"EDISONIA"

ST. LOUIS 1904

DUP

"Edisonia"

A Brief History

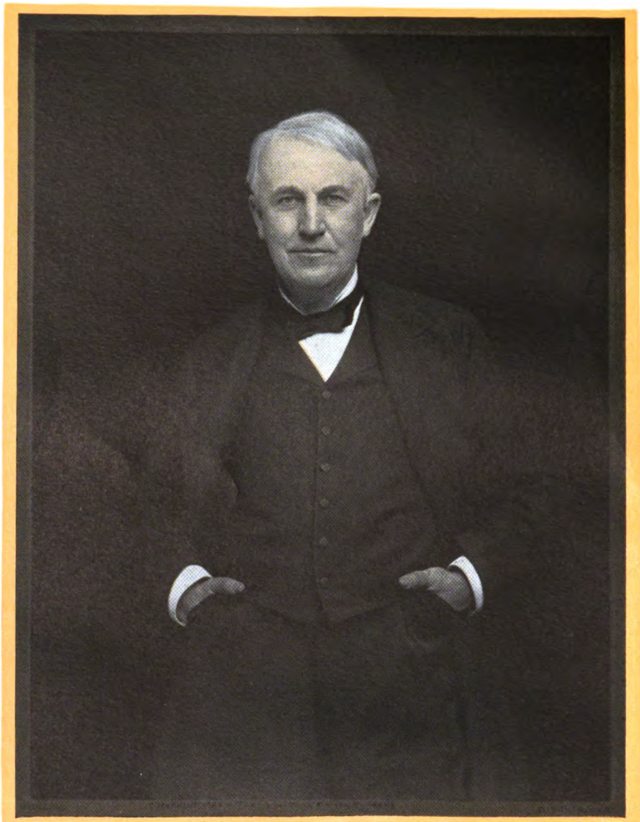
of the early

Edison Electric Lighting System

Compiled and Published
Under the Auspices of the Committee on St. Louis Exposition
of the
Association of Edison Illuminating
Companies

NEW YORK

1904



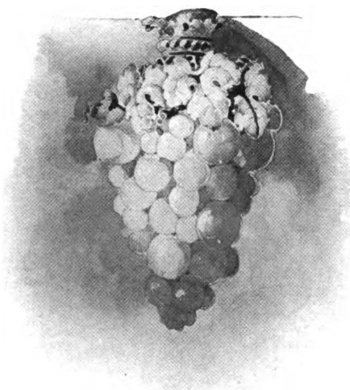
To the Association of

Edison Illuminating Companies

It gave me pleasure to learn that your Committee intended to bring together at the St Louis Exposition a collection of historical apparatus and documents illustrative of the early stages of the Edison electric lighting system. I was glad to co-operate in this work, and I congratulate you on the splendid exhibit you have collected, which should be instructive and inspiring to the young electrical engineer

Thomas A Edison

Orange. N.J. August 22 1904.



Prefatory Note

This volume, issued under the auspices of the Committee on St. Louis Exposition of the Association of Edison Illuminating Companies, is uniform in size and binding, and in general make-up similar to the series of Electrical Handbooks issued under the imprint of the American Institute of Electrical Engineers, in connection with the entertainment of the foreign visitors to the International Electrical Congress, St. Louis, September 12-17, 1904, and may well be considered as completing the series. It contains a series of views and descriptions of the important features of the valuable collection of "Edisonia" brought together by the Committee in the Exhibit of the Association at St. Louis, and a series of articles containing interesting historical matter in connection therewith. Much of the material in the Exhibit is of great historic value, and the Committee desires to express the hope that it may be possible to keep the collection together and find for it a permanent place, where its importance in the history of the art may receive proper appreciation by the engineering specialists and the public at large.

The Committee desires to record the great interest manifested in its work by Thomas A. Edison, and the loan by him of valuable historical exhibits; it is indebted for most efficient co-operation to J. C. Henderson, in charge of the installation and arrangement of the exhibits at St. Louis, and W. S. Andrews, in charge of the collection of the material; to The General Electric Company, W. J. Jenks, C. L. Clarke, W. J. Hammer, the Estate of Luther Stieringer, and others for the loan of valuable historical exhibits and assistance in their presentation; and to Miss Carmelita Beckwith for co-operation in the editing of the Handbook.

The Committee on St. Louis Exposition:

SAMUEL INSULL, Chairman;

CHAS L. EDGAR, J. W. LIEB, JR.,

THOS. E. MURRAY, JOS. B. MCCALL.

The Association of Edison Illuminating Companies:

JOS. B. MCCALL, President.

Electricity Building and Lagoon, St. Louis, 1904

CATALOGUE

OF THE

Principal Objects of Interest

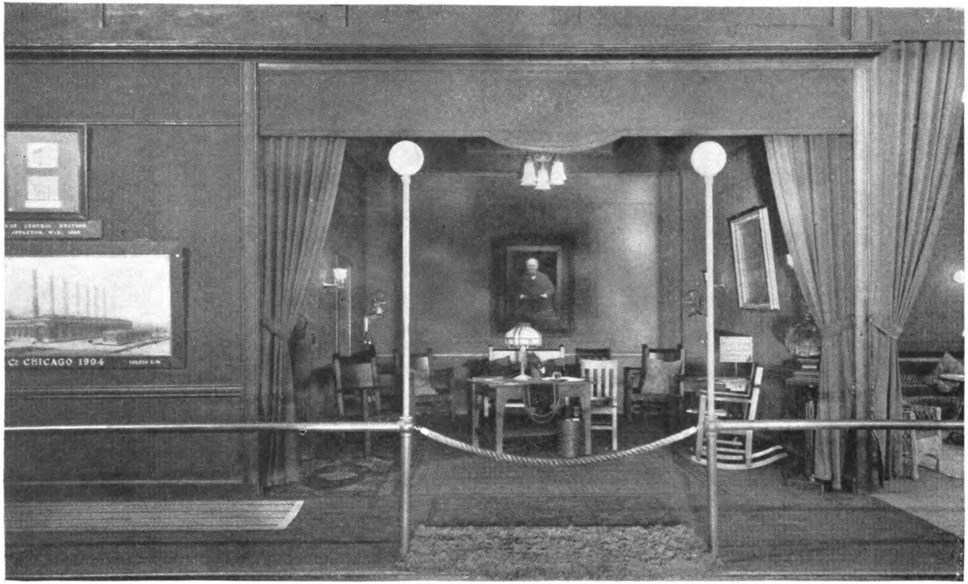
IN THE

"COLLECTION OF EDISONIA"

BY THE

Association of Edison Illuminating Companies

Blocks 26 and 27, Palace of Electricity
Louisiana Purchase Exposition
St. Louis, Mo.
1904



Official Headquarters of the Association of Edison Illuminating Companies

Errata

Page 11—*Reception Rooms*, second paragraph, third line, "Meeting of the Institute of Civil Engineers" should read *Meeting of the American Institute of Electrical Engineers.*

Page 13—Paragraph two, "Loaned by Mr. Thomas A. Edison" should read *loaned by Pratt Institute, and prepared for Exhibit by Mr. W. J. Hammer.*

Page 17—*Model of Pearl Street Central Station in New York City* (foot note)—"Made expressly for the Edison Historical Exhibit and loaned by The New York Edison Company," should read *Made Expressly for the Association of Edison Illuminating Companies for the exhibit of "Edisonia" and loaned by the Association.*

Page 20—List of photographs "Loaned by the Association of Edison Illuminating Companies" should read *Reproduced from Negatives and Photographs loaned by Mr. W. J. Jenks.*

Page 57—First paragraph should end with the sixth line erasing the words *many "B" as "A" lamps.*

Page 135—After the title "Early Edison Lighting Plants" add *by W. J. Jenks.*

"Collection of Edisonia"

THE collection of Edisonia by the Association of Edison Illuminating Companies occupies a floor space of about 3,000 square feet in Blocks 26 and 27, Section C, of the Palace of Electricity.

The headquarters of the Association are centrally located in Block 27, immediately opposite the exhibit of the General Electric Company.

RECEPTION ROOMS.

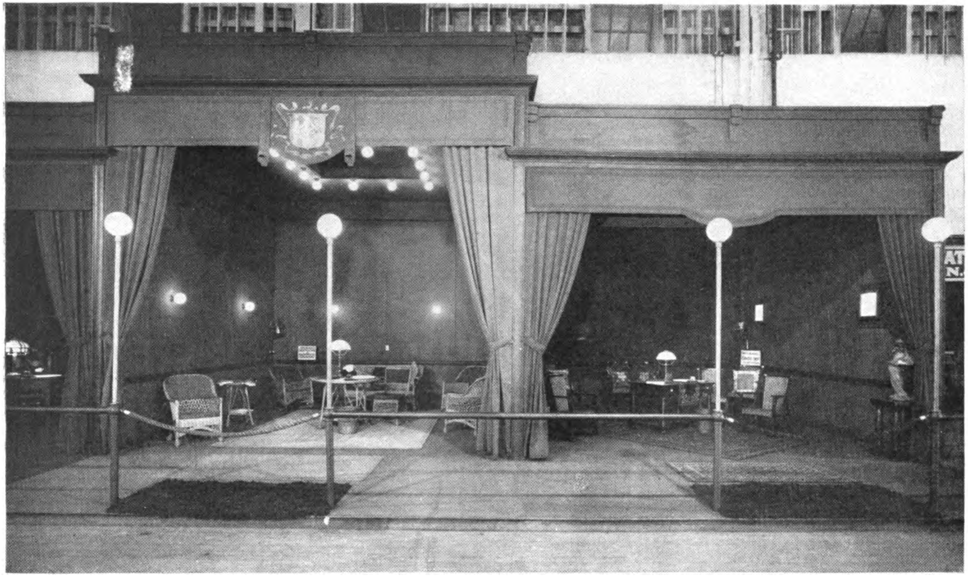
There is a reception room for the members, their families and guests of the Association, in connection with which is a ladies' retiring room and office, with telephone, writing materials, guest book, register, technical papers, and also competent assistants, who will supply visitors with information regarding the exhibits, etc.

In the reception room is the latest portrait of Mr. Thomas A. Edison, taken at the meeting of the Institute of Civil Engineers, when the "Edison Medal," to be awarded to authors of papers in the electrical field, was instituted. The photograph is an enlarged transparency on glass, 36 by 24 inches, and is not only the latest but the best of the "Wizard of Menlo Park."

There is also a very handsome bronze bust on a pedestal, of Mr. Edison, taken some years ago. This is kindly loaned by Mr. S. Insull.

An oil painting of the "Birthplace of Mr. Edison at Milan, Erie Co., Ohio," has been kindly loaned by Mr. W. J. Hammer.

Next and convenient to the above is the reception room of the American Institute of Electrical Engineers, as well as the reception room of the National Electric



Official Headquarters of the American Institute of Electrical Engineers and the National Electric Light Association

Light Association. The assistants will be constantly on hand to cater to any requirements of the members of the different associations, their families and guests. These rooms also are supplied with technical papers of the day, writing materials, guest books, registers, and assistants.

The lighting of the reception rooms is varied by being ordinary chandelier work in the Edison, individual snowball in the American Institute, and secondary diffused lighting in the National Association.

LIST OF THE PRINCIPAL OBJECTS OF INTEREST AT THE "COLLECTION OF EDISONIA."

1.—*Pioneer Installation.*

The first commercial Edison electric lighting plant was installed on the steamship Columbia, running between San Francisco and Portland, Ore. The dynamo exhibited is still in good operative condition, and is one of four machines that formed the pioneer installation for commercial electric lighting by incandescent lamps.

(Loaned by General Electric Company.)

2.—*Edison's First Electric Locomotive and Trailer.*

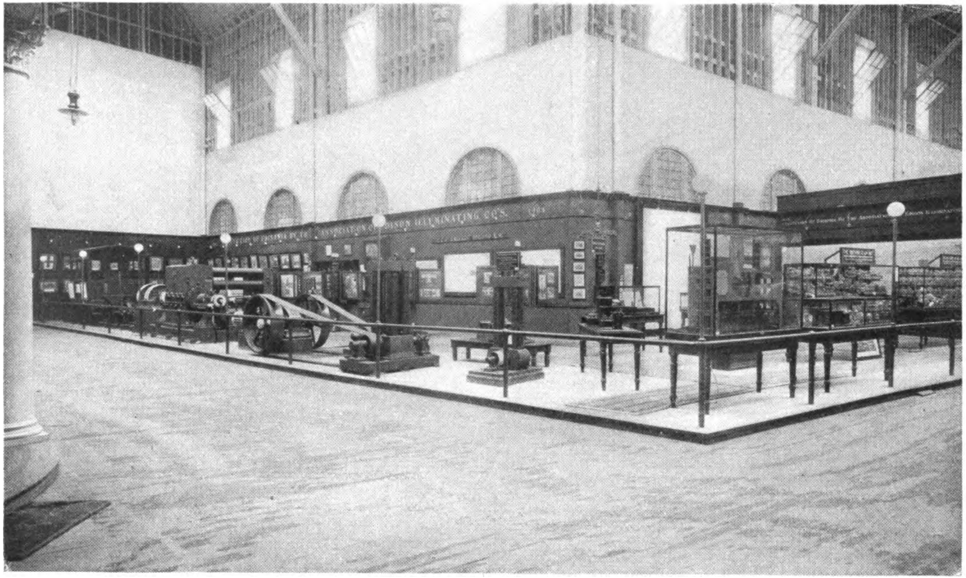
This machine was built and first operated at Menlo Park, New Jersey, May 13, 1880. Improved types of electric locomotives were afterward built and operated at the same place, one in 1881 and another in 1882.

(Loaned by Mr. Thomas A. Edison.)

3.—*The First Three-Wire Installation.*

Engine and dynamos and electrical measuring instruments used in Edison Electric Lighting Station, Sunbury, Pa., 1883.

(Loaned by the Edison Electric Illuminating Company of Sunbury, Pa.)



General view of the "Edisonia" Exhibit, Electricity Building

4.—*Edison First Direct-Connected Steam-Driven Electric Generator, "Jumbo."*

This dynamo is the first of all direct-connected, steam-driven electric generators, which to-day have attained enormous dimensions. The first "Jumbo" was exhibited at Paris, October 11, 1881, and twenty-four similar machines were commercially installed in London, New York, Milan, and Santiago.

The exhibit consists of generator and engine, the total weight of which is 30 tons.

(Loaned by the New York Edison Company.)

5.—*Original Underground Junction Boxes, etc.*

These junction boxes, with original tubes and connections for underground feeders and mains, are interesting illustrations of the early two-wire system, which was operated before Mr. Edison invented his famous three-wire system.

(Loaned by the New York Edison Company.)

6.—*First Electrolier Ever Made, with Original Incandescent Lamps.*

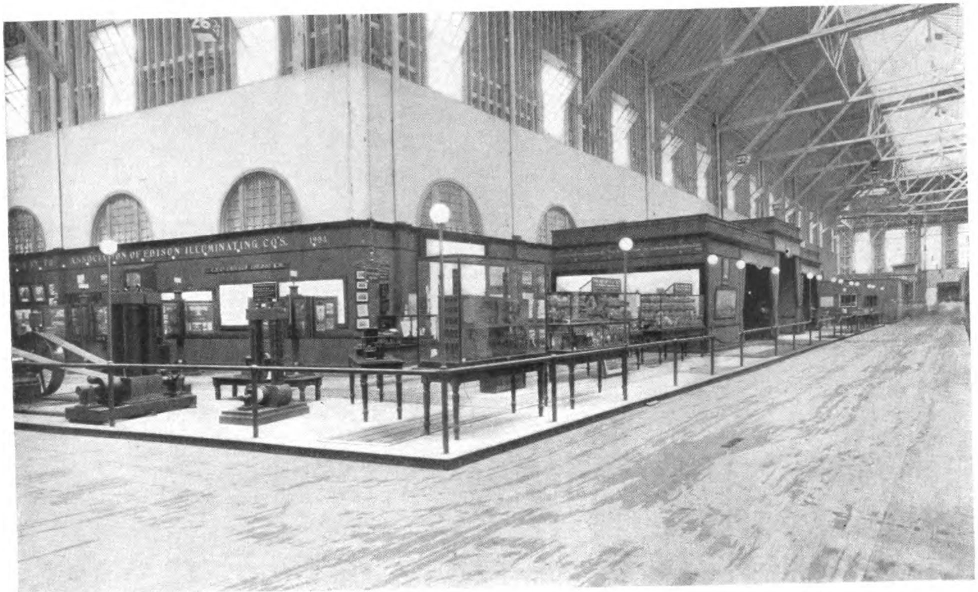
The first electrolier wired for incandescent electric lighting is an interesting relic of the early days of the commercial use of incandescent electric lamps.

It was wired and placed in service some time in 1880 at the residence of Mr. Francis R. Upton, at Menlo Park, near the laboratory where all of Mr. Edison's experimental work in connection with the incandescent lamp was done.

Great care was taken to distinguish the polarity of each conductor, the positive wires being of red and the negative wires of blue flexible cord.

The lamps were from the first placed in the inverted position which is now so familiar, but then so novel.

(This electrolier belongs to the estate of the late Luther Stieringer, and was secured for this exhibition by the courtesy of his executor.)



View of "Edisonia" Exhibit and Association Headquarters

7.—*Model of Pearl Street Central Station in New York City.*

This historical station was started on September 4, 1882. It supplied current to first district built for the Edison Electric Illuminating Company in New York.

In the lower portion of this model are shown the boilers, furnaces, coal conveyor, etc. The second floor contains six "Jumbo" generators, from which the current was supplied to customers through about eighteen miles of underground feeders and mains on the two-wire system.

(This model was made expressly for the Edison Historical Exhibit and loaned by the New York Edison Company.)

8.—*Collection of Electrical Antiques.*

The glass-fronted case against wall contains a collection of original Edison brackets, lamp sockets, and original underground conductors—two-wire and three-wire—first lamps with wooden bases, early key and keyless sockets, original switches, and original wooden cut-outs and wooden fuse plugs.

9.

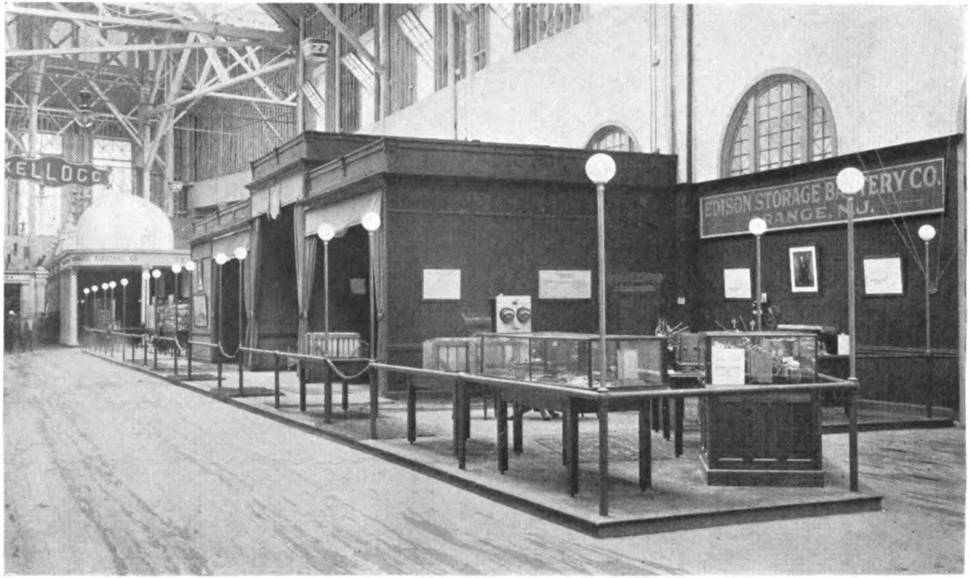
Similar case to above contains old style Edison lamps of from ¼ c. p. to 100 c. p.

(The above interesting collection of early electric lighting fixtures, etc., belongs to the estate of the late Luther Stieringer, and is exhibited by kind permission of his executor.)

10.—*Old Type Edison Chemical Meter.*

In this early type of meter, a German silver shunt, proportioned to the capacity of the meter, was used. The terminals of this shunt were connected to two amalgamated zinc plates immersed in a solution of zinc sulphate. When a current of electricity passed through the meter, the zinc was removed electrolytically from the positive to the negative plate, and the amount of current used was determined by the difference in weight of the positive plate before and after use.

(Loaned by the New York Edison Company.)



Edison Storage Battery Exhibit and Association Headquarters

11.—*Collection of Early Electrical Apparatus.*

First electric motor built by Mr. Edison at Menlo Park in 1879.

First electric meter made at Menlo Park in 1880.

Old style electric meter of the electrolytic type.

Another old style meter of same type.

Another old meter similar to the above.

Another old style of meter.

Old Deprez galvanometer that was used as a voltmeter.

Some early experimental incandescent lamps mounted in mahogany bases.

Models of two and three-wire electric underground Kruesi tubings.

(Loaned by Mr. Thomas A. Edison from his private laboratory.)

12.—*Old Style Edison Automatic Voltage Regulator.*

This voltage regulator was used for automatically maintaining constant voltage at the dynamo brushes, or at the center of electrical distribution.

It operated by varying the amount of external resistance in series with the field magnet of dynamo.

The first of these automatic regulators was set up and started at the Worumbo Mills, Maine, in 1882, by Mr. H. M. Byllesby, who had charge of the early Edison electric lighting plant there installed. The dynamo was operated by water power, and the regulator compensated for changes in speed as well as variations in load.

(Loaned by General Electric Company.)

13 and 14.

Standard glass cases containing manuscripts, data, original sketches, elementary designs, calculations, etc., connected with the introduction of incandescent electric light.

15

An original sketch made by Mr. Thos. A. Edison, and given by him to Mr. J. C. Henderson for the primary installation on the steamship Columbia, 1879.

16.—*Edison Disc Dynamo.*

This unique machine was designed and built by Mr. Thos. A. Edison at Menlo Park, N. J., in 1881.

The usual drum winding over a cylindrical core is rearranged in the form of a disc, thus reducing the usual air gap between the field-poles, and dispensing with the iron core.

(Loaned by Mr. Thomas A. Edison.)

LIST OF PHOTOGRAPHS, ETC.

This list comprises thirty-two bromide photographs in handsome oak frames 32 by 36 inches, which were made expressly for the collection of Edisonia.

(Loaned by the Association of Edison Illuminating Companies.)

Letter from Mr. Edison to Lord Kelvin, accompanying set of bound volumes of Filament Lamp Litigation in the United States.

Lord Kelvin's reply to Mr. Edison's letter accompanying Filament Lamp Record.

First Edison (C) "Jumbo" steam dynamo.

Typical Edison meter room in Kansas station in 1887.

Early Edison factory at Seventeenth Street and Avenue B, New York, for construction of electroliers, switches, meters, cut-outs, and other electric appliances. The top floor of this factory was used for several years as a laboratory by Mr. Edison.

Office of Edison Electric Light Company, 65 Fifth Avenue, New York City, in 1881.

Boarding house, Menlo Park, occupied by Edison employees 1879-1882.

Edison Machine Works at Goerck Street, New York City, in 1881.

Original electric locomotive, canopy car and "Pullman" on Edison Electric Railway, Menlo Park, New Jersey. Started in May, 1880.

First photograph taken by incandescent lamps. Taken at Edison's Laboratory at Menlo Park, February, 1880.

Interior of first Edison lighting station, Pearl Street, New York City, started September 4, 1882, showing the dynamo room, the regulator, and test battery of 1,000 lamps.

Interior of Edison's Laboratory at Menlo Park, showing four of Mr. Edison's assistants.

Entrance to the Menlo Park Laboratory, with group of Mr. Edison and assistants.

Home of Mr. Edison at Menlo Park, where he lived at the time he invented the incandescent electric light, October, 1879.

The Edison Laboratory at Menlo Park, where Mr. Edison invented the incandescent electric lamp, and made many other of his greatest discoveries.

Mr. Edison and a group of his assistants in Laboratory at Menlo Park. Taken February 22, 1880.

Old style Edison bi-polar "K" dynamo, 1881. Capacity 250 16 c. p. lamps.

Old style Edison polar "Z" dynamo. Capacity 60 16 c. p. lamps.

Electric generating plant of S. S. Columbia. Started about May 1, 1880. This was the first commercial installation of incandescent lighting.

Interior of Edison station at Burlington, N. J., showing 1,200-volt municipal generators.

Interior of the Edison station at Shamokin, Pa. Started August, 1885.

Interior of the Edison station at Shamokin, Pa. Started August, 1883.

Interior of the old Edison Boston station.

Interior of old Edison Boston station, showing engine and dynamo.

Interior of Brockton, Mass., Edison station. Started October 1, 1883, by Mr. Edison in person.

Exterior of Brockton, Mass., Edison station. First three-wire plant having underground conductors. Built by Edison Construction Company, and started October 1, 1883.

Interior of Edison station at Hutchinson, Kansas, showing typical old-time switch-board.

Original Edison lamp factory at Menlo Park occupied from October 1, 1880, to May 1, 1882, when the business was removed to Harrison, N. J.

First Central station. Appleton, Wis., 1880.

Interior of first Edison station at Adams Street, Chicago, showing original type of feeder equalizers, 1886.

Original three-wire switch-board in Adams Street station of the Chicago Edison Company. Installed in 1887.

Thomas A. Edison. Taken June 25, 1881.

Old style Edison bi-polar "L" dynamo, 1881. Capacity 125 16 c. p. lamps.

INTERESTING PHOTOGRAPHS.

(Loaned by Mr. Alick G. MacAndrew.)

Twelve photographs showing scenes and machinery at Mr. Edison's Ore Milling Works at Ogdensburg.

Seven photographs showing departments in Edison's Laboratory and group of assistants.

Photographs of Mr. Edison at 14 and present day; corner of library, exterior view of his residence and of his laboratory.

Group of Mr. Edison and some of his assistants.

Reproductions from photographs of materials used by Mr. Edison in his early incandescent lamp filament experiments, 1881.

Seven photographs showing early electric railway experiments at Menlo Park.

Facsimile of the Albert Medal awarded to Mr. T. A. Edison by the Society of Arts, London, and photographic reproduction of the letters from the Prince of Wales and the British Minister transmitting same.

Photograph of Mr. Edison, age 6, with his sister.

Photograph of Certificate from the Edison Electric Light Company, Edison Company for Isolated Lighting, and Edison Electric Illuminating Company to Mr. Thomas A. Edison, signed by the officers, trustees, and directors of the three companies.

Photograph of newspaper cutting from the *New York Daily Tribune* of Sunday, August 18, 1889, regarding Mr. Edison's work, entitled, "An American Abroad."

Photograph of newspaper cutting from the *Evening Sun* of Thursday, January 24, 1889, entitled, "New Millions for Edison."

Group taken in front of Laboratory, Menlo Park, in 1880, with Mr. Edison and his assistants.

General view of Menlo Park, 1881.

Photograph of original order for incandescent lamps.

Mrs. Jordan's boarding-house at Menlo Park, where Mr. Edison lived in 1880.

Mr. Edison at the age of 6.

Mr. Edison's first lamp.

First executive officer of Edison Electric Light Co.

First lamp factory in which lamps covered by first order were made.

Small diagrammatical illustrations showing early inventions of Mr. Edison.

DIAGRAMS, DRAWINGS, ETC.
COMMONWEALTH ELECTRIC COMPANY, CHICAGO, ILL.
FISK STREET STATION.

Designed by Sargent & Lundy, Engineers, Chicago.

Cross section of station, on line A. B.

Cross section of boilers.

Longitudinal section through boiler room looking west.

Ground plan of Fisk Street station.

General arrangement plan.

Architectural elevation of the Fisk Street station, Chicago, Ill. Commonwealth Electric Company, 1904. Capacity 100,000 k. w.

A photograph transparency of the latest steam electric generator, being the Curtiss Vertical Steam Two-stage Turbine Electric Generator, carrying high superheated steam, exhausting into a vacuum with surface condensation, and all the newest auxiliary improvements up to the present time. Normal capacity, 5,000 k. w.; actual capacity, 7,500 k. w. This shows right behind its first prototype "Jumbo."

THE EDISON ELECTRIC ILLUMINATING COMPANY, OF NEW YORK.

Cross section of Twenty-sixth Street station.

Cross section of Pearl Street station.

Map showing original underground system of Pearl Street station.

Map of the present underground system in New York.

Map of the Bronx District.

HISTORICAL COLLECTION OF INCANDESCENT ELECTRIC LAMPS.

"THE HISTORY OF AN ART."

This remarkable collection which is now shown for the first time in complete form, is exhibited by Mr. William J. Hammer, Consulting Electrical Engineer of New York City, at the special request of Mr. Edison and the Association of Edison Illuminating Companies and is elsewhere described by Mr. Hammer in an article which he has prepared especially for this publication.

EDISON'S FIRST ELECTRIC LOCOMOTIVE AND TRAILER.

The electric locomotive and passenger car, popularly known as the "Pullman," constituted part of the train of cars employed on Mr. Edison's first electric railway, operated at Menlo Park, New Jersey, in 1880 and 1881.

The entire train consisted of the electric locomotive, as shown, a platform car used for carrying rails, ties, sand, etc., used in the construction of the road, a platform or observation car carrying two park seats back to back, with a canopy over it, the passenger car or "Pullman," as shown, and for a time another passenger car built by John Stevenson & Sons, was also used, making a locomotive and four cars in the entire train. This equipment carried over 5,000 passengers at Menlo Park in 1880 and 1881, and attained a speed in actual test of 42 miles an hour. The wheels on each side of the train are insulated from one another, the current passing out one rail and back the other, the rails being practically extensions of the conductors leading from the dynamo machines. The field magnet of the motor on the electric locomotive has a fine shunt winding and also a coarse wire winding in series with the armature, this constituting the first instance of combined winding. The lamp used in the headlight shown on the electric locomotive is the first lamp used on the locomotive in Menlo Park.

With very slight repair the electric locomotive could be run to-day on any road in the country, provided the tracks were insulated from each other.

It is interesting to note that the "Pullman" passenger car has an electric brake attached to each axle of the car, and is exactly as installed in 1880. The road was first operated on May 13, 1880. This road was about a mile in length. In 1882-3, a second road was built and operated at Menlo Park which was three miles in length, and embodied certain improvements in construction, two other electric locomotives and various passenger cars, freight cars, etc., were built for its equipment.

STANDARD LIBRARY BUREAU FRAMES.

Containing photographs of buildings and other interesting items connected with—

The New York Edison Company.

The Edison Electric Illuminating Company of Boston.

The Chicago Edison and Commonwealth Electric Companies of Chicago.

The Philadelphia Electric Company.

The Edison Electric Illuminating Company of Brooklyn.

The Topeka Edison Company, the Toledo Edison Company, and miscellaneous photographs.

THE THREE ILLUMINANTS OF THE WESTERN HEMISPHERE.

As distinguished from any others of the Old World.

The oolakan or candlefish of the Northwest Indians.

The kerosene lamp of Abraham Gesner.

The incandescent electric lamp of Thos. A. Edison.

From time immemorial the Indians of the Northwest caught and dried the oolakan or candlefish, and used them as lamps stuck into a lump of clay, or carried them around in the fork of a stick.

In 1846 Abraham Gesner, of Prince Edwards Island, invented the kerosene lamp, using coal oil for the first time.

In 1880, Thomas Alva Edison perfected his invention of the incandescent electric light.

All other forms of illuminants, from the pine torch, the oil lamp, the candle or gas itself, came from the old world.

The three American lights are also peculiar in the fact that one is a product of the ocean, the second the product of the earth, and the last, the product of power.

Edison "Jumbo" Steam-Dynamo

An Historical Review by CHARLES L. CLARKE, Laboratory Assistant at Menlo Park, 1880-1; Chief Engineer of The Edison Electric Light Co., 1881-4.*

IN 1878, Mr. Thomas A. Edison, at his experimental laboratory, at Menlo Park, N. J., where he had already invented the carbon telephone transmitter and phonograph, undertook the task of devising a general system for the generation, distribution, and utilization of electricity for lighting and power purposes that should be as universally capable of useful and economical application to lighting as gas. The problem before him was popularly known as the "subdivision of the electric light." Many unsuccessful efforts had been made to arrive at a practical solution of the problem, which only seemed to support the contention by several eminent scientists that nature's laws stood in the way of its accomplishment.

Early in the progress of his efforts to solve this problem, Mr. Edison arrived at certain conclusions as to the distinctively characteristic features that the principal elements of a general system of electric lighting should possess, and proceeded to give them the tangible operative form in which to-day they continue to survive in the world-wide application of electricity to lighting by incandescent lamps.

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*The material for this outline history of the Edison "Jumbo" Steam-Dynamo has been gathered from numerous sources. Patents, technical journals, bulletins, catalogues, old blue prints of working drawings, and note-books have been searched for data, and supplemented by the recollections of many of those who, including the writer, were identified with Mr. Edison's develcpment of the system of incandescent electric lighting. An effort has been made to present from the data obtained an accurate statement of the progress of the development of the "Jumbo" steam-dynamos, their general features of construction and capabilities, and other matters of special interest in regard to them, which, although not in every respect agreeing with some of the accounts that have been published in technical journals, are believed to be substantially correct.

Almost at the outset he decided that the lamps should be connected in multiple arc with the current-supply mains, so as to be controllable independently of one another; that a constant potential should be maintained upon the mains, and thus the total amount of current supplied be determined by, and proportional to, the number of lamps in use; that the lamps individually should be of high resistance, permitting the operation of many lamps in multiple arc without requiring supply-mains of too large size and cost; and that the dynamos at the generating station should be arranged in series for potential, and these series connected in multiple arc with the mains for quantity (U. S. Patent 227,228, filed February 3, 1879; British Patent 5,306, December 28, 1878).

The first marked accomplishment in operative details was a lamp with a platinum wire burner of high resistance, protected by a high vacuum in an all-glass globe, and with the leading-in wires sealed into the glass by fusion. Such a lamp necessarily had a small illuminating power compared with that of the arc light, which was the only electric light then in commercial use. (U. S. Patent 227,229, filed April 21, 1879.)

Mr. Edison was seeking a small lamp with an illuminating power equal to that of an ordinary gas burner. He dwelt upon the importance of high resistance lamps in order that many lamps could be operated in multiple arc with supply-mains of moderate size, and without great loss of energy in the latter by their resistance. He preferred that the lamps should have the then comparatively very high resistance of 100 ohms when incandescent. The generators were to be connected in multiple arc with the supply-mains. (French Patent 130,910, May 28, 1879.)

In June, 1879, was published the account of the Edison dynamo-electric machine that survived in the art. This machine went into extensive commercial use, and was notable for its very massive and powerful field-magnets and armature of extremely low resistance as compared with the combined external resistance of the supply-mains and lamps. By means of the large masses of iron in the field-magnets, and closely fitted joints between the several parts thereof, the magnetic resistance (reluctance) of the iron parts of the magnetic circuit was reduced to a minimum, and the required magnetization effected with the maximum economy. At the same time Mr. Edison announced the commercial necessity of having the armature of the dynamo of low resistance, as compared with the external resistance, in order that a large percentage of the electrical energy developed should be utilized in the lamps, and only a small percentage lost in the armature, albeit this procedure reduced the total generating capacity of the machine. He also proposed to make the resistance of the supply-mains small, as compared with the combined resistance of the lamps in multiple arc, in order to still further increase the percentage of energy utilized in the lamps. And likewise to this end the combined resistance of the generator armatures in multiple arc was kept relatively small by adjusting the number of generators operating in multiple at any time to the number of lamps then in use. The field-magnet circuits of the dynamos were connected in multiple with a separate energizing source; and the field-current, and strength of field, were regulated to maintain the required amount of electro-motive force upon the supply-mains under all conditions of load from the maximum to the minimum number of lamps in use, and to keep the electro-motive force of all machines alike (British Patent 2,402, June 17, 1879).

The distinguishing characteristics of the Edison dynamo just referred to were also described in an illustrated article published in the Scientific American, October 18, 1879, Vol. XLI., p. 242, in which the powerful field-magnet was considered, and the advantage of making the armature with a resistance relatively low to the resistance of the lamp circuit was compared with the uneconomical prior practice of having the armature resistance equal to the external resistance. Although Mr.

Edison had proposed to have the generators self-exciting, he appears to have still preferred to excite them by current from a separate machine.

It was in this machine that mica was used as the insulating medium in commutators for the first time, supplanting the far inferior vulcanized fibre for that purpose.

The next great step in the development of Mr. Edison's electric lighting system was taken on October 21, 1879, when he discovered that if a carbonized cotton thread were substituted as a burner for the platinum wire of his earlier lamp, and protected in the same way by a high vacuum in an all-glass vessel, with the leading-in wires sealed into the glass by fusion, the slender and apparently frail carbon was mechanically strong, and also durable under the action of the electric current, so that the combination made a lasting lamp of small illuminating power, and possessing the feature of high resistance essential for operating a large number of lamps in multiple arc. (Edison filament suit—The Edison Electric Light Company vs. The United States Electric Lighting Company, printed record, Vol. IV., pp. 2,557-9 and 2,592-4, Edison's testimony.)

This discovery was embodied in the lamp described in U. S. Patent 223,898, filed November 4, 1879, and issued January 27, 1880, in the claims of which the fine, wire-like carbon burner was given the now still universally used name of "carbon filament." Various improvements have since been made in the material for, and method of making, the carbon filament, but the incandescent lamps everywhere in use to-day are like the lamp described and claimed in Patent 223,898 in all essential respects.

