. They earned 111 more patents during the Great Depression, keeping the company alive even as production was cut to two or three days a week.

The early liquid fuses were followed by bayonet-type fuse cutouts for pole-top transformers, with double the interrupting capacity of competitors’ box cutouts. A second generation of liquid fuses used precision silver elements that allowed operations to be coordinated within 1/60th of a second. Next came “solid material” fuses lined with arc-quenching boric acid. These could be fitted with exhaust condensers and used in cabinets, or deployed outdoors to extend fault protection to 750 megavolt-amperes . . . well beyond the limits of liquid fuses.

A bigger problem was switching high-voltage circuits without the buzz and flash of an external arc. It could be done with oil-filled circuit breakers, but they were expensive, heavy, and a fire risk. By the late 1930s, Sig Lindell and Anthony Van Ryan had patented something better. Their “load-interrupter switch” snuffed the arc in an enclosed interrupter featuring spring-loaded contact and liner materials that created de-ionizing gases. These switches would later appear on pole tops everywhere. But they had a more immediate use during World War II. With circuit breakers in short supply, S&C answered the call by mating the switches with fuses inside cabinets. It was the earliest version of S&C’s Metal-Enclosed Switchgear.
Conrad recovered his health by the 1940s and saw great opportunities for growth as suburbia sprawled across America’s landscape. He wanted to get back in the action. Cutler-Hammer was willing to sell, and so was Edmund Schweitzer, who had retained a small interest. Conrad repurchased the company in 1945 and recruited his son, John, as its new leader.

At first, John was apprehensive about joining his father. He had risen to the position of properties manager at Douglas Aircraft, in Long Beach, California . . . a job he loved. But he liked the idea of a privately-owned company where he and his father could invest as they saw fit, pursuing long-term goals instead of short-term profits.

John would spend the next 50 years in an all-consuming drive to create an ideal industrial company. He would build a world-class manufacturing campus, start a subsidiary in Canada and a joint venture in Mexico, and press his teams to invent all-new product categories. Through the force of his personality and his commitment to integrity, John Conrad rose to prominence in an industry dominated by much-larger companies, including General Electric and Westinghouse. His leadership role was cemented in the late 1950s when the U.S. government indicted 29 major electric equipment suppliers for participating in a price-fixing scheme . . . but not S&C. John Conrad refused to be involved in such discussions.

Like George Pullman, who built a model town around his railroad-car plant on Chicago’s South Side, John Conrad envisioned his company helping employees of all races and ethnicities grab hold of the American Dream. Pullman’s ideal was never realized—spoiled by rigid rules and labor strife—but John Conrad made his dream come true.

He provided employees with above-average pay and benefits, a comfortable factory, and a social environment that included bowling leagues, family picnics, and Christmas parties. In return, he asked for complete loyalty, attention to detail, and a very high standard of quality and cleanliness. Overtime added to the income of factory employees when business was good, and helped avoid layoffs when demand slowed. His formula worked. Many employees stayed at S&C for their entire careers.
Years of plenty

S

chweitzer & Conrad, Inc. changed its name to S&C Electric Company after the war and aggressively pursued sales as the economy roared back to life. Utilities posted big orders to build out their grids. The Conrads poured money into the Ravenswood plant, doubling capacity and sales by 1949. But that wasn’t enough.

They borrowed $3 million to buy a six-acre plot along Ridge Boulevard in Chicago, and the first of many new manufacturing buildings. By 1952, when John became S&C President, he had built the first extension on the Ridge campus. He added two more before his father died in 1956. Over the following decades, he methodically acquired more buildings and properties, transforming a jumble of empty lots, railroad sidings, and warehouses into today’s pristine 46-acre campus.

Business boomed. Electricity was cheap. Regulators encouraged utilities to build new generation plants and upgrade their grids. Suppliers had to deliver quality equipment, but as Conrad said to colleagues, “If you were in business in the 1950s, you couldn’t help but make money.” And since Conrad had little interest in money for himself, he reinvested most of the profits to maintain S&C’s leadership position in the industry.

