THE

ST LOUIS

ELECTRICAL

HAND

BOOK

MEMORANDUM.

This electrical handbook is one of a series of ten similar handbooks prepared under the auspices of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS by the local Reception Committees in the Cities of Boston, New York, Schenectady, Montreal, Niagara Falls, Chicago, St. Louis, Pittsburg, Washington, and Philadelphia. These are the stopping places on the circular tour organized by the INSTITUTE for the reception and entertainment of its foreign guests who visit the United States in connection with the International Electrical Congress at St. Louis, September 12th to 17th, 1904. It is hoped in these handbooks to present short historical sketches of the cities visited and a rapid survey of the power plants and important electrical industries along the route.

St. Louis. **No.** 584

THE ST. LOUIS ELECTRICAL HANDBOOK

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Being a Guide for Visitors from Abroad Attending the International Electrical Congress, St. Louis, Mo. September, 1904

St. Louis
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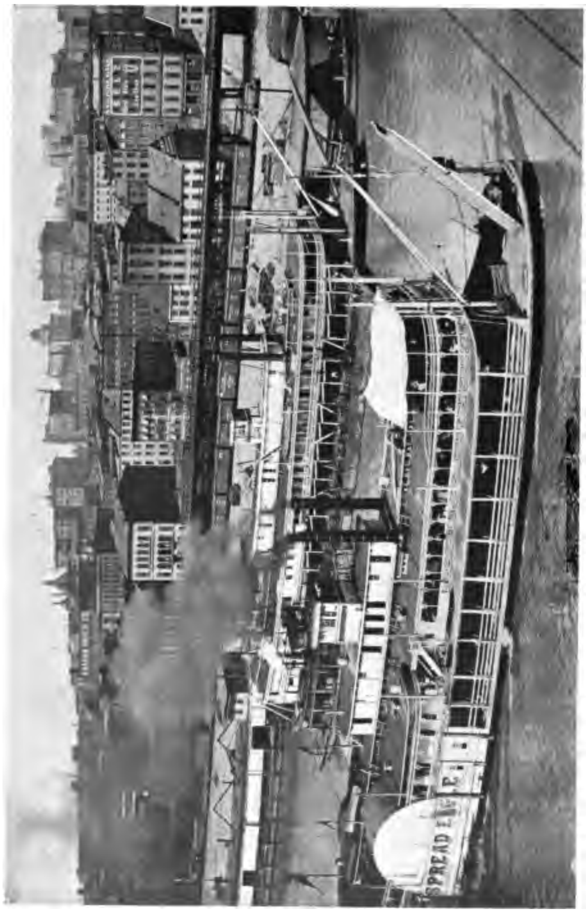
The City of St. Louis

ST. LOUIS is the fourth city of the United States in population and manufactures, ranking after New York, Chicago, and Philadelphia. Its estimated population at the present time, based on the government census returns since 1840, is in the neighborhood of 650,000. The city, by reason of its geographical location, is the natural metropolis of the immense territory of the Southwest, and its industrial development has gone hand in hand with that of this important part of the country. The rapidly increasing settlement of this section, due in part to the reclaiming of heretofore arid lands by irrigation under government supervision, will, undoubtedly, act still further to mark the city as the Gateway of the Southwest.

St. Louis is situated on the west bank of the Mississippi River, about twenty miles below the mouth of the Missouri River. It was founded on February 15, 1764, by Pierre Ligueste Laclède as an Indian trading-post, and was named in honor of Louis IX. of France. In the following year the town was made the capital of Upper Louisiana, under the governorship of Saint-Ange de Bellerive, although the territory in which it was situated had been ceded to Spain by the treaty concluded in Paris in 1763. It remained under French control until November 29, 1770, when the Spaniards, represented by Don Pedro Pierras, took possession. In 1800, however, the French again took possession, and retained it until shortly after the consummation of the Louisiana Purchase under President Jefferson. The formal transfer of the territory of Upper Louisiana took place in St. Louis on March 9, 1804. On November 9, 1809, the town was incorporated.



The River Front, St. Louis

Since that time the development of the city has been similar to that of other typically American municipalities. For many years St. Louis was the headquarters of the great fur trade of the Northwest, and was the starting point of many of the exploring parties which were instrumental in opening up the vast territory west of the Mississippi, notably the Lewis and Clark expedition and that of Fremont. A city charter was granted in 1822, Missouri having been admitted to the Union in 1820, after much stormy congressional legislation due to the slavery question. In 1848 the city was visited by a terrible epidemic of cholera, and in 1849 fire destroyed nearly the whole of the business district and the public buildings, embraced in the district between the river and what is now Fourth street At the outbreak of the Civil War the city was in a turbulent condition, the sympathies of its citizens being about equally divided between the North and South, due to its position midway between the two sections; but the prompt action of Generals Nathaniel Lyon and Frank P. Blair saved the city for the Union. It was constantly occupied by troops and was a base of supplies for the Federal army. The Western Sanitary Commission had its headquarters here and a large military hospital was also maintained. In 1875 the city was separated from the county of St. Louis, the two now having entirely independent governments.

At the present writing, the city covers an area of approximately sixty-two square miles, with a river front of nineteen miles. In general plan it resembles a double convex meniscus, with the longer axis running north and south, its eastern boundary being formed by a wide sweep of the river. The principal business district occupies the central eastern part of the city, the river front being given up to factories, warehouses and railroad yards. The depression of the Mill Creek Valley, running east and west near the median line of the city, is used by the railroads running to the south and southwest. The fine residence district, for which St. Louis is particularly noted, is in the western part of the city; the great number and imposing appearance of the fine residences, the majority of which are set in spacious grounds, makes this section one of which the citizens may well be proud.

There are 23 public parks in the city, with an aggregate area of 2,183 acres. Forest Park, part of which is now occupied by the Louisiana Purchase Exposition, is the largest, with an area of 1,374 acres, and with the exception of Fairmount Park in Philadelphia, is the largest city park in the United States. Tower Grove Park and the Missouri Botanical Garden, in the southwestern part

The Court House

of the city, were both presented to the city by the late Mr. Henry Shaw. The Missouri Botanical Garden, familiarly known as Shaw's Garden, is recognized as the finest botanical garden in the country.

There is at present no system of boulevards connecting the various parks, but tentative plans for that purpose have been prepared by the Kingshighway Boulevard Commission; the principal object of this commission is to map out a scheme for the improvement of Kingshighway and its extension in both directions to the river.

St. Louis has long been noted for the excellence of its public school system, which includes three high schools and 92 grade schools. The architectural beauty and the hygienic appointments of all the more recent buildings are worthy of special mention. Higher education is provided by a number of institutions, of which Washington University is the most important; a more detailed description of this University, which offers instruction in all branches of learning except theology, will be found in another part of this volume. Other institutions are: St. Louis University (Roman Catholic, opened 1829); the College of the Christian Brothers (Roman Catholic,

Residence Section—Portland Place

1849); Concordia Theological Seminary (Lutheran, 1839); Theological Seminary of the German Evangelical Synod of North America (1850); the St. Louis College of Physicians and Surgeons (1879); Homeopathic Medical College of Missouri; St. Louis College of Pharmacy, and the St. Louis Training School for Nurses. There are many scientific and technical organizations which contribute to the advancement of learning and culture, of which the St. Louis Academy of Science is widely known for its valuable *Transactions*.

Before the advent of the railway, St. Louis was famous for its river traffic. The peculiar conditions encountered in navigating the Mississippi and Missouri Rivers, due to a shallow and shifting channel obstructed by sand-bars, brought about the evolution of a type of steamboat altogether unique; and even to-day, when the increased railway facilities have caused the river trade to shrink to a comparatively small volume, the Mississippi boats are objects of the greatest interest to strangers. It now appears probable that river traffic will again assume an important place in the development of the city, due to the government plans for the construction and maintenance of a deep-water channel from the Great

Union Station

Lakes to the Gulf of Mexico, via the Chicago Drainage Canal and the Illinois River. At the present time, however, the commerce of the city is mainly handled by the railroads. As a railroad centre St. Louis has a commanding position, twenty-four trunk lines terminating here. All of them enter the Union Station, which is one of the finest, and certainly the largest, railroad station now in use in the United States. This station, and the extensive terminal facilities connected with it, are controlled by the Terminal Railroad Association of St. Louis. This association controls the operation of the Eads and Merchants' bridges over the Mississippi River, the former famous as the first steel arch bridge in the world. It was designed and built by Captain James B. Eads, and was finished in 1874 at a cost of $6,500,000. It is remarkable for the great number of difficult engineering problems met and solved for the first time by Captain Eads and his associates. It was in the construction of this bridge that pneumatic caissons for sinking foundations to bed-rock were first used.

Local transportation facilities are furnished by two independent systems of electric railways, both of which operate surface lines only. They are the St. Louis Transit Company and the St. Louis and Suburban Railway Company, detailed descriptions of which will be found under another heading. It may be said here, however, that since the installation of the additional equipment ordered by these companies for handling the Exposition traffic the service has aroused universally favorable comment on account of its high efficiency.

Municipal improvements are under the general supervision of the Board of Public Improvements, whose members, appointed by the mayor, are the heads of the various branches of the public works, such as the water, street, sewer, park, and harbor departments.

The city water supply is drawn from the Mississippi river through an intake tower at the Chain of Rocks, about eleven miles north of the Eads bridge, and is pumped to a series of six settling basins, with a total capacity of 170,000,000 gallons, by six compound, condensing, low-service engines with a combined capacity of 160,000,000 gallons per 24 hours. The basins are operated on the weir system of continuous sedimentation, using sulphate of iron as a coagulant. The water is delivered through an 11-ft. masonry conduit, 3½ miles long, to the Baden high-service station, whose engines have a capacity of 80,000,000 gallons per 24 hours, thence through a 9-ft. conduit to the Bissell's Point high-service station, which has a capacity of 110,000,000 gallons per 24 hours. The Baden station delivers water directly to the mains at a pressure of 125 pounds, an overflow tower being located at the Compton Hill reservoir; the latter is in the southern part of the city and has a capacity of 60,000,000 gallons. The Bissell's Point station pumps to two towers on a hill near by, and thence directly to the mains. The distribution system consists of about 700 miles of pipe of various sizes, in connection with which there are about 7,800 fire-plugs and 4,800 meters.

The city sewers of all sizes have a total length of 562.055 miles, whose total cost to date, including maintenance, has been $13,413,052.80.

The streets of the city aggregate 881 miles in length, of which 468 miles are variously improved with macadam, telford, novaculite, asphalt, bituminous macadam, gran-

The Merchants Bridge

ite, vitrified brick, and wood blocks; in addition, there are 124 miles of paved alleys. During the past year 35.27 miles of streets and 5.33 miles of alleys were paved, and it is probable that during the current year a still greater mileage will be constructed. Improved streets are sprinkled by contract, and maintenance is done partly by contract and partly by the city itself.

Street and alley lighting is done by contract, electricity, gas and naphtha being used as illuminants. The total number of miles of streets lighted is 672. Arc lighting is confined to the district east of Jefferson avenue, where there are 1,000 arc lamps of the direct-current, series, enclosed type, current being supplied from the Tenth and St. Charles street plant of the Union Electric Light and Power Company. The same company also furnishes current for 800 30 c-p. incandescent lamps. Gas lighting is furnished for the residence districts by 14,000 mantle lamps at $6.81 per thousand hours, 250 Welsbach lamps at $11 per thousand hours, and 1,400 gas lamps at $37 per lamp-year. Gas is furnished by the Laclede Gas Light Company. In certain districts not piped for gas, naphtha is used.

City Hall

St. Louis being the metropolis of the Mississippi Valley, is deeply interested in all work concerned with the improvement of the river and its tributaries. Here are located the headquarters of the Mississippi River Commission, in charge of improvements from the mouth of the Ohio River to the Head of Passes, near the Gulf of Mexico, and of surveys, topographical, hydrographical and hydrometrical, of the river from its head waters to the Gulf. The United States Engineer Corps (of the Army) has charge of all work between the head waters and the mouth of the Ohio, and of the snag-boat service from St. Louis to Natchez. From the mouth of the Missouri to that of the Ohio, the improvement consists of revetment and contraction work, a low-water channel depth of eight feet being maintained by hydraulic dredges. Examinations, surveys, plans and estimates are now being made by direction of Congress for a navigable waterway fourteen feet deep from Lake Michigan via the Chicago Drainage canal, the Illinois and Mississippi rivers to St. Louis. This project is in charge of a board of army engineers and the Mississippi River Commission.

Post-Office

Industrially, St. Louis has many claims to distinction. Its proximity to the soft-coal fields of Illinois renders fuel very cheap, thus making the city a natural manufacturing centre. It produces more smoking and plug tobacco than any other city in the world; makes more street and railway cars than any other city; is the world's headquarters for the horse and mule trade, and has the largest shoe factory. It has the largest drug house, woodenware house, and hardware house in the United States, is the greatest dry goods market west of the Alleghenies, and leads in the manufacture of American-made chemicals. One of its breweries has the largest output in the country and is one of the most interesting sights of the city. The Cupples station is the largest private freight station in the world, and is a unique solution of the problem of handling freight without the use of teams; in this station is the most extensive single system of elevators in America; the medium for transmission is a special hydraulic oil of very high fire test, which retains its fluidity at a temperature considerably below zero degrees fahr., and which is operated at a pressure of 750 pounds per square inch.

In conclusion, the places of special interest in the city, aside from the Exposition, may be summarized as follows: The new grounds and buildings of Washington University; the central western residence district; the Missouri Botanical Garden, or Shaw's Garden; the Anheuser-Busch brewery; the Cupples station; the Eads bridge, and the terminal plant of the Terminal Railroad Association, in the immediate neighborhood of the Union station.

INTERNATIONAL ELECTRICAL CONGRESS

Festival Hall

International Electrical Congress

SEPTEMBER 12-17, 1904

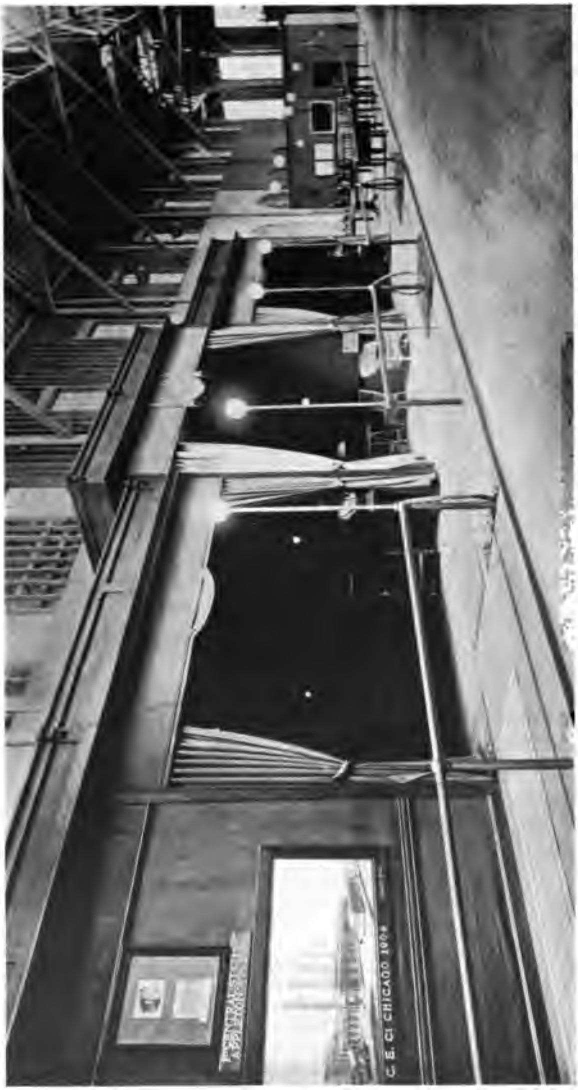
ELECTRICAL Congresses held in the past have had an important influence for good on the world's progress in the knowledge of electricity and magnetism. It is confidently believed that the International Electrical Congress of 1904, to be held during the continuance of the Louisiana Purchase Exposition at St. Louis, will yield results at least as valuable as have any of the congresses preceding.

The last International Electrical Congress was held in Paris in 1900, in connection with the Universal Exposition. The one preceding that was held at Chicago in 1893 during the Columbian Exposition. The International Electrical Congress of 1904 is held under the auspices and at the invitation of the Louisiana Purchase Exposition.

It will comprise three distinct features:

1st. A Chamber of Delegates, appointed by the various governments, and essentially similar to the chamber of government delegates at the International Electrical Congresses of Chicago in 1893, and of Paris in 1900. It would seem that sufficient material has been collected since 1900, calling for international action, to warrant the invitations extended to the various governments to appoint delegates, as they did to Chicago and Paris, to attend the International Electrical Congress of St. Louis.

The delegates appointed up to August 1, were as follows: Austro-Hungary, Prof. Charles Zipernovsky; Italy, Prof. Moise Ascoli, Prof. L. Lombardi, Ing. A. Maffezzini; Switzerland, Prof. Ferdinand Weber, Prof. François Louis Schule; Norway and Sweden, Prof. G. Arrhenius; Australian Colonies, John Hesketh, Esq.; Brazil, Señor Jorge Newbery; India, J. C. Shields, Esq.;



A. I. E. E. Headquarters, Palace of Electricity

Mexico, Señor Rafael R. Arizpe; United States, Prof. H. S. Carhart, Dr. A. E. Kennelly, Prof. H. J. Ryan, Prof. S. W. Stratton, Prof. Elihu Thomson.

2nd. The main body of the Congress, divided into the following sections:

General Theory—Section A, Mathematical, Experimental.

Applications—Section B, General Applications; Section C, Electrochemistry; Section D, Electric Power Transmission; Section E, Electric Light and Distribution; Section F, Electric Transportation; Section G, Electric Communication; Section H, Electrotherapeutics.

3rd. Conventions simultaneously held, in connection with the Congress, by various electrical organizations in the United States. It is proposed that each section of the Congress may be able to hold its meeting under some plan in conjunction with the organization or organizations devoted to the progress of the work selected by that section. Steps were taken to enlist the support of the various organizations, with a view to perfecting the details of co-operation in the work to be done. Prominent among the organizations which will take part are:

The Institution of Electrical Engineers. Delegates—Mr. R. Kaye Gray (pres.); Col. R. E. Crompton, C. B.; Prof. John Perry, F. R. S.; Dr. R. T. Glazebrook, F. R. S.; Mr. H. E. Harrison, B. Sc., B. A.; Mr. W. Duddell, Hon. Sec'y of Delegation.

La Société Internationale des Electriciens.

Associazione Elettrotecnica Italiana. Delegates—Prof. M. Ascoli (pres.); Prof. G. Grassi (vice-pres.); Prof. L. Lombardi (vice-pres.); Ing. E. Jona.

Oesterrichischer Elektrotechnischer Verein. Delegate—Dr. Heinrich Ritter von Kuh.

The Royal Society of Canada. Delegates—Prof. W. Lash Miller, Prof. Howard T. Barnes.

The American Institute of Electrical Engineers, to hold a simultaneous convention and joint sessions with several sections. Delegates—Mr. Ralph D. Mershon, Prof. M. I. Pupin, Prof. C. P. Steinmetz.

The British Pavilion

The American Physical Society, to hold a simultaneous convention and joint session with Section A, 15th September. Delegates—to be appointed.

The American Electrochemical Society, to hold a simultaneous convention and joint sessions with Section C, 13th and 15th September. Delegates—Prof. W. D. Bancroft, Prof. H. S. Carhart (pres.), Dr. Louis Kahlenberg.

The National Electric Light Association. Delegates—Mr. George Eastman, Mr. G. Ross Green, Dr. F. A. C. Perrine.

The Association of Edison Illuminating Companies. Delegates—Mr. W. C. L. Eglin, Mr. L. A. Ferguson, Mr. Gerhard Goettling.

The International Association of Municipal Electricians, to hold a simultaneous convention and joint meetings with Section G. Delegates—Mr. W. H. Bradt, Mr. F. C. Mason, Mr. Walter N. Petty.

The American Electro-Therapeutic Association, to hold a simultaneous convention and joint meeting with Section H, 15th September. Delegates—Dr. Russell Herbert Boggs, Dr. Charles R. Dickson, Dr. James Herdman.

The United States Navy Department has appointed as Delegate to the Congress Lieutenant-Commander Joseph L. Jayne.

The American Institute of Electrical Engineers extended an invitation to the Institution of Electrical Engineers of Great Britain to visit the United States and to hold a joint meeting in St. Louis in connection with the International Electrical Congress. This invitation was accepted by the Institution of Electrical Engineers, and a large number of its members, many accompanied by ladies, have signified their intention to be of the party.

The joint meeting of the British Institution and the American Institute will be held on Wednesday, September 14.

The Department of State, at Washington, acting upon requests sent from the Congress Committee on Organization and from the President of the American Institute of

The Italian Pavilion

Electrical Engineers, forwarded through the Department of Commerce and Labor and the Bureau of Standards, instructed the diplomatic officers of the United States abroad to extend invitations to the various foreign governments to appoint official delegates to the Congress. These instructions were sent out on December 17, 1903. The list of delegates invited was in accordance with the lists of those allotted to the various countries at the Congress in Chicago in 1893 and at the Congress in Paris in 1900.

The proceedings of the Chamber of Delegates are to be conducted in a manner essentially similar to the meetings of the chambers of government delegates at the International Congresses of 1893 and 1900.

The Committee of Organization of the Congress is as follows:

President—Elihu Thomson, past-president of the American Institute of Electrical Engineers.

Vice-Presidents—Mr. B. J. Arnold, president of the American Institute of Electrical Engineers; Prof. H. S. Carhart, president of the American Electrochemical Society; Prof. W. E. Goldsborough, chief Department of Electricity, Louisiana Purchase Exposition; Mr. Charles F. Scott, past-president of the American Institute of Electrical Engineers; Dr. S. W. Stratton, Director of the National Bureau of Standards of the United States.

General Secretary—Dr. A. E. Kennelly, past-president of the American Institute of Electrical Engineers.

Treasurer—Mr. W. D. Weaver, editor of the "Electrical World and Engineer."

Advisory Committee—Mr. B. A. Behrend, Mr. C. S. Bradley, Mr. J. J. Carty, Mr. A. H. Cowles, Dr. F. B. Crocker, past-president A. I. E. E.; Dr. Louis Duncan, past-president A. I. E. E.; Mr. R. A. Fessenden, Mr. W. J. Hammer, Mr. Carl Hering, past-president A. I. E. E.; Dr. C. P. Matthews, Mr. K. B. Miller, Dr. W. J. Morton, Dr. E. L. Nichols, Prof. R. B. Owens, Dr. F. A. C. Perrine, Dr. M. I. Pupin, Mr. H. L. Doherty, Prof. J. W. Richards, past-president of the American Electrochemical Society; Prof. H. J. Ryan, Mr. William Stanley, Dr.

The German Palace

C. P. Steinmetz, past-president A. I. E. E.; Dr. L. B. Stillwell, Mr. Ralph D. Mershon, Mr. J. G. White, Mr. A. J. Wurtz.

Invitations were extended to all persons who are interested in electricity and its application to take part in the Congress and to attend its meetings.

Nearly 2,000 acceptances were received up to August 1, about 1,400 subscriptions were in hand and about 1,300 membership certificates had been issued.

Special letters of invitation to the number of 350 were issued on behalf of the Committee of Organization to prominent electricians and electrical engineers, signed by the president and general secretary of the committee, requesting papers for the Congress in the various sections. Of these about an equal number each were sent to foreign authors and to American authors. Many acceptances have been received from both foreign and American authors. A tentative limit of the number of papers to be accepted was set by the committee at 150, but a greater number than this were already promised early in August. Of these, 103 papers were from Americans and 63 from foreign authors. Sixty-four of these papers were then in hand and were being printed in advance of the meeting.

The proceedings of the Congress will be published in several large volumes and a copy of each will be sent to each member subscribing to the Congress More than 1,800 acceptances of membership had been received up to the end of the first week in July.

Between September 12th and September 17th the office of the secretary and of the treasurer will be at the Coliseum, St. Louis, Mo.

The bureau of information will be maintained in the Coliseum during this time.

Delegates to the Congress of 1904 will arrive in St. Louis from Chicago at noon on Sunday, September 11, They will be received by Mr. W. V. N. Powelson, Mr. W. A. Longman and the members of the St. Louis Reception Committee. They will be taken to the newly-built Jefferson Hotel, at Thirteenth street near Locust, where rooms have been reserved and where most of the delegates will stop. The Jefferson is one of the newest and finest of St. Louis's hotels, and is situated only a block from the Coliseum and Music Hall, where the meetings of the sections will begin on the 12th.

On Sunday evening an informal reception will be held at the Jefferson Hotel, at which all the local engineers, their wives, and the many engineers and others who are visiting the World's Fair will be presented.

The Austrian Building

On Monday at 9.30 a. m. the opening ceremonies of the Congress will be held in the Music Hall of the Coliseum, at Olive and Thirteenth streets. This will perhaps be the last event of any note to take place in this building, which has been the scene of many interesting gatherings of national importance. The building is about to be torn down to make room for a public library, the foundation of which is a million dollar donation by Mr. Andrew Carnegie.

It was in this building that the late Democratic National Convention was held at which Judge Alton B. Parker was named as a candidate for election in November, 1904, to the Presidency of the United States, in opposition to President Theodore Roosevelt, the nominee of the Republican party.

The building was erected for the St. Louis Exposition of September, 1884. Ground was broken for it on August 22, 1883. The building measures 438 feet in length by 338 feet in width and it is 108 feet high. The Music Hall is 200 feet long, 120 feet wide and 80 feet high. It has a seating capacity of 4,000. During the recent Democratic convention the Coliseum seated 12,400 persons.

After the opening ceremonies, the Congress will adjourn and the meetings of the eight sections will begin. These meetings will be called to order at 11 a. m. They will be held in the section rooms on the second floor of the Coliseum. The meetings will adjourn at 1.30 p. m. on Monday, and on Tuesday, Thursday and Friday at 1 p. m., so as to give time for the members to visit the Fair, etc.

The eight sections, among which the work of the Congress will be divided, and the officers of the sections are as follows:

Section A—Subject: General Theory; Dr. E. L. Nichols, Cornell University, chairman; Prof. H. T. Barnes, McGill University, secretary.

Section B—Subject: General Applications; Dr. C. P. Steinmetz, Union College, chairman; Dr. Samuel Sheldon, Brooklyn, N. Y., secretary.

Section C—Subject: Electrochemistry; Prof. H. S. Carhart, University of Michigan, chairman; Mr. Carl Hering, Philadelphia, Pa., secretary.

Section D—Subject: Electric Power Transmission; Mr. C. F. Scott, Pittsburg, Pa., chairman; Dr. Louis Bell, Boston, Mass., secretary.

Section E—Subject: Electric Light and Distribution; Mr. J. W. Lieb, jr., New York, chairman; Mr. Gano S. Dunn, New York, secretary.

Section F—Subject: Electric Transportation; Dr. Louis Duncan, Massachusetts Institute Technology, chairman; Mr. A. H. Armstrong, Schenectady, N. Y., secretary.

Section G—Subject: Electric Communication; Mr. F.

W. Jones, New York, chairman; Mr. Bancroft Gherardi, New York, secretary.

Section H—Subject: Electro-therapeutics; Dr. W. J. Morton, New York, chairman; Mr. W. J. Jenks, New York, secretary.

The chairmen and secretaries of the various sections are also honorary members of the Advisory Committee of Organization.

The following are the preliminary programmes of the different sections, giving the name of the author and the title of his paper:

Section A.—General Theory—Mathematical, Experimental: Prof. Dr. Moise Ascoli, Systems of Electric Units (A. E. L. paper); Prof. Dr. Paul Drude, Metallic Conduction from the Standpoint of Electronic Theory; Prof. Dr. W. Jaeger, Electrical Standards; Prof. H. Nagaoka, Magneto-Striction; Prof. J. S. Townsend, The Theory of Ionization by Collision; Prof. J. J. Thomson, The Corpsucular Theory; M. J. Violle, Secondary Standards of Light; Prof. C. T. R. Wilson, F. R. S., Condensation Nuclei; Prof. P. Zeeman, Recent Progress in Magneto-Optics; Dr. Carl Barus, Atmospheric Nuçlei; Prof. Howard T. Barnes, The Mechanical Equivalent of Heat as Determined by Electrical Means (Roy. Soc., Canada, paper); Dr. L. A. Bauer, The State of Our Knowledge Regarding the Earth's Magnetism and the Recent Remarkable Magnetic Storms; Prof. D. B. Brace, Magneto-Optics; Prof. H. S. Carhart and Prof. G. W. Patterson, Jr., The Absolute Value of the Electromotive Force of the Clark and Weston Cells; Prof. C. D. Child, The Electric Arc; Dr. K. E. Guthe, Coherer Action; Dr. A. E. Kennelly, The Alternating Current Theory of Transmission-Speed over Submarine Telegraph Cables; Prof. E. Percival Lewis, The Electrical Conductivity of Gases; Prof. E. Louis More, Electrostriction; Prof. J. C. McLennan, Radio-activity of Mineral Oils and Natural Gases; Prof. E. F. Nichols, The Unobtained Wave-Lengths between the Longest Thermal and the Shortest Electric Waves yet Measured; Prof. E. L. Nichols, Standards of Light; Dr. H. Pender, The Magnetic Effect of Moving Charges; Prof. M. I. Pupin, Electrical Impulses and Multiple Oscillators (A. I. E. E. paper); Dr. E. B. Rosa and Mr. F. W. Grover, The Absolute Measurement of Capacity and Inductance; Prof. E. Rutherford, Radioactive Change; Prof. J. Trowbridge, Spectra of Gases at High Temperatures; Prof. A. G. Webster, Report on Recent Developments in Electrical Theory; Prof. J. Zeleny, The Discharge from Points; Dr. A. E. Wolff, The So-called International Electric Units.

Section B.—General Applications: Prof. E. Arnold and J. L. La Cour, The Commutation of D. C. and A. C. Machines; Dr. O. S. Bragstad, Theory and Method of Operation of Repulsion Motors; M. André Blondel, Calculation and Tests of Alternators; Col. R. E. Crompton, Standardization of Dynamo-Electric Machinery and Apparatus; Profs. Drs. Elster and Geitel, Concerning Natural Radio-activity of the Atmosphere and the Earth; Herr Clarence Feldmann and Joseph Herzog, The Distribution of Voltage and Current in Closed Conducting Networks; M. Alexander Heyland, Recent Developments in Compounded Alternators with Direct Excitation from Alternating Currents; W. M. Mordey (title to be announced); M. A. Nodon, Rectifiers; Sir W. Preece, Electricity in Ancient Egypt; Prof. C. A. Adams, The Leakage Reactance of Induction Motors; Mr. C. Day, Electric Motors in Shop Service; Mr. H. W. Fisher, Sparking Distances Corresponding to Different Voltages; Prof. H. J. Ryan, The Design of Insulators; Mr. D. B. Rushmore, The Regulation of Alternators; Prof. E. B. Rosa, The Influence of Wave Shape upon Alternating-Current Meter Indications; Dr. Clayton H. Sharp, The Equipment of a Commercial Testing Laboratory; Prof. H. B. Smith, Very High Voltage Transformers.

Section C.—Electrochemistry: Prof. Dr. S. Arrhenius, Methods of Determining the Degree of Dissociation; Geh. Reg. Prof. Dr. W. Borchers, Electrometallurgy of Nickel; Sherard O. Cowper-Coles, Electrolytic Methods for the Rapid Production of Copper Sheets and Tubes; Dr. F. Dolezalek (subject to be announced); J. Sigfried Edström, Electrical Extraction of Nitrogen from the Air; Dr. H. Goldschmidt, Alumino-Thermics; Prof. Dr. F. Haber, Electrolytic Disturbances in the Earth; Dr. P. L. T. Héroult, Electrometallurgy of Iron and Steel; Prof. Dr. Richard Lorenz, Electrolysis of Fused Salts; Prof. Dr. W. Ostwald, Catalysis in Electrolysis; Mr. J. Swinburne, Chlorine Smelting; Prof. W. D. Bancroft, The Chemistry of Electroplating (A. E.-C. S. paper); Mr. A. G. Betts and Dr. Edward F. Kern, The Lead Voltameter; Prof. H. S. Carhart and Dr. C. A. Hulett, The Preparation of Materials for Standard Cells and their Construction (A. E.-C. S. paper); Thomas A. Edison, Alkaline Batteries (by deputy); Dr. K. E. Guthe, The Silver Voltameter; Mr. Carl Hering, The Units Employed in Electrochemistry; Prof. L. Kahlenberg, The Electrochemical Series of the Metals (A. E.-C. S. paper); Prof. J. W. Richards, The Energy Absorbed in Electrolysis; Prof. T. W. Richards, The Relation of the Theory of Compressible Atoms to Electrochemistry.

Section D.—Electric Power Transmission: Sig. E. Bignami, Electrical Transmission Plants in Switzerland; H. M. Hobart, A Method of Designing Induction Motors; Mons. Maurice Leblanc, Transmission of Alternating Currents over Lines Possessing Capacity; Prof. G. Mengarini, Utilization of Hydraulic Powers in Italy; Prof. F. G. Baum, High-Potential Long-Distance Transmission and Control; F. O. Blackwell, The Tower-System of Line Construction; H. W. Buck, The Use of Aluminum as an Electrical Conductor; V. G. Converse, High-Tension Insulators; M. H. Gerry, Jr., The Construction and Insulation of High Tension Transmission Lines; J. F. Kelly and A. C. Bunker, Some Difficulties of High Tension Transmission and Methods of Mitigating Them; L. M. Hancock, The Bay-Counties Transmission System; R. L. Hayward, Some Practical Experiences in the Operation of Many Power Houses in Parallel; P. M. Lincoln, Transmission and Distribution Problems Peculiar to the Single-Phase Railway System; Ralph D. Mershon, The Maximum Distance to which Power can be Economically Transmitted (A. I. E. E. paper); P. N. Nunn, Pioneer Work of the Telluride Power Company;

J. S. Peck, The High Tension Transformer in Long-Distance Power Transmission; Dr. F. A. C. Perrine, American Practice in High Tension Line Construction and Operation (N. E. L. A. paper); Dr. C. P. Steinmetz, Theory of the Single-Phase Motors (A. I. E. E. paper).

Section E.—Electric Light and Distribution: Prof. André Blondel, Impregnated Arc-Light Carbons and Lamps; Herr Max Déri, Single-Phase Motors; Herr E. de Fodor, Rates for Electricity Supply; Sig. Ing. E. Jona, Insulating Materials in High-Tension Cables (A. E. I. paper); Prof. W. Kübler, Upon a Means for Compensating the Series-Connection of Induction Motors; Prof. L. Lombardi, Stroboscopic Observations of the Arc (A. E. I. paper); H. F. Parshall, The Yorkshire and Lancashire Electric Power Companies; Prof. Auguste Rateau, Steam Turbines; Herr Karl Roderbourg, The Prussian System of Electric Train Lighting; Sig. Ing. Guido Semenza, Commercial Limits of Electric Transmission with Special Reference to Lighting Service; Dr. G. Stern, The Applicability of the Alternating Current for Distribution in Large Cities; Prof. S. P. Thompson (subject to be announced); Dr. W. Wedding, Measurements of the Energy of Light and Heat Radiation from Electric Light Sources; Arthur Wright, Recent Improvements in Electrolytic Meters; B. A. Behrend, The Testing of Alternating-Current Generators; Alexander Dow, The Continuous-Current Distributing Systems of American Cities; George Eastman, Protection and Control of Large High-Tension Distribution Systems (N. E. L. A. paper); W. C. L. Eglin, Rotary Converters and Motor Generators in Connection with the Transformation of High-Tension A. C. to Low-Tension Street Current (Assn. Ed. Illg. Co.'s paper); W. L. R. Emmet, The Effect of Steam Turbines on Central Station Practice; Louis A. Ferguson, Underground Electrical Construction (Assn. Ed. Illg. Co.'s paper); Gerhardt Goettling, Storage Batteries (Assn. Ed. Illg. Co.'s paper); G. Ross Green, American Meter Practice (N. E. L. A. paper); Caryl D. Haskins, Metering Efficiency on Customers' Premises; Henry N. Potter, Nernst Lamps; Dr. C. P. Steinmetz, Luminous

Electric Arcs; Philip Torchio, Distributing Systems from the Standpoint of Theory and Practice; Herbert A. Wagner, Electric Transmission and Distribution for Suburban Towns from a General Power Station.

Section F.—Electric Transportation: Ernst Danielson, Theory of the Compensated Repulsion Motor; Philip Dawson, Electrification of British Railways; Herr F. J. Eichberg, Single-Phase Electric Railways; Prof. Dr. F. Niethammer, Alternating vs. Direct Current Traction; Prof. Dr. Rasch, The Buffer Machine in Railway Service and Its Most Suitable Control; A. H. Armstrong, The Electrification of Steam Lines; B. J. Arnold, Electric Railways; Louis Duncan, General Review of Railway Work; J. B. Entz, The Storage Battery in Electric Railway Service; R. A. Parke, Braking High-Speed Trains; W. B. Potter, Electric Railways; F. J. Sprague, The History and Development of the Electric Railway; L. B. Stillwell, Notes on the Electrical Equipment of the Wilkesbarre & Hazleton Ry. Co.; H. G. Stott, Central Station Economics and Operation; W. J. Wilgus, Equipping the Central Terminal.

Section G.—Electric Communication: Señor Don Julio Cevera Baviera, Electric Communications in Spain; Dr. J. A. Fleming, F. R. S., The Present State of Wireless Telegraphy; John Hesketh, A New Danger to Lead-Covered Aerial Telephone Cables; Herr Joseph Hollos, Simultaneous Telegraphy and Telephony; Saitaro Oi, Telegraphy and Telephony in Japan; V. Poulsen, System for Producing Continuous Electrical Oscillations; M. G. de la Touanne, Theory of Telephone Exchange Development; J. C. Barclay, Printing Telegraph Systems; Dr. Lee De Forest, Wireless Telegraph Receivers; Patrick B. Delany, Rapid Telegraphy; Franz J. Dommerque, The Telephone Problem in Large Cities; Reginald A. Fessenden, Wireless Telegraphy; Hammond V. Hayes, Loaded Telephone Lines in Practice; J. C. Kelsey, Features of the Dunbar Two-Strand Common-Battery Systems; Dr. A. E. Kennelly, High-Frequency Telephone-Circuit Tests; Kempster B. Miller, Problem: Automatic vs. Manual Telephone Exchange; Dr. Louis M. Potts, Printing

Telegraphy; Col. Samuel Reber, Military Use of the Telephone, Telegraph and Cable; Prof. George F. Sever, Electrolysis of Underground Conductors; L. W. Stanton, Economical Features in Modern Telephone Engineering; John Stone Stone, The Theory of Wireless Telegraphy.

Section H.—Electrotherapeutics: Prof. M. Benedikt, A Contribution to the Radiodiagnostics of Diseases of the Head and of the Brain; Dr. J. Bergonié (subject to be announced); M. le Docteur G. O'Farrill, Some Improvements in Generator Apparatus of High-Frequency Currents; Prof. S. Schatzky, The Ionic Theory as Biological Basis for the Therapeutic Action of Electricity; Prof. S. Schatzky, Experimental Researches on the Treatment of Tuberculosis by Constant Current; Dr. J. Rivière, Physico-Therapy of Neurasthenia; Dr. Carl Beck, Recent Advances in Roentgen-Ray Science; Dr. G. G. Burdick, Radiations in Therapeutics; Dr. Margaret A. Cleaves, The Nature of the Changes Established in Living Tissue by the Action of Oxidizable Metals at the Anode; Dr. Charles R. Dickson, Some Observations Upon the Treatment of Lupus Vulgaris by Phototherapy, Radiotherapy, and otherwise (A. E. T. A. paper); Dr. Emil H. Grubbé, X-Rays and Radio-Active Substances as Therapeutic Agents; Dr. T. Proctor Hall, The Principles of Electrotherapeutics; Dr. J. H. Kellogg, Electrotherapeutics; Prof. Jacques Loeb, The Control of Life Phenomena by Electrolytes; Dr. John Williams Langley, The Purification of Water for Drinking by Electricity; Dr. G. Betton Massey, The Cataphoric Diffusion of Metallic Ions in the Destructive Sterilization of Cancer and Tuberculous Deposits; Dr. W. J. Morton, Artificial Fluorescence of the Human Organism as a Means of Treating Disease; Dr. C. S. Neiswanger, Static Electricity in Chronic Nephritis; Dr. Clarence E. Skinner, A Large Fibro-Sarcoma Treated by X-Radiance; Dr. William Benham Snow, Static Electricity in Therapeutics.