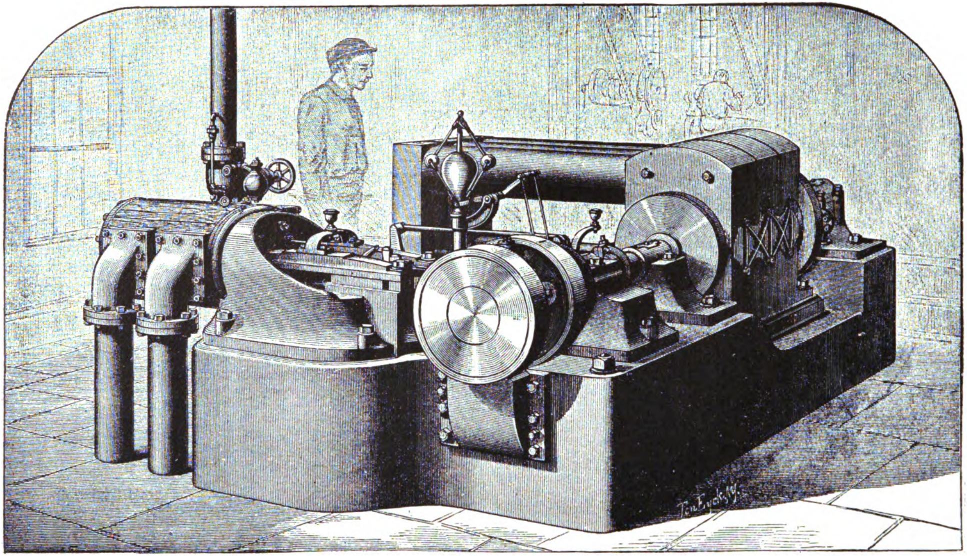
The announcement of the invention of the carbon filament lamp was first made to the public in an article published in the New York Herald, December 21, 1879, along with a description of other details of Mr. Edison's system, and was followed by an illustrated article, indorsed by Mr. Edison, and published in Scribner's Monthly Magazine, February, 1880.

A comprehensive description of the elements of Mr. Edison's constant-potential, multiple-arc system of generating, distributing, and utilizing electricity for light and power, as thus far developed, and their operation, and the statement of their advantages, was embodied in a patent application filed February 5, 1880, which did not issue, however, as Patent No. 369,280, until August 30, 1887.

Soon after the invention of the carbon filament lamp, Mr. Edison desired to test the commercial practicability of his lighting system, as thus far perfected. And to this end, in the summer, fall, and winter of 1880-1, he installed and operated a system, at Menlo Park, on a sufficiently large scale to light the houses and streets, and also the laboratory, machine shop, and other buildings of his establishment, for which 425 sixteen candle-power lamps were employed. The average resistance of the lamps was 110 ohms, and the electro-motive force varied from 95 volts for lamps at the outer ends of the supply-conductor to 110 volts for lamps near the generator. The current was supplied through underground conductors.

The current for the lamps was generated by ten eight-horsepower dynamos, the fields of which were connected in series and excited by a separate similar dynamo. These machines were driven by an engine of the slow-speed type, which were then in universal use for stationary power purposes, through a complicated system of counter-shafting.

It was found that a considerable percentage of the power of the engine was necessarily wasted in friction by this method of driving, and to prevent this waste, and thus increase the economy of his system, Mr. Edison conceived the idea of substituting a single large dynamo for the several small dynamos, and directly coupling it with the driving engine, and at the same time preserve the requisite high armature speed by using



Edison Menlo Park Steam-Dynamo

an engine of the high-speed type. He also expected to realize still further gains in economy from the use of a large dynamo in place of several small machines by a more than correspondingly lower armature resistance, less energy for magnetizing the field, and for other minor reasons. To the same end, he intended to supply steam to the engine under a much higher boiler pressure than was customary in stationary engine driving at that time.

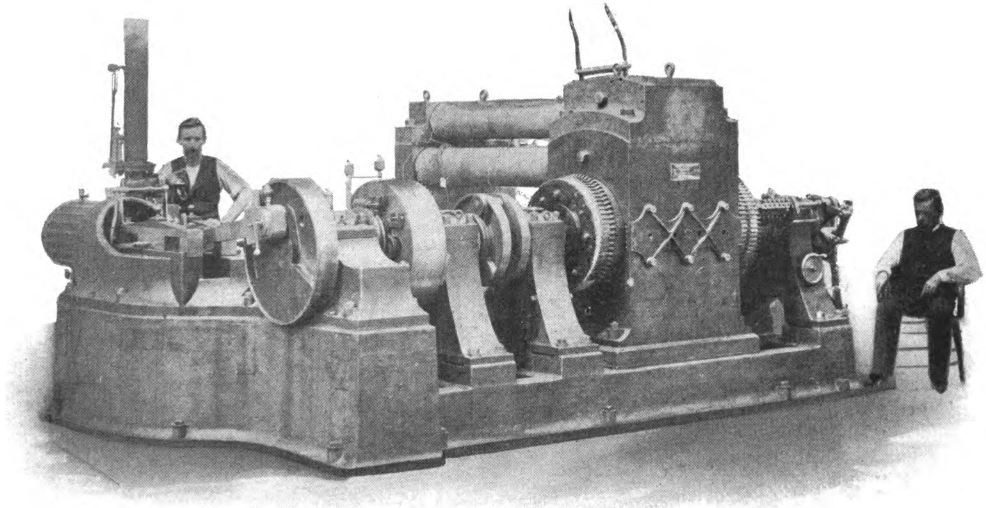
EDISON'S MENLO PARK STEAM DYNAMO.

Late in 1880, Mr. Edison began to reduce these conceptions to practice, and built at Menlo Park a large dynamo, which was direct-connected with a Porter-Allen engine, constructed at the Southwark Foundry and Machine Works, Philadelphia, and designed to run at 600 revolutions per minute. The dynamo and engine were mounted upon the same cast iron bed-plate, so as to form a self-contained generating unit.

A massive field-magnet for economically producing a very powerful magnetic field, and an armature of extremely low resistance for obtaining a small ratio of internal generator-resistance to the external resistance of the full load of lamps in multiple arc, which characterized the earlier Edison dynamo, described in British Patent 2,402 of 1879, and in Vol. XLI. of the Scientific American, were prominent features in this steam dynamo.

The field magnet had six cores, 42½ inches long and 7½ inches in diameter, each wound with 1,860 turns, in six layers, of No. 12 B.W.G. insulated copper wire, and having a resistance of 3.825 ohms. The laminated armature core of thin iron disks was mounted on a 4½-inch shaft, and had an internal diameter of 10 inches, an external diameter of 19.46 inches, and a length of 28 inches. The field poles were 28 inches long, and 20½ inches inside diameter.

The resistance of the armature was reduced to the lowest practicable amount by adopting the bar-method



Edison "Jumbo" Steam-Dynamo No. 1

of winding, in which 138 copper bars on the face of the armature and copper radial and circular end-pieces for connecting the bars into a closed-coil winding, arranged substantially as described in Patent 242,898, were used instead of coils of copper wire. The commutator had 69 sections.

The armature bars and connecting end-pieces were insulated from one another by mica, cemented together into blocks and strips, which completely filled the intervening spaces.

Tests of this machine made early in 1881, developed radical defects in the armature construction. The resistance of the end-pieces was unavoidably proportionately high owing to the character of the construction, and, as the circular pieces covered the radial pieces, the heat was prevented from freely escaping, which unduly raised the temperature and very greatly limited the current-carrying capacity of the armature. It was also clearly demonstrated that a rate of engine speed too high for continuously safe and economical operation had been chosen. And the machine was laid aside.

An accurate illustration of this machine, as it stood in the engine room at Menlo Park, is given in Van Nostrand's Engineering Magazine, Vol. XXV., December, 1881, opposite page 439, with brief description on page 450; also on page 142 of Prescott's book on Dynamo Electricity, published in New York, 1884, wherein, however, it is incorrectly referred to as an illustration of the Edison steam dynamo that was exhibited at the Paris Exposition in 1881. A brief description and somewhat inaccurate illustration of the Menlo Park machine were published in the Scientific American, Vol. XLIV., pp. 47-48, January 22, 1881, and reproduced in La Lumière Electrique, Vol. V., p. 89, October 15, 1881.

EDISON'S "JUMBO" STEAM DYNAMO, NO. 1.

With the experience thus gained, Mr. Edison began, in the spring of 1881, at the Edison Machine Works, Goerck street, New York City, the construction of the first successful direct-connected steam dynamo, which was far greater in size and capacity than any machines made up to that time, and the prototype of the colossal, direct-connected, steam-driven electric generators in use throughout the world to-day. Many discouraging obstables were encountered in the perfecting of this machine, and much experimentation was required to overcome them, so that it was not until early in the fall that the machine was ready for practical use.

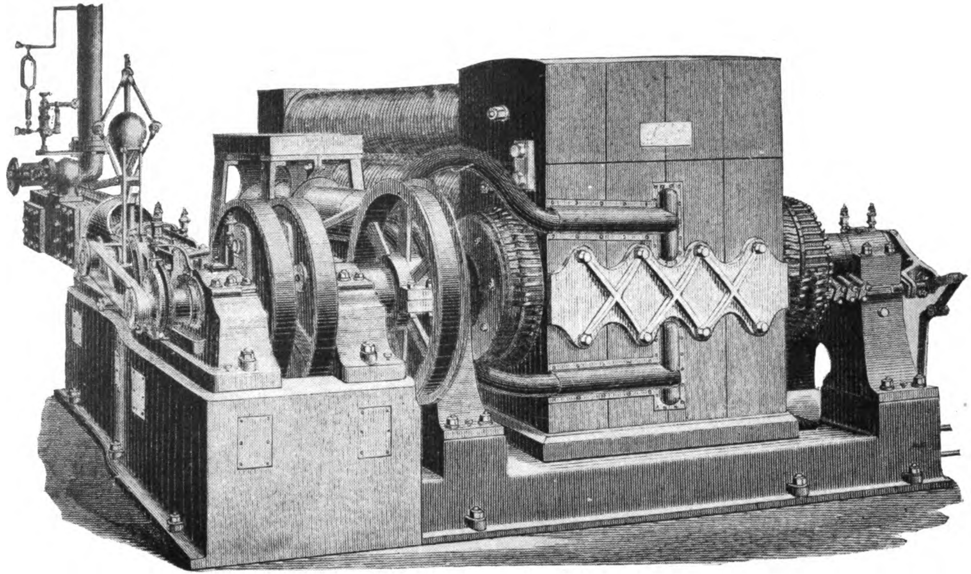
It was then sent to the Paris International Electrical Exposition, and exhibited there in operation from the last of October, 1881, until the Exposition closed. It was then set up for a time at the factory of the Société Industrielle et Commerciale Edison, at Ivry sur Seine, and eventually installed in the lamp factory of M. de Khotinsky, at Rotterdam.

The appearance of the Edison steam dynamo at the Paris Exposition was hailed by scientists and engineers from all lands as a most noteworthy event. It was considered a marvel of perfect electrical and mechanical construction, and nothing but words of praise and commendation on account of its great size, large capacity, and perfection of operation, were heard. Illustrated descriptions of "Jumbo" No. 1 were published in the technical journals of the time, of which may be mentioned: Scientific American, Vol. XLV., p. 367, December 10, 1881; Engineering, London, Vol. XXXII., pp. 409 and 419, October 21, 1881; The Telegraphic Journal and Electrical Review, London, Vol. IX., pp. 431-433; 436-446, November 5, 1881; La Nature, Paris, 9th year, Part 2, pp. 408-409, November 19, 1881 (rear view); Zeitschrift für Angewandte Elektricitätslehre, Munich and Leipzig, Vol. IV., No. 1, 1882, pp. 4-14. 1882; and Dredge's Electric Illumination, Vol. I., p. 261, 1882.

The bar-method of armature winding, as described in Patent 242,898, was also applied in this machine, with the additional improvement of using thick copper disks for connecting the bars at their ends into a closed-coil winding, as described in Patent 263,146, excepting that the bars were disposed upon the face of the armature in a single layer, and not in two layers. Further improvements in armature construction that were incorporated in the Paris dynamo, such as enlarged ends on the armature bars to reduce the resistance and local heating at their junction with the projecting lugs of the connecting disks, gold-plating the enlarged ends, lugs, and their fastening screws to still further reduce the resistance and heating, and to keep the contact surfaces from oxidation, and thus preserve the electrical contact unimpaired, and an insulating wrapping of japanned parchment paper on each bar, are described in Patent 264,647. To prevent the accumulation of heat in the massive armature, and the reduction in capacity of the machine that would result therefrom, a current of air was circulated by a blower through air spaces, which completely surrounded the individual armature bars, as described in Patent 263,133.

The field-magnet of the Paris machine had eight solid cylindrical cores, 8 inches in diameter and 57 inches long, upon each of which was wound an exciting coil of 3.2 ohms resistance, consisting of 2,184 turns of No. 10 B. W. G. insulated copper wire, disposed in six layers.

The laminated iron core of the armature, formed of thin iron disks, was 33¾ inches long, and had an internal diameter of 12½ inches, and an external diameter of 26 7/16 inches. It was mounted on a 6-inch shaft. The field poles were 33¾ inches long, and 27½ inches inside diameter. The armature winding consisted of 146 copper bars on the face of the core, connected into a closed-coil winding by means of 73 copper disks at each end of the core. The cross-sectional area of each bar was 0.2 square inch; their average length was 42.7 inches, and the copper end-disks were 0.065 inch thick. The commutator had 73 sections. The armature resistance was 0.0092 ohm, of which 0.0055 ohm was in the armature bars and 0.0037 ohm in the end-disks.



Edison "Jumbo" Steam-Dynamo, No. 2

With the armature cooled by an air blast from a blower, with which the machine was provided, it was capable of continuously delivering a current of about 500 amperes under an electric-motive force of 103 volts, and had a capacity equal to about 700 of the 16 candle-power lamps that Mr. Edison was then commercially manufacturing, which on the average required about 0.7 ampere, and had an economy of 4.5 watts per candle. At the Paris Exposition the machine operated about 500 lamps without the necessity of using the air blast. The generator was driven at 350 revolutions per minute (which was the speed at which all later Edison steam dynamos were also run) by a high-speed engine built by Armington & Sims, at Lawrence, Mass.

EDISON "JUMBO" STEAM DYNAMO, NO. 2.

The construction of a still larger steam dynamo, after the general plan of "Jumbo" No. 1, was begun immediately after the latter had been finished and tested. It was completed late in 1881, and dubbed the "Jumbo" (Electrical World and Engineer, Vol. XLII., p. 452, March 5, 1904), a name which, on account of its appropriateness at the time, was accepted in the electrical art, and thereafter commonly used to designate this type of Edison machine, including the Paris machine. The dynamo was driven by a Porter-Allen engine of 125 nominal horsepower and 200 maximum horsepower at 350 revolutions and 120 pounds boiler pressure. The "Jumbo" No. 2 was illustrated and described in Engineering, Vol. XXXIII., pp. 226-227, March 10, 1882; Dredge's Electric Illumination, Vol. I., p. 266, 1886; The Electrician, London, Vol. VIII., p. 202, Feb. 11, 1882; and illustrated in rear view in Vol. IX., p. 201, July 15, 1882.

The field-magnet had 12 cores, 57 inches long and 8 inches in diameter, each wound with a coil of 1,456 turns, in four layers, of No. 10 B.W.G. copper wire, and having a resistance of 2.0375 ohms. The field poles were 45 inches long, and 28 1-16 inches inside diameter. The armature, mounted on a 6-inch shaft, had a laminated core 12½ inches internal diameter, 26 7/16 inches external diameter, and 42½ inches long. The armature winding consisted of 106 bars on the armature face, and the same number of connecting end-disks. The bars had an average length of 53.95 inches, and a cross-sectional area of 0.3395 square inch. The end-disks were 0.102 inch thick. The armature resistance was 0.0049 ohm, of which 0.00284 ohm was in the armature bars, and 0.00206 ohm in the end-disks. The commutator had 53 sections.

The capacity of the machine, with the armature cooled by air blast, was about 1,000 sixteen candlepower lamps, requiring approximately 103 volts, and 0.7 ampere, at normal incandescence.

Upon completion the machine was shipped to London, and installed in the central station of the Edison Electric Light Company, at 57 Holborn Viaduct.

EDISON "JUMBO" STEAM DYNAMO, NO. 3.

A still further increase in size and capacity was made in the next "Jumbo" dynamo, which was driven by an engine of 125 nominal horsepower and 200 maximum horsepower, built by the Armington & Sims Engine Company, Providence, Rhode Island.

The field-magnet had 12 cores, 57 inches long, of which the four in the top row were 8 inches and the other eight were 9 inches in diameter. They were wound with four layers of No. 10 B.W.G. copper wire. The resistance of the coils on each of the 8-inch cores was 2.055 ohms, and on the 9-inch cores 2.26 ohms. The field poles were 49 inches long and 28¼ inches inside diameter. The armature, mounted on a 7½-inch shaft, had a core 12½ inches inside diameter, 26 7/16 outside diameter, and 46½ inches long. The armature winding consisted of 98 copper bars on the armature-face, and the same number of connecting copper end-disks. The bars had an average length of 55¼ inches, and were 0.721 inch wide on their top face, 0.69 inch wide on their bottom face, and 0.484 inch deep. The end-disks were 0.102 inch thick. The armature resistance was 0.0039 ohm, of which 0.00267 ohm was in the armature bars, and 0.00123 ohm in the end-disks.

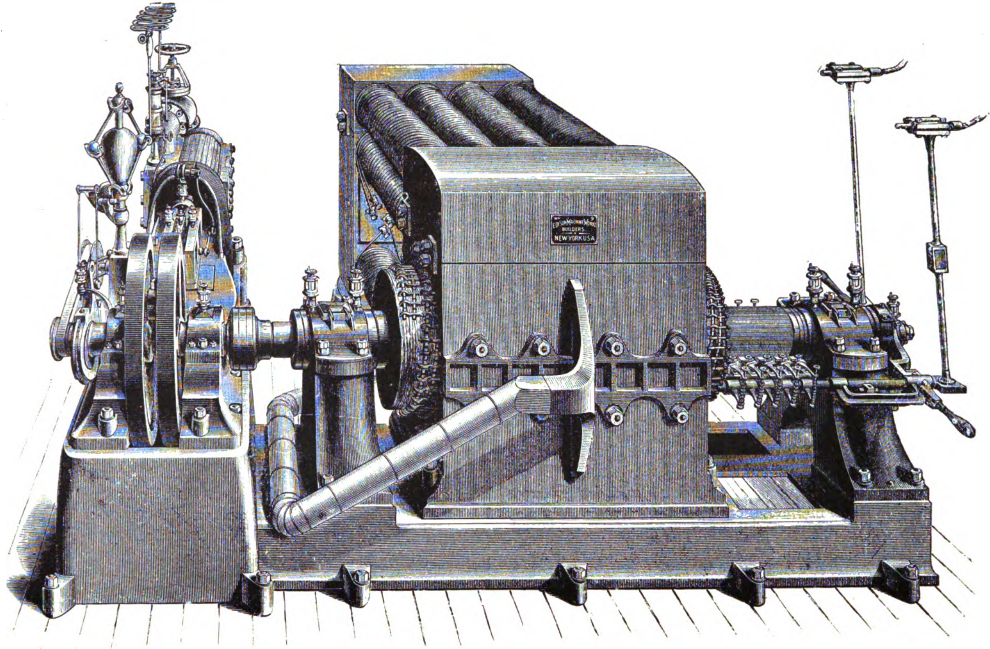
The maximum capacity of the machine, with the armature cooled by air blast, was about 1,200 lamps of 16 candlepower.

This machine was also shipped to London, and installed in the Holborn Viaduct station.

"JUMBO" NO. 4, AND SUBSEQUENT "JUMBOS."

The "Jumbo," No. 4, and subsequent "Jumbo" generators, were constructed substantially like the "Jumbo," No. 3, practically the only changes made being to increase the diameter of the armature shaft to 7¾ inches, and wind the field-magnet cores with No. 12 B.W.G. wire. The resistance of the coil on each of the four 8-inch cores was about 2.8 ohms, and on the eight 9-inch cores, 3.1 ohms. The coils were customarily connected in four multiples of three coils in series, giving a total field-magnet resistance averaging about 2.25 ohms.

The capacity of the machine when cooled with air blast was about 850 amperes under about 115 to 120 volts electro-motive force at the machine terminals, or practically a capacity to operate 1,200 103-volt lamps, with extra voltage capacity to compensate for drop of electro-motive force in the conductors between the machine and lamps. Some of these "Jumbos" were driven by Porter-Allen engines, but the greater number were driven by Armington & Sims engines. An illustration of the machine, with the Porter-Allen engine, was published in the American Machinist, Vol. V., pp. 1-3, July 1, 1882, in connection with a paper by T. A. Edison and Charles T. Porter, entitled, "Description of the Edison Steam Dynamo," read at Philadelphia April 20, 1882, before the American Society of Mechanical Engineers. Babbitt metal was used throughout in the bearings of the dynamo and engine. This instance of its use in heavy,



Edison "Jumbo" Steam-Dynamo, No. 9, with Porter-Allen Engine high-speed machinery in place of bronze, which had been hitherto employed in such cases, was a matter of much interest to engineers, as evidenced by the discussion following the reading of the paper. See Trans. Amer. Soc. Mech. Engineers, Vol. III., pp. 225-228. An illustration of the machine ("Jumbo," No. 9, with Porter-Allen engine, which was the first machine to operate commercially at the Pearl street station, New York City), showing the construction in greater detail was published in Engineering, Vol. XXXVI., p. 192, August 31, 1883; Dredge's Electric Illumination, Vol. II., opposite p. 340; and in Prescott's work on Dynamo-Electricity, 1884, opposite p. 202. See also Handbuch der Elektrotechnik, by Kittler, Vol. I., Stuttgart, 1886, pp. 597-600. An illustration of the machine with the Armington & Sims engine was published in the drawings of Patent 281,351; and also indicated in the machine shown in the foreground in the illustration of the Edison station at Milan, Italy, published in the Scientific American Supplement, Vol. XVII., p. 7,008, May 31, 1884.

The weight of the "Jumbo," as finally developed, was given in the Tenth Bulletin of the Edison Electric Light Company, New York, June 5, 1882, as follows:

Cast iron bed-plate	10,337	pounds
Zinc bases for field-magnets	677	"
Cast iron, field-magnet, pole-pieces	16,372	"
Wrought iron, field-magnet cores	6,044	"
Wrought iron, field-magnet keepers	6,300	"
Pillow-blocks for armature and engine shafts	671	"
Brush-holder arm	125	"
Armature	13,310	"
Engine	6,500	"
Total weight	60,336	pounds

The complete machine, therefore, had a weight of somewhat over 30 short tons.

"JUMBOS" IN EDISON HOLBORN VIADUCT CENTRAL STATION, LONDON.

As before stated, "Jumbos," Nos. 2 and 3, were shipped to London and installed at 57 Holborn Viaduct. The Edison Electric Light Co., of New York, equipped the premises with an exhibition central station plant, primarily for the purpose of demonstrating abroad the practicability of the Edison electric light system, and promoting its commercial introduction. Later the plant was taken over by The Edison Electric Light Company, Limited, London; and finally by the Edison and Swan United Electric Light Company, Limited.

The "Jumbo," No. 2, was first started at Holborn Viaduct, January 12, 1882, and later the "Jumbo," No. 3. On April 8, 1882, the two machines were successfully operated in multiple arc upon a lamp circuit. The electro-motive force of the dynamos was regulated independently of the speed of the automatically governed engines by adjustably-variable resistance in the field-magnet circuits, which were connected in multiple arc with the main conductors from the armatures to the lamps.

This was the first time that steam dynamos, respectively driven by engines independently controlled by automatically-variable, cut-off valves, had been operated together upon the same circuit, and was a practical realization of the method of operating an electric light and power system with independent and automatically governed generating units, which Mr. Edison conceived in 1880, and which was followed by the construction of the Menlo Park steam dynamo, as the first step in the direction of obtaining such a unit in a commercially practical form. The advantages of using, as generating units, steam dynamos operated by independent, automatically controlled engines, and with their electro-motive forces regulable independently of the speed (an enumeration of which here is unnecessary), were fully set forth in Patent 281,351, and are the main controlling reasons for the use of steam dynamos in central stations to-day. This patent represents the consummation of Mr. Edison's inventions for the perfection of the steam dynamo, and may be properly termed his valedictory upon the "Jumbo."

The Holborn Viaduct station was started in practical operation on April 11, 1882, with about 1,000 incandescent lamps installed along Holborn Viaduct and in several buildings. The lamps were supplied with current by underground conductors.

Late in 1882 the capacity of the Holborn Viaduct plant was increased by the addition of a third "Jumbo," and eventually about 3,000 lamps were supplied with current from this station. About 1884, the plant having fulfilled the purpose for which it was installed, operation was discontinued, and the station dismantled. One or more of the machines was sold to the Italian Edison Company, and installed in the Santa Radegonda station at Milan. Unfortunately the published accounts of the Holborn Viaduct installation are few, and give but little account of details. For some mention of this plant see Engineering, Vol. XXXIII., p. 226, March 10; p. 380, April 14, 1882; Ninth Bulletin, The Edison Electric Light Company, New York, May 15, 1882, and Seventeenth Bulletin, April 6, 1883; The Electrician, London, Vol. VIII., pp. 368-369, April 22, 1882; Telegraphic Journal and Electrical Review, Vol. XI., p. 34, July 25, and p. 148, August 26, 1882; Electrical World and Engineer, Vol. XLII., p. 452, March 5, 1904; Electrical Review, New York, Vol. XV., No. 20, p. 4, January 11, 1890.

"JUMBOS" IN EDISON PEARL STREET CENTRAL STATION, NEW YORK.

In the fall of 1881 plans had been practically perfected by Mr. Edison for the installation on a large scale, for the Edison Electric Illuminating Company, New York City, of the first permanent commercial incandescent electric lighting and power system embodying the many main and accessory features of construction and operation that he had invented and laboriously perfected, and deemed essential to make electric lighting a successful competitor with the large gas lighting plants in cities.

The district selected for lighting was the area—nearly a square mile in extent—included between Wall, Nassau, Spruce and Ferry Streets, Peck Slip and the East River; and the property, 255 and 257 Pearl Street, was purchased as the site for the central station generating plant.

The laying of the underground system of conductors in the streets (which was a 2-wire, so-called "feeder-and-main," system, as described in U. S. Patent 264,642); the wiring of buildings for the lamps, and the work of constructing foundations, erecting the iron structure for supporting the generators on the second floor, setting up of the Babccck & Wilcox boilers and accessories in the building, 257 Pearl Street, preparatory to the installation of six "Jumbo" generators, were commenced in the fall of 1881, and were in an advanced stage of completion in April, 1882.

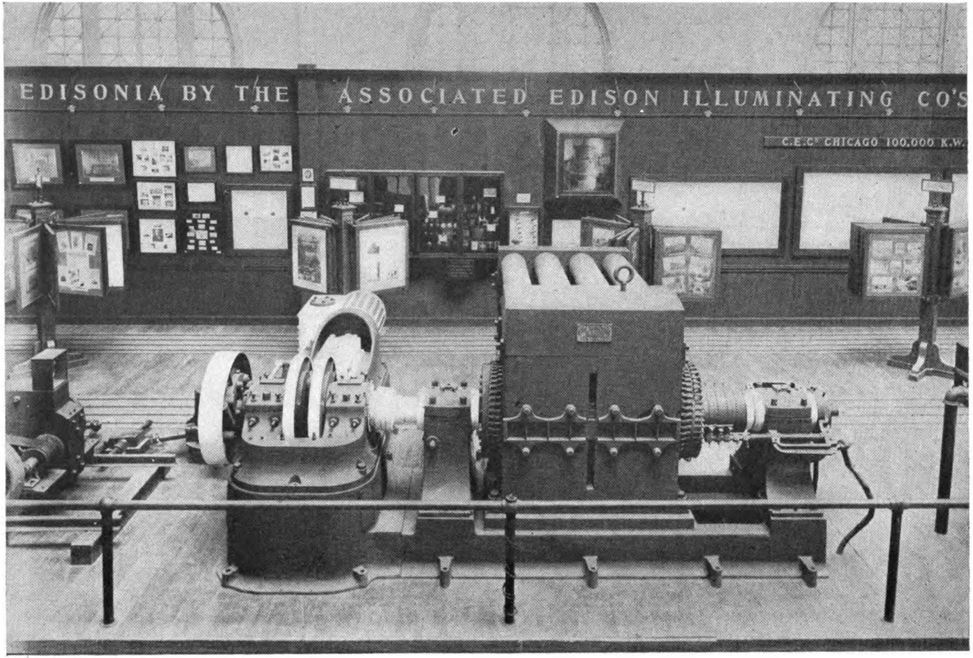
In July, the laying of the underground conductors, aggregating over 80,000 lineal feet of mains and feeders, was practically completed. The installation of the "Jumbos" (Nos. 6 to 9 inclusive, which were at first run by Porter-Allen engines) was completed in June. On June 29 fire was started under the boilers. On July 5 one of the "Jumbos" was started, and on July 8, it was tested upon a bank of 1,000 lamps located in the upper story of the station.

The station was started in commercial operation on Monday, September 4, 1882, at 3 P. M., with a load of about 400 lamps, supplied with current through the underground conductors by "Jumbo" No. 9. This machine was the one nearest to the Pearl Street front of the station. Among the customers first supplied with light was the firm of Drexel & Morgan, corner Broad and Nassau Streets, at the outermost limits of the system.

Everything operated so smoothly at the start that it seemed as if the long, hard labor of Mr. Edison was to be rewarded at once with complete success. But in a few minutes a serious trouble arose, which at first seemed fatal to his plans, and temporarily was very discouraging. After "Jumbo" No. 9 had been running a short time, a second machine was started and connected with the bus-bars in multiple arc with No. 9. 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 see-saw between standstill and a terrific rate of speed. The second machine was at once disconnected from the line and stopped. And for some time the station was operated with only one machine.

Dash-pots were applied to the governors with no practical success. Finally, Mr. Edison overcame the difficulty for the time being, and the machines were operated in multiple, by means of a complicated system of pivoted rods, levers and shafting, as described in patent 271,616, by which the governors of all the engines at any time in operation were mechanically connected together, so that the tendency of any governor to control its engine was communicated to the governors of all the other engines. The shafting was made light, and yet with comparatively great torsional rigidity, which was essential to prevent lost motion in the action of one governor upon another, by constructing it of tubing with a central rod, the tube and rod being first pinned together at one end, then twisted in opposite directions at the other end, and there pinned together in the twisted positions.

In November, 1882, two "Jumbos," driven by Armington & Sims engines, each controlled independently by its own governor, were successfully operated in multiple arc at the Edison Machine Works. And, as a result of this experiment, the Porter-Allen engines were removed from the Pearl Street Station, and Armington & Sims engines substituted in place of them, and the



Edison "Jumbo" Steam-Dynamo, No. 9, with Armington & Sims Engine necessity of tying the governors together was done away with.*

The excellency of the materials, design and workmanship in the machines were signally demonstrated by an endurance test made in the Pearl Street Station, where a "Jumbo," driven by an Armington & Sims engine, and in normal commercial operation, ran continuously day and night for seventeen days, from March 10, to 27, 1883. Inspection after the test showed not the slightest wear or need of readjustment in any part of the machine.

The number of lamps connected with the system, and customers supplied, gradually increased. On December 1, 1883, there were in use 10,297 lamps on the premises of 513 customers. The district was also extended, and toward the end of 1883 the underground system comprised about 95,000 lineal feet of mains and feeders. Electric motors were first connected with the system to furnish power on customers' premises in 1884.

Customers were not charged for lighting until the system was working smoothly and satisfactorily in every respect. The first bill for lighting, based upon the reading of the Edison electrolytic meter, with which the system was equipped, and amounting to $50.40, was col-

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*In the Holborn Viaduct Station the difficulty of "hunting" was not experienced. At the time the "Jumbos" were first operated in multiple arc, April 8, 1882, one machine was driven by a Porter-Allen engine, and the other by an Armington & Sims engine, and both machines were on a solid foundation. At the station at Milan, Italy, the first "Jumbos" operated in multiple arc were driven by Porter-Allen engines, and dash-pots were applied to the governors. These machines were also upon a solid foundation, and no trouble was experienced.

At the Pearl Street Station, however, the machines were supported upon long iron floor beams, and at the high speed of 350 revolutions per minute, considerable vertical vibration was given to the engines. And the writer is inclined to the opinion that this vibration, acting in the same direction as the action of gravitation, which was one of the two controlling forces in the operation of the Porter-Allen governor, was the primary cause of the "hunting." In the Armington & Sims engine the controlling forces in the operation of the governor were the centrifugal force of revolving weights and the opposing force of compressed springs, and neither the action of gravitation nor the vertical vibrations of the engine could have any sensible effect upon the governor.

lected, January 18, 1883, from the Ansonia Brass & Copper Company, 17 and 19 Cliff Street. During the month of November, 1883, a little over one year after the station was started, bills for lighting, amounting to $9,102.45, were collected.

In the spring of 1884, the capacity of the station was increased by installing two additional "Jumbos" in the basement of 255 Pearl Street.

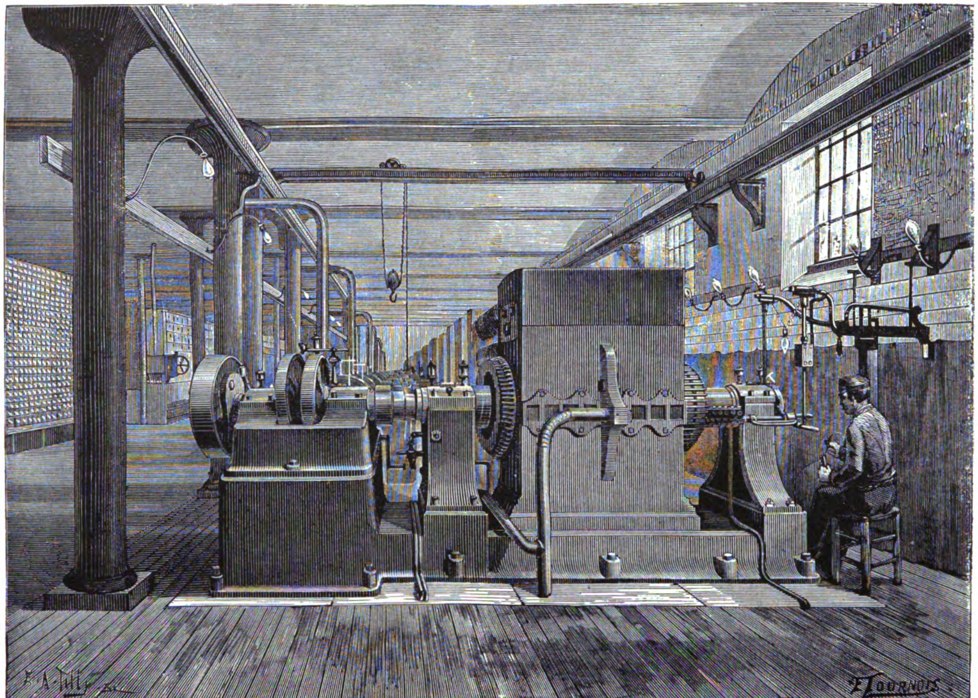
There was considerable sparking at the copper commutator brushes of the "Jumbo," due to the odd number of commutator bars, necessitated by the form of armature winding employed, and also to the comparatively small number of bars and the dissymmetrical disposition of the magnetic field with relation to the armature. In the early operation of the Pearl Street Station, which, it should be remembered, was before the days of carbon brushes, an effort was made to suppress the sparking and accompanying wear of brushes and cutting of the commutator surface, by a liberal application of mercury thereto, and with some success. But the sparking was nevertheless sufficient to fill the air with mercury fumes, which so badly salivated the attendants that the method had to be abandoned, and thereafter a careful adjustment of the brushes and attention to their condition and to the surface of the commutator were relied upon to minimize its harmful effects. The commutator bars were provided with copper plates, or shoes, as wearing surfaces, which could be readily replaced when worn out.

The Pearl Street Station continued in successful, commercial operation until Thursday morning, January 2, 1890, when it was partially destroyed by fire. All of the "Jumbos" were ruined, excepting No. 9, which, on account of its installation on a fire-proof floor and at the front of the building, was covered up and saved. The boilers were unharmed.

Belt-driven generators and engines were quickly installed, and the station was again in operation in a few days, and the uninjured "Jumbo" No. 9 again continued to perform its dutv. But the glory of the old Pearl Street Station, unique in bearing the impress of Mr. Edison's personality, and, as it were, constructed with his own hands, disappeared in the flame and smoke of that Thursday morning fire.

In 1893, "Jumbo" No. 9 was taken from the Pearl Street Station and sent to Chicago, where it was exhibited at the World's Columbian Exhibition. It was then returned to New York City and stored in the station of the Edison Electric Illuminating Company (now the New York Edison Company), on Duane Street, until the present year, when it was shipped to St. Louis, where it is now on exhibition at the Louisiana Purchase Exposition, among the collection of "Edisonia" exhibits, under the auspices of the Association of Edison Illuminating Companies. A "Jumbo" was also exhibited at the International Electrical Exhibition, in Philadelphia, in the fall of 1884.

An illustrated description of the Pearl Street Station was first published in the Scientific American, Vol. XLVII., pp. 127 and 130, August 26, 1882. Also see the Bulletins issued by the Edison Electric Light Company, from January 26, 1882, to April 9, 1884, Nos. 1-22; Electrical Review, New York, Vol. XV., No. 20, p. 4, January 11, 1890; "Mr. Edison's Reminiscences of the First Central Station," Electrical Review, Vol. XXXVIII., pp. 60-63, January 12, 1901; The Electrical Age, Vol. XXXII., February, 1904, pp. 71-79 (the cut on page 73 is an illustration of "Jumbo" No. 1, with a single-crank-disk Armington & Sims engine, which was at the Paris Exposition in 1881, and not, as stated in the article, an illustration of the later form of "Jumbo," that was driven by a double-crank-disk Armington & Sims engine); The Electrical Engineer, Vol. IX., p. 33, January, 1890, and Vol. XV., pp. 454-5, May 10, 1893; and Prescott's book on Dynamo-Electricity, New York, 1884, p. 195 et seq.



