Advancing Technology for Humanity

New York Monitor

A publication of the IEEE New York Section

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September 2014, vol. 61, No. 4

How New York got its electricity

p. 16

Become a Senior Member of the IEEE

p. 6

I E E E

NY Monitor Editor: Amitava Dutta-Roy, LF

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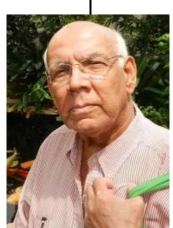
Advancing Technology for Humanity

Hope

that all of you had a wonderful summer full of action items—whatever they were. That must have toned up your body muscles and brain neurons. Now it is time to get back to work! While many of you enjoyed golf, surf or other activities, at the Monitor we have been working throughout the summer to improve the appearance of our postings, readability, and accessibility. However, we do not seem to have succeeded in driving home the point that a decent and informative NY Monitor worthy of an IEEE logo desperately needs your cooperation. We were optimistic on receiving reports on the Region 1 Board of Governors' meeting during the weekend of 2-3 August at Rochester, NY, and on the IEEE Section Congress held in Amsterdam, Netherlands during the weekend of 22-24 August. Those of you who had the privilege to attend these conferences on our behalf are surely aware that you have an implied professional obligation to communicate to us as to what actions the august bodies suggested for the betterment of the IEEE and its goal or advancing technology for the humanity. Should we put more emphasis on networking, should we have free access to the IEEE Xplore library, and should we more frequently hold technical presentations? The responses to these questions may pave the way to attract more young and experienced engineers to join the IEEE. The Monitor was not offered the opportunity to attend either the BoG meeting or the Sections Congress and is therefore in no position to present truthful first-hand reports. In the absence of such reports, in this edition of the NY Monitor we can only post a short report of the recent PES/IAS Fall outing (with some photos), one article on demystifying the process of upgrading your membership to that of a senior by Sandy Mazzola, SM, the Region 1 IEEE Admissions & Advancement Representative. We hope that you will take his suggestions seriously and



make your upgrade application as soon as it is convenient for you to do so. Our cover story on electricity in New York was contributed by Joe Cunningham, a known authority on the history of the early deployments of electrical generating and distribution mechanisms in New York. Finally, please find the rates for advertising in the NY Monitor. If you know the PR or the media personnel in your company or in any other establishment please spread the word that it pays to advertise in the NY Monitor. Hope you will have the time for a leisurely read of the Monitor. Please send your comments to a.dutta-roy@ieee.org. Thank you. —Amitava Dutta-Roy, PhD, LF

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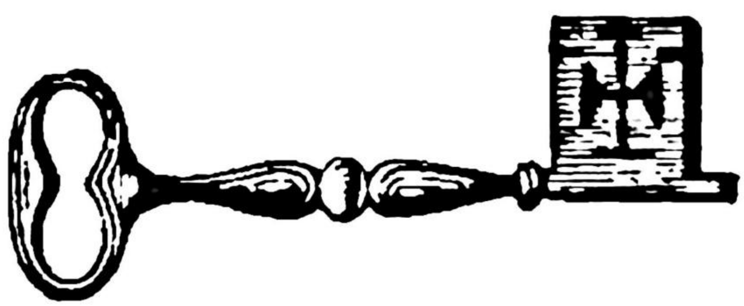


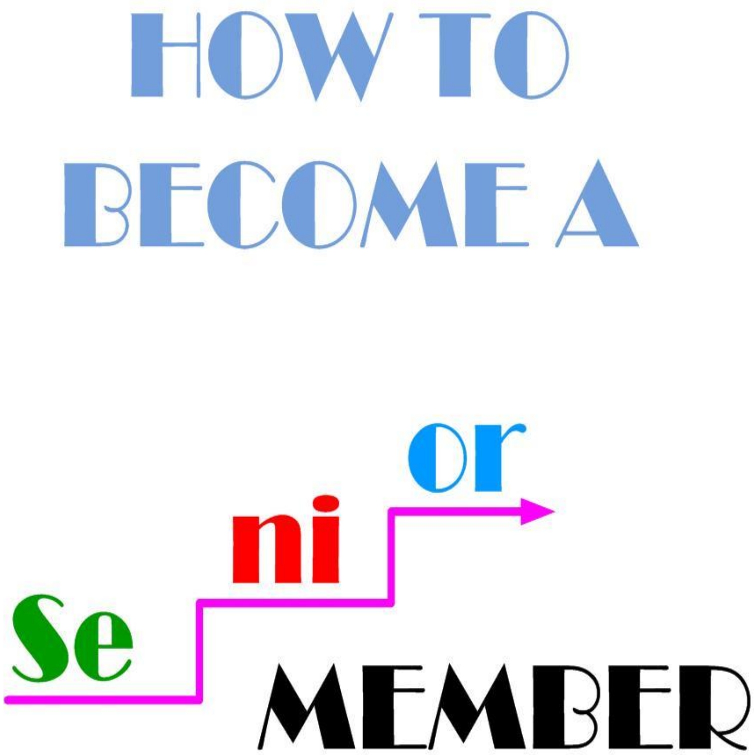
FALL OUTING: Anyone for food and a good time?

Power and Energy Society and Industrial Applications Society of the IEEE New York chapters host a colorful fall outing

The NY chapters of the Power and Energy Society and the Industrial Applications Society of the Institute of Electrical and Electronics Engineers (IEEE) on September 12 hosted their annual Fall Outing at Krucker's Restaurant & Grove situated in a serene hamlet slightly off the Palisades, NJ. Such outings honor the volunteer members who contributed their time to the cause of the IEEE. Probably the first meeting of this nature was held in 1944. It was then called the Committee Get-together Dinner. The first recorded Outing took place at Schmidt's (Scarsdale, NY?) on September 26, 1947. Anyhow, for the last two decades the Outing has always been held at Krucker's. The facility includes areas for some game activities (bacci, baseball and volleyball etc), sheds where food (delicious hamburgers and German bockwursts, and bratwursts, oysters and shrimp cocktail) may be served in the open and a country-style restaurant with ample room. Even without an Outing, I would recommend the place for a family visit.

