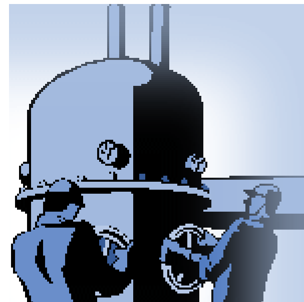
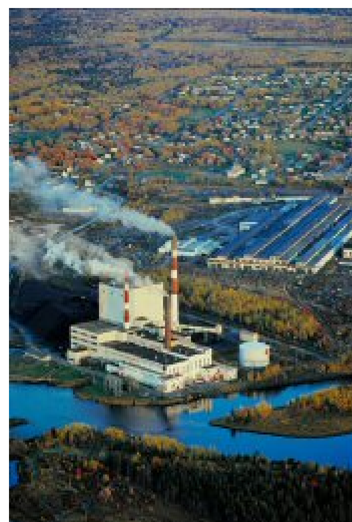
Energy
From Amps to Air Conditioning

Stoking a Revolution in Coal Combustion



In 1957, Stock Equipment Company o f Cleveland introduced the world's first gravimetric coal feeder, a mechanical device that revolutionized almost every coal-fired electric power plant and other facility in the world that used coal-fired boilers. It both accurately weighed and controlled the flow of coal into a boiler in a single unit.

Coal-fired power plants generate most of the electricity in the United States. They use coal that is much different from the big chunks that come straight from the mines. As demand for electricity grew in the 1920s, engineers redesigned the boilers in electric generating stations to burn pulverized, or powdered coal. Blown into the boiler furnace in a stream of air, powdered coal bursts into flame instantly and burns hotter and more completely than lump coal. This means higher efficiencies -- more energy out of each pound of coal -- than conventional combustion provided.



During this time, a mechanical engineer named Arthur J. Stock began inventing devices to stoke boilers, or feed coal into them. He formed a company in Cleveland to build them. Click here for more on Stock and its history. In the 1930s, he introduced several new devices for the electric power industry, and the Stock Equipment Company developed a national reputation as a technological leader.

His gravimetric coal feeder responded to two critical industry needs. One was a more accurate way to control the amount of coal fed into boilers. Popular films like Titanic may leave the impression that workers just toss shovels of coal into the boiler furnace whenever it looks like the fire is getting low. In reality, coal-fired boilers use precision devices to control the amount of fuel that goes into the pulverizer, devices which grind lump coal into powder. That is very important because boiler furnaces need the right proportion of fuel and air for most efficient combustion. Engineers call these devices "volumetric feeders," because they supply specific volumes or amounts of coal.

The other need was a matter of bookkeeping. Electric utilities wanted to keep better track of the amount of coal used in each boiler. With that information, they could keep track of operating costs, figure out how efficiently each boiler was operating, and know how much coal to order to replenish their stockpiles. Many utilities began buying scales to weigh coal, and Stock was a leading supplier.

Weighing units were placed in front of the volumetric feeder unit. These 2-part coal feeding systems were expensive, complicated, and became a huge headache for electric power stations. Sometimes, for instance, they got plugged up and coal stopped flowing freely.

In the 1950s, Arthur Stock combined accurate weighing and coal-flow control systems into a single device, which was named the gravimetric feeder. He designed the unit to be simple and rugged, which meant high reliability. The first unit went into operation in 1957 at Niagara Mohawk Power Corporation's Dunkirk (New York) Station. Design of the gravimetric feeder, which was designated as a technological landmark by the American Society of Mechanical Engineers, was ingenious. Download the ASME brochure, "The Stock Gravimetric Feeder" as a PDF file at www.asme.org/history/brochures/h184.pdf for more information.

More than 7,000 STOCK® gravimetric feeders have been installed worldwide since the initial Niagara Mohawk project, and they are the gold standard for feeding and metering solid fuel into boiler furnaces. Stock manufacturers the devices in the United States, Europe, and Asia.

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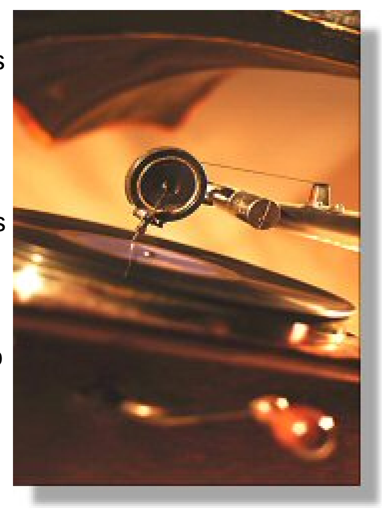
The Wizard From Ohio

Thomas Alva Edison, born in 1847 in Milan, became the world's most famous inventor, with more than 1,000 patents. Edison's in ventions included the incandescent electric lamp, phonograph, and the motion-picture projector. His genius launched hundreds of new industries and changed the world forever.