Edison "Jumbo" Steam-Dynamos in the Santa Radegonda Station, Milan

"JUMBOS" IN THE EDISON SANTA RADEGONDA STATION, MILAN.

A syndicate for controlling the Edison system in Italy was organized early in 1882, and an order for two "Jumbos" was placed in New York, in May. Later the concession was acquired by a company entitled La Società General Italiana di Elettricità, Sistema Edison. Orders for additional machines were given, and by August, three "Jumbos," equipped with Porter-Allen engines, had been shipped for installation in Milan, and the Theatre Santa Radegonda was purchased as a site for a central station (Tenth Bulletin, June 5, 1882; Thirteenth Bulletin, August 28, 1882, the Edison Electric Light Company, New York).

The work of demolishing the theatre and construction of the central station was begun about October, 1882, and on March 8, 1883 the first installation was complete and started in regular operation. Toward the end of June, 1883, four "Jumbos" (three with Porter-Allen engines, and one with an Armington & Sims engine) had been installed, and the station was in operation nightly, until 1 o'clock A. M., upon a load of about 1,000 lamps.

In August, 1883, two more "Jumbos," with Armington & Sims engines were added. And in November continuous service, night and day, was begun. By the end of December, 1884, the load upon the station had increased to 5,500 lamps, the equivalent of 4,700 lamps of 16 candlepower.

Eventually, four additional "Jumbos," with Armington & Sims engines, were installed, or ten "Jumbos" in all, and nearly 10,000 lamps were lighted from the Santa Radegonda Station. One or more of these machines was obtained from the Holborn Viaduct Station, London.

The system was operated continuously with the "Jumbo" generators for seventeen years, until February 9, 1900, when the machines were put out of service, and a converting and distributing plant was installed in their place, taking the high tension polyphase currents generated at the distant water-power plant at Paderno, and converting them into low tension direct currents for distribution on the Edison three-wire system in Milan.

For some account of the Edison station at Milan see: Scientific American Supplement, Vol. XVII., pp. 7008-9, May 31, 1884, in which, in the foreground of an illustration of the station, is shown a "Jumbo" driven by an Armington & Sims engine; La Lumière Electrique, Vol. XI., pp. 116-117, January 12, 1884; Vol. XII., pp. 12-17, April 5, 1884; Vol. XV., pp. 385-398, February 28, 1885; Vol. XIX., pp. 241-246, February 6, 1886; The Electrician, London, Vol. XI., p. 242, July 28, 1883.

EDISON "JUMBOS" AT SANTIAGO, CHILI.

No precise information as to the number of "Jumbos" that were installed by The Illuminating Company of the City of Santiago, Chili, has yet been obtained, but the probability is that two of these machines were at one time in use in the Santiago Central Station. The Twentieth Bulletin, Edison Electric Light Company, New York, October 31, 1883, page 37, announced that "The Santiago Central Station is now serving 98 consumers, wired for 2,500 sixteen-candle lamps, of which about 2,000 are in constant use. The current is sold through a meter, in the same way as the Pearl Street Station in New York City;" and on page 46: "The Central Station plant at Santiago, modelled on that of the First District in this city, is running with success. * * *" The current was supplied to the lamps through Edison underground conductors. No account of the Santiago plant appears to have been published in the electrical journals. Also see: La Lumière Electrique, Vol. XX., p. 479, June 5, 1886.

TOTAL NUMBER OF "JUMBOS" CONSTRUCTED.

All the "Jumbos" heretofore referred to were built by the Edison Machine Works, Goerck Street, New

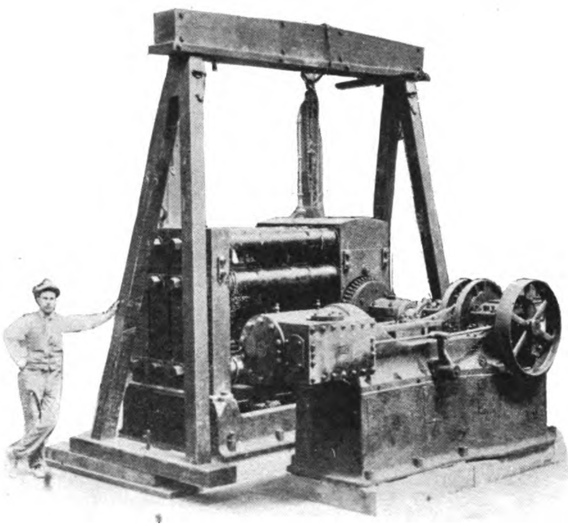
York City, and they were probably twenty-three in number, as follows: One at Paris Exposition, three at the Holborn Viaduct Station, eight in the Pearl Street Station, ten at Milan, of which one, at least, was obtained from Holborn Viaduct, and probably two at Santiago.*

"JUMBOS" IN THE PARIS OPERA HOUSE.

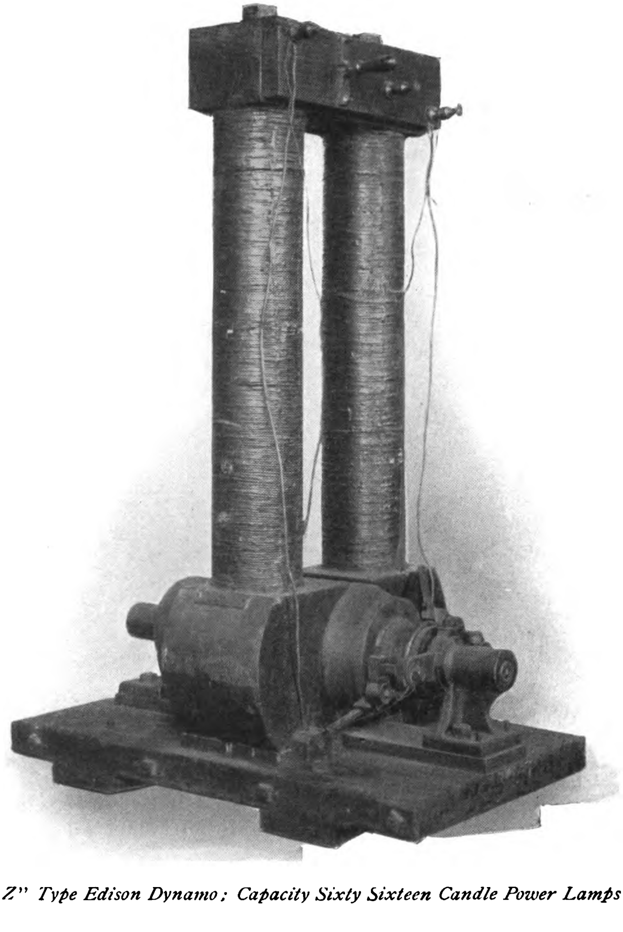
Two "Jumbos" were constructed in France, at the factory of the Société Industrielle et Commerciale Edison, Ivry sur Seine. These machines were installed in the basement of the Paris Opera House in 1884, and employed for a short time in the lighting of the stage and some parts of the house, after which they were dismantled.

New York City, May 19, 1904.

*That the whole number of "Jumbos" (the trade-name of which was the "C" dynamo) built by the Edison Machine Works was probably twenty-three, is in a measure substantiated by the fact that in the record of tests made at the works upon the "Jumbos," a copy of which is in possession of the writer, the highest number referred to is "C dynamo, No. 23."



Jumbo No. 9, at the World's Fair, Chicago, 1893



"Z" Type Edison Dynamo; Capacity Sixty Sixteen Candle Power Lamps

The Old Edison Type Dynamos

THE series of dynamos designed by T. A. Edison and built at Menlo Park and at the Edison Machine Works, Goerck Street, New York, comprised originally four types, the "E" 15 lights, "Z" 60 lights, "L" 150 lights, and "K" 250 lights, to which was added some years later a fifth, many "B" as "A" lamps.

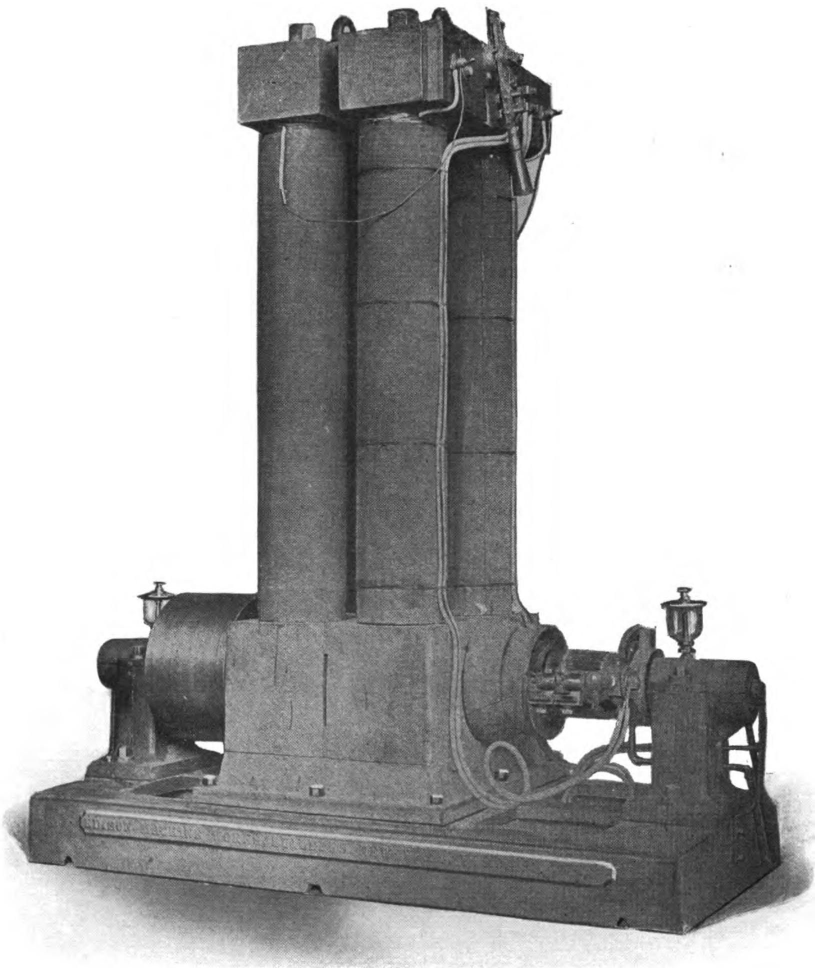
All of these types were built for "A" lamps, 16 candlepower, 110 volts, and some also for "B" lamps, 8 candlepower, 55 volts. Their capacity was twice as many "B" as "A" lamps.

These dynamos were of a characteristic form, with very long field magnets standing vertically. The cores were of wrought iron, and also the keeper, a massive pieced fastened to the two vertical limbs by large bolts.

In case of the "Z" 60-light dynamo, there were two vertical fields, in the case of "L" four and in the "K" six, as shown in the accompanying cuts.

The design and construction was of the simplest character, robust, and without pretense at machine finish or ornamentation of any kind. A number of these dynamos are still in service, without any changes, excepting renewal of the babbitt in the bearings and new brushes from time to time.

These dynamos had the following electrical constants:



"L" Type Edison Dynamo: Capacity One Hundred and Fifty Sixteen Candle Power Lamps

	Designation of Types				
	E	Z	L	K	H
Capacity 16 c.p. lamps, 110 volts at 75 amp......	15	60	150	250	450
Rev. per minute..........	2200	1200	800	900	1100
Length magnet core	17¼	42 13/16	42 13/16	42 13/16	25
Diameter magnet core...	4¾	6½	6½ 4Z mg'ts	6½ 6Z mg'ts	7
Total resistance of field .. ..ohms	—	40	20	13	12½
Size iron bedplate	24¾x17¼	29x44	29x62	29x60½	—
Weight of wire in arm....	6 lbs	23 lbs	—	75 lbs	—
Stand. resist. arm.—ohms	0.36	0.138	0.0175	0.032	0.015
No. of commutator bars .	24	74	54	64	44
Diameter pulley..	5⅛	10	—	14	—
Width pulley.............	3⅛	6½	—	9	—

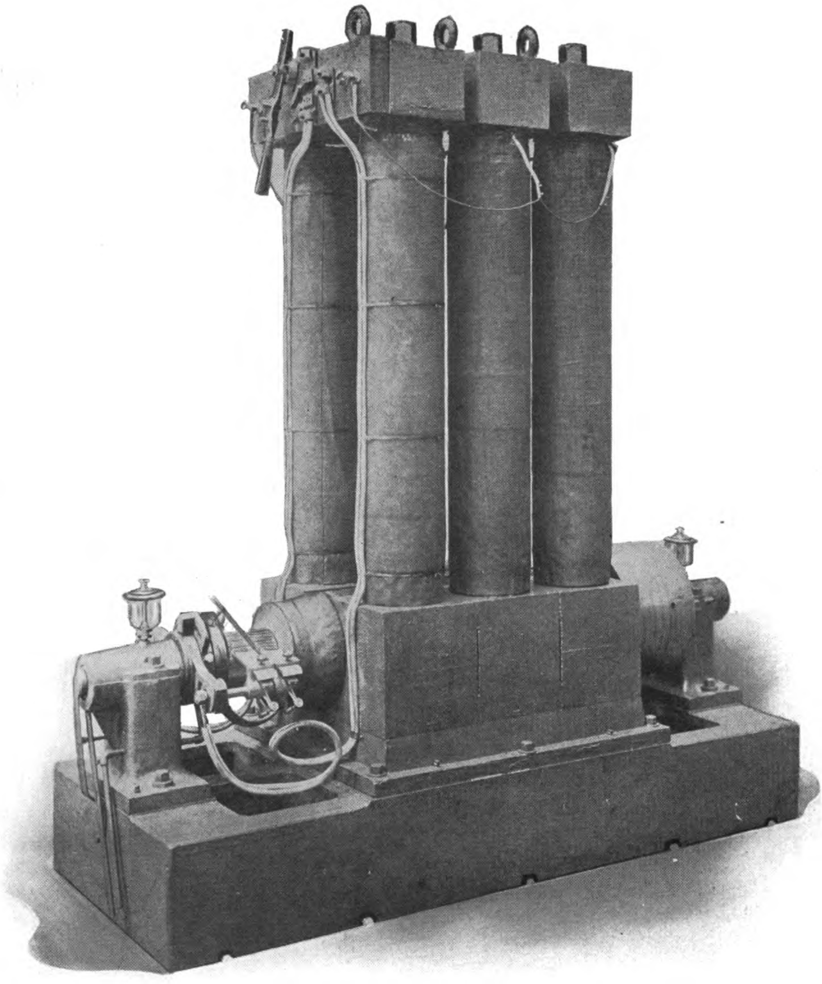
SOME SPECIMEN DYNAMO TESTS

(From an old notebook)

Number of Dynamo..	EA	EB	ZA	ZB	LA
Stamped on Machine.	24	13	283	209	—
Capacity.............	15A	30B	60A	120B	150A
Time Running.......	1 hr.	30 min.	1 hr.	1 hr	—
Arm. Resist..........	.344	.092	.145	.04	.071
Mag. Resist..........	93.35	23.5	40.2	9.9	20.61
Base with Arm	*V H	V H	V H	V H	V H
Base with Mag.	V H	V H	V H.	V H	V H
Speed................	2200	2200	1200	1160	900
Load..................	19A	61A 1B	75A	225A 1B	150A
Volts at Dynamo.....	113	56	108	52.23	106
Volts at Lamps.......	111	—	105	—	104
Lamp in photo	101	51	100	51	-
Candle power.	30	20	24	13	—

*Very high.

These dynamos were superseded by a series of "standard" Edison dynamos numbered serially: Nos. 1, 2, 3, 4, 5, 6, 8, 10, 12, 16, 20, 32 and 60, and which, while they are not manufactured to-day, many thousands of them are still in use and appreciated for their conservative rating, and even now they bring a good price as second-hand machines.



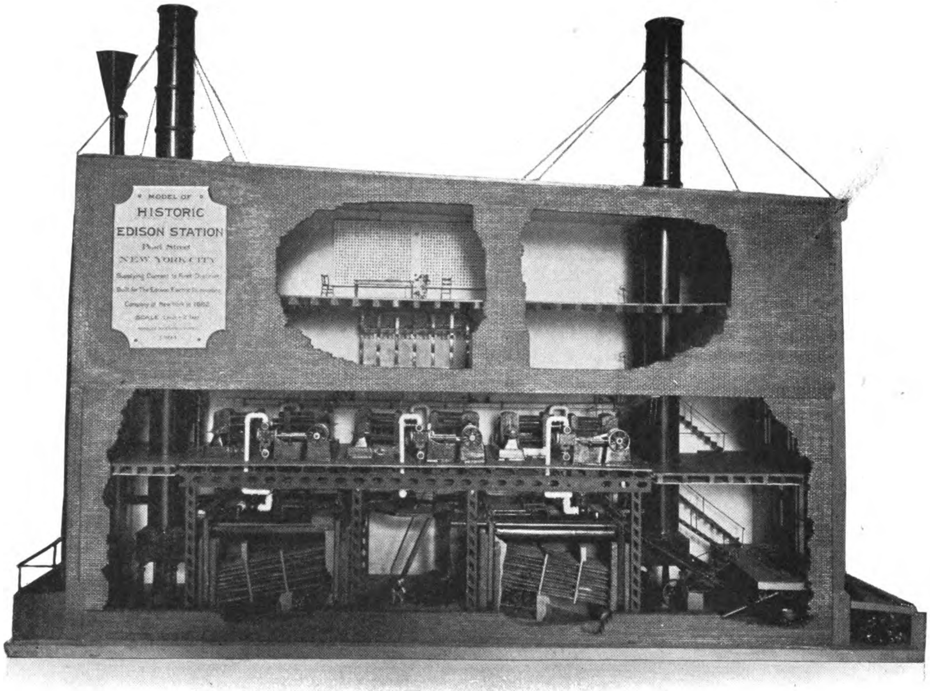
"K" Type Edison Dynamo: Capacity Two Hundred and Fifty Sixteen Candle Power Lamps

The Historic Pearl Street New York Edison Station

BY THE FIRST ELECTRICIAN OF THE STATION

THE property, 255-7 Pearl Street, New York City, occupied a lot 50x100 feet, and the building was four stories high, with a fire wall dividing it into equal parts, one of which was converted to the uses of the station, the remaining half occupied as a tube shop by the underground department, repair shops, storage, etc. The building was originally erected for commercial purposes, and as it was incapable of sustaining the weight of the engines and dynamos planned to be installed on the second floor, the old flooring was torn out, and a floor of heavy girders supported by stiff columns was substituted. This heavy construction, not unlike the supporting structure of the elevated railroad, was erected so as to be independent of the building walls, and occupied the full width of the building, 257 Pearl Street, and about three-quarters of its depth. This change in the internal arrangements, converting the building into an electric lighting station, did not in the least affect the external appearance.

A model, prepared especially for the collection of "Edisonia," exhibited under the auspices of the Association at St. Louis, showing the longitudinal section of the station and built on a scale of one inch equaling two feet, is shown in the photograph. This model was constructed from an original blue-print of the building plans of the station, bearing date of 1882, and reproduced in the following page exhibited at St. Louis, together with detail sketches prepared. This model was in accordance with the recollection of a number of those who were at one time connected with its construction and operation.



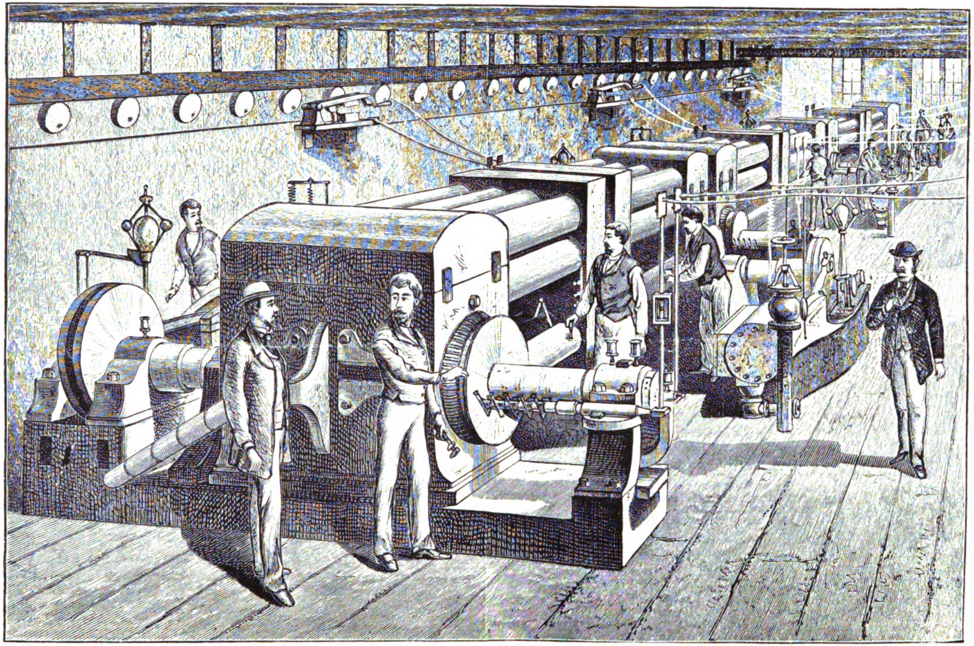
Model of the Pearl Street Station exhibited at St. Louis

The vault under the sidewalk and the basement in the front of the building were fitted out with the machines for the receipt of coal and the removal of ashes. An engine of 20 horsepower drove, by means of countershafting, the screw conveyor for carrying the coal up over the boilers, from whence it was dropped by gravity to the stoke-hole on the basement level between the boilers, and the screw conveyor for taking the ashes from beneath the grates and discharging them into a barrel under the sidewalk. The engine also operated a fan blower, delivering forced draught to the furnace and supplying air for ventilating the stoke-hole. A system of blast pipes was also provided for blowing air to the armatures of the dynamos, as shown in detail in the general view taken for the Scientific American of August 26, 1882.

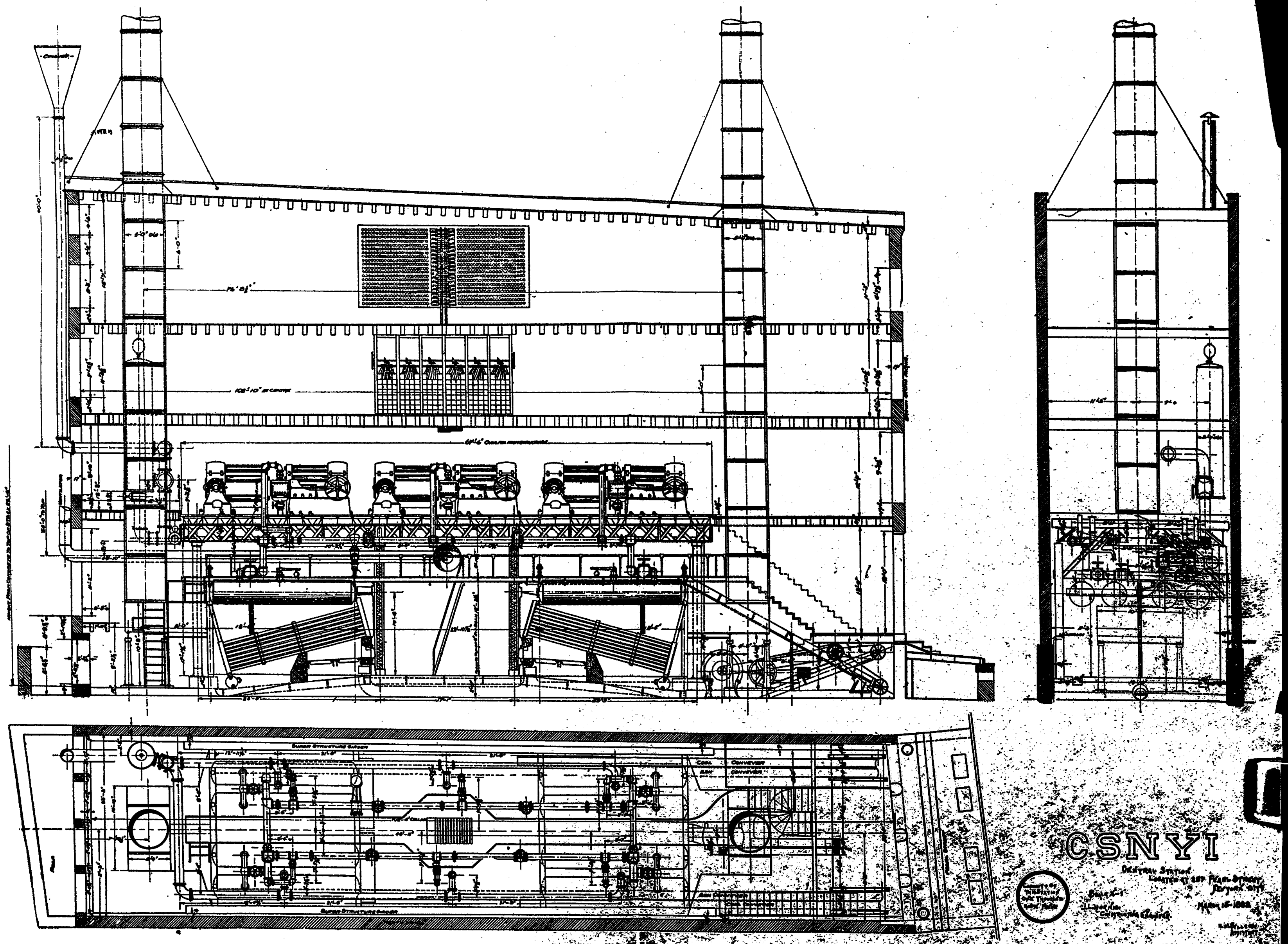
Four Babcock & Wilcox boilers, with a rating of 240 horsepower each, discharged their products of combustion into two steel stacks, one at each end of the building, and they supplied steam to the engines through an 8-inch header with 5-inch vertical branches. These boilers had cast iron headers, and as an evidence of the life of this class of apparatus it may be of interest to note that from the time this station was put into service, September 4, 1882, until March 31, 1894, they were in constant service at this station under very severe conditions; they were then removed and put into service at the 53d Street station, where they continued in regular service until May 22, 1902, nearly twenty years of practically continuous hard service.

A gallery extended over the boilers and gave access to the stoke-hole and the basement in the rear of the building, where a "Z" dynamo (60-light) was installed, which furnished light during construction, and from which the current was taken for the first tests of the underground systems.

The boilers were provided with injectors, supplemented by a steam pump, with connections to each



The Dynamo Room


CSNYI
Central Station
Located at 257 Pearl Street
New York City
March 15-1882

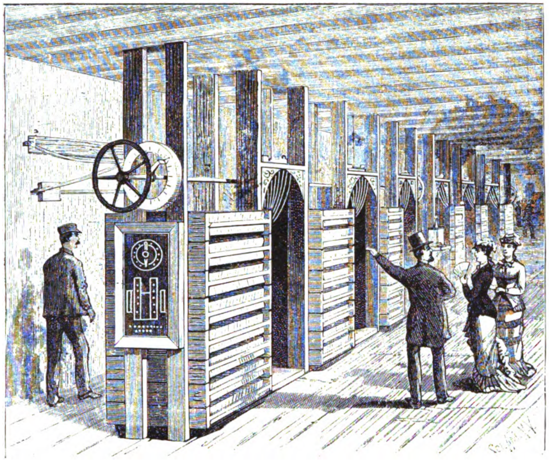
boiler, the water being previously passed through exhaust heaters located in the rear of the building, as shown in detail in the building plans.

The engines and dynamos were located on the iron structure previously described. The original equipment consisted of six Porter-Allen engines, each of 125 horsepower (nominal) with cylinders 11 $^{3}/_{16}$ by 16 inches, steam pressure 120 pounds, 350 revolutions per minute, giving a piston speed of 933 feet per minute. These engines weighed, approximately, 6,450 pounds each, or with dynamo and base-plate a total of 61,550 pounds each, and were subsequently replaced by an equal number of Armington & Sims engines, 14½ by 13 inches, at 350 revolutions per minute.

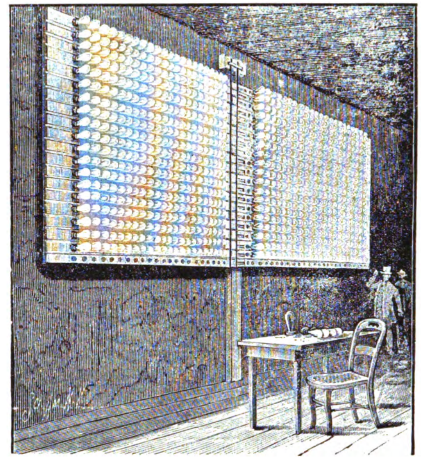
The six dynamos were of the Edison "Jumbo" type, each with a capacity of 1,200 "A," or 16 candlepower lamps of 110 volts and 75 amperes. These dynamos weighing, without base-plate, 44,800 pounds, or with engine and dynamo base-plate, 55,100 pounds each, are described in detail in another article. Suffice it to say here that they were referred to in the article written in 1882, mentioned above, as follows:

"The gigantic proportions of these machines will be appreciated by reference to our engraving, although one can scarcely realize the immense solidity and weight without personal inspection."

The dynamo room was provided with a traveling crane and hoists running the entire length of the building to facilitate installation and repairs. The engines were non-condensing and exhausted into the atmosphere through exhaust feed-water heaters. The engine dynamo units were arranged in lines parallel to the sides of the building, three units on each side, as shown in the illustration. The main bus bars of the station, made up of double half-round copper bars from No. 1 two-wire Edison tubes, were attached to the wall along the sides of the building, with a connection between them across the ceiling, and the dynamos were connected to them by flexible cables spanning the distance between the upright copper



THE REGULATOR.



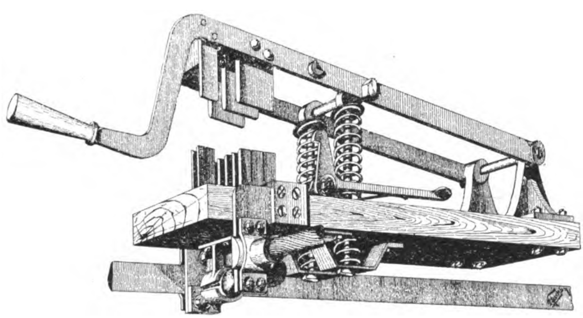
TEST BATTERY OF 1,000 LAMPS.

rods attached to the dynamo brush-holder arms and the wall.

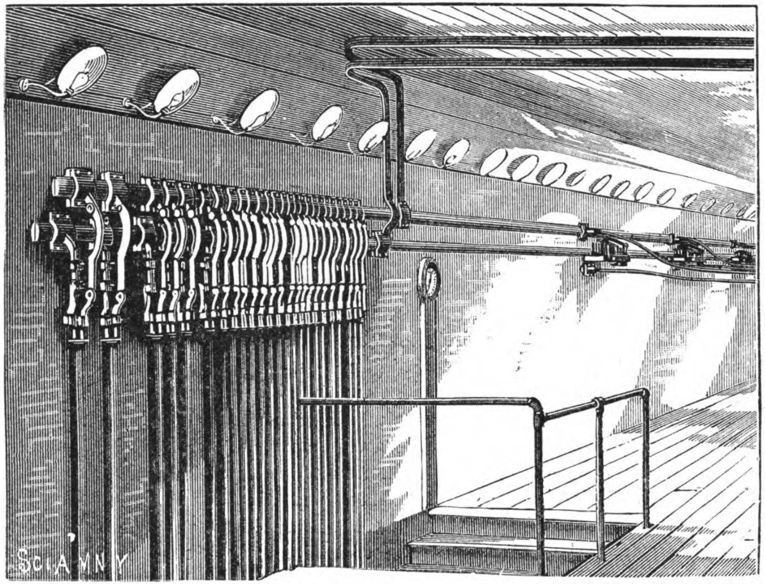
One of the copper uprights was provided with safety catch-holders, but solid copper links supplied the other connection.

The Edison tube feeders entered the Pearl Street end of the building, and were connected to the bus bars by copper arms carrying safety catches, as shown in the accompanying sketch.

There was a set of auxiliary bus bars above the main bus, leading to the lamp bank on an upper floor, and connected to one pole of the dynamo ahead of the switch, and on the other pole to the corresponding pole of the main bus, enabling the dynamo to be operated on the lamp bank for testing or for giving the engine a load before closing the main switch connecting the dynamos in parallel on the main bus. This main switch, or circuit-breaker, as it was called, shown in detail in a sketch reproduced from memory, and subsequently found to be accurate in every detail by comparison with old illustrations, was one of the earliest type of knife switches with contacts in series, and of previously unheard of capacity. It was operated by throwing the weight of the body on a long handle pivoted at one end, and released by heavy steel springs held by a trip pawl.



Original "quick break" switch, used in connection with Jumbo dynamos at Pearl Street Station



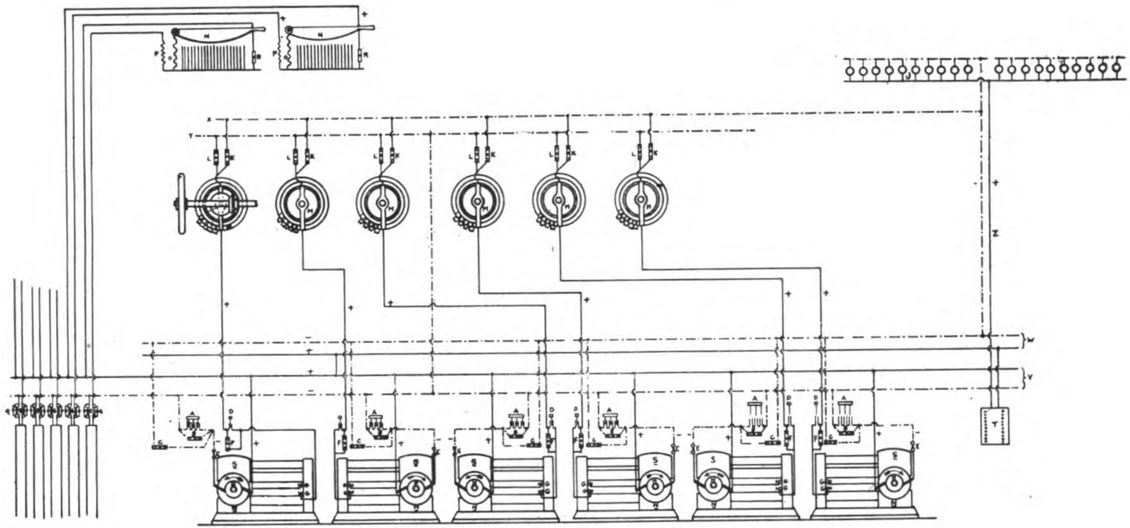
Feeder connections to main bus, Pearl Street Station

It will be noted that in front of the main contacts, and carried by the switch handle, is an auxiliary blade—the field circuit contact—making contact before the main line contacts engage, and breaking after the main circuit is broken. This field switch was supplemented by a plug switch attached to the wall and connected to a field circuit bus bar running the length of the station, with an auxiliary break through a lamp resistance to furnish a by-path for the field discharge.

The dynamo fields were controlled on an upper floor by moving simultaneously, through a horizontal shaft and bevel gearing, a number of horizontal contact arms over contacts connected with copper wire resistances wound on wooden frames. This will be clear from an inspection of one of the views, which adequately illustrates the enormous space occupied by this pioneer equipment.

It may now be interesting to state that when this pioneer station was started, and in fact for some little time afterward, there was not a single electrical instrument in the whole station—not a single voltmeter or ammeter! There was also a total absence of a central switchboard, as each dynamo had its control switches located at the dynamo; the feeder connections were concentrated at the front of the building, and the voltage control was on the floor above. The pressure was regulated from the indications of an automatic indicator, consisting of an electromagnet connected across the main circuit, and whose pull was opposed by a heavy spring. The armature of the magnet carried a contact which engaged two relay contacts on the high side connecting with a relay circuit to a red lamp, and on the low side with a circuit to a blue lamp. At normal pressure neither lamp was lighted, but if the electro-motive force rose above a predetermined amount one to two volts, the red lamp was lighted, and the attendant at the hand-wheel of the field regulator inserted resistance in the field circuit, and if the blue lamp was lighted, resistance was cut out until the pressure was raised to normal. The station was

DIAGRAM OF DYNAMO CONNECTIONS



A. Main Circuit Breaker
B. Main Plug Multiple Arced with A.
C. Lamp Line or Starting Plug
D. Field Breakers
E. Dynamo Safety Catches
F. Field Charging Plug Multiple Arced with D.
G. Main Field Connections
H. Commutators
J. Feeders to Net Work
K. Lamp Line of Field Testing Plugs
L. Field Plug at Regulators for Main Circuits
M. Field Regulators
N. Feeder Regulators
O. Permanent Resistance in Feeder Regulators
P. Shunt to Equalize Resistance of Feeders
R. Feeder Regulator Plugs
S. Feeder Safety Catches
T. Switch Board to Throw In or Out Lamp Battery
U. Battery of 1,000 Lamps
V. Main Line
W. Lamp or Testing Main
X. Lamp or Testing Field Wire
Y. Field Main Line
Z. Cable of 20 No. 10 Wires connecting Lamp Battery to Switchboard T.
N/S } Polarity of Field Magnets
Q. Feeder Plug Multiple Arced with S.

equipped with several of these indicators, and the writer remembers with what care, and incidentally physical discomfort, he carried the indicators back and forth every few days from the Edison Machine Works at Goerck Street (where they were adjusted by comparison with a Thomson reflecting galvanometer and battery of standard Daniell's cells) to the station, the belt-line horse-cars affording a welcome assistance in the transit. Later on this primitive indicator was supplanted by the "Bradley bridge"—a crude form of the "Howell" pressure indicators in use for many years in the Edison stations.