The map below will give you an idea where Krucker's is situated. The photographs show the serenity of the well-tended ground surrounding the restaurant and facilities for recreation. A set of photos of the participants who were in a jolly good mood (induced by an open bar!) may be viewed by accessing the URL given below. (Yes, the photos were taken by your truly the editor.) A sumptuous dinner — lobster, and hamburger steak — followed. Later, the MC, William Coyne was assisted by Bill Perlman and Bill Montgomery distributed prizes to all individuals. Winning names were drawn at random. I received a 20-LED Utility Lantern that would certainly prove useful when I wish to find my way back from a park concert. For a slide show of the Fall Outing please go to: http://1drv.ms/1qIxDji ♦

Sandy Mazzola, SM is the Region 1 IEEE Admissions & Advancement Representative



Achieving Senior Membership: Demystifying the Significant Performance Requirement

In the April 2014 issue of RegiOne,the Region 1 chapters coordinator Dr. Ilir Progri, SM wrote an excellent article on the Senior Member elevation process. Senior Member grade is the highest IEEE grade for which IEEE members can self nominate, or be nominated. Senior Members of the IEEE enjoy the professional recognition by their peers for their technical and professional excellence. Senior Members are eligible to hold executive IEEE volunteer positions. This article focuses on demystifying the requirements and the process of achieving senior membership without repeating the fine information that Progri presented.

The Senior Membership requirements include 10+ years of experience, a demonstration of 5+ years of significant performance and references supplied by 3 Senior or Fellow members (2 references if your Section is nominating you) . In his article Progri showed how to find references within your Section and presented all of the terrific reasons for becoming a Senior Member. This article covers the meaning of significant performance, how to cite it and provide examples as a guidance.

Performances considered significant to meet the requirements for Senior Membership are:

1. **Team leader, supervisor or program manager**
2. **Substantial engineering, responsibility or achievement**
3. **Technical direction or management of important scientific or engineering work with evidence of accomplishment**
4. **Research papers, search oriented course, tutorials**
5. **Substantial design work**
6. **Publications of technical papers, books, or inventions**
7. **Recognized contributions to the welfare of technical professions**

8. **Development or furtherance of important technical courses that fall within the IEEE designated fields of interest**
9. **Contributions as Technical Editing, Patent Prosecution and Patent Law to advance progress in the IEEE-designated fields**
10. **Professional awards and licenses**
11. **Teaching , Research, Industry, Practitioners, Consultants and Entrepreneurs**
12. **Significant contributions to Standards development**

Membership qualifications pertaining to IEEE designated fields include:

- **Engineering**
- **Computer Science & Information**
- **Physical Sciences**
- **Biological & Medical Sciences**
- **Mathematics**
- **Technical Communications, Education, Management, Law & Policy**

Two examples on about significant performance for the area of teaching are described below.

Teaching:

Performing research with some measure of success, publishing in high level recognized journals, publication of technical papers, books or inventions/patents (in the final version the teaching-related skills should go first), departmental chair, supervision of successful PHD students, undergraduate teachers demonstrating excellence and dedication that might result in exceptional student accomplishment, including coaching in LEGO league or Robotics (teachers who are engineers and computer scientists). —

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Engineering:

Engineering analysis, engineering test, engineering design, troubleshooting, engineering process management, quality control, technical sales, sales engineering, etc. are recognized as valid skills for senior membership.

The list above is not all-inclusive. It should be used only as a guideline. The examples cited here not the only ones that demonstrate the areas of significant performance. If you think your experience warrants significant performance and doesn't exactly fall within these categories do not be daunted, present it and your past and present performance will be evaluated by the IEEE and very well may be considered significant performance. In that vein, do not be disheartened if your application does not pass the first time through. Have the application reviewed and find out where the application came up short and where it can be beefed up to meet the requirements of SM grade.

Senior Membership benefits are extremely helpful to one's career. To achieve senior membership the successful applicant will be able to demonstrate 5+ years of significant performance. This article discussed some examples of significant performance. While the requirements for significant performance are stringent, they are not unreachable, take a look at your work achievements and you will realize that you can apply successfully for senior membership. If you have any questions about the Senior Member requirements please contact me directly at mazzolas @i eee.org or check the IEEE Senior Member Grade Portal. If you have any questions regarding assistance in the application process or obtaining references you should contact your Section Chair for assistance

In the words of many Rob Schneider characters from many Adam Sandler movies: **"You Can Do It"**

CALENDAR OF EVENTS (SEPTEMBER-NOVEMBER 2014)

Fri, 26 September
6pm-8 pm
Room HS 118
Long Island University
Brooklyn Campus
Organizer:
Prof Ping-Tsai Chung
All are welcome

September 2014

Sponsor: **Systems, Man and Cybernetics Soc (SMC)**

How to reveal anyone's interests on Twitter using social network analysis

Abstract: This talk introduces graph analysis and how it can be used to infer a Twitter user's interests. All activities such as marketing, promotion, and outreach require a level of intimacy with an individual's interests to make a lasting and positive impression. Few organizations have the resources to achieve personalized service and often have to rely on lower resolution demographic data coupled with surveys. Social media data herald a new era of personalization whee any organization can access an individual's interests.