On Tuesday the section meetings will begin at 9 a. m., and this also will be the rule for Thursday and Friday. On Wednesday at 10 a. m. the annual convention of the American Institute of Electrical Engineers will be formally open at Festival Hall on the grounds of the Louisiana Purchase Exposition.

Festival Hall

Festival Hall, where this convention will be held, is the great central figure piece of the Louisiana Purchase Exposition. It has a dome nearly as large as that of St. Peter's at Rome. It is ornate in treatment but chaste in

The Brazilian Pavilion

spirit. Its height is emphasized by the terrace immediately in its front and by the wide basin at the foot of the slope. It is on the main axis of the grand court and faces toward the principal entrance to the grounds. A monumental archway, 65 feet high, richly decorated, forms the main entrance to the hall. Over the archway is a sculptured group typifying "The Triumph of Music and Art," by Philip Martiny. "Music" and "Dance" are allegorically represented in groups flanking the entrance. All the decorative details of the building are suggestive of music and the drama. Lyres, harps, Greek masks and the names of composers of music are used both for ornamental effect and to express the festive ideas associated with the structure. The main entrance is flanked on the sides by colonnaded walls. The drum of the dome is treated with a series of circular openings decorated architecturally in the same spirit as the rest of the building. This may be said as to the panels into which the bell of the dome is subdivided. This dome is 140 ft. in diameter. That of St. Peter's at Rome is 144 ft. It is 400 ft. from the ground to the highest point of St. Peter's dome, while it is 250 ft. from the level of the grand court to the top of the dome of Festival Hall. The diameter of the building at its base is 192 ft. exclusive of the balustraded terrace upon which it stands. The structure as a whole covers more than two acres.

The auditorium is intended for the accommodation of about 4,000 persons. It is arranged on the interior like a theatre and finished like a permanent building. Its many windows permit excellent lighting by day, and at night the electric illumination both without and within is a triumph of the electrician's skill. The architect of the Hall of Festivals was Cass Gilbert of New York and St. Paul. The design of the interior was prepared by Mr. Masqueray.

The plan of the central portion of the Exposition grounds suggests the lines of a fan. The great exhibit palaces are on avenues which radiate from a common centre, and at this focal point, on the summit of a dominating hill, stands the Hall of Festivals, in the centre of a long, swinging colonnade, called the Colonnade of States. This curved colonnade terminates at either end in circular restaurant pavilions each 140 ft. high, surmounted by domes and somewhat corresponding in architectural treatment to Festival Hall. The colonnade, which is 52 ft. high and over a quarter of a mile in length, extends in semicircular form along the brow of a hill, crowning the crest of a natural amphitheatre 70 ft. high. In the rear of the colonnade and Festival Hall and partially screened by them, though on a higher level, is the Art Palace.

The face of the hillside is a lawn. Descending from the front of Festival Hall and the restaurant pavilions there are three cascades. The water which gushes forth from the central fountain spreads into a stream 50 ft. wide as it pours over the first fall of 25 ft. It widens out still more as one fall succeeds another until it is a stream 152 ft. wide when the Cascades reach the basin at the foot of the slope.

The total fall is 95 ft. and the length of the central

The Chinese Building

cascade is about 300 ft. All three cascades fall into a cascade basin 300 ft. wide which reflects the picture above it and at night aids in enhancing the beauty of the electric illumination. Nearly 90,000 gallons of water per minute are discharged into this basin from the three cascades when they are in full operation. The slope between the cascades and in front of Festival Hall and the Colonnade of States is made into a formal garden, adorned with flowers and shrubs. The design of the Cascades and Colonnade of States and the restaurant pavilions, with the approaches and surrounding gardens, is the work of

Emmanuel L. Masqueray, Chief of Design of the Exposition.

The entire composition made up of the Cascade Gardens, Festival Hall and the Colonnade of States has a historic as well as an allegorical significance and is intended to express the jubilation of a great nation over the fact that the sway of liberty was extended by the Louisiana Purchase from the Atlantic to the Pacific. This idea is especially conveyed in the sculptural decorations, which in a poetical manner portray the various phases of the central theme.

From a distance the Fountain of Liberty, which stands at the head of the central cascades, seems almost to form a part of the archway by which entrance is afforded to Festival Hall. Mr. Herman A. McNeil, who modeled the statuary for these gardens, has succeeded in typifying in sculptural form the idea associated with such sentiments as Liberty, Patriotism, Freedom, Truth, Justice, and Family.

The doorway of Festival Hall bears like a keystone a composition by Charles J. Pike which suggests gaiety and is composed of two flying figures supporting a lyre. The groups entitled Music and Dance, on either side of the entrance to the Hall of Festivals, present an interesting contrast. Augustus Lukeman is the author of Music. The group consists of five figures. In the upper part of the composition is a figure of Orpheus playing the lyre. Orpheus appears to be accompanying on his lyre the voice of a beautiful woman who forms the foremost figure in the group and who represents vocal music or opera. To her left is a female figure playing a Renaissance 'cello as an accompaniment to the voice. On her right is a group of two figures, Pan playing the pipes and a Bacchante playing a timbrel and leading a panther.

Opposite the group by Lukeman stands the companion group by Michel Tonetti, entitled Dance, which presents an admirable foil to the work of his fellow sculptor. This group is full of life and movement and the figures seem possessed by the fire of a joyous, unconstrained spirit. A figure in the upper part of the group seems

Joseph Henry
Palace of Electricity

urging on the dancers and encouraging them to enjoy life while it lasts. The various forms of the dance and its national characteristics are represented by the different figures. A faun dancing with a nymph, both being strong-limbed and unconventional, present a contrast to two other figures, a delicately proportioned girl and a strong but finely cut man, portraying a more modern type of dance. A girl in the centre of the group typifies the grace of the dance.

The Colonnade of States, which closes the background of this picture, is an effective portion of the composition and affords opportunity for the use of statuary typifying the twelve States and two territories formed from the original Louisiana Purchase. Square pylons alternate with the columns and the effect suggests somewhat the majestic approach of St. Peter's at Rome. It may remind some of the beautiful Peristyle at Chicago, while the Cascade gardens with their sculpture may awaken a recollection of some famous European gardens. It is said that the cascades at St. Cloud furnished the designer with some suggestions.

The electrical illumination of the gardens, Cascades, Colonnades, Festival Hall, the Cascade Basin and the Fountain increase the fairylike aspect of the scene at night.

Around the central cascades, stairways descend on both sides and swing away in opposite directions until the level of the basin below is reached. Flanking the waterways and between them and the stairways run a series of groups of sculpture which serve both to illustrate the theme and enhance the decorative effect of the composition. The Fountain of Liberty, with its goddess holding aloft a symbolic torch and its figures of Truth and Justice, commands the scene from its lofty altitude. From beneath springs the arch upon which the figures rest which have for their ideals Liberty, Truth and Justice. From the springing of the arch come forth men of heroic proportions riding fish horses and on either side heralds proclaim the advent of the goddess. At the base of the arch and flanking the ramp which swings from its

Benjamin Franklin
Palace of Electricity

sides are groups representing Patriotism and The Family, these being at the foundation of the Anglo-Saxon idea of liberty. Next beyond these groups, as one descends to the Grand Basin, come two others, one representing the idea of Freedom and Physical Liberty and the other Liberty as it exists under the restraining institutions of civilization. A series of six groups of children riding fishes add to the picturesque character of the composition.

The side cascades, whose sculptural figures and groups are by Mr. Isadore Konti, are equal in importance to the central cascades. Mr. Konti's work for this part of the Exposition is characteristically decorative, imaginative and graceful.

The side cascades are over 400 ft. in length and the architect's plan provided for fifteen groups of sculpture for each side. At the head of each cascade and in front of the ornate pavilions which terminate the Colonnade of States are fountains and the groups surmounting these the sculptor calls respectively the Spirit of the Atlantic and the Spirit of the Pacific. The fountain for the opposite side is surmounted by a flying female figure with an albatross, typifying the Spirit of the Pacific.

ST. LOUIS EXPOSITION

The Colonnade of States by Night

St. Louis Exposition

HISTORICAL

THE Louisiana Purchase Exposition is the third great international exhibition held in the United States, each illustrating a sentiment. Philadelphia in 1876 celebrated the centennial of the Declaration of Independence; Chicago in 1893 commemorated the four hundredth anniversary of the discovery of America by Columbus; while the third recognizes the centenary of the acquisition, in 1803-1804, of the great territory then known as Louisiana. Out of this territory there have been formed twelve States and two Territories,—the State of Louisiana, which bears the original name, and the eleven additional States of Arkansas, Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, Indian Territory and Oklahoma.

The annexation of Louisiana has been declared to be an event in national history ranking in importance next to the signing of the Declaration of Independence and the adoption of the Constitution, for it not only removed a constantly recurring cause for petty disputes between the United States and several European nations, but also cleared the way by which the Union was to take its course westward to the Pacific.

The historical events which brought about the acquisition of this territory are interesting. Previous to the Purchase, the settlers in Kentucky, Tennessee, and on the upper Ohio were in more or less constant friction with the Spanish settlements and hostile Indians along the western border; on several occasions open warfare was avoided only by the diplomacy of President Washington and President Adams. In 1801 the Western people were intensely excited by rumors that Spain had secretly ceded Louisiana to France and that Napoleon, then First Consul of the French Republic, was about to take military possession of the land. President Jefferson appreciated that the time for action had come, and at once opened negotiations with Napoleon for a peaceful acquisition of the Louisiana tract. These negotiations were consummated on April 30, 1803, by a treaty with France, by which the United States acquired over 875,000 square miles of territory lying west of the Mississippi for

The Cabildo

the sum of $15,000,000. It is interesting to remember that this sum is scarcely one-third the amount that has been spent on the buildings and grounds of the Exposition that has been built to commemorate the centennial of the treaty.

The popular demand for a celebration of the centennial was first formulated at a meeting of the Missouri Historical Society in September, 1898, at which a ways and means committee consisting of fifty citizens was appointed. In December, 1898, the Governor of Missouri invited the Governors of all the Louisiana Purchase States to send delegates to a convention, which finally met in St. Louis in January, 1899. The movement met with hearty response from all of the States directly interested. St. Louis, as the chief city of the Louisiana Purchase States, was asked to take the lead in making plans for a world's exposition that would eclipse any other similar enterprise. More than $4,000,000 in private subscriptions was immediately raised, the city of St. Louis voted a municipal subscription of $5,000,000, and the State of Missouri appropriated $1,000,000 for this purpose.

In June, 1900, Congress voted to provide $5,000,000 on condition that the city of St. Louis would raise $10,000,000. On March 3, 1901, it having been represented in the Senate that St. Louis had fulfilled this condition, an act of Congress appropriated $5,000,000 to the Louisiana Purchase Exposition; this act was sent to President McKinley for approval and became a law.

The initial fund of $15,000,000 for the exhibit buildings and grounds represents the amount given 101 years ago for the Louisiana territory; at this rate the cost of the territory was somewhat less than $15 per square mile. Congress also appropriated about $3,000,000 for exhibits, and still more recently advanced, as a loan, $4,600,000, to complete the work. The different States have appropriated about $7,000,000 for the State exhibits (Missouri appropriating $1,000,000), and foreign governments more than $5,000,000. The Pike and its accessories represent an investment of $5,000,000, while exhibitors have expended from $1 to $5 per square foot on the 128 acres of exhibits.

About as much time intervened for the spending of this amount as had been consumed in raising it. A vast amount of exploitation work had to be done,—obtaining liberal participation by home and foreign governments, securing the most attractive and representative exhibits from all countries, in many instances requiring favorable action by slow-moving legislatures and ministerial bodies. The work was pushed forward with vigor and appropriate grounds, buildings, and other equipment were provided. This work was done so efficiently that President

The Illinois State Building

The Illinois State Building

Francis, the executive officer of the Exposition, commended it in public. He said:—

"This universal Exposition is more than an exhibition of products, or even of processes; it is more than a congregation of the grades of civilization, as represented by all races from the primitive to the cultured; it is even more than a symposium of the thought of the thrones, of the student and the moralist. It is all of these combined, and the *toute ensemble* forms a distinct entity whose impress on the present and influence on the future are deep and lasting. It will have a place in history more conspicuous than its projectors ever conceived. For more than a generation to come it will be a marker in the accomplishments and progress of man. So thoroughly does it represent the world's civilization that if all man's other works were by some unspeakable catastrophe blotted out, the records here established by the assembled nations would afford all necessary standards for the rebuilding of our entire civilization."

"By bringing together sections and peoples hitherto remote and unacquainted, and thereby promoting mutual respect, it is a distinct step toward establishing that universal peace for which all right-minded people are striving."

The following comparison clearly brings out the enormous growth of the Louisiana Purchase Exposition over previous noteworthy expositions:—

	Size Acres	Area under roof Acres	Illumination Electric Lights	Cost
St. Louis, 1904...	1,263	300	210,000	$50,000,000
Chicago, 1893....	633	194	102,000	28,000,000
Paris, 1900.......	336	117	76,720	22,000,000
Buffalo, 1901.....	300	15	......	6,000,000
Philadelphia, 1876	236	62	......	....

THE GROUNDS

The site of the World's Fair is in the western part of the city, about five miles west of the Mississippi River, and contains, in a solid tract, 1,263.49 acres, that is approximately two miles east and west by one and one-fourth miles north and south. Of this, 657 acres consists of the western portion of Forest Park (the largest of the city parks), 545 acres west of the park is leased from Washington University and other estates, and 61 acres north of the Park is leased for "The Pike." When work was begun in December, 1901, this tract mainly consisted of heavy rolling, forest-covered land, through which meandered a sluggish, treacherous river known as the Des Peres. There was from 75 to 125 feet variation between the hills and sharp dales, while an artificial lake occupied the sites of the Mining, Liberal Arts, and Manufactures Buildings. To lower the hills and grade up the valleys has required the moving of 2,000,000 cubic yards of earth. The lake has been piled over and the meandering River Des Peres has been confined within a box flume 45 feet wide by 15 feet deep, over which is the central promenade of the Exposition. While much of the old virgin oak forest has had to be sacrificed, quite large maples and elms have taken their place, as the result of a new system of tree transplanting. Lagoons 1½ miles long with 3½ to 5 feet depth of water encircle the Electricity and Education Buildings and afford access by gondola and electric launches to the nine main buildings that form the principal feature of the Exposition. These lagoons have an area of 750,000 square feet and contain 20,000,000 gallons of water.

In order to avoid placing the main exhibit buildings over the river channel, which pursued a tortuous route through the site, a new channel was excavated and lined with timber. This channel was made to traverse the main streets between the buildings and shortened the stream from 8,800 feet to a more direct route of 4,650 feet.

In addition to the main waterway of the River Des

Peres, which is about one mile long, twenty-five miles of storm water drains have been constructed.

Numerous obstructions, in the way of trestle bridges, short bends in the channel, etc., below the World's Fair site in Forest Park, were removed in order to provide sufficient area for storm water and to prevent overflow, such as occurred in previous years.

A Trip on the Lagoons

All storm water drains, including roof drains from buildings, discharge into the main channel of the River Des Peres, except downspouts from the east of the Mines Building and from the Education and Electricity Buildings, the latter two being situated on islands surrounded by lagoons.

The lagoons are provided with eight feed pipes from water mains of such capacity that the entire lake can be filled in forty hours.

A filter plant at the southwest corner of the Mining Building is designed to supply the loss from seepage and

Palace of Varied Industries

evaporation and will be operated continuously during the life of the Fair.

Arrowhead Lake, some 2,000 feet in length and varying in width from 100 feet to 250 feet, and 4 to 12 feet deep, is used by water craft of the Philippine Village.

The Life Saving Lake, situated east of the Ceylon Building, is used by the United States Government for life-saving exhibitions, the life-saving station being situated at the east end of the lake. This lake is 480 feet

The Floral Clock

long, varies in width from 100 feet to 150 feet, and has a depth of water of from 4 feet to 12 feet. It contains about 3,600,000 gallons of water.

A system of overflows is installed, also a system of end drains, so that the entire lake can be drained and refilled with fresh water as often as required.

Smaller lakes are constructed in the Philippine Reservation, east of the Agriculture Building and United States Government Bird Cage, besides a number of small lakes in the concessions district.

A system of sanitary sewers has been constructed to discharge by gravity into two wells in the eastern end of

Palace of Agriculture

the grounds, near the Mines Building, from which sewage is pumped into the city sewer mains, a distance of 3,650 feet, through a cast iron main.

Four electrically-driven centrifugal pumps of 18,000,000 gallons capacity have been installed for this service. Two pumps are installed in each well and connected to mains so that sewage can be pumped directly from the main sewers or from the wells, as may be desired. One or both wells can be cleaned while all four pumps are running.

A handsome pavilion is erected over these wells, and a room above the pumps is used as a motor room.

In addition to the cast iron main, the Exposition has laid 62,000 feet of vitrified pipe mains for sanitary sewers. This does not include pipe installed by the various States, foreign governments and concessions, which are required to install their own systems within their grounds and connect them with the Exposition mains.

A garbage crematory has been erected northwest of the Philippine site, where combustible debris and garbage are taken care of, the moist garbage being deposited in cans at the buildings and removed at night. Combustible street sweepings are also taken to the garbage plant, being cared for in sacks made especially for this purpose.

A total area of 5,800,000 square feet has been paved. This is covered with burnt ballast, gravel, macadam, asphalt and brick. Of this about 500,000 square feet have been covered with brick, 800,000 square feet with asphalt and the remainder with macadam, gravel and burnt ballast. This area is equal to about 55 miles of road 25 feet wide.

The Ainu Workmen

INTERESTING FACTS ABOUT THE EXPOSITION

Opens April 30th. Closes December 1st.
Forty-four states participate.
Fifty foreign countries exhibit.
Exposition cost $50,000,000.
Wireless telephone station in operation.
Speech transmitted via electric light rays.
Edison's personal exhibit of inventions.
Complete assemblage of the world's races.
The widest boiler plate ever rolled.
A practical shoe factory in operation.
Mining Gulch, twelve acres in extent.
Queen Victoria's Jubilee presents.
Philippine exhibit cost $1,000,000.
Airship tournament, $200,000 in prizes.
Largest organ, 140 stops, 10,000 pipes.
Clock dial 112 feet across, largest on earth.
Native Alaska buildings, real totem poles.
Ainu hunters and fishers, Japan aborigines.
Stadium, seating capacity 27,000 persons.
Revival Olympic games of ancient Greece.
Iron statue of Vulcan 50 feet high.
Historical exhibit of Baltimore and Ohio Railroad.
Locomotive tests throughout the season.
Liberty Bell in Pennsylvania Building.
Ice Plant, 300 tons capacity daily.
Giant Bird Cage, 300 feet long.
Rose Garden, ten acres in area.
Full-sized model U. S. warship.
Decorative sculpture cost $500,000.
Model Indian school, one hundred pupils.

Palace of Liberal Arts

FEATURES OF THE EXPOSITION

The main picture of the Exposition centres around Festival Hall, which is 200 feet high, at the head of the Grand Basin, an architectural masterpiece by Cass Gilbert. From this pour the three cascades, with ninety-four feet fall, into the Grand Basin. A curved colonnade flanks each side of Festival Hall, terminating in a restaurant pavilion at each end, with heroic statues, symbolizing the fourteen States of the Louisiana Purchase, occupying intervening alcoves.

The Art Building, which is 450 by 830 feet, is just south of Festival Hall, and this will be the permanent monument of the Exposition. It is constructed of brick, stone and terra cotta, at a cost of $1,000,000; designed by Cass Gilbert of St. Paul.

Radiating from the front of Festival Hall, and on a plane some sixty feet lower, are the following main buildings of the Exposition:—

To the extreme right and marking the eastern end of the grounds is the Government Building, 250 by 800 feet and costing $450,000. It is a dignified, classic structure, designed by J. Knox Taylor of Washington, in which all the different departments of the government are represented. Huge guns are shown on the adjacent terraces. The Fisheries Building, covering an area of 135 by 135 feet, adjoins on the south.

The Mining and Metallurgy Building, which is 525 by 750 feet and cost $500,000, was designed by Theo. C. Link of St. Louis on unique lines, with towering obelisks. It fronts the Government Building, and its twenty-five acres of outside working exhibits lie in the adjoining gulch that runs at the base of the Plateau of States.

The Liberal Arts Building, which is 525 by 750 feet, covering nine acres and costing $450,000, was designed by Barnett, Haynes & Barnett of St. Louis. It is in front of the Mining Building, with an intervening sunken garden. In this building are the civil engineering exhibits.

West of the Mining Building, and surrounded by the

The Palace of Manufactures

lagoon, is the Education Building, which is 525 by 750 feet, costing $400,000. It is one of the purest and most dignified designs in classic architecture on the grounds, and was designed by Eames & Young of St. Louis.

The dimensions of the Manufactures Building are 525 by 1,200 feet, covering twelve acres. The building cost $850,000. It lies between the Plaza of Orleans on the east and the Grand, or Plaza of St. Louis, on the west, has a most imposing entrance on the south side, and was designed by Carrere & Hastings of New York.

Facing the west side of the Grand Basin, and surrounded by the lagoon, is the Electricity Building, 525 by 750 feet, covering nine acres, costing $400,000, designed by Walker & Kimball of Omaha.

West of the Electricity Building is Machinery Hall, 525 by 1,100 feet, covering twelve acres, costing $600,000, with its numerous towers, designed by Widmann, Walsh & Boisselliere. Adjoining to the west is the boiler house, a fire-proof structure covering two and one-half acres.

North of Machinery Hall, and fronting on the Pike, is the Transportation Building, which is 525 by 1,300 feet, covering fifteen acres, costing $700,000, designed by E. L. Masqueray. This building forms the extreme western end of the main group, or principal picture.

Fronting on the west side of Skinker Road are the foreign government buildings, while on a commanding terrace are the dignified Tudor-Gothic granite buildings of Washington University that have been leased for the administration offices. As architectural studies of all nationalities this group is most interesting.

South of the administration offices is the Forestry, Fish and Game Building, 400 by 600 feet. Farther south, on a rising slope, is the Agricultural Building, the largest on the grounds, 500 by 1,600 feet, covering twenty acres and costing $800,000. Adjoining it is the Horticultural Building, 300 by 1,000 feet, costing $200,000, and the huge Live Stock Pavilions, covering forty acres.

In the extreme western part of the grounds is the Athletic Stadium, seating 27,000, and at Intramural Station No. 7 is the Philippine exhibit, a most interesting

The Palace of Transportation

and complete exhibit of our new colonies. It occupies forty-two acres and cost over $1,000,000.

The military camps, garbage crematory, barns, storage warehouses, etc., are in the southwestern corner of the grounds.

In the southern part of the grounds is a remnant of the fine old oak forest that covered the major portion of the Exposition site three years ago.

In the southeastern portion of the Exposition is the Plateau of States and the huge Inside Inn, 400 by 800, accommodating 6,000 guests. The various State buildings present a variety of architectural studies and historic reproductions, some of which are very attractive. The State of Washington Building is noteworthy for the eight Oregon pine timbers which enclose it. They measure 2 feet by 2 feet by 110 feet and are clear sticks of timber. Opposite is the Aviary, or "Bird Cage," a huge cage 300 feet long, occupied by a rich collection of birds.

Conspicuous by their height, and affording a fine view of the Exposition and St. Louis, are the Observatory Tower, 300 feet high, in the northeastern corner of the grounds, and the Ferris Wheel, 250 feet in diameter, on the Skinker Road, adjoining the boiler house in the western part.

Fronting 4,000 feet along the north side of the grounds and extending 2,000 feet along the Skinker Road is The Pike, with its concessions and amusements. The Pike in St. Louis is what the Midway was at the Columbian Exposition in Chicago, only more so. Its dominating spirit is appropriately indicated by the group of statuary placed at its entrance, which represents a company of cowboys "shooting up" a Western town. Here are grouped in the widest profusion circuses, shows, delusions, mechanical effects and fakes, constituting a world of its own. Here are also gathered representatives of nations and peoples from every corner of the inhabited globe. It is safe to say that here the visitor will be separated from more of his money than he will care to compute at the end of a week's visit, but it is also safe to say that with the feeling of sadness at the flattened pocket-

Entrance to "The Pike"

book will come the cheerful recollection that he has received his money's worth.

The Tyrolean Alps, at the main or Lindell entrance, is especially noteworthy in its faithful and beautiful reproduction of an Alpine village. Among the other amusement features to be found on the Pike may be mentioned the following: "Irish Village," "Under and Over the Sea," "Streets of Seville," "Hunting in the Ozarks," "Hagenbeck's Animals," "Mysterious Asia," "Moorish Palace," "Fair Japan," "Hereafter," "Glass-weaving," "Paris," "Ancient Rome," "Creation," "Palais du Costumes," "Infant Incubator," "Indian Congress and Wild West Show," "Siberian Railroad," "Deep Sea Divers," "Cairo," "Chinese Village," "Constantinople," "Esquimaux and Laplanders," "Magic Whirlpool," "Cliff Dwellers," "Battle Abbey," "Naval Exhibit," "Jim Key," an educated horse; "Old Plantation," "Galveston Flood," "Hale's Fire Fighters," "New York to the North Pole," "Jerusalem," "Observation Wheel," "Miniature Railway," "Poultry Farm," "Transvaal Spectacle," "Colorado Gold Mine," "Shoot the Chutes," "Scenic Railway" and "Temple of Mirth."

THE CASCADES

The Cascades descending the gentle slope between the Festival Hall and the Grand Basin form the leading monumental feature of the Exposition, and must be seen to be appreciated in all their beauty. The water for their use is pumped from the Grand Basin and it is expected that the lagoons will be kept fresh by the circulation thus produced in them, as well as by aeration in its frequently-broken fall down the steps. At the top of the hill in front of Festival Hall and at each of the pagodas, there is a fountain, that in the centre being the largest.

The width of the central cascade at the top is about 40 ft., which increases to 160 ft. at the foot. There is a total descent of about 90 ft., including a sheer fall of 21 ft. into the basin. The cascade is made of three sheets of water separated by two curved division walls. Wide

West Fountain, The Cascades

curved promenades with series of shallow steps border both of its sides. The two side cascades resemble it in general features, but are much smaller and have only single sheets of water about 18 ft. wide at the top and 50 ft. at the foot. They are also bordered on each side by low steps, which, unlike those of the central cascade, are carried by a bridge across the lower part of the fall. Beyond this bridge there is a wide curved basin in which the water comes to rest before it passes through an underground conduit to an elliptical basin about 60 ft. long on the opposite side of the main promenade. From this basin the water flows through a concealed outlet into the Grand Basin. The central cascade is designed for a flow of 51,000 gal. per minute; provision is made for eighteen 1¼-in. jets and ten 1-in. jets, which are delivered to it from the sides and bases. The two side cascades are each designed for about half the central flow. The water from the lagoons returns through a wooden flume in the Grand Basin to the pump room under the platform of the east cascade, where the hydraulic and the electric plants are installed. There are three Worthington centrifugal pumps, 11½ ft. high, with 40-in. suction and 36-in. discharge pipes. They are operated by 25-cycle, three-phase Westinghouse induction motors of 2,000 h.p. capacity, which are said to be the largest of that kind yet built. The pumps discharge into a 100,000-gal. steel tank having an air cushion maintained by a special air pump at a pressure of about 60 pounds per square inch to provide a uniform flow and force the water to the upper fountain. Provision is made for draining each of the basins in the fountains and cascades, if necessary, and for draining the Grand Basin and lagoons through outfalls to the waterway if desirable.

When the Cascades pumping plant was designed, it was estimated that it would have a capacity of 90,000 gal. a minute. As a matter of fact the actual flow of water has never been measured, but the important fact remains that the capacity of the plant is 5,400,000 gal. an hour, said to be twice the total consumption of water by the city of St. Louis.

The induction motors are direct connected to the Worthington centrifugal pumps and each unit may work independently. The motors are remarkable for their high efficiency and for the high voltage at which they operate. They are wound for three-phase, 6,600 volts, 3,000 alternations, corresponding to a synchronous speed of 375 rev. per min., the actual speed being about 365 revolutions. The primary winding consists of machine-wound heavy insulated coils put into half closed slots in

Electric Fountain, Tyrolean Alps

the laminations. The secondary is also phase-wound, but for a lower voltage, the ends of the winding going to three collector rings, and from them to the starting rheostat.

Motors of such capacity must be started with great care if the generating plant is not to be affected. In this case, the pumps are kept ready for work and filled with water, being connected to the city water mains in order that they might be filled at any time should they in some way be emptied. As the Cascades run every day and in the evening at regular hours, the attendants at the Westinghouse Exposition service plant in Machinery Hall know the time of starting the motors, keep the voltage at about 4,500, and after the motors have been started the voltage on the generators is gradually raised to 6,600. The starting rheostat consists of many grid-type resistances placed on shelves where they are well ventilated. They are put into circuit by means of large oil-immersed controllers operated by hand. These controllers, because of the exceptional size of the motors, have an unusually large number of steps. The starting has been done since

Missouri State Building

the opening of the Exposition without accidents, and is performed very smoothly, the starting current being raised up gradually from about one-half of the normal current.

The switchboard is provided with high tension oil-immersed automatic circuit-breakers, and with Westinghouse ammeters and voltmeters for each phase. Integrating and indicating wattmeters are provided at the outgoing ends of the cables at the main switchboard of the generating plant in Machinery Hall. The motors operate under exceptionally heavy conditions in a very humid place with a floor at the level of the lagoons. To protect the motors against moisture it has been considered necessary to circulate direct current through the windings during a considerable part of the time when they are out of service.

ILLUMINATION OF THE EXPOSITION

The spectacular effects which make one exposition more notable than its predecessor are due largely to electric lighting. Electrical engineers have learned much

Plaza at St. Louis by Night

about illuminating effects from expositions, for nowhere else are presented the problems of brilliantly lighting such great areas, both indoors and out. After much discussion and experiment it has been decided that the most satisfactory way of illuminating grounds and buildings is by the use of incandescent lamps alone. By spacing the lamps at short intervals the effect is a line of light marking each architectural outline. Inside the buildings the conditions are wholly different, for the light must be such that visitors can examine minute details and read inscriptions anywhere. Arc lights of high candle-power with suitable reflectors give the best results. The success of the illumination is due in large measure to the efforts of Henry Rustin, formerly chief electrical and mechanical engineer of the Exposition.

The magnitude of the lighting scheme at St. Louis is most impressive, for the grounds, a mile wide and two miles in length, must be made conspicuous by the illuminations at night. To make this illumination brilliant and impressive, efforts were concentrated at the architectural centre of the Exposition; this includes the structures surrounding the Cascade gardens, the Grand Basin

The Lagoon by Night

and the Plaza of St. Louis, Festival Hall, and the Colonnade of States. Upon these are distributed 20,000 incandescent lamps. This portion of the lighting scheme is partially experimental, efforts being made to get combinations of color that will give various rainbow effects. On the inside of the pillars forming the Colonnade are vertical lines of lamps, each unit consisting of three incandescent lights, the first having a clear bulb, the second a ruby, and the third an emerald tint. This enables many color effects to be obtained, as all the lights of one color can be turned on or any combination of them can be blended. This is obtained by arranging the colored lamps upon different circuits.

The current supply is from a three-phase system, separate feeders extending to each color of light with a common neutral for all three. Water rheostats are arranged in each circuit so that the effect of the lights gradually increasing in brilliancy up to full power can be obtained. With these different combinations set programs are arranged for the edification of the evening visitors.

For the decorative lighting, incandescent lamps of small candle-power are most effective from both an economic and a spectacular standpoint. No arc lamps for decorative lighting have been used at the Exposition, for the contrast between the white light of the arc and the red of the incandescent is not pleasing. As may be noted from the illustration, the eastern façade of the Electricity Building is exceedingly beautiful with every outline marked with rows of incandescent lamps. About 12,000 lamps have been placed each on the Palaces of Education and Electricity, about 20,000 on Machinery Hall, 17,000 on Varied Industries Building, and 10,000 upon Transportation Building. Incandescent lamps of 8 c-p. have been used almost without exception. About a half million incandescent lamps will be used during the entire season for exterior illumination.

Search-lights are stationed on the roofs of the principal buildings and will play from one interesting feature to another. At the present time the largest search-light in the world surmounts the dome of the Women's Magazine Building; the great beam of light from it is conspicuous over all the grounds and the city of St. Louis.

The arc-lighting plant is used to light the interior of the buildings, the seven miles of stockade enclosing the grounds, and the Pike. Two thousand arc lamps were needed to carry out this plan. After carefully considering the requirements it was decided to adopt the series alternating-current enclosed arc lamp system operating at 60 cycles and 2,300 volts. The current supply is from a 600-kw. alternator direct connected to a Willans type of engine operating at 277 rev. per min. The regulating device of series alternating system is a constant-current transformer having its primary winding connected directly to the 2,300 volt alternator. These transformers are cooled by a natural draft of air which is directed by a light casing that also protects the moving parts.

On "The Pike"

The installation in Machinery Hall consists of eighteen transformers of this type, each with a capacity of 62 kw.; each transformer supplies 100 arc lamps taking a constant current of 6.6 amperes. Each transformer is provided with a switchboard panel equipped with the necessary controlling and measuring apparatus. All wires of every description are under ground, and these are carried in conduits of pump log-ducts which are simply boarded in the trenches, except under the lagoons, where they are enclosed in cement. The lighting mains consist of lead-covered cables.

All the arc lamps used on the Exposition grounds are of the series alternating-current type. This lamp operates on the differential principle with shunt and series magnets which move two laminated armatures connected

Palace of Electricity Illuminated

through a lever to a carbon clutch. The shunt and series magnets work in opposition and tend to oppose any change in the arc pressure. By means of a sliding weight adjustment for the impressed pressure can be made; this helps the series magnet to strike the arc at the proper pressure. A small starting resistance is provided, and a mechanical cut-out is arranged to operate in case of open circuit in the lamp. Vibrations of the armature core due to the alternating current are absorbed by a small leaf spring in each armature. Each of these lamps take 6.6 amperes at 72 volts, or 430 watts.

TRANSPORTATION WITHIN THE GROUNDS

New problems of transportation arise as the international expositions grow in extent; these have been met at St. Louis in several ways. The first and most important means of transportation about the grounds is by the Intramural railway, a double-track, overhead-trolley, electric railway running around the edge of the main Exposition enclosure and designed to give visitors a convenient means of reaching every section of the Exposition grounds. For a considerable portion of its route the Intramural skirts the enclosure of the Exposition. Two miles of its course are directly through the heart of one of the most interesting portions of the grounds, and for about one mile it runs through the fine oak forest of Forest Park. The total length measured as single track is 12.26 miles, in addition to which there is 0.75 mile of storage track for Intramural cars. The length of single track trestle is 1.19 miles. The road runs partly on the surface and partly on trestle work, following the topography of the grounds. The right of way is fenced, and stops are made only at regular stations. Its terminals are located inside the grounds, respectively east and west of the Lindell or main entrance, these being about 600 ft. apart, leaving a broad avenue between, so that the road does not deface the fine central view of the "main picture." The terminal stations of the road are simple dead-end stations, each containing two stub tracks, so that cars may arrive and depart without conflict. There are 17 stations on the Intramural route, consisting of covered platforms with turnstile exits; the same platform is used for loading and unloading. Tickets are sold at the stations and passengers pay their fare before entering, passing to the loading platforms through turnstiles. Wherever there are hills along the route the stations have been placed at the top, so that the passengers are saved much of the fatigue of climbing hills.

In the operation of the road it is the intention to give frequent service rather than to run cars at high speed. It is believed that visitors will use the Intramural as a means of obtaining a general, or as it were, a sky-line survey of the Exposition as a whole, and will desire to travel at a rate of speed sufficiently slow to enable them to enjoy each building and special feature along the route. It is also believed that visitors will find a trip around the Intramural a pleasant means of resting from the fatigue of walking through the buildings and grounds. For these reasons cars will be run on a five-minute headway, or less, and will require about 42 minutes to make

The Intramural Cars

the circuit from terminal to terminal. When traffic is comparatively light, cars will be run singly, but when travel is heavy they will be operated in two or three-car trains, as the traffic may require. The fare from any station to any other station is 10 cents.

The rails are 65 lb. A. S. C. E. standard T-section. The road is standard-gauge and cinder ballasted. Centre-pole construction was adopted except where the road runs through the woodland. There are 51 closed cars and seven 14-bench open cars, it being the intention to use the open cars only on days of very heavy traffic. The cars measure 34 ft. over body, with 5-ft. platforms, making 44 ft. over all. Each car has seating capacity for 52 passengers. The closed cars are fitted with necessary train control apparatus with four motors to each car. Both platforms are vestibuled and are protected by folding gates. There are no car steps, as the loading and unloading platforms at the stations are built to come flush with the car platforms.

Repair and storage shops for the Intramural cars have been built in the extreme southwest corner of the grounds. The shops are temporary in character and are fitted with pits and the small tools required for making light repairs. No heavy repair work will be attempted. Power for the Intramural road is supplied from a group of 600-volt generating units of accepted railway types located in Machinery Hall.

A trip which is even more enjoyable and instructive is one on an electric automobile through the main thoroughfares of the Exposition. This is the first exposition at which such a service has been rendered. The generous patronage received indicates that it meets an actual want. The regular route covers the centre of the Exposition and a visit to each of the exhibit palaces. At intervals a stop is made and the chauffeur describes the various points of interest. A fare of 25 cents is charged. If the visitor wishes the exclusive use of a vehicle he can hire a cab or brougham at a rate of $4 per hour and take his friends to any part of the grounds. There is but one forbidden roadway, which is between the Louisiana Purchase Monument and the Grand Basin; over this no vehicles can pass. The company also has a number of large automobiles running from the principal hotels in the city into the Exposition grounds. The fare for this ride is 50 cents. Arrangements are also made to meet parties or delegations at the trains and convey them to the grounds or to the Inside Inn. A special gate into the grounds is provided for the automobiles. The automobile service begins at 8 a. m. and continues until 1 o'clock at night. In order to reduce the fire hazard, all gasoline automobiles are excluded from the grounds, which leaves the field exclusively to storage-battery vehicles.

The Automobile Company has made an excellent record, as not one accident of any kind has occurred with their vehicles. This is due largely to a rigid system of inspection to keep the automobiles in good condition, and to the careful instruction of all its operators. Each candidate must be an experienced chauffeur and before taking charge of a vehicle is tutored by an inspector with reference to the care and operation of the automobile and also regarding the facts and figures about the Exposition which will be of interest to his passengers. There is no prescribed speed regulation, because fast driving would

Seeing the Fair by Automobile

defeat the purpose of the trip, which is to give the passengers a chance to comprehend the beautiful surroundings. The automobiles seldom if ever exceed eight miles an hour.

The company has built a garage and charging station at the east end of the Model City and near the De Forest Tower. Three 50-h.p. gas engines are belted to 110-volt generators to supply the current. The leads extend to the charging plugs along one side of the building where fifty-five batteries can be charged at a time. Another charging station is downtown at the corner of Thirteenth and Locust streets. There are two batteries for each automobile so that each can be kept in continuous service, one battery being charged while the other is in service. The battery is carried beneath the body of the automobile and when it is released the vehicle is run over a lift which is level with the floor. A wheel truck is pushed over the lift and under the battery. It is raised to receive the battery and when lowered is moved to a charging plug. There are four of these lifts, operated by Ingersol-Sargant oil pumps driven by electric motors. Six batteries can be removed and replaced every ten minutes. The charging generators are kept at 110 volts and the current charge to each battery is regulated by a rheostat. As there is an attendant at the generators and at the batteries all the time, no automatic over-charge or release is employed. The batteries receive charges once a day, which is sufficient for a 25-mile run. Once a week each battery is discharged under the observation of an expert and readings are taken every five minutes. Any necessary repairs or renewals are made at this time. When fully charged the density of the electrolyte is kept at 1,300, which falls to about 1,250 at end of normal discharge. The plates for these batteries are shipped direct from the supply house and assembled and the connections burned together at the station. Wooden separators are employed, as they seem to give better results than rubber. All batteries have 42 Exide cells, with from nine to nineteen M. V. plates, depending upon the size of the vehicle. The motors operate at eighty volts and twenty to thirty-five ampere capacity, with series-parallel control.

