# The Chicago Electrical Handbook

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## 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.

**Chicago.** No. 276

*Compliments of*

**LOCAL RECEPTION COMMITTEE**

**BOSTON MASS.**

# THE CHICAGO ELECTRICAL HANDBOOK

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

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# *INTRODUCTION*

# INTRODUCTION

The purpose of this handbook is to furnish visiting delegates of the International Electrical Congress with a concise description of Chicago and its larger electrical interests. Inasmuch as many of the delegates are doubtless unfamiliar with Chicago's history, it may be permissible to offer a very brief résumé of the city's origin and growth.

The early French cartographers spelled Chicago in whatever way pleased their fancy—Chickagu, Chikagou, Chicago and Chicaqu. Historians of a later date have been even more decorative in their definitions of the word. Without attempting to enter into the subtleties of Indian terminology, it may be sufficient to quote a statement made by Dr. William Barry, first Secretary of the Chicago Historical Society, who says: "Whatever may have been the etymological meaning of the word 'Chicago,' in its practical use it probably denotes strong or great. The Indians applied this term to the Mississippi river, to thunder, or to the voice of the Great Manitou. Edward Hubbard, the genealogist, adopts a similar view and says that the word Chicago, in its applications, signifies strong, mighty, powerful."

*Early Exploration*

The aboriginal owners of Chicago were the Miamis. Louis Joliet and his fellow explorer, the Jesuit missionary, Jacques Marquette, were probably the first white men to land on the site of Chicago, when they explored the Illinois river in 1673. At any rate, the adventurous Robert Cavelier, Sieur de La Salle, has left us a very clear account of his trip down the Mississippi in 1681, *via* the "Chicago portage." This portage is noteworthy because it determined the location of Chicago. It was the shortest and easiest passage from Lake Michigan to the

Mississippi, and the red man had used it from time immemorial. Joliet at once perceived the possibility of going from the Great Lakes to the Mississippi in boats, and advised the Canadian authorities that "there would be but one canal to make, by cutting half a league of prairie, to pass from the lake of Illinois (Lake Michigan) into St. Louis river (the Desplaines), which empties into the Mississippi." La Salle, revisiting the place in 1682, ridiculed the scheme as impracticable and poked fun at Joliet's "proposed ditch." Two hundred and twenty-seven years later the proposed ditch was dug. It cost $42,000,000 and is known simply as the sanitary and ship canal. When it was opened in 1900 the current of the Chicago river was reversed, the waters of Lake Michigan were poured into the Mississippi and the Great Lakes were linked by a navigable route to the Gulf of Mexico. Louis Joliet's right to a charter membership on the drainage canal board would seem to be beyond dispute.

*Fort Dearborn Massacre*

In the summer of 1803 Captain John Whistler, U.S.A., then stationed at Detroit, was ordered to proceed to Chicago with his company and construct a fort, which was named Fort Dearborn, in honor of General Henry Dearborn, then Secretary of War. At this time the settlement comprised three or four cabins, occupied by French-Canadian traders and their Indian wives. In 1812, owing to reverses sustained by the Americans at Fort Mackinac, Captain Nathan Heald, who succeeded Captain Whistler as commandant of the garrison in 1810, was ordered to evacuate Fort Dearborn and return with his force to Detroit. Shortly after their departure from the fort, the little band of soldiers and settlers was waylaid and massacred by hostile Indians. The site of this tragedy, at what is now the intersection of Prairie avenue and Eighteenth street, is marked by a monument commemorating the heroic and hopeless struggle of these brave pioneers against an overwhelming force of savages.

The seed of a great city, however, had been sown, and neither the massacre of 1812 nor the holocaust of 1871 could destroy it. Civilization had come to stay in Chicago, and savagery was to be thrust thenceforth farther and farther westward into the retreating wilderness. Fort Dearborn was rebuilt on a larger scale, the settlers returned in greater numbers, and the close of the Blackhawk War in 1832 marked the collapse of Indian supremacy east of the Mississippi. In 1833 Chicago, having barely the required number of 150 inhabitants, became an incorporated town, and four years later was incorporated as a city, with an area of about ten square miles. That was sixty-seven years ago. In 1903 the population of Chicago, according to the city directory, was estimated at 2,241,000, and its area a trifle under 200 square miles. That such a rapid growth should be possible within the span of an ordinary lifetime, is a fact, the simple statement of which speaks eloquently of Chicago's unconquerable spirit.

*The Great Fire*

The great Chicago fire, which occurred in the autumn of 1871, practically wiped the city off the map, destroying three and one-half square miles of property, valued at about $200,000,000, and sacrificing over 200 lives. At that time the total population was about 300,000, but out of the ashes of the old city a new one soon arose, larger and more enduring than its prototype. In 1870 the population of Chicago was 298,977; in 1880, 503,185; in 1890, 1,099,850; in 1900, 1,698,575; last year it was estimated at 2,241,000.

The foregoing figures predicate something more than mere growth of population and increase of area, for though Chicago is the second largest American city in point of population, it has few superiors in the magnitude and importance of its manufacturing and mercantile activities.

The commercial strength of Chicago is derived not alone from its strategic position as one of the largest industrial centers of the United States, nor from the ramifications of its extensive operations in food products, cereals, steel rails, machinery and other merchandise, but from the fact that the termini of twenty-six railroads, aggregating over 84,000 miles of railway (or more than one-third the total railway mileage of the United States), are here focused to pour their concentrated wealth of traffic upon the Chicago market. A large amount of this freight is also handled by the fleets of the Great Lakes, which, plying between Chicago and eastern ports, carry immense quantities of grain, lumber, coal, ore and other products, the tonnage of vessels entering and clearing the port of Chicago amounting to 15,307,635 in 1903.

*Modern Chicago*

The down-town business district of Chicago is confined to a remarkably small and congested peninsula bounded on three sides by Lake Michigan and branches of the Chicago river. In the heart of this square mile of sky-scrapers lies the retail shopping district, seven blocks in length and five blocks wide. Here, in an astonishingly short space of time, the visitor may traverse the principal thoroughfares and inspect the city's leading business and public institutions. Michigan avenue, which borders the lake, and is separated therefrom by Lake Front Park, is devoted principally to hotels, clubs, musical colleges and studio buildings. Here are located the Art Institute and the Public Library; here also are to be erected in the near future a temple of music for the Chicago Orchestra, and, when the park is extended and completed, a permanent home for the Field Columbian Museum, now housed in the old World's Fair Art Building at Jackson Park.