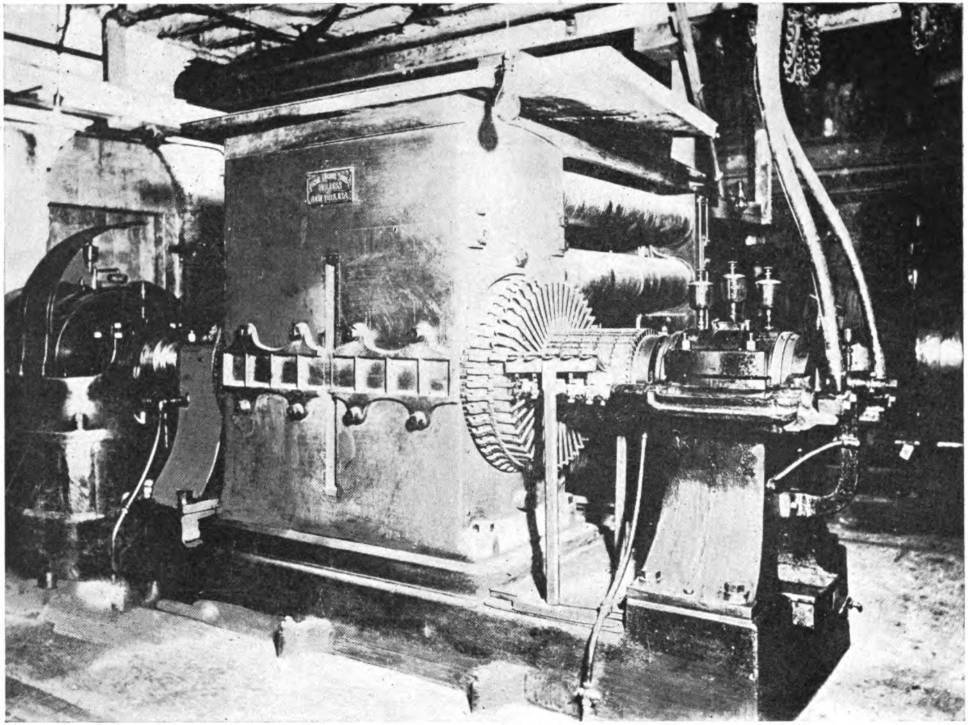
In the adjoining building sleeping accommodations were provided for the station assistants, and here Mr. Edison passed several months day and night making experiments and tests in connection with the starting up of the station.

On one of the upper floors of the station building was located the meter room, where the plates of the "Edison" chemical meter were prepared and weighed.

As stated previously, the station was started September 4, 1882. On October 1, 1882, there was connected to the station, in customers' installations, 1,284 lamps; on January 1, 1883, this had been increased to 231 customers, with 3,477 lamps. The first motor was connected to the system in 1884, and the first multiple arc lamp in 1889. The original underground system—a two-wire system—had a total length of Edison feeder and main tubes of about 18 miles, and covered the district extending from Wall Street to Spruce and Ferry Streets, and from Nassau Street to the East River, a territory covering about one square mile.

A description written some months before the station was started, concludes as follows:

"This electric lighting station is very complete in all of its appointments. Every imaginable emergency has been provided for: coal bunkers in the top of the building to hold a reserve of coal, water tanks to supply water in case of any deficiency or cessation of supply, thorough



"Jumbo" in its original location in the dynamo room at 257 Pearl Street, directly after the fire

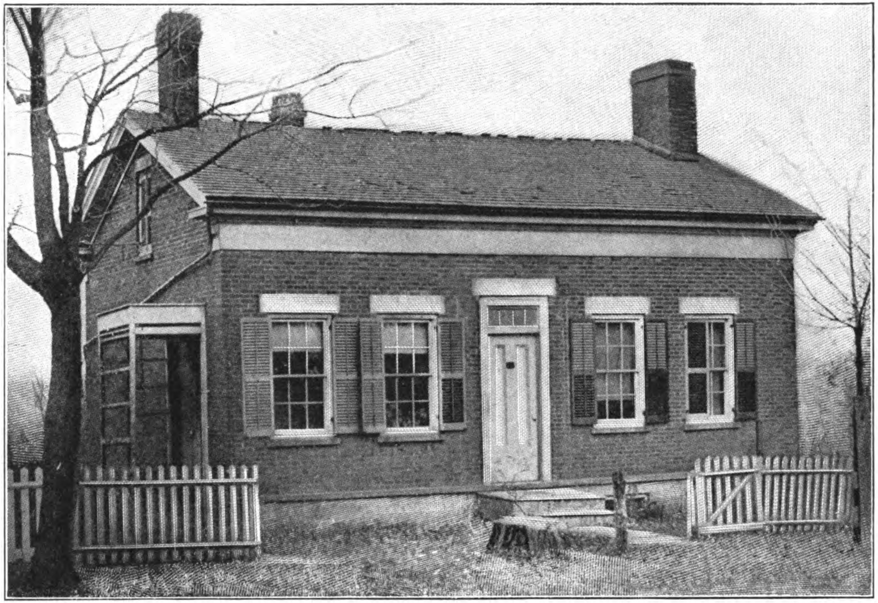
protection against fire, and thorough workmanship everywhere."

Yet it fell a victim to the fire fiend, for on January 2, 1890, the station was totally destroyed, causing the only serious interruption in the supply of current to the New York Edison system that had occurred previous to that time or since then, and only one "Jumbo" survived the wreck, and that is now a prominent feature of the collection of Edisonia at St. Louis. A view of this "Jumbo" in its original location in 257 Pearl Street, closes the series of illustrations.

In looking over the details of this pioneer equipment, one sees here represented many important elements which were characteristic features of the electric light stations built for many years afterward, contributing notably to their technical and commercial success; in fact, in its equipment of direct-connected units it was unique, as this type of apparatus fell into disuse and neglect for over ten years, only to become the standard equipment for all important power stations.

The building was sold in 1895, and there is now nothing left to mark the historic spot, such a conspicuous landmark in the history of the art of electric lighting.

In closing this review of the historic Pearl Street station, it should be pointed out that this was the station which did the remarkable work of demonstrating not only the practicability, but also the commercial success of the Edison multiple arc system—that epoch-making series of Mr. Edison's inventions from the steam dynamo to the lamp, including the dynamos, regulators, feeder and main system, underground distributing system, safety fuses, cut-outs, switches, sockets, meters, and last, but not least, the crowning achievement—the incandescent lamp.



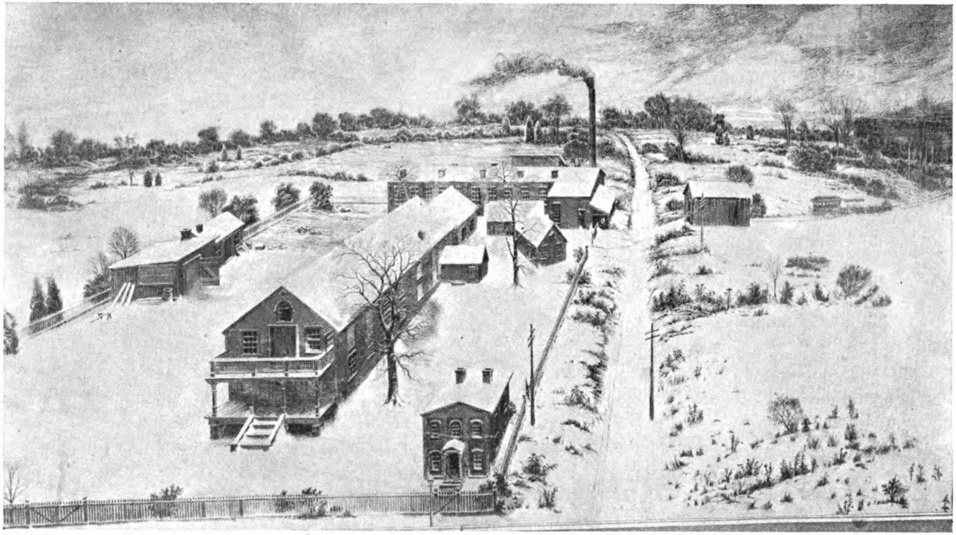
The birthplace of Edison, at Milan, Ohio

Edison at Menlo Park

BY W. S. ANDREWS

IN 1876 Thomas A. Edison established his laboratory and workshops in the modest little village of Menlo Park, N. J., thus destined to become famous as the birthplace of the Edison incandescent lamp, which now radiates its soft and comfortable light throughout the civilized world.

Mr. Edison's attention was first seriously attracted to the problem of producing light from electricity in the summer of 1878, when he became strongly impressed with the great advantage which would attend the subdivision of electric light into a number of small units, equivalent to gas jets. Arc lamps had been invented and used commercially for many years, but this system only permitted the employment of a limited number of large light units, all connected in series with each other on a high voltage circuit. Before his ideas on electric lighting could be materialized, there were two problems to be solved, one being the practical subdivision of the light, and the other its economical adaptation to household and general purposes. Not only was a new kind of lamp required, but it was also necessary to devise a new system of electrical distribution, and Mr. Edison started out to invent these requisites in the face of many discouraging conditions. Every experimenter at that time knew that a small wire could be made red hot and melted by passing a current of electricity through it, but although many had endeavored to make electric lamps on this principle, it had never been developed into a practical device for producing light. Mr. Edison tried it. He twisted fine platinum and iridium wire into loops and spirals, and raised them to various degrees of incandescence by the passage of electricity. At one time the problem appeared to be solved and success assured, but con-



Edison's Menlo Park Laboratory in the Winter of 1880 tinuous service developed defects of such a serious character that it finally became apparent that platinum wire was entirely unsuitable for the service required. Mr. Edison, however, was undaunted by failure, and as the Edison Electric Light Company had been incorporated with a capital of $300,000, he had a liberal fund to draw upon, and he settled down with determination to discover some electrical conductor which would stand a white hot temperature indefinitely without deterioration, and which would be in all other respects suitable for his purpose.

In the fall of 1878 Mr. Edison was created a Chevalier of the Legion of Honor by the French Government, and received the "Grand Prix" at the French universal exposition for his numerous valuable inventions, among which were specially mentioned the quadruplex telegraph, the carbon telephone, the tassemeter, and electric light apparatus then in progress.

Edison's home at Menlo Park

The following extract from the *New York Herald* of April 27, 1879, is a fair illustration of high scientific opinion regarding Mr. Edison's invention at this date:

Edison in 1881

"It was only a few weeks ago that Mr. W. H. Preece, electrician to the British Post Office Department, in a lecture to which great publicity was given, took occasion to whistle down the wind the efforts of Edison and his rivals, pledging a reputation hitherto formidable to the assertion that the successful subdivision of the electric current, so as to effect a popular revolution in the lighting of houses and factories, was a mere chimera, and that all efforts in that direction were doomed to final, necessary and ignominious failure."

Such a disparaging statement from an eminent scientist, coupled with the failure of his long cherished platinum iridium lamp might have discouraged a weaker man. Not so with Mr. Edison, however. Failure in one direction only stimulated him to more strenuous efforts in another. And so the months rolled on—the summer of 1879 passed and winter approached without any material advance. Night after night Mr. Edison and a few of his most able assistants experimented and worked with unabated ardor and with an abiding faith in final success. Such persistent effort might almost change the laws of nature, but no miracle was necessary, for nature had already provided the requisite material, leaving it only for Mr. Edison to discover the necessary form in which it could be used to the best advantage for his purpose.

How this was done is thus related in one of the New York papers of January 3, 1880:

"A new discovery, however, was in store. Toying one night with a piece of lamp-black mixed with tar (used in his telephone), he noticed, as he rolled it between his thumb and forefinger, that it readily became elongated, and the thought struck him that a spiral made of it might emit a good light under the action of the electric current. The experiment was soon tried, and while the result was satisfactory, it was not striking.

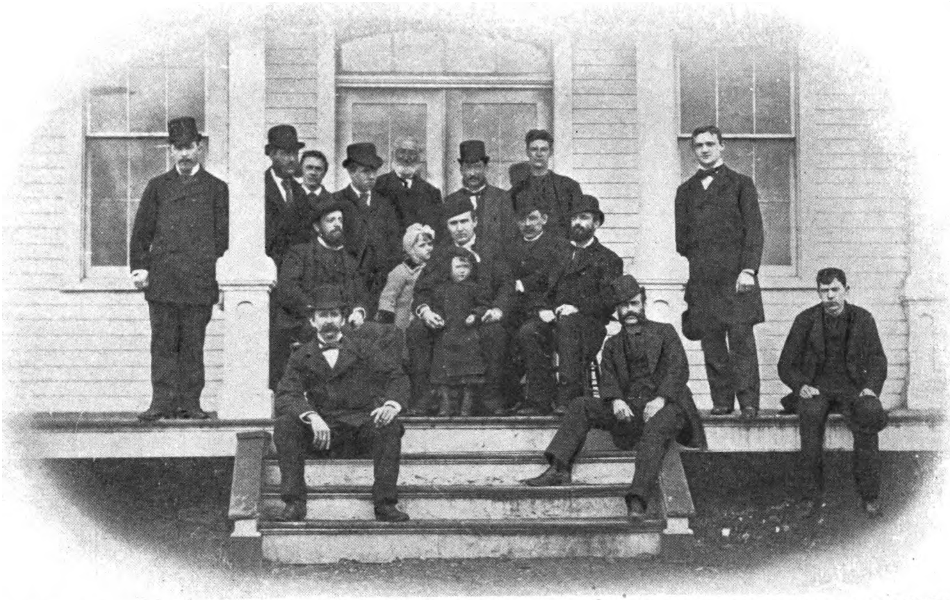
L. K. Boehm C. L. Clarke Chas. Batchelor Will Carman S. D. Mott Geo. Dean Thomas A. Edison Chas. T. Hughes
George Hill George Carman Francis Jehl "Basic" Lawson Charles Flammer C. P. Mott J. V. MacKenzie

Interior of Edison's Laboratory, Menlo Park, February 22, 1880

> Continuing in this same vein of reasoning, the inventor determined to try the carbonized remains of a thread in the same way. He thereupon placed a thread in an iron mould, and put it in the furnace. At the expiration of half an hour he took it out, and placing it in a glass globe, extracted the air, then turned on the current. The effect was surprising. The slender thread emitted a mild, beautiful light. The overjoyed inventor continued his experiments, trying a number of threads twisted together, straw, paper, card-board, and other substances. Paper and card-board gave the best results, the latter being a trifle preferable. * * * The carbon filament appeared to combine all the elements necessary for the purpose to which it was applied—resistance, infusibility and indestructibility, the absence of any one of which would be fatal, were all concentrated in the little piece of charred paper. 'It is as though the Almighty had decreed it,' observed Mr. Edison reverentially."

Such is the story of the "carbon filament," which made possible the Edison incandescent lamp. Commenting on this subject, the *New York Herald* said:

> "Edison's discovery of a substance upon which electricity could produce the light of incandescence with comparative inexpensiveness and perfect effect is one of those little romances of science with which the pathway to every great invention is strewed. Platinum was a great obstacle for a while in this hunt; and, not altogether satisfactory in operation while of extremely high value, it seemed at the moment as if it might make the search altogether vain. But the happy discovery of the uses of a bit of cotton thread has turned in a moment the whole current of this story into a fortunate channel, and we are rejoiced to congratulate not merely Edison, but the people of all civilized nations, upon Edison's success."



Mr. Crosby George E. Carman Albert B. Herrick Charles Batchelor William Holtzer Francis Jehl Samuel " Dad " Edison
Marion " Dot " Edison Thomas A. Edison Thomas A. Edison, Jr Chas. P. Mott Chas. T. Hughes
John W. " Basic " Lawson William Carman James Hipple Ludwig K. Boehm George Hill

Group of Edison and assistants outside Menlo Park Laboratory

After this discovery the path was comparatively clear, although its course naturally continued up hill for a long distance. At length, however, complete and glorious success was achieved, and from the dynamos to the lamps the unique Edison system of electric lighting was practically an accomplished fact. In the late fall months of 1880 Mr. Edison's laboratory and workshops, and also many of the surrounding private houses, were brilliantly lighted every night by the new lamp, and long rows of lamp-posts, each crowned with an incandescent lamp, illuminated the adjacent highways and byways. The public at large were cordially invited to come to Menlo Park to see this wonderful exhibition, and many thousand people from city and country availed themselves of the opportunity. The following extract from the *Scientific American* of June 18, 1881, contains a fair statement of the appreciation of Mr. Edison's great invention:

> "Simply as an exhibition of perfect illumination under perfect control, covering a vast area, this array of lamps presents a most remarkable and delightful sight, and is alone worthy of a trip to Menlo Park. As a demonstration of the perfected working of a great and novel system of illumination, sure to become in a little while a potent contributor to the comfort and economy of city life, it is a spectacle which cannot fail to impress powerfully the mind of any observer."

Before finishing this brief sketch, some mention may be made of those who, with the writer, were privileged to assist Mr. Edison in his great work at Menlo Park, and who devoted all their energy and skill to the accomplishment of his plans. Chief among these was Charles Bachelor, who for eight years had been most intimately associated with Mr. Edison in all his undertakings, working constantly by his side and materializing his ideas with keen intelligence and untiring patience.

Then came Francis R. Upton, whose high mathe-

John F. Randolph John W. Lawson Charles Flammer George Dean Alfrid Swanson David Cunningham
George E. Carman Thomas A. Edison Martin N. Force Stockton L. Griffin John F. Ott
Frank McLaughlin Ludwig K. Boehm Charles Batchelor Francis Jehl Francis R. Upton
John F. Kelly Milo Andrus Dr. A. Haid James Seymour Tom Logan

Another group of Mr. Edison and assistants at Menlo Park matical talents were put to good service in the solution of many intricate and difficult problems connected with the various windings of dynamos and the transmission and distribution of the "juice."

Deep tribute is also due to the late Mr. John Kruesi, to whose indefatigable industry, keen intelligence and long experience in mechanical design and construction the immediate success of all the Edison electric generators and other apparatus may be unquestionably traced.

Many interesting facts could be related about these men and many others, but brief mention of a few of them must suffice.

Stockton L. Griffin and Samuel Insull were intimately connected with Mr. Edison's financial and business interests; Chas. L. Clarke, who made the famous economy test on the incandescent lamp—after reading which Mr. Edison is said to have remarked: "Just wait a little while and we will make electric light so cheap, that only the wealthy can afford to burn candles!" Chas. T. Hughes was intensely interested in the Edison electric locomotive; W. J. Hammer, at one time in charge of exhausting lamps and tabulating results of tests, and who became so enamored with the subject that he has since gathered the finest collection of incandescent lamps in existence; Luther Stieringer, whose work in the development of wiring systems and striking illuminating effects marked the progressive steps in the state of the art; J. H. Vail, whose methodical habits and general knowledge of machinery contributed to the smooth running of the dynamos, of which he at one time had entire charge. Then there were Francis Jehl, whose pet hobby was the Edison meter; Martin Force, whose best talent was directed to the perfection of the Edison loud-talking telephone; John Ott, the expert mechanician, who could make moulds for lamp filaments to the ten-thousandth part of an inch, and was allowed several valuable patents for ingenious mechanical devices, and Ludwig K. Boehm, the artistic glass worker, who prepared all the delicate bulbs for the lamps, and the still more delicate mercury pumps for exhausting them.

The work of Crosby, Mott, Carman, Hipple, Hill, Lawson and many others might all be dwelt upon with interest and pleasure if time and space permitted. One short story, however, to conclude:

One day when Boehm was discouraged after a series of mishaps with his pumps, some one remarked, "Could we not put the lamps in a balloon and send them up high enough to fill them with vacuum and then seal them off up there?" "Good idea," said Mr. Edison, "we'll have to take out a patent on that. sure." "But how could we seal them off if there was no air to use in the blow pipe?" somebody else suggested. "That's always the way," said Mr. Edison with a long drawn sigh—"that's always the way—no sooner does a man bring out a brilliant and practical idea, but some ignoramus must needs interfere and try to show some reason why the scheme is impractical. There's no chance for a real bright inventor now-a-days!"

Mrs. Jordan's boarding house at Menlo Park

Historical Collection of Incandescent Electric Lamps with notes relative to certain of the early Types of the Edison Incandescent Lamps

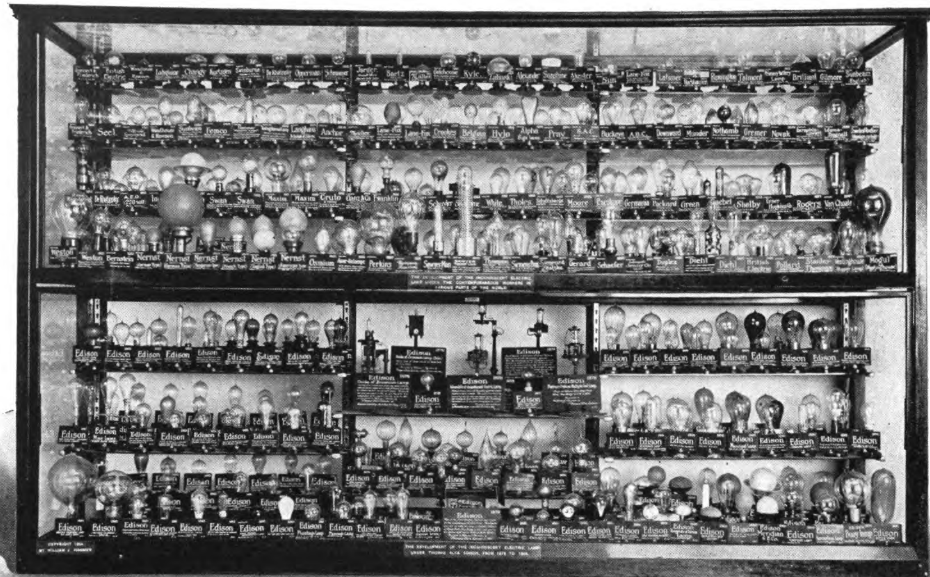
BY WILLIAM J. HAMMER.

THIS collection, which may truly be said to represent "The History of an Art," is the result of systematic efforts on the part of the writer made during the past twenty-five years and dating from the incipient stages of Mr. Edison's work on the incandescent electric lamp, inaugurated at his laboratory at Menlo Park, New Jersey, up to and including the present time.

The writer started this collection when, as an assistant at Mr. Edison's laboratory, he had charge of certain tests and records which were made relative to the life, efficiency and general characteristics of the Edison incandescent lamps, and he has constantly supplemented the collection with important specimens representing the earliest work of the various inventors through the world, which he has gathered from time to time in America, during the past twenty-five years, and during the various sojourns in Europe, covering, in all, a period of about seven years.

This is the first time the collection has ever been shown in its entirety, and it is now exhibited at the St. Louis Exposition at the special request of Mr. Edison and of the Association of Edison Illuminating Companies, on this, the twenty-fifth anniversary of the birth and development of the commercial incandescent electric lamp.

There are over eight hundred incandescent lamps in the collection—illustrated in the accompanying photograph (Fig. 1)—which was made in New York just prior to the shipment of the collection to St.



"The History of an Art"

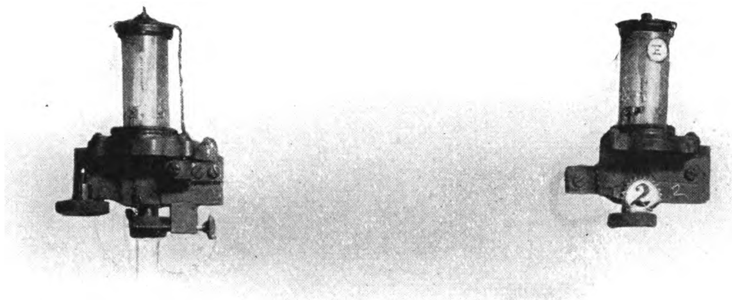
Fig. 1 Historical collection of incandescent electric lamps. Property of William J. Hammer

Louis. As shown in the illustration, the collection occupies two mirror-backed French plate glass cases, each ten feet in length, placed one above the other, the lamps being arranged in four tiers. The lower case is devoted exclusively to Edison lamps, illustrating the development of the incandescent electric lamp under Thomas Alva Edison, starting with his earliest platinum thermostatic regulator lamp, platinum iridium spiral lamps, oxide of zirconium lamp, multiple foil platinum lamp, famous paper horseshoe lamp, plumbago lamp, bamboo and other vegetable filament lamps, etc., up to the standard Edison lamp of to-day.

The other case is devoted to the contemporaneous workers in this art all over the world, and represents among others, the earliest work of Swan, also Edison-Swan, Ediswan, Swan United and Brush-Swan types, Lane-Fox, Maxim, Weston, De Changy, Sawyer, Lodyguine, Cruto, Gatehouse, Kurtzgen, Swinburne, Crookes, Bernstein, Müller, Boehm, Gerard, Latimer, Rogers, Opperman, Diehl, Stanley-Thompson, Thompson, Thomson-Houston, Remington, British Electric, Akester, Alexander, Richter, Schuyler, Duplex Co., Siemens & Halske, Siemens Bros., Greinert & Freiderich, Vitrite-Luminoid, Sawyer-Man, Northomb, Hochhausen, Hammer, Sun, Franklin, Schmauser, Greiner, Schaefer, Jenny, White, Excelsior, Belgian, and includes the more modern developments under Ganz & Co.; United Electric, Van Choate, Gilmore, Monarch, Colonial, Economy, Brilliant, Tipless, Sterling, Comet, Goebel, Von Kammerer, Dubligo, Elblight, Zenith, American, New Universal, Hardy, Trilight, Fostoria, Malden, Esco, Meridian, T. A. Edison, Jr., Premier, Miller, Buckeye, Femco, S. A. C., Sunbeam, Packard, Perkins, Westinghouse Co., Novak Co., Columbia, Seel, Pray, A. B. C., DeKhotinsky, Orient, Banner, Downward, Hylo, Economical, Anchor, Munder, Bryan-Marsh, Talmont, Adams-Bagnall, Pollard, Imperial, Tholes, Shelby, Kyle, Zalinski, Star, Sunshine, Germania,

Fig. 2 Edison's first incandescent electric lamp of 1878

One of earliest Edison platinum spiral lamps with thermostatic regulator



Nernst, Moore, Osmium, Aueros, Langhans, Crawford-Voelker, etc.

In the brief time and space here allotted to the writer, it is impossible to deal with the many progressive steps of the various inventors whose work has left an impress upon this art. The writer will, however, consider somewhat briefly certain of the special types which have marked the development and perfection of the incandescent lamp in the hands of Thomas Alva Edison. To give a complete resumé of all of the steps in Mr. Edison's work alone, would in itself fill a large volume, and the writer must therefore confine himself to a consideration of a few of the salient features.

Many of these early lamps of Mr. Edison's, while not of a thoroughly commercial character, were of very great interest and had a most important bearing upon his subsequent work.

EDISON'S FIRST INCANDESCENT LAMP

This lamp (Fig. 2) consists of a double platinum spiral mounted on two supporting pillars. The double spiral is free to expand or contract by variations in temperature, as both ends are below the spiral. The platinum spiral is in series with a fine thermostatic wire of similar material, which passes longitudinally through the center of the spiral, being connected at its lower end to a lever, which is normally out of circuit. Should an excess of current pass through the platinum spiral, raising it to a temperature near the melting point, the thermostatic wire in the center of the spiral becomes heated to such an extent that it expands and allows the lever which is attached to it to rest upon an adjustable screw in the base of the lamp, thus short-circuiting the platinum spiral. As soon as the spiral begins to cool, the thermostatic wire contracts, lifts the short-circuiting lever off of the contact screw, again allowing the current to flow through the platinum spiral.

In another type of this lamp, devised by Mr. Edison, there is no electrical connection between the central

Fig. 4 Edison's oxide of zirconium lamp

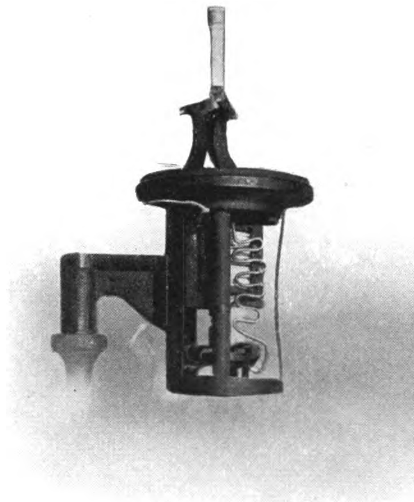
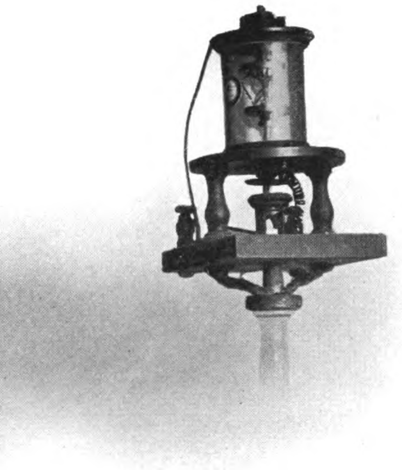


Fig. 3 Edison's multiple foil platinum lamp



thermostatic wire and the illuminating spiral of platinum. In this type the thermostat is operated by the heat radiated from the incandescent spiral surrounding it. The thermostatic wire expanding, causes the lever to short-circuit the platinum spiral in a manner similar to the other type of lamp.

In Mr. Edison's first lamps, the spiral burned in an air-filled glass globe. He noticed that the glass so rapidly discolored that the lamps became useless, whereas where the spiral was placed in a bulb exhausted by a Sprengel air pump, it remained dazzlingly incandescent, and there was not the slightest deposit on the glass; and in his later types of platinum iridium lamps, as well as in his subsequent carbonized paper, bamboo, and other filament lamps, a highly exhausted globe or bulb was universally employed.

Mr. Edison also discovered that, whereas a platinum spiral would only stand a temperature sufficient to give about 4-candles of light, he could by working or tempering the platinum in a vacuum, by alternately heating and cooling and gradually increasing the current sent through it, thus change the characteristics of the platinum, which normally softened and lost its elasticity when heated to a bright incandescence; so that the spiral now became as springy and elastic when heated as when cold; it also became very homogeneous, and could not be annealed by any known process. It was, in fact, a product new to the arts, and the spiral would then stand a temperature which enabled the lamp to be burned successfully at 35 candlepower or thereabouts. Mr. Edison also found it advantageous to alloy the platinum with iridium.

The two lamps shown in the illustration are practically identical. They were both made in 1878. (See U. S. Patent 214,636, granted to T. A. Edison, April 22, 1879.) The one to the left was presented to Mr. William J. Hammer by Mr. Thomas A. Edison at his Menlo Park Laboratory, in 1880. The one to the right was presented to him by Mr. Edison at his Orange

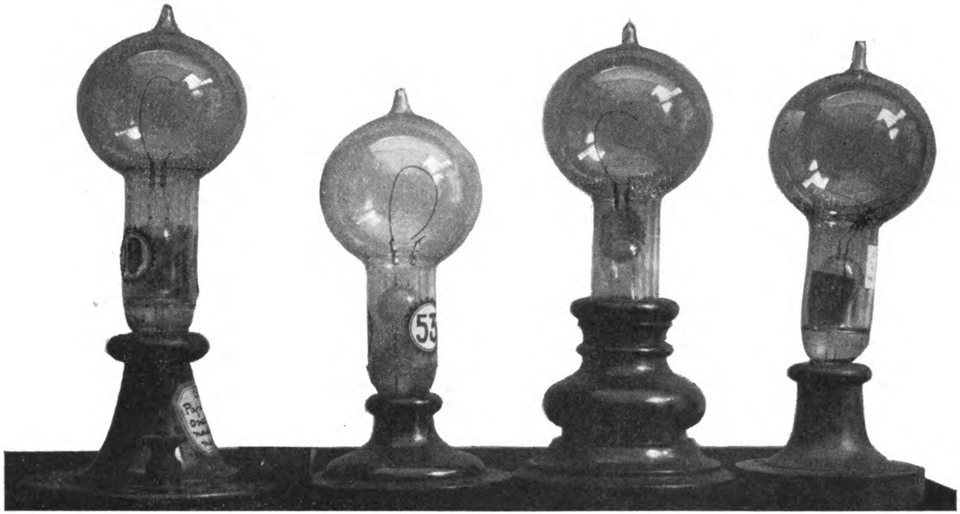


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Fig. 5.—Edison's famous "Paper Horseshoe Filament Lamp" of 1879

Laboratory in 1888, and on the base are the signatures of Messrs. Charles Batchelor, Mr. Edison's partner and chief assistant, and John Kruesi, superintendent of the machine shop at Menlo Park, dated September 23, 1878.

The Edison carbonized paper horseshoe filament lamp of 1879, illustrated in Fig 5, represents the first type worthy of being considered as a commercial incandescent electric lamp.

Before arriving at this form, which gave place to his well known carbonized bamboo filament lamp so extensively employed, and which in turn was in later years superseded by the squirted filament type of lamp now almost universally used, Mr. Edison had, in common with various other inventors, experimented with incandescent platinum as an illuminating agent. In addition to platinum, he used for the incandescent metal, rhodium, iridium, boron, ruthinium, chromium, titanium and other metals, employing these alone, or alloyed with one another. He also saturated various rods, sheets and other forms of metallic oxides with a salt of metal difficult of fusion, and reduced the same by heat to a metallic state, and in other cases he mixed finely divided conductors in fusible materials, such as oxide of magnesium or zirconium in such proportions as to obtain the degrees of conductivity required.

In other types, to secure a conductor of high resistance, he wound a fine platinum or platinum-iridium wire of about thirty feet in length around a spool or cylinder of pipe clay, coating the wire spiral with oxide of zirconium.

One of Mr. Edison's most interesting experiments was in forming sheets out of plumbago by subjecting the plumbago in a powder form to a hydraulic pressure of 50,000 pounds to the square inch. From the sheet so formed, a filament was punched which gave a soft, beautiful light, but the filament was structurally so weak as to make its employment impracticable. Mr. Edison's best results were secured with fibrous

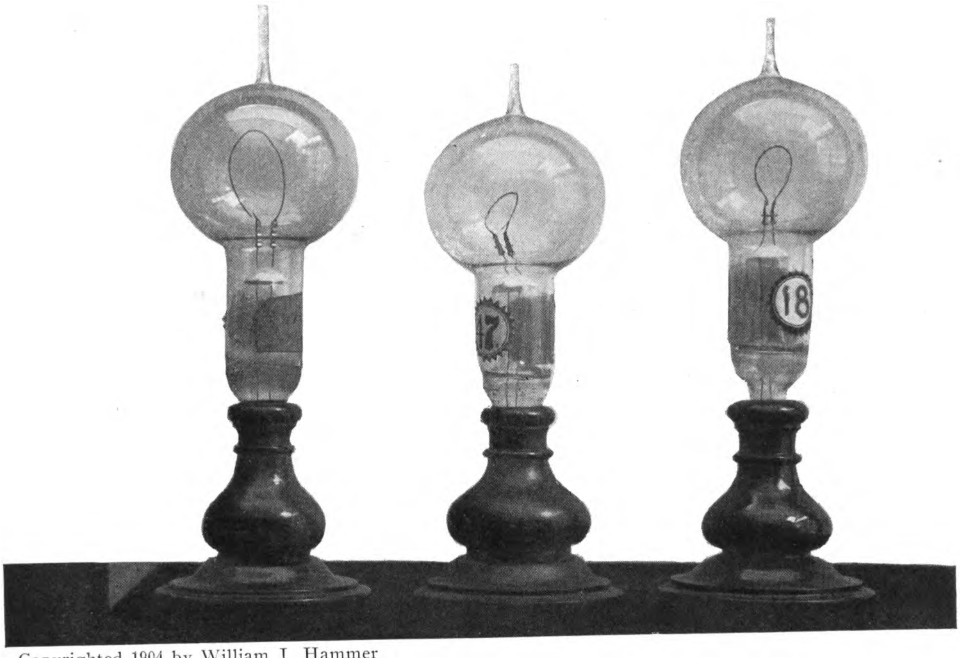

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Fig. 6.—Early types of Edison carbonized paper filament lamps

vegetable filaments, of which he tried over 6,000 different varieties.

He made experiments on the effect of various gases employed in the lamp globe or bulb, and also in treating the filaments after carbonization with hydrocarbon vapors to fill up the pores of the carbon; the subsequent covering of filaments with a graphitic coating after coming from the furnace is now universally employed.

Mr. Edison's researches into the presence of occluded gases in metals and other substances were of paramount importance throughout his subsequent work and in the work of others.

For exhausting his early lamps, Mr. Edison made use of a combination of Sprengel and Geissler pumps and a McLeod gauge and spark gap; subsequently, he employed a simple form of Sprengel pump. The Sprengel pump has been used for the past twenty years more than any other, and has now given place to the mechanical pump with oil covered piston, employed in connection with the phosphorus chemical exhaustion. Whereas it formerly took five or more hours to exhaust a lamp, the whole process can now be done inside a minute's time.

In Fig. 3 is shown Mr. Edison's multiple foil platinum lamp. This lamp followed in general principle the platinum and platinum-iridium lamps previously described, employing a thermostatic regulator, the main difference being in the use of the foil or ribbon in place of the wire, and in the employment of a number of these strips in the multiple or parallel.

In Fig. 4 is shown Mr. Edison's oxide of zirconium lamp. In this lamp a very fine platinum or platinum-iridium wire of a length of about thirty feet was wound in a close spiral on a spool or cylinder of pipe clay. Over this a coating of some metallic oxide, usually the oxide of zirconium, was employed, this serving in some degree to insulate the turns of the spiral from one another.