Erle Nye was first exposed to S&C in 1960 when he was fresh out of engineering school, during a training rotation with a Dallas Power & Light distribution crew. The utility used three brands of fuses, said Nye’s supervisor. But in situations that required precise coordination, they used only S&C fuses. “The supervisor told me about the non-damageable silver fuse elements and I could tell by the reverence in his voice that this was a special piece of equipment.” Nye later rose to CEO of the parent company, TXU, and after retirement became an S&C board member. “There was always something a little bit better about S&C gear,” he said, “or a unique engineering feature that the competitors didn’t have.”
John Conrad believed that staying ahead of the competition required a tight product niche and long-term investments, made possible by the company’s private ownership. He had no interest in selling his company, despite regular inquiries, and especially disliked huge conglomerates. “I’m not about to let S&C become the trinket of some big empire,” he proclaimed.

But competition was stiff. S&C would survive only by offering “the kind of product that no one else makes.”

So S&Cers created a stream of devices that kept customers coming back. The Type XS Cutout, introduced in 1954, became the industry standard because of its rugged construction and single-venting design. The Loadbuster® Tool, first offered in 1958, was a lightweight, portable interrupter attached to a hookstick; it allowed a lineperson to safely open an energized cutout or disconnect switch. In 1959, S&C introduced Circuit-Switcher, a transmission-voltage device that could replace a circuit breaker in many applications, at a significant cost savings. Circuit-Switcher became a whole family of products and remains a big seller today.

Great products alone were not the key to success, however. S&C’s sales force, comprised exclusively of experienced engineers who knew how power systems worked, distinguished S&C from the competition. By spending time at substations and in bucket trucks—helping customers meet real-world challenges—they reinforced S&C’s reputation as a true business partner. They routinely worked with the factory to create gear customized for particular needs, and asked utilities to review products under development.

When a hurricane or ice storm took down power lines, S&C would go into overdrive, working nights and weekends to make and ship replacement fuse links, cutouts, and switches. Customers appreciated these efforts, and often said so.

This same approach kept business booming in Canada, first through a licensee and then a subsidiary. S&C Canada was started in 1953 with seven people and a couple of drill presses. It employed 60 by 1958, became self-sufficient in production of Metal-Enclosed Switchgear in ’59, and moved to a new plant in 1961. By providing on-site engineering and manufacturing capabilities, S&C Canada earned business from most of that country’s utilities as well as export markets. Today, it provides the blueprint for S&C’s expansion into Brazil, China, Mexico, and Europe.
Investing for tough times

One of John Conrad’s most strategic investments came in 1959 with construction of the Nicholas J. Conrad Laboratory Building. With its powerful generator and testing equipment, the $2 million lab expanded S&C’s knowledge of high-voltage plasma fields, inrush currents, and transient recovery voltages. This widened the gap between S&C and its competitors, said Jacinto Rodriguez, who managed the 11-person lab. “In circuit-interruption testing,” he said, “the amateur uses the brute force approach, which can result in devices that are overweight, underdesigned, and overpriced.” In contrast, S&C’s “instrumentation finesse” produced devices that did what they were supposed to do, consistently and accurately.

Thanks to the lab and other investments in Chicago, employment grew to 1,200. But difficult times loomed. The 1970s, Conrad warned employees, would be an “era of survival.” Rising electricity costs were forcing utilities to reduce capital spending. New competitors included the giant European conglomerates ASEA Brown Boveri and Siemens. And smaller suppliers were undercutting S&C on price.

Conrad had been running the company for more than 30 years, and would turn 65 in 1980. He knew fresh blood was needed, so he ramped up his recruitment efforts at university engineering departments and began cultivating new leaders, including a group he called the “young Turks.”

One of those young leaders was John W. Estey, who joined S&C in 1972 as a 22-year-old electrical engineering graduate from Queen’s University in Canada. Estey’s plan was to work a while in Chicago and then return to S&C Canada. Instead he moved through various...
departments, earned an MBA at the University of Chicago, and by 1977 was a vice president. In 1988, Estey became President and in 1997 President and CEO.

The 1990s brought more upheaval, as regulators sought to inject competition into the electric utility industry. Rate cuts and squeezed profits caused utilities to diversify, cut their staffs, and push suppliers for price reductions. This created new pressures on S&C.