West of Michigan avenue is Wabash avenue, a highway for the down-town loop as well as for surface lines penetrating the South Side, and the home of many large wholesale concerns. One block west, Wabash avenue is paralleled by State street, the main artery and principal shopping thoroughfare of the city. At its northern end stands the vast bulk of the famous Masonic Temple, from the roof of which, 354 feet above the street level, a fine

MICHIGAN AVENUE, FRONTING GRANT PARK

panoramic view of the city and lake may be enjoyed. The whole block immediately south of the Temple is occupied by the several fine buildings of Marshall Field & Company, unquestionably the largest and finest mercantile establishment in America. This immense retail store has a floor area of twenty-three acres, is equipped with fifty elevators, lighted by an equivalent of 40,000 sixteen candle-power lamps, and is frequently visited in one day by as many as 200,000 people. Many other large retail houses and office buildings line both sides of State street, from Lake street on the north to Congress street on the south, and midway is situated one of Chicago's largest and oldest hotels. Dearborn street, the next street west, is walled in by such an imposing double line of sky-scrapers as to suggest a deep and wind-swept mountain gorge. On this street the First National Bank Building is now in course of construction; when completed it will contain 9,000,000 cubic feet of space. On a square formed by the intersection of Dearborn, Jackson, Adams and Clark streets, the massive granite Government building is now nearing completion, its tremendous gilded dome towering far above the surrounding structures and dominating the whole city. Three blocks north, between Clark and La Salle streets, are located the municipal and county administration buildings, and on La Salle street are the Stock Exchange, the Board of Trade, the Illinois Trust and Savings Bank Building and a number of other fine structures devoted largely to banking and insurance interests.

Still farther west lies a portion of the city's wholesale district, and beyond the river, in zones of varying size, are manufacturing settlements and suburban residence districts extending north, south and west for distances ranging from twenty to thirty miles.

The environs of Chicago are encircled by a beautiful system of parks and boulevards, the scope of which is constantly being enlarged to keep pace with a rapidly increasing population. A complete circuit of the parks and their connecting boulevards may be made very pleasantly in three or four hours, covering a distance of forty or fifty miles, and this is a very popular automobile trip for visitors who desire to obtain a glimpse of the city's æsthetic development as expressed in its places of amusement and outdoor recreation, its picturesque drives, artistic homes and fine educational institutions. The University of Chicago, located near Jackson Park, is one of the youngest and largest universities in the United States, and its noble groups of buildings are models of architectural beauty. Four thousand five hundred students attended the university in 1903; the present endowment is $15,000,000, but the powerful support of Mr. Rockefeller and other wealthy and public-spirited men will probably quadruple this amount within the next decade.

*The Park and Boulevard System*

Chicago is exceptionally rich in her technical schools, chief of which are the Lewis Institute and the Armour Institute of Technology. The latter school, located at Thirty-third street and Armour avenue, was founded by the late Philip D. Armour, and its president is the Rev. Frank W. Gunsaulus. The institute offers a very broad and thorough four-years course in the various branches of engineering, and connected with it is the American School of Correspondence, which presents similar courses for the instruction of students who are unable to attend the institute in person. Lewis Institute, founded under the will of Allen C. Lewis, is a school of engineering and the applied arts, dedicated to the teaching of science, literature and technology. It has a total attendance of two thousand five hundred students, over half this number attending the evening classes. It has an endowment of $1,000,000 and receives an income of $50,000 from tuition fees. The institute is under the directorship of George N. Carman, and is located at the intersection of West Madison and Robey streets.

*Educational Facilities*

Chicago has built up a very efficient public school system, on which it spends over $12,000,000 annually for the free education of its children. During the first half of 1903 the enrollment showed a total attendance of 258,968 pupils and 5,444 teachers. Over $500,000 is disbursed every month by the city to the teachers and officials of the Board of Education, as against $775,000 paid to all other city employees. These figures are particularly significant and interesting, since they serve to explain, in a great measure, the wonderful ease and celerity with which Chicago digests and assimilates the perennial juvenile increment of its large foreign population. From the kindergarten to the high school, these children of two-score alien races rub elbows with the sturdy native stock and not only become thoroughly "Americanized" themselves, but carry home to their elders the broad and wholesome lessons of right living and thinking which they have absorbed at school.

*Newspapers and Periodicals*

There are 564 publications issued in this city, including 33 newspapers (printed in twelve languages), 46 religious periodicals, 35 scientific journals and 32 literary papers and magazines. The total circulation of the 15 leading daily newspapers is, 2,161,782 copies.

Space will not permit more than the mention of Chicago's organized charities and numerous hospitals, nor more than a passing reference to the sociological work being carried on at the well-known settlements of Hull House and the Chicago Commons. The former was founded in 1899 by Miss Jane Addams and Miss Ellen Starr; it now occupies commodious quarters in a group of eight buildings situated at 335 South Halsted street, and its work is devoted to training and uplifting the polyglot population of that congested district, with notable success. The Chicago Commons conducts a similar crusade of education and social development at the corner of Grand avenue and Morgan street, under the leadership of Professor Graham Taylor, a broad-minded economist and untiring worker for civic betterment.

*Libraries*

Chicago is excellently equipped with three large public libraries—the Chicago, the John Crerar and the Newberry—the two latter being reference libraries solely and the former a reference and circulating library. The Newberry occupies an imposing granite edifice on the north front of Washington Square, and its spacious rooms and book-lined alcoves are a favorite haunt of students and literary workers. It contains 260,273 volumes in its various departments of art, science and letters. The Crerar, organized in 1895, is a fine scientific library founded by the will of the late John Crerar, a wealthy and philanthropic citizen of Chicago. It has at present a collection of about 103,000 volumes, devoted almost wholly to the natural, physical and social sciences and their applications. Its endowment amounts to $3,400,000 and it occupies temporary quarters in the fifth and sixth floors of the Marshall Field building, pending the proposed erection of a beautiful permanent home on Lake Front Park. The Chicago Public Library, located at the corner of Washington street and Michigan avenue, represents the highest type of modern methods in library equipment and the happiest blending of utility with classic design. Its exterior is severely simple, but this only accentuates the contrast when the visitor passes within its portals and stands on the threshold of its lofty entrance hall, leading to two stately stairways in pure white marble, inlaid with exquisite mosaic patterns of green and gold. It is probably one of the most artistic examples of interior decorative effect in the country. At the close of the library year, May 31, 1903, the Public Library contained 285,000 volumes, and its aggregate circulation for the year was 1,609,983 volumes, not including the use of reference works. It is an exceptionally strong library in its chosen field, and through the medium of its sixty-eight branch stations it keeps in close touch with the remotest districts of the city. In addition to the above-mentioned libraries, Chicago has a number of others, more or less public in their privileges, connected with the Field

Columbian Museum, Lewis Institute, University of Chicago, Northwestern University and other institutions.