Less well known, however, are Edison's contributions in inventing the framework that generations of other inventors used in systematically researching and developing their new products. Edison invented the first true industrial research and development (R&D) center. He built the "Invention Factory" in 1887 in West Orange, NJ, that consisted of a complex of brick buildings, each devoted to a different part of the invention process. There were buildings devoted to chemical research, physics, and metallurgy, for instance. A research library allowed Edison and his team to avoid wasting time trying to reinvent the wheel. Instead, they stood on the shoulders of giants from the past, giving old ideas new life. A pattern shop and machine shop changed ideas into prototypes of marketable products. That was Edison's goal, and it remains the bottom line for industrial R&D today: To take ideas to market and bring back a profit. Edison designed his Invention Factory to develop "useful things every man, woman, and child in the world wants at a price they could afford to pay."



In the R&D complex, Edison and his team worked out the basics for the phonograph and motion pictures. One of their longest and most difficult projects resulted in the alkaline storage battery, which vastly improved on existing batteries and became a standard in the battery industry. Perfecting the storage battery took 10 years, but that battery became Edison's single most profitable invention.

Edison also integrated R&D into production. Prototypes, or working models, of products went from the Invention Factory to a complex of real factories that Edison built nearby in 1888. Workers produced Edison's inventions in huge quantities to sell around the world.

In 1882 Edison made another tremendously important, but often-forgotten, contribution. He discovered that an electric current would flow between two wires separated by empty space in a vacuum. The discovery of this phenomenon -- known as the Edison effect -- led to development of "vacuum tubes." These devices, which amplified and changed electric signals in other ways, were used in early radios, televisions, and other electronic devices before invention of the transistor. Applications of the Edison Effect eventually led to foundation of the global electronics industry.

Find out more…

- The Inventions of Thomas Edison
  (http://inventors.about.com/library/inventors/bledison.htm)
- Edison's Timeline of Invention
  (http://americanhistory.si.edu/timeline/05ed.htm)
- Edison Birthplace Museum - History
  (http://www.tomedison.org/)
- Smithsonian's Edison After Forty
  (http://americanhistory.si.edu/edison/index.htm)

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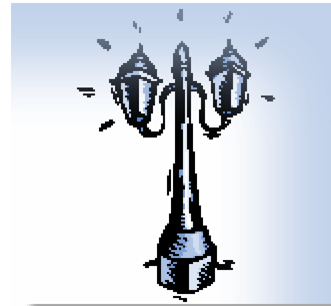
Electrifying America's Cities



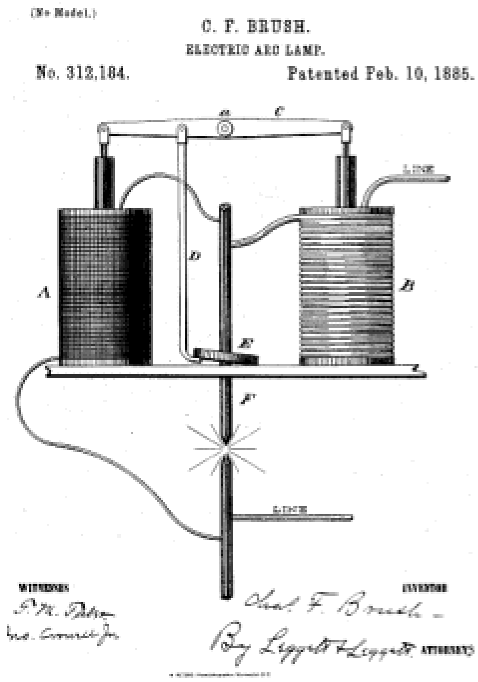
In 1875, Charles F. Brush (1849-1929) invented the electric arc lamp and the dynamo, devices which brought electric lights to the streets of American cities, years before electric lights were available for homes. Brush was born on a farm near Cleveland, Ohio. Throughout his childhood he had a love of anything scientific -- and he especially loved working with electricity. He built an electrostatic generator when he was only 12.

Brush attended Cleveland's Central High School, well recognized as an excellent school that would support his interests. At school Brush constructed an arc light that produced light by passing current across two carbon electrodes. He graduated in 1867 as an honor student and went on to study at the University of Michigan. After graduating, Brush worked as a consulting chemist, but then, after reestablishing a friendship with a boyhood friend, George Stockly, he began to refocus on his love of electricity and lighting. Stockly -- then vice president and general manager of the Telegraph Supply Company of Cleveland -- decided to financially back Brush. With funding, Brush began work on a dynamo, which would become U.S. Patent No. 189 997, "Improvement in Magneto-Electric Machines", issued April 24, 1877. The dynamo served as a low cost and reasonably efficient source of electricity for the arc light, and helped make lighting a commercial industry.