After a circuit of the grounds in an automobile has been made during the day, the visitor will find great pleasure in a launch trip about the lagoons during the evening. The most beautiful effect imaginable is during the illumination when the myriad lights on the buildings are reflected in the waters of the Grand Basiin and lagoons. A journey of two and one-half miles can be made through the Grand Basin, across the base of the Cascades, around the palaces of Electricity, Education, and past the Machinery, Varied Industries, Manufactures, Mining, and German Buildings. During the day-time the launches are covered with awnings, in the evening the awnings are removed. The Launch and Gondola Concession Company has 31 electric, 5 gasoline launches and 15 gondolas. The gasoline launches are made in fantastic designs representing swans, peacocks, dragons, etc. The gondolas are imported direct from Venice and the singing Venetian gondoliers who accompany them have been selected both for their voice and skill with the oars. The launches are 30 feet in length and seven beam and draw thirty inches of water when loaded. About 40

Charging Station, Electric Launches

passengers can be carried. The fare for the trip is 25 cents. The electric boats travel at the rate of four and one-half miles per hour and make the circuit in about a half hour.

The launches are equipped with Willard storage batteries. Each contains 44 cells of 140 ampere-hour capacity, the positive plates having the new type envelope, which gives excellent results by preventing to a great extent the shedding of active material. Each battery is divided into two parts and by means of a series parallel controller gives three speeds forward and two on reverse. The motors are of 2 horse power, compound wound, four-pole, with ball thrust and axle bearings. On account of the slack water and the lagoons being sheltered from the winds a boat will run one hundred miles on a charge. At present they are in service from five to six hours a day.

INTERCOMMUNICATION ON THE GROUNDS

The best examples ever shown of temporary installations of telegraph, telephone and fire alarm systems are those throughout the World's Fair grounds. The latest and most modern equipment is used, and the whole installation would be a credit to any city. This result has been through the combined efforts of the electrical manufacturers, the operating telephone and telegraph companies and the World's Fair officials. The central stations and most of the apparatus are located in the Electricity Building, where the exhibit and commercial features can be combined to best advantage.

The rate of improvement in telephone apparatus to the layman's mind is judged by his daily contact with the receiver and transmitter. He has no conception of the many engineering difficulties overcome until he has the opportunity to inspect a central exchange and the apparatus therein. No better opportunity will be afforded for this than a visit to the operating telephone exchanges in the Electricity Building.

Telephones are freely distributed for the use of both exhibitors and the public, and, by means of the connection through the St. Louis exchanges, one can converse from one exhibit to another, to any building on the Fair grounds, to any place in the city or as far east as the Atlantic and west to the Rocky Mountains. Telegrams, cablegrams and even aerograms can be sent from the telegraph stations within the building to any part of the world. Although these facilities are in universal use, yet but very few understand the operations necessary to give such service, so that the different operating companies have demonstrators to explain the workings of the apparatus and systems.

The Exposition grounds are threaded with underground cables, connecting the separate departments of the Exposition, the greater portion of the exhibitors and most of the State and foreign buildings. The independent telephone service is handled by the Kinloch Company through the exchange of the Kellogg Switchboard and Supply Company, which is exhibiting a full lamp, full multiple, common battery board of 1,200 lines, but equipped for an ultimate capacity of 3,600 lines. Current is supplied by a power plant and its complement of batteries and generators on the floor of the exhibit. The

Kinloch Telephone Central, Palace of Electricity

cables, terminals, relays and distributing frames are subject to inspection.

Besides the exchange switchboard, there is an 1,800-line section of switchboard which is an exact duplicate of the sections of those at Buffalo, Cleveland and Los Angeles, three of the largest installations, all of which are in successful operation. Each piece of apparatus used in the construction of telephones and switchboards is shown in the minutest detail. All the several styles of telephones have been erected and their uses made plain. Machines for insulating copper wire are in full operation with skilled mechanics in attendance. A visit and careful inspection of the Kellogg exhibit is of interest for everyone.

The American Telephone & Telegraph Company occupies 3,000 square feet adjoining the Western Electric Company in the Electricity Building. Here is located the complete equipment of a standard Bell exchange in active operation. Service is rendered to all subscribers on the Exposition grounds, and connection is made to all exchanges in the United States reached by long-distance lines. The switchboard has an ultimate capacity of 9,600 lines, 9,600 multiple jacks and 600 trunks, but the Exposition service requires only 1,500 lines, which are brought into the exchange through an extensive underground plant. There are nine operating positions, the one in the west end handling all incoming calls from other offices of the St. Louis exchange and from long-distance points, while the others answer the calls of subscribers connected with this board, each operator being capable of handling a maximum of sixty lines. When a subscriber makes a call a small electric lamp is lighted near the lower part of the board. Associated with each lamp is an answering jack by means of which the operator plugs in on the subscriber's line and takes the call. Just above the small electric lamps are the jacks for trunk lines to outlying exchanges. Through these trunk lines the operators complete connection with parties called for by subscribers connected with the exchange. In the upper portion of the board are the multiple jacks by means of which parties calling for subscribers connected with this exchange are placed in communication with them. At the left of the board and on the same platform is a complete power plant, including a motor-generator charging set, storage battery, ringing generator and power board; also a line relay rack and an intermediate distributing board. In addition to the contract stations about the grounds, there are a large number of slot-pay stations at convenient locations in the buildings, where any visitor can secure local and long-distance connections at the regular rates. Besides a corps of operators at the exchange, there are several demonstrators who explain to visitors the operations and telephone connections. The exchange and exhibit is under the direction of Mr. Henry W. Pope.

The Automatic Electric Company combines with its exhibit a service throughout the Electricity Building. At convenient locations in the building and throughout the offices of the department are located automatic telephones. By this means the chief and superintendents can keep in close communication with the stenographers, assistants, clerks, janitors and guards.

The Bell Telephone Exchange, Palace of Electricity

The exhibit includes two complete working automatic exchanges of 10,000 type, each with 100 stations installed. These two exchanges, now giving service throughout the Electricity Building, are connected together by a system of trunks, similar to that generally used in manual telephone practice to connect branch exchanges to each other and to the main exchange. The selection of trunks, however, is done automatically, and not through human agency, as is the case in manually-operated switchboards where a call originating in one exchange must pass through the hands of two operators to secure connection with a telephone in another; a method which, since the number asked for must be repeated by the original to the secondary operator, of necessity consumes time. This method has the added disadvantages that it offers double opportunity for errors to occur, and requires that the subscriber's memory be burdened by the use of names prefixed to the numbers to designate various exchanges. The automatic system requires the use of no name prefixes, and the subscriber need not be aware that he is calling through more than one exchange, since the directory contains only numerical designations. In all cases three or four rotations of the calling dial will secure instantaneous and direct communication with the telephone desired.

The telephones exhibited are of three types, the wall, the desk and the pedestal. This last may be used as a substitute for a desk telephone. It is movable, like the latter, but instead of resting on the subscriber's desk it stands beside it at his elbow. All of these telephones are fitted with the regulation calling dial, a circular metal piece, on whose periphery are ten finger holes numbered from 1 to 0. This dial is fixed on an axis at its centre, and as the finger is placed consecutively in the holes corresponding to the digits of the numbers desired, and the dial turned once for each digit, electrical impulses are conveyed to the switches at the central office, setting them in operation and bringing through them the proper connections.

A toll board of ten stations is also in service, demonstrating the manner in which toll connections are given to users of automatic telephones. The rest of the apparatus displayed is of the same general character as that which may be seen in connection with any up-to-date telephone exchange, save the "tell-tale" board. This is simply a device for the instantaneous location of trouble, wherever it may arise, and consists of a number of lamps mounted on a slate slab together with a magneto bell. In case of trouble this magneto bell rings, calling the attention of the attendant, and a lamp glows, by the position of which on the board, the location of the trouble can be instantaneously ascertained and promptly rectified.

The Western Union Telegraph Company's main World's Fair office in the Electricity Building represents a model, up-to-date working telegraph office. There are three light oak sextette tables equipped with quadruplex, duplex, repeaters, automatic Wheatstones, etc. There is also a ticker service supplying New York stock quotations and New York, Chicago and St. Louis grain reports. Twenty-two wires leading from this office to the main down-town office give direct connection with the larger cities. Branch offices on the grounds are located at the Inside Inn, New York State, Missouri State, Govern-

The Automatic Telephone Switchboard

ment, Mines and Metallurgy, Manufactures, Agricultural, Administration, and Press Buildings, The Stadium, Philippine Village and in the Siberian R. R. Station on the "Pike." These offices are connected with the Electricity Building by loops, and placed on the different through circuits. Add to these the three offices of the Associated Press and the four commission houses in the grounds, and it is apparent that visitors to the Fair command telegraph facilities unexcelled.

A large globe above the main office of the Postal Telegraph-Cable Company shows how, with its Pacific and Atlantic cable connections, the company circles the earth. The equipment of this office is modern in every particular and shows the standard types of apparatus adopted by the Postal Company. At the rear of the space there are six Holtzer-Cabot motor-generators, each giving twenty-five amperes and forty volts for supplying power. There is also a complete switchboard with all the instruments and switches for regulation. Three quadruplex sets are in operation. On the tables are basket resonators and typewriting machines.

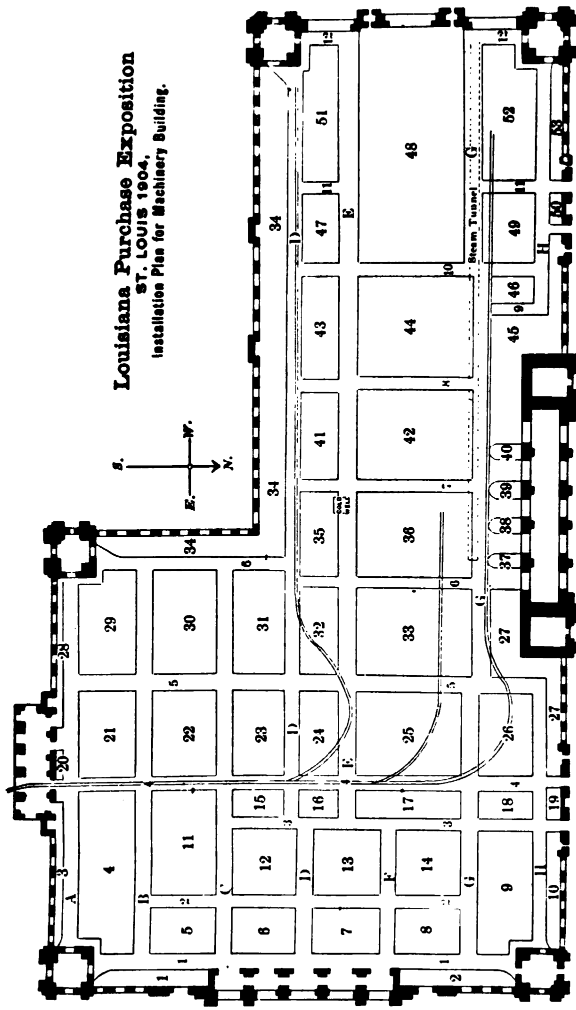
The branch offices work through the common and polar sides of these sets with the St. Louis offices, thus making substantially two wires of every single one between the Fair and the city.

Branch offices throughout the grounds are located at the Administration Building, Press Building, Inside Inn, New York State Building, Manufactures, Mines and Metallurgy, The Pike, Illinois State Building, the Agricultural Palace, the Philippine Reservation and the Government Building. In this way visitors are accommodated anywhere on the grounds.

Besides this, a money order department has been established, and visitors who become unexpectedly "broke" have found this service very convenient.

POWER FOR THE EXPOSITION

With the exception of a few isolated plants built for private use by some of the individual concessionaires, all the power required in the entire enclosure constituting the Louisiana Purchase Exposition for lighting, pumping and the operation of various motors, including the Intramural Railway, is developed in Machinery Hall and its annex, the Steam, Gas and Fuels Building. The generating apparatus, although all housed in Machinery Hall, is divided into two separate power plants. One is known as the Exhibitor's power plant, and is made up entirely of apparatus entered as exhibits by more than ninety engineering firms, including many of the leading manufacturing concerns of the United States as well as several from foreign countries. The total generating


Louisiana Purchase Exposition
ST. LOUIS 1904.
Installation Plan for Machinery Building.
S.
W.
N.
E.
Steam Tunnel

22

capacity of the Exhibitors' power plant amounts to 40,000 h.p., with an output of about 25,000 kw. of electrical energy at normal load.

In addition to the plant supplied by exhibitors, there is the Exposition power plant, made up of machinery leased by the Exposition Company as a service plant for furnishing power during the pre-Exposition period as well as during the time the Fair is open. The Exposition power plant, which was furnished by the Westinghouse Companies, has a capacity of 8,000 kw. The commanding size of the four large electrical generating units, each of 2,000-kw. capacity, appeals to practically all visitors to the Fair. These generators operate at a speed of 83½ revolutions per minute and deliver a 25-cycle current at 6,600 volts. It is interesting to note the advantage in floor space economy of direct-connected generators. The space occupied by the smallest of the belt-driven generating units at the Chicago exposition was about 65 by 27 feet, and the units at St. Louis, which are almost three times the capacity, are direct driven and the over-all space occupied by each, including the 36 and 75 by 54-inch Westinghouse-Corliss vertical cross-compound engines, is only about 55 by 15 feet and 32½ feet in height, the flywheel being 23 feet in diameter.

The total space devoted to the service electric plant in Machinery Hall, with the exciter units, condensers, cooling towers and 35-panel switchboard, is 26,260 square feet. The entire plant was designed and equipped by Westinghouse, Church, Kerr & Co., and all the motive power apparatus was furnished by the Westinghouse Machine Company.

Power for Intramural Railway

The Intramural Railway plant constitutes one of the systems of the Exhibitors' power plant. The generating units for the Intramural are divided into two groups. The first consists of three steam engines and a water wheel, each driving 550-volt, direct-current generators furnished by the Crocker-Wheeler Company. The four

The Exposition Service Plant

generating units in question were furnished by the following exhibitors:—

The Lane & Bodley Company exhibits a 900-h.p. cross-compound engine, with cylinders 20 and 40 inches by 54-inch stroke, direct connected to a 600-kw. generator making 85 rev. per min.

A 750-h.p. single-cylinder Murray-Corliss engine, with 26-inch cylinder and 48-inch stroke, was furnished by the Murray Iron Works, this being direct connected to a 500-kw. generator operating at 100 rev. per min.

The other engine of the group is from the Harrisburg Foundry and Machine Works. It is the Fleming type, four-valve, tandem-compound, with cylinders 15 and 40½ inches with 26-inch stroke, with a reheater between the high and low pressure cylinders, and running at 150 rev. per min. This engine is direct connected to a 400-kw. generator.

A unique feature of this installation is a tangential water wheel exhibited by the Abner Doble Company of San Francisco. This wheel develops 160 h.p. at 700 rev. per min. and is direct connected to a 100-kw. generator. Water for driving the wheel is furnished at a pressure of 300 pounds per square inch, by a triple expansion condensing pump from the Jeansville Iron Works.

The second group of the Intramural plant consists of a 1,400-h.p. cross-compound Buckeye engine with cylinders 26½ and 50 inches and 48-inch stroke, direct connected to a 900-kw. generator operating at 100 rev. per min., together with two Brown-Corliss vertical cross-compound engines, with cylinders 18 and 36 inches and 36-inch stroke, running at 135 rev. per min., each direct connected to a 500-kw. generator. All the generators of this group were also furnished by the Crocker-Wheeler Company.

The Wheeler Condenser and Engineering Company furnished for this group an Admiralty type of surface condenser with pumps complete. This condenser also takes care of the exhaust steam from a Greenwald 600-h.p. cross-compound engine, which is direct connected to a Fort Wayne Electric Works 400-kw., 250-volt, direct-current generator used on lighting load. The Greenwald engine has cylinders 18 and 36 inches and 42-inch stroke, and operates at 100 rev. per min. The Walker Electric Company of Philadelphia furnished the complete switchboard installation for the entire system.

The generation of power for the Intramural involves no special engineering features except those arising from the fact that power is secured from so many different classes of units. The switchboard is a typical railway board with the usual machine and feeder panels. Direct current is generated at 550-575 volts and passes out over aerial feeders. Inasmuch as the power plant is approximately in the centre of the Intramural line, which takes the form of an irregular circular belt, the problem of feeder distribution was a comparatively simple one, the chief requirement being to provide sufficient carrying capacity in copper for the heavy traffic anticipated.

Lighting and Power

The largest individual unit forms part of a three-phase, 25-cycle, 6,600-volt system situated in the central block of Machinery Hall. This consists of an Allis-Chalmers 5,000-h.p. vertical and horizontal compound engine, direct connected to a Bullock 3,500-kw. alternator; the engine is of the Manhattan type with horizontal high pressure cylinder and vertical low pressure cylinder, both working on the same crank; the cylinders are 44 and 94 inches in diameter, stroke 60-inch and rev. per min. 75. The exhaust steam is taken care of by a barometric tube condenser furnished by the Alberger Condenser Company. A vertical Alberger engine drives both the vacuum and circulating pumps, the latter being a rotary pump made by the Connersville Blower Company. That part of the water required for boiler feed is delivered to the cold wells by a De Laval motor-driven centrifugal pump.

A. L. Ide & Sons installed a 300-h.p. Ideal engine, direct connected to a Bullock 200-kw., 250-volt, direct-current generator, part of the current produced being used for exciting the 3,500-kw. alternator, the remainder passing through a Bullock balancer and being used for driving the variable speed motors of machine tools shown by various exhibitors in Machinery Hall.

The next system is one delivering a three-phase, 25-cycle, 6,600-volt current. It consists of a 1,500-h.p. Rateau turbine direct connected to a Bullock 1,000-kw. alternator making 1,500 rev. per min., and a 2,250-h.p. vertical cross-compound engine with cylinders 34 and 68 inches by 54 inches direct connected to a National Elec-

Willans-Stanley Unit for Arc Lighting

tric 1,500-kw. alternator operating at 83 rev. per min. Both the turbine and vertical engine are exhibited by the Hooven-Owens-Rentschler Company of Hamilton, Ohio.

The Stilwell-Bierce & Smith-Vaile Company of Dayton, Ohio, furnished two condensers with pumps; one for the turbine, designed to maintain a vacuum of 28 inches, and the other, for vertical engine, to carry a vacuum of 26 inches.

In connection with the arc lighting system there is a complete installation consisting of boilers, engines, condenser and pumps from the Société Anonyme des Etablissements Delaunay Belleville, of Paris, with a generator from the Société l'Eclairage Electrique, also of Paris; a complete installation of engine, condenser, pumps and generator from the Société Alsacienne de Construction Mécaniques, of Mulhouse, Germany, and Belfort, France; also a complete engine installation made by the engineering firm of C. H. Bradley Jr. & Co., of Pittsburg. The Belleville exhibit consists of three marine type boilers of 500 h.p. each, a 1,500-h.p. engine, a condensor complete with pumps, and a 1,000-kw., 2,400-volt, three-phase, 50-cycle alternator. The Mulhouse engine is of the horizontal tandem-compound type, with cylinders 600 mm. and 1,100 mm. in diameter and stroke 1,300 mm., developing 1,000 h.p. at 94 rev. per min. The generator from the Belfort branch of the same company is of 700 kw. capacity, and delivers a 2,300-volt, three-phase, 50-cycle current.

The Bradley installation consists of a 1,000-h.p. Willans central valve engine, direct connected to a Stanley 600-kw., three-phase, 60-cycle, 2,300-volt alternator; a 50-h.p. Willans engine direct connected to a Northern Electric 30-kw., 110-volt, direct-current generator; a Worthington surface condenser with Worthington circulating pump driven by a Northern Electric 25-h.p. motor, and a Blake twin air pump.

The General Electric Company is exhibiting a 2,000-kw. Curtis turbo set complete, the condenser and pumps being supplied by H. R. Worthington of New York. This turbine will operate at 750 rev. per min. and has a capacity for short periods of 100 per cent. overload; the current delivered will be three-phase, 25-cycle, 6,600 volts.

Greenwood & Batley, of Leeds, England, are exhibiting a De Laval turbine of 225 h.p., operating generators of 150 kw. capacity, 500-volt, direct current. The generators are four-pole type, two in number.

The Buffalo Forge Company is operating a 175-h.p. horizontal tandem-compound engine, direct connected to a Stanley 132-kw., 2,400-volt, two-phase, 60-cycle alternator, for which the Northern Electrical Manufacturing Company furnished the exciting set.

The Skinner Engine Company furnished a 200-h.p. engine, direct connected to a Warren 150-kw., 2,300-volt, single-phase, 60-cycle alternator, the Wagner Electric Manufacturing Company providing the exciting set. The American Engine Company has a 200-h.p. engine, direct connected to a 125-kw., 110-volt, direct-current generator of its own make. Above the power plant are two electric cranes for erecting and dismantling the machinery. The Shaw Electric Crane Company installed a 60-ton electric traveling crane, and Pawling & Harnischfeger a 50-ton electric traveling crane, with 10-ton auxiliary hoist.

Steam, Gas and Fuels Building

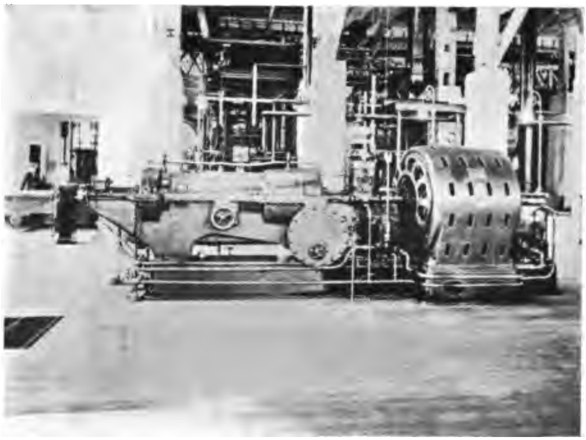
A separate fireproof building is provided for the installation of boilers, gas generating plants, briquette machinery and other apparatus for use in connection with boilers and fuels. Steam is furnished to the contract plant by sixteen Babcock & Wilcox boilers, set in two groups of eight units each. Each group is provided with a short steel stack and induced draft produced by twelve-bladed steel plate fans fourteen feet in diameter and six feet wide, two fans to each stack, direct connected to small horizontal Buffalo Forge Company engines. The plant has its own boiler-feed pumps, which take the water from the city mains through a large Cochrane open heater and send it to the boilers. The Babcock & Wilcox boilers have a total heating surface of 5,028 square feet, and are served by Roney stokers. The mechanical draft system is controlled by a regulating valve which varies the speed of the fan to meet the fluctuations of pressure.

There are four cooling towers, each consisting of a rectangular brick stack 52 feet in height, containing ten tiers of wooden gratings, occupying 20 feet of the height. A space of 12½ feet below the gratings provides for the fans, and a space of 20 feet above the gratings conveys the vapor above the roofs of the adjacent buildings. Draft is supplied to each tower by four 120-inch Seymour fans, arranged in two pairs, each driven by a single shaft. All sixteen fans are belted to a jackshaft with a Neptune waterproof belt. The jackshaft is carried by brackets attached to the building wall and driven by an 18 and 20 by 16-inch Westinghouse standard compound engine, the strain of the main belt being taken up by a structural steel tower built independent of the main wall.

Injection water for the condensers and water for the cooling towers is handled by a battery of three 24-inch Worthington turbine centrifugal pumps, one being

Constant Current Transformers

normally used for the two condensers and one for the towers, while the third is held in reserve. These pumps are driven by 18 and 30 by 16-inch Westinghouse engines and operate under a head of 45 feet, including suction. Each unit has a capacity of 17,000 gallons per minute. The governors may be adjusted while the engines are running, by means of hand-wheels at the ends of the engine shafts, so that the water circulated may be proportioned to the load. The Exhibitors' boiler plant has a rated capacity of more than 15,000 B.h.p., this being provided by a number of different varieties, but all of the water-tube type. The largest installation is that made by the Aultman & Taylor Machinery Co., which furnished sixteen horizontal and three vertical Cahall boilers with a total rating of over 8,000 h.p. The horizontal boilers are installed in batteries of two each; two of these batteries are designed for a steam pressure of 225 pounds per square inch and supply steam for the operation of the turbines, the steam being delivered at throttles with pressure of 185 pounds. The remaining boilers carry steam at 175 pounds per square inch, this



600 h.p. Steam Turbine

being delivered to engines in Machinery Hall at 150 pounds.

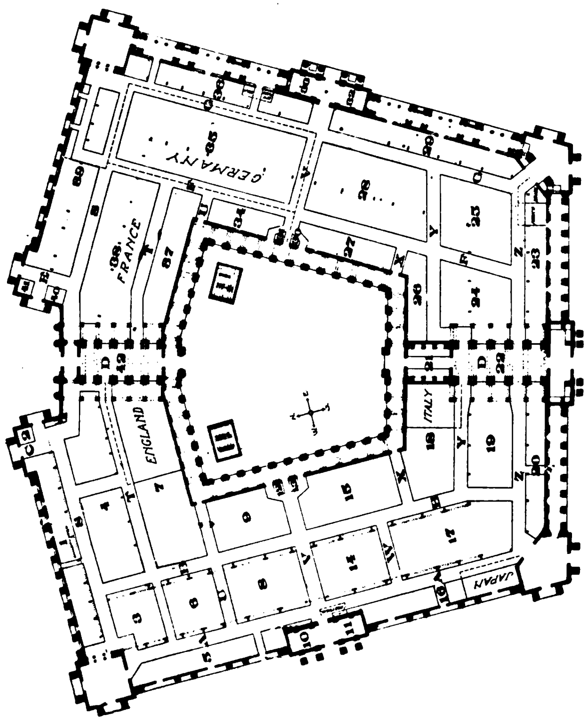
The Aultman & Taylor Company provided chain-grate stokers in connection with all Cahall boilers. The Heine Safety Boiler Company has an installation consisting of eight 400-h.p. Heine boilers, for which the Green Engineering Company provided the mechanical stokers. The boilers provided by the Belleville Company of Paris, to furnish steam for the Belleville engine, are three in number, of the Belleville marine type. J. & A. Niclausse, of Paris, are exhibiting two of their marine boilers, each of about 400 h.p. The Buffalo Forge

Company furnished a complete induced draft installation for all the last mentioned boiler exhibits.

The Clonbrock Steam Boiler Company provided two Climax boilers, marine type, one of 300 and the other of

Entrance to Service Plant

250 h.p.; the Dusseldorf-Ratinger-Rohrenkesselfabrik (formerly Durr & Co.), of Dusseldorf, Germany, a 500-h.p. marine type boiler; and the Schuette-Kessel-Konsortium, of Geestemuende, Germany, a 500-h.p. Conti marine boiler.



Installation Plan—Palace of Electricity

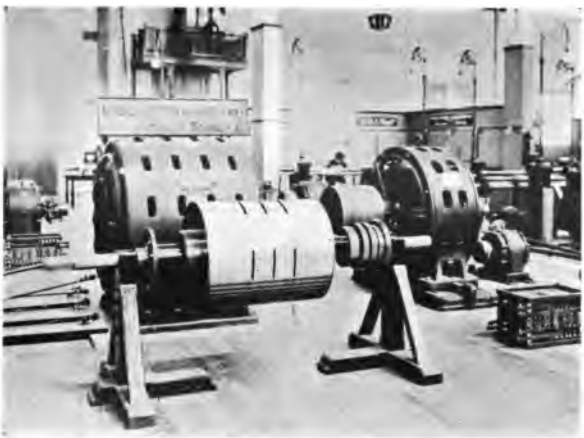
ARRANGEMENT OF ELECTRICAL EXHIBITS IN THE PALACE OF ELECTRICITY

The exhibits in the Palace of Electricity have been secured and arranged under the direction of W. E. Goldsborough, chief of the Electrical Department.

The accompanying ground plan indicates the manner in which the aisles and sections have been laid out in the building. All the exhibit space is on the ground floor, with ample head room; in fact, over the centre sections the roof is eighty feet above the floor. Over blocks 1 and 2 is a gallery 22 feet wide by 250 feet in length, which is divided and furnished as offices for the department, jury, committee and the Exposition Electricity Club rooms. Beneath the gallery are the main offices of the Postal and Western Union Telegraph companies, through which the news is sent from the exposition, and also the booths of the technical press. High-speed telegraph systems are shown in operation by Patrick B. Delany and Walter P. Phillips, while a transmitting typewriter applied to telegraph work is exhibited by Charles E. Yetman. The Gray telautograph, or writing telegraph, reproducing at a distance drawings or writings, also exhibited here, is a very ingenious application of electricity to the transmission of intelligence.

A fine collection of electrotherapeutic exhibits occupies the eastern end of block 4. Near the centre of this block is located the substation that contains the transformers, switchboards and rotary converters through which the high potential alternating current is received from the service power plant and transformed to a lower voltage or converted into direct current for distribution through the building. This machinery was furnished largely by the General Electric and Westinghouse Electric and Manufacturing companies. Adjoining the station the latter company has one of the largest exhibits in the building, embracing varied types of electrical machinery and apparatus. Across aisle B are the electric railway trucks and locomotives of Burnham, Williams & Co. Along the north side of block 3 the Standard Underground Cable Company and the McRoy Clay Works have installed a model conduit system, such as is used in the best city construction, showing the method of placing cables in conduits. A very conspicuous object is a Burdett-Rowntree electric dumb waiter running from the floor to the roof above the block. Its operation is automatic, starting or stopping in response to a push button.

Over blocks 3 to 17, along the west side of the building, is the craneway with a span of 57 feet 5½ inches.



Turbo-Generator Rotor

Upon this is a four-motor, 30-ton electric traveling crane, furnished by Pawling & Harnischfeger. A 20-h.p., 220-volt motor gives a horizontal speed of 250 feet per minute; an 8-h.p. motor gives a trolley transverse speed of 150 feet. The main hoist is equipped with a 30-h.p. motor with a speed of 25 feet, and the auxiliary hoist with a 15-h.p. motor, and has a travel of from 30 to 90 feet per minute. The crane has proved very serviceable in the installation of exhibits, and will be used in handling heavy machinery when exhibits are dismantled. With one exception the heavy exhibits are installed under or adjoining the craneway.

In the northwest quarter of the building are several displays of electric-railway equipment. The Westinghouse single-phase railway system and the electric air-brake apparatus of the National Electric Company are shown.

Block 9 is equally divided between the Fort Wayne Electric Works and the Wagner Electric Manufacturing Company, both having working exhibits. The Fort Wayne display consists of a line of direct-current machinery, transformers, fan motors, wattmeters and a series arc-light system. The Wagner space contains a variety of single-phase alternating current power-motors running under different conditions; motor-generator sets charging a storage battery, static transformers and indicating switchboard instruments.

The remaining space adjoining the court is occupied by the Bullock Electric Company, and contains one of the notable machinery exhibits. Power at 6,600 volts alternating is received and transformed to 340 volts for a rotary converter to supply 500 volts direct current for operating street railway apparatus. Other motor-generators and balancing sets furnish current for the multi-voltage system, as applied to speed control of machine tools.

In section 14 the Northern Electrical Manufacturing Company has a most complete demonstration of the adaptation of the electric motor to many forms of industrial machines. In this exhibit the manufacturing of motor parts is carried on to show the convenience and increased efficiency of motor drive for tools.

All of block 17, under the craneway, is taken up by the Western Electric Company. Near its centre is a large 100-kw. motor-generator set, which, with a compensator, furnishes 110 and 220-volt direct current throughout the exhibit. There are several direct-connected marine sets, transformers and regulating apparatus. On the opposite side is a series alternating arc light equipment with ornamental lamps and stands.

There are two collective exhibits, one supervised by the Wesco Supply Company of St. Louis, in block 8, and another by the Ewing-Merkle Company of St. Louis in block 14. In the former a large Warren synchronous motor drives a Triumph generator supplying power for the motors and apparatus in operation. In the second exhibit the Commercial Electric Company has a number of direct-current motors of from 1¼ to 35 h.p., and a 30-kw., three-bearing generator, direct connected to a gas engine, furnishes power to these items.

The western entrance embraces two large spaces, which are occupied by unique exhibits. Morris & Palt-

Historical Collection of Incandescent Lamps

ridge show stereopticons, lanterns, projectors and automatic electric curtain-hoists in operation. Opposite is the electroplating exhibit of the Hall Gold and Silver Plating Works. The different processes of plating and finishing of plated wares are shown in a most attractive manner.

The Gould Storage Battery and Gould Coupler Companies have a fine combination exhibit in section 16, which will include motor-generator sets and rotary transformers, arranged so that many ingenious applications of batteries to different lines of work can be illustrated. An interesting item is a motor-driven unipolar dynamo, charging two immense cells at from 3,000 to 5,000 amperes at about five volts.

The northern half of block 16 is devoted to the artistic exhibit of Japan. This electrical apparatus was designed and made by Japanese, most of whom received their education and training in this country.

The Italian space, occupying block 18, is especially worthy of notice on account of the scientific and electrical measuring instruments it contains.

A model central station storage battery plant, in a

Edison Historical Exhibit

fire and acid-proof enclosure, is shown by the Electric Storage Battery Company. A conspicuous feature is an immense map of the United States, showing the location of between 1,600 and 1,700 plants installed by this company, the railway, lighting, telephone and isolated installations being indicated by different colored lamps.

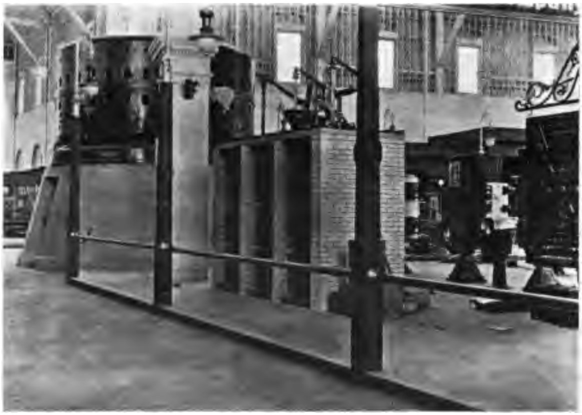
In section 19, three 75-foot towers by the De Forest Wireless Telegraph Company support the antennae from which wireless messages are sent and received from other stations in the building and to the large station in the Model City. Within the same block is the exhibit of the American Electric and Novelty Manufacturing Company, the booth being conspicuous from the lighting effects of 600 colored lamps.

Two telephone operating exchanges are located in the south side of the building, both enclosed by handsome booths. That part of block 17 not covered by the crane is occupied by the exchange of the American Telephone

Hutchison Wireless Telephone, Court Palace of Electricity

and Telegraph Company. This connects with the local and long-distance lines of the Bell Company, so that there is direct communication from the building to all parts of the grounds and city and all points reached by telephone lines. In block 24, the exchange of the Kellogg Switchboard and Supply Company gives a similar service through its connection with the Kinloch system of St. Louis. Recent developments in automatic and semi-automatic telephone systems are shown in a thorough manner by the Automatic Electric and the Faller Automatic Telephone Exchange companies, and an instructive historical collection of telephone apparatus is shown by B. F. Wasson in block 25.

The Hutchison Acoustic Company exhibits the "acousticon" and "massacon," giving daily exhibitions of deaf mutes being made to hear and taught to speak



10,000 h.p. Generator and Oil Break Switches

through their instrumentality. M. R. Hutchison also demonstrates a wonderful adaptation of the wireless telephone. Around the court of the Electricity Building is a circuit of wires connected to a booth in block 21. Before a telephone transmitter in the booth music will be played. In the court no sound of this is heard until a pocket telephone receiver, without any wire connection, is placed to the ear, and then the music becomes audible. At any point in the court music can be heard by the aid of the receiver.

Two beautiful booths in block 25 are those of the Holophane Glass Company and the Weston Electric Instrument Company, the latter showing a full line of standardized electrical instruments. The brilliant illumination of the Holophane exhibit is most conspicuous, as 1,000 incandescent lamps cover the exterior and interior of the handsome structure.

The laboratories of the National Bureau of Standards, covering a space of 23 by 200 feet, contain over $50,000 worth of instruments for testing every kind of electrical machine and apparatus. About twenty Government experts are connected with the laboratories to conduct tests and investigations. No preceding exposition has ever had such facilities for making complete records or for assisting the juries in making their awards.

The largest individual exhibit is that of the General Electric Company, embracing block 28, and covering a quarter of an acre of floor space. The great variety of electrical apparatus manufactured by this company is shown in operation. The Edison exhibits are in blocks 26 and 27, and include the iron-nickel storage battery and a historical collection of great merit.

SPECIAL EXHIBITS

The special exhibits showing the great progress since the Columbian Exposition are chiefly in the Palace of Electricity, where they are classified under five groups: machines for generating and using electricity, electrochemistry, electric lighting, telegraphy and telephony and the various other applications of electricity. The large generators, direct connected to engines, are placed in the Palace of Machinery on account of the proximity to the boiler house. Among the prime movers the Curtis steam turbine with an electric generator designed in connection therewith represents a recent development. The General Electric Company exhibits a 3,000-h.p. turbo-alternator unit consisting of a Curtis steam turbine direct connected to an alternating current generator. The condenser for the turbine is in the base of the machine and thus the entire outfit occupies the smallest possible amount of floor space, not more than ordinarily required for a generator. In power station equipment

500,000-Volt Transformer

the exhibits consist of very comprehensive lines of switchboards, with instruments and switches of types which are all of recent development. This is especially true of the oil break switches, which will safely break a circuit of 60,000 volts.

The distribution of power over long distances is one of the most important fields of usefulness for electricity. To do this economically very high potential currents are necessary. While ten years ago 10,000 volts was considered excessive, to-day lines of 50,000 volts potential are in commercial service. Even this is not the limit, for experiments are still being carried on and some of the most fruitful will doubtless be those at the World's Fair.

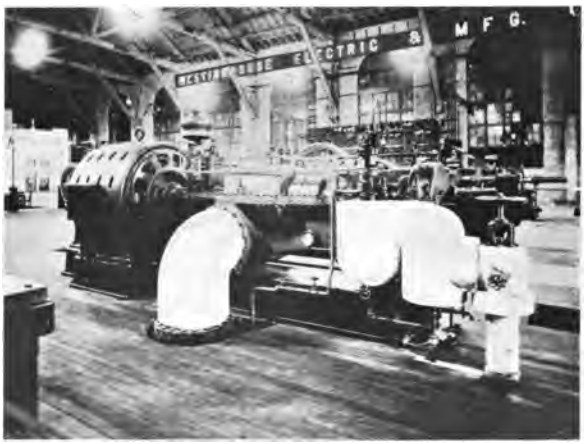
C. H. Thordarson has in operation a transformer which raises the potential from 120 to 500,000 volts. It has a regulator in the primary circuit which gives a secondary potential from zero to 504,000 volts. A series of alternating current induction experiments are being made with 60 and 120-cycle current. The transformer has a maximum capacity of 20 kw. and is primarily intended for testing and laboratory purposes.

The successful production of a single-phase alternating current motor constitutes one of the most important electrical developments of the past two years. The possibilities for the application of electricity to broader fields of railway service opened up by this achievement are not easily realized. The Westinghouse exhibit will contain two such motors mounted and in operation on a truck, with induction regulators, a large auto transformer, air operated switches, a master controller, and the usual air brake equipment.

The single-phase railway system, as illustrated in the Westinghouse exhibit, is not revolutionary, but simply an improvement over the old. For example:—With an existing direct current system it is possible to use the same generators and the same line and transformers, changing only the equipment of the cars. Moreover, cars equipped with alternating current motors can be operated over districts in which the cars are operated with direct current motors.

The mercury arc rectifier is shown in operation. In the General Electric exhibit it is receiving an alternating current which is converted into a direct current driving a 7½-h.p. motor.

One of the features of the lighting exhibits is the display of Cooper-Hewitt mercury vapor lamps in the Palace of Electricity. About two dozen tubes are used for the illumination of the Westinghouse exhibit service plant and for a special demonstration in the Westinghouse auditorium. Over the auditorium itself is a mer-



Westinghouse-Parsons Steam Turbine

cury vapor tube eight feet long; and in the Palace of Electricity, in the Westinghouse exhibit, is a tube of similar size. The Cooper-Hewitt lamp is used by the Official Photographic Company for portrait work in its booths on the Plaza, by the Official Pass photographers for all pass portraits taken on the grounds and in the postal photo booths in the Tyrolean Alps. In the Westinghouse auditorium three exhibitions are given daily of an interesting series of biograph and mutoscope pictures of scenes in and around the Westinghouse works in Pittsburg, in which are included the first interior moving pictures ever taken. These pictures were obtained by means of the Cooper-Hewitt lamp and are the most striking demonstrations that have yet been made of the lamp's actinic efficiency. By its use it was possible to take pictures at a speed of 900 a minute, or 15 a second, in the blackest forge rooms and foundries.

