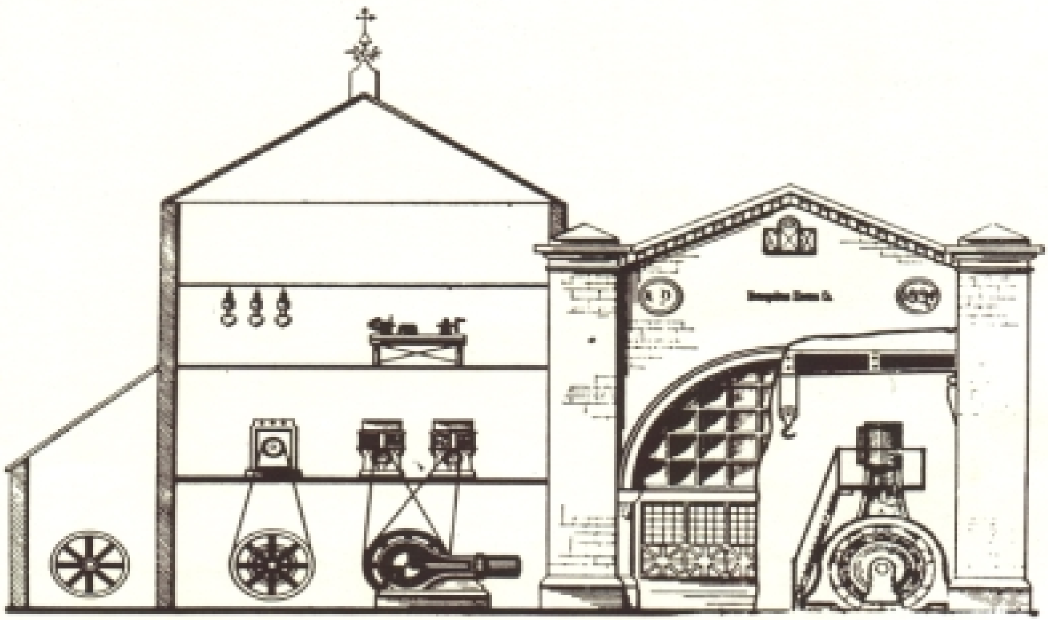


National Historic Mechanical Engineering Landmarks:

Edison "Jumbo" Engine-Driven Dynamo

and

Marine-Type Triple Expansion Engine-Driven Dynamo

Program

Greenfield Village
Dearborn, Michigan
May 29, 1980

Welcoming Remarks	**John Pope** Vice President — Region V American Society of Mechanical Engineers
Introduction	**James P. Macey** Chairman — Detroit Section American Society of Mechanical Engineers
ASME Landmark Program	**J. J. Ermenc** Chairman National History and Heritage Committee ASME
History of Landmarks	John Bowditch Curator, Power and Shop Machinery Greenfield Village and Henry Ford Museum
Presentation of Jumbo #9 Plaque	**Donald N. Zwiep** President American Society of Mechanical Engineers
Acceptance	**Frank Caddy** President Greenfield Village and Henry Ford Museum
Remarks	**Charles M. Heidel** Executive Vice President — Operations Detroit Edison Company President Michigan Electric Association
Presentation of Triple Expansion Plaque	**Donald N. Zwiep**
Acceptance	**Frank Caddy**
Remarks	**Ernest Rambaugh** Manager Engineering Bechtel Power Corporation
Closing Remarks	**James P. Macey**

Informal viewing of the landmarks will follow the ceremony

We wish to express our gratitude to the following organizations which made this booklet possible:

Bechtel Power Corporation — Detroit Edison Company — Hoad Engineering Company
Michigan Electric Association — Society for Industrial Archeology

To the staff of Greenfield Village and Henry Ford Museum our deepest appreciation — for without them there would not be a landmark ceremony.

Prologue

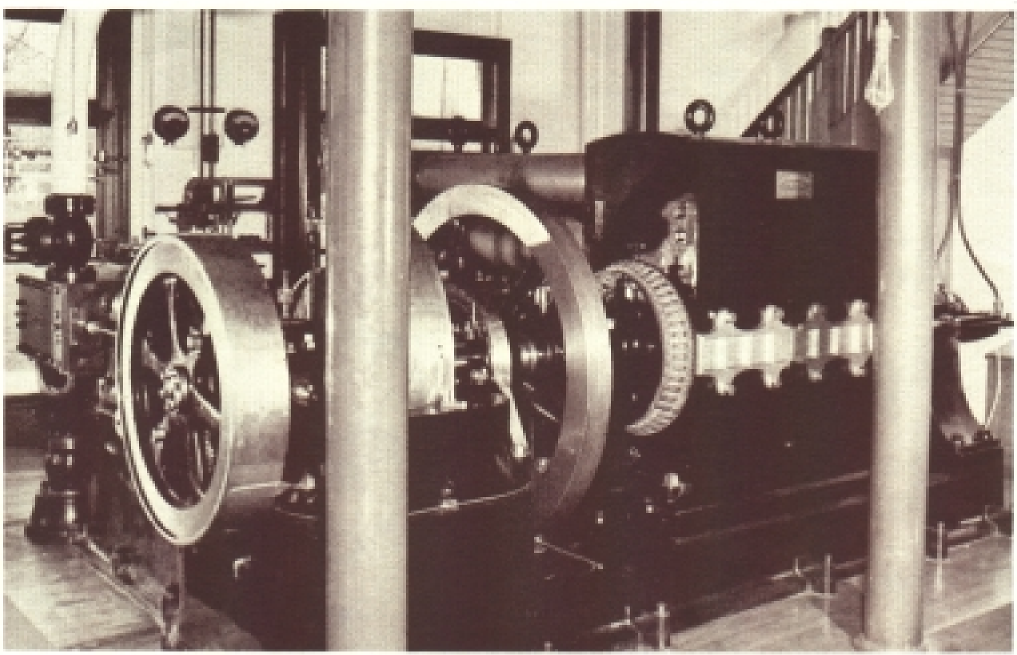
Dr. R. H. Thurston, the first president of ASME, made the following comment regarding the work of the mechanical engineer in his formal address to the Society at the Annual Meeting, November 4, 1880:

> "We have for our work the cheapening and improvement of all textile fabrics, the perfecting of metallurgical processes, the introduction of the electric light, . . ."

Development of large-scale electric utilities and electrical distribution systems has profoundly changed and improved our way of life. Popular sentiment credits Edison's invention of the incandescent lamp in 1879 with starting these changes, however, Edison's lamp would have been of little consequence had not practical "systems" been developed to supply current to the lamps. An essential part of all of these systems was efficient and reliable prime mover activated generators. The two machines being dedicated today represent two very important steps in the early development of the power industry.