Speaker: **Brian Lee Yung Rowe** is the founder and CEO of Zato Novo that licenses quantitative models as a service. He has developed a suite of social network models that analyze and predict user interests and influence. His models can be used in the financial industry to forecast individual consumer spending, construct portfolios of consumer loans and optimize them. For the legal industry his models may be used o classify contracts according to their semantic structure. Brian is an adjunct professor in the graduate program for data analysis at CUNY School of Professional Studies where he teaches courses on mathematics and machine learning. ♦

¶**Calendar of events continues on next page**

Calendar of events (September)

Mon, 29 Sep
Networking: 5:00pm
Lecture: 5:30pm-7:00pm
ConEd Building
4 Irving Place, NY 10003
One blk. E of Union Square
Organization: Arnold Wong, Sukumar Alampur and Michael Miller (LMAG)
RSVP required For reasons of security no admission without prior RSVP.
to Arnold Wong
<wongar@coned.com>

Sponsors: Power Engineering Society, Industrial Applications Society and Life Members' Affinity Group

Magnetic Resonance Imaging (MRI)

Abstract: Magnetic resonance imaging: basic ideas and latest developments. This lecture will describe magnetic resonance imaging (MRI) for a general audience. It will review the basic MRI ideas for image formation (Fourier encoding) and tissue contrasts (relaxation, transport and magnetism). It will then focus on latest developments on tissue magnetism that can be studied using gradient echo MRI. Problems in studying tissue magnetism include lack of quantitative and geometric specificity. The fundamental cause for these problems is the ill-posedness of inversion from the measured field to its magnetic susceptibility source. Quantitative susceptibility mapping (QSM) using Bayesian approach has recently been developed to address these problems. The latest QSM technology and its clinical applications will be described.

Speaker: Yi Wang (PhD 1994, University of Wisconsin-Madison) is the Distinguished Professor of Radiology and professor of Biomedical Engineering at Cornell University. He is a Fellow of AIMBE, IEEE, and ISMRM and an active grant reviewer for many agencies including NIH and the European Research Council. Dr. Wang as has been the recipient of multiple NIH grants. Dr Wang has published more than 130 papers in peer-reviewed scientific journals, authored a textbook "Principles of Magnetic Resonance Imaging" and a monograph, "Quantitative susceptibility mapping: magnetic resonance imaging of tissue magnetism", and co-authored a book "Electro-Magnetic Tissue Properties MRI". He invented several key technologies in cardiovascular MRI, including multi-station stepping table platform, bolus chase MRA, time-resolved contrast enhanced MRA, and navigator motion compensation for cardiac MRI. Dr Wang has pioneered quantitative susceptibility mapping (QSM), a vibrant new field in MRI for studying magnetic susceptibility properties of tissues in health and diseases. ♦

Calendar of events continues on the next page

Mon, 29 Sep
Social:6:00pm
Pizza: 6:30pm
Lecture:7:00pm
Bethpage Public Library
47 Powell Avenue
Bethpage, NY 11714
Reservation requested by 28 September 2014
Contact: David Paris
Davidsparis@optonline.net
or call (516) 458-8593
Directions:
The library is west of Route 135 in Bethpage. Take Route 135 to Exit 8, then West on Powell Ave. for about 0.25 miles. The library is on the south side of the street. Park across Powell Ave., opposite the library.
Organization: David S Paris

Calendar of events (September)

Joint sponsors: American Institute of Aeronautics and Astronautics (AIAA)/ AFA/AOSNY/ASME/ISA/ /IEEE(AES)/IIE

Development of a Commercial Crew Space Vehicle: The Next Phase

Abstract: Before the date of this meeting, NASA will have announced phase II of the Commercial Crew Transportation Capability (CCtCap) Program. Boeing has been one of three companies under Phase I NASA contracts to develop a crew carrying vehicle that will provide US capability for safe, reliable and cost effective access to low-Earth orbit including the International Space Station (ISS) with a goal of first crew flight no later than 2017. Currently there are three funded first phase projects: Boeing CST-100 (Crew Space Transportation) Capsule; Sierra Nevada Corporation DreamChaser; and SpaceX Dragon V2.0. NASA funding for at least one of these projects will not be continued. Additionally, Blue Origin is developing an orbital Space Vehicle, without NASA funding. This talk will provide an overview of the Commercial Crew Program with an emphasis on the capabilities of the Boeing CST-100.

Speaker: **Dr Michael T. Kezirian** received his Bachelors from Brown University and his Doctorate from MIT, both in chemical engineering. He has been a propulsion analyst at TRW Space and Technology Group (now Northrop Grumman) and later built software algorithms for spacecraft autonomy at the Hughes Space and Communication Group (now Boeing). At Boeing, he has worked on commercial and government communication satellite programs, and has supported human spaceflight in both the Space Shuttle and ISS Programs. Now an Associate Technical Fellow at Boeing, he is working on the design of the CST-100. At USC, he teaches "Safety of Space Systems and Space Missions." Dr Kezirian has received numerous honors and awards; in 2009 he was awarded the Astronauts' Personal Achievement Award, or Silver Snoopy award.♦

Calendar of events continues on the next page

Calendar of events (October)

Fri, 10 Oct (IEEE Day)
6:00pm-8:00pm
Room HS 118
Long Island University
Brooklyn Campus
Organizer: Prof Ping-Tsai Chung
All are welcome

Sponsor: Systems, Man and Cybernetics Society

ITS and IoT – From V2X to Cohesive Intelligent Transportation Systems

Abstract: While the focus of Intelligent Transportation Systems (ITS) has been on employing and integrating communication and information technologies with transportation infrastructure, vehicles and users to achieve greater safety and less environmental impact, the recent proliferation of consumer mobile devices, and advancement of connected devices, particularly in the context of Internet of Things (IoT), will provide many more opportunities to further enhance the values of what ITS may contribute to communities. However, great opportunities also come with great challenges. In this talk, the objectives of ITS and current efforts will be reviewed, the potential opportunities in IoT, especially in the context of ITS,will be explored, and discuss the future technical and business challenges.