With Conrad’s backing, Estey began a complete revamping of manufacturing. He restructured the company to spread decision-making more widely and to improve communication with customers. “We were drifting into weakness,” remembered Estey in 1994, one of the few years when S&C produced no profits.

“We had to create a competitive cost structure and our shipments had to be on time. And frankly our quality, although very good, had to get better.”

This was an uncomfortable message for many employees, who believed that the company would go on forever. The payroll was filled with fathers and sons, husbands and wives, and networks of friends. There were more than 450 members in the company’s Quarter Century Club. Many stayed much longer. Yet Estey was telling everyone, at regular company-wide meetings, that S&C was in a battle for survival. He warned employees not to simply assume that S&C was “the best.” That would have to be proven, every day.

The focus of discussion throughout S&C: how to increase sales and reduce costs.

Success Through Employee Participation—the STEP program—led to more than 1,000 implemented improvements in its first two years, for an estimated savings of over $1 million per year.
As part of the turnaround effort, Estey ramped up training and safety programs and asked all employees to bring their best ideas to work.

For many years, piecework incentives and rigid top-down supervision kept production moving. But times had changed. Estey instituted team-driven manufacturing cells and phased out piecework because it created too much inventory. Virtually every manufacturing area was reorganized to create smaller batches of parts when needed, a process that has continued to evolve and is now termed “lean manufacturing.”

And Estey was especially impatient on the new-product front. He pushed S&C’s engineers to develop a stream of unique high-tech devices.

In 1990, S&C introduced the industry’s first all-in-one switch for automating overhead distribution feeders, the Scada-Mate® Switching System. Remote Supervisory Pad-Mounted Gear, which accomplishes the same function for underground distribution feeders, was introduced in 1991. Fault Tamer® Fuse Limiter debuted in 1995 and brought a whole new level of protection to pole-top transformers.

**Fault Tamer® Fuse Limiter** provides enhanced transformer protection, energy limitation, and coordination . . . plus higher interrupting ratings and no expelled parts or sparks during operation.
Two years later, S&C came out with an advanced type of underground gear, Vista® Switchgear. The remote supervisory version of Vista, fitted with specially configured relays, allowed S&C to introduce the High-Speed Fault-Clearing System—a *no-outage* system offering a level of service reliability unmatched in the industry. And for substation transformer protection, S&C brought out the Trans-Rupter II® Transformer Protector in 2000.

These products had one thing in common. They all fit the S&C niche: They did things that no other device could do.

Remote Supervisory Vista® Underground Distribution Switchgear offers automated switching and fault protection and is suitable for advanced applications such as the High-Speed Fault-Clearing System.

Trans-Rupter II® Transformer Protector combines the three-phase tripping, high interrupting ratings, and sophisticated protection capabilities of higher-cost circuit-switchers and circuit breakers . . . with the simple installation procedures and minimal maintenance requirements of lower-cost power fuses.
Global growth and services

But the pressure never let up. To boost sales, Estey focused on three strategies: increase international volume, develop cutting-edge products, and add services. These approaches helped double revenues in just 10 years.

Sales growth outside North America had begun in the 1960s when John Conrad and Murray Kurland established beachheads in the Philippines, Latin America, and the Middle East. Kurland’s successor, Salvador Palafox, traveled constantly to promote S&C’s offerings. In 1997, using S&C Canada as a model, S&C founded a “regional center” in Curitiba, Brazil. The subsidiary started by selling switches and Loadbuster® Tools, then landed contracts to design and build two electrical substations. It rode out a five-year economic drought and was ready when business rebounded in 2007. One recent sale was a multi-million-dollar Vista® Switchgear automation network for a new government center in Minas Gerais.

China was next. Palafox made three trips there before seeing a single Omni-Rupter® Switch installed in Shanghai in 1995. Two years later, Chinese utilities had purchased 1,000 switches. S&C opened its China subsidiary in Suzhou in 2000, and today, 100-plus employees are serving customers in 17 Chinese provinces, Australia, and around the world.

S&C Mexico and S&C Europe followed, each tailored to local markets. “Having engineering horsepower locally is key,” said Angelo Gravina, who helped start the Brazil and European regional centers and is now Director of Sales at S&C Canada.