These two machines are sole survivors of important classes of central station generation units. Each represented the "state-of-the-art" when it was constructed. The jumbo dynamo is unique in American history since it was the first to generate power in the first central power station in the United States. The triple expansion engine-driven dynamo set is representative of the type of generator which provided power during the 1890's.

In this the 100th anniversary of our society, 101 years after the invention of the incandescent lamp, we recognize these machines as National Mechanical Engineering Landmarks.

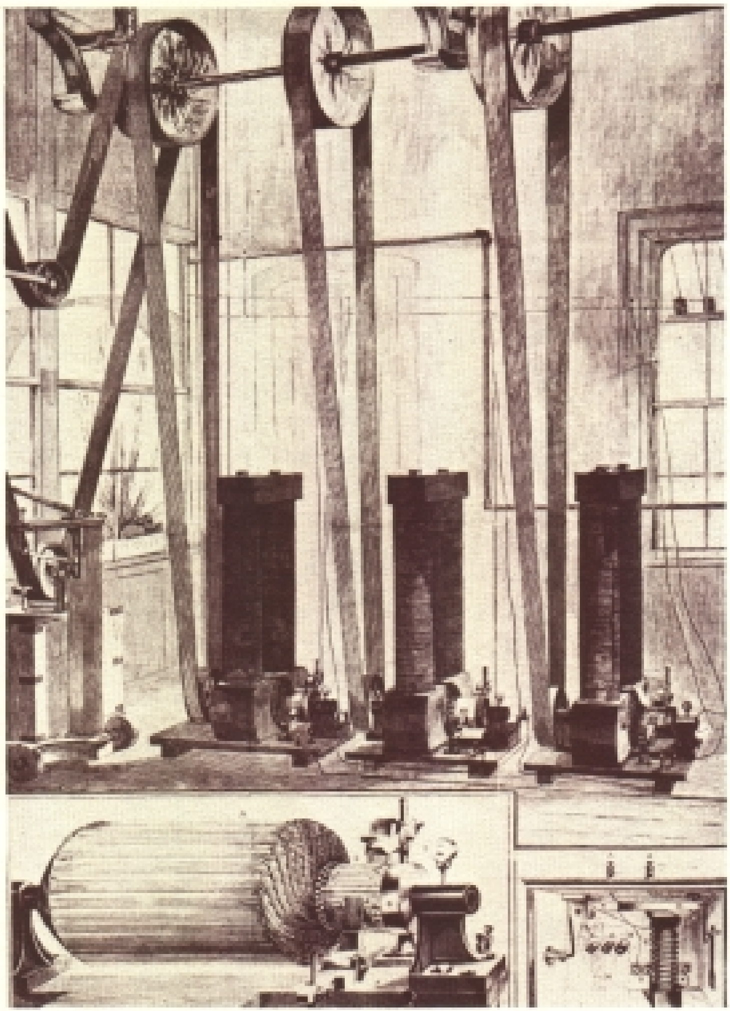


Greenfield Village and Henry Ford Museum

Jumbo No. 9 as it appears today on display in the Detroit Edison "A" station replica at Greenfield Village.

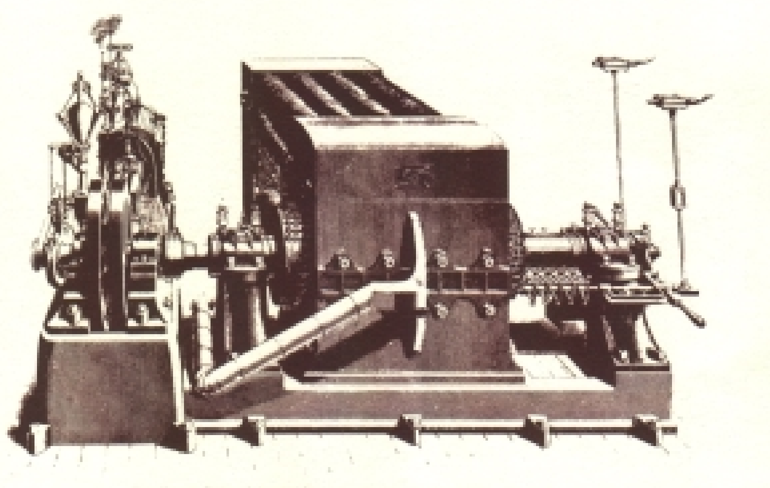
Cover picture: (Electrical Engineer — 1898.)

Example of belt and triple expansion direct drive power plant operation



Scientific American

Testing Long-waisted Mary Ann Dynamos—1879.



Greenfield village and Henry Ford Museum

Jumbo No. 9 fitted with the original Porter-Allan Equipment.

Edison "Jumbo" Engine-Driven Dynamo

Edison's dream was to transform the incandescent light into a commercially successful product. His plan was to develop a central station that would supply electrical power to the masses. Edison adapted the system developed for gas lighting for his electrical distribution system. He felt that electricity could ultimately replace gas as an illuminant in all residential and commercial capacities. In 1878, Edison boasted that he "would soon light up the entire downtown area of New York with 500,000 incandescent lamps powered by a few steam dynamos."

Western Union executives were intrigued by Edison's claims and immediately pledged the company's financial support. Several other investors took Western Union's lead. The result was the formation of the Edison Electric Light Company in October of 1878. All had invested in a product that had yet to be created! The company provided funding and, in return, Edison relinquished all electrical lighting patents that he would acquire over the following five year period.

With his finances secured, Edison set to work. He enlarged his Menlo Park facility and expanded his laboratory staff. University trained men such as Frances Upton and C. L. Clarke were hired to translate Edison's ideas into experimental forms. By the summer of 1879, the Edison-Upton dynamo had been developed. Due to its two upright columns, the bipolar form dynamo was soon nicknamed Edison's "Long-waisted Mary Ann." Using another Edison invention, the dynamometer, the two men were astonished to discover that their dynamo proved to run at over 80% efficiency, almost twice that of previous dynamos!