Stock Certificate from Brush Electric Light and Power Company

Next, Brush focused on the arc light, which was not a new concept but at the time was impractical due to lack of consistent regulation. Brush's solution was a reliable electromechanical regulator. It was first installed in Cleveland in 1878, and within a few years Brush arc light systems could be found brightening city streets all across the U.S. and Canada.

Over the next decade the Telegraph Supply Company of Cleveland restructured, becoming the Brush Electric Company in 1880. Next, it merged with the Thompson-Houston Electric Company, and then merged again with the Edison General Electric Company, now known as the General Electric Company. Brush eventually sold his interest in his inventions and went on to other ventures, but is known for the arc lighting revolution he helped start.



Find out more...

- The Brush Arc Lamp
  (http://www.lafavre.us/brush/lamparc.htm)
- Arc Lamps, by Charles Brush (grandson)
  (http://www.voltnet.com/arclamps/)

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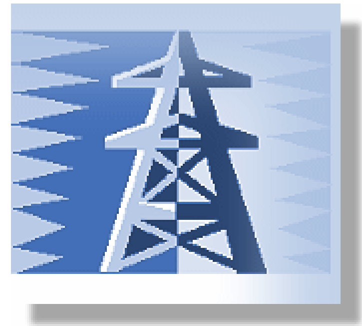
World's First in Electric Power



The world's first commercial "supercritical" electric generating unit went into operation in 1957 at an American Electric Power (AEP) generating station in Philo, Ohio, about 55 miles east of Columbus. Unit 6 of AEP's Philo facility made a technological leap – from "subcritical" to "supercritical" steam – that the American Society of Mechanical Engineers (ASME) compared to aviation's advance from subsonic to supersonic flight.

The facility included mechanical engineering innovations that resulted in greater efficiency in generating electricity. By using higher steam pressure and temperature, Philo could produce more electricity with less coal than previous electric power plants. That reduced the cost of making electricity, and also cut the amount of air pollution produced as a by product, since efficient plants need less coal to make the same amount of electricity. Every 1 per cent increase in thermal efficiency results in a 2-3 per cent decrease in emissions of carbon dioxide, the major greenhouse gas linked to global warming.

In the 1950s, the best electric power plants had an efficiency of about 30 per cent, meaning that they converted only 30 per cent of the energy in a ton of coal into electricity. The rest went to waste. Philo boosted efficiencies to almost 40 per cent. By breaking the critical steam barrier, Philo 6 became the model for a new generation of other highly efficient electric generating units built around the world.

Thomas Edison built the world's first central power plant in 1882. Central generating plants make large amounts of electricity in one place, and then ship it over wires to customers.

The Pearl Street Station in New York City burned coal to heat water in a container called a "boiler," where liquid water converted into steam. The steam built up to high pressures, and then hissed out to drive a steam engine, much like a locomotive engine. The engine powered a "dynamo," or electric generator, which produced electric current.

The basic technology used to make most electricity in the United States -- turbines and steam –- are the same today.

However, the equipment for making electricity with coal -- the energy resource Ohio used most -- changed in the 20th Century as engineers tried to make the process more efficient, squeezing more energy out of each ton of coal. One, for instance, involved eliminating the steam engine that Edison used to turn the generator. Engineers replaced it with a steam turbine that used steam power directly, with less waste, to turn generators. New materials and technology gradually allowed construction of electric power plants that worked more efficiently at higher and higher pressures. Edison's Pearl Street Station in New York City operated at a maximum pressure of 160 pounds per square inch (psi). It had an efficiency of only 2.5 per cent and needed 10 pounds of coal to make one kilowatt of electricity.

By the mid-1950s, pressures had reached thousands of pounds per square inch and power plants needed less than 0.7 pounds of coal to make each kilowatt of electricity. All of them, however, operated below the so-called "critical" pressure of 3,208 psi and temperature of 705°F. That's the point where water and steam have the same density, and the two act like they are the same substance.

Breaking that barrier to produce steam at higher temperatures and pressures ("supercritical" steam) was the key to further increases in efficiency; it involved solving many engineering challenges. Philo 6 operated from 1957 to 1975 when AEP decided to retire the facility. AEP demolished the entire Philo plant in 1983, but kept rotors from Philo 6's steam turbine, and used them in a sculpture at AEP headquarters in Columbus. They are a symbolic representation of Philo 6, which ASME designated as a Historic Mechanical Engineering Landmark.