*Stock Yards*

Such a host of noteworthy plants, places and buildings are located in and around Chicago that it is impossible to mention all of them and unfair to make invidious distinctions, so that many matters of interest must be either touched upon very cursorily, or wholly omitted. But no account of Chicago would be complete without some reference to the gigantic live stock market known as the Union Stock Yards, and the various associated packing concerns that constitute in their entirety the greatest center of meat products in the country. The Stock Yards district comprises a tract of about 500 acres, hedged with huge packing plants, crosshatched with 22,000 cattle pens, gridironed by railway tracks and traversed in all directions by overhead viaducts. Half a million cattle, horses, sheep and swine are often handled here in one day. The Stock Yards give direct employment to 50,000 men and handle fifty per cent of all the cattle slaughtered in this country. In 1903, Chicago received 16,232,000 animals, valued at $295,217,000. The conversion of this tremendous amount of raw material into the innumerable primary and by-products for which Chicago is famous, is principally accomplished by Armour & Company, Swift & Company, Libby, McNeill & Libby, Nelson Morris & Company and several other large firms, whose various industries in packing and canning are collectively one of the main sources of the world's meat supply. The Stock Yards district is connected with all railways entering Chicago by the Chicago Junction Railway Company, which has two belt lines around the city and about 300 miles of trackage.

A word in conclusion. According to the census of 1900, the annual value of Chicago's manufactures was $888,786,311. Carl Buck, Professor of Sanskrit and Indo-European comparative philology at the University of Chicago, in his work on the "Linguistic Conditions of Chicago," enumerates over forty foreign languages that are spoken in this city. Here, then, is the extenuation for many of the crude and unlovely conditions that are, unfortunately, more obvious to the casual visitor than the promise of better things which they foreshadow. Chicago, the city of factories, is also the rendezvous of all nationalities. At present it is passing through a period of social and industrial evolution; it has had little time, as yet, for dreams and ideals, but it is beginning to realize the potentialities of its environment, and plans are now well under way for the conversion of its downtown lake front into parks and pleasure grounds, which will eventually conceal the existing wilderness of waste land and railway tracks. Chicago's corporate existence as a city covers only sixty-seven years; its faults are the faults of youth, and any final conclusions drawn from present conditions should be tempered by this consideration.

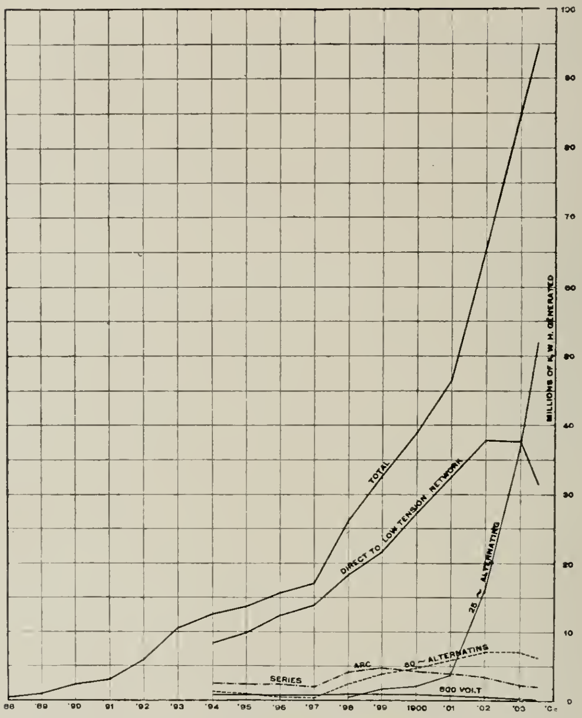
*ELECTRIC LIGHT AND POWER SERVICE*

## *Central Station Situation in Chicago; General Features.*

Since the earliest days in the history of electrical development, Chicago has been a prolific field for the application of electricity to the requirements of light and power service.

Turning back to fifteen years ago, we find the "Chicago Edison Company," the "Chicago Arc Light and Power Company," and then soon springing up the "Englewood Electric Light Company," and others innumerable. To-day there are two companies, the "Chicago Edison Company," and the "Commonwealth Electric Company," the latter having now outstripped the former in generating if not in distributing facilities. The Commonwealth Electric Company, a composite formation of the many earlier electric light enterprises, owes its birth to the economical possibilities of combination. This unification occurred about six years ago, and since that time entire harmony has characterized the co-working of these two companies: the Chicago Edison Company generating and distributing electricity in its territory and the Commonwealth Company doing likewise in its own territory. The latter, born in a period of rapid electrical development, was supplied in its earlier years with much of its electrical energy by the former. To-day this situation is reversed and the Chicago Edison Company is being supplied with alternating high tension current for its Converting Substations by the Commonwealth Electric Company from its new generating center, the "Fisk Street Station."

Of the entire 9,000-volt output, the predominating generated product of the two companies for the twelve months preceding July 1, 1904, 69.7 per cent was distributed on the Edison three-wire network; 14.7 per cent as 500-volt direct current for street railway




SHOWING VARATIONS IN TOTAL AND CLASSIFIED GENERATED OUTPUT

work, and 15.6 per cent as alternating current for lighting and general power.

The increase since 1888 in total load on the Chicago Edison and Commonwealth Electric companies' systems is illustrated above, which also shows the variation in annual maximum demand on the different classes of generated output. It is to be noted that since the development of the 25-cycle transmission system which has taken place since 1897, and the consequent centralizing of generating capacity in the Harrison street station of the Chicago Edison Company, and more recently in the Fisk Street Station, the proportion of electrical energy generated as 25-cycle current is rapidly increasing.