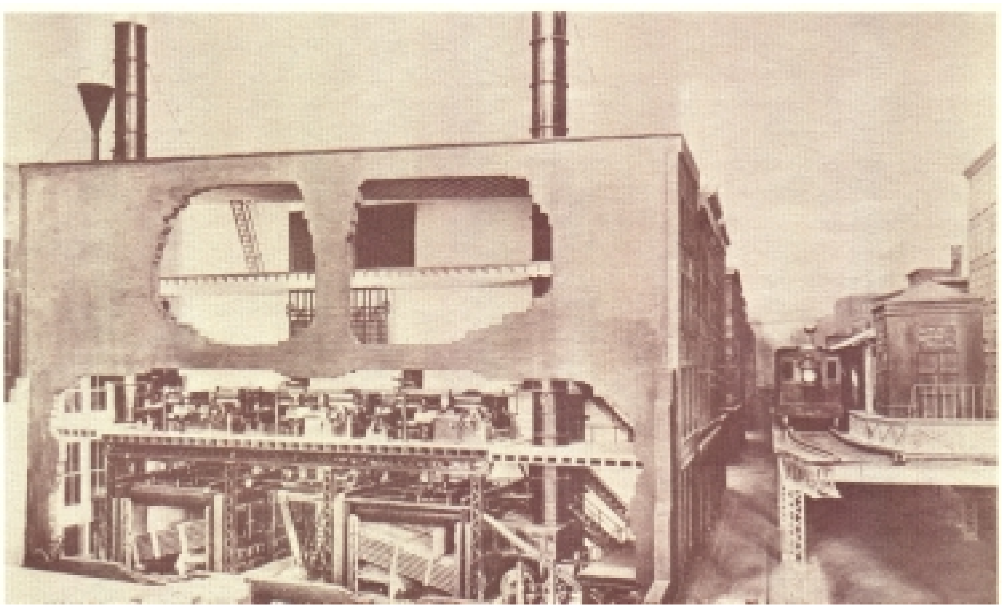
Although his dynamo experiments were proceeding with great success, Edison remained plagued by disappointments concerning the development of a practical and economical incandescent lamp. He could not find a proper filament nor an adequate method for evacuating the glass globe. His investors were rapidly becoming disillusioned. After months of agonizing trials, on October 21, 1879, Edison sealed a carbonized cotton filament in an evacuated bulb. The lamp operated successfully through the night. On New Year's Eve Edison put on display the Menlo Park laboratory and grounds completely illuminated by his new invention. That night provided his backers with enough reassurance to continue their funding.

News of the display also brought Edison new investors. Henry Villard, a railroad magnate, contracted him to install an independent lighting plant in the *S. S. Columbia,* one of Villard's many properties. In May, 1880, the *S. S. Columbia* sailed with 115 lamps run by four bipolar "Mary Ann" dynamos. The lighting system ran successfully until 1895 when it was renovated.

1880 also saw the beginnings of Edison's experimental central station experiments. He attached a power station to his Menlo Park Machine Shop which housed several dynamos driven from a central steam engine using belts and shafting. The awkwardness and inefficiency of such a system prompted Edison to develop an alternative means of power transmission. His solution was to directly couple a large dynamo to a high speed engine.

Edison assigned Upton and Clarke to the project and ordered a high speed

Menlo Park Reminiscence
Exterior of the Pearl Street Station—1882.



Greenfield Village and Henry Ford Museum
A cutaway model showing the interior of the Pearl Street Station.

engine from the Porter-Allan Engine Company in Philadelphia. The engine arrived in January of 1881 and tests were run at speeds up to 700 r.p.m.; however, it was found that 350 r.p.m. was sufficient. After this first directly coupled engine-dynamo proved successful, a second was constructed at the Edison Machine Works on Goerck in New York City. The unit was built especially for the 1881 Paris Electrical Exposition. The massive machine and its successors were nicknamed "Jumbo" after P. T. Barnum's famous elephant. The Jumbos definitely lived up to their namesake. The dynamos weighed 44,820 pounds each, their poles used 12 field coils, and the Siemans' type armature and its shaft were over 10 feet long!

While the machinery was being developed, Edison took on the task of finding a location for his first central power station. He chose New York City, but discovered most of the property was painfully expensive. Edison directed his search to a rundown part of town in hopes of finding a cheap piece of real estate. In August of 1881, his search ended at an old commercial building at 257 Pearl St. Not only was it inexpensive, but it was near the financial district so that Edison could easily display his product to wealthy potential backers.

Work to convert the building into a power plant was immediately initiated. Edison chose to retain the building's exterior but planned to rearrange it internally. Lattice girders and floor beams similar to those used by elevated railroads were installed to support the 180 tons of generating machinery.

Installation of the machinery continued throughout the summer of 1882. Four Babcock and Wilcox boilers of approximately 250 horsepower each were placed on the ground floor. All fed into a single 8" supply pipe. An elaborate heating and feedwater system was developed to purify the water before it entered the boilers. Six Jumbo dynamos and their driving engines were located on the second floor. The trestlework on which they stood was entirely disconnected from the main building to minimize the effects of vibration. It was expected that each machine would provide for 1200 sixteen candlepower incandescent lamps with a maximum output of 1400 lights continuously.

The street outside also played a vital role in Edison's arrangements for the central station. Edison planned to dig fourteen miles of trenches to house the underground conduits. Previously, power services used overhead wiring, but Edison felt that leakages of electrical current would be prevented if wiring was placed underground. City officials disagreed and decided to discourage Edison. They threatened to tax each foot of wiring laid and suggested that inspectors from the Department of Public Works should monitor the daily digging with Edison paying their salaries. Edison supposedly protested saying, "Why, you don't lift water pipes and gas pipes on stilts!" After several battles Edison finally was allowed to construct his trenches, however, his problems with underground wiring were not over.

Tests were run during the summer of 1882 with an amazing result. While the staff at Pearl St. was pleased with the station's performance, the police were getting reports that "juice" from the station was leaking out onto the streets! Several incidences were recorded:

> "A peddler of tinware, with a ten dollar 'nag,' drove through the crowd. At the moment he entered the charmed spot, his quadruped gave a snort, and, with ears erect and tail pointing to the North Star, dashed down the street at a 2:40 gait . . . Next came a big truck with paper. No sooner had the horses stepped upon the magic spot than they dropped kicking upon their knees."