Find out more....

- How Power Grids Work
  (http://science.howstuffworks.com/power1.htm)

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More Gasoline Per Barrel

William M. Burton was a chemist who developed the first commercially successful catalytic cracking technology for refining crude oil into gasoline. Burton was born in Cleveland and graduated from Western Reserve University with a B.A. in chemistry in 1886. His process doubled the potential yield of gasoline from crude oil and in the first 15 years of its application more than one billion barrels of oil were saved. The Burton Process was credited with averting a gasoline shortage during World War I. Burton started his research at Standard Oil Company in Cleveland as a chemist and eventually became president of Standard Oil of Indiana.

What is Cracking?

Petroleum refineries are huge factories that break crude oil down into its components. Some components are low density, like gasoline. Others are relatively heavy, such as the components of heating oil and diesel oil.

Catalytic cracking is the main method that refineries use to change heavier components of crude oil into lighter ones. Cracking uses a catalyst, a substance that speeds up chemical reactions, plus heat and pressure to break apart heavy hydrocarbon molecules.

The lighter components, including gasoline, are usually in greater demand than heavier ones. They also are the most profitable for oil refiners. In the early 1900s, refineries could get only about 11 gallons of gasoline from a 42-gallon barrel of crude oil. Many now produce about 22 gallons of gasoline from a barrel, thanks to catalytic cracking and other advances.

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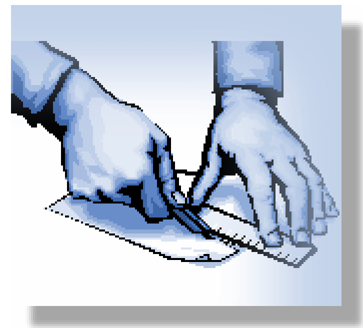
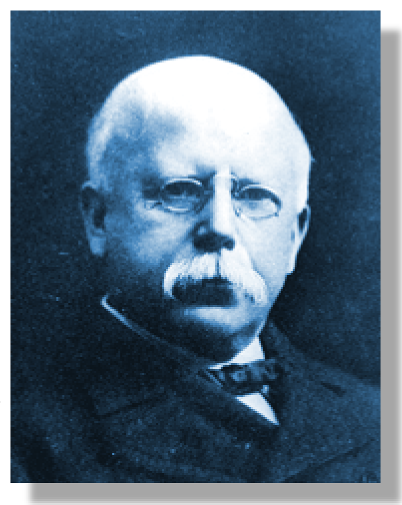
Metric System Pioneer



In 1893, Thomas C. Mendenhall, a native of Hanoverton, Ohio, decided that the international meter and kilogram would be the fundamental length and mass standards for weights and measures in the United States. Mendenhall was then Superintendent of Weights and Measures for the U.S. federal government. His decision, known as "The Mendenhall Order," was a major departure from past United States policy of maintaining length and mass standards identical to the Imperial systems of weights and measures used in Great Britain. In that system, length was the English yard and mass the pound.

Mendenhall (1841-1924) was a renowned scientist, appointed by President James Harrison as superintendent of the U.S. Coast and Geodetic Survey in 1889. He had been chairman of physics at Ohio State University, chief of the Instrument Division in the U. S. Signal Corps, and president of Rose Polytechnic Institute.



The Mendenhall Order redefined customary British-U.S. units in terms of metric units. The yard became 3600/3937 meter and the avoirdupois pound-became the mass of 0.4535924277 kilogram. The National Bureau of Standards (now the National Institute of Standards and Technology) used those same definitions from its founding in 1901 until 1959. In 1959, English-speaking countries agreed to define one yard as 0.9144 meter and one pound-mass as 0.45359237 kilogram.

Mendenhall did not need any new laws for the action because the metric system had been legal in the U. S. since passage of the Metric Act of 1866. It regarded metric units as the fundamental and internationally accepted standards for the United States.

President Harrison appointed Mendenhall director of the U.S. Coast and Geodetic Survey in1889, and he served until 1894. The weights and measures office then was part of the geodetic survey. Mendenhall helped to determine the boundary line between the United States and Canada, including the boundary of Alaska. As a member of the International Electrical Congress, he also had a hand in defining basic units of electricity.