It is asserted that actual tests have shown this lamp to be less fatiguing to the eyes than any other artificial light; that it is the most economical light, and that its absolutely even illumination makes it particularly pleasing to draftsmen, machinists and stenographers, and in all places where the question of color does not come into consideration. The Cooper-Hewitt lamp is simple in construction, with no mechanism to get out of order and no carbons to trim or replace. The lamps are shown on exhibition as designed for use for general illumination, photography and photo-engraving, with simple printing outfits for photographers. In many of the Pike shows the lamps are used for illumination in places where their peculiar greenish light affords entertainment and amusement.

The General Electric Company also exhibits mercury vapor arc lamps, which are here shown for the first time in any exposition; also a new arc lamp, using magnetite instead of carbon. This lamp has a very marked increase in efficiency over the carbon burning lamps, and is especially suitable for street lighting. It is also worthy of note that the entire system of arc lighting used by the Exposition has been developed since the World's Fair at Chicago. This is known as the series alternating street lighting system, using enclosed arc lamps for lighting the interior of the buildings, the outlying parts of the grounds and the Pike.

The first public exhibition of Nernst lamps in any considerable number was at the Pan-American Exposition in 1901. To-day the new lamp is an important feature in the lighting of the Exposition. The most important installation of Nernst lamps is in the Fine Arts Building, where over 6,000 glowers are used. For this purpose the pure white light of the Nernst lamp has effectively solved the problem of the illumination of the works of art. The Westinghouse exhibits in the Palaces of Electricity, Machinery and Transportation are all brilliantly lighted by the Nernst lamp, and special demonstrations of its strength are given daily in the Westinghouse auditorium by comparison with incandescent light globes. The handsome Illinois State Building is lighted by Nernst lamps and the National Cash Register Company uses them in its various exhibits.

The peculiar advantages claimed for the Nernst lamps may be summarized briefly as high efficiency,

Nernst and Cooper-Hewitt Lamps

beautiful quality and perfect distribution of light, absence of shadows of the lamp itself, its steadiness, and the fact that the glassware is removable for cleaning, as there is no vacuum. It is but slightly affected in candle power by variations in the line voltage and is free from noticeable pulsations, even on alternating circuits of low frequency.

The exhibit of the United States Incandescent Lamp Company is located in the southwest corner of the building. In the space occupied by this company can be seen the various steps and processes in the manufacture of an incandescent lamp. These are carried on in such a manner that, starting with the squirting of the filament, one can see, by walking entirely around the exhibit, each step in the proper order.

The De Forest Wireless Telegraph Company has extensive exhibits in the Electricity and Government Buildings, including a 300-ft. tower and a 250-ft. mast for sending commercial messages to Springfield and Chicago. Exhibits are also made by Marconi and Ducretet.

The exhibit of a radiophone transmitting and receiving station, made jointly by the American Telephone and

Westinghouse Theatre Lighted by Nernst Lamps

Telegraph Company and the General Electric Company, is proving one of the most attractive exhibits in the Palace of Electricity. The radiophone is a combination of an arc light, reflectors, and a selenium cell. By these means speech is transmitted to distant points without the use of wires or other such intervening medium, the translation taking place by a beam of light furnished by the arc, and projected in a slender beam by a parabolic reflector.

In the court of the Electricity Building the Electra Water Purifier Company is exhibiting the Kune process of purifying water by electricity, for commercial purposes. The electric purifier has a capacity of 500 gallons of purified water per hour, the power consumption being 15 amperes at 15 volts.

On the map of the grounds, between pages 48-49, the numerals indicate some principal points of engineering

The Radiophone Receiving Station

interest. No. 1 locates Festival Hall, which has the largest dome in the world, 144.50 feet in diameter; top of dome 274 feet above the Grand Basin. In the auditorium of Festival Hall concerts of all descriptions will be given during the Eposition. No. 2 shows the Cascade pumping station, which is located under the east cascade and contains three 2,000-h.p. induction motors, direct connected to centrifugal pumps, each set having a capacity of 30,000 gal. a minute, working against a head of 100 feet. No. 3 indicates the power plant, Machinery Hall, which includes excellent examples of every kind of prime mover connected to generators of all types. The largest item is the Bullock-Allis-Chalmers 3,500-kw. engine-generator. The Steam, Gas and Fuels Building is located by No. 4. This building, constructed of cinder concrete, contains a large installation of Babcock & Wilcox boilers, in addition to a large number of other

The First Electric Locomotive

boilers, both foreign and domestic. Gas generating apparatus is also being exhibited in the west end.

No. 5 shows the De Forest wireless telegraph mast, which forms a part of the high-power, long distance transmitting and receiving station of the De Forest Wireless Telegraph Company. It consists of a single mast 200 feet high, with a 50-foot outrigger at the top, from which hang the aerial wires. The Ferris Wheel (No. 6) was the mechanical wonder of the World's Columbian Exposition of 1893. No. 7 locates the German outdoor railway exhibit, which consists of several thousand feet of track, equipped with operating, signaling, and block devices in use on the government railroads of Germany.

Pennsylvania locomotive testing laboratory (No. 8) is equipped for working tests on locomotives of any size or type. A most comprehensive series of tests will be made during the Exposition. The locomotive drivers are supported by wheels attached to water brakes, while the

Wireless Telegraph Tower

drawbar pull is measured by a delicate yet very powerful dynamometer. Outdoor mining exhibit (No. 9), in the gulch south of the Mines and Metallurgy Building, shows working mines, stamp mills, concentrators, etc.

De Forest observation tower (No. 10) is a steel structure 300 feet high. In addition to being equipped with a complete De Forest wireless telegraph installation, it is provided with electric express elevators, by means of which visitors can ascend to the platform at the top, from which a view of the Exposition and St. Louis can be obtained. No. 11 locates the general offices of the Electrical Department, also offices of the telegraph companies and technical press. The electric railway test track (No. 12) is a stretch of track located north of the Transportation and Varied Industries Buildings, equipped for making tests upon electric railway equipment of both direct and alternating type.

NEW APPLICATIONS OF ELECTRIC MOTORS EXHIBITED

The use of electric motors for all power purposes has expanded so rapidly that it has been difficult even for those directly interested to keep in touch with the latest developments. The ingenious applications of motors to tools and machinery resulted mainly from the efforts of electrical engineers and manufacturers, and, until recently, this has been done without the co-operation of tool makers. Objections were raised to changing designs and patterns so that the motors might be most advantageously placed for driving purposes. Later with chain, gear or direct connection, the driving power was so increased that the machinery had to be altered and strengthened, and in this way the motors have become more nearly an integral part of the tools. In the Electricity Building the electrical manufacturers are exhibiting the most recent adaptation of their motors to tools and machines. Wherever power is required, whether it be for a sewing machine or for pumps taking 2,000 h.p., the motors have been perfectly designed for their work. In fact, it might be said the display of electrical apparatus is in all parts of the Exposition; for the work, whether in the exhibit palaces, the mining gulch, the cascades or on the Pike, is done by means of electric motors. The widening adaptation of electric motors to every kind of tool developed such varying conditions that the electrical engineer had to make the motor a most versatile machine. Examples of machine tools driven by electric motors may be found in the local shops of any industrial centre, but a number of new ideas in motor drive have been recently developed, and advantage has been taken of the World's Fair to show ingenious adaptations of motive power.

The line of motor-driven machine tools exhibited by James Clark Jr. & Company represents a new departure in the application of motors to machine tool drive. Instead of attaching a motor to a machine through a combination of belts, gearing or speed boxes, a special variable speed motor is embodied in the design of the


De Forest Wireless Telegraph Apparatus

machine itself. The symmetrical appearance and ease of operation fully demonstrates the advanced step in machine tool design taken by the makers of these machines. The location of the driving motor on the head of a radial drill allows the power to be applied direct to the spindle without loss; it is simple and compact as can be made and all parts needing attention are accessible for examination and adjustment. The motor frame is cast into the head of the machine and is directly geared to the spindle. It has a multipolar field, iron clad armature, self-feeding carbon brushes and self-oiling bearings. It is made with two commutators in order to get a wide speed regulation with high efficiency on any speed. The motor has nine speeds, which, in connection with the back gears, give eighteen spindle speeds, from 14 to 250 rev. per min. in geometrical progression.

A small electric breast drill is another product of this company. The tool is designed for drilling many small holes in large pieces, replacing hand or small pneumatic drills. Power can be applied wherever there is an incandescent lamp socket. There are two sizes wound either for 110 or 220 volts, direct current. No. 1 will drill holes in iron up to 3/8 inch diameter and requires 1/8 h.p. The drill weighs fifteen pounds. No. 2 takes one-sixth h.p., weighs twenty-two pounds and will drill a hole 3/4 inch in diameter. All of these motor drills are in full operation in the southwest corner of the Electricity Building.

In the past the planer has been one of the least efficient metal working tools. With the belt drive only a single cutting speed has been provided, this speed in general being too low for cutting cast iron at maximum efficiency and too high for cutting steel without very rapid depreciation of the tool. With the motor drive in connection with clutches, this condition has been relieved somewhat by the introduction of change gears between the clutch, which imparts the cutting motion, and the driving shaft of the planer, thus rendering available two or three cutting speeds. This arrangement, however, is more or less complicated and expensive, requires considerable time for adjustment of the gears, and in general does not provide a sufficient range of cutting speeds.

The Electric Controller and Supply Company has developed a direct-connected motor drive which gives a number of cutting speeds, and these are instantly available by a simple operation of the controller. By this means the cutting speed may be instantly and accurately adjusted for securing maximum cutting efficiency with any material which is to be worked. The planer is direct driven by a variable speed motor without the use of belts or clutches, the motor being, wherever possible, directly coupled to the cross shaft of the planer. By means of a reversing switch, operated by dogs adjustably mounted on the platen of the planer, and an automatic controller, the motion of the driving motor is reversed at either end of the stroke. An operating controller is provided, by means of which the speed of the motor, in the cutting direction, may be accurately regulated. The automatic controller is so arranged that on the cutting motion, at each stroke, the table on the planer will be automatically accelerated to a speed determined by the operating controller, and, on the return, the table will in general be accelerated to maximum speed, as it is, of course, desirable that the table be returned as rapidly as possible on the idle stroke.

Where desirable, however, as in the case of planers which cut in both directions, the controller may be so arranged that the speed in either direction may be varied at will. The operation of the controller is such that the driving motor will reverse and accelerate the platen of the planer just as rapidly as is consistent with the power of the motor. The maximum current which can flow to the motor is absolutely limited, so that there is no sparking or undue mechanical straining at the instant of reversal. The platen may be reversed by hand through the operation of a shifter attached to the reversing switch. When the shifter is brought to the central position, the platen is instantly stopped. The operating controller is provided with a notched dial which plainly shows the cutting speed, and the automatic controller requires no attention whatever from the operator.

In the exhibit space of the Electric Controller and Supply Company a Pond planer is driven by a Westinghouse motor, and shows the operation of cutting iron and steel surfaces.

The ever-increasing magnitude of the power plants, now being constructed, requires steam and water valves of large proportions, too big to be operated conveniently by hand. Hydraulic, pneumatic and steam-operated valves have by experience been proven unsatisfactory for all purposes and pressures, but with the steadily increasing application of electricity to all kinds of machinery, a large demand has arisen for valves to be operated by electric motors.

The merits of the electric motor as a means of supplying power for a multitude of purposes have led the Chapman Valve Manufacturing Company to adopt this method of operating valves and sluice-gates. This development practically solves the problem of the rapid handling of large gate-valves, under ordinary conditions and especially in cases of emergency.

In the designing of such apparatus, the conditions governing the application of the electric motor to the valves were found to differ entirely from the application to all other machinery, inasmuch as the travel is, of course, limited to the size of the valve opening. The problem presented was overcome by the use of a motor especially adapted for the purpose and a lost motion device enabling it to attain practically a run-away speed, as it is series wound. Valves of this class are especially suited for water, steam and oil lines, and for low pressure work, such as exhaust and condenser piping, pump-suctions and discharge sewerage, and irrigation systems. They are also extensively used on the receiver piping of compound and triple-expansion engines, and are rapidly coming into use as throttle valves on steam turbine units. If emergency closing or opening is desired it is only necessary to push any one of the numerous buttons, located at different points. The valve will close, and automatically cut off the current. This apparatus may be seen in operation at the General Electric Company's exhibit, Space 28, Palace of Electricity.

The single-phase motors of the Wagner Electric Company are filling a field which has been hitherto unoccupied, for they can be used in places where a supply of either single or polyphase current is available. This motor is applicable except where frequent starting and stopping or where wide speed variation is desired. It is of the induction type and can be operated upon a single-phase alternating current circuit, or upon one phase of a polyphase circuit. A single pair of wires furnishes power to this motor, and if the voltage is to be reduced but one transformer is used. No starting box or any other auxiliary device is required. The attendant simply closes the main line switch, and the motor takes care of itself. This one feature alone is of great convenience, as the switch may be located at any desired point, however distant from the motor, and the same satisfactory starting results be secured. For hydraulic work, the circuit may be opened and closed by an automatic float or pressure switch. While running up to speed, the armature connections are such as to place the commutator in service, it being short-circuited through the brushes bearing upon it. On attaining full speed, the automatic governor comes into play, short-circuiting every commutator bar and simultaneously lifting off the carbon brushes. When it is very essential to hold down the starting current, an ordinary rheostat may be used to cut down the pressure at starting. It is possible for these motors to be wound to provide any degree of starting torque necessary. Where the conditions of starting are particularly severe, calling for as much as 50 to 75 per cent. in excess of full load torque, such torque can be provided by special winding without affecting the full load running efficiency of the motor. The motors are being used very successfully for pumping work, linotype machines, constant speed shop drive, blowers, church organs, and like service. Among other applications shown in the Electricity Building is one with the motor geared to a triplex pump with water tank and a float for automatically starting and stopping.

FOREIGN ELECTRICAL EXHIBITS

Argentine

This country has a small exhibit in the Electricity Building. This exhibit includes telegraph instruments, carbon and lightning-arresters; there are also maps and diagrams showing the development of the telephone and telegraph systems.

Belgium

In the Belgium national pavilion are some very artistic electroliers, storage-batteries, telephone and telegraph apparatus, and many photographs of electrical works in that industrial country.

Brazil

Brazil's exhibit is devoted largely to the telegraph and fire-alarm systems used by the Brazilian government. Insulators, and telegraph and telephone apparatus are also exhibited.

Canada

The Ontario Power Co. of Niagara Falls has a fine model of the great electrohydraulic plant now building on the Canadian side of the falls.

Denmark

The principal exhibit from Denmark consists of primary batteries. An extensive display will be made by Hellesens Enke & V. Ludvigsen of Copenhagen.

France

France occupies an area of approximately 25,000 square feet, just east of the main entrance to the Palace of Electricity, this being the largest section allotted to a foreign country.

In response to the request for representative machines for use in the Exhibitors' Power Plant, France contributes two generating sets, second in size only to the Allis-Chalmers-Bullock 3,500-kw. unit. These two machines are the finest types of two widely-different classes of European practice, one being a low speed horizontal set somewhat similar to American machines of this size, while the high-speed vertical machine is an excellent sample of a type recently developed abroad, but as yet unknown in large sizes in this country.

The former, built by the Société Alsacienne de Constructions Mécaniques, consists of a 3-phase alternator, constructed at the shops in Belfort, France; this machine is direct connected to a horizontal tandem engine, built at the Mulhouse shops (Alsace) of the same company. This engine is rated 1,000 h.p. at 94 rev. per min. The steam pressure is 150 lb. per square inch. The generator is of the fly-wheel revolving-field type, generating 3-phase current at 2,300 volts, 50 cycles.

The second set has been contributed by the Société Delaunay-Belleville and the Société l'Eclairage Electrique, of which the former are the engine builders, the latter constructing the generator. The engine is a triple-expansion vertical high-speed ma-

General Electric Exhibit

chine, rated at 1,500-h.p., normal speed 330 rev. per min., and taking steam at the comparatively high pressure of 250 pounds per square inch. A characteristic feature of the engine is the system of forcing oil circulation through the shaft and bearings by means of a geared pump.

In addition to its exhibit in the power-plant the Société Alsacienne de Constructions Mécaniques shows different types of machines of different sizes in the Palace of Electricity, among which the most noticeable, perhaps, is a type of multiple-speed alternating-current motor. The patents for this machine are owned by this company. An alternating-current booster and other machines for special purposes are shown.

The Société Gramme, which has stood preëminent among the electrical manufacturers since the very earliest days in history, makes one of the most interesting and valuable exhibits. This company is now building the most modern types of generators. As a special feature of its historical exhibit, this company shows the first dynamo built in Europe by Zenobe Gramme, in 1869. The evolution of the generator from this first crude machine to the latest types is also shown by a carefully-arranged series. The exhibit includes several of the company's latest multi-speed direct-current motors, as well as a new and improved magneto, designed for automobile use.

Electric cables and wires are exhibited by the Cie des Trefileries du Havre, Francois & Grellon, Société des Téléphones, Geoffroy & Delore, as well as Gramont and the Société Francaise des Cables Elect Berthoud Borel, which manufactures the so-called peripheral cables.

Special carbons for dynamo brushes, batteries, microphones, etc., are exhibited by J. A. Berne; the Compagnie Francaise de Charbons pour l'Electricité, which also makes a fine display of carbons for lighting purposes.

Dynamo brushes and brush-holder mechanisms are exhibited by Mr. Bourdreaux, who will also show a patented safety-nut which is meeting with great success in electrical and mechanical construction abroad.

The Dolter system of surface contact for electric railways is exhibited, contact-pieces being shown assembled and in sections. A sample model illustrates the working of this ingenious system. Among the new and genuine inventions shown should be mentioned an ingenious fuse, which is renewed by pressing a button. This has been tested under adverse circumstances with satisfactory results. A new form of permanent wire connector is also shown.

The electrochemical display consists largely of primary and secondary batteries. Several new French types of the latter deserve the attention of engineers. Provision will be made for tests on these batteries. At least two are shown for which very broad claims are made.

The arc-lamp section includes standard devices and novelties. Among these the most recent and

California State Building

interesting creation is the Blondel flame lamp, which is meeting with great success in France. The excellent regulation obtained from the regular commercial types exhibited by Bardon, Vigreux & Brillie and others may be somewhat of a revelation to those unaccustomed to the niceties of the regulation which prevails in French arc lighting.

The most effective demonstration of French taste in artistic lighting is offered by the magnificent display of bronzes and brasses shown by Milde, Guinier & Boulanger, who are famed the world over for artistic electroliers and fixtures. A striking and spectacular display is made by Paz & Silva, the well-known pioneers in the line of signs and other methods of decorative lighting. Weissmann has recently brought out the so-called "electric pearl" system of lighting, which is very artistic.

It is to be regretted that no projectors are exhibited. However, drawings and photographs of the best works of Henry Lepaute make an attractive exhibit; he also shows a line of electric clocks. The Compagnie Générale de Electricité, one of the largest manufacturers of French incandescent lamps and electric supplies of all kinds, insulators, etc., makes a complete and interesting display. Another well-known exhibitor of suppilies, possessing equal attractiveness, is the Appareillage Grivolas.

Parville and the Société de Folembray exhibit insulators for both high and low-pressure, telephone and telegraph work. The French government, which controls the telephone and telegraph system of France, makes a display of the apparatus in common use, among which the Baudot and Picard are well known types. A number of others which have been officially adopted by the French government, will demonstrate the excellent qualities of the French apparatus. A. Darras, who also manufactures apparatus for the government, exhibits telephone apparatus and several relays for special purposes, while the Société Indle des Telephones, which supplies nearly 90 per cent. of the telephones used in France, exhibits a quantity of its apparatus.

The Ducretet physical electrical apparatus and space-telegraph sets will attract considerable attention, especially as the list will be in working order.

France will appear at her best in the section which includes electrical measuring instruments, as the productions of Dépres d'Arsonval and Carpentier & Richard are of world-wide reputation. The Richard exhibit is especially broad-guage. as measuring apparatus of all classes demonstrative of his inventive genius will be shown. Chauvin, Arnoux, Réné are equally well-known manufacturers of portable instruments, indicating such high quality that they may be seen in a number of installations in this country. The French exhibit would not be complete without the Blondel oscillograph; one of these direct from the laboratory of Blondel will be shown in use in his exhibit.

Pennsylvania State Building

The Sartiaux Mors signalling system, now in use on the Northern Railway of France, together with the Rochefort system of telegraphy, will be exhibited by the Société Mors. A special type of transformer for high-pressure, high-frequency work, together with wireless apparatus, will be shown by the same Rochefort, who has brought out some interesting types of apparatus. Mr. Ancel will exhibit systems of space telegraphy and telephony, and will also show striking applications of radium. All together, there will be nearly 100 exhibitors in the French section.

Germany

The section allotted to Germany has been largely devoted to electrochemistry. An exhibit has been developed with characteristic attention to detail that shows the progress which German chemistry and electrochemistry have made in the last 150 years. The arrangement of the exhibit is made with a view to comparison, for in walking from one end to the other one can trace the development of one of the most important sciences, which has, since the era of electrical research, passed from the laboratory stage to a commercial basis. To-day the field of electrochemistry is one of the most important from the commercial viewpoint as well as from that of the scientist and electrician.

A fact worthy of note is that the exhibit contains nothing but purely German inventions and products. This portion of the exhibit was made without any idea of commercial gain, but simply from an educational and scientific standpoint.

Entering the German pavilion from the south, one finds at his right the laboratory of an alchemist of the fifteenth century. This laboratory is equipped with relics loaned by the "Germanischen Museum," in Nuremberg, Germany. In the next room the development of inorganic chemistry begins. The most important exhibits are by Professor Hempel of the Technical High School of Dresden and Professor Bunte of Carlsruhe, who show some very fine apparatus for analyses of gases. The Royal Prussian Porcelain Works of Berlin contributes a very fine collection of apparatus for chemical laboratories, electrochemical purposes, and the electrical industries. In the same section are shown the sample apparatus of Schott-Genossen, Jena.

There are also installed some work benches for qualitative and quantitative analyses, put up according to the specifications of the First Chemical Institute in Berlin. On one of these tables, which is nine feet long, is shown the development of apparatus for measuring the density of vapors, according to Professor Viktor Meyer, who shows original apparatus of high value. Another table shows a series of apparatus for measuring molecular weights.

In the section for pyrochemistry a very interesting collection of chemical apparatus is shown, which are made from platinum and quartz; these are the first appliances ever made out of quartz.

A section which will interest every electrical engineer contains the apparatus for the demonstration

New York State Building

of the welding process of Theodore Goldschmidt of Essen. Schmidt & Haensch of Berlin exhibit a collection of apparatus for spectral analyses. There are also shown some original compositions leading to the discovery of germanium made by Clemens Winkel.

There follows a section of apparatus for the investigation of steel and iron, and a dark room for demonstrating the properties of radioactive substances.

Siemens & Halske exhibit modern apparatus for the manufacture of ozone by electricity. As this application of electricity is one of the very latest, it will be of great interest to see the results which have been attained by this prominent German firm.

On the right side of the entrance, just opposite the laboratory of the alchmist, is shown a reproduction of the laboratory of the well-known chemist, Professor Liebig, for analytical chemistry as he used it in 1835 at the University of Giessen. In viewing this laboratory the visitor is struck by the simplicity of the equipment; it is astonishing how this man could accomplish things of such great scientific value with such a primitively-equipped laboratory.

Hugo Bremer of Neheim exhibits his new system of arc-lamps—the so-called Bremer lamps—the patents of which have been acquired by the Westinghouse Electric & Mfg. Company, Pittsburg. In these lamps a special kind of carbon is used. These carbons are impregnated with chemicals, having the effect of increasing very largely the amount of light produced by these lamps. The lamps are much more efficient than the ordinary arc-lamp, the current consumed being about 50 per cent. less. The light has also a peculiar color, which is more agreeable to the eye than the white-blue light of the enclosed arc-lamps. Mr. Bremer has built up a new system of arc-lamps, which have given very satisfactory service in Europe.

Great Britain

With the exception of dynamo electric machinery, the British exhibit consists of apparatus used in almost every branch of the industry, exhibited by various makers to illustrate in a measure the advance made in recent years in testing, measuring, calibrating, and recording electric phenomena both in the laboratory and in actual work.

The space allotted to Great Britain, comprising seven thousand square feet, to the right of the main entrance of the Palace of Electricity, is fronted by imposing and dignified façades. Nearly all of the instruments exhibited have been tested at and have received certificates from the National Physical Laboratory and the laboratories of Lord Kelvin and Dr. Muirhead, the latter dealing especially with submarine-telegraph instruments. The General Post Office exhibits a set of instruments illustrating the progress made in the transmission of telegraphic messages from 1883 to the present time.

An interesting working exhibit is a model of F. B. Behr's mono-railway, a high-speed car authorized by act of Parliament for the railway between Manchester and Liverpool, a distance of 70 miles. This car is designed to run at a speed of 110 miles an hour; the entire distance will be covered without a stop; the road is practically straight, the sharpest curves having a radius of 1,500 feet.

The Consolidated Electrical Company makes a fine display of switchboard apparatus. Messrs. Sherard and Cowper-Coles exhibit samples of electrochemically made reflectors and copper tubes, and also samples of electroplating. Various lamps, X-ray and high-frequency apparatus, will be exhibited by A. C. Cossor, while Muirhead & Co. show an extensive line of submarine telegraph apparatus with the latest Kelvin syphon recorders. The Cambridge Scientific Instrument Company has a representative exhibit consisting of oscillographs, and various electric recorders for laboratory use. Potentiometer sets, accurate to a remarkable degree, are exhibited by R. C. Crompton & Co. Elliott Brothers have a fine exhibit of switchboard instruments of all kinds and types, while Nalder Brothers and Everett & Edgecumb also exhibit on the same line. The India Rubber and Gutta Percha Company, which is known all over the world for its cable work, is showing an extensive collection. This company has supplied cables for various American and other cable companies. Mr. Darton exhibits a 10-in. induction coil, one of the finest instruments of its kind shown in the Electricity Building. Lord Kelvin and James

White, whose reputation is world-wide, exhibit a typical line, which covers all of the finest instruments they manufacture. Nalder Brothers and P. Paul are showing some extremely accurate testing and laboratory instruments, while the Synchronome Company has a full line of its electrically-operated clocks.

Italy

A notable part of the Italian exhibit is a historical collection of the early apparatus made by Volta, Pacinotti, Belli, and Farraris. The indicating, recording, and integrating instruments made by Olivetti & Co. of Milan are perhaps, the best of this kind. Wires and cables exhibited by Pirelli of Milan, carbons by the Società Italiana dell'Electrocarbonium, of Rome, occupy the remainder of the space. Photographs and diagrams of typical central stations and electric installations illustrate the progress made by electricity in Italy.

Japan

While Japan has been represented at previous expositions in the Department of Electricity, the St. Louis Exposition is the first one in which it has shown electrical machinery of Japanese design and construction. Its exhibit, located in the southwest corner of the Palace of Electricity, contains several articles quite advanced in design and workmanship.

Probably the greatest interest will be attracted by the 150,000-volt testing transformer, designed by Mr. Iijima and built at the Shibaura Engineering Works in Tokio. This same company will also exhibit a direct-current generator. While this is not of large size, still it shows that the Japanese are actually and successfully taking up the building of generators and similar classes of machinery.

The largest exhibitor is the Oki Company of Tokio, its exhibit including a Morse ink writer, a double-current key, several Tervil telephone transmitters, a transmitter designed by Iwata, desk tele-

On the Lagoon

phones, self-restoring annunciators, and switchboards. This company also makes cables for various uses, and wires for use in telephone work. It will show single- and double-core telephone cables, three- and five-core cables and subscriber's receiving cords. Its exhibit of electrical instruments will include a Wheatstone bridge, tangent galvanometer, differential, and astatic galvanometer, etc.

Tanaka & Co. of Tokio will show electromedical instruments. The Japan Electrical Association of Tokio exhibits a table showing the status of electrical industry in Japan, while the Kioto City Council sends plans and photographs of a canal route with water-power electric plan. Several models of hydraulic electric power station in Iyo, as well as photographs of the same installation, will be exhibited by Saiga Tokichi.

Mexico

The Mexican display consists largely of photographs and plans of the water-power plants, electric railways, and the telephone and telegraph systems throughout the country.

Portugal

Virgilio Mackado, of Lisbon, exhibits a case of books which he has written upon different electrical subjects.

ELECTRIC RAILWAYS

St. Louis Transit Company

Historical

THE first horse railway in the city of St. Louis was built in the year 1859 on Olive street between Fourth and Seventeenth streets. Between 1859 and 1870 many horse railway lines were constructed in different parts of the city. The first cable railway was built in 1885 and opened for traffic in 1886. It is now the St. Louis & Suburban Railway, and, at the time of its construction, terminated at Vandeventer and Franklin avenues, connecting at that point with the narrow gauge steam line which ran out a distance of eighteen miles through Cabanne and Normandy to Florissant. In the years between 1886 and 1890 the Olive street, Franklin avenue and Broadway lines were equipped to operate by cable power. Experiments with electric power were begun in 1887, when the Julien Electric Company of New York built a storage battery car which ran spasmodically on Washington avenue. In 1888 the Short Electric Railway Company installed an experimental line on South Broadway for the St. Louis Railroad Company. The first experiments made by this company were attempts to operate cars in series, using a Brush arc-light dynamo to furnish power. This method was abandoned and the multiple system was experimented with. No practicable results were reached and the experiments were abandoned in 1890, when the St. Louis Railroad Company converted this line into a cable road. The first permits to use the overhead trolley system in St. Louis were granted in April, 1889, and authorized its use on Chouteau avenue west of Jefferson, on Finney avenue west of Vandeventer and also on the California avenue division south of Chouteau avenue. It was not until April, 1890, that permission was granted by the city authorities for these lines to be extended into the business portion of the city. In March, 1890, the first electric cars in the city were commercially operated by the overhead trolley, and between 1890 and 1896 all of the existing horse railways were electrically equipped. The cable roads began changing their lines to electric railways in 1895 and the last of them were changed in 1900, making the entire traction system of the city overhead trolley.

Up to 1899 there were ten independent operating companies in the city. In that year all of the city transpor-

Standard Car

tation companies were consolidated into two, one the St. Louis Transit Company and the other the St. Louis & Suburban Railway, which is the present condition.

The traction development in St. Louis has been particularly interesting from a historical point of view, as it was here that many of the problems of heavy city electric transportation were first worked out. This was due partly to the fact that St. Louis was early in the electric railway field, and partly because of the keen competition for business between the various independent railroad companies. The early experiments with the storage battery and the series system have already been mentioned. It was here that the first development of the double truck car for city use took place, and it was here that the first direct-coupled generators for railway power plants were installed in the Cass avenue plant in 1893. St. Louis was the first to use 60-ft. rails for track, and the first city to use cast-welded joints.

General Lay-Out

The various lines of the city may be roughly divided into trunk lines radiating from the business portion of the city as a centre, and cross-town lines which intersect

Northern Power Station

the trunk lines at right angles. As transfers are freely granted, this makes an admirable system for the transportation of passengers from one point in the city to another for one fare. The layout is complicated by the fact that the streets are not always parallel, and contain frequent off-sets on account of the various additions which have been made to the city from time to time. Many of the principal streets have followed the general lines of the country roads, whose location was determined by the topography of the ground. The city is hilly and well drained, many of the streets having grades of 6 and 7 per cent.

TRACK

The original horse-car track was built with flat rails laid on wooden stringers, the girder rail coming into use just before the time of the electric developments. For a long time the standard rail was 7 in. high with a step head, but within the last year quite a good deal of grooved rail 7 in. and 9 in. in height has been laid. Considerable track, especially old track, has been cast-welded.

CARS

The original cars used on the electric railways were single truck, closed body, about 18 ft. or 20 ft. in length,

Interior of Compressed Air Station

with two-motor equipments. The advantages of the large double-truck car were early discovered, however, and all the cars now in service are of this type. Some of these have been made by splicing together two of the single-truck cars. The latest type is a double-truck car with a body 33 ft. in length by 9 ft. in width, supplied with cross seats seating forty-eight people. The cars are run single ended, with a small platform for the motorman on the front end and a large platform 7 ft. in length on the rear end. They are equipped with four 40-h.p. motors and weigh about 40,000 lb. empty. All of the cars belonging to the St. Louis Transit Company are now being equipped with air brakes operating on the storage system. An electric-driven air compressor station is established on each line or at junctions where several lines terminate or intersect. These air compressors furnish air at 300 lb. pressure. Each car is equipped with two tanks, one a reservoir tank holding air at 300 lb.

Northern Power Station

pressure, connected by means of a reducing valve to a service tank holding air at 45 lb., at which pressure it is used in the air cylinders.

POWER PLANTS

Both direct and alternating current is used. The direct current is furnished from four plants belonging to the Transit Company, and the alternating current partly from a plant belonging to the company and partly by a lighting company. The alternating current is transmitted at 6,600 volts and 25 cycles to substations whose output is 600-volt direct current. Both overhead and underground feeders are used in the alternating current distribution. The underground feeders are triplex, paper covered and lead armored. One of the substations is equipped with a large storage battery. The general policy of the railway company is toward an increased use of alternating distribution. The equipment of the plants and substations is as follows:

Central Station, Park and Vandeventer avenues.

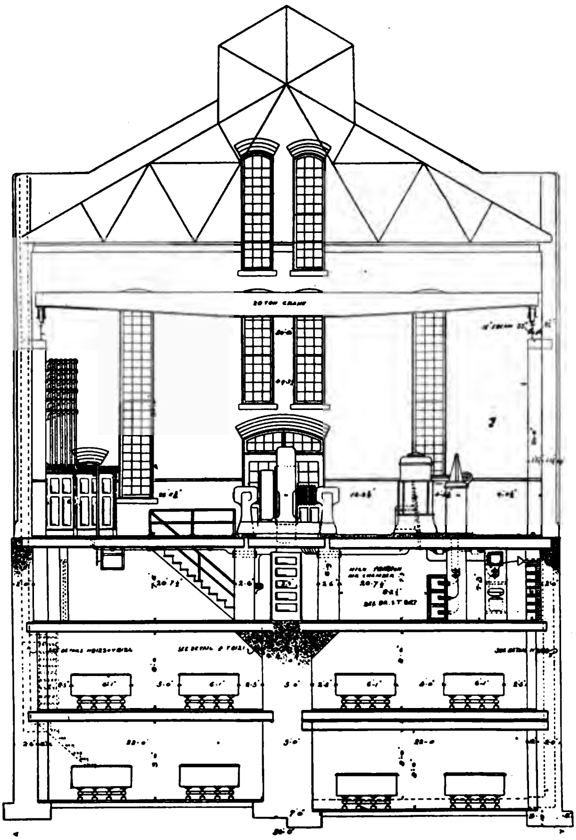
Engines: Three 20 and 40 by 30-in. tandem-compound, non-condensing Porter-Allen engines, 150 rev.

Central Substation

per min., direct connected to 600-kw. generators. Four 36 and 70 by 60-in. cross-compound Fulton Iron Works condensing engines, 75 rev. per min., direct connected to 2,250-kw. Westinghouse generators. Two 32 and 62 by 60-in. Fulton Iron Works cross-compound condensing engines, 75 rev. per min., direct connected to 1,500-kw. Westinghouse generators.

Boilers: Sixteen 400-h.p. O'Brien water-tube boilers, equipped with Green traveling chain grate stokers and

Hoppes purifiers. All heaters in this station are of the Excelsior type. Eight 325-h.p. Stirling boilers. Six 400-h.p. Stirling boilers, equipped with Hawley down-draft



Section—Central Substation

furnace and Hoppes purifiers. Coal and ashes handled by McCaslin conveyor.

Condensers: Two Worthington jet condensers. Twelve cooling towers. Two 1-million, duplex, triple-expansion Epping-Carpenter pumps. Six centrifugal pumps. Three dry-vacuum pumps.

Northern Station, Broadway and Salisbury streets.

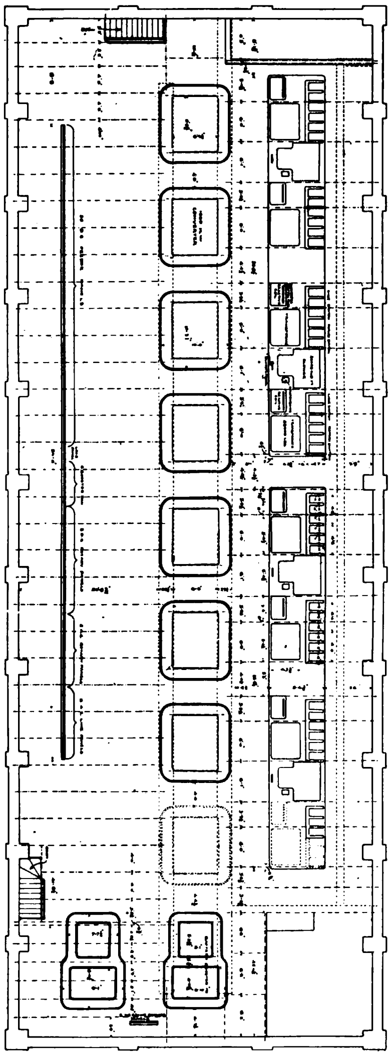
Engines: Two 36 and 70 by 60-in. cross-compound condensing engines, built by Fulton Iron Works, 75 rev. per min., direct connected to 2,250-kw. G. E. generators. Two 28 and 56 by 60-in. cross-compound condensing en-

Interior Central Substation

gines, 75 rev. per min., built by Fulton Iron Works, direct connected to 1,200-kw. three-phase G. E. generators, 6,600 volts, 25 cycles.

Boilers: Sixteen 400-h.p. O'Brien water-tube boilers, equipped with Green traveling chain grate stokers. Hoppes purifiers and Excelsior open heaters.

Condensers: Two Wheeler surface condensers, 10,000 sq. ft. cooling surface, with two Conover air pumps and two Knowles circulating pumps; also four cooling towers on roof of building; coal and ashes are handled by McCaslin conveyor. Epping-Carpenter feed pumps.



Plan - Central Substation

Geyer Avenue Station, Jefferson and Geyer avenues.

Engines: One 36 by 48-in. Allis engine, direct connected to 800-kw. G. E. generator. One 28 by 54-in. Hamilton Corliss, belted to 500-kw. Westinghouse generator. One 36 by 60-in. Allis twin, direct connected to 1,500-kw. G. E. generator. Two 22 by 60-in. Porter-Allen engines, direct connected to 400-kw. G. E. generators. One 38 by 60-in. Allis engine, direct connected to 1,050-kw. G. E. generator. One 36 by 60-in. Rankin-Fritch, direct connected to 800-kw. G. E. generator. One

Central Substation

22 by 42-in. Allis twin, direct connected to 600-kw. Western Electric booster.

Boilers: Seven 500-h.p. Heine. Four 300-h.p. Babcock and Wilcox. Two 250-h.p. O'Brien. Nine 250-h.p. Heine. Twelve of these boilers are equipped with downdraft furnaces and the remainder are straight fired; feed water heaters are of the Cochrane type and switchboard of the G. E. type.

Cass Avenue Station, Spring avenue and N. Market street.

Engines: Three 34 by 60-in. Allis engines, 94 rev. per min., direct connected to G. E. 800-kw. generators. One 18 by 36-in. Allis, 150 rev. per min., direct connected to 150-kw. G. E. generator.

Boilers: Sixteen 200-h.p. tubular boilers with Hawley down-draft furnaces. One old type link-belt ash conveyor.

Central Substation, 1711 Locust street.

One 3,000-kw. Electric Storage Battery Company storage battery. Seven 1,000-kw. General Electric rotaries. Two 252-kw. General Electric boosters and complete

Compressed Air Station

direct-current and alternating-current switchboards with transformers, etc., of General Electric type.

Delmar Substation, Delmar and DeBaliviere avenues.

Four 600-kw. and one 1,000-kw. rotary converters, with necessary alternating-current and direct-current switchboards, transformers, etc., of G. E. type.

Repair Shops

At Park and Vandeventer avenues are located the shops for the repairs of trucks, motors and electric equipment, and at Jefferson avenue and Gravois road the shops for car repairs. The company does all of its own repairing, and at the Park avenue shops there is quite an extensive installation of machinery and appliances for general repairs and also for the manufacture of the double truck with which the company is equipping its new cars.