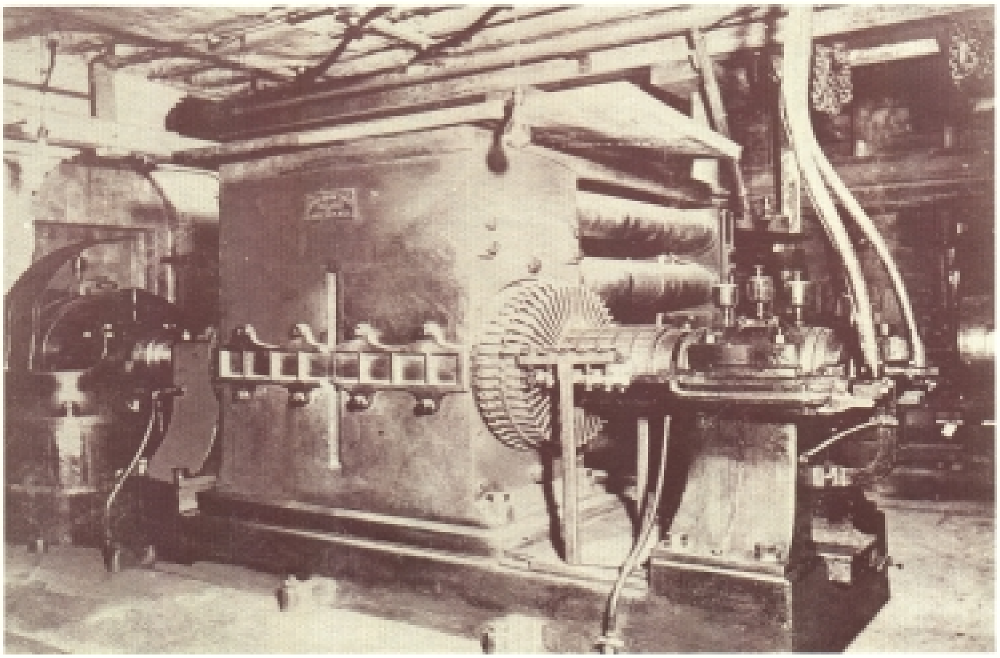
It was later discovered that some men had accidently punctured one of the electric tubes. Thus, current was being transmitted to innocent passersby.

Harper's Weekly

Installation of the Underground System of Distribution from the Pearl Street Station-1882.

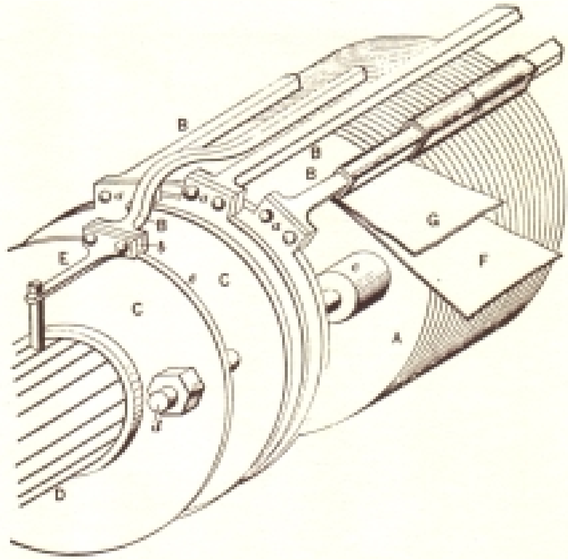
Finally, on September 4, 1882, the long awaited Pearl St. Station began commerical operation with a "load of about 400 lamps supplied with current from Jumbo No. 9." A problem concerning its operation immediately arose when attempts were made to operate two Jumbos in parallel. Mr. Charles Clarke, the first chief engineer of the New York Edison Company, described the incident. "Immediately the two machines began to 'hunt,' the engine governors first cutting off and then giving full steam admission, and causing the machines to alternately seesaw between standstill and a terrific rate of speed." One of the machines was immediately stopped. The problem was traced back to the governors on the Porter-Allan engines. An emergency order was sent out to Gardiner Sims at the Armington & Sims Engine Company in Providence, Rhode Island. In the meantime, Edison devised a system of levers, shafting, and pivot rods to mechanically connect all of the Porter-Allan engine governors so that the machines could be run simultaneously. The Armington & Sims engines arrived in November. Sims guaranteed that his engines would not show a variation of speed over 2% from no load running light, to full load. Each could run at steam pressures varying from 60 to 160 lbs. at 350 r.p.m. Sim's engines proved to be entirely satisfactory.

Edison had anticipated that several problems might arise during the first months of operation. He decided not to charge his customers until the station was running smoothly. "The first bill for lighting, based upon the reading of the Edison electrolytic meter, with which the system was equipped, was collected on January 18, 1883 amounting to $50.40 from the Ansonia Brass and Copper Company. By November, 1883, bills for lighting, amounting to $9,102.45 were collected."



Greenfield Village and Henry Ford Museum

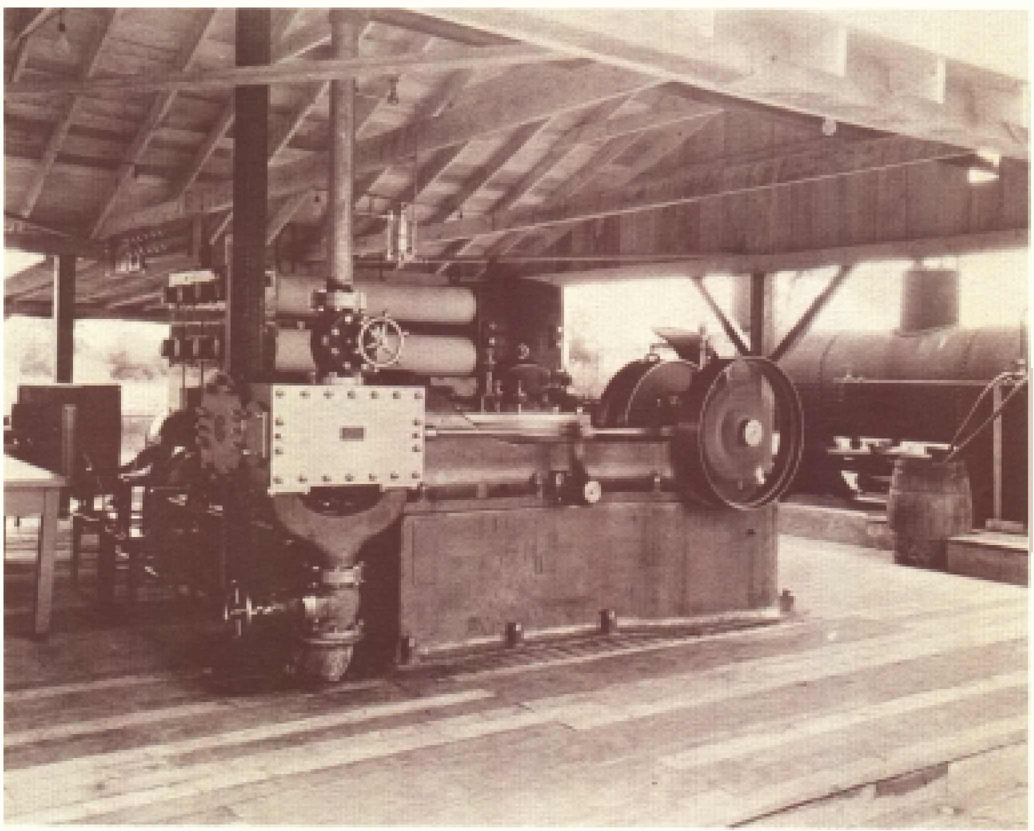
Jumbo No. 9 after the fire at the Pearl Street Station—1890.



-Construction of the armature of the Edison steam dynamo.