Find out more…

- International Bureau of Weights and Measures
  (http://www.bipm.org/en/home)
- The National Conference on Weights and Measures
  (http://www.ncwm.net/main.html)
- The American National Standards Institute
  (http://www.ansi.org/)
- The National Institute of Standards and Technology Office of Weights and Measures
  (http://ts.nist.gov/ts/htdocs/230/235/owmhome.htm)
- The Central Weights and Measures Association
  (http://www.cwma.net/)
- The Ohio Division of Weights and Measures
  (http://www5.state.oh.us/agr/W&MDivision.html)

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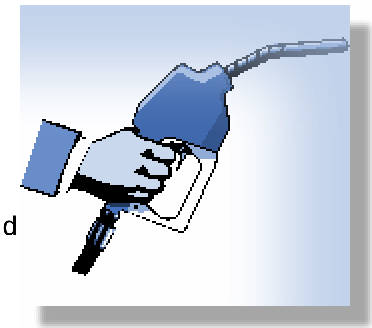
From Leaded Gas to Air Conditioning



In 1921, Thomas Midgley, Jr. discovered that adding tetraethyl lead to gasoline would allow engines to run smoothly on low-octane gas. Midgley earned 117 patents during his career which began as a mechanical engineer and chemist. Midgley was raised in both Pennsylvania and Ohio, and graduated from Cornell University in 1911 with a degree in Mechanical Engineering. His father was an inventor who immigrated to the U.S. from London. One of Midgley's most well known accomplishments was developing tetraethyl lead as an "anti-knocking" additive to gasoline. Midgley discovered that "knock" in internal combustion engines was actually the result of fuel failure, not engine failure.

He also developed the refrigerant dichlorodifluoromethane -- known as Freon. Freon was valuable because it was nonflammable and nontoxic. At the time, ammonia, sulfur dioxide, or chloromethane were used in home refrigerators. These gases could cause illness and even death when leakage occurred.

Midgley also discovered chlorofluorocarbons (CFCs) which were originally used as aerosol spray propellants. They are also used in the manufacture of insulation foam, packing materials, pesticides, and a variety of cleaners. Ironically, two of Midgley's major discoveries, ozone-burning CFCs and leaded gas have since been banned by the U.S. Environmental Protection Agency.

Find out more...

- The History of Freon (http://inventors.about.com/library/inventors/blfreon.htm

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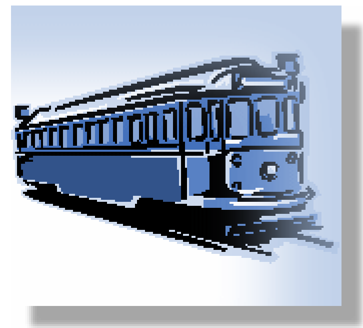
The Black Edison



Granville Woods, born in Columbus in April 1856, was a famous African-American inventor who received more than 60 patents for electrical and other devices. He became known as the "Black Edison" due to the variety of his inventions.

His inventions focused on the railroad industry and on electricity flow. One of his inventions boosted railroad safety: a system to gauge distance between trains which would alert the conductor prior to any impacts. Woods attended school in Columbus, OH until age 10, and was then self taught either through books or on-the-job training. He also attended night school. He valued a good education and sought to expand his knowledge in order to bring his inventions to fruition.

Wood had a variety of jobs prior to dedicating himself to his inventions full time. He served as fireman and engineer on the Danville and Southern Railroad in Missouri, he worked in a Missouri rolling mill, and he also traveled east to work in a machine shop. Eventually he returned to Ohio, settled in Cincinnati, and opened the Woods Electrical Company with his brother. He succeeded in selling several inventions to large corporations including American Bell Telephone Company, General Electric, and Westinghouse Air Brake Company. In 1888 Woods patented his system for overhead electric conducting lines for railroads. This invention laid the groundwork for rapid transit and trolley systems throughout the U.S.

Woods' Many Patents

Granville Woods was awarded more than 60 patents. Among them:

- His first patent, for a Steam Boiler Furnace, June 3, 1884
- Apparatus for Transmission of Messages by Electricity, April 7, 1885
- Electro Mechanical Brake Apparatus , Oct. 18, 1887
- Galvanic Battery , Aug. 14, 1888
- Automatic Safety Cut-Out for Electric Circuits, Oct. 14, 1890
- System of Electrical Distribution, Oct. 13, 1896
- Overhead Conducting System for Electric Railway, May 29, 1888
- System of Electrical Control, April 15, 1902
- Motor Controlling Apparatus, April 15, 1902
- Safety Apparatus for Railways, Oct. 16, 1906

Find out more...

- Selection of patents issued to Granville T. Woods (www.princeton.edu/~mcbrown/display/gwpatents.html)
- MIT Inventor of the Week Archive: Granville T. Woods (http://web.mit.edu/invent/iow/woods.html)
- United States Patent and Trademark Office (www.uspto.gov)