During the year 1904, the amount of energy generated as 250-volt direct current and also that generated at 60 cycles has begun to decrease, due to the shutting down of the Washington and 56th street stations for a large portion of the day during ten months in the year.

In general, the policy of these Central Station Companies is to generate their output at 9,000 volts in large central stations by large units and to transmit this output to the substations at this pressure. In the substations supplying the downtown districts—where 50 per cent of the load is power, or, in comparison with the total generated load, 14 per cent is elevator motors and 21 per cent general power—low-tension, direct-current distribution is used, the conversion being effected by step-down transformers and rotaries. Thus the character of the load determines largely the kind of distribution.

From the description of substations given later, it will be seen that the battery capacity installed at the one-hour rate is about 30 per cent of the total generating capacity, which insures the system against interruption, a factor paramount in central station service. The policy for the residence districts, where the percentage of lighting load is high, is to install frequency changing sets and to distribute 60-cycle current at 2300/4000 volts; a practice again admirably adapted to the load and the district supplied.

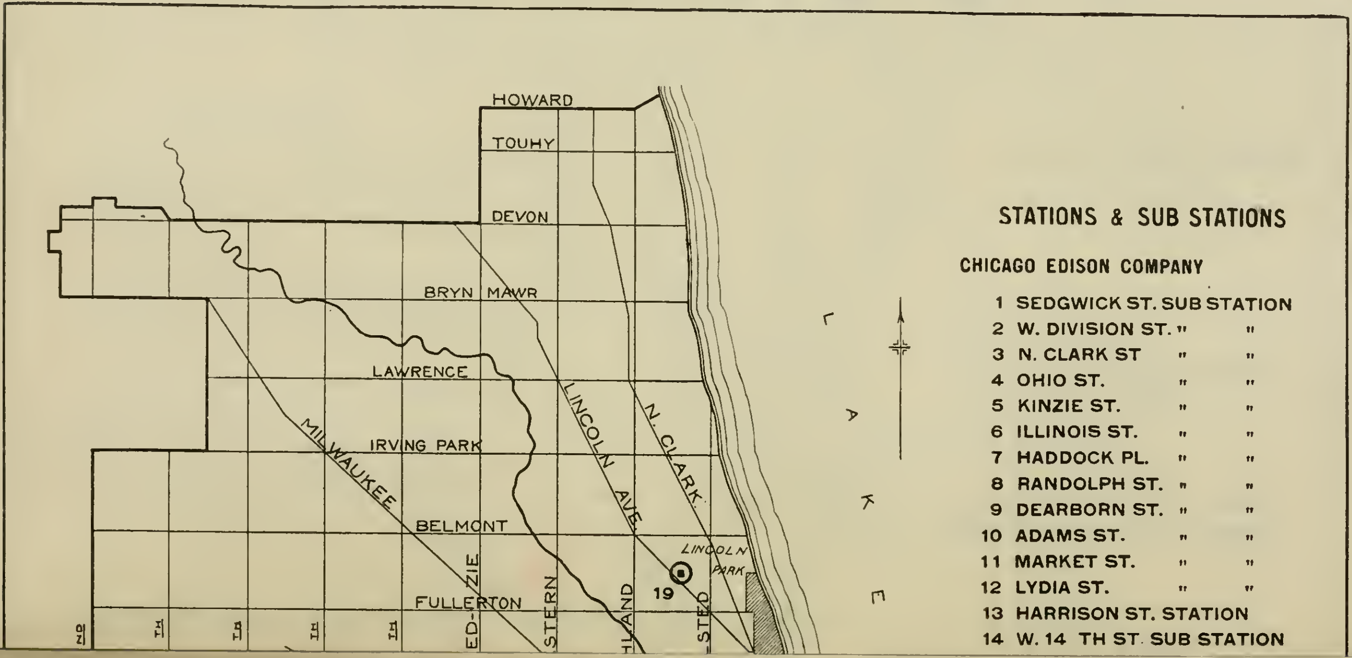
### GENERATING AND TRANSMISSION SYSTEM

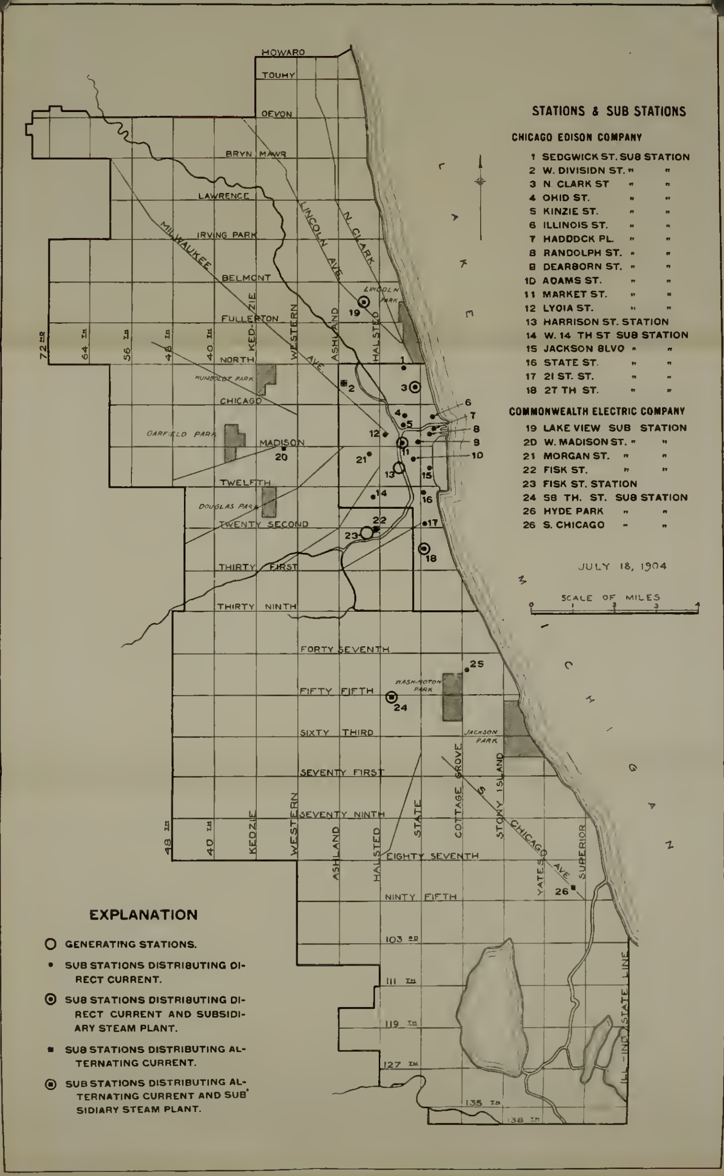
The Chicago Edison Company supplies both the business and older residence sections of the city of Chicago with direct current, employing for this purpose the well-known 115/230-volt Edison three-wire system installed under ground. Service is supplied by this company for all purposes: lighting, general power and elevator power proportionately in the order named. The company serves 17,000 customers with 1,330,000 lights and 44,270 horse-power in motors.