Speaker: **Chiao-Wei Lee** is currently a Senior Manager in Global Application Development of Ansell Healthcare. His primary responsibilities in Ansell include the design and development of global mobile strategy and enterprise service architecture. He had served as principal investigator and architect at Advanced Technology Solutions, Telcordia Technologies, Ericsson in many R&D collaboration initiatives that covered a wide spectrum of technologies. Mr. Lee has over 12 year experience in key information and communication technologies, including mobile wireless architecture, fault-tolerant auto-recovery, Telematics services, mobile adhoc networks (MANET), vehicular communications, ITS services, and mobile applications. He received his MS degree in electrical engineering (telecommunication and wireless communication) from Columbia University, NY and earlier a BS degree in electronic engineering from Chung Yuan Christian University. ♦

Calendar of events continues on the next page

Fri, 17 Oct
2pm-6pm
833 MUDD, 500 West 120th Street, Columbia University, NYC

Register now at http://tinyurl.com/dl-tour-cu-2014 http://www.cisl.columbia.edu/seminars/seminars.html
Organizer:
Prof Mingoo Seok Teng Yang
All are welcome!

Calendar of events (October)

Sponsor: Solid-State Circuits Soc and Electron Devices Soc

Three Distinguished Lectures on:
Recent Advances in RF, Mixed-Signal and Digital IC designs:
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♣On-chip voltage and timing diagnostic circuits

This talk introduces practical and powerful techniques and circuits to observe and characterize on-die circuitry. Measuring voltage and timing information on the chip itself alleviates the bandwidth and noise limitations. Many of these techniques leverage existing circuitry and are highly digital.
Speaker **Frank O'Mahony** currently leads the I/O Circuit Technology group within Advanced Design at Intel in Hillsboro, Oregon, where he is a Principal Engineer.
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♣THZ millimeter –wave frequency generation and synthesis

This invited talk presents an overview and comparative study of recent research efforts leading to highly efficient frequency synthesis, signal generation, and mm-wave LO distribution networks in silicon, which are most critical and daunting tasks in a THz/mm-wave system.
Speaker **Payam Heydari** is a Prof of EE at the University of California, Irvine. His research covers the design of terahertz/millimeter-wave/RF/analog integrated circuits. More info at http://www.ece.uci.edu/~payam/
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Low-power, high-bandwidth, and ultra-small memory design ♣
This work proposes a novel DRAM module and interconnect architectures in an attempt to improve computing energy use and performance. The DRAM architecture is inline with ITRS roadmaps and can consume 50% less power while increasing bandwidth by 100%.
Speaker **R. Jacob Baker** is a Professor of ECE at the University of Nevada, Las Vegas. His research interests are integrated electrical/biological circuits and systems, interfacing CMOS to Silicon Photonics, and the delivery of online engineering education. More information at http://CMOSedu.com.♦

Mon, 27 Oct
6:00pm-8:00pm
Columbia University
116 Street (x Broadway)
New York, NY

Subway No. 1 train to 116th Street
All are welcome
Organization: Profs Ioannis Kymissis and Charles Zukowski (both at Columbia), and Robert Pellegrino (PACE, NY IEEE) and Dr Amitava Dutta-Roy (Historian at IEEE NY Section)

More information on this even t will be available through direct fliers and the NY Monitor of October 2014

Calendar of events (October)

Cosponsors: Armstrong Foundation, Columbia University, IEEE NY Section Historian, SMC, PACE and IEEE History Center

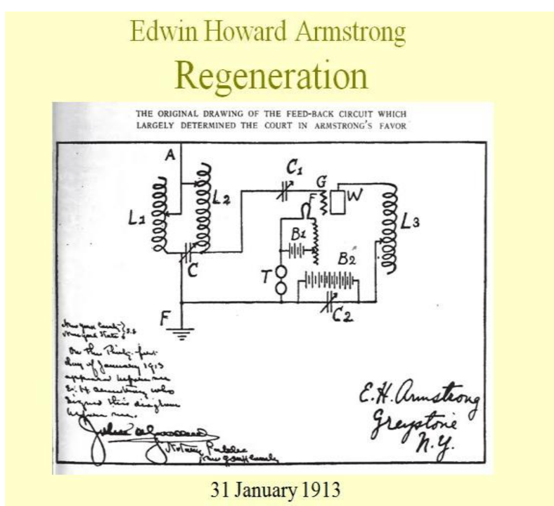
Centenary of granting of a patent by the USPO to Edwin Armstrong (a graduate of Columbia University and the inventor of FM radio transmission) for his regenerative circuit. The patent was granted one hundred years ago, on 6 October 1914.) At this event the Armstrong Foundation will put on display several artifacts used by Armstrong himself.

Speakers:

♣Al Klase, a wireless technology historian who will describe Armstrong's early research work, some of which were conducted at Columbia University.

♣Gilmore Cooke, LSM, a former historian at the IEEE Boston Section will describe Armstrong's creation of the "Yankee Network" that spanned NY, NJ and Mass. At the presentation, Cooke will also play some original voice recordings of Armstrong.

Notes: Some of the younger members may not have heard of Armstrong. They are urged to Google Armstrong's name. Even in these days of MP3 Armstrong is respected all over the world as the inventor of FM radio transmission.



Note: incidentally, this year Armstrong's alma mater Columbia is also celebrating 150 years of its existence

Come and join us in the celebration!!

Calendar of events (November)

Fri, 7 Nov
6:00pm-8:00pm
Room HS 118
Long Island University
Brooklyn Campus
Organizer: Prof Ping-Tsai Chung

Distinguished Lecture:

The Big Data Challenge: From Machine Learning and Pattern Recognition Perspective

Abstract: Will be available later

Speaker: **Prof Daniel S. Yeung**, South China University of Technology. ♦

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Wed, 12 Nov
IEEE Operations Center,
Piscataway, New Jersey
08854,
Organizer: Dr Amruthur Narasimhan

For detailed information on program, registration and fees please visit the Web site of NJ Coast Section

http://sites.ieee.org/njcoast/

Sponsor: **IEEE NJ Coast Section**

Conference on Information Security/Cyber Security and Privacy

Since the turn of the century, information security, cyber security, and privacy have become more critical in our business, government, travel, healthcare, and every-day lives. With society's exploding dependence on online, digital, and wireless technologies, effective government-compliant security solutions have become increasingly important in everyday life. Whether you are a security expert or a novice, practical solutions are crucial in your industry as well as personal life. Join us at this upcoming conference to hear more about these important topics from business, academia, and research. Take some time with us to Amrathurcatch up on the latest trends, review the issues, and take away practical ideas to enhance security of your world.