“You need to be there to hear what the customer wants and to design the customized gear that they need.”

Also in the 1990s came the push into services, just as utilities were cutting their engineering staffs to reduce costs. The new Power Systems Services Division found customers for everything from system studies to turnkey engineering, and in recent years has leveraged its expertise in renewable energy and emerging technologies.

S&C had a leading role in designing and building what was then the largest wind farm in Canada. S&C has become the nation’s leading integrator of battery storage into utility systems.

Murray Kurland (second from the left) and others at the dedication of a new manufacturing facility in Seoul, Korea.
As the integrator for a Smart Grid SMS™ Storage Management System project, S&C was responsible for overall project management, including all aspects of engineering and equipment installation.

Power Systems Services’ Smart Grid Project Services promote the successful design, implementation, and operation of customers’ distribution automation strategies, including the IntelliTEAM SG® Automatic Restoration System, High-Speed Fault-Clearing System, and SCADA systems.

And Power Systems Services additionally offers dedicated training for IntelliRupter® PulseCloser and other S&C equipment for distribution automation, plus services relating to other Smart Grid solutions, such as the Smart Grid SMS™ Storage Management System, and PureWave® Power Quality Products.

Factory acceptance testing of a customer’s IntelliTEAM SG® Automatic Restoration System, performed at S&C’s Chicago Headquarters, confirms that it works as intended.

Maintenance and troubleshooting services for PureWave® Power Quality Products help assure the continuity, reliability, and quality of electrical service.
Electronics are at the core of the emerging Smart Grid because microprocessors and other digital devices can monitor the electric waveform and respond within microseconds. S&C jumped into electronics in the early ’70s when John Zulaski invented a device to prevent cascading failures of substation capacitor banks. S&Cers later invented the Fault Fiter® Electronic Power Fuse and the Micro-AT® Source-Transfer Control. In the early 1990s, they developed polymer-encapsulated current and voltage sensors for the Scada-Mate® Switching System.

Even so, small competitors were ahead of S&C in some areas. Fortunately, help was on the way.

Milwaukee-based Omnion had developed an energy-efficient uninterruptible power supply system that could detect problems with the utility source and switch seamlessly to a battery backup. And a company near San Francisco, EnergyLine, offered “smart” capacitor controls and a sophisticated software package called the IntelliTEAM® Automatic Restoration System. S&C bought both companies in 1999. Three years later, S&C purchased a distributed static compensation product from Siemens. In the process, S&C gained world-class engineering talent in power electronics and power systems.

One hundred years after Schweitzer and Conrad developed the liquid fuse, S&C is still shaping the frontiers of the industry. Front and center is IntelliRupter® PulseCloser. It offers PulseClosing™ Technology, the first major advancement in the power-handling aspects of fault isolation since reclosing was introduced in the 1940s. Instead of simply reclosing to determine if a fault is still present—potentially slamming full short-circuit current back into the system—IntelliRupter sends a tiny blip of power down the line, reads the wave, then decides whether to close in or remain open. Mated with S&C’s IntelliTEAM SG® software, the device is the leading technology in the creation of self-healing circuits.
In early 2010, S&C commissioned its new $37 million Advanced Technology Center, a high-power laboratory that greatly expands S&C’s capacity for on-site testing. It will speed the development cycle and help S&C be first to market with more Smart Grid devices and software.
John Conrad would have enjoyed all of this . . . especially that his company is competing aggressively in an era as exciting as when his father began taming the high-voltage arc.

On August 30, 2005, at the age of 89, John Conrad died at home. He had labored for decades to ensure that his company would not be sold off after his death.

John would have been very pleased that on October 1, 2007, S&C became an employee-owned company.

Every one of its 1,900 U.S. employees now has a stake in S&C’s future.

No one knows what that future will bring. But as S&C Electric Company celebrates its 100th anniversary, it remains what it has always been: an innovation leader, a company with integrity, and a place where employees apply talent, ingenuity, and hard work to serve customer needs.

John Conrad can rest easy.

S&C will thrive in its second century.

John R. Conrad breaking ground for the N.J. Conrad Laboratory in 1959.