The following are the statistics of operation of the St. Louis Transit Company for the year ending December 31, 1903:

Gross earnings from operation	$7,259,460
Total number of passengers carried	210,238,108
Total car miles run	32,535,626
Total miles of track	358.65
Miles of public highway occupied	185.38
Miles of right of way occupied	22.61
Percentage of revenue passengers using transfers	40.25

The St. Louis and Suburban Railway

THE ST. LOUIS AND SUBURBAN RAILWAY had its origin in the Central Railroad Company, organized in July, 1872. The road at that time was defined as five miles long, extending from a point 150 feet north of Olive street at Grand avenue. Nothing was done towards the actual construction of this road, and in August of the same year the name was changed to the St. Louis and Florissant Railroad and built to Kienlan avenue. A year later the line was extended fifteen miles to what was then called St. Ferdinand, now Florissant. This road was built narrow gauge, and steam cars were operated upon it until 1882, at which time it was sold to the St. Louis, Crevecoeur and St. Charles Railroad Company, which road owned and operated it until 1884, when it was sold to the St. Louis Cable and Western.

The St. Louis Cable and Western was the first street car company to operate a car line in the city of St. Louis by other motive power than horses. The St. Louis Cable and Western held a franchise authorizing it to build an underground cable railway from Sixth and Locust to Vandeventer and Morgan streets. In 1891 the St. Louis and Suburban purchased the rights and properties of the combined roads and converted them from steam and cable to electric. Since 1891 the St. Louis, Brentwood and Clayton Railroad, the St. Louis and Meramec River Railroad, and the Brentwood, Kirkwood and Forest Park Railway have been built and added to the Suburban Railway system. A few extensions have been built in the county and some cross-town lines added in later years.

As the original company, now part of the Suburban system, operated under a steam railroad charter and owned its right of way, the present company operates its cars for the most part over private right of way. There is but one line to the business portion of the city, and all other divisions run into this main line at various junctons west of Vandeventer avenue.

Interior Standard Car

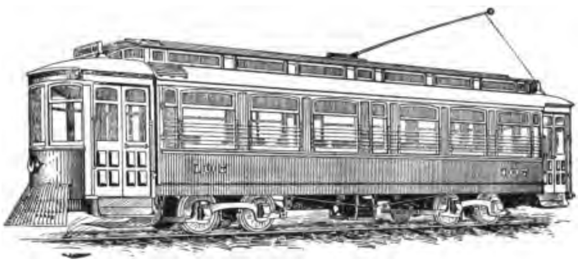
TRACK

The original cable track was a small girder-rail laid on iron yokes, and the narrow gauge was a 35-lb. iron T-rail laid on wood ties. In converting the cable line to electric, it was necessary to remove the iron yokes and cable conduit, and for a long period the rails consisted of girder rails 5 in. high set on chairs and laid on wood ties,

but within the last year all the lines on city streets have been reconstructed with girder rail 9 in. high, or with girder rail 6 in. high. The rails on the right of way were 40- and 35-lb. T-rail; these have been removed and standard 80-lb. T-rail laid within the city limits. In the county on private right of way 60-lb. standard T-rail is used, with the exception of ten miles where the old original 35-lb. T is still in use.

Power Plant

The system has but one plant at which power is generated. Both direct and alternating current are used.



Standard Car

This power plant is located at De Hodiamont on the Wabash Railroad, and is equipped as follows:

Boiler Plant: Fifteen O'Brien safety water-tube boilers with a rated capacity of 550 h.p. each, Jones underfeed stokers, and coal- and ash-handling machinery.

Power Plant: Two 32 in. by 60 in. simple Hamilton-Corliss engines, 80 rev. per min., direct connected to 800-kw. direct-current generators; one 31 in. by 72 in. simple Hamilton-Corliss engine, 68 rev. per min., belted to two 300-kw. direct-current generators; two 30 in. by 50 in. by 60 in. compound Allis-Chalmers engines, 75 rev. per min., direct connected to 1,200-kw. alternating-current generators; one 30 in. by 56 in. by 60 in. compound Fulton Iron Works engine, 75 rev. per min., direct connected to 1,200-kw. alternating-current generators; one 30 in. by 48 in. simple Allis-Chalmers engine, 80 rev. per min., direct connected to 800-kw. direct-current generator.

Sixteenth Street Transforming Station: Three 600-kw. rotary transformers.

Brentwood Transforming Station: Two 600-kw. rotary transformers.

The direct current is used for the lines in the vicinity of the power station and is distributed by overhead feeders. The alternating current is transmitted at 6,600 volts and 25 cycles to the above named substations, whose output is 550 volts direct current.

Cars

But two types of cars are used on the system; they are known as large and small cars. Both types are equipped with the St. Louis Car Company's No. 47 truck. The large cars are 46 ft. 8 in. long over all, 9 ft. 2 in. wide, weight 48,000 lb., with a seating capacity of 52 passengers. These cars are equipped with four General Electric No. 67 motors or four Westinghouse No. 49 motors and air-brakes. The small cars are 38 ft. long over all, 9 ft. 1.5 in. wide, weight 34,000 lb., with a seating capacity of 40 passengers. These cars are equipped with four Westinghouse No. 49 motors or two General Electric No. 57 motors and air-brakes. The repair and paint shops for motors, cars, truck and electrical equipment are located at De Hodiamont.

The following are the statistics of operation of the St. Louis and Suburban Railway Company for the year ending December 31, 1903:

Gross earnings from operation	$963,806.96
Total number of passengers carried	19,931,178
Total car-miles run	5,515,536
Total miles of track	95
Miles of public highway occupied	46.5
Miles of right of way occupied	48.5
Percentage of transfers	12.1%

East St. Louis & Suburban Railway

AN important factor in the wonderful growth of East St. Louis has been the electric railway system which had its beginning in 1890. This system has extended steadily, not only to all parts of the city, but also to the surrounding towns. The East St. Louis & Suburban Railway Co. now controls and operates the following lines, which were formerly independent:

1. The East St. Louis Electric Railway Co., which began operating its cars in East St. Louis in 1890, with current furnished from its own power station.

2. The St. Louis & East St. Louis Electric Railway Co., which began operating across the Eads bridge in 1890. This company had its own power station at the east pier of the bridge.

3. The St. Louis & Belleville Electric Railway Co., built in 1896 and 1897. This company operates over a private right of way between East St. Louis and Belleville. It also owned the lines in Belleville. Its power station was located on the bluffs, one mile east of Edgemont. This line is now operated as a coal road with electric locomotives.

4. The East St. Louis & Suburban Railway Co., which in 1897 constructed its double-track road between East St. Louis and Belleville along the Belleville Turnpike. Its power station was situated at Edgemont.

5. The Collinsville, Caseyville & East St. Louis Electric Railway Co., which built its line in 1899, between Collinsville and Edgemont. This line was supplied with power by the St. Louis & Belleville Electric Railway Co.

6. The Mississippi Valley Traction Co., which

built a line from East St. Louis to Collinsville in 1901; this was later extended from Collinsville to Edwardsville. Its power station was located one mile west of Collinsville.

7. The St. Louis, O'Fallon & Lebanon Electric Railroad Co., which in 1903 built a line from Edgemont to O'Fallon and Lebanon. It is supplied with power from a sub-station. Its road-bed, trestles, and bridges were constructed with a view of sup-

Power House

porting heavy freight traffic. The maximum grade is 1.5 per cent. compensated for curvature. The maximum curvature is 10 degrees. The bridge over Silver Creek is a deck-plate girder, and that over the Baltimore & Ohio Southwestern Railroad, near O'Fallon, is a through plate girder bridge.

8. Subsequently, the property of the Citizens Electric Light & Power Co., including power house, was acquired.

At the present time the entire system of the East St. Louis & Suburban Railway Co. includes 111 miles of track. One branch of the suburban line extends east from East St. Louis to Edgemont, another branch runs northeast to Collinsville, while a north and south line between Edgemont and Collinsville completes a triangular loop. From Edgemont a branch extends southeast to Belleville, another branch runs from French Village, just north of Edgemont, east to Lebanon and a third branch extends from Collinsville north to Edwardsville.

Belleville, a city of about 20,000 people, is the center of a rich coal and agricultural region. Its manufactures now cover a wide range of products which contribute largely to the business of the railway. This city has been the county seat of St. Clair county since 1814 and was the home of three of the governors of the state of Illinois.

Collinsville is a progressive city of about 7,000 population and is growing rapidly. It lies in a large coal-mining district and contains numerous manufacturing industries. O'Fallon is now a thriving town and illustrates the value of an electric railway to a small community, as since the advent of electric cars the growth in population and amount of building has been marked. The coal mines at this place constitute one of its leading industries. Lebanon has a population of 3,000, and forms the present eastern terminus of the line.

Edwardsville is the northern terminus of the line and is a rapidly-growing city. It is a place of much historical interest, being the home of Governor Edwards, the first territorial governor of Illinois, for whom the place was named.

In order to generate power for the various properties to the best advantage, a power station was erected in East St. Louis, with sub-stations properly distributed; the five smaller stations used before the consolidation were abandoned. The new power station is located between the two belt railroads, and on the electric lines to Belleville. Fuel is received over the company's coal road, which is here connected with both belt railroads, and which in turn connect with all steam roads entering East St. Louis.

The dimensions of the power station, which is a brick structure, are 207 ft. 6 in. by 115 ft. The foundation walls are of concrete, resting on piles. All engine and boiler foundations, built also of concrete, are on piles. Steel roof-trusses carry the gravel roof and the coal-bunkers above the boilers. The greater portion of the current generated at this sta-

Interior of Power House

tion is used in the city railway service of East St. Louis, with a centre of distribution a little more than a mile distant.

The low cost of coal and the absence of a cheap water supply made the use of simple non-condensing engines necessary. The coal used is nut, pea, and slack, which is handled from the mines in the company's bottom-dump cars. These discharge their contents into a steel hopper over the conveyor. This conveyor is of the overlapping bucket type, with 18 by 24 in. buckets, delivering the coal to steel bunkers holding two car-loads each, over the boilers. The ash is taken from the pits beneath the boilers by the same conveyor, and emptied into a hopper overhead, from which it is discharged into the coal cars by gravity.

The boiler room contains five 1,000-h.p. batteries of Heine water-tube boilers. In order to obtain enough grate surface, owing to the grade of coal used, it was necessary to set two 250-h.p. boilers side by side to form each half of the battery, instead of using the single 500-h.p. units. Demand for large grate-surface prompted the construction for this plant of the first traveling link-grates 12 ft. in width.

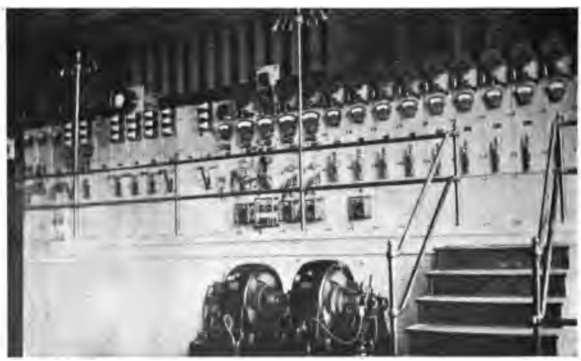
The engine-room, which is served by a 35-ton crane, contains five engines direct connected to their generators, three motor-generator sets, one synchronous converter, besides one motor-driven and two steam-driven exciters. The direct current at 550 volts, supplying the city trolley lines, is furnished by a 1,600-kw. generator, driven by a twin Corliss engine, having cylinders 34 in. in diameter by 60 in. stroke, and by two 425-kw. generators, each direct connected to a 22 by 42 in. Corliss engine. The 300-kw. synchronous converter also stands ready to convert 13,200-volt alternating current into 550-volt direct current, on demand.

The current for the suburban lines is generated at 13,200 volts having 25 cycles. Two 750-kw., 3-phase revolving-field alternators supply this current. Each alternator is keyed to the shaft of a Corliss engine, running at 94 rev. per min. The alternators are operated in parallel without difficulty.

The blue Vermont marble switchboards occupy the south end of the engine room. The lower board is used for the 550-volt direct-current railway and for the control of the 13,200-volt, 25-cycle alternating current. The alternating current is distributed to the three sub-stations now in operation through oil switches. Behind each of these oil switches the line may be again opened by means of knife switches. This double-switch arrangement was carried out through the whole of the 13,200-volt system.

The upper switchboard is set on a gallery supported by a 36-in. plate girder. It is used for the control of the 2,300-volt lighting current, the arc circuits and 550-volt direct-current power circuits.

The sub-stations are located as shown on the accompanying map. Those near Maryville and O'Fallon each contain two 200-kw. synchronous converters, and seven 75-kw. oil-cooled transformers, with reserve space for another set. The sub-station on the bluffs east of Edgemont contains at present two 300-kw. synchronous converters with 125-kw. oil-cooled transformers. It also has reserve space.



Switchboard

The arc and incandescent lighting for East St. Louis is done from the main power station by means of motor-generator sets. As this lighting load is comparatively small it is handled by taking 550-volt current from the railway bus-bars and changing it to 2,300-volt, 60-cycle alternating current, by means of motor-generator sets. There are two of these sets in the station, governed by a Tyrrill regulator, each being of 420-kw. capacity. The 550-volt power circuit is changed from grounded to metallic circuit in the same way, through the medium of a 300-kw. set. The arc lighting is done through three 100-light constant-current transformers.

The bare high pressure lines and insulated suburban feed-wires are of aluminum on glass insulators. White cedar poles are used throughout. The trolley wire is mainly of the No. 00 figure 8 type, hung from brackets on suburban lines, and No. 00 round in East St. Louis.

A feature of interest in connection with the system of the East St. Louis & Suburban Railway Co. is its telephone system which covers the whole of the city and suburban lines. Arrangements are made

Substation

for attaching portable telephones to the poles at about every 1,600 ft. Each suburban car carries its own portable telephone as well as a pole list, so that in case of accident communication can be quickly had with shops or the superintendent. The telephone list contains the names and numbers for both the private line, the Bell telephones, and the Kinloch telephones of the various offices and stations on the road and of the company's physicians which are to be called in case of accident. The poles on all the suburban divisions are consecutively numbered and on the back of the telephone list is given the number of each pole to which telephones may be attached. By means of this system a car on any part of the lines can immediately communicate with all of the shops, stations, and offices of the company.

The cars in the city service seat 36 passengers. They are of the closed type, with 26 ft. bodies, each having two G. E. No. 67 motors on Brill trucks. Twelve bench open cars are in service during the summer.

Interurban Car

The suburban cars are supplied with four G. E. No. 57 motors, and are equipped with air-brakes. They have a seating capacity for 60 people. The bodies are 40 ft. long and platforms are 5 ft. wide. These are mounted on St. Louis Car Co.'s No. 23 B trucks.

The freight traffic on the line between East St. Louis and Belleville is handled by two 50-ton electric locomotives, each equipped with four 160-h.p. motors and air-brakes.

ELECTRIC LIGHTING AND POWER STATIONS

Electric Lighting and Power Stations

THE beginning of electric lighting in the city of St. Louis was in the fall of 1878, when Carl Heisler, electrical engineer, brought from Paris two small Gramme dynamos. One of these was the generator, the other its exciter. The generator had a stationary armature and revolving field, and produced alternating current. This apparatus was erected by Mr. Heisler, assisted by Mr. William Wurdack, at Faust's Restaurant at the corner of Broadway and Elm street.

A small boiler and engine were set up to drive this apparatus, but as these were insufficient for the purpose the service furnished was intermittent and unsatisfactory. The plant, however, was run for several months. The lamps consisted of Jablochkoff candles, there being twelve candles set on three stands, with four candles connected to each.

When this service proved unsatisfactory, the Gramme machine was replaced by a Hochhausen arc machine. An arc-light was suspended at the corner of Broadway and Elm street, and the first street lighting in this city began. On account of its novelty, this arc-light attracted great crowds, who assembled to watch its operation. The arc-light was of foreign manufacture and was imported by Mr. Adolphus Busch, who was associated with Mr. Faust in this first plant. After operating this lamp for several weeks for street lighting, the little plant was moved and set up in the old Polytechnic Building, corner of Seventh and Market streets. The lamp was hung in the library and was operated at this place for a much longer period. The operation of the lamp was crude and uncertain and it was found necessary to attach a string to the upper carbon, carry it over a pulley and have a small boy stationed always within reach to pull the carbons apart when they came together and the lamp mechanism failed to separate them again and strike the arc.

Following this first attempt at electric lighting, the Brush Company of Cleveland, Ohio, established an electric lighting plant at the southwest corner of Seventh and Walnut streets. This plant consisted of six Brush arc dynamos driven by two Watertown high-speed engines. The lamps consisted of both single carbon and double carbon lamps of the Brush type. There were also some incandescent lamps run in series with the arc-lamps on the Brush multiple-series system. The output of this plant was used for commercial lighting only.

After the establishment of this Brush plant followed the organization of the St. Louis Illuminating Company by Carl Heisler in 1884. This plant was located at Third and Gratiot streets and consisted of eight Heisler, 5-ampere alternating-current generators, driven by Fitchburg, Buckeye, and Russell engines. The first four-valve type of engine manufactured by the Russell Company was installed in this plant. These dynamos each had a capacity of 550 thirty candle-power incandescent lamps, which were used for commercial lighting.

In the year 1889 the Missouri Electric Light & Power Company was organized by Guido Pantaleoni. The plant, built under the supervision of Mr. Herbert A. Wagner, electrical engineer, was started in August, 1889, and comprises the plant known at the present time as Station A of the Union Electric Light & Power Company. This plant started with a capacity of 10,000 sixteen candle-power lamps, which increased to 20,000 at the end of the first six months. From this promising beginning the success of electric lighting in this city was assured.

About the time that the Missouri Electric Light & Power Company was organized, the Municipal Electric Light & Power Company was formed to carry out the city lighting contract that had been awarded to Charles Sutter. In 1893 the Edison Illuminating Company of St. Louis was organized and acquired the property of the Municipal Electric Light and Power Company.

This company was operated as an independent lighting company until 1897, when the Missouri-Edison Electric Company was organized for the purpose of consolidating the electric lighting and power interests of the city. This new company absorbed the Missouri Electric Light & Power Company, the Municipal Electric Light & Power Company, and the St. Louis Electric Light & Power Company, the latter being a smaller organization which had built up considerable business in the supply of commercial series arc lighting and electric power with 220-volt direct current. The plants of these three companies in 1893 comprised the following equipment:

The Missouri Electric Light & Power Company, 4,100 h.p. of steam engines and 40,000 16 c-p lamp capacity in generators.

The Edison Illuminating Company of St. Louis had a total capacity of 4,800 h.p. in engines and 12,000 16 c-p. capacity in alternating-current generators and 4,500 arc lamp capacity in arc machines; also 280-kw. capacity in 500-volt power generators.

The St. Louis Electric Light & Power Company had an engine capacity of 1,100 h.p., alternating-current generator capacity of 3,600 16 c-p. lamps and 420 lamp capacity in arc-lighting machines; also power generators of a total capacity of 440 kw.

The latter station was operated only for a short period after the consolidation until arrangements could be made for transferring its load to larger stations.

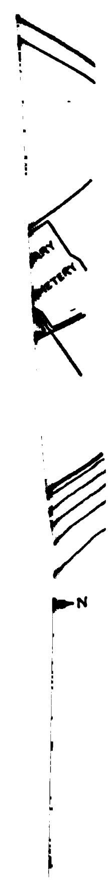
In 1897 the Imperial Electric Light, Heat & Power Company was organized to operate under a franchise obtained covering the new underground district of the city. This plant was designed for serving the underground district, which comprises the principal business part of the city. The plant was located approximately in the centre of the underground district, at Tenth and St. Charles streets, and the 220-440 volt direct-current system of distribution was adopted. This plant was absorbed about a year ago by the Union Electric Light &

Power Company, and is now known as their Imperial Plant.

The development of the electric lighting and power business in St. Louis has been similar to that in other American cities where smaller plants have been consolidated and larger ones rebuilt to replace them. In some respects, however, pioneer work has been done in this city by the engineers in charge of the designing of these properties. In 1893 the Edison Illuminating Company of St. Louis was operating the largest series arc lighting station in the world. This system was afterwards changed by Herbert A. Wagner to a series alternating-current system by making slight changes in the arc-lamps themselves, and connecting them through a regulator and a step-up transformer, giving variable secondary so that the current could be maintained constant by the switchboard attendant. By changing over the entire system in this way, the small arc-light machines were replaced and all of the arc-lamps operated from the large alternating-current units.

When, in 1897, the city ordinances required all wires throughout the business district to be put underground, the Missouri-Edison Electric Company put down a complete network of underground mains operating at 110-220 volts, on a three-wire alternating-current system, fed by large transformers placed in manholes at street intersections. These transformers were supplied at 1,100 volts pressure through duplex underground cables. This was the largest single-phase underground distribution attempted in this country and attracted a great deal of attention on account of the original lines on which it was laid out. Its practicability and efficiency have been proved by its successful operation.

The plant of the Imperial Company was also the first attempt in this country to install a high-pressure 220-440 direct-current system on an extensive scale. The growth in output from this plant, as shown in a later article, has demonstrated the practical engineering and commercial success of this design.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The Union Electric Light and Power Company

THE UNION ELECTRIC LIGHT AND POWER COMPANY was incorporated in 1903, being a combination into one company of the Missouri-Edison Company, the Imperial Electric Light, Heat and Power Company, the Seckner Contracting Company and the Citizens' Electric Light and Power Company. Through its ownership of the physical property and franchise rights of these companies, the Union Company acquired all the principal generating stations, together with nearly all the underground conduit used for electric light and power purposes in the city of St. Louis. At the present time the Union Company owns and is operating four generating stations as follows:

The Ashley Street plant at Ashley street and the Mississippi river;

The Imperial plant at Tenth and St. Charles streets,

The Missouri-Edison Station "A" at Twentieth and Locust streets,

The Missouri-Edison Station "B" at Nineteenth and Gratiot streets.

The Ashley Street plant is not yet fully completed, there being installed ready for operation but 12,000 kw. of engine-driven generating capacity. There remain to be installed two 2,000-kw. and four 5,000-kw. turbine units of the Curtiss type. Before January 1, 1905, there will be installed 36,000 kw. at the Ashley Street plant, 24,000 of which will be turbine driven.

The combined capacity of the Imperial and the Missouri-Edison plants, which are older, is 11,000 kw. It is the intention to convert such of these plants as are suitably located into substations, operating the steam machinery during the winter peak only.

Ashley Street Plant

The Union Company will furnish to the St. Louis Transit Company from its Ashley Street plant eighteen hours per day, 9,000 kw. of 6,600-volt, 3-phase, 25-cycle energy. In addition to this business the Union Company has at present a connected load as follows:

Direct-current motors	9,300	h.p.
Alternating-current motors	1,000	"
Alternating-current arc-lamps	3,500	
Direct-current arc-lamps	4,100	
Series direct-current arcs, city lighting	1,000	
Incandescent lamps in 16 c-p. equivalent	590,000	

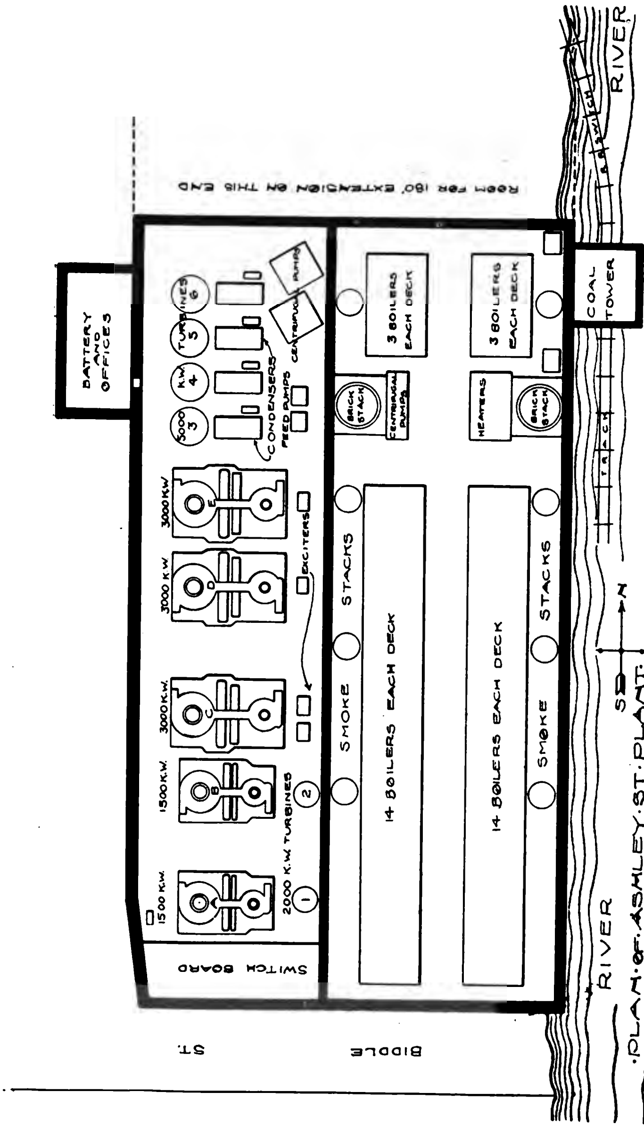
The Union Company has fully covered all the territory within the city limits with either its underground or its overhead systems of distribution. The extent and character of its distributing circuits are as follows:

UNDERGROUND		
Trench feet conduit	490,085	feet
Duct feet conduit	2,863,133	"
Laterals	154,616	"
Cables	250	miles
OVERHEAD		
Poles	10,000	
Overhead wire	550	miles

THE ASHLEY STREET PLANT

The Building

The new central station of the Union Electric Light and Power Company known as the Ashley Street plant, is situated on the west bank of the Mississippi river at the foot of Ashley street, about half a mile from the centre of the business district. The building consists of an engine room 319 feet long, 78 feet wide, and 84 feet high, adjoining a boiler room 319 feet long, 96 feet wide, and 117 feet high, the boiler room being on the river side and the length of the building being parallel to the river. The foundations of the building are of concrete, resting in every instance upon the solid rock, which is of a hard white limestone formation. The concrete foundations,



·PLAN·OF·ASHLEY·ST·PLANT·
·UNION·ELECTRIC·LIGHT AND·POWER·CO·
FIG·4·

where the foundation walls are high, are strengthened by steel framing. The foundation wall for the boiler room on the river side is 60 feet high and 323 feet long, and its base rests upon the solid rock at a depth of 10 feet below the low-water stage, a depth of 48 feet below the high-water stage and a depth of 25 feet below the average stage of the Mississippi river.

The superstructure is of brick, terra cotta, and steel construction, the steel resting on top of the foundation walls. The building is most ornate both externally and

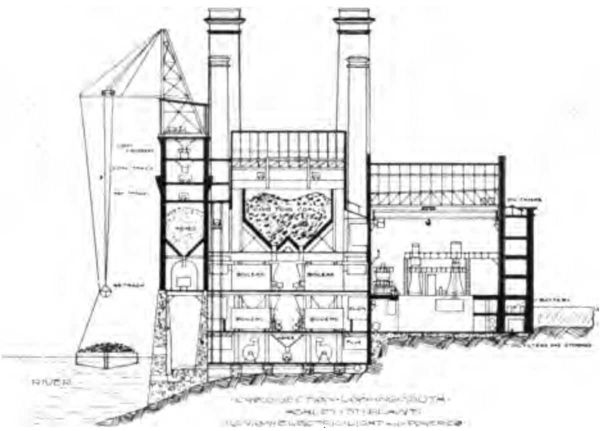
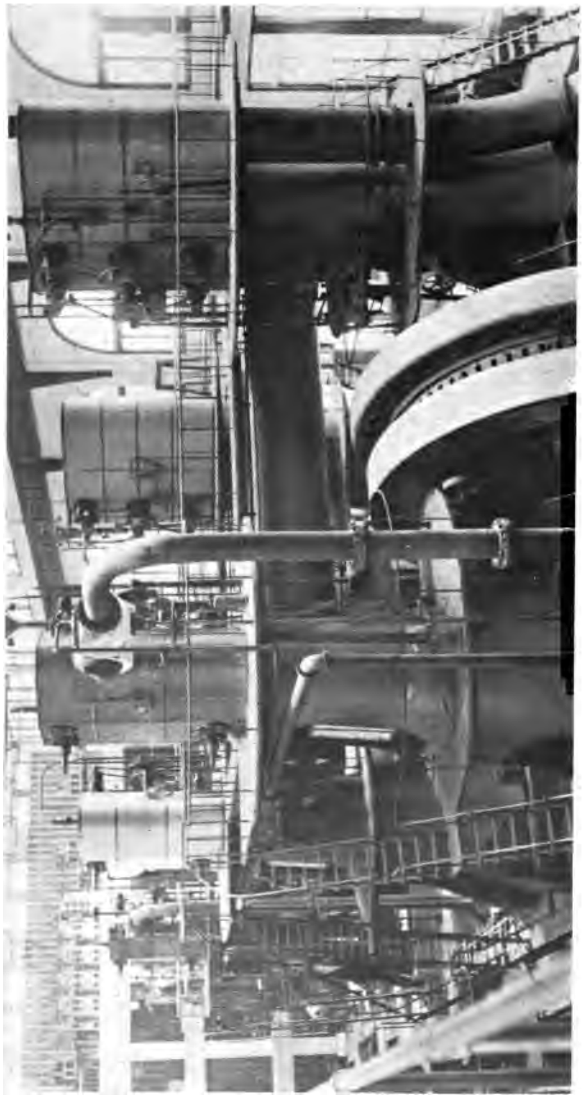


FIG. 5.

internally. The exterior is largely of terra cotta and the form of architecture is Roman. The general impression is a series of Ionic pilasters joined by round Roman arches and surmounted by a cornice all in terra cotta. The remainder of the external surface is of gray St. Louis pressed brick.

The interior of the engine room is of white enamel pressed brick except at the engine-room floor, where for a height of 12 feet the white enamel brick is replaced by a brick of brown enamel. The insides of the boiler-room walls are faced with gray pressed brick. The engines rest on concrete foundations 24 feet high resting on the solid rock.



Engine Room—Ashley Street Plant

The switchboard is located at the south end of the building and is contained on five galleries. The columns and the fronts of these galleries are in white enameled terra cotta and conform in general architectural design to the exterior of the building. Adjoining the engine room is an annex six stories high, 58 feet long, and 14 feet wide. The basement of this annex contains the oil-filtering tanks and the mezzanine floor the exciter storage-battery. The upper four floors contain the offices, shower and tub bathrooms, wash-basins, lockers, closets, etc., for the use of the operating force.

The boiler room structure has a basement 20 feet high, two boiler rooms one over the other, 24 feet and 18 feet high respectively, and above this a 10,000 ton coal bunker 42 feet high surmounted by a roof in the form of a series of monitors joined by portions of flat concrete roof.

Adjoining the northeast corner of the boiler room on the river side is a coal- and ash-handling tower 33 feet square and 93 feet high from the top of the building foundation to the track for the revolving hoist tower. The coal tower is built of steel and brick, and corresponds to the main building in architectural treatment. The railroad switches pass through arched openings on the level of the foundations.

The floors, roofs, coal-bunkers, and ash-bins are constructed of concrete arches on I-beams, using the Roebling system of steel reinforcement.

Engines: There are installed five engines built by the Allis-Chalmers Company, direct connected to 3-phase, 25-cycle, alternating-current generators built by the Westinghouse Electric and Manufacturing Company. There are two 1,500-kw. units and three 3,000-kw. units. The engines are of the vertical Reynolds-Corliss type with steam and exhaust valves placed in the cylinder heads. The generators are mounted between the two cylinders and adjacent to large fly-wheels, the weight of the fly-wheels being 155,000 pounds for the 1,500-kw. units and 310,000 pounds for the 3,000-kw. units. The principal dimensions of the engines are as follows:

	3,000 kw.	1,500 kw.
High-pressure cylinder	46 in. diam.	32 in. diam.
Low-pressure cylinder	94 in. "	64 in. "
Stroke	60 in.	60 in.
Revolutions per minute	75	75
Steam pressure	180 lb.	180 lb.

Each engine is provided with a receiver between the high- and low-pressure cylinders, having a volume of 1.5 times the low-pressure cylinder. The cylinders are not jacketed and there is no reheating in the receivers. The bed-plates are of vertical pattern cast with oil receptacles. The bearings are water jacketed and babbitt lined. The cross-head slides are also water jacketed. The frames are of the circular "sweep up" type and bored to form cross-head guides. The galleries are of cast iron, bracketed and carried by the main frame having brass handrails with polished steel stanchions.

For the 3,000-kw. engines the cross-head and crank-pins are 14 in. by 14 in. The crank-shaft is 37 in. in diameter, hollow and made of open-hearth steel, fluid-compressed, oil-tempered, hydraulically-forged. The cranks are counterbalanced. The connecting-rods are of open-hearth steel with bolted-strap crank ends. The pistons are fitted with bull-rings which cover the entire face. The piston-rods are secured to the cross-heads by thread and jamb nuts for equalizing clearance spaces. An auxiliary governor is provided and controls a butterfly throttle-valve. When the engine speed reaches the predetermined maximum the auxiliary governor trips the butterfly valve and shuts off steam. The engines are designed for the generators to run in parallel and regulate within 2% from no load to 50% overload. The normal load for these engines is considered 4,600 i.h.p., but the engines are built to carry continuously a load of 7,000 i.h.p.

The 1,500-kw. units are similar in all respects to the 3,000-kw. units, but of reduced dimensions, and the shafts are solid. The engines are provided with permanent indicator motions. The weight of the larger engine is 1,200,000 pounds and the smaller engine 600,000 pounds.

The floor space required for the 3,000-kw. units is 31 feet by 46 feet and for the 1,500-kw. units 25 feet by 38.5 feet.

The five engine-units, aggregating 12,000 kw., with their condensing apparatus and exciters, occupy a floor space in the engine room 204 feet by 78 feet. Two 2,000-kw. turbines have been installed in part of this area and occupy, with their auxiliary apparatus, a floor space of 17 feet by 20 feet each, just east of the 1,500-kw. engine units.

Boilers: There are installed at the present time 26 internally-fired boilers of the marine type, and contracts have been awarded for 2 additional boilers of this type and 40 additional boilers of the water-tube type. The marine boilers are 11 ft. 6 in. in diameter and 24 ft. over all. Each boiler contains two 44-in. and one 50-in. corrugated suspension-type furnace 7 ft. 6 in. long. These furnaces terminate at the rear into a combustion chamber. Leading from this chamber there is a bank of fire-tubes each 3.5 in. in diameter and 11 ft. long. The tubes are spaced 4.75 in. on centers. The total number of tubes to each boiler is 408, of which 70 are used as stay-tubes. Each furnace is provided with an automatic stoker of the Jones underfeed type. These stokers are capable of burning in each boiler a minimum of 2,800 lb. of coal per hour under a 2 oz. air pressure; and when coal in this amount is burned each boiler evaporates 21,000 lb. of water per hour from and at 212 degrees fahr.

These underfeed stokers require forced draft, the air being blown from opposite sides directly into the coal in a horizontal jet. Induced draft is also used to keep up the circulation of gases through the long economizer passages.

Four 9 ft. 6 in. diameter fans driven by single-cylinder engines form the forced-draught equipment for the first installation of 26 boilers. The furnaces of the upper-deck boilers are to be supplied by individual motor-driven blowers. Two 13 ft. 6 in. fans driven by double cylinder simple engines are used for induced draft on the economizer flues.

Piping: All steam piping and high-pressure water piping is of boiler tubing, with semi-steel flanges of the tongue-and-groove type shrunk on and riveted. The joints are packed with sheet-rubber gaskets. The circulating-water piping and the main exhaust-header are of riveted-plate piping, with cast flanges riveted on. The central feature of the steam piping is the 24-in. steam-header adjacent to the dividing wall between engine and boiler-rooms and equal in length to the space occupied by the 26 marine boilers. The boilers are connected in

Marine Boiler—Ashley Street Plant

pairs, one on either side of the central alley running the entire length of the boiler room. Each pair of boilers discharges steam through goose-neck bends into a common pipe parallel to the axis of the boiler and which enters the steam-header opposite the pair of boilers, there being a connection into the steam-header for each pair.

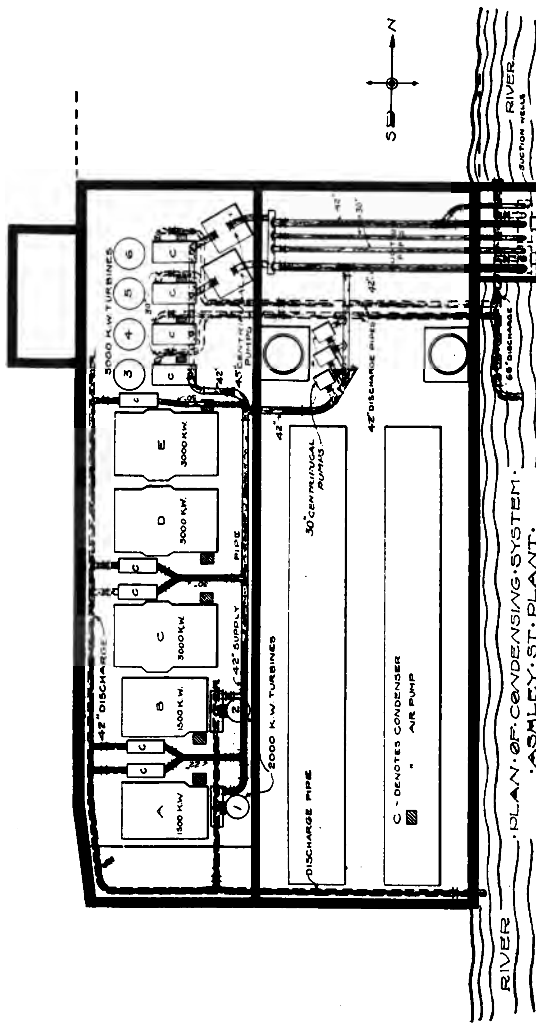
Opposite each engine a connection is taken off from the steam-header which, after passing through a steam separator, goes to the engines. The exhaust-pipe from each engine has a connection to the condenser and to the atmospheric exhaust-header which runs along the engine-room wall in the basement on the side opposite the steam-header. An auxiliary steam-header for supplying the auxiliary machinery runs underneath the boiler-room floor and has a connection erected to each boiler.

The high-pressure piping for the additional boiler equipment is to be extra-heavy pipe with special extra-heavy screwed flanges. The low-pressure piping is to be standard weight with standard fittings. The atmospheric exhaust-pipes are to be spiral riveted.

The plans for the steam piping, feed-water piping, etc., for the additional equipment of 40 boilers, have not been entirely completed at this writing.

Condensing System: The five engine-units are equipped with Wheeler surface condensers each containing 11,000 square feet of condensing surface for the 3,000-kw. units and 5,500 square feet for the 1,500-kw. units. Each condenser has a bucket air-pump driven by a vertical simple engine. The two 2,000-kw. turbine units are equipped with Wheeler condensers, each having 8,000 square feet condensing surface, suspended by means of car-spring hangers from the floor-beams under the turbines. Each of these condensers has a motor-driven Edwards air-pump. The four 5,000-kw. turbine units are each equipped with a 20,000 sq. ft. Worthington surface condenser. Each of these has a rotative steam dry-vacuum pump and a motor-driven centrifugal wet-vacuum pump. The air pumps all discharge into a large hot well, from which the water is pumped into Hoppes open heaters.

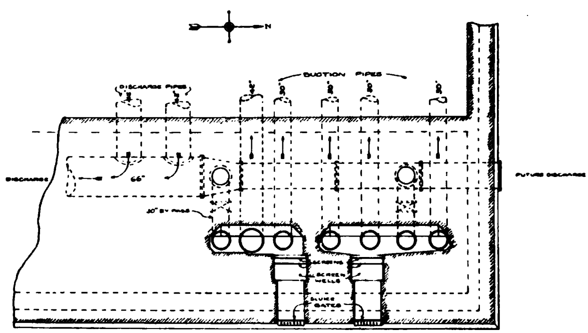
Condensing water is supplied by five large centrifugal pumps, three having 30 in. and two 45 in. discharge openings. The three 30 in. pumps, which were a part of the original installation, are located in the boiler-room basement. They are driven by four-valve, vertical, throttling engines. These pumps supply the engine-units and the 2,000-kw. turbines. The two 45-in. pumps which are to be located in the engine-room will supply the 5,000-kw. turbine condensers. Each of these is driven by an 18 in. by 38 in. by 42 in. steeple-compound Corliss condensing engine. The pump impellers are designed to act as fly-wheels for the engines and are mounted on the



·PLAN·OF·CONDENSING·SYSTEM·
·ASHLEY·ST·PLANT·
·UNION·ELECTRIC·LIGHT·AND·POWER·CO·
FIG·1·

engine-shafts. Each of the 45-in. pumps has a capacity of 70,000,000 gal. of water per day against a head of 40 ft. running at 100 rev. per min.