The day will begin with a social breakfast. The morning keynote, **'Wanted: A Revolution in Security Research'** will be delivered by Dr. Gus de los Reyes, AT&T Chief Security Officer, R&D, and the afternoon keynote, **'Mobile Management and Security'** will be delivered by Mr. Caleb Barlow, IBM Director, applications, data and mobile security. Both talks promise to be up to the minute, exciting, informative, and thought-provoking.

Visit the many industry representatives participating in the event to learn about the latest commercial solutions. Lively discussions with the keynote speakers, invited speakers, peers, and student poster judging will continue over breakfast, lunch and afternoon snack breaks – which are included in the modest attendance fee. Concluding remarks, prizes and awards will end the day.

This conference is geared to IEEE members, non-members, students, and guests who would like to review the state of the art in security, cyber security, and privacy and become aware of issues and directions of research, academic, and practical solutions.

If you have considered learning more about security, this is an ideal event to attend. Awareness of security, cyber security, and privacy improves your job, consulting, and life skills. You will get Professional Development Units PDU (Continuing Education Units (CEU).

The venue for this conference, IEEE Operations Center (OC) in Piscataway New Jersey, is a premier location to attend an event. The IEEE OC is steeped in history; this location holds artifacts and multimedia installations recounting the achievements of IEEE engineers and marks the significant engineering innovations from various disciplines worldwide. Bring a friend, colleague or student. For More Information please visit the IEEE New Jersey Coast Section website.♦

How New York Got its Electricity

Joe Cunningham

Contemporary electric power production

and its delivery rest upon more than 150 years of discoveries and inventions from around the globe. In this part of the world, Manhattan has been the nation's financial center from the inception of the United States and that made it attractive to both inventors and the investors who sought to profit from commercial utilization of the inventions related to electric power. Furthermore, the unique electrical load density of Manhattan, and the demands and constraints encountered therein, made it both a challenge and an opportunity for innovators. Confined to a narrow island, Manhattan refined the techniques of building upward for commercial, industrial, and residential purposes to create an area of unmatched concentration of people.

The midtown area was perceived as the most lucrative market by inventors and promoters of the concept of electric power sold and supplied as a utility. The first to secure a franchise in the region was electric arc light pioneer Charles Brush. In late 1880, his arc lights illuminated Broadway for the first time; early in the following year, they extended the illuminated stretch from Herald Square to Union Square. Power was also available to holders of properties with large interior spaces. Madison Park was illuminated with a 160 feet-tall lamp installation, and franchises were issued to Brush and his competitors for arc lamp installations on major public streets of New York City. The system was supplied by 2,000V direct current generators with power distributed through wires hung from iron poles along the curb.

Thomas Edison took a different approach. He used the electrical resistance, a characteristic of conductive materials, to produce incandescence that simulated the glow of gas mantles in small indoor spaces. After a pioneering installation in lower Manhattan by his Edison Electric Illuminating Co., in late 1882, he too began seeking the potential market of midtown Manhattan. Cognizant of a possible public outcry against the myriad communications and arc light power lines strung over city thoroughfares, Edison developed underground ducts for his 110V light circuits. However, the lights were kept lit only for a few hours daily and the business was not found to be profitable.

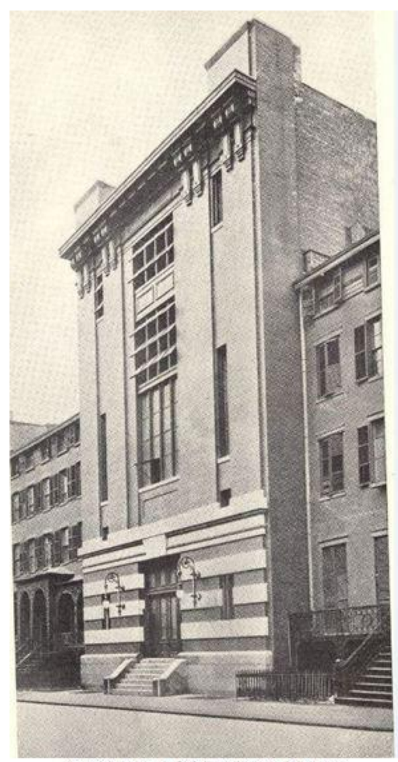
> "If we did all the things we are capable of doing we would literally astound ourselves" —Thomas Edison

In 1884, the availability of a practical electric motor developed by inventor and electric railway pioneer Frank Sprague opened the door to improved return on investment for electrical utilities. Soon, electric motors proved vital to the financial success of the Edison system.

Sprague subsequently developed a more powerful motor designed to operate on 220V "three wire" distribution circuits that Sprague had developed earlier for Edison. The three-wire system employed a "neutral wire" connected between a pair of series-connected generators to provide 110V for lamps. That system reduced the losses and tripled the effective power range while reducing the requirements for copper by more than 60%.

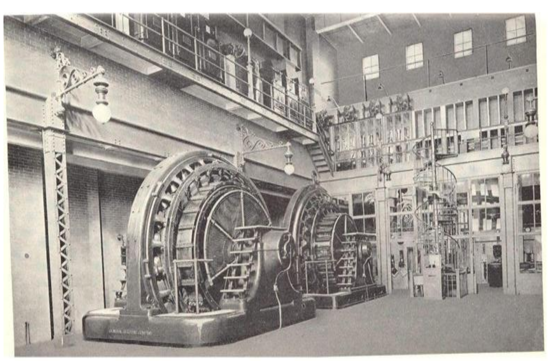
At the close of 1888, two generating stations were built in midtown New York for powering light and motors that both business and residential customers demanded. The availability of reliable motors and the three-wire distribution system made those stations profitable from the outset. By 1890, the electric motors marketed by Sprague and competitors accounted for a substantial part of the revenue from the sale of power and the Edison company decided to open an office and repair shop to cater to the needs of its customers' motors.