The Electric Light–1882

A diagram showing the Jumbo's highly unusual armature construction.



Greenfield Village and Henry Ford Museum

Jumbo No. 9 in full operation at the 50th anniversary celebration for the Pearl Street Station, Dearborn, Mich., September 4, 1932.

The Jumbo engine dynamo was considered to be one of the wonders of the world when it was first exhibited. Several times larger than any previous dynamo electric machine the Jumbo's design had many highly original features, particularly in mechanical details. Edison was preoccupied with reducing armature resistance to a minimum. The long-waisted Mary Anns had pioneered this idea and efficiency had been dramatically improved. For the Jumbos, Edison's staff developed a unique "winding" built from copper bars and brass discs. This design reduced resistance to an absolute minimum and also allowed for quick replacement in the event of winding failure. As was typical of the period, these windings were applied on the surface of the armature drum. Clever though this arrangement was, it was not used in later dynamos.

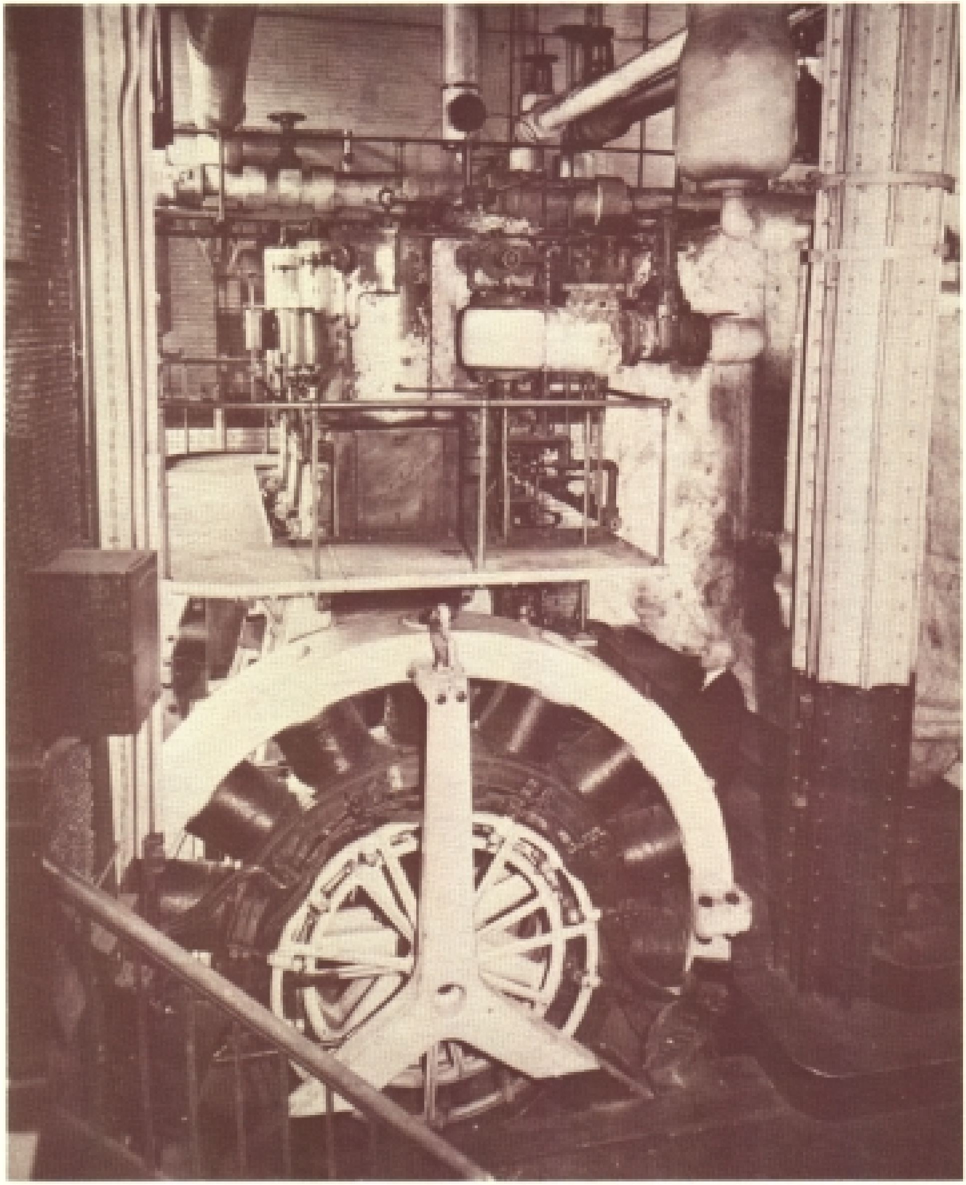
Another design detail was the cooling system which blasted air onto the armature near the center of the field magnet. This helped to reduce heat generation in the armature.

As was stated earlier, the Jumbos were originally equipped with Porter-Allan engines. These were replaced when their governors failed to regulate properly. It is interesting to note that this failure was probably caused by the design of the station itself; the Porter governors were sensitive to vertical motion of the engines, this motion was in part caused by the system of latticework girders used to support the floor of the dynamo room. The Armington and Sims engines which replaced the Porter-Allan machines used a shaft-mounted governor which was less subject to this problem. Both the Porter-Allan engines and the Armington and Sims engines were well-designed carefully balanced machines.

The Pearl St. Station continued to run successfully until January 2, 1890 when an early morning fire partially destroyed it. Jumbo No. 9 was the only one of the six original dynamos to survive. It was soon put back into commission working in conjunction with belt driven generators and engines which were installed as temporary equipment.

Jumbo No. 9 operated until 1893 when it was sent to the Columbian Exposition in Chicago. The dynamo was returned to New York and rebuilt, It presumably continued to run until it was exhibited at the Louisiana Purchase Exposition in St. Louis in 1904. During World War I, it was stored in Hoboken, New Jersey where wire was stolen from its field magnets. In 1924, Jumbo No. 9 was exhibited at the Grand Central Palace in New York for the 40th Anniversary of the American Institute of Electrical Engineers.

The engine and dynamo were presented to Henry Ford for his new museum of technology in 1930. In 1932, the machine was completely rebuilt and made operational for the 50th anniversary of the original Pearl St. Station. Today, Jumbo No. 9 is exhibited in a partial replica of the original Detroit Edison "A" Station. It remains fully operational and stands as a monument to the "Edison system" of electric lighting that insured the ultimate success of electrical utilities and changed the lives of all whom it touched.



Greenfield Village and Henry Ford Museum

The Marine Triple-Expansion Engine-driven generator in its original location at Duane Street in New York City–1928.