An idea of the piping of the circulating suction-supply and discharge-pipes may be gained from the sketch, Fig. 1. It will be seen from this diagram that all of the pumps take their suction from two steel and concrete chambers located deep down in the foundation of the coal-tower. Plan and elevation sections of these chambers are shown in Figs. 2 and 3. These chambers each have a reinforced steel-plate screen well opening out

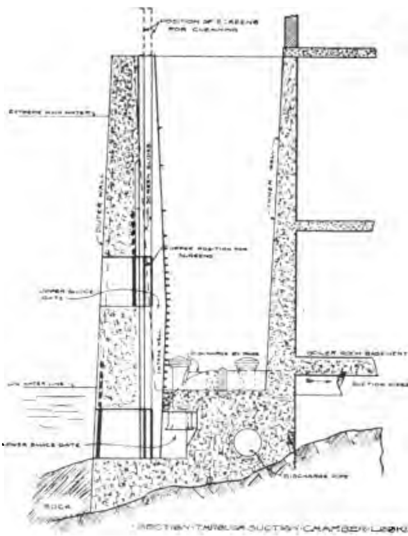


· PLAN · SECTION · THROUGH · SUCTION · CHAMBERS
· ASHLEY · ST · PLANT ·
· UNION · ELECTRIC · LIGHT AND · POWER CO ·
FIG · 2 ·

at the top of the foundation. Each of these steel wells has two screens which may be used at the level of either of the two gates, and may be raised to the top for cleaning. It is proposed to use the upper sluice gate at times of high water to avoid drawing in the mud and sand which is carried in suspension in greater quantities at the lower levels.

The ends of the suction pipes are five feet below the low-water line; the centres of the pumps are 13 feet above low water; the highest point in the circulating pipe-lines is 40 feet above, and the ends of the discharge pipes are 6 feet below this line, so that at times of extreme low water the pumps have to work against a head of only about ten feet more than the friction head after the siphon has been established. It will be noted on the plan Fig. 1 that there is a 30-in. by-pass from the discharge-header to each suction-chamber. These are to be used for clearing the chambers of rubbish or ice.

Oiling System: A gravity oiling system is used. Oil is supplied to the engine-bearings from three storage tanks which are set on a platform between the engine-room trusses 50 feet above the engine-shafts. Two tanks



·SECTION·THROUGH·SUCTION·CHAMBER·LOOKING·SOUTH·
·ASHLEY·ST·PLANT·
·UNION·ELECTRIC·LIGHT AND·POWER·CO·
FIG·3·

are for engine-oil and one for cylinder-oil. Engine-oil runs by gravity from these tanks to pressure oil-cups located on the bearings, and the cylinder-oil runs by gravity to Richardson oil-pumps located on the high- and low-pressure cylinder of each engine. After the engine-oil has gone through the bearings of each engine it returns by gravity to two Turner oil-filters. These filters are situated in the basement of the engine-room annex. After the oil passes through the filters it runs into a reservoir, from which small steam-pumps supply the tanks located on the engine-room roof-trusses. Both cylinder- and engine-oils are pumped from the basement to the supply tanks and each tank is supplied with an overflow which runs back to the storage tanks. The overflow connections are arranged so that it will be visible at a glance if the supply tanks on the engine-room trusses are receiving the required quantity of oil to feed the systems. Both cylinder- and engine-oil are run from the supply tanks on the engine-room trusses to the three 30-in. centrifugal circulating pump engines and six fan engines located in the boiler-room basement. As these engines are located below the filter tanks, the waste-oil is returned to the filters by a 1.5 in. motor-driven centrifugal pump which is arranged to pump automatically.

Coal- and Ash-Handling Apparatus: As shown in Figs. 4 and 5, the plant is designed to have a railroad track run alongside the boiler-room at the river side. Coal may be brought to the plant by rail or by barge. At the northeast corner of the boiler-room a coal- and ash-tower is designed to be built over the railroad. The upper part of the tower rests on a turntable and is capable of revolving in either direction. This part of the tower contains all the turning, hoisting, and cracking apparatus, these being steam-driven. The revolving tower is equipped with a 50-foot boom and the hoisting of coal is accomplished by a two-rope grab-bucket.

The vertical hoist of the coal is 107 feet and the bucket makes three round trips per minute, taking 1,500 lb. of coal per trip. The coal is thrown from the bucket into a hopper and passes by gravity into two crackers, and from the crackers by gravity into a lower hopper, from which the coal passes through valves into automatic side-dumping four-ton cable cars. The cable for these cars is engine-driven. The cars pass from the coal-tower down one side of the 10,000 ton overhead coal-bunker and back on the other side, making the circuit back to the tower and automatically dropping the coal at whatever point desired. The gauge of the cable road is 20.5 inches.

From the overhead bunker the coal is fed by downspouts directly into the mechanical stokers, which are of the Jones underfeed type. Each furnace is provided with an individual spout.

From each furnace ash-spouts descend into an ash-hopper, there being an ash-hopper for each pair of boilers installed. These hoppers are immediately under the lower boiler-room floor and are fitted with ash-valves at the bottom, through which the ashes pass into ash cars running on an industrial railway in the basement. These cars run to two elevators at the northeast corner of the basement and are elevated to the level of the top of the ash-tank which forms the lower part of the coal-tower, and are run from the elevator over the ash-tank and dumped into it. The ashes from this tank pass through valves by gravity into the empty coal cars or out into barges.

Smoke-Stacks: For the 26 boilers already installed 2 brick stacks have been provided, resting on concrete foundations carried down to bed rock. These stacks are 14 feet inside diameter at the top and 200 feet high above the foundation.

The balance of the boilers which remain to be delivered under contract and which were not contemplated in the original design of the boiler room, will be provided with metal stacks, ten in all, each 10 feet in diameter and 140 feet high above the grates of the upper-deck boilers.

Economizers: Two large sets of economizers of the Green type are provided, one set for each 13 boilers of the original installation. Each set consists of nine banks of 20 sections, each section having fourteen 12-foot tubes. Each set is guaranteed to raise 170,000 lb. of water per hour 130 degrees fahr. with flue-gases entering at 500 degrees fahr. and water entering at 100 to 110 degrees fahr.

Traveling Crane: The engine-room is equipped with a large traveling crane supported by a girder on each side of the engine-room attached by brackets to the steel columns of the engine-room walls. The crane sweeps the entire space covered by engines, generators, and auxiliary apparatus. It has four motors operated by alternating current at 200 volts, 25 cycles. It has a capacity of 50 tons with a speed of 10 feet per minute at the main hoist, and a capacity of 10 tons with a speed of 30 feet per minute at the auxiliary hoist. The bridge travel is 200 ft. per minute and the trolley travel 100 ft. per minute. The maximum travel of the hook is 76 ft., the span 76 ft. and the weight 130,000 lb.

Engine-Driven Generators: These are standard Westinghouse apparatus with three-phase, 25 cycle, 6,600 volts stationary armature with the revolving field fed at 100 volts direct current. The armature frame is so mounted as to permit motion in a horizontal direction sufficient to uncover the field poles.

Following is a table showing the guarantees for the performance of these machines:

	1,500 kw.	3,000 kw.
Excitation at full load:		
100% power-factor..	200 amperes at 100 volts	260 amperes at 100 volts
Regulation, no load to full load:		
100% power-factor..	8%	8%
Efficiency, 100% power-factor:		
½ load............	91.5	94.25
¾ load............	94.	95.5
Full load..........	95.	95.5
Temperature rise, 90-100% power-factor:		
Full load 24 hrs.....	40 cent.	40 cent.
25% overload 24 hrs.	50 "	50 "
50% overload 1 hr..	60 "	60 "

Steam Turbines: The Ashley Street plant will contain four 5,000-kw. and two 2,000-kw. turbine units of the vertical Curtis type, both turbine and generator being built by the General Electric Company.

As stated above, the 2,000-kw. units are placed in the south end of the engine-room opposite the 1,500-kw. engine-units. The four 5,000-kw. turbines are to be placed in the north end of the engine-room, and, together with their condensing apparatus and air-pumps, will occupy a floor space 90 ft. by 54 ft. as compared with 204 ft. by 78 ft. for 12,000 kw. of engine-driven capacity.

Switchboard: The switchboard is built to accommodate eleven generating units, consisting of three 3,000-kw.

Fig. 7—Switchboard—Ashley Street Plant

and two 1,500-kw. engine-type Westinghouse generators, four 5,000-kw. and two 2,000-kw. Curtis turbine units, with all auxiliary and exciting apparatus and 31 high-pressure feeders.

The switchboard apparatus occupies a series of galleries across the south end of the engine-room. There are five of these, designated as mezzanine floor, first (engine-room) floor, second, third, and fourth floors.

All galleries, with the exception of the first floor, have railings on the side facing the engine-room.

The generator oil-switches and generator bus-bars, together with all generator and feeder-control apparatus, are located on the fourth floor. On the third floor are located the generator disconnecting switches and the main bus-bars. The second floor contains the feeder hook selector-switches and the non-automatic feeder oil-switches; also the generator field-rheostats. The first floor contains the automatic feeder oil-switches and the auxiliary low-pressure control panels. On the mezzanine floor are located the auxiliary transformers, bus-bars, oil switches, and secondary switches. This arrangement can be readily followed out by consulting Fig. 6, which shows a cross-section through the switchboard galleries.

The switchboard apparatus and instruments are of the Westinghouse make. The oil-switch and bus-bar chambers are built of gray pressed brick with Alberene stone barriers. On the two upper galleries the selector and generator cables are carried in a system of brick and slate ducts covered by a false floor of slate plates. The instrument and control wires are enclosed in iron-pipe conduit throughout.

On the fourth floor the generator instrument posts are located in the line of the railing and serve as stanchions for the railings. Each generator instrument post carries a power-factor meter, two alternating-current ammeters, an indicating wattmeter and a field ammeter. The station post, which occupies a central position, contains three voltmeters, one for each set of bus-bars and one for the generator, two synchroscopes and a direct-current voltmeter.

The generator control pedestals are set just back of the instrument posts and in line with them, so that the operator can see generator and instruments when working the control-switches. These control pedestals, which are 16 in. square and 4 ft. 10 in. high, are constructed of cast iron and marble and each has mounted on it the following apparatus:

Three oil-switch controllers,
Field-switch controller,
Field-rheostat controller,
Voltmeter receptacle,
Synchronizing receptacle,
Signal switch,
Seven telltale and signal lamps.

A view of the instrument posts and control pedestals is shown in the cut Fig. 7.

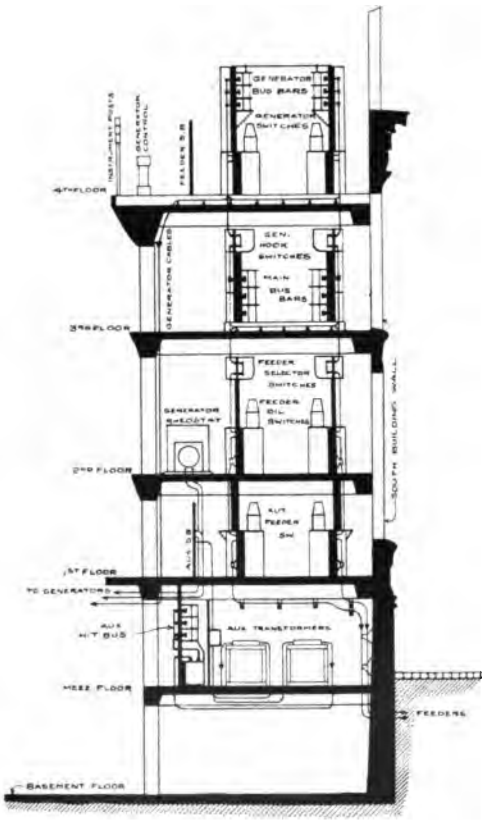
Back of and facing the control pedestals is a blue Vermont switchboard, 44 ft. long, on which is mounted the control apparatus and instruments for 31 high-pressure feeders, generator wattmeters and station ground-detectors. Each feeder has one ammeter, a power-factor meter, an integrating wattmeter, two oil-switch controllers, two mechanical switch indicators, two indicating lamps and a time-limit relay.

Referring to diagram Fig. 8, it will be seen that the generator cables lead first through the main oil-switch to the generator bus-bar and thence through selector oil-switches and disconnecting switches to one of the two sets of main bus-bars. The main generator switch is first closed and the machine is synchronized over one of the selector switches. An electrical interlocking connection makes it impossible to operate the selector switch other than the one over which it is being synchronized.

The bus-bar selection for a feeder is made by means of interlocking hook-switches. From these the feeder passes through a non-automatic oil-switch on the second floor, then through an automatic oil-switch on the first floor and out underground under the mezzanine floor. These oil-switches and generator switches are Type C size.

One set of selector and feeder switches is used to supply the auxiliary high-pressure bus-bars which are located on the mezzanine floor. To these bars two sets of three 100-kw. transformers are connected through Type E oil-switches, for supplying current to the auxiliary alternating-current low-pressure bus-bars at 200 volts.

The auxiliary and exciter switchboard which is located at the front of the first-floor gallery facing the



·CROSS·SECTION·THROUGH·SWITCH·BOARD·
·ASHLEY·ST·PLANT·
·UNION·ELECTRIC·LIGHT·AND·POWER·CO·
FIG·6·

engine-room is built of blue Vermont marble panels and is 41 ft. long.

On the east panels of this switchboard are mounted the alternating-current 200-volt switches and instruments, supplying current for the exciter motors, crane, and other auxiliary apparatus. The west end is devoted to the exciters, battery, direct-current lighting and control circuits, and on the last six panels are mounted the electrically-operated field switches for the generators. One cable is led from each of the field switches up to the second floor to the electrically-controlled field rheostat. The five rheostats for the engine-driven generators are of the standard Westinghouse make and the six turbine generator rheostats are standard General Electric.

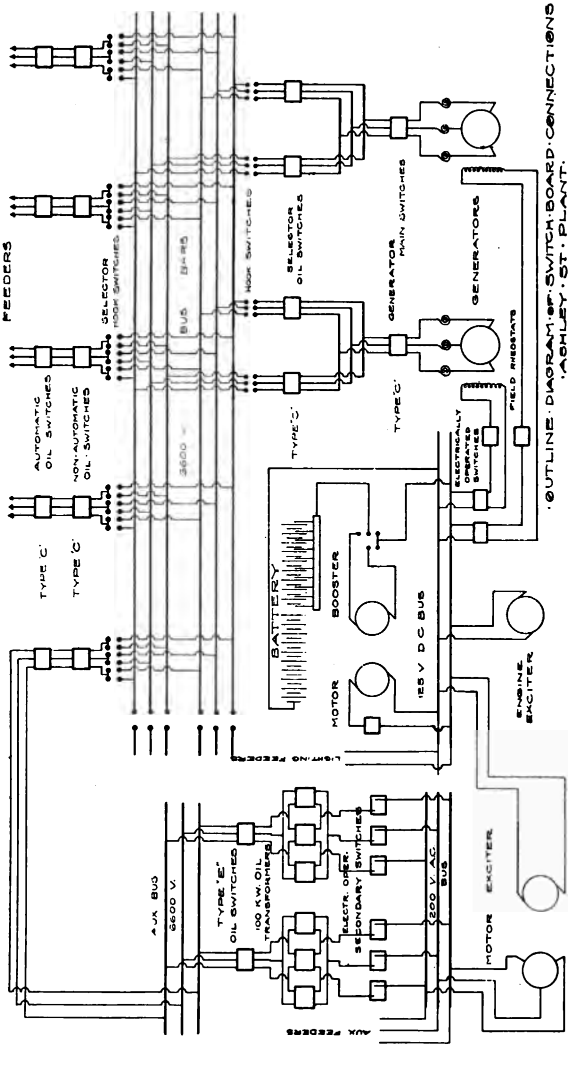
In addition to the two 100-kw. engine-driven exciter units there are two 100-kw. Westinghouse exciters direct connected to induction motors. An Electric Storage Battery Company battery of 78 cells, type G 39, is used on the exciter bus-bars. This battery is connected directly across the bus-bars with an end-cell switch and is charged by means of a Western Electric shunt booster driven by a 125-volt direct-current motor.

The exciter bus-bars, which also supply current for station lighting and for the electrically-operated valves, are operated at a pressure of 125 volts. There are six high-pressure and seven low-pressure valves operated by direct-current motors.

The auxiliary apparatus in addition to the two exciter units which is to be driven by 3-phase 200-volt induction motors are: the 50-ton crane described, with the mechanical equipment; two 10-h.p. motors driving the scrapers on the Green economizers; two 30-h.p. motors driving Edwards triplex air pumps for the condensers of the 2,000-kw. turbines; two 30-h.p. motors driving 10 in. centrifugal sump pumps; four 15-h.p. motors driving Worthington centrifugal air-pumps for the condensers of the 5,000-kw. turbines, and a number of smaller motors, driving pumps, tools, etc.

The building is lighted throughout by incandescent lamps placed in rows along the galleries and relieved by clusters on the pilasters.

The cables leading from the generators to the switchboard are rubber-insulated and have lead sheaths up to the points where they go under the false floors. All the high-pressure wiring about the switchboard structure



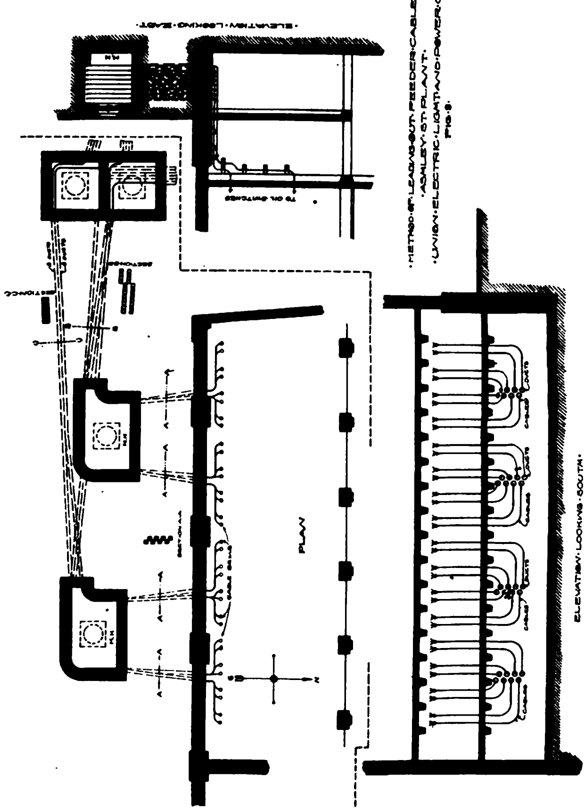
·OUTLINE· DIAGRAM·OF·SWITCH·BOARD·CONNECTIONS
·ASHLEY·ST· PLANT·
·UNION·ELECTRIC·LIGHT·AND·POWER·CO·
FIG·8·

and under the false floors is rubber-covered, protected with fire-proof braid. The high-pressure cables from the four smaller generators are three-conductor; those from the seven large machines are single-conductor. The cables from the engine-driven units are carried out to the west side of the engine-room through ducts built into the engine foundations. They then enter a vitrified conduit run which is built on the mezzanine floor along the west wall and swings over to the switchboard gallery columns in a long radius curve suspended from the floor-beams above. The cables for the 5,000-kw. turbine units and for the storage-battery occupy the lower ducts of this run. The generator leads leave this conduit at the columns and run up to the fourth gallery in deep flutings made in the backs of the terra cotta which encases the columns.

The cables from the exciter units and the 2,000-kw. turbines which are located on the east side of the engine-room are pulled into a vertical row of vitrified ducts laid along the face of the east wall covered by a brick wainscoting.

The low pressure auxiliary cables are all lead covered and are carried on hangers made of oak and channel-irons up to the points where they enter the vitrified conduit runs.

The main feeder-cables are carried from the floor-tubes under the oil-switches on glass insulators mounted on lines of special oak cross-arms suspended from the floor-beams of the first floor. At the south wall these cables pass into the brass bells of the three-conductor, lead-covered, outgoing feeder-cables. These cables are carried down the wall on iron supports through the mezzanine floor and are then carried horizontally to the ducts leading out to the manholes. The accompanying sketch, Fig. 9, shows the method of fanning out the cables on the south wall under the first floor and the arrangement of manholes and conduits which has been adopted to lead the feeders out from the plant. These cables are carried out in two groups, which are kept in separate



· METHOD · OF · LEADING · OUT · FEEDER · CABLES ·
· ASHLEY · ST · PLANT ·
· UNION · ELECTRIC · LIGHT AND · POWER · CO ·
FIG · 3 ·

duct-runs and in separate manholes after leaving the plant.

The two manholes at the south end of the plant and four others in the immediate vicinity, which are submerged at times by extreme high water, are made waterproof and are provided with water-tight inner covers. These manholes are connected by a system of drains to a sump which has a 6-in. suction-pipe leading to a pump in the plant.

Exciters: Four 100-kw. exciter sets have been provided, two of them driven by 25-cycle, 3-phase, 200-volt induction motors, and two by single-cylinder, vertical Buckeye engines. These units deliver current to the exciter bus-bars at 125 volts.

THE IMPERIAL PLANT

Building

The plant is located at the southeast corner of Tenth and St. Charles streets, on a lot having a frontage of 235 ft. on St. Charles street by 85 ft. 2.5 in. on Tenth street and 98 feet on the east line. An exterior view of the building is shown in Fig. 1. Fig. 2 gives a sectional view of the building, and Fig. 3 a plan of the engine and dynamo room.

The main building is of dark red brick, three stories high above the basement and of the same dimensions as the lot above the street level. The second story is omitted everywhere except over the main office, thus giving a clear height in the engine and boiler rooms of 30 ft. The third story, which is 15 ft. high, is devoted to store rooms, testing department, etc. The entire structure is fireproof. All floors are of cinder concrete carried on corrugated iron arches sprung between I beams. The roof is of book tile with composition gravel covering. Engine and boiler rooms extend the entire length of the building, and are separated by a division wall having fire doors at all openings. Beneath the engine room are the storage batteries, extending partly under the sidewalk. Beneath the boiler room is space for coal storage, ash handling, and the location of condensing apparatus and piping. The floor of the engine room is laid with hexagonal tile, and the walls for 6 ft. above the floor are wainscoted with marble. On part of the lot just east of the brick building is erected a temporary building of wood and corrugated iron sheltering a 1,500-kw. Westinghouse unit and the city arc lighting plant.

Boilers: There are four 445 h.p. and eight 360 h.p.

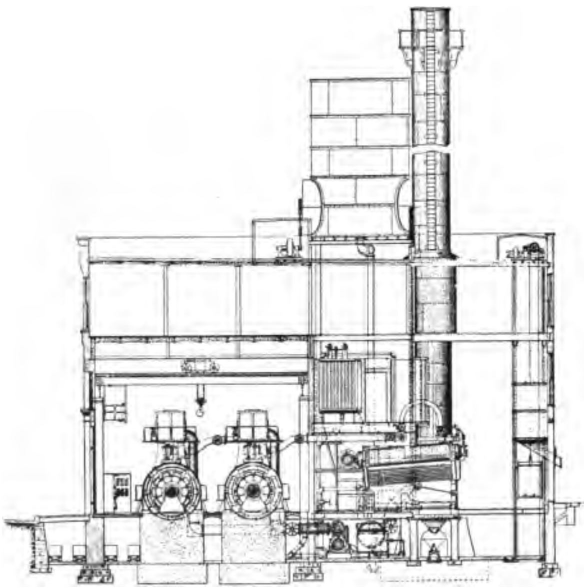


FIG. 2. CROSS-SECTION OF PLANT.

Heine boilers. Each boiler has a guaranteed efficiency of 70 per cent. of the calorific value of the coal at any load between rating and 20 per cent. above. This is equivalent to evaporating 7.21 pounds of water per pound of Mount Olive Illinois nut coal of 10,600 B.t.u. The boilers are designed for a working pressure of 175 pounds per square inch, and were tested under a hydrostatic pressure of 250 pounds. The entrainment is guaranteed to be less than 1 per cent. at rating, and not more than 1.5 per cent. at one-third above rating.

Chimneys: The boilers are served by three steel stacks, two 7 ft. and one 8 ft. inside diameter, 140 ft. high above street level. They are self-supporting and unlined. The bases are supported upon and rigidly bolted to massive brick foundations 14 ft. deep, and which are solid except for the ash-car passage which extends through them.

Coal and Ash Handling: Coal is dumped from wagons through openings in the alley wall of the boiler room on the floor directly in front of the boilers, which are

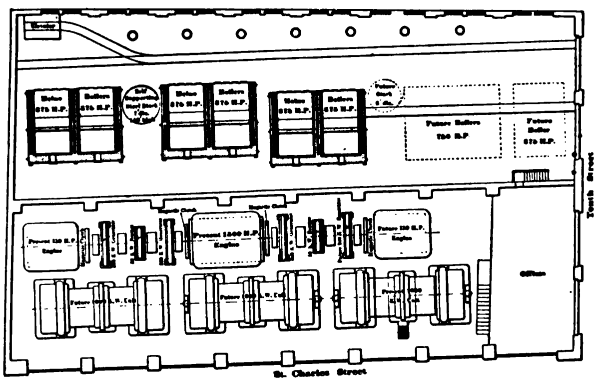


Fig. 3 Floor Plan of Boiler and Engine Room

fired by hand. The ash handling plant is of simple and economical design, and consists of a system of cars, tracks, elevator and overhead ash-bins. The cinders and ash from the lower grates drop directly into a metallic ash-hopper under each boiler. Running east and west immediately under these hoppers there is a narrow gauge track. The ash is dumped from these hoppers into small cars, which are pushed by hand along the track to an elevator, on which the cars are raised. The ash is then dumped into an overhead ash-bin, from which it runs by gravity into the wagons in the alley.

Steam Engines: There are two engines (Fig 6) of the Williams vertical two-cylinder, cross-compound, condensing, automatic cut-off pattern, built by William Tod & Co. of Youngstown, Ohio, and designed for direct connection to the dynamos by means of the "Arnold System." The east engine, No. 1, is of 750 i.h.p., and is designed for driving one 500-kw. generator. Engine No. 2 has double the capacity, and is similar in design to No. 1. Both are designed to run at 150 rev. per min.

Their dimensions are:

Engine No. 1—Cylinders, 18 in. and 40 in. by 30 in.

Engine No. 2—Cylinders, 26 in. and 57 in. by 30 in.

A 1,500 h.p. engine, designed and built by the Lake Erie Engineering Works, Buffalo, N. Y., has been installed, direct connected to two 500-kw. generators. Dimensions of cylinders, 23 in. and 48 in. by 36 in.; speed, 120 rev. per min.

Another 2,250 h.p. cross-compound horizontal engine, built by the Fulton Iron Works of this city, has been installed for operating a 1,500-kw. Westinghouse generator. Dimensions of cylinders, 34 in. and 56 in. by 54 in.; speed, 80 rev. per min.

Condensers, Pumps and Cooling Tower: The condensing plant consists of one Worthington surface condenser, one Worthington cooling tower, two air pumps and two circulating pumps of the rotary type. The rated capacity of the plant is 33,750 lb. of steam per hour, but it will take care of overloads up to 49,500 lb. per hour with but slight reduction in vacuum. It is guaranteed to produce a vacuum of not less than 22 in. at above rating and under the worst conditions of service; 25 in. under fair and average conditions, and 26 in. under the best. The condenser has 34,000 square feet of brass tube cooling surface.

The cooling tower, located on the roof, is 18 ft. in diameter, 29 ft. high and its filling or cooling surface is composed of galvanized iron pipe cylinders. It has duplicate fans located on opposite ends of the same shaft drawing air into the tower. These fans are driven by a belted motor in pent house on top of the building.

There are two air pumps, one of sufficient capacity to handle the water for the 1,500 h.p. engine, and the other of sufficient capacity for 750 h.p. engine, and two independent rotary circulating pumps of the same capacities. These pumps are driven by direct-geared motors, so designed that the speed may be varied at least 33 1-3 per cent.

It will be noted from the capacity of condensing apparatus installed that a large part of the plant is now running non-condensing.

Power Transmission System: The two Williams engines and three generators are connected by means of the Arnold system of power transmission (see Fig. 6), consisting of quills and internal shafts with double bearings, connected by magnetic clutches. The arrangement was intended to make it possible to drive any one, two or all three of the 500-kw. generators, and either one or both of the boosters, from the large engine in case of accident to the small engine. Two generators and one booster may also be handled by the small engine in case of accident to the large one.

The generators are connected to the engines by means of magnetic couplings, so arranged that either intermediate generator of booster may be disconnected from one engine and connected to the other while all are in motion. When it is desired to start up a generator, it is brought up to speed as a motor and then connected to the engine by the magnetic clutches.

Pipe Work: The entire high pressure system is designed to operate under a working pressure of 175 pounds per square inch, and was tested to 250 pounds hydrostatic pressure. All fittings are extra heavy. All pipe above three inches in diameter has flanged couplings and fittings. All valves on live steam pipes and on the feed water connections under boiler pressure are bronze seated. All valves above 10 inches in diameter are by-passed. The cylinder jackets, reheaters, separators, steam headers and the entire pipe system is drained by means of the Holley system. There is a combined hot well and oil filter located between the condenser and boiler feed pumps. All the pipes are covered with magnesia. Each engine has a Cochran separating receiver located near the main throttle valve. Oil extractors are located between exhaust pipe and condensers. A suitable blow-off tank is provided and connected to boiler furnaces, oil extractors and other hot-water drains, with suitable discharge to catch-basin, which in turn overflows to sewer.

Generators and Boosters: There are three 500-volt, constant potential, electric generators, built by the Siemens & Halske Electric Company of America, of the internal iron-clad armature type. They are designed specially to suit the system of power transmission adopted. The field frames of the generators may be slid parallel with the shaft a sufficient distance for reaching the armature for repairs. The capacity of each generator is 500 kw. at 525 volts when operated at 150 rev. per min.

There are two separately excited shunt-wound boosters, each of 50 kw. capacity at 150 rev. per min., and capable of carrying 500 amperes and delivering any voltage from zero to 130 volts. The boosters are of the same general construction and design as the generators, except that the field frames are divided vertically. There are also two 30-kw. Western Electric boosters direct connected to a 500-volt motor.

There are two 500-kw., 500-volt Siemens & Halske generators operating at 120 rev. per min. and driven by the Erie engine. These dynamos are similar in design to those already described except that their rating is more liberal and they have greater overload capacities. The generator driven by the Fulton engine is a shunt wound 1,500-kw., 500-volt Westinghouse machine, designed to run at 80 rev. per min.

Rotary Converters: There are two 500-kw. Westinghouse rotary converters which deliver direct current at 500 volts to the main bus-bars, running in parallel with the steam driven generators. These rotaries are supplied with 3-phase, 25-cycle current at 6,600 volts from the Ashley Street plant. This voltage is stepped down through three 187-kw. air-cooled transformers for each machine. Two 50-kw. induction regulators and two blowers are installed in connection with this apparatus.

City Lighting Station: In the temporary building east of the main engine room are installed six sets of series arc lighting apparatus. Each set consists of a 200 h.p., 500-volt Western Electric Company motor driving two 110-light 6.8 ampere Western Electric Company series, direct-current, arc lighting machines.

Switchboard: The switchboard at the Imperial plant is divided into five separate parts; the main board, the auxiliary board, the arc motor board, series arc lighting board, and the 6,600-volt alternating-current board.

The main board is provided with two sets of bus-bars for the 250-500 volt direct current distribution. It consists of twenty panels of two-inch black enameled slate as follows: Four panels for the rotary converters; six panels for the generators; two booster panels; two battery panels, and six feeder panels.

The auxiliary board contains switches and apparatus for operating the auxiliary motors. (In this connection it might be stated that the plant was designed to have all pumping apparatus motor driven, but, with the exception of the air pumps and cooling tower, all of this apparatus has been replaced with steam driven apparatus.)

The arc motor board consists of three marble panels containing apparatus and instruments for starting and controlling the six 200 h.p. Western Electric Company motors.

The series arc lighting switchboard consists of three marble panels containing instruments and plug and cord switches for twelve series arc lighting machines and twelve city lighting circuits.

The 6,600-volt switchboard consists of three panels having the necessary oil switches and instruments for one 2,000-kw. incoming feeder and for the two sets of air cooled transformers for two 500-kw. Westinghouse rotaries.

Storage Battery: There are 296 cells of the Electric Storage Battery Company's accumulators, each containing fourteen positive Manchester-type plates and fifteen negative chloride plates. These are contained in lead-lined wooden tanks which are supported on large porcelain insulators. The capacity of this battery is 2,000 ampere hours at a discharge rate of 250 amperes, and it is capable of maintaining a maximum discharge rate of 1,000 amperes for one hour. It is guaranteed to give a discharge of 500 kw. for one hour without a drop in pressure below 1.7 volts per cell.

The battery as mentioned above is located in the basement, partly under the engine room, partly under the sidewalk.

The growth of this plant is indicated by the maximum output as given below, for the end of the first, second, and fifth year of its operation. The following tabulation gives also the average output for 24 hours and the load factor, or the percentage that the average output is to the maximum:

	Average	Maximum	Load Factor
Load 1st year..	2,200 amperes	5,600 amperes	40%
Load 2d year..	6,350 "	13,000 "	50%
Load 5th year..	11,000 "	21,000 "	52%

MISSOURI EDISON STATION "A"

This station was the one originally built by the Missouri Electric Light & Power Company. The building is 135 ft. by 155 ft., being divided longitudinally into two rooms, one 152 ft. by 63 ft., containing engine and generator plant and switchboard; the other, 152 ft. by 67 ft., containing the boiler plant. The construction is of brick and stone, with iron and slate roof. The building is one story, and 35 feet high.

The generating apparatus of this station consists of three 1,200 h.p. three-cylinder compound engines, built by the Lake Erie Engineering Works, direct coupled to three 800-kw. alternating-current generators, built by the Westinghouse Electric and Manufacturing Company; one 20 in. and 36 in. by 18 in. Westinghouse compound engine direct connected to a Westinghouse dynamo, 1,100 volts, 136 amperes, 212 rev. per min.; three 120 h.p. Westinghouse compound engines direct connected to two 75-kw. Westinghouse 125-volt direct-current generators and one 100-kw. General Electric 125-volt direct-current generator, all three being used for exciters. The steam is generated by fourteen 208 h.p. and four 235 h.p. Babcock & Wilcox boilers.

Generators: The 800-kw. generators are designed to operate at 180 rev. per min. and deliver current at a pressure of from 1,100 to 1,300 volts at a frequency of 60 cycles. They are of the stationary field type, being similar in design to the modern direct-current railway generator of large size, the commutator, of course, being replaced by collector rings. The winding is so designed that these machines may be used either single-phase or two-phase as desired, the entire amount of copper being utilized in circuit when operated in either way. The rating of these generators is based on their single-phase capacity, but a large margin for overload was provided in their design, and they are regularly operated for several hours per day during the winter months at an output of 1,200 kw. each. With this load the rise in temperature of all parts of the machines is hardly appreciable.

The armatures are ten feet in diameter and weigh about 80,000 pounds, providing ample fly-wheel capacity within themselves without any additional wheel. The mechanical features of each of these generators are so arranged that the entire field frame may be moved in a direction longitudinally with the shaft, by means of suitable screws, to a position where the armature is completely uncovered for inspection and repairs and where field coils may be removed from the pole pieces with ease.

Engines: The engines, being provided with three cylinders, distribute the power through three cranks placed at angles of 120 degrees.

The regulation of the engines is effected by governors of the shaft type, but of special design. Connected to the rocker arm operating the high pressure admission valves on each engine is a double acting air compression cylinder. This acts as an inertia balance to arrest the motion of the valve at the end of each stroke, storing up energy, which is delivered to the valve again on beginning the new stroke. The two ends of this compression cylinder are connected to each other through a by-pass pipe and hand valve, by means of which the amount of compression can be controlled at will. The effect of this inertia balance is to relieve the governor of a great deal of the pressure which would be thrown upon it at certain portions of each revolution. By varying the amount of relief to the governor afforded in this way, by means of the by-pass valve, the speed of the engine may be varied between 5 and 10 per cent.

Exciters: The exciters are of the type of direct-coupled, direct-current, multipolar generators built by the Westinghouse and General Electric companies. Each is of a capacity sufficient to excite the fields of all the generators in the station, two relays, or spare generators, therefore, being ready at all times in case of accident.

Boilers and Smokestacks: The boilers are of the Babcock & Wilcox type, and are operated at 150 lb. pressure. The furnaces are designed for hand-firing.

The products of combustion are led through underground flues to two steel smokestacks, one 150 ft. high by 10 ft. in diameter, and the other 135 ft. high by 8 ft. in diameter. These stacks are bolted at the base to concrete foundations.

Switchboard: The switchboard is built of white Italian marble and is 58 ft. long and 16 ft. high. It is constructed with two floors at different levels and a liberal basement is provided for cables, rheostats and feeder regulators. The upper portion of the board provides room for 56 feeders and the lower portion will accommodate all the apparatus for regulating and controlling six generators. The board is so designed that all generators are operated independently and the feeders grouped at will on any generator desired. The utmost flexibility of operation is thereby provided for. The feeders may be switched at will from any one of the generator busses to any other, without interrupting the current for more than a fractional part of a second.

Each feeder is provided, in addition to its switch, with an ammeter, voltmeter and potential regulator. Each potential regulator consists of a regulating transformer, which is made by means of suitable switching devices to add more or less of its secondary potential to that of the feeder. Each regulator is hung under and supported by the upper floor of the switchboard and is provided with a switch dial controlled by a wheel on the front of the board within reach from the main station floor. By means of these switch dials the pressure of each feeder may be independently raised or lowered 18 per cent., making a total possible independent variation of 36 per cent.

The entire regulation of both feeders and generators is accomplished from the main floor of the engine room, the second floor of the switchboard being used only when feeder switches are to be thrown. A gallery is provided at a third level along the rear of the switchboard, from which feeder fuses, lightning arresters, ammeters, and voltmeters are accessible.

In addition to an indicating wattmeter, each generator is provided with a Thomson recording wattmeter, and by means of these recording wattmeters the entire station output is recorded. No feeder is operated nor regulation attempted without the use of pressure wires. All the indicating instruments were made by the Wagner Electric Manufacturing Company and are of their horizontal scale illuminated dial type, made dead beat by the use of oil in which their mechanism moves and is retarded by suitable aluminum vanes.

This switchboard was constructed from the designs of the lighting company's engineers. The greater part of the current used for alternating-current incandescent lighting, constant potential arc lighting and alternating-current motors is distributed through this switchboard. Tie lines of large capacity connect the switchboard of this station with that of station "B."

Opening from the basement under the switchboard and extending at a still lower level is the main cable terminal vault or tunnel through which all cables are led from the underground conduits to the switchboard. This vault is 50 ft. long, 9 ft. wide and 7.5 ft. high. Along its side are arranged adjustable cable racks, by which all cables are supported and carried to their proper position on other racks provided under the switchboard, which in turn carry them to their respective panels.

MISSOURI EDISON STATION "B"

This station was originally built by the Municipal Electric Light and Power Company. Since the property was acquired by the Edison Illuminating Company, both the building and steam apparatus have been almost entirely remodeled and a very large amount of new machinery has been installed. The main building, containing the engine room, is 105 ft. long by 96 ft. wide, and was originally constructed with four stories. Most of the second floor, which contained shafting and clutch pulleys has been removed, thereby increasing the height of the engine room to 28.5 ft. Across the street from this building is another, 108 ft. long by 57 ft. wide, containing the boiler plant. The extreme height of this building is 60 ft. In this are placed sixteen 350 h.p. Heine water tube boilers. The floor of this boiler room is 23 ft. below the street level, and connecting it with the engine room across the street is a large room excavated under the street, with floor at the same level as the boiler room proper. This room is 50 ft. long by 50 ft. wide and in it are located the heaters and the main steam and exhaust pipe lines running from the boiler room to the basement of the engine room. The street above is supported by iron columns and I-beams.