The Chicago Edison territory is divided into four districts all interconnected by a vast network of underground conductors, the Chicago river being crossed by submarine cables and undermined by tunnels to effect this juncture. Four stations with a total capacity of 23,000 kilowatts, and eighteen substations equipped with 18,000 kilowatts in rotary converters and 12,500 kilowatts in batteries (one hour rate of discharge), supply these districts with current. In addition a supply of 10,000 kilowatts is available from the Commonwealth Electric Company, thus insuring excellent service for the customers of both companies.

The Chicago Edison Company has remaining only one large generating station, the Harrison Street Station, which is yet the mainstay of this company. The Washington Street Station, formerly interesting from the standpoint of adaptability of an old plant to a modern system and ranking second to Harrison Street, has been stripped of much of its power, a large, new, rotary substation adjacent having been substituted to provide direct current for the Edison three-wire system at this point. Two other so-called subsidiary steam plants (combined generating plants and substations), viz., the North Clark Street Station and the Twenty-seventh Street Station, complete the list of generating plants of the Chicago Edison Company.

The transmission system of the Chicago Edison Company is a striking example of evolution and shows clearly the wonderful power-transmitting possibilities in a crowded business district of a great municipality, where safety, reliability and appearance are factors of primary importance. The high tension transmission system of the Chicago Edison Company from the generating sta-


HOWARD
TOUHY
DEVON
BRYN MAWR
LAWRENCE
IRVING PARK
BELMONT
FULLERTON
MILWAUKEE
LINCOLN AVE.
N. CLARK.
LINCOLN PARK
19
L A K E
STATIONS & SUB STATIONS
CHICAGO EDISON COMPANY
1 SEDGWICK ST. SUB STATION
2 W. DIVISION ST. " "
3 N. CLARK ST " "
4 OHIO ST. " "
5 KINZIE ST. " "
6 ILLINOIS ST. " "
7 HADDOCK PL. " "
8 RANDOLPH ST. " "
9 DEARBORN ST. " "
10 ADAMS ST. " "
11 MARKET ST. " "
12 LYDIA ST. " "
13 HARRISON ST. STATION
14 W. 14 TH ST. SUB STATION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CHICAGO EDISON COMPANY
1 SEDGWICK ST. SUB STATION
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9 DEARBORN ST. " "
10 ADAMS ST. " "
11 MARKET ST. " "
12 LYDIA ST. " "
13 HARRISON ST. STATION
14 W. 14 TH ST SUB STATION
15 JACKSON BLVD " "
16 STATE ST. " "
17 21 ST. ST. " "
18 27 TH ST. " "
COMMONWEALTH ELECTRIC COMPANY
19 LAKE VIEW SUB STATION
20 W. MADISON ST. " "
21 MORGAN ST. " "
22 FISK ST. " "
23 FISK ST. STATION
24 58 TH. ST. SUB STATION
25 HYDE PARK " "
26 S. CHICAGO " "
JULY 18, 1904
SCALE OF MILES
0 1 2 3 4
LAKE MICHIGAN
HOWARD
TOUHY
DEVON
BRYN MAWR
LAWRENCE
IRVING PARK
BELMONT
FULLERTON
NORTH
CHICAGO
MADISON
TWELFTH
TWENTY SECOND
THIRTY FIRST
THIRTY NINTH
FORTY SEVENTH
FIFTY FIFTH
SIXTY THIRD
SEVENTY FIRST
SEVENTY NINTH
EIGHTY SEVENTH
NINTY FIFTH
103 RD
111 TH
119 TH
127 TH
135 TH
138 TH
MILWAUKEE
LINCOLN AVE
N. CLARK
ELSTON AVE.
72 ND
64 TH
56 TH
48 TH
40 TH
KEDZIE
WESTERN
ASHLAND
HALSTED
STATE
COTTAGE GROVE
STONY ISLAND
S. CHICAGO AVE.
YATES
SUPERIOR
ILL.-IND. STATE LINE
LINCOLN PARK
HUMBOLDT PARK
GARFIELD PARK
DOUGLAS PARK
WASHINGTON PARK
JACKSON PARK
EXPLANATION
GENERATING STATIONS.
SUB STATIONS DISTRIBUTING DIRECT CURRENT.
SUB STATIONS DISTRIBUTING DIRECT CURRENT AND SUBSIDIARY STEAM PLANT.
SUB STATIONS DISTRIBUTING ALTERNATING CURRENT.
SUB STATIONS DISTRIBUTING ALTERNATING CURRENT AND SUBSIDIARY STEAM PLANT.

tions to all substations is installed underground, and so thoroughly has this system been developed, installed, and protected that it could probably be used without alteration for transmission at twice the present system potential.

The transmission system of the Commonwealth Electric Company, employing as it does the same voltage and frequency, is being rapidly developed in accordance with the same high standard, thus making possible any desired exchange of energy and the best economy in operation, of mutual advantage to the two companies.

The Commonwealth Electric Company covers the entire City of Chicago, but thus far has devoted itself almost entirely to the outlying suburban and residential districts, leaving the business and older residence sections to the Chicago Edison Company. All of this large outlying territory is covered by a 2300/4000-volt, 4-wire, 3-phase, 60-cycle, overhead system of primary distribution, supplied from two subsidiary steam plants, the Fifty-sixth Street and the Lake View stations, and five substations, the latter receiving energy from the new Fisk Street Station.

The accompanying map shows the location of the generating and distributing centers of the two Central Station Companies in the City of Chicago.