However, the industry required increasingly powerful motors. The current drawn to operate those motors was of real concern as it was much more than what the Edison system could supply. Hence, the newer Sprague industrial motors were designed for operation at 400V while those developed for the fledgling electric street railway industry were rated at 500



Exterior view of the West 16th Street substation taken about 1907 volts or more. Customers for higher voltage operations were required to install their own isolated power plants, as there was no system available to change voltages in the basic DC system developed by Edison. Such constraints, in addition to the limited distribution range of the existing direct current distribution system, led to the invention of a technology that could accommodate heavier loads.

In response to a request by the Edison Company for a possible solution in 1886, Sprague had recommended the development of ac systems in which the voltages could be "transformed" to meet the voltage and power requirements of the customers. A test installation constructed in Great Barrington, Mass by transformer pioneer William Stanley and funded by industrialist George Westinghouse, had proven the practicality of the concept. Sprague proposed that the high voltage generated at the power stations be transformed to a lower level at intermediate substations and applied to "receiving motors" (reversed alternators) to drive generators for supplying direct current to customers. The Edison Company was by that time heavily involved in direct current systems and had little in the way of capital to explore the yet unknown systems, though Edison himself had acknowledged that some 36 of his DC stations would be required to light only the area south of Central Park.



Interior view main floor of 123rd Street DC conversion substation: standard rotary converter with 170 volt 25 Hz. ac input output 250 volt dc is on main floor.

At that time, very little was understood about the behavior of ac that often failed to follow the standard rules and equations developed by research for work with dc. Westinghouse and other pioneers such as Elihu Thomson and William Stanley became the primary force in research on AC. Most of the electric utility companies entered the commercial market through the business of arc lighting that seemed to guarantee an immediate financial return. Westinghouse, with the capital for investment available from his railway air brake and signal companies, acquired many patents related to ac. He entered the NY market in 1889 by purchasing the United Electric Light & Power Co., a small arc light company that was later to act as a spearhead in establishing the use of AC in an urban environment. Rather than arc lamps, his primary focus was on incandescent lighting by AC in direct competition with Edison.

At the outset, the United Company's efforts were not commercially successful because of the need for individual transformers for supplying power to each customer. The early transformers were crude, and still somewhat experimental. Moreover, there was scant understanding of the behavior of ac circuits as affected by inductive and capacitive reactance. Nor was there any means to control and manage the "reactive" power drawn by the transformers and experimental ac motors. Substantial research was conducted to develop a working system by the mid 1890s. The Edison company by that time had already installed three power stations in mid and lower Manhattan and all of them distributed direct current to customers.

By then the superiority of AC for large-scale generation and transmission had clearly been demonstrated by Westinghouse. The company developed and installed Nikola Tesla's polyphase system at the Chicago Columbian Exposition of 1893. It was the first demonstration of an electrical installation of such a large scale. The subsequent operation of the hydro-electric installation at Niagara Falls, NY two years later made it clear that large scale ac generation and transmission were the most efficient means to distribute electric power over a region. Westinghouse also developed a technique to manage the "power factor" utilizing overexcited synchronous motors to offset the reactive power consumption. A new competitor, General Electric, was formed in 1892 through the merger of the Thomson-Houston and Edison manufacturing companies. General Electric research mathematician Charles Steinmetz directed research at the company and wrote theorems that are still in use today. He was the leading ac figure that enabled GE to enter the AC field. General Electric installed the first long distance alternating current transmission lines in the USA and connected the Niagara Falls station with Buffalo, NY.

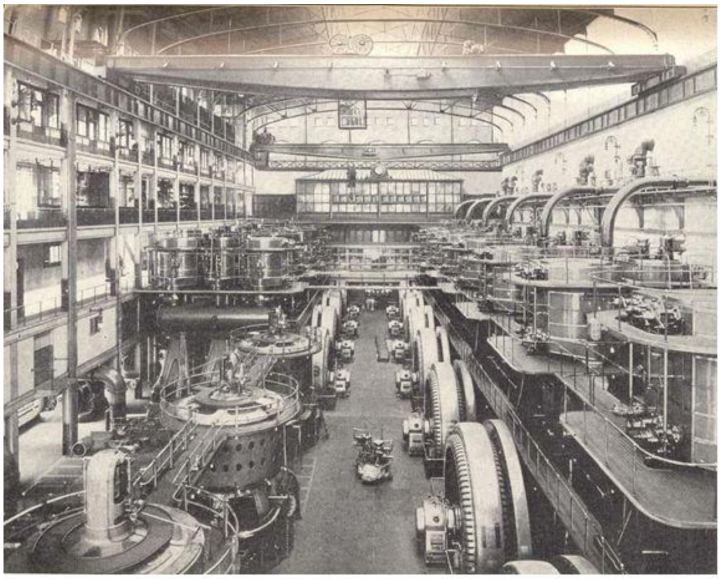
In NY City, the issue with electrification was also financial — a problem that stymied further development of electrical systems until Albany investor Anthony Brady began acquiring the electrical franchises issued to small companies to create a company with a customer base and income adequate to finance large-scale construction. His vehicle to drive the mammoth efforts was the Consolidated Gas Company, and his point man for development was Thomas E. Murray, a gifted engineer and inventor whose work dominated the electrical system of New York City for the following half century.

In Manhattan, the Murray/Brady organization combined the original Edison Lighting Company and small competitors into the New York Edison Company and in 1901 constructed a large scale generating station on the East River at 38th Street. Named Waterside, it supplied 25Hz power to sixteen local substations that distributed 120/240V DC to its customers. In stages, the economies of scale reduced the price of power so that both new customers and those that had formerly operated private generators created an unanticipated demand which required the construction of an additional station within five years.