Marine-Type Triple Expansion Engine-Driven Dynamo

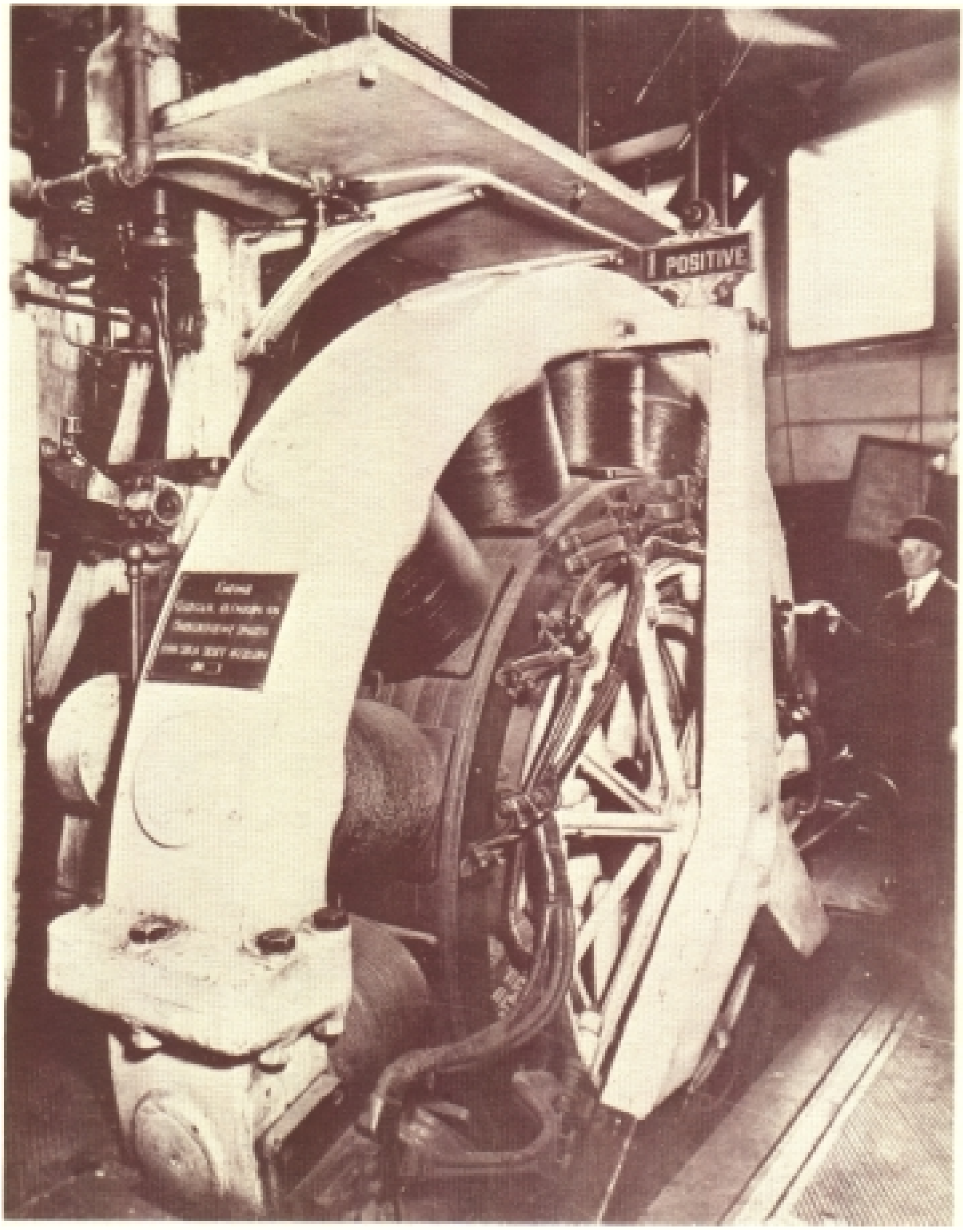
Success of the Pearl St. Station and other similar installations stimulated the electrical industry in the United States in both the manufacturing and power generation areas. During the 1880s, a proliferation of manufacturers sprung up to produce everything from lamps to generators. It was a period of great engineering advances and constant legal battles over patent rights. As 1890 approached, two major electrical firms—the Thompson-Houston Electric Company and the Edison-General Electric Company — dominated the field while the newly formed Westinghouse Electric and Manufacturing Company wasn't far behind.

While the industry grew larger and advances in engineering were made, the typical central power station, unlike the Pearl St. Station, used high-speed generators belt driven from slow-speed steam engines. This type of installation worked reasonably well and enabled efficient slow-speed engines like the Corliss to drive high-speed bipolar generators. These stations were often designed with the engines located on the ground floor and dynamos on the floor above.

As the capacity of the generators increased, this station arrangement became limiting. Refined versions of the basic bipolar designs developed by Edison and others around 1880 proved to be extremely massive as their power increased. The zenith was reached between 1889 and 1892 when the Edison-General Electric Company built some 200 kilowatt monsters that weighed nearly 20 tons. Bipolar generators were also inherently high-speed machines, although the Pearl St. generators had operated at 350 r.p.m., most large later machines operated at over 500 r.p.m., a speed far greater than traditional large engines would run. Belt drives also retained all the defects noted by Edison in 1880—they were dangerous, wasteful of space and inefficient. The solution to these problems was to build multipolar generators that would operate efficiently at speeds between 100 and 150 r.p.m. These could be directly coupled to the engines in the same way as had been done at Pearl St. in 1882, however, the power outputs of these new machines could be far greater.

On December 15, 1891, the Edison Illuminating Company of New York put the first of its revolutionary new marine-typetriple-expsansion engine driven generator sets into operation at the Duane St. Station. This unit represented the true beginnings of massive scale electric power generation in the United States. For its time the machine was extremely compact and powerful. It represented a major advance in station equipment engineering. Power output was 400 kilowatts D.C. Similar units began operation at the same company's 26th street station almost simultaneously, these were described in detail in the March, 1892 issue of *Power* Magazine which stated that the designers of these machines were contemplating the construction of larger versions with 5,000 horsepower capacities.

This new type of central station generator set was designed by John Van Vleck, chief engineer of the Edison Illuminating Company with the assistance of David Joy (from London, England) and S. F. Prest. The engine was built by the Dickson Manufacturing Company of Scranton, Pennsylvania under the supervision of J. W. Sargent, chief engineer. The generators were supplied by the Edison-General Electric Company of Schenectady, New York. The choice of a marine design for this application made a great deal of sense; the requirements of an urban power station were not dissimilar to those of a high speed Atlantic liner; as much reliable power as possible had to be produced in the smallest space possible *(See Cover).*



Greefield Village and Henry Ford Museum

Closeup view of one of the Edison-General Electric 14 pole dynamos — Duane Street, New York — 1928.