The proximity of these centers gives at once a fair indication of the relative density of the load, at least in the older portion of the city, in which, as previously stated, the distribution is by means of the Edison three-wire direct current system.

## CENTRAL STATION OPERATING CONTROL

The greater possibilities in central operating control of these two great interdependent companies were early recognized.

The rapid growth of the business, the intricate character and multiplicity of apparatus employed, made it advisable to further concentrate this control of the operation of the system and resulted in the creation and maintenance of the office of Load Dispatcher.

The duty of the "Load Dispatcher" is to perpetuate operating service and to control the transmission and transfer of any and all "Load," that is, all electrical energy between all stations and substations of the two companies. He is thus particularly responsible for the high potential transmission system and controls absolutely the operation of all lines, line switches, and bus bar tie switches which comprise this system.

This service is maintained throughout the twenty-four hours of the day and requires the services of three men. A chart bearing graphical representation of all transmission lines and station busses, and characters representing all generators and switches, is provided for convenient reference. This chart is manipulated in accordance with switches opened or closed or generators put on or taken off the system, and represents at any instant the actual operating conditions of the system as a whole. Direct telephone service with all of the stations is afforded through lines from the many station operators to an exchange which the "Load Dispatcher" alone controls.

This in no wise lessens the importance or the vigilance required in the operation of the generating stations or their dependent substations, but insures their fullest co-operation and the most satisfactory net result in maintaining central station service.

Of great importance also in the operation of these large companies is their system of central coal storage.

### COAL STORAGE

But a few years since it was the practice of the Chicago Edison Company to arrange with some of the big coal handling concerns of the city for the storage of a large quantity of coal whenever there were any indications of an approaching shortage or restriction in coal supply. This method soon proved unsatisfactory, and the recent purchase of a tract of land about 250,000 square feet in area, located just across the river from the Fisk Street Station, provides the storage space for about 25,000 tons of coal. This property borders on the river and is entered on the south by the tracks of the Chicago & Alton Railroad. The capacity of 25,000 tons is based on the deposit in the shape of an open "pile" or rather a lot of coal simply spread over the ground from cars on parallel tracks. This can be done either by means of a locomotive crane or by shoveling and wheeling. This coal reserve is about two and one-half miles from the Harrison Street Station down the river, and coal can be quickly conveyed to that station whenever the occasion requires.

A provision such as this is, of course, essentially an insurance, while economy demands that the coal be handled as infrequently as possible. A large quantity, say 50,000 tons, judiciously bought, can thus be allowed to remain here until the emergency necessitating its use arises. The company is thus assured of possession in times of need.

STORAGE BATTERIES

A further safeguard of almost immeasurable value to their customers, and particularly to those supplied with direct current, is the judicious distribution over the direct current system of a large capacity in storage batteries.

The Chicago Edison Company has a large amount of storage battery capacity distributed among its various substations. About 30 per cent of the total annual maximum demand can readily be carried by the storage batteries for one hour. The type of battery used is uniformly that of The Electric Storage Battery Company, the "Chloride Type." This form of cell is well known, and the continued installation of this same type of battery is the best indication of their satisfactory commercial operation.

The installations up to the present time have been chiefly for system operation, there being only one for station operation. These different system batteries range in size from plates of the G. type, 33 in number, capable of a 1,000-ampere discharge rate, to plates of the H. type, 83 in number, capable of 6,000-ampere discharge rate; these discharge rates being on a one-hour basis. These system batteries average about 78 cells, with 23 end cells on either side of the three-wire system, and are generally provided with two or three end cell switches, allowing flexibility in charging, discharging and "floating." The "end cells," so called, are those to any one of which connection can be made at will by an end cell switch, thus varying the number in series and giving different potentials. Booster sets, capable of use also as balancing sets, varying in size from 30 to 100 kilowatts (one generator for each 78 cells), provide the necessary charging energy in all cases except one, where specially arranged rotary converters are employed to give the necessary increased voltage for charging.

The booster sets are three-unit type, made by the General Electric Company, and consist of two 60-volt shunt-wound generators, mounted on the same shaft with a shunt-wound, 250-volt motor. In charging, one of the generators is connected to the positive and the other to the negative main of the system, thus increasing the pressure to a suitable voltage.

Special features in connection with the battery installations of the Chicago Edison Company are apparent at once, whether brought to notice through inspection or detailed study of the battery substations. The electrical indicator, neater, more reliable and more logical than the previously used mechanical device, and the switchboards, conforming in a general way to the standardized rotary and feeder panels and occupying about one-half the space of the previous American practice, unite to indicate the already recognized permanency of the storage battery in direct current distribution systems.

The maintenance of the batteries is wholly in the hands of an expert, a storage battery superintendent who devotes his entire time to this purpose. Tests are regularly made, so that the condition of any cell in any battery is known at all times. If a cell develops any vital weakness, steps are taken immediately to overcome this defect, with the result that batteries are always in best possible condition.

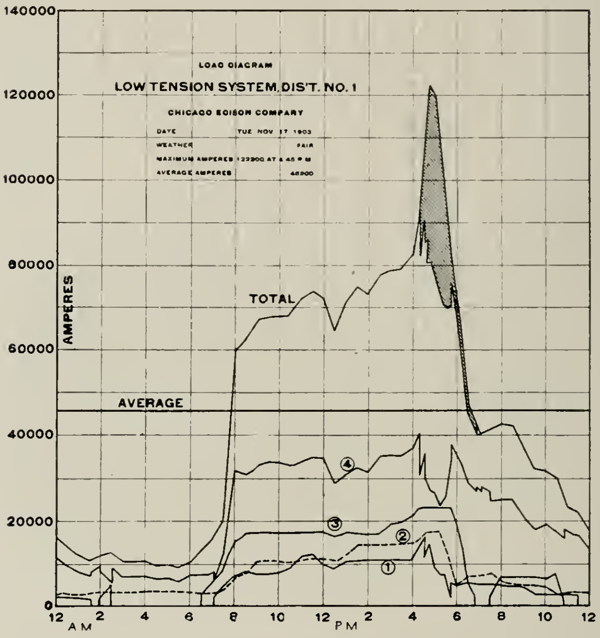
A valuable aid to the upkeep of the batteries is the practice of installing double tiers of insulators under the cells. This decreases leakage to ground, facilitates inspection, and permits easy cleaning. Generous ventilation, either natural or artificial, generally the latter;

REPRESENTATIVE BATTERY ROOM

thorough sanitary equipment and careful construction render the largest of the storage batteries of the company unobjectionable tenants in the finest of buildings.