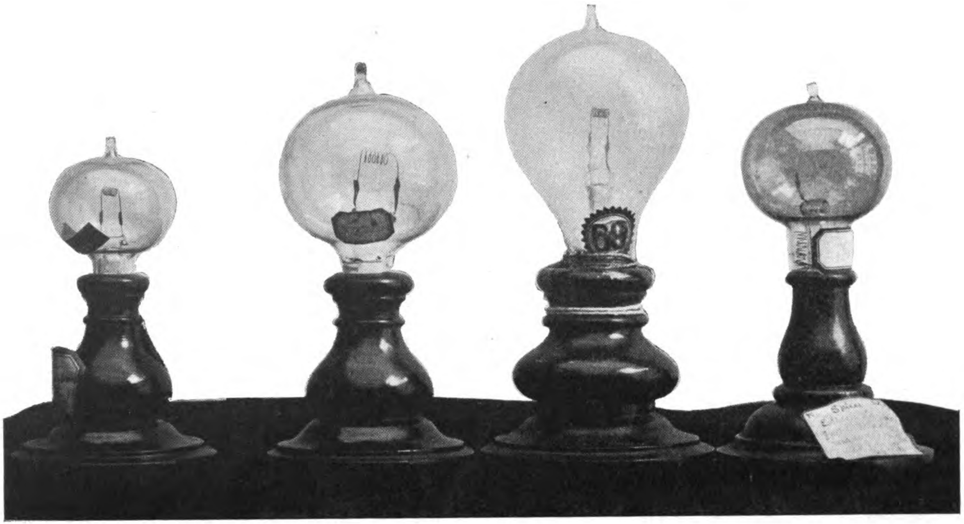

Fig. 7.—Early types of Edison spiral filament lamps

When the current was passed through the spiral, the whole spool, or cylinder, would become incandescent. A thermostatic regulating device was employed in this lamp to prevent a destruction of the incandescent spiral.

The spool was placed in a highly exhausted and hermetically sealed glass globe. This, I have removed in order to show more clearly the incandescent spiral and spool. For full particulars of the construction of this lamp, see Edison's U. S. Patent No. 227,229, May 4, 1880, and others.

Following his extensive experiments in employing platinum and platinum alloyed with other metals, and in his search for still more refractory substances and such as would give him an incandescent conductor of higher resistance, Mr. Edison took up the carbonization of many materials, utilizing cotton and linen threads, wood splints, fibrous vegetable substances and carbon compositions, in one instance rolling out a compound of lamp-black and tar into a conductor as small as 7-1000 inch in diameter prior to carbonization, and after carbonization between 4 and 5-1000 inch in diameter.

He also devised a wonderfully ingenious contrivance, which would "rout" out complete filaments ready for carbonization from solid blocks of wood fed into the hopper of the machine.

The methods developed by Mr. Edison and employed by him in the manufacture of the incandescent lamp and which made it a commercial article, are embodied in the incandescent lamp of to-day, namely, the employment of a high resistance filament of carbon hermetically sealed in a receptacle entirely of glass with conductors leading through the glass and the exhaustion of such receptacle on a vacuum pump to a high degree prior to its being sealed hermetically. These special features are fully described in Mr. Edison's United States patent for an electric lamp, No. 223,898, of January 27, 1880.

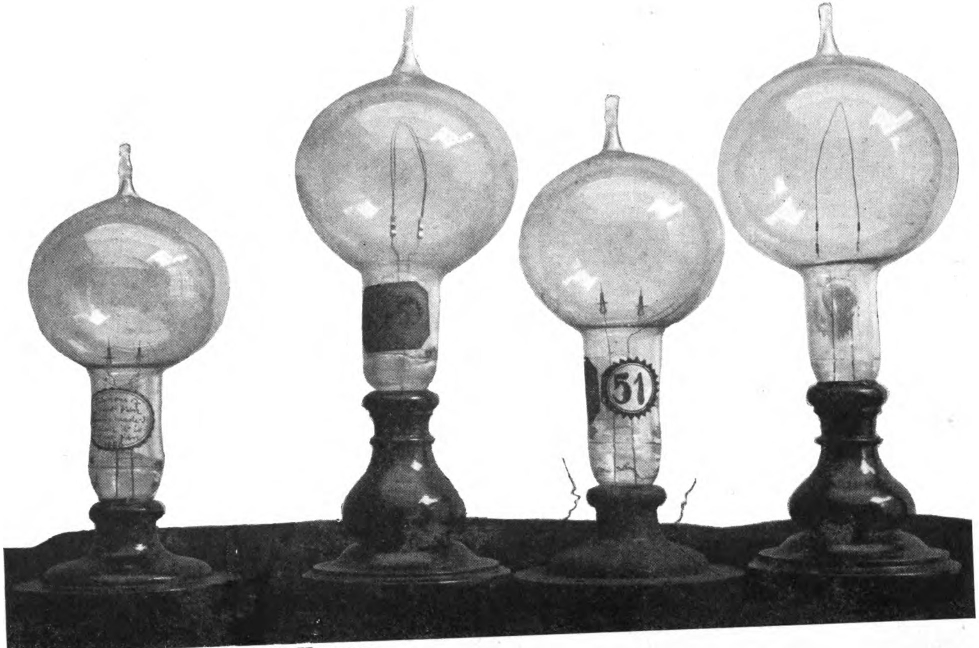

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Fig. 8.—Early vegetable filament types of Edison lamps of 1880

In this patent he describes the true reason for the consumption of the low resistance "carbon rod" burners employed in prior lamps, and he calls attention to his discovery that the disintegration of the carbon was not due to the action of the electric current, as was universally believed, and he discloses the true reason for the consumption of the carbon when no oxygen was present in the following words:

> "The use of a gas in a receiver at the atmospheric pressure, although not attacking the carbon, serves to destroy it in time by "air-washing," or the attrition produced by the rapid passage of the air over the slightly coherent, highly heated surface of the carbon."

He refers in the following words to his discovery of the stability of carbon in a high vacuum:

> "I have discovered that even a cotton thread properly carbonized and placed in a sealed glass bulb, exhausted to a millionth of an atmosphere, affords from 100 to 500 ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures."

Aside from Lane-Fox, of England, none of the early workers in this art, except Mr. Edison, understood the principle underlying the employment of high resistance in the incandescent lamp filament, and no one had produced a high resistance lamp suitable for subdivison prior to Edison.

Fig 5 is an illustration of four of the earliest of the famous paper horseshoe lamps employed in the historic light-up at Menlo Park, New Jersey, in December, 1879. The four lamps, which are all of the same general type, show plainly the paper horseshoe filament mounted in vise-like platinum clamps, and the bulbous form of the inside part with the platinum leading-in wires passing through the glass, and also illustrate the method of sealing the inner and outer parts together at the bottom of the lamp.

Fig. 9 Egg shaped Edison lamps with carbonized bamboo filament of 1880

The small round bulbs show the method of forming the tip when the lamp is sealed off of the vacuum pump.

In Fig. 6 is shown the next step in the paper horseshoe filament lamp. The one to the left is the regular paper horseshoe filament, the other two being round filaments of parchment paper in the one case, and Japanese bamboo paper in the other.

It will be noted that a white German glass has been used on the inside part where the platinum wires pass through the glass. There was some difficulty experienced at this time in retaining the vacuum in these lamps, and while the co-efficient of expansion between platinum and glass is nearer alike than any other metal and glass, it was believed that air worked its way between the glass and the platinum when it was alternately heated and cooled. It was also feared that the air leaked in through the tip where the bulb was sealed off of the vacuum pump, therefore a supplemental tip was employed, as shown in these and subsequent lamps, the glass being worked until it became absolutely solid.

The normal life of the paper horseshoe lamp was about 300 hours, although there were several instances of these lamps remaining in use about Menlo Park upward of 1,000 hours.

In Fig. 7 is shown several of the many forms of carbon spiral lamps which have been specially designed for surgical purposes, stereopticons, trolley car headlights, etc. In certain of the early types the spiral was mounted in platinum clamps with a large copper collar or washer put around each wire to lower the temperature at the point where the platinum wires pass through the solid glass.

The general construction of this lamp is illustrated in Mr. Edison's United States Patent No. 223,898, of January 27, 1880.

In Fig. 8 are shown lamps employing a considerably

Fig. 10 Standard "Pear shaped" Edison lamps of 1880

larger globe, Mr. Edison believing that this might augment the lasting qualities of the filament.

The second and fourth lamps in the illustration are interesting as showing some of the first vegetable filament lamps employed, the clamps of the second lamp supporting two filaments in multiple, these being of carbonized manila hemp.

The platinum clamps used in this lamp and in the paper horseshoe type cost 8 cents each, and many experiments were made to find a suitable and more economical clamp.

One of the first of these is shown in the fourth lamp, this consisting of tiny cylinders of carbonized cocoanut shell, drilled at each end. Into these holes were inserted platinum leads and the ends of the filament. As a result of the much greater length of the bamboo and various other vegetable filaments which Mr. Edison found far superior to the paper and cardboard he had previously made use of, it became necessary to abandon the small round globes, and the egg-shaped form shown in Fig. 9 was devised.

The second lamp in Fig. 9 employs the vise-like platinum clamp, and the third one employs a similar clamp, but of larger dimensions, made in nickel.

The first lamp employs the usual rounded inner seal, whereas the second and third lamp show a depressed seal with the glass drawn up from the center of the depression around the wires. This method of inner seal shortly afterward gave place to the pressed seal, so extensively employed to the present time, in which the glass, while heated, is squeezed flat, imbedding the leading-in wires in the solid glass.

Very few of the egg-shaped globes were made, and in Fig. 10 is shown the type of lamp adopted as standard, and which has, with very slight modification, remained the standard form up to the present time.

In the fourth lamp in this illustration is shown the first lamp of this type ever made.

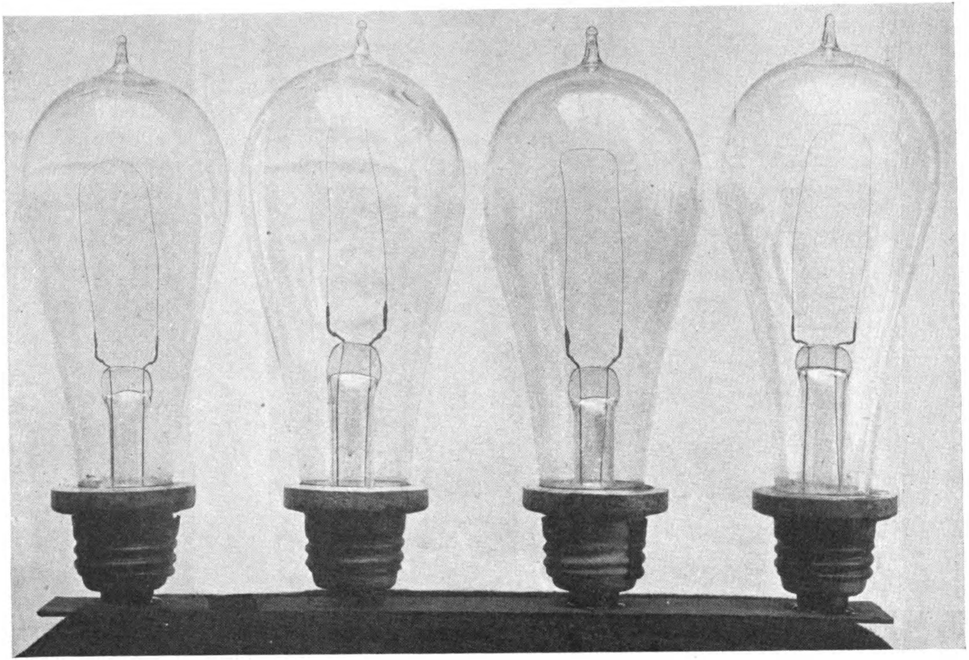

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Fig. 11 Edison bamboo filament copper plated lamps

All of these lamps contained the "hairpin" form, of carbonized bamboo filament, which became the standard form in 1880, and remained in use until the comparatively recent adoption of the squirted filament type of lamp.

The last lamp in the row is of particular interest, as it is the first long record incandescent lamp. It lasted 1589 hours in a carefully conducted life test.

About this period (1880) Mr. Edison made quite a number of experiments with stopper lamps, usually forming the inside part as a glass stopper to a bottle, the outer globe representing the bottle, the contact surfaces being ground to fit and the joint subsequently luted or sealed with various substances. Certain of these lamps are shown at St. Louis, and one of them contains a paper hairpin filament treated with hydrocarbon vapor, which method of filament treatment Mr. Edison was working upon in 1880.

Fig. 11 illustrates the next important step in the perfection of the Edison lamp, which was the electroplating of the joint between the filament and the supporting wires. A small piece of copper wire was fused to the platinum leads of the inside part, and this, after flattening, was bent around the shank of the filament. The inside part was then placed in an electro-plating bath and copper deposited around the joint.

This system, which was most economical and which was for many years employed by the Edison Company, did away with the greater portion of the platinum used in the Edison lamp, which has, however, since been very much lessened in various ways, notably by using only a short section of platinum, embedding it together with the joints of the copper wire extensions in the solid flat seal.

The lamps in this figure are shown with plaster of paris butts or bases and flat collars and contained the standard type of bamboo hairpin filament.

A type of lamp was made just previous to this with

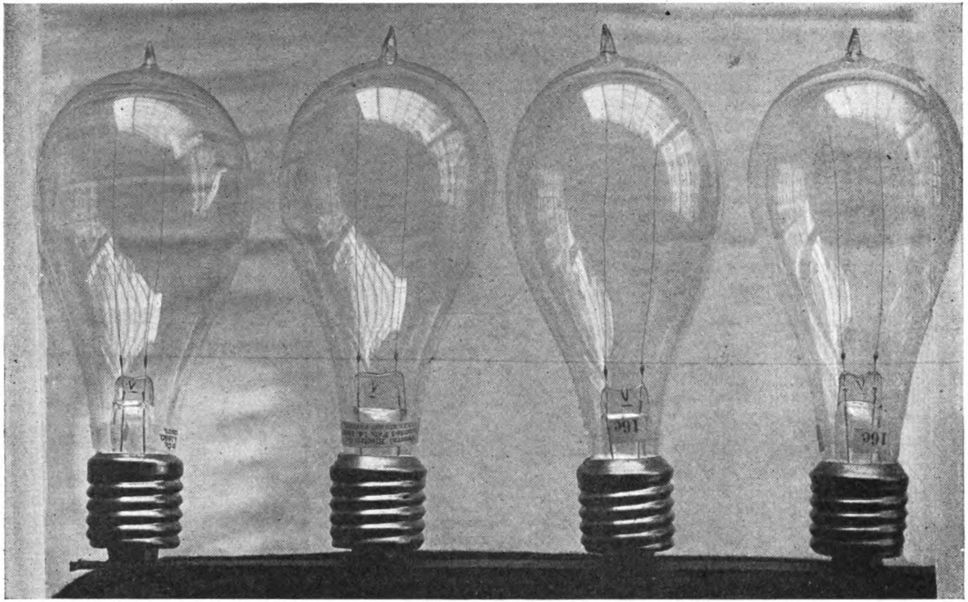


Fig. 12 Edison "squirted" filament lamps with carbon paste clamps

the collar slightly beveled, and, prior to that, wooden bases or butts were employed, also huge wooden sockets, which in common with the various other types referred to and, in fact, practically every step in Mr. Edison's work may be seen in my collection at the St. Louis Exposition.

In Fig. 12 is shown the step from the bamboo filament to the squirted filament and the use of carbon paste clamps. The squirted filaments were made longer than necessary and cut off to the required length. The enlarging of the filament at the point of clamping, used in nearly all lamps heretofore made, was abandoned.

The first method in clamping was to heat the joints to a high temperature in a vapor of gasolene, which deposited carbon around the joint. This subsequently gave way to the carbon paste which is extensively employed to-day.

This lamp also illustrates the abandonment of the supplemental seal and rounded tip of the previous set, also the abandonment of the collar on the base of the lamp and the changing of the screw thread. It also illustrates the use of the short length of platinum in the solid seal of the inside part.

Fig. 13 shows the Edison lamp of to-day, and embodies all of the latest methods of manufacture which, to a considerable extent, have become automatic.

The lamp comprises the moulded glass globe, the glass butt or base, the chemical exhaustion, the squirted filament, carbon paste clamp, short platinum sealing wire, flat pressed inside seal, oval looped filament, pointed tip seal, etc. The principal advantages of the oval loop being the employment of a longer filament in a small globe, and a more uniform distribution of light from the filament, as an illustration in the "hairpin" type of filament; whereas, the light through the tip would only represent three candles, in the oval loop form it is seven candles.

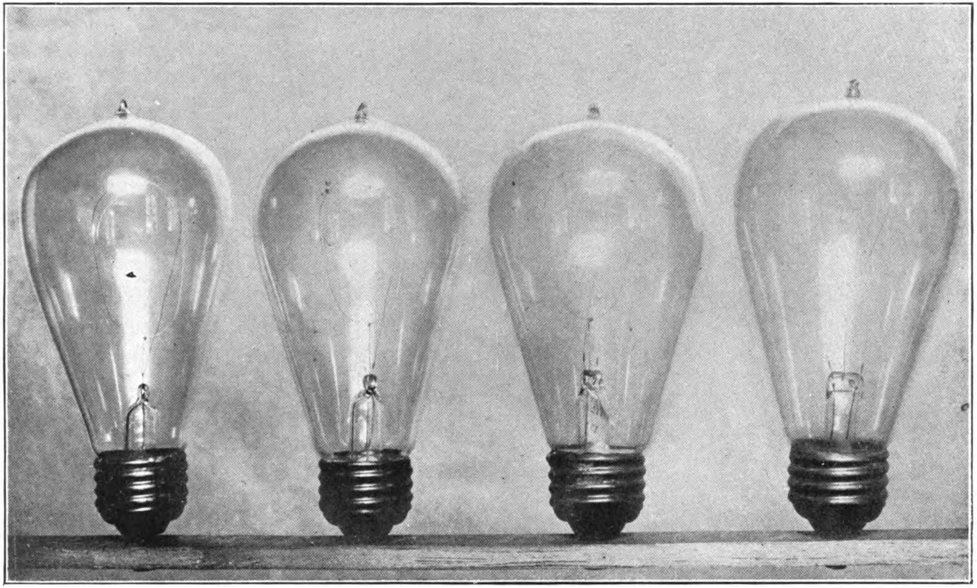


Fig. 13 Standard type of Edison incandescent lamp of 1904

There are various other forms of spiral filaments and forms of globes, including a tipless form of globe.

It is interesting, however, to note that some of the very earliest incandescent lamps made were sealed at the side or at the bottom.

An infinite variety of special types of Edison lamps have been developed, ranging from the tiny surgical lamp of ¼ of a candlepower, up to multiple filament lamps of 500 candlepower; also series lamps for street lighting, buoy lamps, torpedo lamps, night lamps, range-finder lamps, headlight lamps, stereopticon lamps, and many other forms, practically all of which are shown in the exhibit at the St. Louis Exposition.

In conclusion, the writer desires to say that he regrets exceedingly his inability at this time to describe the many interesting and valuable features of the lamps of Mr. Edison's American and foreign contemporaries. He has, however, prepared descriptive cards for the exhibit at St. Louis, which will give considerable information regarding each lamp, the period to which it belongs, and the name and nationality of the inventor.

First electrical fixture ever made for the commercial incandescent lamp

First Electrical Fixture Ever Made for the Commercial Incandescent Electric Lamp

THIS illustration represents the first electrical fixture for the incandescent electric lamp. It was put up in Mr. Edison's laboratory at Menlo Park, New Jersey, in 1879, and was used with the paper horseshoe lamp shown in the socket of the fixture on the occasion of the historic "first light up" at Menlo Park in December, 1879.

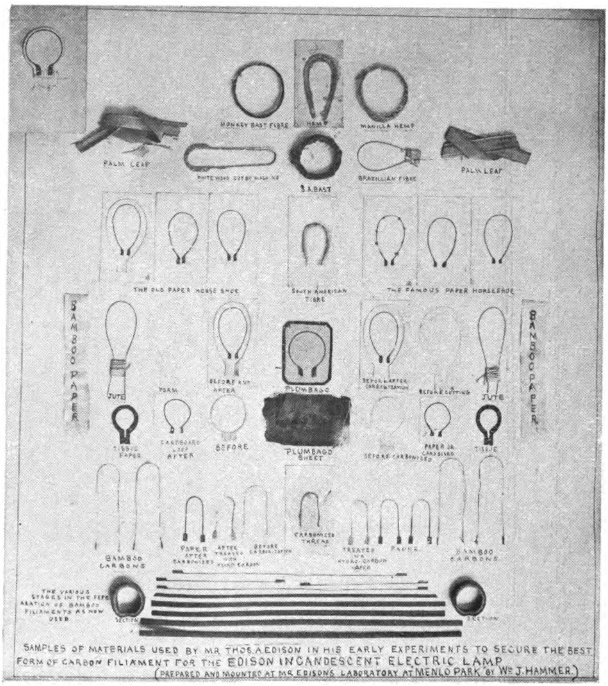
The bracket was made of wood, painted black, and had a wooden socket attached thereto. This wooden socket had a brass screw key for turning the light on and off.

The inside of the socket was furnished with two perpendicular brass plates to which the supply wires were attached, these wires passing through the grooves on the side of the bracket and out through the solid base of the bracket.

The lamp as shown is one of the standard Edison paper horseshoe filament lamps, which represents the first "commercial" incandescent electric lamp ever made, and it will be noted that the lamp has in addition to the carbonized paper horseshoe filament the platinum clamps employed at that time, the round internal seal and the round bulb; and the tip of the lamp is without the supplemental tips subsequently employed. The lamp is also fastened in a wooden base or butt.

The leading in wires were attached to two brass springs on opposite sides of the wooden lamp butt or base, these springs making contact with brass plates on the inside of the socket, the springs also serving to hold the lamp firmly in place.

This bracket and lamp were removed from the wall of the laboratory shortly after their installation and presented by Mr. Thomas A. Edison to Mr. William J. Hammer, who has ever since that time had them in his possession.



Collection of materials used by Mr. Thomas A. Edison in his early experiments made at Menlo Park, New Jersey, to secure the best form of carbon filament for the Edison incandescent electric lamp.

Collection of materials used for filaments in the early types of Edison Incandescent Lamps

THIS collection embraces samples of carbonized thread, paper horseshoe and paper hairpin filaments carbonized and uncarbonized, and also those treated with hydro carbon vapors to fill up the pores of the carbon, filaments made from Japanese Bamboo paper, parchment paper and cardboard; also filaments stamped out of sheets of plumbago formed under a pressure of 50,000 lbs. to a square inch, filaments routed out of solid blocks of wood by automatic machinery, various vegetable filaments such as Manilla hemp, jute, bass, monkey bast, palm leaf, etc., and samples of the early forms of "madake," bamboo, showing the steps which the bamboo passes through in preparing the filaments, and samples of the A & B filaments, or 16-candle and 8-candle filaments both carbonized and uncarbonized.

These are all shown mounted in a frame, having been thus prepared by Mr. William J. Hammer, at Mr. Edison's Laboratory at Menlo Park in 1880.

Edison passenger locomotive and cars of 1882, at Menlo Park, Charles T. Hughes at the throttle

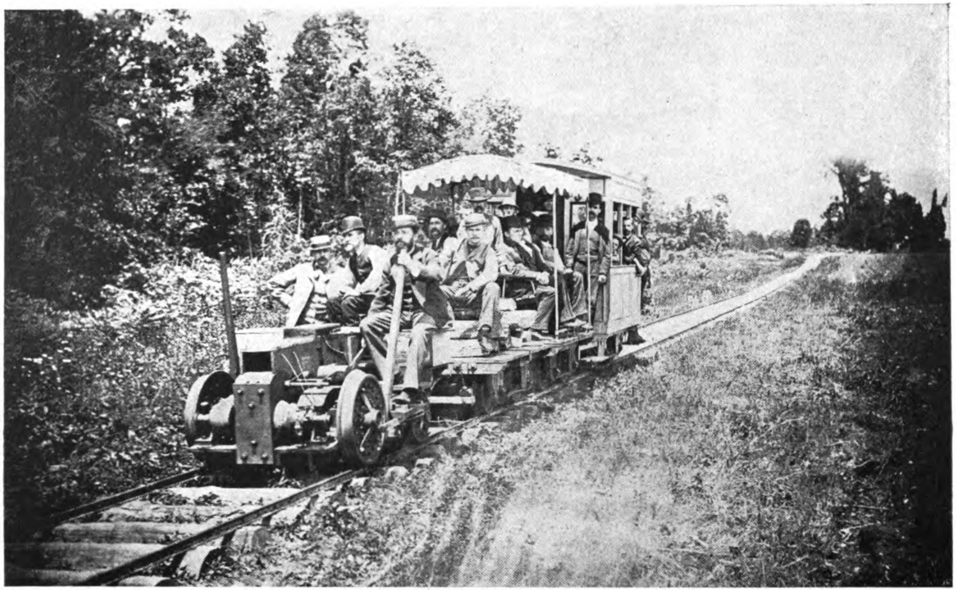
Edison Electric Railways of 1880 and 1882

BY EDWIN W. HAMMER

TWENTY years ago the "Wizard of Menlo Park" was stirring up the scientific and commercial worlds by the announcement of one revolutionary discovery and invention after another. The press and public were clamorous for news of what was being done in that obscure little New Jersey settlement. They were exciting times. Learned disquisitions were written on the impossibility of "dividing the electric light," notwithstanding the fact that the electric light had been "divided" and the "wizard" had several hundred of his lamps burning on one circuit. Those were the days when mathematician Francis R. Upton was kept busy replying to press articles decrying the Edisonian claim to a generator which would return over 90 per cent. of the energy delivered to it in electrical power, the days when gas stocks were going down with a rush and electric stocks were correspondingly inflated.

Those were, indeed, heroic times, and we, seated unconcernedly beneath our incandescent lamps, whirled along metropolitan thoroughfares or country turnpikes in luxurious cars electrically propelled, or busily engaged in some great electrical undertaking involving, perhaps, millions of money, are apt to forget the hard work, the steady plodding, the infinite pains, the exhaustless faith, the disappointments and triumphs of that quiet man of genius and indomitable will at his Menlo Park laboratory from 1878 to 1882.

The story of those times has never been told in comprehensive or connected form, but it is to be hoped that some day it may be; there is a wealth of information ready for the searcher, whose labor will be rewarded. We know that the old laboratory was the Alma Mater



First Edison electric locomotive and train of 1880, at Menlo Park

Charles T. Hughes *William Mills* *William Mungle* *Julius Hornig*
Francis Jehl *Charles Stilwell* *Charles Batchelor* *John W. Lawson*
William J. Hammer *Tom Logan*

of many of our successful electrical engineers.

Although it is a matter of common knowledge and general acceptance that the incandescent lamp was first successfully produced in Menlo Park, it is surprising that so little appreciation is had of the pioneer work Mr. Edison did in dynamo and railway development. It will be the purpose of this article to relate some of the circumstances concerning this early railway work, and to show that in 1880 Mr. Edison built a commercial electric railway which was eminently successful; that in 1882 he built a second and more ambitious road: and that many important problems were presented and solved, and difficulties met and overcome, in these undertakings.

We must remember that Edison had been making some most valuable contributions to the dynamo art. He had developed the dynamo with low resistance armature and relatively powerful field-magnets, and had, as early as his caveat of August 19, 1879, described it and its combination with the compound-winding of field-magnets. He was the first man in the world to put the compound-wound dynamo into practical operation for the maintenance of a constant potential, and it is interesting to note that this use was in connection with electric railroading. He was thoroughly familiar—more so than any other living engineer or scientist—with the regulation and distribution of potentials and currents. He was accustomed to operating generators in batteries connected in series or in multiple arc, self-excited, or separately excited, shunt-wound, series-wound or compound-wound. At his laboratory were worked out some of the most important laws relating to motors and dynamos, as well as to the distribution of electricity. This brings us to 1880.

We are complacent in our present knowledge, perhaps, but we should stop to think for a moment as to what was the "state of the art" in those days. There was only one isolated incandescent lighting plant in the world—that at Menlo Park; not a single central station had been planned; "drop" in contemplated conductors was ascertained by actually measuring it upon a model, constructed to scale, with artificial resistances to represent lamps and small batteries to represent generators. The most powerful generator in the world was at Menlo Park, and would give a current of about 75 amperes at 110 volts; the Edison "system" was just being evolved. But the brain of the inventor was ceaselessly busy; he was the person described by the then Commissioner of Patents as "the young man who kept the way to the Patent Office hot with his footsteps." Order was being brought from chaos, and great things were in contemplation.

In 1878 Mr. Edison had been a member of a party of astronomers and scientists who visited Rawlings, Wyoming Territory, to witness the "Transit of Venus." Mr. Edison had invented an instrument, the tasimeter, for measuring minute changes in temperature, and he was desirous of trying it in connection with the transit observations. While on this journey, he noticed that in the wheat lands of the West the farmers would sometimes transport wheat by wagon for two hundred miles, and he conceived a plan, which he subsequently worked out in detail, for putting an electric tram road in such neighborhoods to act as feeders to steam trunk lines. The trains on these roads were to carry no engineers or other operators, but were to be automatically controlled from stations along the way. In this manner, it was thought, the expenses of operation would be reduced to a minimum. His work in this connection—especially after the great improvements he made in dynamos and motors—impressed him with the entire feasibility of applying electricity for purposes of general traction, and so, early in the year 1880, he began the construction of a piece of track near the Menlo Park laboratory, upon which to make a demonstration of his ideas.

The section of road first laid was about one-third of a mile in length. The rails were light and were spiked to ordinary sleepers, with a gauge of about three and one-half feet. The sleepers were laid upon the natural grade, and there was comparatively no effort made to ballast the road, which started from a point about fifty feet from the machine shop, and took a direction almost directly north along a country road.

The dynamos for this road were originally two in number, of the standard size then being made at the laboratory, and were known as the "Z" type—in the laboratory vernacular "Long-waisted Mary Anns." These dynamos were first placed in the machine shop, and were connected to the two rails of the road by underground conductors. It will be seen that this road was one in which one rail acted as positive conductor and the other rail as negative conductor. These first dynamos were 110 volt machines, and had a capacity of about 75 amperes each. No especial precautions were taken to insulate the rails from the earth or from each other; and it may seem surprising that, under these circumstances, there was so little loss of current due to leakage.

The locomotive that was to be used on this road was being built while the construction of the roadbed was in progress. It consisted of a four-wheeled iron truck, upon which was mounted a "Z" dynamo, to be used as a motor. This machine was laid on its side, with the armature in a horizontal position and the armature end of the motor pointing toward the front of the locomotive. The gearing originally employed consisted of a friction pulley upon the armature shaft, another friction pulley upon the driven axle, and a third friction pulley which could be brought in contact with the other two by a suitable lever. Each wheel of the locomotive was made with a metallic rim and a center portion made of wood or papier maché. A three-legged spider connected the metal rim of each front wheel to a brass hub, upon which rested a collecting brush. The other wheels were subsequently so equipped. It was the intention, therefore, that the current should enter the locomotive wheels at one side, and after passing through the metal spiders, collecting brushes and motor, would pass out through the corresponding brushes, spiders and wheels, to the other rail.

On Thursday, May 13, 1880, everything was in readiness, and the various laboratory assistants gathered to see the fun. The laboratory engine was belted to the generators and current was delivered to the rails. At 4 P. M. the locomotive was packed with as many of the boys as could possibly find roosting places upon it, the switch was thrown over, the armature revolved, and the engine driver brought his friction gearing into operation, and they were off. It was a memorable occasion, and everything worked to a charm, until, in starting up at one end of the road, the friction gearing was brought into action too suddenly, and it was wrecked. This accident demonstrated that some other method of connecting the armature with the driven axle should be arranged.

As thus originally operated, the motor had its field circuit in permanent connection as a shunt across the rails, and this field circuit was protected by a safety catch made by turning up two bare ends of the wire in its circuit and winding a piece of fine copper wire across from one bare end to the other. The armature circuit had a switch in it which permitted the locomotive to be reversed by reversing the direction of current flow through the armature.

After some consideration of the gearing question, it was decided to employ belts instead of the friction pulleys. A counter-shaft was put across the rear of the locomotive frame, and the armature shaft was belted to a large pulley on this counter-shaft, and a belt then ran from a small pulley on the counter-shaft to a larger pulley on the driven axle. The lever which had previously been employed to bring the adjustable friction-gear into place was now equipped with an idler pulley, which could be used to tighten the belt between the driven axle and counter-shaft. As now arranged, the locomotive could be started by turning on the current and allowing the armature to come up to speed before the main driving belt was sufficiently tightened to apply power to the driven axle. Of course, this meant that the belts must slip a great deal before the locomotive actually started, and that consequently the belts would be badly burned at times. It also meant, as was very soon found, that if the belt was tightened prematurely, the armature would be burned out. This happened a number of times, and proved to be such a serious annoyance that resistance boxes were brought out from the laboratory and placed upon the locomotive in series with the armature. This solved the difficulty. The locomotive would be started with these resistance boxes in circuit, and after reaching full speed, the operator could plug the various boxes out of circuit, and in that way increase the speed. In stopping, the first operation would involve the opening of the armature circuit by the main switch, and then applying the brakes by means of long levers within convenient reach of the locomotive driver and his assistant.

This general arrangement proved very satisfactory, but Mr. Edison finally decided that the resistance boxes, which were scattered about the locomotive, under the seats, on the foot-rests and platforms, were a nuisance, and so directed Martin Force to take some No. 8 B. & S. copper wire and wind it on the lower leg of the motor field-magnet. By doing this the resistance was put where it would take up the least room and where it would serve as an additional field coil when starting the motor, and it replaced all the resistance boxes which had heretofore been in plain sight. The boxes under the seat were still retained in service. Of course this coil of coarse wire was in series with the armature, just as the resistance boxes had been, and could be plugged in or out of circuit at the will of the locomotive driver. The general arrangement thus secured was operated with practical continuity as long as this road was in commission, and will be found on this same old locomotive to-day.

This locomotive was up to date in having an electric headlight and a signal bell; it carried thousands of interested passengers, who made pilgrimages to Menlo Park from all over the world; and it was used in transporting all of the material necessary to the extension of this road from its original length of one-third of a mile to about one mile in length. When completed, the road was run in a northerly direction for about one-third of a mile, then turned to the left for about the same distance, and then ran in a southerly direction for nearly one-third of a mile more. The very end of this road was at the bottom of a steep grade, about 300 feet long, which dropped about 60 feet in that distance. The curves were so sharp, the grades so steep, and the speeds attained so great (as high as 42 miles an hour), that a number of derailments took place, and there were several narrow escapes in consequence.

From the beginning there had been three cars in use on the road, in addition to the locomotive itself. One of these was a flat car used for freighting purposes; one was an open car with two park benches placed back to back and protected by an awning, and the third a box car, familiarly known as the "Pullman." All of these cars were built at Menlo Park.

Later in the year the railroad generators were moved to a room adjoining the machine shop, opposite the end of the track, and were compound-wound to better regulate for the changes in load on the railway circuit.

This public exhibition of the railway naturally attracted much attention, and numerous articles were written about it. The New York Herald for May 15, 1880, gave an account of the starting of the road and the action to the friction gearing which has been mentioned. The Scientific American of June 6, 1880, also gave an interesting article, in which editorial mention is made of a trip upon the road by representatives of the paper and a dozen other passengers at a speed of 25 to 30 miles an hour, up and down the grades, around sharp curves and over humps and bumps, and that all were convinced there was no lack of power in the machine. The *Herald* of July 23, 1880, asks: "Why not apply it to New York's elevated railroad?" This was followed by an article in the next day's *Herald*, saying: "The possibilities of the future, * * * when the engine dashing through the streets shall be noiseless, dustless and smokeless, are most pleasing to the average New Yorker, whose head has ached with noise, whose eyes have been filled with dust, or whose clothes have been ruined by oil." The New York *Graphic* of July 27, 1880, also gave an admirable illustrated article upon the same subject. One of the illustrations was a sketch made by Mr. Edison of a proposed 100 horsepower locomotive to be used on the Pennsylvania Railroad, between Perth Amboy and Rahway.

Many railroad men from all over the world visited Menlo Park and rode upon the electric railway. Among them were Messrs. Henry Villard and J. C. Henderson, of the Northern Pacific; Messrs. Haines and Navarro, of the Manhattan Elevated; Mr. Frank Thompson, of the Pennsylvania, and Messrs. Biedermann and Thury, of Switzerland.

Before leaving the subject of this 1880 road, attention should be called to an interesting adjunct to the "Pullman" box car. This was the system of electric braking employed, a system described in the Edison Patent No. 248,430, also applied for on July 22, 1880. Each car axle had a large iron disk mounted on and revolving with it, between the poles of a powerful horseshoe electro-magnet. The pole-pieces of the magnet were movable and would be attracted to the revolving disk when the magnet was energized, grasping the same and acting to retard the revolution of the car axle.

The first railroad was operated almost continuously during 1880 and a large part of 1881, but on Sept. 14, 1881, an agreement was entered into between Mr. Henry Villard and Mr. Edison, from which the following is an extract:

> "Edison will build 2½ miles of electric railway at Menlo Park, equipped with three cars, two locomotives—one for freight and one for passengers; capacity of latter, 60 miles per hour. Capacity freight engine, 10 tons net freight; cost of handling a ton of freight per mile per horsepower to be less than with ordinary locomotives. * * * If experiments successful, Villard to pay actual outlay in experiments and to treat with the Light Company for the installation of at least 50 miles of electric railroad in the wheat regions."

Mr. Edison says Villard paid between $35,000 and $40,000 on account of this road, and that the work, while eminently satisfactory, did not result in the proposed road in the wheat regions, because the Northern Pacific went into the hands of a receiver.