In the engine room are located one 2,000 h.p. cross-compound Hamilton-Corliss engine, directly connected to a 1,500-kw. single-phase generator built by the General Electric Company; one 1,200 h.p. cross-compound Hamilton-Corliss engine, directly connected to an 800-kw. alternating-current generator built by the General Electric Company; one 1,200 h.p. simple Hamilton-Corliss engine, direct connected to an 800-kw. General Electric alternating-current generator; one 750 h.p. simple Hamilton-Corliss engine, direct connected to a 500-kw., 500-volt, direct-current General Electric generator; two 300 h.p. Westinghouse compound engines belted to two 200-kw., 500-volt, direct-current generators. Three 125 h.p. Westinghouse compound engines direct connected to three 100-kw., 125-volt, direct-current General Electric generators used for exciters are also located on the engine room floor.

Along one wall of the engine room, 18 ft. from the floor, is the main switchboard, supported from the wall and partly hung from the girders overhead. The fourth floor is used for repair shops and storage.

Steam Piping: All of the steam piping in this station is placed under the main floor in suitable basement passages between the engine foundations. A duplicate steam pipe system provides each engine with a double steam connection.

Boilers: The boilers are placed in batteries of four boilers each and are connected by steel flues, lined with fire brick, to a single steel smokestack. The furnaces are all arranged for hand firing.

Smokestack: The smokestack is of steel construction, lined with fire brick to a point 60 ft. above the furnace grates. It is 13 ft. in diameter and 204 ft. high. The base is bolted to massive foundations surrounded with concrete, covering it to a depth of about 6 ft. This smokestack successfully withstood the severe tornado which visited St. Louis about seven years ago, although it was well inside of the edge of the path of the storm, and most of the buildings surrounding it were unroofed and more or less completely demolished. A massive brick smokestack at a street railway power house, less than half a mile distant, was lifted bodily from its foundations by this same storm and dropped a shapeless pile of bricks within 20 feet of its former location.

Coal Handling: Above the boilers a large coal-bin is built, occupying the entire width and length of the building. This bin is constructed of steel, supported on I-beams and columns, the sides being sufficiently inclined to deliver the coal to a central position, from whence it descends through iron chutes to the boiler room floor. Coal is delivered to this storage bin from wagons in the alley running along the other side of the building. The ash is elevated by conveyors to overhead bins, whence it can be dumped into cars.

Electrical Generators: The alternating-current generators in this station at the time of their construction were the largest alternating-current generators ever built, and the largest in output, with the exception of the generators at Niagara Falls, which, however, run at much higher speed. Their capacity, when operated single-phase, is 1,000 kw.

In addition to the single-phase winding, another winding was provided in which current is generated differing in phase 90 degrees from the main winding. This quarter-phase winding can be connected so that the generators may be operated on the so-called monocyclic system. The generators are now operated at 1,200 volts on single-phase only, as the company has adopted the single-phase system as most suitable for its general distribution of current for light and power.

The armatures of these generators are constructed without polar projections, the copper bars forming the winding being embedded in slots. They are 16 ft. in diameter and weigh 100,000 lb. each. There are 80 field poles and the shaft is 22 in. in diameter, this enormous mass being provided to take the place of the flywheel and to give the engines a very uniform angular velocity. A large margin for overloading was allowed in the design of these machines. The frequency adopted by the company for its entire system is 60 cycles, and the armatures revolve at 90 rev. per min.

Located near these generators are three 100-kw. exciter generators, directly connected to compound engines. These exciter generators are of the General Electric type of multipolar direct-current dynamos and deliver current at a pressure of 125 volts.

Switchboard: As in station "A," the main switchboard is so located along one of the walls of the engine room that it forms a gallery above the engines and generators. From its floor every part of the engine room can be seen and signals exchanged between engine tenders and switchboard operatives.

The switchboard is constructed of white Italian marble, mounted in panels on an iron framework. The flooring is all made of black slate, as in the switchboard at station "A." The central part of the board is occupied by switches, regulating devices and instruments for the alternating-current generators and exciters; on either side are the feeder panels containing the necessary switches, regulating devices, and instruments for each feeder. Beyond these feeder panels, at one end of the board, are located the switches, devices, and instruments necessary for controlling all the 500-volt generators and feeders. Each alternating-current feeder takes up a space on the switchboard panels 1 ft. in width and 6.5 ft. in height.

Present Distribution Systems

Alternating Current: The present underground alternating current distribution system of the Union Electric Light & Power Company, supplied from the Missouri-Edison plants, consists of 1,150-volt primary feeders with pressure wires, feeding transformers which are located in the manholes. All manholes in the joint subway were constructed with square covers in order to admit of the installation and removal of these transformers. The underground transformers are all oil-cooled and are rated at 110 kw. each, each transformer being supplied by an 1,150-volt primary feeder of 150,000 cir. mils cross section. The secondaries of these transformers are connected by three 1,000,000 cir. mils lead-covered cables to the bus-bars of large cast iron junction boxes, also situated in the manholes; these junction boxes supplying three-wire secondary cables and Edison tubing. This system is very complete, and has service on practically every street in the underground district. The pressure wires for the feeders in this system are connected to the bus-bars in the junction boxes, so that transformer drop is included with feeder drop, and standard pressure can be maintained at the junction boxes by means of booster transformers located in the station on each feeder. These feeders are fused in the station, and the secondary feeders from the transformers to the bus-bars in the junction box are also fused, so that in the event of trouble on either feeder or transformer other transformers on the system are protected. The neutral of the secondary system is not fused and is grounded. The outside wires within any section are all connected into a network through fuses in the junction boxes. The feeders are supplied from single-phase machines. Under this system the underground district is divided up into a number of sections, so that any one section will at no time exceed the safe load of its generator. The Missouri-Edison alternating equipment was the first large installation of its kind in the United States. Due to angular variation in speed, it has never been found practicable to run the generators in parallel.

This same general system is used for the supply of alternating current outside of the underground district. The entire city is generally well covered with a system of 1,150-volt mains, except that portion lying north of Cass and Easton avenues. The mains are divided up into separate networks, each of which is supplied at the most advantageous point by a feeder; pressure wires being taken back from the feeder end at primary pressure. In districts where the customers are located sufficiently close together to make it profitable, the primary mains are paralleled by three-wire secondary mains, which are supplied at intervals by transformers hung on the poles. The transformers vary in size from 5 to 25 kw. Before transformers are installed, the probable maximum and average loads are carefully calculated, and the calculations are later checked by installing a Wright discount meter on the primary of the transformer. Readings are taken of these discount meters three or four times a year, as the seasons change. This enables the size transformer to be installed on any particular secondary to be very accurately gauged. The labor of reading these discount meters is performed by emergency men on Sundays or at other times when the weather is good and their services are not required at their regular duties.

The pressure on overhead feeders is maintained at standard at feeder end by means of the pressure wires, which are led back to the station, and by booster transformers installed in the station.

Feeders are connected to the network of the mains at the feeding point through single-pole knife switches installed on the pole. Protection against dead short-circuits or grounds is obtained by fusing feeders in the station. Each main branch of the network is controlled by single-pole switches installed on the poles, so that in the event of trouble on a network the trouble-man by going to the feeder end can tell at once whether trouble is on the feeder or on the network, and by opening the switches installed on the branches can locate the branch in trouble. This allows the greater portion of the circuit to be kept in operation while trouble is being located and remedied. These circuits are all single-phase, and derive their power from single-phase machines, which are not operated in parallel for the reasons above mentioned. When the load increases or decreases, feeders are transferred from one bus to another by means of oil transfer switches and plug selector switches, each generator having a separate bus.

Direct Current: The direct-current distribution system of the Union Electric Light & Power Company is a three-wire Edison system, operating at a pressure of 235-470 volts at the feeder ends. This system also quite completely covers the underground district and very generally covers a section outside of the underground district at a radius of from 2.25 to 3 miles from the Tenth and St. Charles streets, or Imperial station. The entire system is a network, practically without fuses up to the customers' installation. This system was also the first large high voltage three-wire system in the United States. In the underground district, this system consists of three conductor lead-covered main cables joined together at intersecting points through cast iron junction boxes located in the manholes. Copper catches are used in these junction boxes having a cross section sufficiently large that a cable in trouble will generally burn itself clear before melting the catch. Feeders are connected to the junction boxes through catches of such a cross section that they will not melt out under any circumstances; trouble on feeders being cleared entirely by burning. The neutral in the main cables is the same size as the outside wires. The mains vary in size from No. 2 B.&S. to 250,000 cir. mils. Feeders are 500,000 cir. mils and 1,500,000 cir. mils, having neutrals of 000 B.&S. and 500,-000 cir. mils respectively. Two 500,000 cir. mils feeders are made up with a 000 B.&S. neutral into a three-conductor cable, having pressure wires in the interstices. The 1,500,000 cir. mils feeders are single conductor and are supplied with a separate three-conductor pressure cable. In the underground district, most of the feeders are 1,500,000 cir. mils and are not supplied with separate neutrals leading back to the station, the feeder neutral system being a network of 500,000 cir. mils single-conductor cables. Rubber insulation has been used exclusively for the three-conductor main cables, and both rubber and paper have been used with equal satisfaction for the feeders.

The Imperial station being located within the underground district, feeders reaching out into the overhead district are carried underground for a portion of the distance. These feeders are carried through conduit to the limit of the underground district and there led up the side of a terminal pole, on which is located the terminal head and lightning arresters. Five hundred thousand cir. mils weather-proof wire is used to continue feeders in the overhead district. These feeders are cut into the network of mains, at the most advantageous points, solidly, and have neither catches or fuses in circuits. The pressure wires are carried on the same insulators that carry the feeder cables.

The Imperial station being located in almost the exact centre of its load, enables it to distribute current over this large area with two sets of bus-bars, at the same time maintaining very close regulation; the regulation within the underground district being at all times within 2 per cent. above or below standard pressure, and on all the feeders reaching out into the overhead district, the variation at no time exceeding 5 per cent. and being generally within 3 per cent. The regulation on this system is aided by a storage battery having a capacity of 500 kw. hours at the one-hour rate, battery being located in the Imperial station.

On account of the generally untried condition of high-voltage lighting apparatus, it was considered advisable when this system was first put in operation, about six years ago, to connect all customers two-wire, balancing one customer against another. This practice was continued for two or three years, when three-wire connections were adopted to aid in keeping the load balanced. Newly wired buildings, or buildings in which the wiring is thoroughly overhauled and put in good order, are connected three-wire throughout, the same as on any three-wire system. Considerable trouble was experienced in the beginning in obtaining incandescent lamps which would not short-circuit or explode and burn up the socket and cord. This trouble has been almost entirely eliminated, instances of lamps short-circuiting at the present time being extremely rare. Difficulty was also at first experienced in obtaining arc lamps which gave a satisfactory white light and at the same time did not consume an abnormal amount of current. The first lamps installed were 2½-ampere lamps using ½-inch carbons. These lamps drew an arc an inch and three-quarters long and produced a very unpleasant light. Lamps consuming 3½ amperes and with the length of arc somewhat shortened, using ½-inch carbons, were soon substituted, and gave perfect satisfaction to the customer, but were inefficient. These lamps were later rebuilt to use ⅜-inch carbons and the current reduced to 2¾ amperes, this lamp now being the standard single burning direct current arc lamp of the company. Lamps burning two in series and taking from 5 to 5½ amperes have been installed in large numbers wherever the number of lamps taken by a customer warranted using lamps of this character. These lamps, of course, are just as efficient as any direct-current, low-voltage lamp.

With new customers formerly supplied from a low-voltage system it has generally been found that the only changes necessary in order to fit the installation for 235-470 volts has been to change cut-outs, switches and sockets. At first thought this would appear to be a heavy expense for a company to incur. It has been found, however, that the labor cost of doing this work was surprisingly low, due to keeping a force of men thoroughly familiar with the requirements and expert in making the changes.

Almost every conceivable class of service has been connected to the direct-current lines; installations having a connected kilowatt capacity as high as 600 being at present supplied.

It was feared in the beginning that fires might be started by introducing the higher voltage on old wiring. Experience has shown, however, that fires which can be traced to the introduction of this voltage into buildings are extremely rare, and that where such has been the case a fire would probably have resulted had any other system been installed. The reason for this is probably due to the fact that a slight ground or short-circuit is immediately developed and the fuses blown on the high-voltage system, smouldering or slow burning grounds being unknown. The neutral of the entire system is well grounded in the station.

General Plan of Future Distribution

The consolidation of the Citizens' Electric Lighting & Power Company, the Imperial Electric Light, Heat & Power Company, and the Missouri-Edison Electric Company into the Union Electric Light & Power Company gives the latter company three separate and distinct distribution systems, at present supplied from the Missouri-Edison stations and the Imperial station. These distribution systems will be rearranged so that the new Ashley

Street plant of the Union Company may supply current to them through substations advantageously. In the underground district the three-wire secondary alternating-current mains of the Missouri-Edison Company parallel the three-wire direct-current mains of the Imperial Company. The cross section of copper installed in these mains within the underground district is more than sufficient to supply the district at 125-250 volts direct current. The feeders used by the Imperial Company for its direct-current system are admirably adapted for rearrangement, to be supplied from additional substations and from two of the old generating stations which are to be converted into substations. The 500-volt motors now being supplied from the 500-volt power distribution system of the Missouri-Edison Company and from the three-wire system of the Imperial Company will be changed to 250 volts as rapidly as seems expedient. Motors which are not changed over will be supplied from the Missouri-Edison two-wire 500-volt mains, which will be left intact. The operation of the present steam generating equipment in stations A and B of the Missouri-Edison Company will be discontinued, and Station A will be converted into a substation to be supplied with current from the new Ashley Street plant. The generating equipment in the Imperial station will probably be changed over to a lower voltage and held in reserve and to assist at the peak. Three additional substations, two located down-town close to Broadway and one about one-half mile west of the present underground district, will be built and will be supplied with current from the new Ashley Street plant. The two new down-town substations will be equipped with motor generators, and will transform current from the Ashley Street plant into 250-volt current for the low tension direct-current system. The substation to be located at Station A will contain rotary transforming apparatus for the low tension direct current and frequency changers to supply current to the present alternating-current underground distribution system until it is changed over, and to such overhead lines as can conveniently be brought into this station. The new substation located west of the underground district will at first contain only alternating-current transforming apparatus and will be used as a distribution station for current supplied to the sections of the city outside of the underground district. The direct-current low tension distribution system will be practically confined to the present underground district, and the present 1,150-volt alternating-current distribution system overhead will be changed to 2,300 volts. Conduits are already laid and cables installed for the transmission lines from the new Ashley Street plant to all of the substations above mentioned.

In addition to the substations of the Union Company, the new Ashley Street plant will also supply current to street railway substations of the St. Louis Transit Company, located at Delmar and De Baliviere avenues and Seventeenth and Locust streets, which are already constructed and in partial operation.

Direct-Current Series Arc Street Lighting

In addition to the other systems which are now in operation in the joint subway, there is a constant current, series, direct-current arc system supplying street lights. In this system single-conductor No. 8 rubber and lead-covered cable is used, except in those cases where circuits are carried from the station through the underground district to supply lamps outside of the underground district, in which case twelve-conductor rubber and lead-covered cable is used. This cable is led to a terminal pole and thence to a terminal head and box from which the wires are led to lightning arresters and circuits placed on cross-arms. Each underground circuit consists of from 105 to 108 lamps, each taking 480 watts at the arc at 6.8 amperes. In the underground district connections are made to the lamps from manholes to iron arc-lamp poles erected at the corners of the streets by means of laying an iron pipe between the manhole and the hollow base of the pole. Two single-conductor cables are drawn through this pipe and terminate in hard rubber bushings about 18 in. above the ground. Connection between the lead-covered cable and a flexible duplex cable leading up through the pole is made in this hard rubber bushing, which is filled with paraffine. This flexible duplex cable is led up through the pole to a point about 10 ft. from the ground, where it leaves the pole through a rain-drip cast-

City Street Lamp and Iron Pole

ing and wood bushing and is carried up to the lamp. The lamp is supported on a flexible galvanized iron rope leading over pulleys in the mast-arm and the pole to a windlass in the base. Short-circuiting switches located in the base of the poles were tried at first, but were abandoned on account of insulation trouble, lamp changing being effected at present by placing jumpers across the wires just below the lamp. The lamps are insulated from the ground by a special insulated hanger, which is located between a short cross-arm and a hook on the end of the rope. This cross-arm holds the wires while the lamp is being changed. When this system was first put in operation great trouble was experienced from static potential on the lines, especially on the underground circuits. Various schemes were tried to eliminate this static potential. The method finally adopted, and which is entirely successful, was as follows: Each lamp was equipped with two small carbon blocks separated by a thin piece of perforated mica held in position by two clips insulated from each other and connected to the terminals of the lamp. At the station end of the circuits a rotating switch driven by a small motor was installed, which alternately connects each side of the circuit to the ungrounded pole of a Leyden jar condenser. Static potential from the circuit is used to charge this condenser, and the rotating switch, after charging the condenser, short-circuits it before connecting the next circuit. It has been found that by discharging each circuit through the condenser two of three times a minute, all static potential can be removed from the lines. The function of the carbon blocks installed in the lamps is to transmit the static potential that accumulates in a particular lamp, or series of lamps, through the various lamps and back to the static arrester installed in the station. It was feared, when this scheme for eliminating static potential was first adopted, that the carbon blocks would short-circuit the lamps. This has been the case in rare instances, but in general it has been found that the carbon blocks do not require attention before the lamp requires changing for general overhauling.

While the arc circuits are not in use in daylight hours, each circuit is connected to a 235-volt direct-current lighting circuit through test lamps in such a manner that open circuits, grounds, and live crosses can be immediately detected by the switchboard operator. This system of continuous test has been of great value in giving immediate notice of trouble, so that the remedy could be applied before the schedule time for starting the lights.

The Construction of Subways

Prior to 1898, practically all wires in St. Louis were carried on poles. In 1898 all wires in a district about seven-eighths of a mile wide and one and three-fourths miles long, in the central portion of the city, were placed underground, in accordance with an ordinance known as the Keyes bill, which was passed in 1896. This ordinance directed that wires of companies supplying current for electric light or power should be on one side of the street, and designated this the high-tension subway. The opposite side was reserved for conduits of companies using wire for the transmission of messages; subways of these companies were called low-tension subways. The ordinance required companies using wires classed as high tension to place their conduits in the same trench and to occupy the same manholes. This created a joint subway, which contains quite a variety of distributing systems.

The construction of high-tension subways in St. Louis has been about equally divided between vitrified clay, multi-duct conduit of the McRoy type, laid with three inches of concrete surrounding the conduit, and cement-lined, iron pipe conduit furnished by the National Conduit and Cable Company, laid with 1 in. of concrete between ducts and 3 in. of concrete on each side of a conduit section.

The joint high-tension subway was constructed entirely of the latter type of conduit. All conduits have been laid to drain to manholes, and the manholes, whenever possible, have been connected to sewers.

The manholes of the joint high-tension subway are constructed of hard red brick laid on a concrete foundation, with walls 13 in. thick. The tops of the manholes are arched brick supported by I-beams which carry the cover frame. These manholes are ventilated by a grating cast in the cover. In some of the individual systems it has been found necessary to ventilate manholes by drilling 1-in. holes through the covers.

In the individual conduit laid by the Citizens' Electric

Lighting and Power Company and the Union Electric Light and Power Company, McRoy multi-duct section has been used throughout, laid with 3 in. of concrete surrounding the conduit. The manholes are constructed of vitrified brick laid on a foundation of concrete, with walls 13 in. thick. Where manholes are less than 5 ft. square, the walls are racked at the top and the cast-iron cover frame forms the roof of the manhole. Where manholes are larger than 5 ft. square, concrete tops supported by I-beams carrying the cover frames have been adopted. Round cast-steel covers 30 in. in diameter have been used on this work throughout.

In the manholes of the joint high-tension subway cast-iron cable racks are bolted to the walls at convenient places. In the individual manholes of the Citizens' and Union companies 1-in. iron pipes have been laid in the vitrified brick walls, in which cast-iron pins are inserted carrying wooden spools on which to rack the cables.

Protection from Manhole Fires: Cables are protected from manhole fires by being wrapped with 3-16 Sisal rope, the turns of rope being about 1/8 in. apart. The cable wrapping is then covered with Portland cement mortar, mixed one part cement to one part sand. It has been found that this covering resists any ordinary manhole fire, and as long as the cable is not moved it is practically indestructible. Where it is necessary to move the cable a part of the cement covering cracks off. This, however, can be replaced at very small expense.

Construction of Service Connections

Underground: Except for about 42,000 feet of Edison tubing, the underground mains consist of three-conductor, lead-covered cables. The service connections from Edison tubing are taken off in the usual way. The Edison tubing, however, is laid in only a few of the most important streets, and is at present used entirely in connection with the underground three-wire secondary alternating-current distribution system. The joint subway was constructed with large manholes at street intersections in which there was ample room for transformers and junction boxes of the various companies. Between manholes at street and alley intersections, at intervals of from 30 ft. to 75 ft., 3 by 3 service connection boxes or handholes were constructed to include the first, or possibly the second, row of ducts in the conduit. Main cables are drawn through ducts entering these service boxes or handholes and service connections are made by laying a 3-in. pipe between the service box and the customer's basement. Through this iron pipe a lead-covered cable is drawn and is joined to the main service cable by means of a cast-iron box filled with an insulating compound. As a large proportion of the service connection pipes or laterals were installed when the subway was constructed, this method of taking off service connections from the distribution system had the advantage of avoiding, to a large extent, tearing up the streets and alleys, and has the further advantage that if trouble occurs on the service connection cable or on the main cable, it is not necessary to take up the street to repair the damage, as the cable can be drawn out and a new one drawn in between the service box and the customer's premises or between the service box and the manhole.

The cast-iron service connection boxes referred to above are constructed with three or more outlets, two outlets always being used for the main cable, which passes straight through the box. The box is turtle-shaped and divided through the middle, the joint being ground, and the box being provided with bolts and lugs for holding it together after being placed in position around the cables. A brass plug is provided on one side, through which an insulating compound is inserted. A tight joint between the lead sheath of the cable and the box is obtained by wrapping friction tape around the cable to the required thickness.

The service connection cable terminates in the customer's basement at a fusible knife switch, which is usually located on the meter board. The customer's wiring is brought to this switch, the meter loop being installed by the customer.

Overhead: Overhead construction in St. Louis is fairly well standardized, eight-pin 10-ft. cross-arms being used almost exclusively. The standard cross-arms of the Union Electric Light and Power Company are made 10 ft. over all, bored for 1½-in. pins. Pole pins are 40 in. centre to centre, and balance of pins 12 in. on centres. Galvanized braces and bolts are used throughout.

In the portions of the city where overhead wires are still permitted, the city authorities have endeavored, as far as possible, to reserve one side of the street for poles of electric light and power companies, the other side for telephone and telegraph companies. This rule, however, has not been adhered to in all cases. It is generally customary in St. Louis for the electric light and power companies and the telephone companies to exchange space on their poles, in most cases charging a nominal rental of 60 cents per annum per cross-arm attached.

The telephone companies gain their poles 18 in. centre to centre. This brings the cross-arms so close together that it has been necessary to adopt some other method beisdes that of buck-arming, or taking the wires directly from pins where service connections are taken from overhead lines. A cross-arm from which a service connection is to be taken is supplied with two or three-point spreaders, as the case may require, which carry the service wires across the arm to the extreme end, from which point good clearance can be obtained. The absence of buck-arming, or wires leading from pins, greatly improves the appearance of line work, in addition to making the poles safer for the men to climb.

Recent High-Tension Overhead Construction: Six-thousand-six-hundred-volt, 3-phase, 25-cycle power transmission lines having a cross section of 211,000 cir. mils have been constructed for the transmission of power generated in the new Ashley Street plant of the Union Electric Light and Power Company.

Four overhead circuits, each about four miles long, were constructed for the purpose of supplying current to the Delmar substation of the St. Louis Transit Company and to the World's Fair. These circuits are extensions of underground circuits, each about three miles long, and begin at Garrison and Franklin avenue and end at De Baliviere and De Giverville avenues. For about one-half of the distance they are constructed on three sepa-

Terminal Poles—Garrison and Franklin Avenues

rate pole lines running through more or less crooked alleys, which made it necessary to adopt a peculiar type of construction in order to hold the corners and to prevent the entire run giving way in case a corner pole should fail. The spans on these lines are exceedingly long for this class of work, varying from 110 to 150 ft. The lines were constructed on telephone poles, telephone wires having been lowered down to provide space in the top gains for the transmission lines. Triangular construction was adopted wherever it was possible to obtain the necessary clearance for wires.

The wires are strung on standard yellow pine cross-arms, with pin holes so arranged as to provide ample space for a man to climb the poles without coming in contact with the lines—the pole pins being 45 in. on centres. Standard 1½-in. locust pins and triple petticoat glass insulators are used, except at corner and terminal poles, where 1½-in. drop-forged pins with glass insulators are used. Where the angle made by a corner is more than 135 degrees, double arms with iron pins and glass insulators are used. On each side of the corner pole, terminal pole construction was adopted, so that in the event the corner pole should fail the wires would simply slack off between the corner pole and the first pole on each side.

Terminal pole construction consists of double cross-arms mortised to receive four-pin oak buck-arms each 55 in. long with pins 12 and 22 in. on centres. The oak arms are also mortised to fit the yellow pine double arms, and are further held securely in place by a ⅝-in. galvanized bolt through each arm. Drop-forged iron pins and triple petticoat glass insulators are used, to which the 0000 wire is attached by means of No. 4 B. & S. solid ties soldered to the 0000 wire. The terminal pole is held in position against the strain of the wires by ⅜-in. galvanized stranded guys attached to eye-bolts passing through the double cross-arms; the guys either being led back to an anchored guy-stub, or to other poles in the run. If the terminal pole is at the end of an underground line, the underground cable is led up the side of the pole to a point about 12 ft. above the ground through a 3½-in. pipe. Above this point it is cleated to the side of the pole and terminates in an end-bell under a wooden hood above the double cross-arms on which the overhead transmission line terminates. The wires from the end-bell to the transmission line are led out through the open bottom of the hood, over the end bell, the opening being sufficiently large to provide proper clearance. Above this hood are erected the lightning arresters, line connection to which is taken off about 6 or 8 ft. out in the span and ahead of the reactance coil which is inserted between this connection and the cable terminals. The reactance

Corner Construction—Lake and McPherson Avenues

coil is made by twisting the 0000 conductor fifteen times around a split wood bushing 1½ in. in diameter, which is placed over the line just ahead of where it is attached to the pins on the oak buck-arms. The general construction is well shown in the illustration, though the pole from which the photograph was taken is not complete, no platforms having been provided for the men to work on. Platforms are provided so that there is plenty of room for a man to work on one circuit on one side of the pole with the other circuit in operation, without being in any danger of coming in contact with live wires. Each terminal pole provides space for two circuits. When a line consists of more than two circuits, additional terminal poles have to be provided for each pair of circuits.

Where a right-angle corner is turned, as shown in the illustration, a type of construction has been adopted

Terminal Poles—DeBaliviere and DeGiverville Avenues

which effectually keeps the lines in position, at the same time relieving the insulators of undue strain, and preventing the line coming down in the event of an insulator or pin breaking. The small extension arms shown in the illustration are sections of oak arms 22½ in. long bored for two 1½-in. drop-forged iron pins 12. in. on centres and furnished with wrought-iron clevice securely bolted to the oak. Before being bolted to the oak this clevice is passed through an eye-bolt which extends through the double arm. After the wire is in position and has been drawn up to grade, No. 4 solid copper ties are soldered to the conductor around each glass insulator, after which the nut on the eye-bolt is screwed up so as to relieve the strain between the insulators on the double cross-arms and the insulators on the oak extension arm.

The corner poles shown in the illustration are 50-ft. poles with 7-in. top, set 8 ft. in the ground, and with gains 18 in. centre to centre.

The lines on which the above described construction has been adopted were built during the past year and have withstood a number of very severe storms and have not yet caused any trouble nor required any repairs.

All guys used on this class of work are double insulated with mica strain insulators insulating the guys in such a manner as to protect linemen working on either pole to which the guy is attached.

The Electric Plant of the Laclede Power Company of St. Louis

THIS company started its business in 1890, supplying power to small consumers located in the central part of the city. It adopted the 500-volt, direct-current system of distribution, and operated twenty-four hours per day. It supplied power only, until May, 1900, when it completed a new and modern power house and began serving light as well as power. To accomplish this result, chloride-accumulators were installed in a substation in the centre of its business district, making a neutral wire with a pressure midway between the pressures of the conductors of the two-wire 500-volt power system. A third wire was used as a neutral on the overhead pole lines, and the lead sheath of the duplex cables was used as a neutral in the underground district. This gave a direct-current three-wire system, and the pressure was changed slightly, so as to give 240 volts on each side of the lighting circuit and 480 volts between the outside wires of the power circuit. This system has proved entirely satisfactory for all kinds of service.

The equipment at the power station, which is located on the river adjacent to the business district, consists of direct-current, 500-volt, compound-wound, railway generators, direct connected to cross-compound Corliss engines, carrying 175 lb. steam pressure.

Increased service is being provided for by vertical Curtis turbo-alternators, 3-phase, 60-cycle, 2,300-volt, to operate at the same steam pressure with 200 degrees of superheat and 27-in. vacuum. The circulating water will be taken from the Mississippi river with submerged discharge and circulated by means of centrifugal pumps driven by compound reciprocating engines, which with the other auxiliaries, will exhaust into open feed water heaters. The feed water will then pass through economizers and be raised to a temperature of about 300 degrees fahr.

The 60 cycle, 2,300 volts will be carried to synchronous converters located in sub-stations, and be supplied to the three-wire network.

The company is owned exclusively in St. Louis and has an authorized capitalization of $2,000,000, a part of which has not yet, however, been paid in. It is in the unique position financially of having no bonded or other debt. Its stockholders, therefore, own the property subject to no encumbrance whatever. This condition is almost without parallel in the history of large central-station equipments.

The Electric Plant of the Laclede Gas Light Company

THE electric plant of The Laclede Gas Light Company is located at Mound street and Levee. It was built and began operation in May, 1890. From this plant, light and power for commercial purposes are furnished to the different parts of the city, the lighting being confined chiefly to the northern half of the city. The lighting circuits are all alternating current, the primary distribution being at 2,200 volts with the secondary at 100 volts and 220 volts. The power circuits are all direct current, the distribution being at 550 volts.

The power house equipment has a total capacity of 2,400 kilowatts. The boilers are of the water-tube type, with fuel economizers and forced draft. Illinois slack coal is used for fuel. The engines are all compound and are operated condensing. Water for the surface condensers is pumped from the Mississippi river.

The switchboard is of marble, equipped with oil-break switches and the necessary complement of instruments. The distribution is both overhead and underground. There are in the overhead district approximately 100 miles of pole lines, and in the underground district 200,000 ft. of duct.

THE TELEPHONE IN ST. LOUIS

The Telephone in St. Louis

IT is a fact of considerable interest that one of the first telephone exchanges in the United States went into commercial service in St. Louis on May 1, 1878. Yet, in spite of this early start, local development has not kept pace with that of other smaller cities, particularly some of those of the Far West, for at the present time the total number of subscribers of the two companies is somewhat below the normal for a city of the size of St. Louis. A marked improvement has, however, manifested itself recently, especially in the last two years, while the number of subscribers per hundred of population has increased 250 per cent. since January, 1901. A study of the subjoined table shows clearly the present healthy rate of growth and indicates that in the near future the city will take its proper rank in the telephone field:

Date	Population*	Subscribers		Subscribers per hundred of population	
		Bell	Kinloch	Bell	Kinloch
January, 1898	542,000	4,659	......	0.86	.....
February, 1899	556,000	......	4,000	.....	0.72
January, 1900	569,000	......	5,433	.....	0.96
" 1901	583,000	6,155	5,999	1.06	1.03
" 1902	597,000	7,655	7,355	1.28	1.23
" 1903	612,000	10,329	8,483	1.69	1.39
" 1904	626,000	13,931	10,000	2.22	1.60
July, 1904	636,000	20,000	14,000	3.14	2.20

*The figures for the population are based upon a curve prepared by Mr. Robert Moore, Past-President of the American Society of Civil Engineers, for a paper on "The Vital Statistics of St. Louis."

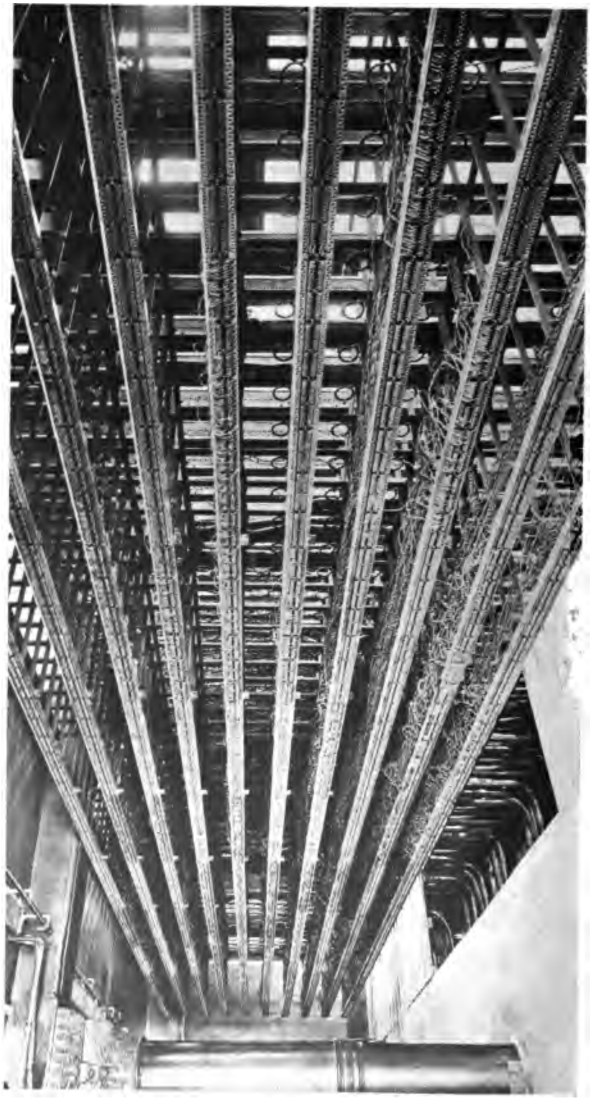
A review of the local situation may perhaps be made to best advantage by separate consideration of the two companies, the Bell Telephone Company of Missouri and the Kinloch Telephone Company, beginning with the former, since it was first in the field.

Main Exchange

The Bell Telephone Company of Missouri

THE pioneer work of this company presents many features of interest, and is typical of the evolution that has transformed the telephone in a single generation from a scientific toy to an instrument of enormous industrial importance.

The original exchange, which was located at 417 Olive street, had, at the time of its opening, four subscribers. A magneto system was employed, and receiver and transmitter were practically identical, the Blake transmitter not having been invented at that time. Somewhat later the Law system of horizontal multiple switchboard with local battery was adopted, and the system was extended by the addition of branch exchanges. In May, 1884, "Main" exchange was located at 417 Olive street, "Leffingwell" on Leffingwell (Twenty-eighth street), between Washington avenue and Locust street, "Cass" on Twelfth street and Cass avenue, "Rutger" on Third and Rutger streets, and "East" in East St. Louis, in what was then called Flanagan's Hotel. In July of the same year another exchange was opened in Carondelet, the southern part of the city. All of these exchanges were equipped with the Law system, except Leffingwell, where a magneto system was still retained; the distribution, as a whole, foreshadowed that now in use. During the winter of 1885-6 the cupola of the Main exchange was destroyed by fire, whereupon a new Main was installed at Fourth and Pine streets, with a capacity of 1,800 subscribers. The board was enlarged from time to time until about 4,600 lines were connected, when all of the branch exchanges were abandoned, all traffic being handled at Main. In 1893, however, the growth of the



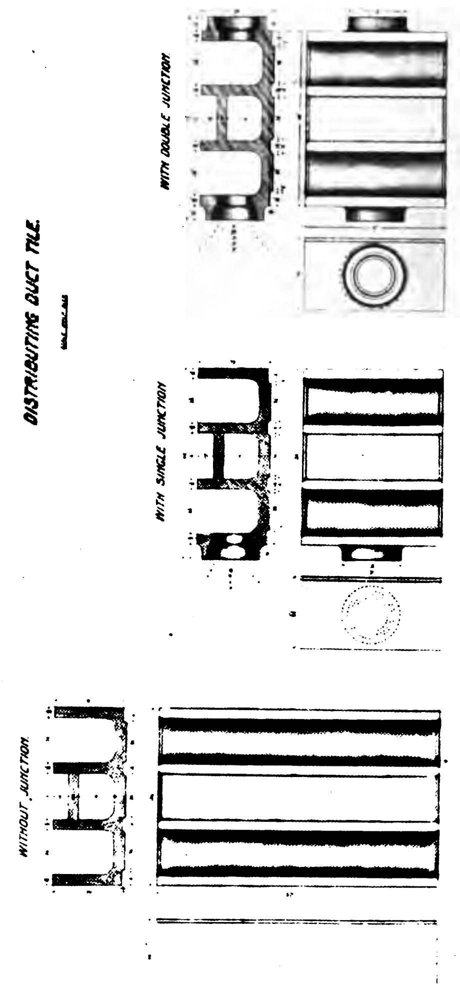
Distributing Rack—Main Exchange

system required the addition of branch offices, and others have since been added as necessity has demanded.

The original Law boards were quite small according to modern standards, having been only large enough to accommodate four operators, three for local work and one for incoming calls. The board was so arranged that all local subscribers' lines terminated near its centre, the rest of the board being provided with a series of brass strips spaced about one-quarter inch apart, and provided

Cable Vault

with numerous holes, which were used partly for local and partly for incoming and outgoing trunk connections. A subscriber desiring a local connection had first to push a button which connected his set to a call circuit constantly held by the operator, and then to call his own number as well as that of the station wanted. The operator, in turn, acknowledged the receipt of the call by tapping caller's bell, and, after ringing the bell of subscriber wanted, plugged both lines to one of the brass strips. In case of a call for a non-local subscriber, the operator would use a call button to the particular ex-


DISTRIBUTING DUCT TILE.
WITH DOUBLE JUNCTION
WITH SINGLE JUNCTION
WITHOUT JUNCTION

change in which the called line terminated, after which the method outlined above was followed.

After the abandonment of the branch offices, which, of course, did away with trunking, the service was considerably improved, and the system reached its greatest perfection. It is hardly necessary to state, however, that even at its best it could not compare in efficiency with the present standard; for example, trouble on a single call line affected all subscribers using that wire, and leakage from power circuits rendered the service very poor over all lines near the leak. Another prolific cause of trouble was the battery at the subscribers' stations.

Following the reintroduction of branch exchanges in 1893, Messrs. Durant, Shaw and Dean perfected and installed a trunking system called the Columbia trunk system, or the Dean common battery system. This was operated between Main and the Lindell exchange, at that time located at 3456 Lindell avenue. The trunk lines, connected in multiple at every fourth or fifth position on the board, were provided with signal lamps at corresponding intervals, which remained lighted while the line was busy, so that all operators could see whether a line was in use or not. An operator at Main receiving a call for Lindell would connect to an unused trunk, thereby lighting a lamp at Lindell on that line; Lindell operator, picking up the corresponding cord, would ask number and then plug to the proper jack, thereby putting out the signal lamp. After the Main subscriber called off, Main operator would strip the connection, thus putting out all lamps at Main on this trunk and at the same time again lighting the lamp at Lindell, whereupon Lindell operator would strip connections, and again extinguish the lamp. About this time also, a few subscribers were provided with metallic circuits, which were operated at a toll board distinct from the main one.