However, the matter of distribution of power was not easily resolved — the power losses experienced with alternating current due to reactive power in areas with a dense concentration of heavy load exceeded the savings of the simpler ac system. In many instances, the ac reactive power losses exceeded even those due to the resistive losses in dc cables that carried the high current inherent in the distribution of power at 110/220V.

In 1896, Charles Steinmetz promulgated a simple rule: wherever the customer base was sufficient to amortize the construction and operational expense of a substation for supplying DC customers, it would be the best to provide them with dc power. Not only there would be no reactive power problems, dc also permitted the use of batteries for backup and peak load shaving that had already been adapted in local dc power stations. Moreover, customer metering and most of the early motors were designed for direct current. Steinmetz's rule dominated system development in most cities and towns for the following three decades. Thus, local substations supplanted the small generating plants and the economy of scale produced a 50% reduction in the price of power during the first decade of the 20th century and an additional 15% by 1917.

Meanwhile, proponents of alternating current systems had developed a variety of ac motors, improved transformers, and had pioneered new techniques to manage reactive power. They had fostered metallurgical research to formulate steel with superior magnetic characteristics suitable for use in alternating current motors and transformers. Utility companies



Waterside Station Generator Hall: Vertical turbine- alternator sets are seen in the row on left (foreground) and older reciprocating engine-alternator sets stand at right.

across the United States had installed alternating current systems for customers outside the densely populated areas in which direct current distribution was deemed superior. In Manhattan, in 1896, the United Company, under the Westinghouse ownership, initiated the installation of two phase 60Hz power distribution. After acquisition by the Murray/Brady Consolidated Gas Company in 1900, the United management remained independent of the New York Edison Company although some assets were shared. United thus developed a substantial 60Hz distribution system in areas where the Edison Company had not extended the DC system.

Further developments led to United's entry into the once sacrosanct urban territory dominated by New York Edison's dc distribution. Reactive power losses continued to be a prime concern and, hence, various methods were employed to improve the power factor of the system. Synchronous compensation was being used in transformer substations. Furthermore, whenever practical, United's distribution techniques helped connect factories with induction motor loads to the same feeders as the synchronous motors of refrigeration plants. Thus, the reactive power consumed by the induction motors was compensated by that produced by the synchronous motors; their respective owners were provided with financial incentives to operate their systems so as to improve overall power factor. The United system consequently avoided power factor "swings" between daytime industrial load peaks and nighttime lighting peaks. Other 60-Hz AC utilities experienced power factor "swings" of as much as 30% over a 24-hour period.

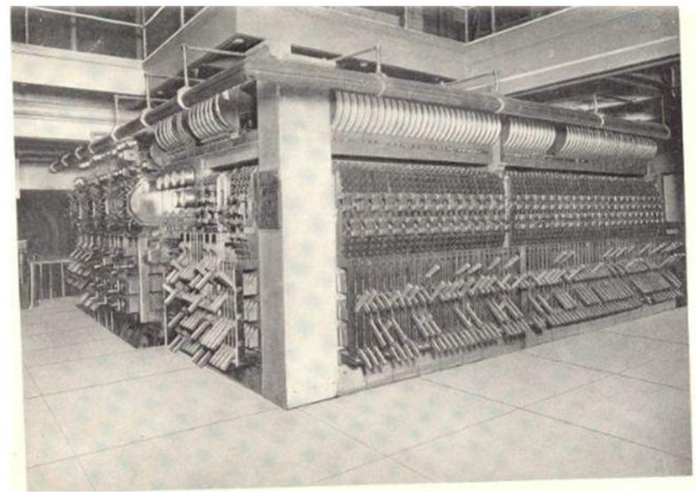
While the coupling of ac generation and transmission with dc distribution as practiced by NY Edison had proven ideal to meet the demand in areas with high concentration of load in 1900, changes were to come by 1910. The expense of the necessary conversion equipment at substations and also that of the heavy copper cables required by the high load current at 120/240V comprised half of the infrastructure cost of an installation. As the density of the electrical distribution system increased, the investment required to meet the demand multiplied.

Distribution of alternating current promised a substantial cost reduction obtained through the replacement of the dc substations and heavy cables of the dc systems by high voltage AC lines to transformers located near, or in some instances even in, the customers' premises. It obviously depended on perfecting a system that would be as reliable as the dc system taking into consideration that the reactive power would have to be controlled and that there would be no battery backup. Moreover, there were other issues with ac systems. By 1900, the frequency of 60Hz had largely been standardized for ac systems, usually supplied over the two-phase systems developed by Westinghouse. Single-phase lighting loads were not, as yet, easily balanced on the more efficient three-phase system promoted by General Electric. Consequently, the latter was largely restricted to the delivery of power to industrial motors and converters for dc distribution. In those situations, the use of 25Hz power was common as that offered greater efficiency and a reduction of heat losses in the coils of such machines.

Research had determined that interconnected cables of a direct current distribution network were not adequate for the dynamic characteristics of an ac system. Hence, manufacturers such as Westinghouse, in concert with utilities like United, initiated intense development efforts. The goal was to build an interconnected network that would provide the same reliability as the DC systems installed so far. It would have to be compact, easily accommodated in the available spaces, would use standardized components, and would be able to function with some feeder cables out due to a fault or maintenance. Additionally, it would need to operate at a power factor close to unity under varying loads, and would have to do so with lower construction and operational cost than that of a DC system.

By 1920, most utilities in the US were seeking to reduce, if not eliminate entirely, the use of dc distribution through installation of networks supplying ac power to customers in dense urban areas specified in their respective franchises. Those systems were far from perfect, often lacking in one or more desirable characteristic such as reliability, efficiency, or simplicity. Moreover, each was unique, their components involved were often not standardized, and many lacked the economy and reliability of DC systems that continued to be used at some locations.