Construction work began at once, but the road was not ready for use until early in 1882, and has consequently come to be known as Edison's 1882 road. The track was straighter than that of the 1880 road. There were three sidings, two turn tables, a freight platform, japanning oven and car house, on the line of the road, which ran from a point above the laboratory buildings nearly due south to Pumptown, almost three miles away. This road was nearly standard gauge, and was well and substantially constructed, with numerous trestles along its length; one trestle was 200 or 250 feet long, and 10 feet high; another was 75 or 100 feet long and 2 to 4 feet high; a third was 75 feet long and 6 feet high, and a fourth was 75 feet long and about 2 feet high. There were numerous cuts and fills, and every effort was made to have a thoroughly good roadbed. Current was supplied to the road by underground feeder cables from the dynamo room of the laboratory. The rails were insulated from the ties by giving them two coats of japan, baking them in the oven, and then placing them on pads of tar-impregnated muslin laid on the ties. The ends of the rails were not japanned, but were electro-plated, to give good contact surfaces for fish-plates and copper bonds.

The passenger locomotive was the first one finished, and it was used for hauling the ties, earth, rails, etc., used in building the road. The freight platform was at a point nearest the laboratory, and material was carted there and then distributed along the road as needed, by the locomotive and train of six or eight small flat cars. Thousands of tons of earth and other materials were transported on the road in this manner.

The two 1882 locomotives were pretentious affairs, compared with that of 1880, having cab, cow-catcher, head-light and other appurtenances, which made them look much like steam locomotives. The electrical features were very similar to those already described. but were worked out with much greater refinement of detail. The motor was placed on its side, as before, and was supplied with shunt and series field-windings. The series winding could be plugged out of circuit at will; resistance boxes supplemented the series winding and these resistances could also be plugged in or out, as desired. The resistance boxes were placed under the seats of the cab. The passenger car weighed about five tons when in commission, and the freight locomotive about twice as much.

The freight locomotive had single reduction gears, as is the modern practice, but the power was applied through a friction-clutch. The passenger locomotive was very speedy, and ninety passengers have been carried at a time by it; the freight locomotive was not so fast, but could pull heavy trains at a good speed. Many thousand people were carried on this road during 1882.

On June 19, 1882, Mr. Edison entered into an agreement with Charles W. Havemeyer, of Brooklyn, and Ernest Biedermann, of Switzerland, under which these gentlemen agreed to build works and install electric railways in Switzerland according to Edison's ideas, but this agreement was afterward modified so they could handle electric lighting instead of railway apparatus. Mr. Edison's attention and that of the Edison Electric Light Company was being concentrated more and more upon the development of the lighting industry, and railway interests correspondingly suffered. From the standpoint of the electric railroader it was a great misfortune that the financial difficulties into which the Northern Pacific road was plunged prevented the carrying out of Mr. Villard's comprehensive and broad-minded schemes for rural transportation. Had these gone through, electric railway history would doubtless have been made more quickly.

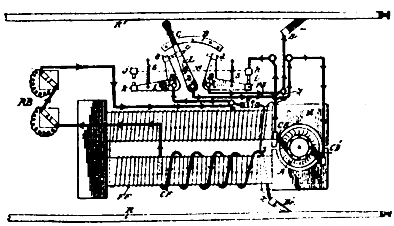


Diagram of connections, Edison's Electric Locomotive of 1880, showing shunt and series field coils

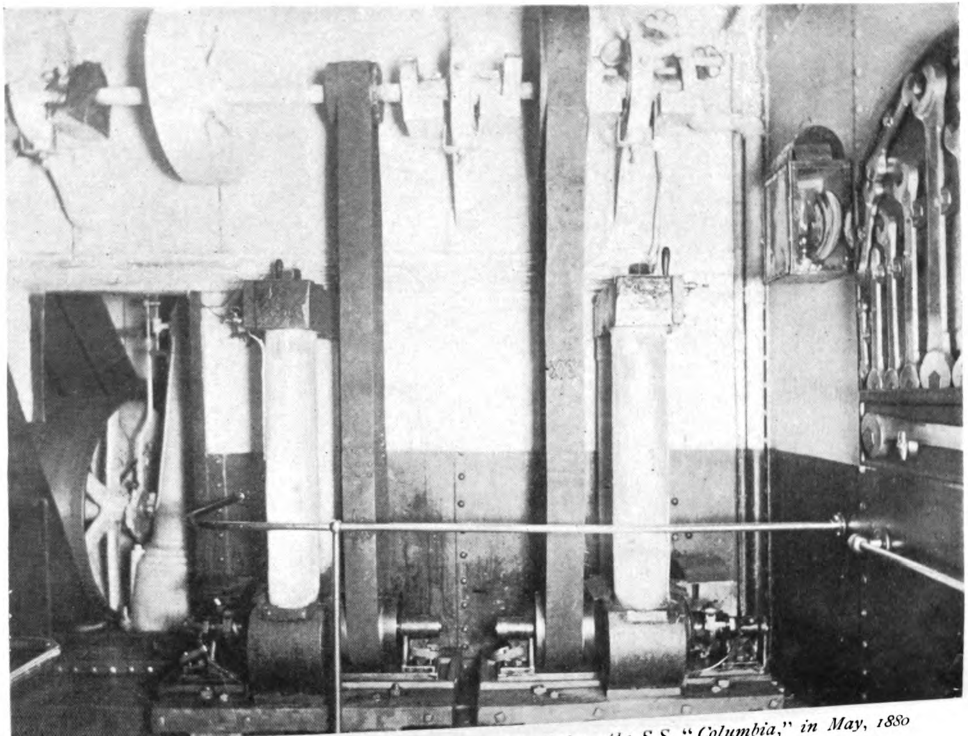
The Steamship Columbia

BY W. J. JENKS

THE steamship Columbia was built by John Roach at Chester, Pa., in 1879, for the Oregon Railway and Navigation Company, of which the president was the late Henry Villard, then also a director in The Edison Electric Light Company, of New York, and afterward its president. Early in 1880 the vessel was sent to New York to be fitted out for her voyage around Cape Horn, and the electric light plant was then installed. She sailed from New York in May, 1880, loaded with 13 locomotives, 200 cars and other railroad supplies, and arrived at Portland, Oregon, two months later, July 26.

Generators.—The generating plant consisted of three separately-excited 100-volt constant-potential dynamos (constructed at the laboratory of Thomas A. Edison, Menlo Park, N. J.,), each capable of supplying 60 lamps of 16 candlepower. They were belted to a countershaft driven by two vertical engines, and having armatures of low resistance (Scientific American, Oct. 18, 1879; p. 242), were connected in parallel and supplied current to the lamp circuits; a fourth dynamo, driven at half the speed of the others, was used as their exciter; (Patent 369,280). By regulating this exciter, the potential of the other three was standardized and maintained; (Patent 288,318). Two of these dynamos, one of the vertical engines, and a portion of the countershaft, are shown in this photograph, which clearly indicates the long magnets characteristic of the early Edison machines, which were afterward designated, according to their capacity, as "Z," "L," or "K" dynamos.

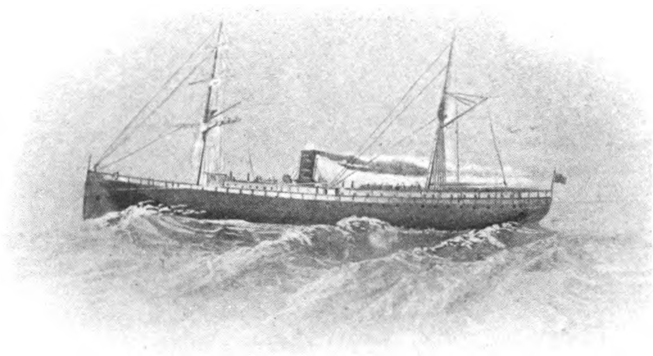
Distributing System.—The main leads from the generators were connected on a switch board in the engine room with omnibus conductors, each of which was made up by bunching all the distributing wires of the



First commercial Edison electric lighting plant; installed on the S.S. "Columbia," in May, 1880 same polarity and covering the stranded cable thus formed with soft rubber tubing. From these cables radiated seven independent feeder circuits, each connected at its outer end with an independent distributing circuit supplying current to the lamps of some section of the ship. One feeder supplied the staterooms on the upper deck, another those on the lower deck, still another the saloons, etc.; (Edison caveat, August 19, 1879; patent 264,642). Each feeder conductor consisted of a single strand of No. 11 B.W.G., copper wire, and No. 20 wire (some accounts say as small as No. 32) was employed for the branch conductors of the distributing circuits. All these conductors were insulated by a paraffined double cotton covering, oiled and painted; those of one polarity being white and those of the other red. All of the conductors were secured to the woodwork by iron staples.

Controlling Switches.—Each dynamo circuit was independently controllable by one single-pole plug-switch. The picture shows the plugs of two dynamos standing upright in holes bored in the wooden dynamo-switch bases for securing the plugs when not in use. Each feeding circuit was independently controllable by a single-pole plug-switch on the switch-board in the engine room, and thus all the lamps on that circuit could be lighted or extinguished by its plug. A switch provided with a key-hole and lock was placed outside each stateroom, and the lamp inside was thus controllable by the steward.

Safety Cut-Outs.—The system was remarkably well provided with safety devices. One single-pole fusible lead wire was placed in each dynamo circuit. (French patent, No. 130,910; Fig. 69.) Each lamp in the staterooms and some other localities was provided with a single-pole safety-catch consisting of a small lead wire surrounded by a glass tube about an inch in length, the ends of which were secured by wood screws and washers; (patent 227,226). In chandeliers one similar safety-fuse for all the lamps was placed at the top.



From an old engraving of the S.S. "Columbia"

Sockets and Fixtures.—Wooden sockets not containing fuses were originally provided for all the lamps (Patent 265,311), but the lamps then in use were so easily broken by shocks that the stateroom sockets, first fastened by short brackets directly to the woodwork, were removed, and the lamps suspended from the supply wires, thus securing more flexibility. The fixtures in the saloons were so arranged that oil lamps could be readily substituted for the electric light in case of necessity.

Early Lamps.—These were the all-glass chambers inclosing carbon filaments of high resistance described and claimed in Patent 223,898. 115 such lamps, each of 16 candlepower and requiring about 100 volts, and then known as "A" lamps, were originally installed, and the lighting was confined to the passengers' staterooms and main saloons, although circuits were run throughout the ship. The lamps first used had horseshoe-shaped paper carbon filaments (Patent 317,676), and frosted globes to soften the light. During the time occupied by the trip around the Horn, Edison made the first bamboo carbon filaments, and sent a supply of the improved lamps across the continent to meet the ship at Portland and replace the fragile paper carbon lamps.

Philip Seubel had charge of the installation of the wiring system, fixtures, switches; Francis R. Upton had general superivision of the work.

In a letter to Mr. Edison, February 24, 1882, John C. Henderson, the advising engineer of the Oregon Railway and Navigation Company, said:

"On the night of the 2d of May, 1880, we started up the dynamos, and from the time when the steam was first turned on until the present they have worked to our entire satisfaction under all circumstances. * * * Since the arrival of the ship on the Pacific Coast, we have received a full supply of new bamboo carbon lamps. How well they have worked can best be seen from the following report of Chief Engineer Van Duzer: 'I have now 115 lamps in circuit, and have up to date run 415 hours and 45 minutes without one lamp giving out.'"

Long Commercial Usefulness.—The plant continued in service, substantially unaltered excepting as to minor details, for more than fifteen years, until July, 1895, when the ship was given a general overhauling, and the old Edison plant was removed to make way for one of modern construction. The Electrical Journal (San Francisco) of July, 1895, says (p. 22):

"The plant has a record of service for a period of nearly a quarter of a million hours, with no repairs to the machines, it is said, except the rewinding of one field coil, and a few minor repairs to the bearings, etc. So far as can be ascertained, the Columbia never lost an armature, and the commutators have received only such attention and renewals as has been necessary from normal and proper usage."

Further details may be found in the following printed publications:

New York Daily Tribune, April 28, 1880, p. 8, col. 1.

Scientific American, Vol. 42, p. 326, May 22, 1880; Vol. 43, p. 96, August 14, 1880.

Fourth Bulletin, The Edison Electric Light Company, New York, February 24, 1882, pp. 1-2.

The Electrical Journal, San Francisco, Cal., Vol. 1, No. 1, July 1895, pp. 22-23.

Defendant's testimony in Schlesinger Railway suit on Patent 546,059; W. J. Jenks, pp. 468-471; F. R. Upton, pp. 899-900.

Electrical Engineer, New York, Vol. XV., No. 252, March 1, 1893.

Early Edison Lighting Plants

FIRST EXPERIMENTAL MARINE PLANT

THE "Jeannette"—formerly the "Pandora"—left San Francisco, where she had been refitted by James Gordon Bennett for Arctic exploration, by way of Behring Straits, July 8, 1879, under the command of Lieutenant George W. DeLong, U. S. N., with a crew of thirty-one men. She had been provided, through the generosity of Mr. Edison, with a small dynamo somewhat less in capacity than the type afterward standardized for sixty 16-candle lamps—commercially known as the "Z" machine—and a few platinum lamps which were used to a limited extent. This was one of the first Edison dynamos made for any purpose, and the first which was placed upon a seagoing vessel.* It went down with the ill-fated ship amid the ice of the Arctic Seas.

EDISON COMMERCIAL PLANTS INSTALLED IN VARIOUS PLACES

The first Edison dynamo ever placed on land for the lighting of incandescent lamps in a business establishment was of the old "Z" type, placed in January, 1881, in the establishment of Hinds, Ketcham & Co., lithographers and printers of colored labels and show cards, at 449 Water Street, New York. The usefulness of the light in distinguishing colors was the motive for the placing of this first commercial plant on land, and the firm stated a year later: "It is the best substitute for daylight we have ever known, and almost as cheap."

The first mill plant of the Edison Company was started in the woolen factory of James Harrison, Newburgh, N. Y., about September 15, 1881. In February, 1882, Mr. Harrison wrote: "I believe my mill was the first lighted with your electric light, and therefore may

*The installation on the S.S. Columbia was really the first *commercial* installation anywhere made. C. L. C.

be called No. 1. Besides being job No. 1, it is a No. 1 job, and a No. 1 light, being better and cheaper than gas, and absolutely safe as to fire."

The first yacht lighted by incandescent lamps (120 "B" lamps, 8 candlepower each), was that of James Gordon Bennett, the "Namouna," early in 1882.

FIRST HOTEL LIGHTED

The first Edison plant in a hotel was started in October, 1881, at the Blue Mountain House, in the Adirondacks. It consisted of two "Z" machines, 230 "A" and 102 "B" lamps, of which 125 lamps were run at one time, and showed an average life of 800 hours. Here the first lamp was placed on an elevator car July 12, 1882. This hotel is situated at an elevation of 3,500 feet above the sea, and was at that time 40 miles from the railroad. The machinery was taken in pieces on the backs of mules from the foot of the mountain. The boilers were fired by wood, as the commercial transportation of coal was a physical impossibility. For a six-hour run of the electric plant, one-quarter of a cord of wood was required, at a cost of 25 cents per cord. Regulation of the dynamo was effected by a rheostat in the office about 100 feet from the center of distribution.

FIRST THEATRE LIGHTED IN THIS COUNTRY

The Bijou Theatre, of Boston, was lighted by an Edison isolated plant December 12, 1882. The installation of boilers, engine, and dynamos, wiring, switches, three stage regulators, and 650 lamps, was completed eleven days after receipt of order. Gilbert & Sullivan's "Iolanthe" was the first attraction. The generators were 500 feet from the theatre. On the stage was a bank of 11 switches; there were no footlights; 192 "A" lamps surrounded the proscenium arch; 140 were placed in the borders and 60 in the chandelier of the auditorium, making a total of 644. No other method of lighting was provided.

FIRST SINGLE LAMPS, FLEXIBLES AND CUT-OUTS

In 1881, the residence of J. Hood Wright, in New York City, was lighted by Edison lamps. The practice regarding fusible cut-outs, or "safety-catches," was variable, but most of the lamps, with the exception of those on fixtures, were individually protected by fuses.

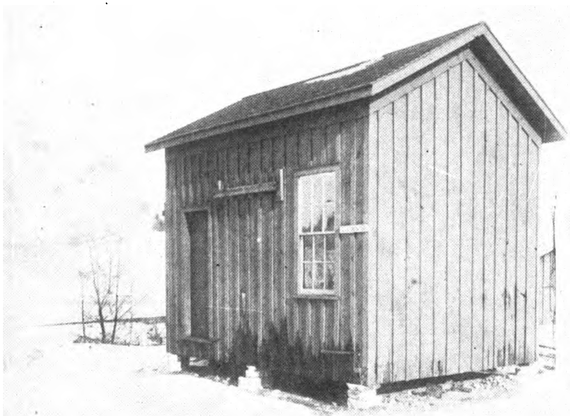
The first single lamp cut-outs on flexibles were used in the Mechanics' Fair, which opened in Boston, September 6, 1882. Here four Edison dynamos were employed, two of the "K" type, one of the "L" type, and one of the "Z" type. The state of the art is indicated by the fact that while two dynamos were running in multiple, one of them reversed the other and operated it as a motor. The Fair was lighted by 650 lamps of 16 candlepower, a few of 10, and a few of 32 candlepower, of the Edison type. No ceiling construction for flexible pendants had thus far been used. At this Fair, five such pendants had been made of ordinary cotton telephone cord sewed into a flat webbing and covered with an ornamental coating. The earliest regular flexible conductors for incandescent lamp pendants were made for the Louisville exhibition of 1883, and consisted of ordinary cotton-covered wire impregnated with Kruesi's compound, and covered by Bishop.

An Edison lighting plant was started at the Everett House in lower New York, February 9, 1882. This was the first contract where the isolated company controlled the work, in which cut-outs were placed in the lamp circuit at the top of each fixture.

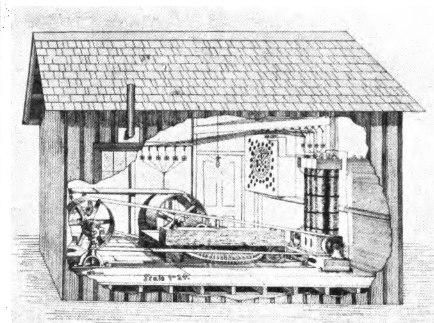
The first cut-out ever put in a canopy at the top of an incandescent lamp fixture, was placed in a rear office at 65 Fifth Avenue, then the headquarters of the Edison Company, at the suggestion of Philip Seubel, after the conductors inside the fixture had repeatedly burned out.

BOSTON POST OFFICE PLANT OF 1882

Two Edison dynamos of the "K" type, 110 volts, and about 200 amperes, were belted to an intermediate shaft



First commercial Edison station, started at Appleton, Wisconsin, in 1882

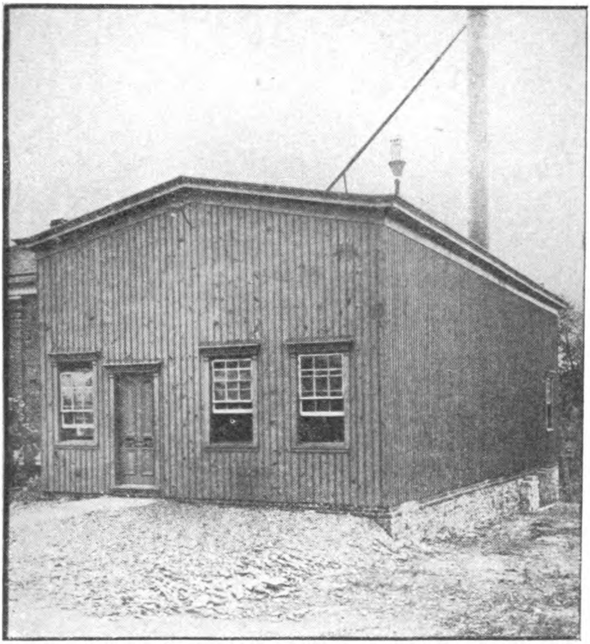


Interior view, showing "K" dynamo, which continued in operation until 1899 between short countershafts which could be coupled to either one of two engines by positive clutches. The two dynamos could thus be thrown from one engine to the other at full speed, and were thus changed once in about every twenty-four hours. A thirty-day test was to be made the basis of a decision as to an increase from the original 500-light equipment to 1,200 lamps. At the end of the month, during which these two dynamos had not been allowed to stop for a moment, the increase was ordered, and the light was so desirable that the original dynamos were kept running without cessation until the enlarged plant was installed, the current having then not been interrupted for an instant during their continuous run of 87 days, or 2,088 hours. On the eighty-seventh day an engine slide got so hot that a stop was necessary before the clutch could be thrown upon the other engine. The second engine was immediately started, however, and the run continued; about ten days after this accident, another stop for a quarter of an hour was made to repair a belt; with the exception of these two short stops the dynamos were run continuously for something over 130 days. This performance has been justly characterized as the most remarkable ever made by an electric generator during the early years of electric lighting. It was also the first time a dynamo was successfully speeded, and then with a single motion thrown upon a countershaft by a positive clutch. The records of the postoffice show that the saving in cost over gas during the first year was something over $8,000.

EDISON'S LAMP FACTORIES

Prior to November, 1880, a large number of lamps were made at Menlo Park, but the first regular payroll of the Edison Lamp Company was November 11, 1880, and this fixes the starting of the lamp factory.

From that date to April 1, 1882, when moving was commenced to East Newark, now Harrison, the factory was constantly operated, except for a period of about



Exterior of the station at Sunbury, Pennsylvania six weeks. The largest number of men employed at any one time was 135. About 80,000 lamps were shipped from Menlo Park, and at the time of removal about 50,000 were in stock.

The lamp factory at East Newark was started June 1, 1882, and 150 men were employed.

FIRST TWO-WIRE EDISON ELECTRIC LIGHTING STATION AT APPLETON, WISCONSIN

The first commercial Edison electric lighting station on the two-wire system was started at Appleton, Wisconsin, about August 15, 1882. The generating apparatus consisted of one "K" dynamo driven by water power and having a capacity of 250 ten candle power incandescent lamps. The original machine was continued in active operation until 1899.

SUNBURY, PENNSYLVANIA

This was the first three-wire central station actually started and put into operation, although it was contracted for at a later date than the Brockton station.

The generating plant consisted of two "L" dynamos belted to a high speed Armington & Sims engine, the total capacity being about 400 16 candlepower lamps. The indicating instruments were of the crudest construction, and consisted of two volt meters which were connected by "pressure wires" to the center of electrical distribution; one ammeter interpolated in the "neutral bus" to indicate when the load was out of balance, and half a dozen roughly made plug switches.

The "bus bars" were made of No. 000 line wire, straightened out and fastened to the wooden sheathing of station by iron staples without any pretense to insulation.

This installation was made under the supervision of Lieut. F. J. Sprague and Mr. W. S. Andrews, and it was formally started for commercial service by Mr. Edison on the 4th of July, 1883, with about 100 lamps connected. Sunbury was provided with the first chemical meters used outside of New York City.

The two "L" dynamos were in regular commercial service in Sunbury station for about twenty years, and were afterwards used as spare machines. Together with the Armington & Sims engine, they now form a part of the "Collection of Edisonia," and are practically in as good operative condition as when they were originally installed.

ROSELLE, NEW JERSEY

Closely following the starting of the First District of New York City, the Edison Company for isolated lighting desired to make an exhibition of the possibilities in illuminating small towns, and urged Mr. Edison to install a plant convenient of access to visitors to the New York office. This was done at Roselle, where the buildings were scattered, by furnishing a dynamo giving 330 volts, and a two-wire multiple arc system with three lamps in series in each branch. By this method stores, hotels, and even residences were lighted, with the disadvantage of extinguishing three lamps whenever one was put out. This installation, the only representative of its kind, continued in successful operation for nearly ten years following the fall of 1882, when it was started.

EDISON PLANT ON THE UNITED STATES FISH COMMISSION'S STEAMER "ALBATROSS"

The alleged decline of the food fishes along the sea coast and in the lakes of the United States, induced the passage by Congress in 1871 of an act authorizing the appointment by the President, with confirmation by the Senate, of a Commissioner of Fish and Fisheries to investigate the subject and report the facts. The questions arising in regard to the movements of deep sea fish made it necessary to provide a seagoing steamer, and as a consequence the "Albatross," an iron twin-screw vessel, built at Wilmington, Del., was launched August 19, 1882.

In April, 1883, the vessel made her first cruise; her length over all was 234 feet, with 27 feet 6-inch beam, and a registered tonnage of 384 tons. The operation of the dredge in great depths sometimes carried the day's work past midnight; after the contents of the dredge were safely deposited on board the vessel, the naturalists were required to preserve the specimens. To facilitate this, the Commissioner authorized the installation of an incandescent plant. The dynamo provided was of the "Z" type, 51 volts, with a current for 120 lamps of 8 candlepower. It was driven by an 8½ by 10 A. & S. engine. The wiring was protected from dampness by the use of the ordinary underwriters' covering. In wet places rubber tubes and in hot lead tubes were used. Two-belt circuits were arranged so that in case of an accident to one, the lamps might be fed by the other. The most interesting feature of this installation, which was the first ever placed upon a United States steamship, was the employment of deep sea lamps, supplied with current through a cable 940 feet in length for the purpose of capturing specimens. By means of the brilliancy of these lamps, marine animals were attracted and readily ensnared by nets.

LOUISVILLE EXPOSITION OF 1883

This plant was a pioneer in the lighting of large spaces by incandescent lamps. It was constructed on the three-wire plan, and was formally started in August, 1883, with its full capacity of 5,000 incandescent lamps of 16 candle-power each. It was two years after the successful operation of this isolated plant before any three-wire central station of like capacity was developed.

Its construction was phenomenally rapid. Careful surveys and calculations were made by the late Luther Stieringer, and on the 17th of June, 1883, after his plans had been completed and approved, orders were placed. On the 23d of June the material was shipped; on the 27th constructors went forward to undertake the work; on the 9th of July the material and supplies arrived; on the 1st day of August Chester A. Arthur, then President of the United States, opened the exhibition with the Edison plant complete, though the lamps were not lighted because the buildings were unfinished.

Inasmuch as there were two types of engines, one of 650 horsepower Corliss, and three of 125 horsepower each, Armington & Sims, these sources of power were attached to separate omnibus conductors and cribbed mains served by separate feeders. There was also a night circuit supplied by an additional Armington & Sims engine of about 35 horsepower.

The Jury on Awards reported November 9, 1883, and four medals were presented to the Edison Company: (1) for the best incandescent light system; (2) for the best dynamo; (3) for the best electric lamp; (4) for the best incandescent light. The chairman of the jury was Professor Benjamin Rankin, of the Kentucky Institute of Technology, who was at that time superintendent of the Louisville Gas Company. The jury said: "The tests of the Edison system are more satisfactory as to efficiency of the various appliances and steadiness of light, and the general results may be worthy of notice. * * * During the 100 days of the Exhibition, with over 4,000 lights, there was not at any time a suspension of light from the failure of the appliances of the Edison Electric Lighting Company."

Mr. Stieringer always considered that the rapid installation of this plant was made possible only by the use of a roller scaffold, capable of extension from 30 to 60 feet in height. Of course it would have been impossible to operate a system so large without the regulating instrument of later days, not then developed, except on a nearly constant load, or without the individual fusible cut-outs or "bugs," with one of which each lamp was separately provided.

The length of runs was invariably from 8 to 9 hours, and the shellac used for protecting the insulation of the conductors from the leakage which was inevitable if their flimsy cotton coverings were exclusively depended upon, was almost constantly hot in some places. It was nearly ten years after this plant was dismantled before any three-wire system was developed having so large a watt output per day.

So successful was this first exhibition lighting that when it was decided, after the machinery and conductors had been removed, to repeat the exhibition in the same building in the following year, no change was made in replacing the system of distribution, as to the sizes or numbers of conductors, or number of lamps employed. This magnificent success did more to stimulate the growth of the incandescent lighting business than any other event in the history of the Edison Company. The building had no arc lights, although the floor space of 14 acres included an art gallery 800 feet from the main building, supplied by a two-wire feeder with two lamps in series across the full potential of the system.

BOSTON FOREIGN FAIR OF 1883

This second exhibition was started September 3, 1883, and operated until December. About 1,500 Edison lamps were employed, and the Christmas tree took several hundred more. This tree was designed to be operated by an automatic device which would make the light of these lamps appear and disappear in time with whatever music might be played, and it was manipulated by means of a keyboard of switches, the operator being concealed at the base of the tree. The effect was so pleasing that Christine Nilsson, the Swedish Nightingale, who was in the audience, begged to be allowed to manipulate it.

THE FIRST UNDERGROUND THREE-WIRE SYSTEM AT BROCKTON, MASS

In February, 1883, the Edison Electric Illuminating Company, of Brockton, was organized by William Lloyd Garrison, Jr., and a number of his financial friends, with the object of organizing, installing, and operating central station incandescent lighting plants by the three-wire system which Mr. Edison had devised in the fall of 1882 as a solution of the difficulty of distributing considerable quantities of electrical energy without impracticable losses or excessive copper outlay over wider areas than could be served by the simple multiple arc system which had been used in the First District in New York. Application had been made in 1882 for a patent in this country, which was issued to Mr. Edison in March, 1883. The contract first made by the Brockton Company with the Edison Electric Light Company contemplated the installation of an overhead pole line system, but it was found that by reason of many large trees, and a public sentiment adverse to overhead lines which would interfere with those trees, an underground tube system was indispensable. The construction company organized by Mr. Edison to build and equip central stations, took entire charge of building and starting the plant, and Mr. Edison attended the formal opening on October 1, 1883, and remained a week in consultation with his engineers and in watching the operation of the first three-wire underground system in the history of the art, which then supplied current to only about 200 lamps of 10 candlepower each, and had a capacity of about 1,600 lamps.

The equipment consisted of two Babcock & Wilcox boilers of 73 horsepower each; one Armington & Sims engine of 125 horsepower, 14½ by 13-inch cylinder; one 35 horsepower 8½ by 10, and three Edison "H" dynamos, the third dynamo being so arranged by a breakdown switch as to supply both sides of the system during light loads.

This arrangement of using one dynamo on both sides was found to interfere with chemical meter registration, the meters on one side of the system registering backward during the hours when this combination was employed, so that after running an all-night customer having lamps on one side of the system, the company might be found to owe him something for the privilege of supplying him current. Hence about six months after the starting of the station, when the meter registration assumed permanent importance, the third "H" dynamo was replaced by two dynamos of the "S" type, each of 200 lamps capacity.

Lieutenant Frank J. Sprague was Mr. Edison's engineer for the installation and early operation of this plant. It was in the office of this station that he wound the first model of his railway motor, the iron work being made according to his plans at a machine shop near by.

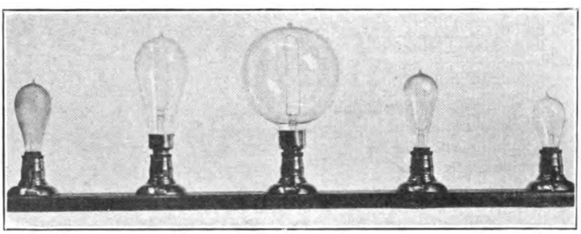
H. Ward Leonard was Mr. Edison's meter man at this station, and during his stay of two months or more, made careful meter experiments and drew valuable deductions which contributed much to the success of the meter practice of the next ten years, particularly in three-wire systems.

The first theatre operated from an Edison three-wire, or any other central station, was one which opened at Brockton in 1884, with an equipment of 500 lamps, connected with the distributing mains by two three-wire services, the current being sold through four 100-light meters connected in multiple arc. The confidence which by that time had been established in the reliability of the light was such that this theatre was never piped for gas, and its illumination was perfectly satisfactory, even with the small number of lamps installed. It was at first planned by Bergmann & Co. to place the 50-light central fixture in this theatre auditorium on a single main cut-out, without branch cut-outs in the fixture itself. The suggestions of the late Luther Stieringer, the widely known lighting expert, resulted in the division in the wiring of this fixture so that a separate cut-out was provided for each group of five lamps, 20 of which were placed on one side of the three-wire system and 30 on the other side.

The first residence ever lighted from a three-wire system, and the first fire engine house supplied by any incandescent lighting central station, were connected with this plant in 1884, the latter building being so equipped that the striking of the fire alarm during the night would automatically light all the lamps through the house, and liberate the horses, and thus for the first time assisting the work of the fire department.

Many attractive features of what was for two years the show plant of the Edison Company, were particularly noted by a multitude of distinguished visitors, among them being Professor Elihu Thomson, who was present at the opening, and Professor W. H. Preece, of London, who visited this country at the time of the Franklin Institute Exhibition of 1884. The methods pursued in Brockton formed the basis of similar installations in Lawrence, Mass., in November, 1883; in Fall River, Mass., in December, 1883; and in Newburgh, N. Y., the following spring.

*In this connection, see article in *New York Electrical Review* of August 23, 1884; also statement by W. L. Garrison at a meeting of the Association of Edison Illuminating Companies about 1892.



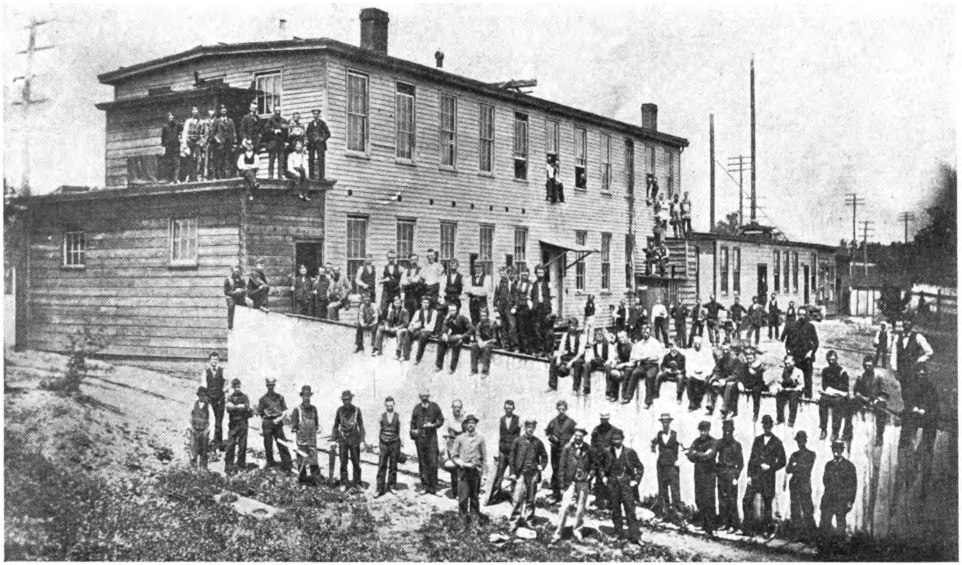
First Edison Lamp Factory

THIS illustration represents the first factory established in the world for the manufacture of incandescent electric lamps.

The main building was originally occupied as the Edison Electric Pen and Duplicating Works, and for a time for the manufacture of a gummed paper. It was situated along the line of the Pennsylvania Railroad, at Menlo Park, N. J., a short distance from Mr. Edison's house.

In 1880, the glass blowing, carbonizing, testing, and other departments connected with the experimental work and early manufacture of the Edison incandescent electric lamp were removed from the laboratory to the electric pen works, which was equipped with several hundred of the modified form of Sprengel vacuum pumps, devised at that time at the laboratory, which were supplied with mercury by a huge steel pump on the Archimedes screw principle.

The plant was equipped with its own plant for manufacturing gas for use of the glass blowers and for use in the carbonizing furnaces, and there was also installed a large engine and boiler plant for heating the buildings and driving the Edison dynamos, of which there were six in number, of the original "Z" type. These dynamos supplied electricity for lighting the buildings, for lamp testing, for flashing the lamps on the pumps, and for supplying current to a number of electric motors which were employed in driving the saw used in cutting up the bamboo, at that time used for the manufacture of the filament of the Edison lamp; also for rotating the annealers in the glass-blowing department, and driving the blower used for the carbonizing furnaces and for glass blowing; and an electric motor was also used for driving the Archimedes screw mercury pump. There were four motors in all, some series and some shunt.



First Edison incandescent lamp factory at Menlo Park, N. J., 1880
Executive Staff—Philip S. Dyer, William J. Hammer, Francis R. Upton and James Bradley

It is therefore interesting to note that this original plant of 1880 and 1881 employed a system of electric transmission of power in connection with its manufacturing operations, and it is also interesting to note that, prior to the installation of the engine and dynamos, the factory was run for a period of some months by power supplied by an overhead line from the Edison laboratory, three-quarters of a mile distant, 10 horsepower being transmitted for lighting and power purposes.

Underground cables were employed between the power plant and the lamp factory and testing department.

The engine and dynamo room and boiler house are not shown in the illustration. They run parallel to the main building and to the right.

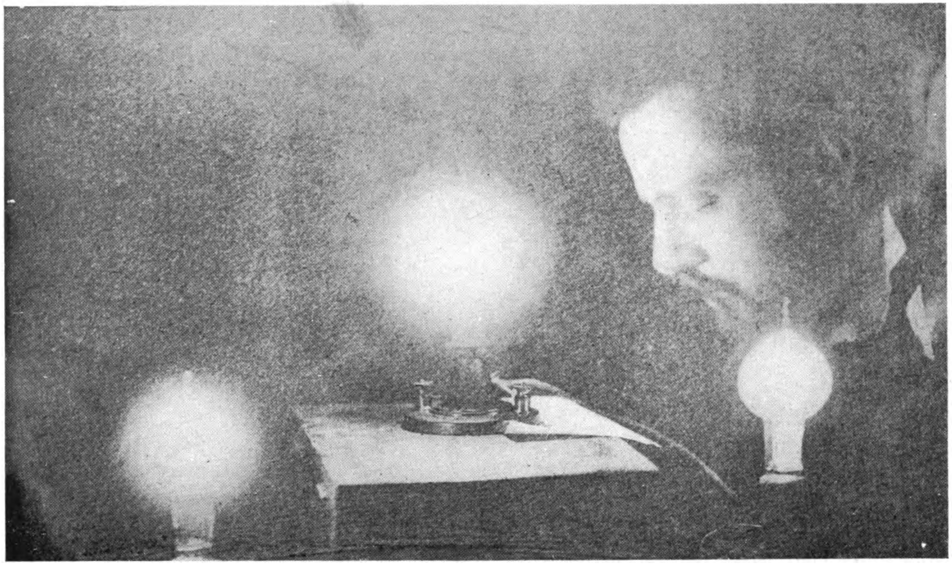
The testing department was well equipped with a photometer room, two electro-dynamometers, a Thompson reflecting galvanometer, Wheatstone bridge calorimeters and other apparatus.