During this period of the growth of the system, the subject of putting all wires underground in the business district began to be seriously considered. After much hampering legislation, a Subway Commission was appointed by the Mayor in November, 1893, to consider the

Cable Head

matter thoroughly. An ordinance was finally adopted on September 8, 1896, which regulated the construction and operation of underground conduits in the city, and is still in force. It provided, in brief, that no wires, tubes or cables, conducting or transmitting electricity, should be placed above the surface of the street, alley or public place in the district of the city bounded on the east by the Mississippi River, on the west by the west line of Twenty-second street, on the north by the north line of Wash street, and on the south by the south line of Spruce street, and its prolongation to the west line of Twenty-second street, after December 31, 1898. It further provided that poles might be placed in the alleys for purposes of distribution, provided that plans had been approved and permits had been issued by the Board of Public Improvements. The construction of the conduits of the Bell company was started on April 19, 1897, and four months later, on August 17, cables were drawn through the ducts. At the present time the conduit system is much more extensive, as trunk line conduits have been built to all of the branch exchanges, even those situated far out in the residence, or overhead, district.

Twelfth street divides the underground territory into east and west districts. In the latter, terminal poles carrying the runs are located at the entrances of alleys intersecting the streets. The cables on leaving the manholes are led through 3-in. iron pipes to the terminal poles and terminate in a cable head. The various circuits are then distributed to the subscribers by short overhead lines. East of Twelfth street, in the purely business district, the underground construction has been rigidly adhered to. From the street manhole, distributing ducts are run through the alleys, each being provided with a manhole at its centre and one at the end where the cable is dead-ended. The cable head is located in the manhole in the centre of the alley, and along the duct, at intervals determined by the requirements, junction sections are inserted, from which the single pair lead-covered cables are led through 3-in. iron pipe into the basement of the building in which the subscriber is located.

In office buildings containing a large number of subscribers an entire cable enters the basement and terminates in a cable head. The distribution tile used in these short lateral runs is of the Johnston type. It is made in 2-ft. lengths, and consists of two through ducts for single pair cables, one enclosed cable duct, and a shallow channel above the latter, which is provided for the purpose of admitting a device for drawing in the single pairs. The

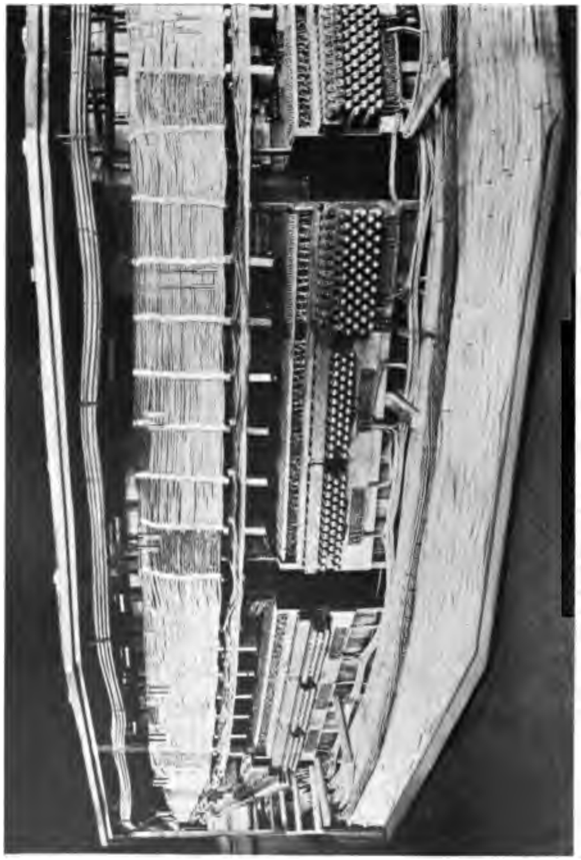
Underground Construction

junction sections are like the distributing tile, but have in addition a 3-in. side opening for lateral connections.

All the main runs consist in general of 3¾-in. hollow brick tile 18 in. long, of octagonal exterior, made of sewer pipe clay, glazed inside and out, made by Evens and Howard of St. Louis. This pipe was laid 5½ in. between centres, the intervening space being filled in with cement mortar; successive rows being separated vertically by a half-inch layer. The abutting joints, broken horizontally and vertically, were encased in cement mortar consisting of one part of cement and two parts of sand. The mandril used for aligning the joints and keeping the ducts clear consisted of a cylindrical piece of wood three feet long, provided with a washer at its inner end and a hook at its outer end. The best American Portland cement was used. The concrete foundations for the conduits varied in depth from 4 to 6 inches, according to the number of layers of duct. The sides and top of the conduit were covered with from 3 to 4 inches of concrete mixed in the proportion of one part of cement, three of sand and six of broken stone.

Electric Cable-Drawing Automobile

Only a short length of multiple duct was laid at the time of the original construction, and none has been built since. The ducts in the short length in use consist of four rectangular compartments, 3¾ in. wide by 4 in. deep, with 1-in. walls. It is made in 2-ft. lengths and is intended only for places where multiples of four were used, since the roof of one layer is formed by the bottom of the one above; a close fit is insured by a tongue-and-groove joint. The top is closed by an arched sheet of No. 22 mild steel, bent to lap over the sides. The standard manhole is 5 ft. cube with 9-in. brick walls, concrete bottoms, a 6-in. clay tile sewer with a ¾ S iron trap, and a grated cover when necessary. The roof is of concrete 10 in. thick, with an opening for a 24-in. by 30-in. self-locking cast steel cover, either of the solid or ventilated



Rear of Switchboard—Main Exchange

pattern, and provided with dirt pans beneath. The largest manhole is the main vault under the street on the west side of the Telephone Building, where the Main exchange is located. It is 24 ft. by 12½ ft. by 8 ft., with 17-in. brick walls, a 1-in. air space being left on the inside course to render the manhole moisture proof. The roof consists of 17 in. of concrete, supported by 12-in. steel I beams.

The original contrivance used for drawing the large lead-covered cables through the ducts consisted of a small 3½-h.p. steam engine mounted on a low wagon and connected to a capstan. With this arrangement a speed of 25 ft. of cable per minute was easily attained, but it has recently been abandoned in favor of an electric automobile carrying an electrically-driven capstan.

In the meantime, while these improvements were being made in the distributing system, the exchanges themselves were undergoing a transformation. The "Sidney" exchange, at Eleventh and Sidney streets, was opened for service on May 15, 1897. It was the first modern common battery board in St. Louis. In January, 1898, the new Main exchange, in the Telephone Building at Tenth and Olive streets, was put into operation. It had a common battery, multiple switchboard, and was the second one of the kind to be installed in this country. It was the largest board manufactured at that time, with a capacity of 5,600 multiple jacks. This office has since been equipped with an incoming trunk board of 9,600 lines capacity, and a complete new power and storage battery plant. The power plant has a total capacity of 36 kw., and the storage battery consists of two sets of Chloride Accumulators, of 22 volts each, and with a discharge rate of 400 amperes for eight hours. With the additional equipment ordered, this exchange will be one of the largest outside of New York City.

The present system of the Bell Telephone Company of Missouri consists of eight exchanges, viz.: "Main," at Tenth and Olive streets; "Beaumont," at Twenty-seventh and Locust streets; "Lindell," at 3844 Olive street; "Forest," at 5144 Delmar avenue; "Grand," at 1625 South Grand avenue; "Sidney," at Eleventh and Sidney streets; "South," at 6817 Minnesota avenue, and "Tyler," at Eleventh and Chambers streets. There is also an exchange at 105 Collinsville avenue, East St. Louis, Ill., which is called "East" or "Bridge." In general, all exchanges are equipped with common battery relay type of switchboards; the later exchanges, such as Beaumont, Grand and Forest, have a capacity of 9,600 lines each, and are typical examples of the best modern telephonic engineering. The underground conduit system occupies forty

Electric Cable-Drawing Automobile

miles of streets and alleys, and contains about 27,000 miles of wire; this is arranged in cables varying in size from 1 to 480 pair. There are also 200 miles of pole line, carrying approximately 20,000 miles of wire, of which about 75 per cent. is aerial cable. The toll line system consists of about 3,000 miles of line wire.

The Kinloch Telephone Company

ON December 5, 1896, just three months after the adoption of the city ordinance regulating the construction and operation of underground conduits, the Kinloch Telephone Company was organized, and has almost from its inception enjoyed the distinction of being the largest "independent" telephone system in the country.

After its incorporation the company lost but little time in putting its plans into execution. The construction of

Main Exchange—"A" Division

the underground system was begun on March 7, 1897, some time ahead of any of the other wire-using companies. The conduit was finished in four months, and by April of the following year the underground work was complete. Simultaneously, about 12,000 poles were set in the outlying districts, and cables and wires were strung for the overhead lines. This construction was remarkable for the exceptionally straight poles and the perfect alignment.

In the underground district there are three principal lines of conduit running north and south on Seventh, Ninth and Eleventh streets. West of Eleventh street the alleys take the runs east and west. East of Seventh street, in the business district, the conduits are on alternate streets running east and west, distributing from cable heads on poles in the alleys or from terminal heads located in the basements of office buildings.

Rear View of Switchboard—Delmar Station

The company used a multiple-duct vitrified clay conduit manufactured by John T. McRoy of Chicago. This tile was laid in two, three, four and six-duct sections, the last two sizes preponderating. The duct is in 6-ft. lengths and is of hard burned shale with an exterior and interior salt glazing, the cross-section being rectangular with rounded corners. Joints between adjacent sections were made with steel dowel pins ½ in. in diameter and 6 in. long, the dowel hole running through the entire length of the duct to permit of joints between pieces cut from the standard size. The joints were covered with wet burlap and plastered with a coating of cement mortar.

The manholes were built in three sizes—3½ by 3½ ft., 4 by 4 ft., and 5 by 5 ft., with head room of 6 ft. and 12-in. concrete floors. The smallest size has a corbeling top, supporting a cast iron frame and circular cover 36 in. in diameter. The larger manholes have 18-in. walls half way up and 13-in. walls the rest of the way. The roof is of concrete supported on 6-in. by 2-in. I beams.

The main exchange is located on the tenth floor of the Century Building, a fire-proof office building on the

Delmar Exchange

northwest corner of Tenth and Olive streets. All underground cables enter the building through a vault in the northeast corner of the basement, and pass to the operating room above through a shaft 120 ft. long and 8 ft. by 10 ft. in cross-section.

The original board consists of a four-division multiple switchboard having an ultimate capacity of 20,000 lines. It was built by the Kellogg Company of Chicago, and is the only one of its kind in operation. The original system contemplated the construction of the main exchange only, the intention being to do away with all

Distributing Room—Delmar Exchange

Power Room—Delmar Exchange

branch offices and the incidental trunking. The system has since been changed, however, and at present there are three branch offices scattered about the city and the immediate vicinity. It is claimed that the main board handles at the present time a greater daily number of connections than any other exchange of equal size in the United States, and that the storage battery used in connection with it has the largest capacity of any used for telephone purposes in the world.

The three exchanges at present in operation in addition to the Main exchange are: "Delmar," at Delmar and Newstead avenues, with a capacity of 7,200 lines and a 22-volt common battery switchboard; "Victor," at Ann and Indiana avenues, with a capacity of 7,200 and a 44-volt common battery switchboard; "St. Clair," at Fifth and Missouri avenues, East St. Louis, Ill., with a capacity of 5,000 lines and a 44-volt common battery switchboard.

The outside equipment consists of 21,000 miles of wire and cable, partly of aerial and partly of underground construction. There are 300 miles of pole line and 228 duct miles of conduit. The cables very in size from 1 to 400 pair.

ISOLATED
ELECTRICAL PLANTS

Washington University

THE new grounds and buildings of Washington University, situated within the boundaries of the Louisiana Purchase Exposition, constitute one of the finest university plants in the United States, and furnish an admirable example of what may be done by careful and consistent designing. Of the eleven buildings now completed, seven had been erected before the

University Hall

constructional work of the Fair had been started, and were to have been occupied by the University in the fall of 1902; but early in that year, because of mutually advantageous reasons, the University leased the property to the Exposition Company for the period of the Fair, remaining in the meantime in temporary quarters. Since that time four more buildings have been completed.

The University was founded on February 22, 1853, at

cept that its property is exempt from taxa-
rounds and buildings and endowment fund
derived from the donations of public-spirited

grounds on the World's Fair site cover an
acres, and are approximately three-fourths of
by one-fourth of a mile wide. The prevail-
architecture throughout the entire group is
; all the buildings are of fire-proof con-

Liggett Hall—Dormitory

ction, and are built of red Missouri granite with Bed-
ord limestone trimmings. They are all heated and
ighted from a central power plant, and are arranged in
quadrangles, only one of which, however, is complete at
the present time.

The power house, located at the foot of the hill on the
north side of the grounds and on a spur track of the
Frisco-Rock Island Railroad, contains seven 66-in. by
fire tube boilers, which furnish steam for three
single-cylinder, non-condensing engines, each direct
ected to a 90-kw., two-phase alternator. The alter-
rs are of the General Electric, form D, compensated

field type, and supply 60-cycle current at 600 volts per phase. The power house is connected with the four buildings of the first quadrangle (University, Busch, Library, and Cupples Hall No. 1), and with Eads Hall, Cupples Hall No. 2 and the Cupples Engineering Laboratory, by an underground tunnel, 7 ft. wide by 7 ft. high at the centre, and about 1,900 ft. long. In this tunnel are carried the power and lighting circuits and the steam pipes for heating. Provision has been made for future

Interior of Power House

extension of this tunnel to other outlying buildings, but at present steam is carried to the two dormitories by a pipe laid in a brick duct, the power and lighting current being transmitted by overhead lines. The gymnasium, at the extreme western end of the grounds, has an independent heating system.

All of the buildings are heated and ventilated by the low-pressure indirect system, using the exhaust steam from the engines, and, if necessary, live steam taken through a reducing valve. The warm air is forced through the buildings by Sturtevant fans, driven by General Electric two-phase induction motors. The motors are of the squirrel-cage type with autotransformer starting compensators, and vary in size from 5 h.p. to 15 h.p., taking current directly from the line. Air is forced into all recitation and lecture rooms at the rate of 2,000 cu. ft. per hour per person. Temperature regulation is effected by the Johnson system of thermostats.

All of the buildings are electrically lighted, a bank of two General Electric, type H, oil-cooled transformers being installed in the basement of each one of them. The banks vary in size from 5 kw. in the engine room to 50 kw. in University Hall (Administration Building). Both power and lighting circuits are wired on the three-wire, two-phase system. This was due to the fact that an outside connection to a three-wire, single-phase system from a neighboring county power house was provided for lighting the dormitories at night and during the summer months when the University plant might be shut down. No trouble from unbalanced phase regulation has been encountered, the plant having been running to its full capacity since the opening of the Fair, with frequent overloads of 50 per cent. The overload is due to the fact that the Exposition authorities have temporarily added two arc-light transformers, each of 62 kw. capacity, for illuminating the grounds.

Immediately after the close of the Fair the buildings will be occupied by the Undergraduate Department (the College and the School of Engineering and Architecture). The plans adopted some time ago contemplate an extensive equipment for instruction in the various branches of engineering, all of which will be of the most modern description.

The Anheuser-Busch Brewery

THE brewing of malt liquors is one of the chief industries of St. Louis. The plant of the Anheuser-Busch Brewing Association, the largest brewery in the world, is located here. This fine property has been for many years one of the most interesting sights of the city. The main office of the works is at Ninth and Pestalozzi streets, and may be reached by the south-bound Broadway (Fifth street) and the Cass avenue trolley car. The plant covers 125 acres, extending eastward to the river front, and is completely equipped for the manufacture of all auxiliaries necessary for marketing its product; for example, kegs, barrels, boxes, and bottles.

From an engineering standpoint the plant presents many features of interest. It has its own power house, refrigerating plant, water-works, and mechanical filter plant,—all these are on a scale that compare with municipal installations in many large towns. There is also a complete system of switching tracks connecting the various buildings, aggregating six miles of track, operated by five steam locomotives. An idea of the magnitude of the works may perhaps be obtained from the following data:

Number of employees, 5,000; daily capacity of brew-house, 6,000 barrels; bottling works, 800,000 bottles; malt-house, 9,000 bushels; storage elevators, 1,250,000 bushels; stock-house, 450,000 barrels; the steam power plant has a rated capacity of 7,750 h. p.; electric light plant, 4,000 h. p., and the ice and refrigerating plant has a daily capacity of 3,300 tons. The total output for the year 1903 was 1,201,-762 barrels.

The boiler houses, of which there are seven in all, contain a total of 10,125 boiler horse power, distributed as follows:

Boiler-house No. 1,	11 boilers, 450 h.p. each,	4,950 h.p.
Boiler-house No. 2,	5 boilers, one of 650 h.p.	
	one of 500 h.p.	
	three of 400 h.p.	
	——	2,350 h.p.
Boiler-house No. 3,	5 boilers, 300 h.p. each,	1,500 h.p.
Boiler-house No. 4,	2 boilers, 200 h.p. each,	400 h.p.
Boiler-house No. 5,	3 boilers, 200 h.p. each,	600 h.p.
Boiler-house No. 6,	2 boilers, 125 h.p. each,	250 h.p.
Boiler-house No. 7,	1 boiler, 75 h.p.	75 h.p.
		10,125 h.p.

Five of the boilers of No. 1, and all of those of No. 2, are equipped with Hawley down-draft grates, all of the other boilers having plain grates. Boiler-houses Nos. 1, 2 and 3 have brick stacks 275 feet, 200 feet, and 200 feet high, respectively, while those of Nos. 4, 5, 6, and 7 are smaller, varying from 60 to 80 feet in height.

The refrigerating plant supplies a large amount of ice for the local market as well as all ice and refrigeration required in the cold-storage vaults of the brewery itself. The refrigerating machines, all of the De la Vergne type, are located in two plants, No. 1 and No. 2. No. 1 contains seven machines, ranging in capacity from 75 to 500 tons, while No. 2 has one machine of 470 tons capacity.

The electric light and power plant contains two 500-kw., 220-volt, direct-current generators, each direct connected to 800 h.p., compound condensing engines. At the present time there are being installed two 200-kw., 220-volt, direct-current generators, each direct connected to a 300 h.p. De Laval steam turbine.

The water-works, located near the river front, contain three Worthington triplex electric pumps, each of 2,000,000 gallons capacity; and a centrifugal pump is now in course of erection. The water is partially clarified in two steel settling tanks, each 75 ft. in diameter and 20 ft. high, and is stored in a settling reservoir of 1,000,000 gallons capacity. There is also a mechanical filter plant consisting of twelve 14-ft. filters.

At Main and Dorcas streets is located the bottle-glass factory of the A. Busch Glass Manufacturing Company, which contains the largest tank-furnace in the world; it is a 20-ring regenerative furnace, with a capacity of 50 tons in 24 hours. At Belleville, Ill., 15 miles from St. Louis, is the bottle factory proper; this is equipped with three continuous tank-furnaces of 32 rings. The capacity is 82 tons in 24 hours, or the equivalent of 164,000 bottles.

The plant, as a whole, is a model self-contained unit, and is well worth visiting.

The New Carleton Wholesale Building

THE modern fire-proof building designed for conducting the business of a wholesale dry goods company in the most efficient and economical manner has passed through various stages of development, until it has become closely associated with electrical engineering, since all the operations required for ventilating and lighting the building and handling the goods are accomplished by means of electric power. The building recently erected in St. Louis at the northeast corner of Twelfth street and Washington avenue for the Carleton Dry Goods Company is a good example of the latest practice in this class of building. The engines driving the dynamos and the boiler-feed pumps are the only steam-driven units in the plant. All other machinery and appliances are operated by electric motors.

The building itself comprises ten stories, a basement extending under the entire building, and a sub-basement occupying about one-fourth of the area. The total floor space is 217,500 sq. ft., or about 5 acres. Space was considered of sufficient value to warrant placing all machinery in the sub-basement. The building is of fireproof construction throughout with steel framework enclosed in concrete fire-proofing, and all floors are made of solid concrete with corrugated iron bars for reinforcement. The building is faced with brick, with tile trimmings. The first floor is 17 ft. high and the other floors and basement are each approximately 12 ft. high.

The mechanical and electrical equipment of the building consists of a boiler and heating plant, dynamos and engines, a storage battery, and the electric elevator plant.

The boiler plant consists of three 165 h.p. safety

ISOLATED
ELECTRICAL PLANTS

boosters are used either for charging the battery or for controlling the load on the engines when the elevators are in operation.

The battery is so connected by means of the regulating booster that it takes the fluctuations of load produced by the elevators so that the variation on the engine is less than 50 h.p., and one engine will therefore carry the entire elevator load throughout the day. In addition, this engine will furnish the lights required during the day, and also furnish power for about 30 h.p. of motors driving heating and ventilating fans, cash-carrier system, pumps, etc. This leads to decided economy in the use of coal in the plant. The storage-battery also serves an important function in providing for light at night, making it unnecessary to operate the plant after business hours. The building was not piped at all for gas, entire dependence being placed upon the storage-battery.

The electric-elevator plant consists of three high-speed passenger elevators, operating at a speed of 400 ft. per minute, and five large freight elevators carrying 3,000 lbs. at a speed of 275 ft. per minute. In addition there are two one-story lifts operating from the basement to the first story only. Each carries a load of 4,000 lbs. at a speed of 100 ft. per minute.

The building is lighted throughout by standard enclosed arc-lamps, provided with porcelain shade reflectors. The arc-lamps are hung on pendent fixtures, and near each lamp is a push-button switch, suspended from the ceiling, by which it may be controlled. The lamps are also connected so that they can be controlled two on a circuit from a central panel or switchboard near the elevator shaft.

The wiring of the building is in iron conduit throughout except the feeders which run open in the elevator shaft. All circuit connections, terminals, etc., are located on a fireproof marble tablet and the entire tablet enclosed by a fireproof cabinet with door provided with lock and key.

ELECTRICAL
MANUFACTURING PLANTS

The Wagner Electric Manufacturing Company

IN the line of electrical manufacturing, the largest individual enterprise in St. Louis is the plant of the Wagner Electric Manufacturing Company, located at 2013-21 Locust street. This company began its mercantile career in 1891 in a $10,000 corporation for the manufacture of alternating-current desk fan-motors. The founders of the company contemplated a very small enterprise only, but by rapid stages the business expanded to its present condition of being one of the recognized leading electrical interests of the United States.

The products of the Wagner company are at present practically confined to four specialties—single-phase alternating-current power motors; static transformers; switchboard instruments, and direct current motors and generators.

From an engineering point of view the most interesting product of the company is its single-phase alternating-current power motor. European engineers will be especially interested in this motor, as its wide adoption in American practice is a distinct departure from the prevailing European practice. It is unusual on the Continent to install single-phase motors where polyphase current supply is available. In the United States exactly the opposite practice holds; single-phase motors are frequently installed on polyphase systems, in fact, to-day all of the best polyphase stations of America are large users of single-phase motors, the prevailing sizes varying from 0.5 h.p. to 40 h.p.

The Wagner company's form of motor is built under the patents of Professor E. Arnold, as combined with a number of important subsidiary patents. The method of construction and operation is as follows:

Mechanically the motor consists of a stationary primary, or inducing member, with a revolving secondary. The primary member for standard constant-speed motors, is wound with so-called "pancake" coils, the wire being threaded through partially-closed slots. The secondary corresponds to the

Fig. 1

well-known direct-current armature, except that a vertical rather than a horizontal commutator is used. The rotor also carries mounted closely upon the shaft a centrifugal governor mechanism by means of which the commutator may be completely short-circuited through a series of small links when the speed of rotation is such as to throw this governor into action. The same centrifugal operation also serves either to entirely remove the carbon brushes from the commutator, or to remove the tension from the brushes. In electrical performance, two sets of

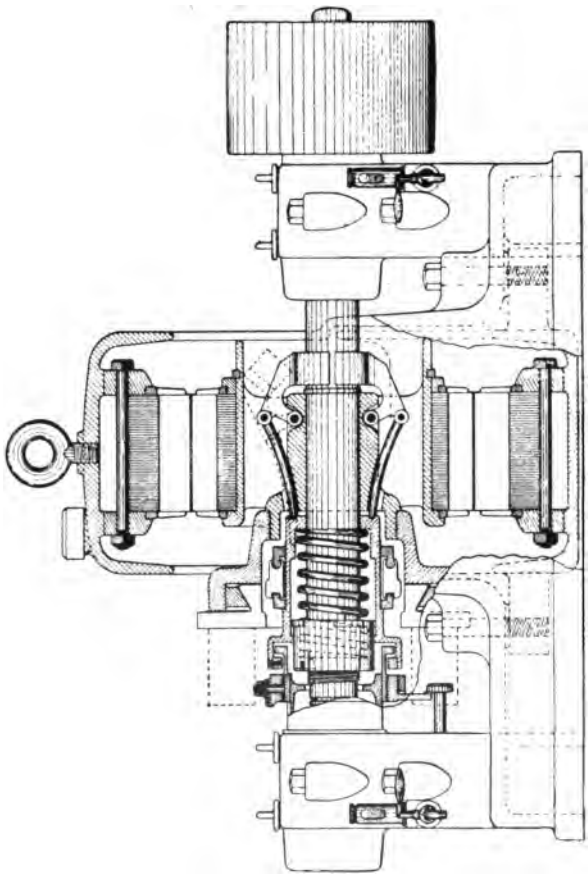


Fig. 2. Cross Section of Wagner Co.'s Motor

working connections are utilized, one for starting and the other for running. In the starting condition the secondary member is short circuited through the carbon brushes, these brushes being shifted to such angular displacement as to start the motor on the repulsion principle. Under these starting conditions, the motor quickly attains synchronous speed, at which point the centrifugal governor comes into action, short circuiting the commutator, and removing the brushes. In this condition the rotor cor-

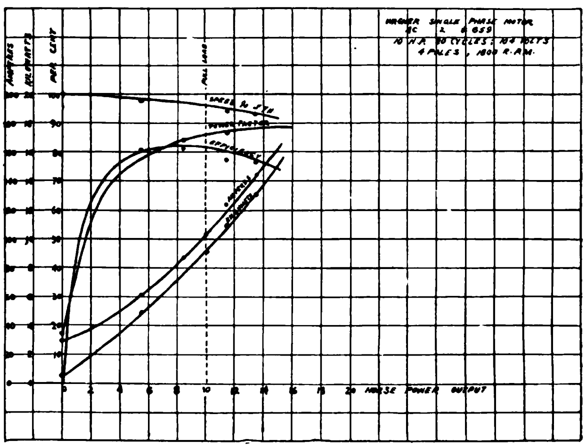


Fig. 3

responds substantially to the rotor of a polyphase motor.

The external appearance of the Wagner motor is illustrated in Fig. 1; the internal construction in Fig. 2; running characteristics for a 10-h.p. motor in Fig. 3, and starting characteristics in Fig. 4.

In explanation of Fig. 4 it may be stated that the Wagner form of motor is capable of being started either by the direct application of supply voltage to the motor terminals, or by the introduction of a non-inductive starting rheostat in the stator circuit. The torque and current characteristics for the former starting condition are shown by the dotted lines in Fig. 4, while the corresponding characteristics for the latter condition are shown in the solid lines on the diagram. It is the practice of the majority of American central stations to apply motors of 5 h.p. or less capacity without a starting rheostat, while for larger motors the rheostat is used.

The factors contributing to the successful introduction of the single-phase motor are the simplicity

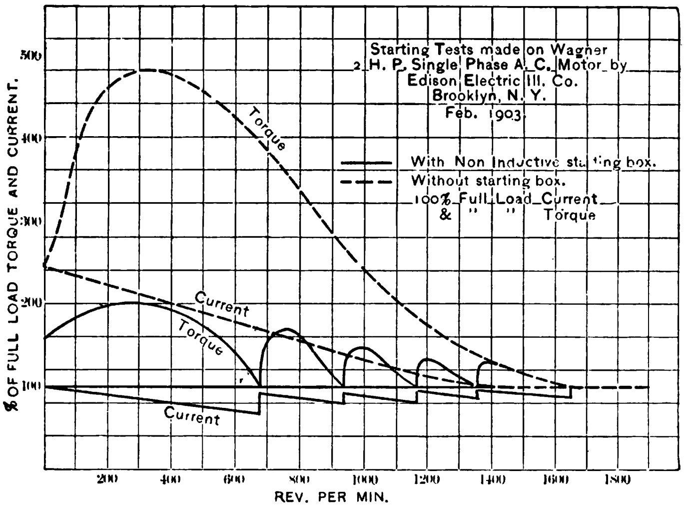


Fig. 4

of line construction, and ability to serve power consumers from lighting circuits through a single step-down transformer and a single integrating wattmeter. Under the control of individual feeder regulators, service regulation is not seriously impaired by giving single-phase motor service from the lighting system; and not only in outlying, but in concentrated districts, the American central stations are finding the single-phase motor a profitable means for the development of day load.

The transformers manufactured by the Wagner

Company are of the single-phase type. The shell form of construction is employed throughout all sizes.

In the remaining lines of manufacture, the products of the Wagner Company correspond to the usual standard forms of construction, the distinguishing characteristics being in details largely.

The Wagner Electric Manufacturing Company's general offices are located at the works of the company. A comprehensive display of the products of the company may be seen in Electricity Building, on the Louisiana Purchase Exposition Grounds.

The Emerson Electric Manufacturing Company

MANUFACTURERS OF ALTERNATING AND DIRECT-CURRENT MOTORS OF SMALL SIZES

THIS company was organized in 1890 by Judge J. W. Emerson, A. W. Meston, and C. R. Meston. The company brought out in 1891 the first successful alternating-current fan-motor designed for use on high-frequency circuits. This was a brush and commutator magnetic motor. Many of them are still in successful operation on this kind of current.

About 1895 the use of 60-cycle current became quite general and the company took up the manufacture of induction motors to operate at this low frequency. In 1897 they also designed the first direct-connected slow-speed alternating-current ceiling fan-motor. This motor at once became the standard, and has remained the standard ceiling fan-motor for the alternating current up to the present time.

The success of this motor has changed the laying out of central station fan circuits. Before the introduction of this fan it was considered necessary to run separate ceiling fan circuits from a direct-current machine, and handle these fan circuits as power circuits; now the practice is to run all fans, both desk and ceiling, from the lighting circuits, and thus render double wiring unnecessary. Many stations have discontinued their high-pressure direct-current fan circuits entirely on this account.

This company manufactures a varied line of single-phase alternating-current power motors of the induction type, from the smallest size (about 1-50

h. p.) up to and including ½ h. p. They also manufacture single-phase alternating-current motors with brushes and commutator from 1 h. p. to 2.5 h. p. During the past two years they have commenced manufacturing direct-current motors of practically the same sizes as the alternating current. This company makes about 400 different kinds of motors under 1 h. p. in size.

In 1903 this company built a new factory fronting 108 ft. on Washington avenue, 150 ft. on Twenty-first street and 108 ft. on St. Charles street. This is a heavy, slow-combustion building, with six stories and basement. The basement contains the heavy work, such as punching, and also a heavy stock of castings. The first floor is the general office, sample room, and shipping department. The second floor is the drafting room and machine shop. The third floor has the time-keeping and production office and stock room. The fourth floor is the assembling room. At the present time the fifth and sixth floors are rented out on a short lease.

The light and power for the entire building is supplied by a power plant located at one end of the basement. The plant contains two 50-kw., 500-volt generators, driven by high-speed four-ported enclosed engines. The lighting is on the three-wire system at 225-450 volts, the balance being provided by a 10-kw. balancer set. This balancer also furnishes current at 250 volts for testing small motors. All machinery used throughout the entire factory, as well as the elevators, are operated by electric motors.

The Moloney Electric Company

THE Moloney Electric Company was organized in July, 1898, for the manufacture of alternating-current transformers. It occupied at the outset one small room of about 1,200 sq. ft. of floor space; later on the growth of the business necessitated removal to a new three-story brick building at Seventh and Hickory streets, containing

Factory

35,000 sq. ft. of floor space. This building is light and airy, and the shops are provided with a modern equipment for the economical manufacture of its product. The machine tools are electrically driven, current being supplied from the street mains, and the building is electrically lighted throughout.

The standard Moloney transformer is of the core type, and is made to meet all commercial requirements as to capacity and voltage, though a large portion of the output consists of special types to meet particular conditions. The new plant has been specially designed for the manufacture of high-voltage transformers.

The core consists of high-grade sheet steel, cut into rectangular strips; these are assembled so that joints are broken in alternate layers. The secondary is wound next to the core and is insulated from it

so as to withstand a break-down test of 3,000 volts. In the smaller transformers the winding is composed of round wire, while in the medium and large sizes, square or rectangular copper strip is used. In sizes of over 2.5-kw. capacity, the winding is equally divided between the two legs of the core. A low current density is used, thus insuring small copper loss and close regulation.

The primary winding is placed outside the secondary coils, the insulation between the two consisting of a cylindrical shield of mica and varnished cloth. For high-voltage transformers, working at 6,600 volts or higher, a grounded metal shield is placed between the primary and secondary for the protection of the latter in case of the development of a fault in the insulation. Standard transformers designed for 2,300 primary volts are subjected to a shop break-down test of 12,000 volts between primary and secondary windings; this potential is proportionally increased for higher working voltages.

The primary coils are wound over the insulating shield which separates them from the secondary and the insulation between layers extends three-fourths of an inch beyond the last turn of each layer. The primary coil is subdivided in transformers of large size so as to limit the electromotive force between layers.

After assembling, all transformers are tested for iron and copper losses and regulation, and the primary coils of 2,000-volt transformers are tested by the application of a pressure of 6,000 volts for five minutes.

The Columbia Incandescent Lamp Company

THE manufacture of incandescent lamps in America has assumed tremendous proportions since the beginning of incandescent lighting 25 years ago. It is estimated at the present time that there are used annually in this country about 40,000,000 incandescent lamps. It has never been possible to determine the exact number, but the figures do not seem to be very far away from those given.

When incandescent lamps were first introduced the selling price was from $1.00 to $1.25 each. At present the process of manufacture has been developed to such an extent that the cost is reduced to from 16 to 18 cents each.

The old forms of commercial incandescent lamps were not markedly different from those in use now, although in the past 10 or 15 years there have been a number of developments along particular lines, giving a peculiar appearance to some of the lamps. Some lamps were manufactured with a flat instead of a spherical bottom at the end opposite the base. Others were exhausted at the neck of the lamp instead of at the bottom of the bulb. Other lamps were made flat on one side,—all of these peculiarly shaped lamps have given way to the pear-shaped bulb now generally used.

The incandescent lamps as made in America include in addition to the 16 and 32 c-p. lamps which burn on circuits of 110 and 220 volts, battery lamps which are operated from an ordinary primary battery, and lamps which run as low as 1 or 2 c-p. These are made in various shapes, including spherical bulbs, pear-shaped bulbs and decorative bulbs of the various sorts. The realm of incandescent lamps is further increased by various forms which are made for use in medical and surgical work. The sizes vary from a small bulb having a diameter of, say, one-eighth of an inch to lamps as high as 150 c-p. The larger sizes, however, are rarely used, though they may be obtained from some sources. Some of the designs of the decorative lamps are very pretty and add materially to the illuminating effect where decoration is desired.

There are also added to the styles of lamps those having frosted bulbs and reflector lamps, the latter being a

relatively recent innovation. These latter very frequently have the lower half of the lamp bulb frosted, while over the upper half fits closely a prismatic glass reflector, or an aluminum cap with a tinned or silvered surface which increases the illuminating power of the lamp. It is claimed that an ordinary 16 c-p. lamp burning at 110 volts will increase its illuminating power practically to double its ordinary light.

In the manufacture of incandescent lamps the greatest care is necessary that all of the parts are carefully made and carefully assembled. The glass composing the bulb must be of the best quality for the work. The filaments, which most manufacturers make for themselves, receive very careful attention, and in the process of sealing-in the filaments and exhausting the lamps a high degree of workmanship is required. In America the lamps must not only give 16 c-p., but they must as well maintain their initial candle-power for periods running from 600 to 800 hours. The demand for good incandescent service and the competition between the manufacturers is so keen that this is an important feature.

In the manufacture of incandescent lamps the filament, which is the life of the lamp, receives a great deal of attention. The majority of lamp manufacturers now use cellulose filaments. These are drawn through glass dies, carbonized, and flashed in a hydrocarbon-vapor, securing a result that has given the best work. The different manufacturers use filaments of various shapes. Very frequently the length and the particular shape of the filament is used by the manufacturer as a selling-point for his lamps. Some users of lamps affect to disregard the shape of the filament so long as the photometric test gives a 16 spherical candle-power. It has been found that the lamp with a generous filament distributed in the bulb in an advantageous way will give good lighting service.

In the manufacture of the Columbia incandescent lamps every precaution is taken to make a completely successful product in every respect. The company was organized in July, 1889, and incorporated in 1890, with J. H. Rhotehamel, president; W. H. Welch, vice-president, and E. J. Keist, secretary and treasurer. The company began business at 515 Elm street, St. Louis, with an output of about 50 lamps per day. The latter part of the year of their incorporation the factory and offices were moved to 1912 Olive street, where the manufacturing capacity was doubled and the output increased to 100 lamps per day. For twelve years the company continued at that address, turning out a splendid quality of incandescent lamp and making a special feature of careful inspection over every step of the manufacture of each lamp.

Towards the end of 1902 the company changed its location to its present quarters at 2115-2117-2119 Locust street, St. Louis, thus moving into a new and modern factory building where every facility is afforded for the making of a good lamp. The company has been foremost in all that is good and progressive in the making of an incandescent lamp, and is now turning out so many lamps that there is probably only one other manufacturer in America that exceeds it in annual output. The policy of the company directs that the lamps must be perfect in every respect, that they shall stand up under hard and long continued use, and that their quality must be maintained. As a result of this policy, rigidly adhered to through all the years of the manufacture, the business of the company has extended into every part of the United States of America, into Canada and into Mexico, in addition to which a very considerable foreign trade has been secured.

In 1891 Mr. W. O. Garrison was elected vice-president of the company and Mr. A. C. Garrison secretary and treasurer. In 1898 the original president of the company died and Mr. W. O. Garrison was elected as his successor.

The company has kept pace with the increasing and varied demand for lamps by manufacturing almost every conceivable shape and size, including not only a full line in standard voltages and for high-voltage circuits, from 200 to 250 volts, but also special lamps for railroad car lighting on low voltage, on storage-batteries, as well as for the axle-lighting system. In the high-voltage lamps export orders from England and Scotland have grown to immense proportions. The manufacturing establishment is thoroughly equipped and is complete in every detail.

The company has been notably active and successful in the fifteen years of its existence. This success is due chiefly to the fidelity of its officers and its employees, the heads of the various departments being men of large experience in their respective lines of work and having remained with the company for long periods of time.

The United States Incandescent Lamp Company

THE U. S. INCANDESCENT LAMP COMPANY, located at 201-203 South Jefferson avenue, was organized in 1898. Their principal business has been done with the leading electrical supply houses throughout the United States.

This company manufactures all standard-type lamps from 45 to 260 volts, and with candle-power range from 2 to 150 candles. Daily capacity is 5,000 lamps. This company has a working exhibit in the Palace of Electricity at the Louisiana Purchase Exposition, it being the first public exhibition of all processes employed in the manufacture of incandescent lamps. These processes are in general familiar to all electrical engineers, but particular interest will be centred in the method employed to obtain a vacuum, known as the chemical process. The company also exhibits a method of manufacturing cellulose.

The cellulose is made from absorbent cotton and is dissolved in a chloride of zinc solution to the consistency of glucose, and is then squirted through a glass die and falls into a vessel of alcohol. This vessel revolves at the same rate of speed as that at which the cellulose is squirted, this action being necessary to keep the cellulose from being drawn. The cellulose is then dried, formed as desired, and carbonized in the well-known manner. It is then treated in a vacuum chamber into which gases are admitted, giving the filament a carbon deposit of great density, and making it of uniform cross-section; then it is mounted on a stem by a graphite cement which holds it firmly to the platinum leading-in wires.

The stem is made of glass tubing flanged to fit the neck of the bulb at one end and the copper leading-in wires at the point at which the platinum wires are joined to the copper, are pressed into the glass, making a perfect seal at the other end.

The glass bulb is first cleansed and then a glass tube is attached to the bottom of the bulb, thus furnishing the means for obtaining the vacuum, as well as for use by the operators in handling the bulb while performing the operation of removing the neck preparatory to sealing-in the stem.

The stem to which the filament is attached is then

Squirting Cellulose Filament

hermetically sealed in the bulb. This, like all other glass-working operations, is performed by revolving the glass so as to heat it uniformly in a gas glass-blower's fire; this operation is usually done by mechanical means, thus insuring uniform heating.

Then comes the most important process of all, the obtaining of the vacuum in the bulb. The process employed is known as the "chemical." It consists first in introducing into the glass tube, at the bottom of the bulb, a chemical which at a low temperature volatalizes, producing a vapor which unites with gases generated or freed