The interior of one of these installations is given on this page.

The functions of the storage battery, installed as these are in connection with a large distribution system, are well known, and a record of the performances of the batteries of this company shows how well they fulfill their purpose.* Sometimes a demand comes for the service of nearly all the batteries simultaneously, and their "readiness to serve" at such a period makes them




LOAD DIAGRAM FOR DOWNTOWN BUSINESS DISTRICT, SHOWING USE OF STORAGE BATTERY AT PEAK OF LOAD

Curves 1, 2, 3, and 4 show loads on Randolph St., Dearborn St., Market St., and Harrison St. Substations, respectively.

a most valuable ally to the central station and an unfailing friend to its thousands of customers, large and small.

CENTRAL STATION SUPPLY TO LARGE CONSUMERS

Some of the largest wholesale and retail concerns are central station dependencies for their light and power

* The diagram herewith shows a typical case of this kind.

supply, and a detailed description of one of these large customers is given herewith.

One of the most notable examples of the use of electric current for both power and lighting from central station service in Chicago is to be seen on the premises of Marshall Field & Company's large retail department store. The store in question occupies almost an entire city block, and has a floor area of 960,000 square feet.

MARSHALL FIELD & COMPANY'S RETAIL STORE

The connected load is 3,650 horse-power in motors, and an equivalent in lighting of over 40,000 16-candle-power lamps. Fig. 6 shows the exterior of the building.

When the problem of providing power and lighting mains arose at the time the new building was erected, it was decided after a most thorough investigation to adopt central station service. The main features which led to this decision were: The high rental value of the space which would be necessary for the installation of an isolated plant, and the necessary coal storage; the difficulties in arranging for a steady supply of coal, the location of the building being such that coal could only be delivered in wagons; and contrarywise the fact that the Chicago Edison Company's system included several plants and storage batteries, all interconnected, and that service was obtainable through three different channels.

Such a mercantile center requires a varied application of power, and the electrical features in the installation preponderate—electrically driven machinery being used almost exclusively. The mains of the Chicago Edison Company enter the basement of the several buildings at fourteen different points, feeders for light and power purposes being separate and so connected that in case of failure of supply through one channel the load can be immediately thrown to another. Switchboards provided with the necessary switches and meters for measuring the current are installed at each service.

The lighting presents no unusual features; there is one 16-candle-power lamp installed, or its equivalent, for every twenty square feet of floor area. The maximum variation of potential between any two lamps in the building does not exceed two volts. The maximum power on any tap circuit is 660 watts. The wiring is done according to the most modern methods, concealed in the walls and ceilings and protected by iron conduit, into which it is drawn. Each circuit is provided with a switch and enclosed fuse. These switches and enclosed fuses are installed on panel boards in fireproof cabinets on each floor.

There are about 200 enclosed arc lamps used in the various buildings, where the violet rays are not detrimental to their use. Incandescent lamps are used exclusively in the salesrooms, the yellow light from incandescent lamps being more desirable than the arc lamp rays. A very efficient installation of incandescent lamps in show cases has been installed. Miniature lamps are used in mirror reflectors; the reflectors being installed in the top of the glass case, and hidden from view by means of bands of silvering about two inches wide inside the glass.

The installation of elevators is of the tandem double worm gear direct connected type, each being equipped with a 40 horse-power motor. There are forty-six of these elevators throughout the buildings, making a total of 1,840 horse-power for elevator service alone. The passenger elevators have a capacity of 3,000 pounds 350 feet a minute; the freight elevators have a capacity of 3,500 pounds 250 feet a minute, the former reaching a maximum acceleration in the up trip of from five to six seconds. The operating mechanism of these elevators is located in the attic. The motors are controlled by an electro-magnetic system. Besides the elevator installation there are four dummy package elevators, motor driven. These are automatically operated by a push button system, which starts and stops the elevator at any floor.

The general power installation consists of some 150 motors, ranging in size from $\frac{1}{4}$ to 125 horse-power. These are all 220-volt motors, some being constant and others of variable speed, according to the requirements. The speed regulators are so arranged that at a normal speed no armature or field resistance is introduced, so that there is no waste of energy when operating under normal conditions. A reduction of 50 per cent below normal speed is obtained by armature resistance, or an increase of 33 per cent is obtained by field resistance. The ampere turns of both series and shunt field winding are the same; a better starting torque and regulation is thus obtained. A great many of the motors are also equipped with the Reynolds silent chain, as the floor space is limited, prohibiting the use of leather belts.

In addition a refrigerating plant has been installed, consisting of two 50-ton duplex compressors. The brine, which is a calcium-chloride solution of 1,250 degrees Beaume, is circulated throughout the system for cooling the large fur vault located on the 12th floor, and refrigerators in the kitchens. As a supply of dry air is required for the fur vault, which is kept at 15 to 20 degrees F., the air is circulated by means of a motor-driven fan. After it has been through numerous coils the temperature difference between the outgoing and incoming air varies from 4 to 7 degrees. The water for cooling is used for household purposes, after being discharged from the ammonia condensers, and as the demand for water greatly exceeds the requirements, the system is operated at a high efficiency. The head pressure is 125 pounds, whereas the back pressure is 7½ pounds. Water for drinking purposes is cooled to about 40 degrees F. by means of a Beadelot coil filter, and forced by two 8 x 6-inch duplex circulating pumps to various parts of the building.

Two Ingersoll-Sargent air compressors and one 8 x 8-inch Christensen compressor, driven by variable speed motors, supply air at 140 and 80 pounds respectively for the elevator doors and carpet renovators. Two 75-horse-power and two 40-horse-power motorsdrive four blowers of the positive type, which maintain a 2-inch vacuum for 200 stations of the cash carrier system. In addition, motors operate five house service pumps, supplying 18,0C0 gallons of water per hour, and are used for miscellaneous purposes, such as driving sewing machines, small tools, etc.

The heating plant consists of ten 80-horse-power boilers, of the Marine firebox type, which were formerly used for supplying steam to the engines. These boilers are hand fired, as they are installed in very close quarters. Two loop mains, for high or low pressure service, furnish the steam for heating, cooking and many other purposes. A pressure of 40 pounds is carried, this being considered the best for the existing conditions, avoiding high pressure on the boilers and at the same time high enough to eliminate the irregularities of hand firing.