In the foreground of the picture are shown the original staff of the first Edison lamp factory. Reading from left to right the group consists of Mr. Philip S. Dyer, Secretary; Mr. William J. Hammer, Electrician; Mr. Francis R. Upton, General Manager, and Mr. James Bradley, Master Mechanic.

In this, the first factory established for the manufacture of the incandescent electric lamp, were developed and put in practice many of the manufacturing methods which contributed so greatly to the success of the Edison incandescent lamp and its competitors throughout the world.

The manufacture of the Edison incandescent electric lamp was removed to Harrison, N. J., late in 1881, where it has ever since remained.

The building originally occupied at Menlo Park, shortly after its abandonment was set on fire by tramps, who made it their headquarters, and it was entirely destroyed.



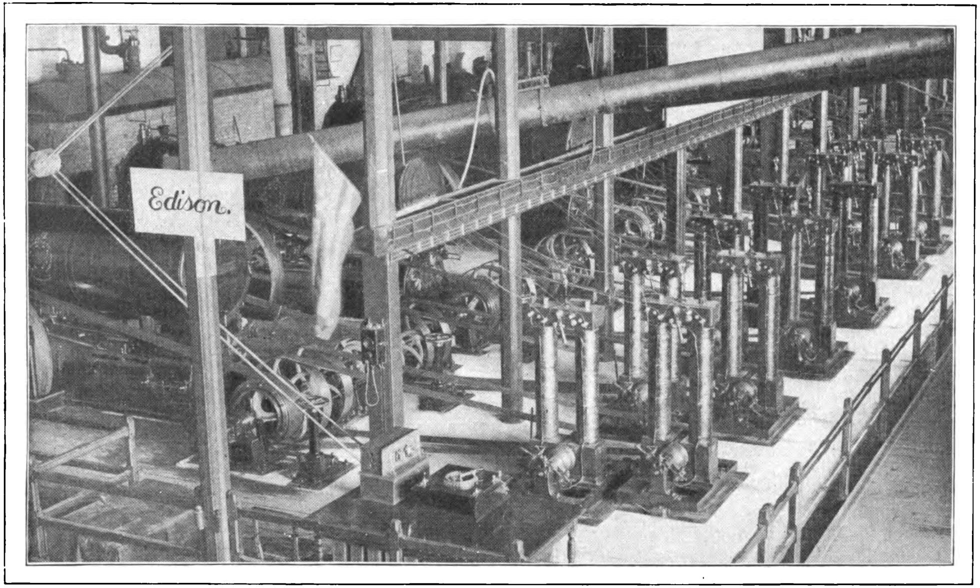
Picture of Mr. Charles Batchelor, being the first photograph taken by incandescent light

First Photograph taken by the Light of the Incandescent Lamp

THIS photograph was made at night in the Edison laboratory at Menlo Park, N. J., during the month of March, 1880, by Mr. Isaacs, an employee of Mr. Edison.

The three Edison lamps shown in the illustration were of the standard carbonized paper horseshoe type of sixteen candlepower each, mounted on mahogany bases, and were placed on one of the long work tables on the second floor of the laboratory. The central lamp of the three was placed on a wooden box which raised it above the other two and the base of this lamp served to hold a letter which is being read by Charles Batchelor, Mr. Edison's chief assistant, who is shown leaning over the table so that his face should be in close proximity to the lamps, and be powerfully illuminated thereby.

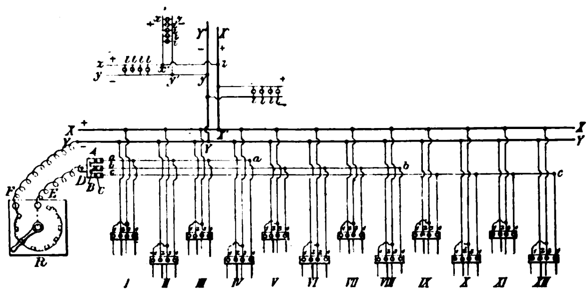
This represents the first portrait, and in fact the first photograph ever made by the light of the incandescent electric lamp.



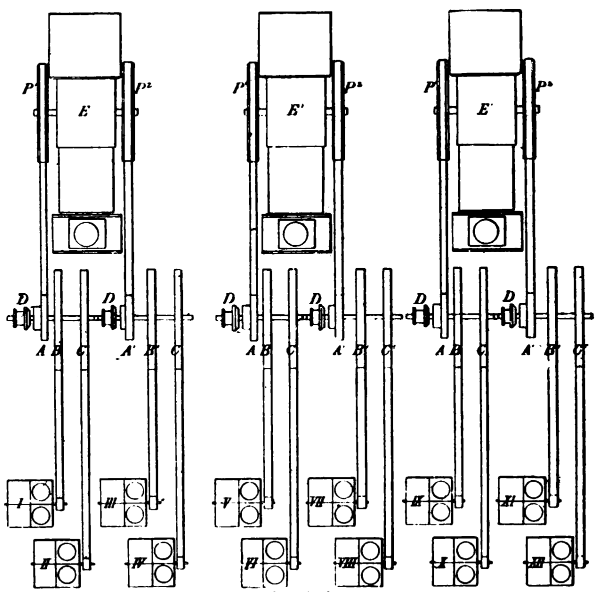
Edison Isolated Plant at Crystal Palace International Electric Exposition of 1882

Edison Isolated Plant at the Crystal Palace Electrical Exposition of 1882

THE illustrations show a most interesting and unique isolated plant which was installed for lighting the various Edison departments at the Crystal Palace International Electric Exposition held at the Crystal Palace, Sydenham, England, in 1882. It was put in operation on January 14th, 1882 and represented the largest isolated electric lighting plant which had been installed up to that time. It consisted of 12 "Z" type Edison dynamos, each with a capacity of sixty 16 C. P. lamps and having an E. M. F. of 110 volts, operating at a speed of 1200 revolutions. The entire working installation represented 1500 lamps. These 12 machines were erected in two parallel rows and were driven by three 25 H. P. semi-portable "Robey" engines. Each engine carried two fly wheels, each of which by means of a belt drove a separate counter-shaft, which could be thrown in and out of action by a conical clutch or coupling, actuated by a hand wheel. To each of these counter-shafts were keyed three pulleys, one smaller than the other two, which was driven by the engine belt, the two larger pulleys being used for driving two of the generators, so that the plant in all represented three engines, six sets of friction clutches and twelve dynamos. A single rheostat controlled all of the fields of the 12 dynamos, which were of the shunt wound type. The general details of this interesting plant are clearly shown in the accompanying illustration and diagrams. The plant was installed by Mr. Edward H. Johnson, Mr. Edison's representative, and Mr. William J. Hammer, Electrical Engineer.



Plan showing arrangement for operation and regulation of Edison Dynamos at Crystal Palace International Electric Exposition of 1882



Plan showing arrangement of Engines, Dynamos, Friction Clutches, Shafting, etc., of Edison Isolated Plant, Crystal Palace International Electric Exposition of 1882

First Edison Central Station for Incandescent Electric Lighting

THE first central station for incandescent electric lighting established in the world was that erected at 57 Holborn Viaduct, London, Eng land, in 1881 and 1882. The station was started on January 12th, 1882, and consisted of two, and subsequently three, Edison "Jumbo" direct-con-

Fig. 1. View showing buildings on Holborn Viaduct, London Eng., lighted from the first Central Station for incandescent Lighting established in the world.

nected steam-dynamos. These machines weighed from 23 to 30 tons each and employed bar armatures weighing 4½ tons, revolving at 350 revolutions a minute, the field magnet consisting of 12 magnet cores placed horizontally, 8 above and 4 below the armature. In Figure 1 is shown an illustration of the Holborn Viaduct: the sixth building—number 57—is the one in which the plant was installed. This property belonged to the Crown and by special permission a brick stack 96 feet in height was erected through the rear of the building. The machinery was placed in the basement. Babcock & Wilcox boilers were employed and one of the dynamos was driven by a Porter-Allen engine and the other two by Armington & Sims engines, all being direct-connected. In April, 1882, the dynamos which had been operated alternately were for the first time run in multiple. The plant supplied some 3,000 lights, which were placed in the various hotels, churches, stores and dwelling houses, and in addition to this the streets of the Holborn Viaduct, the Farringdon Road Bridge and its approaches, shown in Figure 2, and Doctor Parker's City Temple, shown in the centre of the illustration, Figure 3, were also lighted. It is interesting to note that Doctor Parker's City Temple was the first church in the world to be lighted with the incandescent electric light. A large number of lamps were also supplied for lighting the main operating room of the General Post Office on St. Martin's-le-Grand, some three-quarters of a mile from the station. The consumers were supplied by a net-work of feeders and mains of the standard underground two wire Edison tubing, such as were subsequently employed for a long time in New York City, Milan, Italy, and elsewhere. The Edison electrolytic meter was extensively used and a mechanical meter devised by Doctor John Hopkinson was also experimentally employed. Siemen's differential arc lamps were run from the circuits as were several small motors. This was the first plant in which double pole

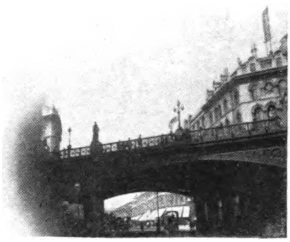


Fig. 2. Farringdon Road Bridge, over which Holborn Viaduct passes. Bridge and approaches and streets lighted by the Edison lamp in 1882.

fuses were used, it having been customary up to that time to always place the switch on one wire and the fuses on the other. Among the earliest, if not the first, insulated fixture joints were used in this plant and the various electroliers were equipped with verity ball and socket insulating joints, enabling the fixtures to be rotated.

This most interesting plant, which was installed by Mr. Edward H. Johnson, Mr. Edison's representative, and Mr. William J. Hammer, electrical engineer, was installed in connection with the formation of the English Edison Company to demonstrate the commercial character of Mr. Edison's central station system and was subsequently abandoned as it was intended that a very large station should be erected in the Strand district on property belonging to the Company.

The British public had suffered greatly from the gas and other monopolies and were fearful that a similar experience would result from the introduction of the

Fig. 3. "City Temple" Church on Holborn Viaduct, London, England, the first Church in the world to be lighted by the incandescent lamps, in 1882.

electric light and the celebrated Electric Lighting Act was passed by Parliament and the restrictions of this Act were so severe that capitalists were unwilling to embark in the important central station projects then in hand and the Edison Company which subsequently consolidated with the Swan Company, decided to confine their attention to the manufacture of the incandescent lamp and electric lighting appurtenances. Nevertheless, the Holborn Viaduct installation represents the first central station for incandescent lighting established in the world and was in all respects a typical Edison central station.

Information Relating to the Old Edison Companies

THE EDISON ELECTRIC LIGHT COMPANY

"THE Edison Electric Light Company" was incorporated under the laws of the State of New York in New York City in October, 1878, with a capital stock of $300,000. Later on, offices and show rooms were established at 65 Fifth Avenue, which continued to be the headquarters of the Edison interests until 1885, when the executive offices were moved down town to quarters at No. 16 Broad Street temporarily. Shortly afterwards The Edison Electric Light Company purchased a location at No. 44 Broad Street, on which a handsome building was erected, and the offices of the company were transferred thereto.

THE EDISON MACHINE WORKS

Early in 1881 Mr. Edison moved all the tools and machinery from his shops in Menlo Park, N. J., to extensive works at 104 Goerck Street, New York City, which were then named "The Edison Machine Works," and additional machinery was purchased with a view of manufacturing electric generators in quantities sufficient to meet the rapidly increasing demand.

The Edison Electric Light Company agreed with Mr. Edison to do no manufacturing, but to purchase all the electrical generators that were required from the Edison Machine Works.

The Edison Electric Light Company also established a testing department at the Edison Machine Works, of which the writer was superintendent from October 8, 1881, to June 1, 1883. After the various dynamos were completed, they were handed over to be tested, and the company required a certificate from the superintendent of testing department for each machine before the in-

Edison Machine Works at 104 Goerck Street, New York City voice for same from the works could be passed for payment.

The Edison Machine Works was operated as a firm by Mr. Edison and his associates until 1884, in January of which year it was incorporated in New York under the laws of the State of New York, the name of the organization being "Edison Machine Works," with a capital stock of $200,000.

THE ELECTRC TUBE COMPANY

This company was incorporated in the city of New York under the laws of the State of New York in January, 1881, with a capital stock of $25,000. Shops were started by this company first in New York and afterwards in Brooklyn for the "manufacture and sale of electric tubes for conducting electricity."

THE EDISON SHAFTING COMPANY

This company was organized in July, 1884, with a capital stock of $10,000, and was incorporated at this time in New York City under the laws of the State of New York, for the manufacture and sale of shafting, pulleys, hangers, couplings, etc., the business being carried on as a department of the Goerck Street Works.

The last two companies, viz.,

The Electric Tube Company and
The Edison Shafting Company,

were absorbed by the Edison Machine Works with the consent of their respective stockholders on January 30th, 1886. The business of the Edison Machine Works was moved to Schenectady, N. Y., in December, 1886.

THE EDISON LAMP COMPANY

Mr. Edison first equipped a building at Menlo Park, New Jersey, in 1880, for the manufacture of incandescent lamps, this building being known by the name of *Lamp Factory*. The manufacture of incandescent lamps was carried on in this building from October 1st, 1880, to May 1st, 1882, when the business was removed to its present location in Harrison, N. J. A firm was then organized by Mr. Edison and his associates under the name of *Edison Lamp Company*. In January, 1884, it was incorporated at Harrison, N. J., under the laws of the State of New Jersey, with a capital stock of $250,000.00, under the name of "The Edison Lamp Company."

BERGMANN AND COMPANY

Mr. S. Bergmann first started a small shop at 108 Wooster St., New York City, about 1880, for the manufacture of telephone apparatus, a large amount of which was shipped to England. In 1881 he began to make electroliers, cutouts, switches, sockets and other appliances used in the Edison electric lighting and wiring system.

The firm of Bergmann & Co. was afterwards organized and the large brick building located on the northwest corner of Seventeenth Street and Avenue B, formerly occupied by the United States Electric Lighting Co., was purchased to meet the growing requirements of the business. Bergmann & Co. moved from 108 Wooster St. to Avenue B and Seventeenth St., in October 1882.

THE EDISON COMPANY FOR ISOLATED LIGHTING

This Company was incorporated in New York City under the laws of the State of New York in November, 1881, for the purpose of selling and installing small plants for the electric lighting of single buildings. This Company had its offices at 65 Fifth Avenue, until 1890.

EDISON ELECTRIC LIGHT COMPANY

Succeeded "The Edison Electric Light Company," 1886–1887.

THE EDISON UNITED MANUFACTURING COMPANY

This company was incorporated in July, 1886, for the purpose of consolidating all the Edison manufacturing interests under one head. The company went into liquidation and withdrew from business October 31st, 1889, being succeeded by the

UNITED EDISON MANUFACTURING COMPANY

which was incorporated in New York City under the laws of the State of New York in May, 1889, and settled up the affairs of its predecessor.

THE EDISON GENERAL ELECTRIC COMPANY

This company was incorporated in New York City under the laws of the State of New York in April, 1889, with a capital stock of $12,000,000.00, consolidating all the Edison interests that existed at that time.

W. S. ANDREWS.

*Economy Test of the Edison Electric Light at Menlo Park, 1881**

BEFORE the trial of the 100 horse power dynamo-electric machine, which is now approaching completion, and which is to be driven by a Porter-Allen engine acting directly on the armature shaft, Mr. Edison desired to have a thorough test made to satisfy himself as to the economy of the lights resulting from the employment of the present small dynamos, large, slow-speed engine, and boilers, which are acknowledged by mechanical engineers as being among those of the most modern and economical types.

The results have proved so satisfactory that Mr. Edison desires to place the information gained before the engineering world.

The tests were conducted with the aid of the assistants at Menlo Park, New Jersey; but in order that there could be no doubt as to the correctness of the methods employed for obtaining accurate data, several gentlemen, eminent as practical engineers, were pres-

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*This report, entitled "Economy Test of the Edison Electric Light," is an account of a test which was made on Friday night and Saturday morning, Jan. 28-29, 1881, at Menlo Park, N. J. The test began with a fresh fire started under the boiler at 9:07 P. M., and ended when the fire was drawn at 9:35 A. M. The engine was started at 9:22 P. M., and carried the full load of lamps from 9:26:30 P. M. until it was stopped at 9:21 A. M. Mr. Edison had then invented and perfected his incandescent lamp with a filamentary carbon burner of high resistance; a dynamo of high efficiency, specially adapted by an armature of low resistance to supply current to such lamps in multiple; and a multiple arc system of distributing conductors from the dynamo to the lamps. To demonstrate the practicability of this system a plant had been installed at Menlo Park by which all the buildings and streets were lighted. And to satisfy himself and the capitalists interested with him in the enterprise as to the commercial efficiency of the lamp, Mr. Edison had the test made upon the plant that was embodied in this report. He had intended to publish the report, but at the desire of Mr. Henry Villard, then an influential director in the affairs of the Edison Electric Light Company, who regarded it important to keep the information from possible business rivals, this was not done, and the report has remained unpublished until now.

C. L. C., Feb., 1904.

ent by invitation. The logs kept by the several assistants were posted in a conspicuous place, and at all times open to inspection, and I have placed, with this manuscript, in the hands of the editors of the American Machinist, the original logs without erasures.

The boiler is nominally of 75 horsepower, with 853 square feet of heating, and 26.5 square feet of grate surface. It is of the type known as a water-tube boiler, and has been in constant use for more than two years, and one week before the test was thoroughly cleaned and inspected by the makers, Messrs. Babcock & Wilcox. An Ashcroft dust-burning grate is used, and during the test the fire was supplied by natural draft only.

The engine is nominally of 80 horsepower, built by Mr. Charles H. Brown, of Fitchburg, Mass., and after two years of continuous work, on rigid inspection one week previous to the test, was found to be in perfect working order.

The cylinder is 16 inches, and piston rod 2.5 inches in diameter, with a piston displacement [stroke] of 42 inches.

The fly-wheel is 3.5 tons in weight, 12 feet in diameter, and carries a 42-inch belt. The steam pipe is 5 inches inside diameter, and thoroughly lagged; the exhaust pipe, also 5 inches in diameter, leads to the air through a Berryman feed-water heater.

The dynamo-electric machines are of the well-known horseshoe form, as they have been always constructed by Mr. Edison, with the so-called Siemens armature modified, and are capable of returning 8 horsepower in outside work without heating. The magnet coils have an average resistance of 1.55 ohms, and the armature a resistance of 0.14 ohm. A separate machine with an armature of 0.55 ohm's resistance was employed to excite the fields of ten dynamos, its own magnet and armature being in the same circuit, and all connected in series.

The dynamos and lamp circuits were multiple-arced to one switchboard in the dynamo room.

The electromotive force was controlled by varying the resistance in the magnet circuit. The resistance in the magnet circuit during the test was as follows:

11 magnets........................17.05 ohms.
1 armature........................ .55 ohm.
Regulating resistance..............13.9 ohms.

Electromotive force on 30.95 ohms, 240 volts.

The total length of the street light circuits in use during the test was 39,000 feet, and the longest distance from the station of any one circuit 3,800 feet.

The resistance of the entire system to ground with the gas and steam pipes was 22 ohms.

The electromotive force on the lamp circuits was uniformly 110 volts.

Two sizes of lamps were included in the test. The "A" size on an average gave a light of 16 candlepower with an electromotive force of 104.25 volts and a resistance under these conditions of 114 ohms.

The "B" size is half the "A" size in every respect [in length of filament, resistance and candlepower], and two were placed in series and counted as one "A" lamp, which will give 8 lamps per horsepower by calorimeter test.

The calorimeter test was conducted as follows: A lamp is selected, which at 110 volts gives a light of 16 candlepower. This is immersed in a copper calorimeter, filled with water and carefully fitted to prevent loss of heat [by evaporation]. The water at the commencement of the experiment is several degrees below the temperature of the atmosphere, and the current of electricity is allowed to pass through the lamp with a drop of electromotive force of 110 volts until the temperature of the water is just the same amount above the atmosphere as it was below at the commencement to prevent correction for loss by radiation.

The experiment then terminates, and the circuit is broken. The data obtained were as follows:

W = weight of water.

w = weight of copper in calorimeter and immersed parts of stirrer.

S = specific heat of copper.

W^1 = weight of glass in lamp and immersed part of thermometer (generally neglect the mercury or count it as glass, for the error will be inappreciable).

s = specific heat of glass.

t = increase of temperature, in degrees Fahrenheit.

T = duration of experiment, in seconds.

N = number of lamps per horsepower.

Then

$$N = \frac{\dfrac{33000}{772t\,(W + wS + W^1 s)}}{\dfrac{T}{60}}$$

$$N = \frac{0.712435\,T}{t\,(W + wS + W^1 s)}$$

In the calorimeter test the full value of the economy of the lamp is obtained, but in practice energy must be lost in the conductors. The system laid down in Menlo Park was calculated for a loss of 10 per cent. for lamps of 100 ohms resistance; that is, the electromotive force should drop one-tenth on the conductors.

With the present lamp of 110 ohms average resistance, the electromotive force should drop to 100.35 volts. The average electromotive force of all the lamps has been already stated as 104.25 volts. Those requiring 110 volts were placed in the laboratory (70 "A" size and 54 "B" size) and on the circuits near the station, while further out upon the circuits, lamps were placed requiring a lower electromotive force to give a light of 16 candlepower, gradually diminishing to only 95 volts.

Under these circumstances, it is positive that the lamps gave 16 candlepower, and in most cases exceeded this amount.

The electromotive force was measured by the deflection method with a Thomson high-resistance, mirror galvanometer (Elliott Bros., London), having 60,000 ohms in the circuit.

The standard cells (40 in series) were Daniell porous cups, and the electromotive force of each cell was taken as 1.079 volts, the value assigned by the best authorities.

The gauge on the boiler (Schaeffer & Budenberg, Magdeburg) was tested one week previous to the economy test.

The thermometers were standards (Green Bros., New York), the one used in the steam calorimeter tests reading accurately to the tenth of a degree.

The holosteric barometer was set to Green's standard one week previous to the test.

The revolutions of the engine were recorded by a Schaeffer & Budenberg counter, and the speed of the dynamos by an ordinary speed indicator.

Diagrams were taken in all cases simultaneously from both ends of the cylinder—from the front end by a Tabor, and from the back end by a Thomson indicator.

The length of the stroke was reduced to one-tenth for the indicator motion by a pantograph connected to the cylinder-hood and crosshead.

The indicator springs were tested by connecting the indicators with the boiler and comparing the line marked on the paper with the reading of the steam gauge. There was a slight difference, and the two indicators did not read alike, but when connected with the cylinder the readings varied much less.

Great care was taken to insure accuracy in the calorimeter tests for ascertaining the quality of the steam. A half-inch pipe, projecting into the center of the steam pipe, led directly downward, and was thoroughly lagged. From this pipe the steam was led to the bottom of the barrel through a short length of thick, half-inch rubber hose. By an extra attachment the scales weighed accurately to one-twentieth of a pound. Great care was observed in weighing, taking the temperatures and leveling the scales, and never less than 350 pounds of water were used to condense the steam.

The method of conducting such a test is too well known to need any description. The amount of heat in the steam relative to that in dry steam was obtained by the following formula:*

$$E = \frac{W\ (t^1 - t)}{w\ (H - t^1)}$$

The results uniformly showed that the steam was superheated. But from the construction of the boiler and height of water in the gauge, this could not possibly have been its true condition. This was also the opinion of the makers.

The discrepancy was accounted for by Mr. Charles T. Porter, whose pardon I ask for advancing his views, perhaps before he is ready to give them to the public. In his own language:

"By such a method [calorimeter test] we know nothing of the quality of the steam, and if it shows some superheat, it is in all probability only dry," is expressed what doubtless was the quality of the steam in this case. The steam flows through the pipe [to the calorimeter] with great velocity, and in condensing, its motion is instantly arrested, and its energy of motion converted into heat, which adds to the temperature of the water, thus showing an excess over

*In the formula, W is the original weight of water in the calorimeter; w the weight of water added by steam condensed to heat the water; t^1 total heat in water corresponding to final temperature of the water in calorimeter; t total heat in water corresponding to initial temperature of the water in calorimeter, and H the total heat in steam at the observed pressure.

C. L. C., Feb., 1904.

that due to the steam alone. By opening the steam valve more or less, the flow takes place with greater or less velocity; hence the discrepancies between the different observations.*

The temperature of the gases escaping in the flue was measured by a thermometer inserted in the iron stack just above the brickwork.

Preliminary tests were first made to ascertain the amount of power consumed in friction, and in exciting the magnets. The lamp circuits were connected with the dynamos and the electromotive force brought up to 110 volts. The lamp circuits were then disconnected and indicator diagrams taken, which showed the power taken by the exciter and friction, as well as the drag due to the cutting of the lines of magnetic force by the iron in the armature. Diagrams of friction alone were taken after the magnet circuit was opened.

The fire under the boiler was then drawn and started anew with 240 pounds of dry, soft wood. In justice to Messrs. Babcock & Wilcox, I have not charged this wood (equivalent to 90 pounds of coal) to the fuel account, for the following reasons: Through some misunderstanding steam was not blown off to keep the pressure at 85 pounds and account taken of the amount of feed-water supplied to the boiler, but the pressure was allowed to go up to 120 pounds; and when my attention was called to it, the wood was consumed and the coal well fired. Steam was immediately allowed to escape, and record kept of the feed-water, the height at commencement of test being marked on the water gauge. Under the cir-

*Mr. Porter expressed the opinion at that time that in the calorimeter method of testing the quality of steam, kinetic energy was imparted to the current of steam flowing into the calorimeter additional to that due to its own heat energy, which would result in too high a value for the calculated amount of heat in the condensed steam. For standard code rules for conducting a calorimeter test, see Trans. Amer. Soc. Mechanical Engineers, Vol. VI., 1885. pp. 288-294. C. L. C., Feb., 1904.

cumstances the omission of the wood from the fuel account was nothing in their favor.

The coal, which was accurately weighed, was a clear, free-burning egg coal from the Lehigh Company, containing 12.8 per cent. of ash.

The feed-water was pumped by hand into two barrels, and its weight between two cleats determined. A Knowles donkey pump forced the water into the boiler.

All valves connecting the boiler with different parts of the works were closed, the only exits possible being through the Brown engine, Knowles pump and safety valve.

After the close of the test the fire was drawn and steam allowed to escape so long as the boiler made steam at 85 pounds. When it ceased to do so, the measurement of the feed water ceased.

The clinkers were carefully picked out from the unconsumed coal, and the latter washed, to separate the ashes.

RESULTS.

Water evaporated in 15 minutes before engine was started	310 lbs.
Water evaporated while engine was running 4.5 minutes, with lamps off, and developing 20.054 horsepower; and 11 hours and 54.5 minutes with lamps on, and developing an average of 83.67 horsepower	27,674 lbs.
Water evaporated in 14 minutes after engine was stopped	203 lbs.
Total water evaporated	28,187 lbs.
Average boiler pressure	85.36 lbs.
Average temperature of feed-water	195.07° F.
Average temperature of boiler room	79.07° F.
Average temperature of escaping gases	410.00° F.
Average barometrical pressure—not taken account of in the calculations	14.855 lbs.
Revolutions per minute of engine with lamps off	78

Revolutions per minute of engine with lamps on. The counter failed after a record of 47,435 revolutions in 10 hours and 28.5 minutes had been made	76.69
Average revolutions per minute of armatures of dynamos—determined by speed indicator......................	1,203
Theoretical revolutions per minute of armatures—that is, with belts of no thickness, and no slip....................	1,296

(Ten dynamos were running all the time and eleven were running five hours.)

Lamps in circuit, 399 "A" size, and 54 "B" size, together equivalent to 426 "A" size, of which 3 failed during the test. And considering the time when they failed, the average number of lamps in circuit of "A" size, or equivalent was.	424 2-3

Combustible clinkers and ashes are classed as fuel; combustible and clinkers as coal.

Fuel weighed out........................	3,345 lbs.
Fuel weighed back......................	27 lbs.
Fuel on grate...........................	3,318 lbs.
Clinkers	134.25 lbs.
Coal	3,183.75 lbs.
Coal drawn at end of test...............	306 5 lbs.
Coal fired.............................	2,877.25 lbs.
Fuel fired.............................	2,998.58 lbs.
Ashes	263 lbs.
Clinkers due to fuel fired................	121.33 lbs.
Combustible burned, 2,998.58—263—121.33..	2,614.25 lbs.
Per cent. of foreign matter in fuel, 384.33 ÷ 2,998.58.	12.8
Water evaporated per lb. of fuel under actual conditions, 28,187 ÷ 2,988.58 ...	9.4 lbs.
Water evaporated per lb. of combustible under actual conditions, 28,187 ÷ 2,614.25	10.782 lbs.
Water evaporated per lb. of fuel from and at 212° F............................	9.9 lbs.
Water evaporated per lb. of combustible from and at 212° F..................	11.358 lbs.

Water evaporated per lb. of fuel at 120 lbs. pressure and feed-water at 212° F.....	11 lbs.
Per cent. of actual evaporation to greatest theoretical amount—boiler room at 79.7° F. and temperature of steam at 85.36 lbs. pressure 327.6° F...........	79.9
Average indicated horsepower developed with the lamps in circuit..............	83.67
Indicated horsepower with lamps off, and exciter circuit closed.................	20.054
Indicated horsepower with friction only, all circuits open.........................	15.109
Indicated horsepower consumed by the exciter and local currents in armatures	4.945

While the engine was running 27,674 pounds of water were evaporated, the engine developing 20.054 horsepower for 4.5 minutes, and 83 67 horsepower for 11 hours and 54.5 minutes. At this rate the gross amount of steam consumed per hour per indicated horsepower would be 27,733 pounds. Strictly, this total should not be charged to the engine, since 27,-674 pounds of water had to be lifted 6.75 feet and forced into the boiler by the steam pump against an average pressure of 85.36 pounds. The work required for this duty alone, without considering friction of pump, etc., would be 19.64 horsepower. One horsepower could not be developed in such a pump, and at the slow speed at which it was working, for less than 45 pounds of steam. Upon this assumption, 26.790 pounds of steam are to be charged to the engine, or 26.847 pounds per indicated horsepower per hour, with a consumption of 2,856 pounds of fuel (12.8 per cent. ash).

Lamps per gross horsepower, 424.66÷83.67	5.08
Fuel per lamp per hour, 26,847 ÷ 9.4......	2,856 lbs.

In the magnet circuit the fall of electromotive force was 240 volts on 30.95 ohms. Therefore the total amount of energy developed in the circuit per minute was:

$$\frac{44.3 \times (240)^2 \times (30.95 + .55}{(30.95)^2} = 83{,}910 \text{ ft. lbs.}$$

The total indicated horsepower due to the dynamos (on open circuit), with the exciter circuit closed, was 4.945 horsepower, or 161,185 ft. lbs.; and the difference between this and the energy developed in the magnet circuit, 161,185 — 83,910 = 79,275 ft. lbs., is the energy consumed in local currents induced in the iron of the armatures. During the test the armatures were 11 in number, so that the energy consumed by each in local currents was 7,207 ft. lbs. per minute, or 0.2184 horsepower.*

Of the 83,910 ft. lbs. developed in the magnet circuit of 31.5 ohms, that developed and lost on the 13.9 ohms in the regulating resistance was $\frac{139}{315}$ (83,910) = 37,027 ft. lbs.

The energy effectively applied to excite the magnets was 46,883 ft. lbs., or 4.262 ft. lbs. for each magnet.

Soon after the commencement of the test one dynamo was disconnected, and the load carried by the others.

The lamp circuits having been calculated for a loss of 10 per cent. of the total energy with 100-ohm lamps, the loss by substituting 114-ohm lamps was 8.77 per cent. On the laboratory circuit, with 96 2-3 lamps, the loss was inappreciable, the conductors being large and of short length. The average number of lamps on the street circuits was 328. Expressing the 8.77 per cent. loss of energy in equivalent lamps, the number would be 359 53. The resistance of the circuits to ground was 22 ohms, representing a loss of energy equivalent to 5.2 lamps.

The total energy developed in the lamp circuits, expressed in "A" lamps, was, therefore, 461.4; the net indicated horsepower was 83.67 — 20.054 = 63.616;

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*The armature cores were made of thin sheets of iron, separated by tissue paper. And the greater part of this energy must have been due to the then unknown hysteretic action, and not, as stated in the report, to local Foucault currents.
C. L. C., Feb., 1904.

which gives 7.25 lamps per horsepower. It has been stated that the average economy by calorimeter test was 8 lamps per horsepower. The discrepancy of 0.75 lamp per horsepower can be mostly accounted for in the increased friction of the engine and system of driving pulleys and belts due to the extra 63.6 horsepower, allowing also errors inseparable from the measurement of power by steam indicator.

An important question naturally arises: What can be done to increase the economy?

Improvements may be looked for in better methods of utilizing the heat from the fuel, but it is not best to predicate results upon this. But by the addition of an economizer, which will be assumed to heat the feed-water to only 212° F. (much below what is obtained in practice), and generating steam under a boiler pressure of 120 lbs., the evaporation per pound of fuel of the quality used in the test becomes 11 lbs.

With a high speed engine connected directly to the armature shaft of a large dynamo all the intermediate losses by belts and pulleys will be eliminated, and only the friction of engine and shaft will be lost.

By perfect insulation the loss from leakage will be prevented.

With these facts in view, and the results of the present test, accurate conclusions can be arrived at. With the same loss of energy in conductors as during the test the number of street lamps would be 328. And allowing on the laboratory circuit a loss of 8.77 per cent. in the conductors the equivalent loss, expressed in "A" lamps, will be 8.77 per cent. of 95 2-3, or 8.4 lamps. The total number, with an addition of 5.2 lamps equivalent to leakage, will be 415.3 lamps.

The horsepower developed in the lamp circuits is 63.616, or 2,099,328 ft. lbs. The energy to excite the magnets of a large dynamo, and that lost in local currents in its armature are assumed equal to that in the 10 dynamos in this test, namely, 42,620 ft. lbs. and 72,070 ft. lbs., but in reality would be less. Assume friction of engine and shaft as 5 per cent. of the gross power developed.

Then, the total energy would be $\frac{100}{95}$ (2,09),328 + 42,620 + 72,070) = 2,330,545 ft lbs. = 70.60 horsepower. And the commercial efficiency of the lamps would be 5.9 per horsepower.

With engine giving same economy as in this test, and a boiler with economizer evaporating 11 lbs. of water per pound of fuel, 0.414 lbs. of fuel per lamp per hour will be required.

The lamps used in this test were the first products of the factory only recently built and equipped for their manufacture. Now that the details of manufacture have been systematized and improved methods introduced, the average economy by laboratory test is 10 lamps per horsepower, and with conductors so proportioned as to give the same per cent. of loss as in the present test, the number of lamps per horsepower on the circuits would be 7.38, and the amount of coal per lamp per hour 0.331 per lb.

In conclusion, I may state that the approaching completion of the large dynamo,* it is hoped, will soon place it within Mr. Edison's power to give to the engineering public complete and reliable data showing even a greater increase in the economy of lighting by electricity.

C. L. CLARKE,
Edison Laboratory.

Menlo Park, N. J., Feb. 7, 1881.

*The dynamo here referred to was driven by a Porter-Allen engine, direct-connected with the armature shaft, at a speed of 600 revolutions per minute. It was set up at Menlo Park, and intended to develop 100 horsepower at 120 pounds boiler pressure. But, owing to the impracticability and even danger of running the engine continuously at such a high speed, the machine was never used, and was set aside, to be followed by the first so-called "Jumbo" Edison dynamo, driven by a direct-connected Armington & Sims engine at 350 revolutions, which was built the following summer, 1881, at the Edison Machine Works, Goerck Street, New York City, and exhibited that year at the Paris International Electrical Exposition.

C. L. C., Feb., 1904.

Early Government Report on Electric Lighting

AS illustrating the state of the art prior to 1880, the following abstract from the Appendix of the Annual Report of the United States Light House Board for the year ending June 30, 1879, will be found of historic interest.

After speaking of the electric arc the report passes to the consideration of the production of light by electricity by means of incandescent conductors, as follows:

"In some of the early experiments of Sir Humphrey Davy we find mention of the heating to luminosity of wires of various metals, as tests of the comparative power of different batteries; and, in 1858, so great an advance had been made in the practical utilization of this means of lighting, that M. Jobart, in a report to the Academy of Sciences, in Paris, was able to speak as follows:

" 'I hasten to announce to the Academy the important discovery of the dividing of an electric current for lighting purposes. This current, from a single source, traverses as many wires as may be desired, and gives a series of lights ranging from a night lamp to a light house lamp.

" 'The luminous arc between the carbons produces, as is well known, a very intense, flickering, and costly light. M. de Changy, who is a chemist, mechanician, and physicist, is thoroughly conversant with the latest discoveries, and has just solved the problem of dividing the electric light.