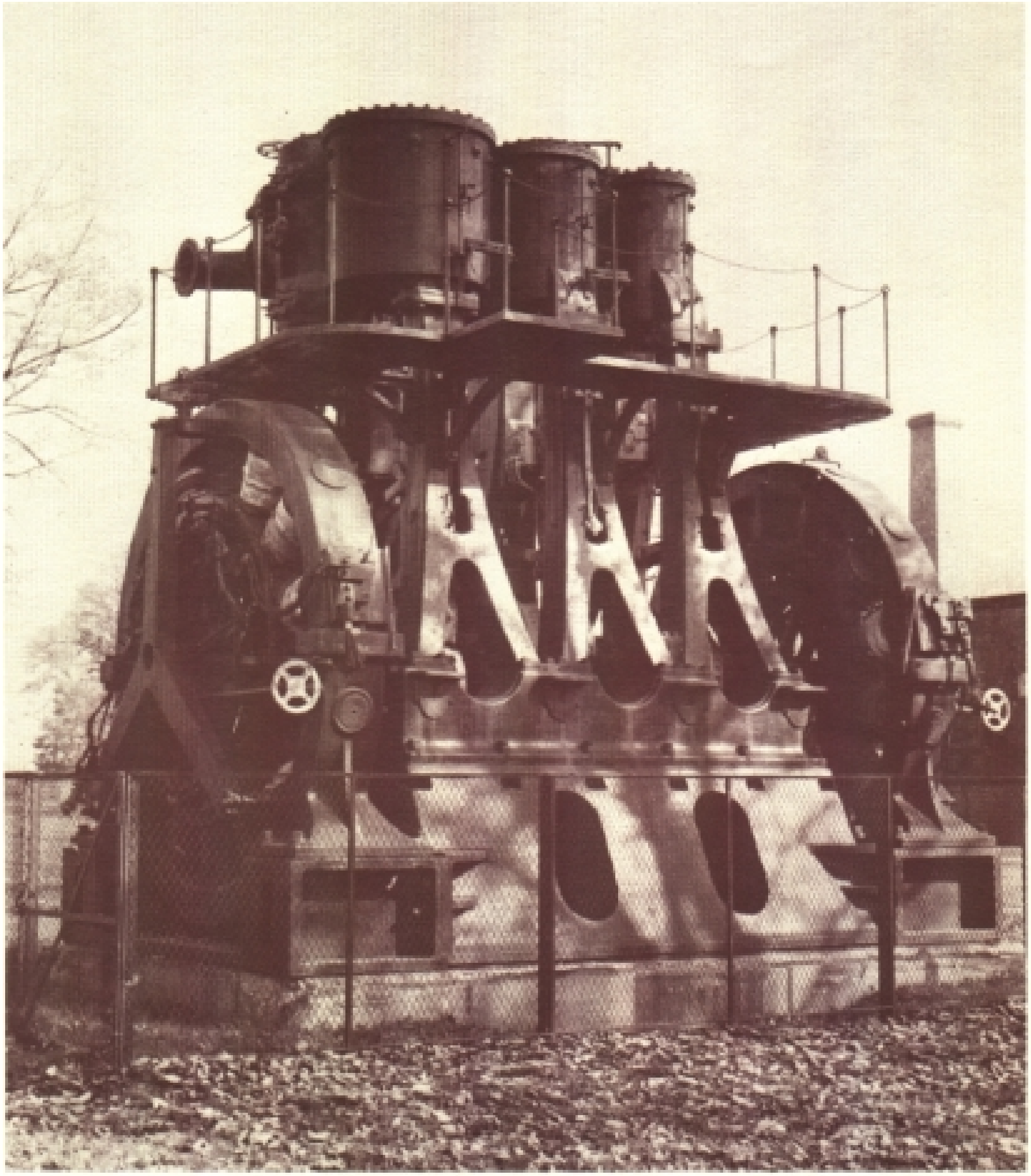
The engine driving the two dynamos was designed to be compact and reliable. For example, the valves were located at the sides of the cylinders, whereas the usual practice was to place them in line with the cylinders. This enabled the overall length of the engine to be reduced by about 40 percent. Placing the valves in this location also simplified inlet and exhaust manifolding which was quite complex on this machine. Cate valves were placed in various positions on the manifolding, these could be closed and opened in different ways to change engine operating modes. It was possible with this system to operate the engine as a three-cylinder simple high-pressure machine or as a conventional triple expansion machine. This feature was particularly useful for startup or under heavy load conditions.

Valve motion was derived directly from the connecting rods in David Joy's design. Joy's valvegear was also used on many British locomotives and on the Doble steam car. It featured few working parts and gave reliable service.

Probably the most interesting feature of the engine was its governor and the hydraulically operated valve cutoff. Most 19th Century stationary steam engines were fitted with some form of speed governor, however, this usually directly controlled a throttle valve or the engine's inlet valves. The designers of this engine wanted powerful and accurate control so the governor did not directly control the valves. Instead, a small high-pressure oil (or water) valve was controlled by the governor and this valve was used to regulate the position of a hydraulic cylinder. This cylinder in turn controlled the cutoff point.

The generators were each designed to produce 120 volts direct current with a continuous power output rating of 200 kilowatts. Each generator fed one side of a standard Edison three wire system. The generator design was essentially an adaptation of traditional bipolar features modified to suit the new multipolar arrangement. The armature was ring-wound on the surface and copper brushes collected current from the outside ends of the rings. The machines each had 14 field coils and poles. This allowed for efficient power output at the rated speed of 130 r.p.m.

Both the engine and the generators were designed to handle heavy overloads. The engine was rated at 625 horsepower, however, it was capable of producing up to 900 if necessary.



Greenfield Village and Henry Ford Museum

The Triple-Expansion Engine-Driven Generator
as exhibited at Greenfield Village today.

Epilogue

Perfection of large triple expansion engine driven generator sets that operated at slow speed represented the beginning of large scale central power generation but at the same time represented the end of the first phase of electric utility engineering. Within fifteen years of the construction of this first machine both the reciprocating steam engine and Edison's beloved direct current were obsolete for central utility use. Nevertheless central station design was dominated by these machines during this period.

In 1884, Charles Parsons tested his first steam turbine. Prophetically it was used to drive a high-speed electric generator. Turbines proved to be the ideal power source for generators—compact, simple and capable of operating at optimal generator speeds. The reciprocating steam engine had forced engineers to build generators adapted to its limitations; the turbine allowed designers to create the best generators possible. In a sense, the turbine provided the same advantages, size and power that the marine triple expansion engine did and not surprisingly history repeated itself only in reverse. Soon the turbine, first developed to power a generator, was driving large ships at speeds unknown before its use.