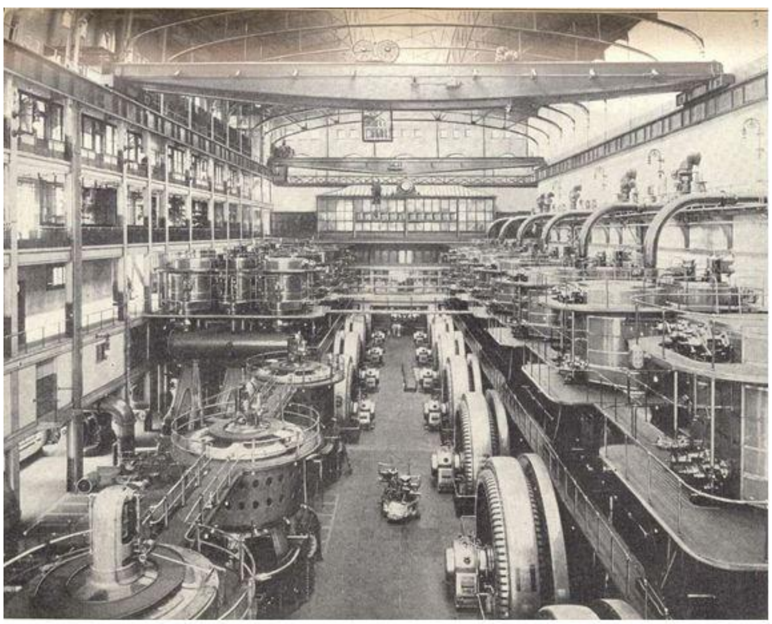
By 1914, the United Company had installed AC



West 26th Street substation converter control panel is in the center, the feeder switches on the right control power to outgoing dc feeders Note the wooden switch handles, wood was a common insulator at that time.

distribution systems throughout the Manhattan Island that relied on transformer stations in which power factor and voltage regulations were controlled manually. A complicated system of "manhole" switches was required to isolate faulted feeders or other components. The company supplied only 15% of the utility power needed in Manhattan, the bulk of it was consumed in areas north of 135th Street where it enjoyed exclusive franchise. Still, it had important industrial and commercial customers in midtown, especially in the market for large illuminated signs in Times Square. The flashing ad signs performed better on ac because of reduced arcing between the contacts.

In 1922, the United Company made the long awaited breakthrough with the development of a fully automatic distribution network that interconnected transformers through automatic relays for balancing power flow and controlling the reactive power. By that time, new equations developed by Charles Fortescu at Westinghouse, and Edith Clark at General Electric, made it possible to balance single phase loads on three-phase systems to attain a 50% increase in power capacity for the same investment in copper as compared to the two-phase system. In 1928, The New York Edison Co. initiated the replacement of dc distribution systems by the 60Hz United Automatic Network (aka New York Network) Though it took some eight decades to retire it completely, the day of the direct current distribution system was gone.



Waterside Station Generator Hall: Vertical turbine- alternator sets are seen in the row on left (foreground) and older reciprocating engine-alternator sets stand at right.

Generation and transmission systems continued to evolve during the mid-20th century. Waterside opened with 3,500kW alternators driven by reciprocating steam engines. In 1904, the first 5,000kW steam turbine alternators appeared. By 1913, 15MW alternators were common and by 1920, the standard capacity of the alternators reached 35 MW and that capacity was steadily increasing. By 1930, 160MW became the standard for the New York City. The Depression slowed the development of new systems but allowed time for the transition from dc distribution lines to ac networks. Major change came after WW II when 300-400MW hydrogen gas pressure-cooled alternators became common. In 1965, with the installation of the 1,000MW Unit #3 in the Ravenswood Station of ConEd, the capacity per unit reached a peak.

Transmission lines evolved as well. In 1900, those carried 3,000V two-phase 60Hz power for the United system and 6,600V, three-phase 25 Hz power for the Waterside station (1901). Soon after, United installed 7,500V two-phase, primary transmission that was supplanted by 13,200V three- phase transmission (1920). A massive program undertaken by NY Edison in the 1921-1922 time period raised the 6,600V three-phase 25Hz transmission system to 11,400V. The 27,600V, three-phase 60Hz lines were introduced in Brooklyn during the 1920s to reduce the number of cables and duct space required in congested areas. Distribution voltage on the United automatic network was standardized at 120V single-phase and 208V three-phase to replace a variety of systems of different voltages utilized in the early decades. The final selection reflected the desire to maximize the light bulb performance while assuring that motor performance and power factor were optimized as well.

The advent of federally funded large-scale hydroelectric plants called for the simultaneous development of transmission systems. Such systems were developed to exchange power and share investment in generation in other areas of the nation. The development of nuclear power stations in the 1950s and the 1960s required adequate transmission capacity in the form of new and enhanced transmission lines. Within the New York City, the growth in load experienced after the WWII required a significant increase in generating capacity. A 69,000V primary transmission system was constructed in the 1950s and 1960s, and that was ultimately supplanted by a 138kV system. By the mid 1960s, long- range transmission and interconnection with other utilities and nuclear stations employed 345kV lines including pipe/oil insulated underground lines.

Those voltages exacerbated the capacitance and charging current issues in underground cables while the lack of space for new transmission corridors outside city limits forced new directions in planning. Flexible ac transmission systems were developed to improve and increase transmission capacity. Concurrently, the development of High Voltage Direct Current (HVDC) transmission to eliminate reactive power problems advanced. Both approaches, however, have been made practical by new developments in solid-state conversion devices.

Deregulation has complicated some technical issues: power factor is now often the subject of sale of reactive power and most “merchant power producers,” that is, the owners of the power stations that were previously owned by the utility companies, contract to provide reactive power for “voltage support” as a component of the total power sold by the utilities. The deregulation, the effort to reduce urban pollution, and change in the energy market have diminished the significance of the urban power station once located at the “load center” of a particular territory. Consequently, urban power stations have largely disappeared in favor of distant plants to supply power in a region through independently owned facilities. Still, the supply of adequate power to areas of heavy load concentration such as midtown Manhattan, will remain a challenge and will require continued evolution in the future just as it was in the past.♦

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