" 'In his laboratory, where he has worked alone for the past six years, I saw a battery of twelve Bunsen elements producing a constant luminous arc between two carbons, in a regulator of his own invention —this regulator being the most simple and perfect I have ever seen. A dozen small miners' lamps were also in the circuit, and he could, at pleasure, light or extinguish either one or the other, or all together, without diminishing or increasing the intensity of the light through the extinction of the neighboring lamps. The lamps, which are closed in hermetically sealed glass tubes, are intended for the lighting of mines in which there is fire damp, and for the street lamps, which would by this system be all lighted or put out at the same time, on the circuits being opened or closed. The light is as white and pure as Gillard's gas, with which it has one point in common, namely, its production by the incandescence of platinum. The gas-pipes are replaced by simple wires, and no explosions, bad smells, or fires can take place.

"'The trials that have been hitherto made, with the object of producing an electric light by means of heated platinum, have failed on account of the melting of the wires. This difficulty has been overcome by M. de Changy's dividing regulator. The cost of the light is estimated to be half that of gas. A lamp placed at the masthead of a ship would form a permanent signal for about six months, without the necessity of changing the platinum. With several such lights, placed in tubes of colored glass, it would be easy to telegraph by night, as they could be extinguished and relighted rapidly from the deck.

"'For light-house purposes considerable amplitude can be given to the light. I also saw a lamp so arranged in a thick glass globe that it could be immersed to considerable depths without being extinguished by any movement. This lamp has already been used in the taking of fish which were attracted toward the light.

"'The above slight description will suffice to show to what a variety of applications this discovery can be put. The communication which I have had the honor of laying before the Academy is founded upon no illusion; a lamp was, to my astonishment, lit in the hollow of my hand and remained alight after I had put it in my pocket with my handkerchief over it.'

"In Comptes Rendus, or minutes of the French Academy, I find that the communication of M. Jobart was received at the meeting held March 1, 1858, and was referred to M. Becquerel. At a meeting of April 5, M. Becquerel reported that he did not find anything sufficiently definite to warrant the Academy to express an opinion as to the importance of this discovery. 'All that was desirable at present was fuller information.' At the meeting of April 19 M. Jobart responds to this request by stating that 'he could not give more precise details without exposing the author to see another profit by his discovery.

"It would appear as if this brilliant and complete success described by M. Jobart as achieved by M. de Changy in Paris, in February, 1858, was very rapidly followed up in this country, for I learn from a letter in the Salem Observer of November 2, 1868, that Mr. Moses G. Farmer, in Salem, lit his parlor every evening during July of 1859 with electric lamps operated on a like principle.

"Notwithstanding this very promising beginning, however, little or no progress seems to have been made in this method of lighting for the twenty years intervening between the dates above given and the present time, for we certainly have no system of electric lighting by incandescence superior to that above described, nor has this older one or any of its newer rivals come into any general use. As the reasons of this have a very important bearing on the objects of the present report, a few words about them will, I think, be in place here.

"The difficulties presented in the problem of producing light by incandescence were:

"1. Its wastefulness of the energy employed and consequent costliness.

"2. The difficulty caused by the disintegration of the substance heated.

"Thus, if platinum was used as the substance to be heated, it was found that heating it as nearly as possible to its melting point, the amount of electric current which would yield in the arc a light of 1,000 to 2,000 candles would only produce a light of about 50 to 100 candles, and also, that when the platinum had been thus used, it became very brittle and finally broke up.

"Small rods of carbon placed in exhausted tubes admitted of higher temperatures, but were quite rapidly consumed, or, rather, vaporized and disintegrated.

"According to the statements recently published by Mr. Edison, it would seem that he has succeeded in reducing platinum to a condition in which it will endure a much higher temperature without fusing, and therefore yield a more economical light, and also remain unaltered indefinitely.

"If these statements are confirmed by continued experience, it would seem that the electric light from incandescence would rival that from the 'electric arc,' and, by reason of its convenience and steadiness, would supersede it in most cases.

"At all events, for light-house use, even if far less economical, such a light would be of great value; and I think that this subject should be carefully investigated before any important steps are taken in the practical application of electricity as a source of light even experimentally in our light-houses.

"Though none of them have proved practically useful as yet, nevertheless some notice of methods of lighting by incandescence should be here given historically for future reference.

"The first electric lamp operating by incandescence of which we have any actual record seems to be that invented by the American, Starr, a patent for which was taken out in England by his agent, King, in 1845, and which has thus come to be known as the King lamp. This lamp has been modified in details until it has reached a form known as the Koun lamp.

"This apparatus consisted of a glass vessel provided with a metal cap and packing box below, by means of which it can be closed air-tight.

"Various slight modifications of this lamp have been made and elaborately experimented with; but they all show the same essential characteristics.

"The first of these is that, as long as any oxygen remains in the vessel, the carbon rods consume rapidly, the first one generally lasting only twenty minutes. The second carbon will, however, last two hours if the light does not exceed forty burners; but even when all active gas has been removed, the carbon suffers a sort of vaporization.

"The second characteristic of these incandescent lamps is that, with the same current, they develop much less light than is obtained from the electric arc. Thus, a battery of forty-eight elements, with a Serrin lamp, gave an electric arc equal to 100 burners; but with one of these lamps gave a light equal only to 80 burners, and when divided between three lamps, gave only the light of 10 burners each.

"The third characteristic is the manner in which the light-producing power of the current diminishes as it is distributed between a number of lamps. Thus the current from a given battery, acting on one lamp, produced a light between four and five burners; on two lamps of one and a half burners each; on three lamps, one-third to two-thirds of a burner each. From another battery the current on a single lamp gave a light of 11 to 12 burners; with two lamps, one-half burner each; and on three lamps, one-ninth of a burner each.

"In another case a given battery with one lamp gave the light of 9 burners; with two lamps 2½ burners; and with three lamps, one-third of a burner each. Another battery with one lamp gave a light of 65 burners; with two lamps, 7½ burners; with three lamps, 1⅓ burners; with four lamps, three-fourths of a burner, and with five lamps, one-half burner each.

"Another modification of this Starr or Koun lamp is found in that which has been recently exhibited in New York as the Sawyer-Mann lamp.

"This differs from the former apparatus in no important feature, except that the interior of the vessel is said to be filled with pure nitrogen at the ordinary pressure. The carbon rods are said not to waste away in these lamps. Without knowing anything positively on the subject, my opinion is that this is only because they have not been subjected to strong currents, but have only been heated to the extent of yielding the light of one or two burners. Under these circumstances, the carbons of the Koun lamp will last a long time, but, on the other hand, the light so obtained is not economical, as we see above.

"When exhibited in New York recently, we understand that five lamps only were operated by a magneto-machine of Arnoux & Hochhausen, driven by a 3 horsepower steam engine, said to be developing only 1½ horsepower.

"Another method of electric illumination by ignition is that suggested by Jablochkoff some time since, but which seems to have been abandoned practically on account of the costliness of the apparatus, not to mention other difficulties.

"This consists in causing the main current to pass in a series of intercepted or reversed pulses through the primary circuits of numerous induction coils, and then to pass the induced sparks, obtained from the secondary coils of these instruments, across or around little rods of porcelain, which thus become heated to whiteness.

"Fully to understand this it will, however, be necessary to explain the structure and operation of an "induction coil," and this comes naturally now in order in connection with the third method of obtaining light from electricity, namely, electric light from incandescent gas.

"In order to obtain electricity in such a state that it will pass through a gas and thus heat it to luminosity, we must, in practice, make use of an induction coil. * * *"

Historical Sketch of the Association of Edison Illuminating Companies

BY AN EX-PRESIDENT.

THE organization meeting of the Association of Edison illuminating Companies was held at Harrisburg, Pa., April 15, 1885. There were represented at that meeting four companies which were licensees under the Edison patents; the companies at Cumberland, Maryland; Mt. Carmel, Pennsylvania; Piqua, Ohio; and Sunbury, Pennsylvania. The Edison Electric Light Company, the parent organization at that time, was represented by F. S. Hastings; the Edison United Manufacturing Company, by Samuel Insull; the Edison Lamp Works, by Francis R. Upton. Mr. Insull was the only delegate attending this organization meeting who is now connected with the Edison Association, and the Cumberland Company was the only one represented which is at present a member of the Association.

The first officers of the Association elected at this meeting were: James S. Humbird, of Cumberland, Md., President; H. K. Wood, of Piqua, Ohio, Vice-President; Frank S. Marr, of Sunbury, Pennsylvania, Secretary; Westley Auten, also of Sunbury, Treasurer.

The following abstract from the minutes of the first meeting may be of interest:

"The different views presented, and the experience of the various stations showed conclusively that the success of a station depended more upon proper management than anything else; that a majority of the difficulties which occurred were occasioned more from the want of knowledge on the part of the management than from any defects inherent in the system."

The second meeting was held at Pittsburg, Pa., June 3, 1885, and showed an increase in the attention and interest of the delegates—eleven delegates attending—nine representing seven central station companies, and two representing manufacturing companies. The object of the Association, as shown by the by-laws adopted at this meeting, was mutual protection and the collection and dissemination of information. The membership was made open to all companies operating the Edison system from central stations.

At that meeting many subjects were brought up for discussion, such as the methods of street lighting by incandescent lamps, the meter system vs. the flat rate system of selling light to customers, engines and boilers for use in electric light plants and the advantages of high vs. low speed engines, and direct drive or countershafting. The question of lamp breakage came up at this meeting, and was discussed by John W. Howell, representing the Edison Lamp Works, who referred to the lamp test made by the Franklin Institute at its electrical exhibition in Philadelphia. Mr. Howell claimed that the life of the Edison lamp was over one thousand hours. Questions of station management, the best kind of coal and oil, and other kindred questions were discussed.

The third meeting, which was held at Atlantic City, N. J., June 9, 1886, brought many new members and put the Association at once on an excellent footing. Among the ten companies represented at this meeting are the following, which to-day are members of the Association: Cumberland, Chester, Fall River, Harrisburg and Atlantic City. At this meeting a communication was read from C. J. H. Woodbury, Inspector of the Factory Mutual Insurance Companies, whose headquarters were at Boston. Mr. Woodbury offered to aid in the formation of an electric mutual insurance company if the National Electric Light Association would co-operate, as he was compelled to decline applications from electric lighting stations for insurance under the Factory Mutual Companies. A new set of by-laws was adopted at this meeting.

Among the subjects discussed were the following:

The selling of motive power and the various purposes to which it could be applied; street lighting, and the relative merits of the municipal and the three-wire systems; safety fuses; a cypher system for marking the candlepower of lamps permanently on the bottom contact plate instead of the paper labels; the subject of lamp troubles, especially the blacking of lamps, commanded considerable attention. The Lamp Company was asked to explain the cause for this and apply a remedy, and also requested to make the globes of the ten, thirteen and sixteen candlepower lamps larger and of uniform size. Action was taken on the subject of the non-uniformity of the charges for light with a view to the adoption of a standard table of rates, the following resolution being adopted:

> "*Resolved*, That the sense of this meeting affirms the judgment of the meeting of last year in favor of meter rates in dwelling houses, and where the consumption is not known, and of fixed rates where the consumption is known."

Competition with arc lamps by means of incandescent lamps of large candlepower was considered, and the Lamp Works was asked to make lamps of 250 candlepower and 210 volts. The effects of lighting on overhead lines was discussed, and the experience of several companies was given.

John W. Howell, of the Edison Lamp Company, exhibited a new standard voltmeter of suitable size and form to carry in the pocket. This instrument continued to be the standard voltmeter for station inspectors, especially in its larger sizes, until the development of the Weston instruments, by which it was superseded.

At this, the third meeting of the Association, station load curves were presented for the first time. The proper method of keeping central station accounts was discussed, a topic receiving exhaustive attention at many subsequent meetings, and finally resulting in the complete and detailed system of cost sheets and monthly operating reports which have ever been a valuable feature in the management of the leading Edison companies, and no doubt contributed not a little to their commercial success.

At the fourth meeting a much larger delegation was in attendance. It was held at Long Beach, N. Y., August 11, 1886, and was attended by many whose names are very familiar to those who have been connected with the Association during the past ten years. This was also the first meeting attended by Mr. Edison. Among the delegates were:

John Kruesi and Samuel Insull, representing the Edison Machine Works; E. H. Johnson, President of the Edison Electric Illuminating Company, of Boston, Massachusetts; C. E. Chinnock, Superintendent of the Edison Electric Illuminating Company, of New York; Luther Stieringer; John W. Howell, representing the Edison Lamp Company; F. S. Hastings Secretary and Treasurer of the Edison Electric Light Company, of New York; W. S. Andrews, Chief Electrical Engineer, Edison Light Company; Frank J. Sprague, of the Sprague Electric Railway & Motor Company, and Wilson S. Howell, the Superintendent of the New Brunswick, New Jersey, company.

John I. Beggs was president of the Association at that time, representing as general manager the Edison Electric Illuminating Company, of Harrisburg, Pennsylvania.

At this meeting the subject of electric motors was presented for the first time, and a discussion took place as "to the best method of promoting the business of selling electric motive power," and methods of charging therefor; a recommendation was adopted in favor of the introduction of three-wire services to buildings to facilitate the balancing of street circuits.

From this time on, the growth of the Association was quite rapid, and the interest in its meetings increased greatly. Various papers were presented to the Association and careful records kept of the proceedings, as shown by a list of papers read before the Association up to date. Previously there had been no record of the proceedings kept, except in the most desultory way, but as the importance of the proceedings increased, the necessity of an accurate report became apparent, and full stenographic reports were thereafter kept by the secretary.

The next meeting—the fifth—was held at Rochester, New York, February 9-10, 1887. Sixteen operating companies and several Edison manufacturing interests were represented.

At this meeting a committee presented a report calling attention to the advantage of membership in the Association, and to this end offered a draft of a circular letter for distribution among local companies, inviting them to join. From this I quote:

> "*Resolved*, That this Association appoint a committee to inform the local Edison illuminating companies in detail, by circular letter or otherwise, of the true purposes and benefits to be derived from membership in the Association, and impress on them the momentary importance of the attendance of their general manager or superintendent at these meetings, and that the committee urge full attendance at the next meeting.
>
> "In compliance with this resolution, we respectfully invite your attention to the following remarks:
>
> "As the great advantages of combination of those engaged in similar industries are too well known to require comment, the special benefits from such general unity of our own interests concerns us at present.
>
> "Our energetic brothers in the arc lighting business have an association which is productive of much good, while the gas companies of both continents have for years met in council to exchange views and experiences in the management of their business.

"The central station manager has the extremely difficult task of pushing a new business into favor and profit. He is a manufacturer who sells his product directly to the consumer, and in so doing meets all the complaints of price, quality and quantity from a host of people ignorant of the severe conditions under which he operates. He stands between two fires; on the one hand, his board of directors or the management committee, on the other, the customers, who always want $2 worth of light for fifty cents, and insist on comparing the cost of kerosene oil or gas with the cost of Edison light.

"Besides this he has a hot crank pin or a broken pressure wire, a bad commutator, or a short circuit, and occasionally a pole to remove from some one's side-walk, and numerous incidents, which require not only rapid manipulation, but some ingenious expedient to prevent extinguishment of light and loss of public confidence.

"Do you wonder that we want help to solve the problems of operation and management?

"How can we get this help? The books are silent, our experience is short, experts are scarce and cost money, and each one works on his own theory and experience, and tells you very little which is of real value.

"Let us, therefore, do as the enterprising gas man does, hire a hall and talk the matter over. Let us help each other. Let those who have had the most experience in engines, post those who want help, and those who are most successful in regulating the light, or managing their business, give their less fortnuate brothers the benefit of their experience."

The principal subjects of discussion at this convention were meter vs. contract systems; standard systems of operating accounts; the Edison standard wire guage; the application of motors to industrial purposes, and for the first time attention was called to the use of arc lamps on constant potential lighting circuits.

At this meeting resolutions were adopted restricting thereafter the attendance at the conventions of the Association to bona-fide representatives of firms or corporations whose direct investments in the Edison business reached a certain sum. This was the beginning of what some of the good friends of the Association have seen fit to characterize as the "Star Chamber" method of conducting the Association's conventions, a criticism just enough in itself, and if there is no escape from this benevolent criticism, there is also no remedy for it, and perhaps, also, no further explanation need be given than to say that it has business corporations for its members and not individuals, and that its conventions deal with important business and commercial relations and interests, as well as the interchange of technical information and experience.

It has, however, been the policy of the Association of late years, recognizing the value to the profession of many of the papers presented at the conventions, to authorize their publication by the technical press where such publication would not result in disadvantage to the commercial interests of the member companies.

It may be of interest to note that at the Rochester convention, February 9-10, 1887, it was announced that there were then in operation 121 Edison central station illuminating companies supplying current to 330,180 lamps.

At the semi-annual meeting, held at Chicago, Illinois, February 8-9, 1888, papers were read on the general progress of the Edison business during the year, incandescent lighting by high potential systems, automatic balance connections of feeders and low load regulation. In a paper on the "Alternating Current Transformer System," it is amusing to note that this system was alluded to as a failure because:

"They cannot make it safe.

They cannot make it reliable.

They cannot make it run 12 16-candlepower lamps per horsepower.

They cannot make its lamps even.

They cannot make its lamps last a reasonable length of time.

They cannot make it run motors.

They cannot make it sell by meter."

Tempora mutantur, et nos mutamur in illis is about the only commentary that it is necessary to make at this time and place on this interesting bit of "ancient history"—venerable enough when it is considered what changes seventeen years have wrought in the electrical industry. Even more delicious historical tid bits may be readily found by a perusal of the minutes of the Association, which form a most valuable addition to any technical library or that archive of ancient electrical history, the Bulletins of the Edison Electric Light Company, 1882, *et seq.*

It is indeed unfortunate that the storehouse of information and experience locked up in the minutes of the Association is not accessible to the electrical profession at large, but a perusal of the list of papers and the authors which appears as an appendix will convince those having the future direction of the affairs of the Association that the most liberal policy possible should be pursued in the publication of the papers by the technical press in justice to the electrical art.

Prominent among the Association's activities, and most valuable to its members, have been the interesting reports of its standing committees on contact with high tension circuits, lightning protection, grounding the neutral, incandescent lamps, storage batteries, and meters.

The committee on meters has performed excellent work in standardizing types of meters, and co-operated with the manufacturer in developing several types of meters which have become standard with the Association.

One of the most valuable branches of work undertaken, and which in addition to the benefits it has conferred on the member-companies has no doubt contributed notably to the advance of the art, was the organization of the "Lamp Testing Bureau," now an independent stock company under the corporate title; "Electrical Testing Laboratories." The organization of this enterprise was the outcome of a condition of affairs which sometimes arises in business enterprises when the interests involved become large and when the determination of the quality of a product, which the manufacturer produces and the customer uses, becomes difficult and requires a greater amount of special skill and more careful methodical following up than the average corporation can afford to supply. Hence the organization of such important arbiters of quality—as it were—as the testing laboratories in various departments of the Government, the testing laboratories of the Pennsylvania Railroad Company, and such commercial corporations especially organized to handle testing work for the public as the Pittsburg Testing Laboratories. There are a number of firms who furnish experts for the general public who may require advice in the inspection of iron, either at the works or after its erection in the field; or the testing of materials, such as paints, cements, rubber, and other industrial products.

Five of the larger companies of the Association—New York, Chicago, Boston, Brooklyn and Philadelphia—in consultation with the leading manufacturer of one of the products—incandescent lamps—of which the Association, taken as a whole, is probably the largest single consumer, agreed upon a tentative set of specifications to be applied to the product, and organized a testing bureau to act as their representative and as a kind of disinterested party in making the tests. This temporary organization, carried into effect 1895, was subsequently made permanent by placing it under the general direction of the Lamp Committee of the Association, as its members more generally availed themselves of this form of sale and purchase of lamps by test, and in 1900 it was incorporated under the name of the "Lamp Testing Bureau," with an office and laboratory in New York and main lamp testing laboratory at the General Electric Lamp Works, at Harrison, N. J., with a branch at the Bryan-Marsh factory, at Marlboro, Massachusetts. The stockholders of this enterprise are the member-companies of the Association to whose work the bureau's test was originally confined. As the equipment of the bureau became more extensive, and as there arose from the electrical industry at large a demand to enjoy the advantages of the testing facilities of the bureau, it was determined to extend the equipment and enter the general field of electrical testing for the public. In conformity with its enlarged field of work, the bureau has recently changed its corporate title to the Electrical Testing Laboratories, and has leased the old Manhattan Electric Light Company's station at the foot of 80th Street and East End Avenue, New York City, equipping it with the most complete laboratory apparatus in the world for general commercial electrical testing. The officers of the company are at present J. W. Lieb, Jr., President; Charles L. Edgar, Vice-President; E. A. Leslie, Treasurer; Wilson S. Howell, Secretary.

In entering thus into detail as to one branch of the Association's work and showing into what this branch has incidentally developed, it was desired to show one feature in which this organization differed from other national electrical engineering societies, and perhaps better appreciating this difference, the friends and well-wishers of the Association may be more charitable and less inclined to criticise it for conducting its conventions on narrow, restrictive and exclusive lines.

We shall conclude this rapid review with a list of the Conventions held to date, presidents and officers—past and present—and the list of the membership of the Association as it exists to-day.

From its organization in 1885 and up to the year 1890, the Association held two conventions each year, but as the work to be accomplished increased and the papers increased in numbers, becoming more exhaustive and valuable, requiring more discussion, and reports of standing committees demanded more time for their consideration, it was decided to have but one convention each year, and that in the fall and covering at least three days.

A list of conventions to date:

I. Harrisburg, Pa., April 15, 1885.
II. Pittsburg, Pa., June 3, 1885.
III. Atlantic City, N. J., June 9, 1886.
IV. Long Beach, N. Y., August 11, 1886.
V. Rochester, N. Y., February 9, 1887.
VI. Altoona, Pa., August 10, 11, 1887.
VII. Chicago, Ill., February 8, 9, 1888.
VIII. Nantasket Beach, Mass., August 8, 9, 1888.
IX. Kansas City, Mo., February 12, 13, 1889.
X. Niagara Falls, N. Y., August 13, 14, 15, 1889.
XI. Minneapolis, Minn., September 16, 17, 1890.
XII. New York City, N. Y. August 11, 12, 1891.
XIII. Toronto, Canada, August 9, 10, 1892.
XIV. World's Columbian Exposition, Chicago, Ill., August 8, 9, 1893.
XV. Boston, Mass., August 14, 15, 1894.
XVI. Detroit, Mich., August 13, 14, 15, 1895.
XVII. Manhattan Beach, Brooklyn, N. Y. August 11, 12, 13, 1896.
XVIII. Niagara Falls, N. Y., September 14, 15, 16, 1897.
XIX. Sault Ste. Marie, Mich., September 12, 13, 1898.
XX. Philadelphia, Pa., September 12, 13, 14, 1899.
XXI. Saratoga Springs, N. Y., September 4, 5, 6, 1900.

XXII. Pan American Exposition, Buffalo, N. Y., September 11, 12, 1901.

XXIII. Mount Washington Hotel, White Mountains, N. H., September 9, 10, 11, 1902.

XXIV. New Frontenac Hotel, Thousand Islands, N. Y., September 8, 9, 10, 1903.

XXV. Hotel Wentworth, New Castle, N. H., August 30, 31, and September 1, 1904.

PAST PRESIDENTS AND OFFICERS.

1884.

President, JAMES S. HUMBIRD, Cumberland, Md.
Vice-President, H. K. WOOD, Piqua, Ohio.
Secretary, FRANK S. MARR, Sunbury, Pa.
Treasurer, WESTLEY AUTEN, Sunbury, Pa.

1885.

President, JAMES S. HUMBIRD, Cumberland, Md.
Vice-President, WM. SCHWENCK, Mt. Carmel, Pa.
Secretary, FRANK S. MARR, Sunbury, Pa.
Treasurer, H. K. WOOD, Piqua, Ohio.

1886

President, JOHN I. BEGGS, Harrisburg, Pa.
Vice-President, JAMES S. HUMBIRD, Cumberland, Md.
Secretary, J. H. VAIL, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1887.

President, JOHN I. BEGGS, New York, N. Y.
Vice-President, F. A. Copeland, La Crosse, Wis.
Secretary, J. H. VAIL, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1888.

President, JOHN I. BEGGS, New York, N. Y.
Vice-President, C. P. GILBERT, Detroit, Mich.
Secretary, J. H. VAIL, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1889.

President, JOHN I. BEGGS, New York, N. Y.
Vice-President, C. P. GILBERT, Detroit, Mich.
Secretary, W. J. JENKS, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1890.

President, JOHN I. BEGGS, Chicago, Ill.
Vice-President, C. L. EDGAR, Boston, Mass.
Secretary, W. J. JENKS, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1891.

President, JOHN I. BEGGS, Chicago, Ill.
Vice-President, C. L. EDGAR, Boston, Mass.
Secretary, W. J. JENKS, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1892.

President, JOHN I. BEGGS, Chicago, Ill.
Vice-President, FREDERIC NICHOLLS, Toronto, Canada.
Secretary, W. J. JENKS, New York, N. Y.
Treasurer, WILSON S. HOWELL, New Brunswick, N. J.

1893.

President, C. L. EDGAR, Boston, Mass.
Vice-President, G. H. FINN, St. Paul, Minn.
Secretary, W. S. BARSTOW, Brooklyn, N. Y.
Treasurer, WILSON S. HOWELL, Orange, N. J.

1894.

President, C. L. EDGAR, Boston, Mass.
Vice-President, A. L. SMITH, Appleton, Wis.
Secretary, W. S. BARSTOW, Brooklyn, N. Y.
Treasurer, J. W. LIEB, JR., New York, N. Y.

1895.

President, C. L. EDGAR, Boston, Mass.
Vice-President, SAMUEL INSULL, Chicago, Ill.
Secretary, W. S. BARSTOW, Brooklyn, N. Y.
Treasurer, J. W. LIEB, JR., New York, N. Y.

1896.

President, SAMUEL INSULL, Chicago, Ill.
Vice-President, R. R. BOWKER, New York, N. Y.
Secretary, W. S. BARSTOW, Brooklyn, N. Y.
Treasurer, J. W. LIEB, JR., New York, N. Y.

1897.

President, SAMUEL INSULL, Chicago, Ill.
Vice-President, R. R. BOWKER, New York, N. Y.
Secretary, WILSON S. HOWELL, Newark, N. J.
Treasurer, W. S. BARSTOW, Brooklyn, N. Y.

1898.

President, R. R. BOWKER, New York, N. Y.
Vice-President, G. R. STETSON, New Bedford, Mass.
Secretary, WILSON S. HOWELL, Newark, N. J.
Treasurer, W. S. BARSTOW, Brooklyn, N. Y.

1899.

President, John W. Lieb, Jr., New York, N. Y.
Vice-President, Wm. Chandler, Sault Ste. Marie, Mich.
Secretary, Wilson S. Howell, Newark, N. J.
Treasurer, W. S. Barstow, Brooklyn, N. Y.

1900.

President, John W. Lieb, Jr., New York, N. Y.
Vice-President, A. W. Field, Columbus, Ohio.
Secretary, Wilson S. Howell, New York, N. Y.
Treasurer, W. S. Barstow, Brooklyn, N. Y.

1901.

President, Louis A. Ferguson, Chicago, Ill.
Vice-President, A. W. Field, Columbus, O.
Secretary, W. H. Johnson, Philadelphia, Pa.
Asst. Secretary, Wilson S. Howell, New York, N. Y.
Treasurer, Alex Dow, Detroit, Mich.

1902.

President, Louis A. Ferguson, Chicago, Ill.
Vice-President, A. W. Field, Columbus, O.
Secretary, W. H. Johnson, Philadelphia, Pa.
Asst. Secretary, Wilson S. Howell, New York, N. Y.
Treasurer, Alex Dow, Detroit, Mich.

1903.

President, Joseph B. McCall, Philadelphia, Pa.
Vice-President, Chas. C. Perry, Indianapolis, Ind.
Secretary, Wm. S. Barstow, Portland, Ore.
Asst. Secretary, Wilson S. Howell, New York, N. Y.
Treasurer, Alex Dow, Detroit, Mich.

OFFICERS AND COMMITTEES FOR 1904

Joseph B. McCall, President, Philadelphia, Pa.
Charles C. Perry, Vice-President, Indianapolis, Ind.
Alex Dow, Treasurer, Detroit, Mich.
William S. Barstow, Secretary, Portland, Ore.
Wilson S. Howell, Asst. Secretary, New York, N. Y.

EXECUTIVE COMMITTEE.

Joseph B. McCall, Chairman, Philadelphia, Pa.
Charles L. Edgar, Boston, Mass.
Louis A. Ferguson, Chicago, Ill.
Samuel Insull, Chicago, Ill.
E. A. Leslie, Brooklyn, N. Y.
John W. Lieb, Jr., New York, N. Y.

C. C. Perry (*ex-officio*), Indianapolis, Ind.
Alex Dow (*ex-officio*), Detroit, Mich.
W. S. Barstow (*ex-officio*), Portland, Ore.

COMMITTEE ON INCANDESCENT LAMPS.

(Sub-Committee of Executive Committee.)
John W. Lieb, Jr., Chairman, New York, N. Y.
C. L. Edgar, Boston, Mass.
Samuel Insull, Chicago, Ill.

COMMITTEE ON METERS.

Alex Dow, Chairman, Detroit, Mich.
A. H. Ackermann, New York, N. Y.
Oliver J. Bushnell, Chicago, Ill.
Joseph W. Cowles, Boston, Mass.
George Ross Green, Philadelphia, Pa.
John W. Lieb, Jr., New York, N. Y.

COMMITTEE ON NATIONAL CODE.

Wm. C. L. Eglin, Chairman, Philadelphia, Pa.
Louis A. Ferguson, Chicago, Ill.
Thomas E. Murray, New York, N. Y.

COMMITTEE ON STORAGE BATTERIES.

Louis A. Ferguson, Chairman, Chicago, Ill.
Wm. C. L. Eglin, Philadelphia, Pa.
Gerhard Goettling, Boston, Mass.
E. A. Leslie, Brooklyn, N. Y.
John W. Lieb, Jr., New York, N. Y.

COMMITTEE ON STEAM TURBINES.

Wm. C. L. Eglin, Chairman, Philadelphia, Pa.
Fred. Andrews, Boston, Mass.
W. H. Norris, Philadelphia, Pa.
C. H. Parker, New York, N. Y.
Fred. Sargent, Chicago, Ill.

COMMITTEE ON ST. LOUIS EXPOSITION.

Samuel Insull, Chairman, Chicago, Ill.
Charles L. Edgar, Boston, Mass.
John W. Lieb, Jr., New York, N. Y.
Jos. B. McCall, Philadelphia, Pa.
Thomas E. Murray, New York, N. Y.

HONORARY MEMBERS

THOMAS A. EDISON
LORD KELVIN
EDWARD H. JOHNSON
WILSON S. HOWELL
R. R. BOWKER
EDISON ELECTRIC LIGHT COMPANY

MEMBERS OF THE ASSOCIATION.

Altoona—Edison Electric Illuminating Co. of Altoona; E. B. Greene, Superintendent.

Amsterdam, N. Y.—Amsterdam Street Railroad Co., F. Seixes, General Manager.

Appleton, Wis.—The Appleton Electric Light and Power Co.; H. D. Smith, Secretary and Treasurer.

Atlanta, Ga.—Edison Illuminating Co.; G. W. Brine, Secretary and Treasurer.

Atlantic City, N. J.—The Electric Light Co. of Atlantic City.

Birmingham, Ala.—Birmingham Railway and Light Co.

Boston, Mass.—Edison Electric Illuminating Co. of Boston; C. L. Edgar, President.

Brockton, Mass.—Edison Electric Illuminating Co. of Brocton; H. T. Edgar, Manager.

Brooklyn, N. Y.—Edison Electric Illuminating Co. of Brooklyn; E. A. Leslie, General Manager.

Buffalo, N. Y.—Buffalo General Electric Co.; Chas. R. Huntley, Manager.

Canton, O.—Canton Light, Heat and Power Co.

Chattanooga, Tenn.—Chattanooga Light and Power Co.; Byron T. Burt, Manager.

Chester, Pa.—Chester Electric Light and Power Co.; Geo. N. Tidd, Manager.

Chicago, Ill.—Chicago Edison Co.; Samuel Insull, President.

Cleveland, O.—Cleveland Electric Illuminating Co.; Robt. Lindsey, Superintendent.

Columbus, O.—Columbus Edison Co.; A. W. Field, Secretary and General Manager.

Cumberland, Md.—Edison Electric Illuminating Co. of Cumberland; W. M. Roberts, Jr., General Manager.

Des Moines, Ia.—Des Moines Edison Light Co.; R. H. MacMullan, Vice-President and General Manager.

Detroit, Mich.—Edison Illuminating Co. of Detroit; Alex. Dow, General Manager.

Elgin, Ill.—Elgin City C. & A. Ry. Co.

Erie, Pa.—Edison Electric Light and Power Co.; S. C. Walker, Secretary.

Fall River, Mass.—Fall River Electric Light Co.; Albert F. Dow, Treasurer.

Grand Rapids, Mich.—Grand Rapids Edison Company.

Harrisburg, Pa.—Harrisburg Light, Heat and Power Co.; W. H. Stone, Secretary.

Indianapolis, Ind.—Indianapolis Light and Power Co.; C. C. Perry, Secretary and Treasurer.

Jackson, Mich.—Jackson Light and Power Co.; W. A. Foote, President.

Johnstown, Pa.—Johnstown Electric Light and Power Company.

Kansas City, Mo.—Edison Electric Light and Power Co.; R. E. Richardson, General Manager.

La Crosse, Wis.—Edison Light and Power Co.; C. H. Greenwood, General Superintendent.

Lawrence, Mass.—Lawrence Gas Company; C. J. R. Humphreys, Agent.

Minneapolis, Minn.—Minneapolis General Electric Co.; A. M. Robertson, General Manager.

New Bedford, Mass.—New Bedford Gas and Edison Light Co.; Geo. R. Stetson, President.

New Orleans, La.—Edison Electric Co.; W. J. Kehl, Secretary and Treasurer.

Newport, R. I.—Newport Illuminating Co.; Mr. Geo. P. Magner, Manager.

New York, N. Y.—The New York Edison Co.; J. W. Lieb, Jr., Associate General Manager.

Paterson, N. J.—Paterson & Passaic Gas and Electric Co.; Wm. M. Brack, Manager.

Philadelphia, Pa.—Edison Electric Light Co. of Philadelphia; Jos. D. Israel, Secretary and Manager.

Piqua, O.—Miami Light, Heat and Power Co.; S. M. Rust, Manager.

Pottsville, Pa.—Edison Electric Illuminating Co. of Pottsville; Van Dusen Rickert, Secretary and Mgr.

Reading, Pa.—Metropolitan Electric Co.; K. A. Ficthern, Secretary.

Renovo, Pa.—Renovo Edison Light, Heat, and Power Co.; F. M. Noecker, General Manager.

Rochester, N. Y.—Rochester Gas and Electric Co.; Geo. A. Redman, General Superintendent.

Rockford, Ill.—Rockford Edison Co.; M. A. Beal, Sec'y.

San Francisco, Cal.—San Francisco Gas and Electric Co.

Sault Ste. Marie, Mich.—Edison Sault Electric Co.; Wm. Chandler, Vice-President.

Schenectady, N. Y.—Schenectady Illuminating Co.

Scranton, Pa.—Scranton Illuminating, Heat and Power Co.; E. M. Stack, General Manager.

Seattle, Washington—Seattle Electric Co.; Geo. W. Dickinson, General Manager.

Spokane, Wash.—Washington Water Power Co.; D. L. Huntington, General Manager.

St. Louis, Mo.—Missouri Edison Electric Co.; S. B. Pike, Secretary.

St. Paul, Minn.—Edison Electric Light and Power Co.; A. P. Lathrop, General Manager.

Syracuse, N. Y.—Syracuse Lighting Co.; John J. Cummings, Treasurer.

Tamaqua, Pa.—Edison Electric Illuminating Co. of Tamaqua; F. B. Spiese, Secretary.

Tiffin, O.—The Tiffin Edison Electric Illuminating Co.; C. B. Rodgers, General Manager.

Toledo, O.—The Toledo Railways and Light Co.; Albion E. Lang, President.

Topeka, Kan.—Edison Electric Illuminating Co.; Mr. C. R. Maunsell, Superintendent.

Washington, D. C.—United States Electric Lighting Co.; Geo. H. Harris, Vice-President.

Wilkesbarre, Pa.—Wyoming Valley Electric Light, Heat and Power Co.

Williamsport, Pa.—Edison Electric Illuminating Co. of Williamsport; Ernest H. Davis, Treasurer.

Wilmington, Del.—The Wilmington City Electric Co.; C. R. Van Trump, Superintendent.

York, Pa.—York Light, Heat and Power Co.; H. E. Ross, General Manager.

Chicago, Ill.—Commonwealth Electric Co.
Hazelton, Pa.—Hazelton Electric Light and Power Co.
Trenton, N. J.—Trenton Light, Heat and Power Co.
Norristown, Pa.—Norristown Electric Light and Power Company.
Nashville, Tenn.—Nashville Railway and Light Co.
Peoria, Ill.—Peoria General Electric Co.
Louisville, Ky.—Citizens' General Electric Co.
Sacramento, Cal.—Sacramento Electric, Gas and Railway Company.
Oakland, Cal.—Oakland Gas, Light and Heat Co.
Portland, Ore.—Portland General Electric Co.
Baltimore, Md.—United Electric Light and Power Co.
Milan, Italy—Soc. Generale Italiana Edison di Elettricita; Ing., Carlo Esterle.

INTERESTING ASSOCIATION PAPERS

List of papers read before the Association, and printed in the minutes of the meetings:

General illumination by night

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