Specifications of the Landmarks

Edison Jumbo No. 9
Engine Driven Dynamo
Built 1882

Engine: High-Speed Center Crank Single Stage Expansion, Automatic Cutoff from Shaft Governor

Bore: 14.5 inches
Stroke: 13 inches
Speed: 350 r.p.m.
Weight: 6,500 lbs.

Built by the Armington & Sims Engine Company
Providence, Rhode Island

Dynamo: Bipolar, Drum Wound Armature with Horizontal Field Magnet

Voltage: 110
Amperage: 900 (approx.)
Speed: 350 r.p.m.
Capacity: 99 kilowatts (approx.)
1,200, sixteen candlepower lamps
Weight: 53,836 lbs.

Built by the Edison Machine Works, New York City

Triple Expansion
Engine-Driven Dynamo,
Built 1891

Engine: triple-expansion, three cylinders, equipped with automatic cutoff and Joy valve gear

Bores: 18, 27 and 40 inches
Stroke: 30 inches
Speed: 120 r.p.m.
Horsepower: 625

Built by the Dickson Manufacturing Company,
Scranton, PA

Dynamos (two): armature ring-wound, fourteen field poles

Volts: 150 (DC)
Amperes: 1333
Capacity: 200 k.w.
Total Capacity of Both Units: 400 k.w.

Built by the Edison General Electric Company,
Schenectady, New York

Total Weight of Engine and Dynamos: 100 tons

The National Historic Mechanical Engineering Landmark Program

The American Society of Mechanical Engineers reactivated its history and heritage program in September 1971 with the formation of the National History and Heritage Committee. The committee's overall objective is to promote a general awareness of our technological heritage among both engineers and the general public.

One of the committee's responsibilities is to gather data on all works and artifacts with a mechanical engineering connection that are historically significant to the profession. It's an ambitious goal, and one achieved largely through the volunteer efforts of the section and division history and heritage committees and interested ASME members.

Two major programs are carried out by the sections, under the direction of the national committee. One is a listing of industrial operations and related mechanical engineering artifacts in local historic engineering records, and the other is the national historic mechanical engineering landmark program. The former is a record of detailed studies of sites in each local area, while the latter is a demarcation of local sites which are of national significance—people or events which have contributed to the general development of civilization.

ASME also cooperates with the Smithsonian Institution in a joint project to contribute historic material to the National Museum of History and Technology in Washington, D.C. The Smithsonian's permanent exhibition of mechanical engineering memorabilia is directed by a curator, who also serves as an ex-officio member of ASME's national history and heritage committee.

The Jumbo #9 and the Triple Expansion Engine are the 46th and 47th landmarks to be designated since the program began in 1973.

Other Historic Landmarks

Ferries and Cliff House Cable Railway Power House, San Francisco, Calif.

Leavitt Pumping Engine, Chestnut Hill Pumping Station, Brookline, Mass.

A.B. Wood Low-Head High-Volume Screw Pump, New Orleans, La.

Portsmouth-Kittery Naval Shipbuilding Activity, Portsmouth, N.H.

102-Inch Boyden Hydraulic Turbines, Cohoes, N.Y.

5000 KW Vertical Curtis Steam Turbine-Generator, Schenectady, N.Y.

Saugus Iron Works, Saugus, Mass.

Pioneer Oil Refinery, Newhall, Calif.

Chesapeake & Delaware Canal, Scoop Wheel and Engines, Chesapeake City, Md.

U.S.S. Texas, Reciprocating Steam Engines, Houston, Texas

Childs-Irving Hydro Plant, Irving, Ariz.

Hanford B-Nuclear Reactor, Hanford, Wash.

First Air Conditioning, Magma Copper Mine, Superior, Ariz.

Manitou and Pike's Peak Cog Railway, Colorado Springs, Colo.

Edgar Steam-Electric Station, Weymouth, Mass.

Mt. Washington Cog Railway, Mt. Washington, N.H.

Folsom Power House #1, Folsom, Calif.

Crawler Transporters of Launch Complex 39, J.F.K. Space Center, Fla.

Fairmont Water Works, Philadelphia, Pa.

U.S.S. Olympia, Vertical Reciprocating Steam Engines, Philadelphia, Pa,

5-Ton "Pit-Cast" Jib Crane, Birmingham, Ala.

State Line Generating Unit #1, Hammond, Ind.

Pratt Institute Power Generating Plant, Brooklyn, N.Y.

Monongahela Incline, Pittsburgh, Pa.

Duquesne Incline, Pittsburgh, Pa.

Great Falls Raceway and Power System, Paterson, N.J.

Vulcan Street Power Plant, Appleton, Wis.

Wilkinson Mill Pawtucket, R.I.

New York City Subway System, New York, N.Y.

Baltimore & Ohio Railroad, Baltimore, Md.

Ringwood Manor Iron Complex, Ringwood, N.J.

Joshua Hendy Iron Works, Sunnyvale, Calif.

Hacienda La Esperanza Sugar Mill Steam Engine, Manati, Puerto Rico

RL-10 Liquid-Hydrogen Rocket Engine, West Palm Beach, Fla.

A.O. Smith Automated Chassis Frame Factory, Milwaukee, Wis.

Reaction-Type Hydraulic Turbine, Morris Canal, Stewartsville, N.J.

Experimental Breeder Reactor (EBR-1), Idaho Falls, Idaho

Drake Oil Well, Titusville, Pa.

Springfield Armory, Springfield, Mass.

East Wells Power Plant (Oneida Street), Milwaukee, Wisconsin

Watkins Woolen Mill Lawon, Montana

C-E First Welded Steam Drum Chattanooga, Tenn.

Georgetown Steam Plant Seattle, Washington

Equitable Building Portland, Oregon

Shippingport Atomic Power Station Pittsburgh, Pa.

Acknowledgments

The Detroit Section of the American Society of Mechanical Engineers gratefully acknowledges the efforts of all who cooperated on the landmark dedication of the Jumbo #9 and Triple Expansion Engines, Greenfield Village, Dearborn, MI.

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This booklet was compiled and written by Terri Sinnott and John Bowditch of the staff of Greenfield Village and Henry Ford Museum and edited by Edward C. Trachman, History and Heritage Chairman of the Detroit Section. The text is based on the following materials: *A Century of Light* by James Cox, 1979; *A History of Electrical Power Engineering* by Percy Dunsheath, 1962; *Edison A Biography,* Matthew Joseph, 1959; *Menlo Park Reminiscences,* Vol. 3 by Francis Jehl; *American Machinist,* July, 1882; *Metropolitan Electric Topics,* c. 1928; *Power,* March, 1892; *Scientific American,* August, 1882; Collections & Records of the Edison Institute.

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