The heating system is of the single pipe type and is used in connection with the Paul vacuum system. In the basement the heating and ventilating systems are combined, a change of air being effected every twelve minutes by motor-driven fans.

Two motor-driven fire pumps, each capable of delivering 850 gallons per minute, of the horizontal triplex type, are used in connection with the sprinkler system installed throughout the building. A pressure of 180 pounds is maintained on this system. Separate feeders are run from the near-by rotary converter and storage battery substations to these motors, they being entirely independent of the regular street mains. The installation of these fire pumps is notable in that they are the first of the kind to be installed to take the place of constant-running steam pumps, which the underwriters have previously specified for the sprinkler system where low rates of insurance are allowed.

The Chicago Edison and Commonwealth Electric companies have both been remarkably successful in securing customers who formerly operated their own isolated plants. The result has been that very rarely an isolated electric plant is installed in any new building, and comparatively few isolated plants remain in old buildings in the downtown business district of the city.

### HARRISON STREET STATION

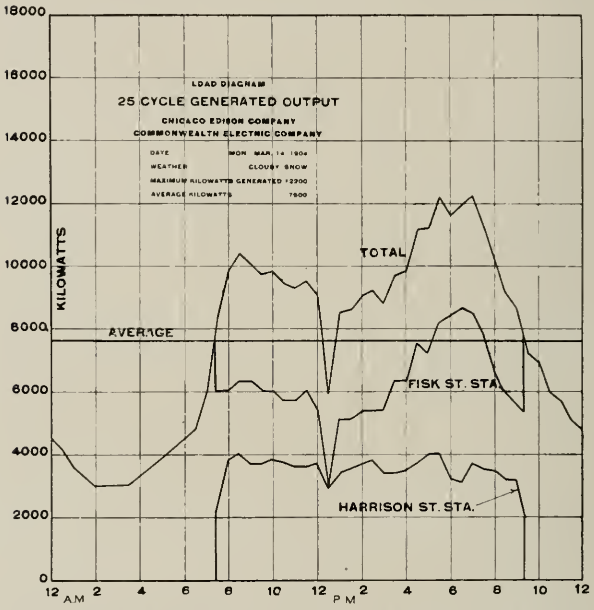
This, the main generating station of the Chicago Edison Company, embodies many indications of the growth of the company, and illustrates as well the advance in central station practice.

Essentially a direct current station, it has been enlarged until one finds now a great direct current station supplying customers directly, a large alternating current generating station supplying a considerable number of substations, double current machines performing either function or doing duty as rotary converters, and, installed under the same roof, a large storage battery. The diagram on page 38 shows the load conditions prevailing at this plant at the time of the present writing.

The Harrison Street Station occupies a plat of land on the west bank of the south branch of the Chicago river at Harrison street. The station has been enlarged until every available foot of ground is occupied. The river on the east and the Chicago & Alton Railroad tracks on the west provide facilities for coal delivery.

The building, the exterior of which is shown on page 39, is a steel structure. Red pressed brick walls give a tone to the building not unfavorable in comparison with large structures in the vicinity devoted to less active purposes. On the south there is an annex containing the offices and 3,800 kilowatts of alternating current generating machinery. The large central portion of the building from east to west contains the older direct current generators, aggregating 6,400 kilowatts in capacity. Just north of this is the old boiler room, and at the extreme north is the storage battery annex.

In the old boiler room there are 24 Heine boilers equipped with Babcock & Wilcox chain grate furnaces aggregating 14,000 horse-power, and in the south annex there are four Babcock & Wilcox boilers with chain grates, each of 512 horse-power, making a grand total for the station of about 16,000 boiler horse-power, all equipped with mechanical stokers and chain grates.




LOAD DIAGRAM, SHOWING RELATIVE LOAD ON PRINCIPAL GENERATING STATIONS

Four steel stacks, 188 feet in height and 13 feet in diameter, furnish the draught for the boilers in the old boiler plant, while another 175 feet in height and 9 feet in diameter performs a similar function for the four boilers in the new annex.

One Robbins and two McCaslin conveyors supply coal to the 1,000-ton bunkers above the boilers.

Upon entering the engine room one is impressed with the varying size and the number of units employed in the generation of electricity, and it is at once apparent how conditions imposed by a rapid business development may be met when demands are made upon engineering concerns. As before stated, there is a great variety of apparatus, yet it is well disposed and the general appearance of the station conveys the impression of a great, powerful, though compact, generating center. The

EXTERIOR OF HARRISON STREET STATION

large, double-decked switchboard gallery at the east end of the central aisle has lost none of its attractiveness, although additions and alterations innumerable have created an electrical metamorphosis in its vital parts. Adjacent to it at the south is the alternating current switchboard, with generator and line control panels.

These switchboards on the operating gallery are varied in construction and purpose. The old direct current board belonging to the original installation controls the direct current machines, the generator control panels forming a lower tier, while above these are the feeder panels. Heavy copper construction behind this board and comparatively little secondary wiring for the switchboard are typical of the days of manual control.

A later addition, the new high-tension control switchboard, is of the type combining the instrument panel and the operating table. On the instrument panels are indicating meters for the lines and machines, while on the operating table are the controls for the various oil switches.

On the engine room floor there is a group of direct current engine-driven units, 6 in number. These are all of the vertical, triple-expansion type, two being of Edison General Electric design (94 revolutions per minute) and the other of the Southwark Foundry design and manufacture (120 revolutions per minute). Each is rated at 1,200 horse-power and is direct connected to two 400-kilowatt, direct-current, multipolar, 150-volt, shunt-wound generators, one of which operates on the positive and the other on the negative side of the three-wire direct-current system. These machines have been in active operation for about ten years and are still doing good service.

Four more Southwark engines, of 600 horse-power each, having two 200-kilowatt, direct-current machines direct connected and of the same type as above, complete the Harrison Street Station of the 19th Century. Among these are two pair of double-current generators, rated on the alternating current end as 3-phase, 25-cycle, 85-volt machines. The pressure of these machines is raised to 9,000 volts by means of six 150-kilowatt air blast transformers.

Next are the large units, defining clearly the new epoch in the station's development. The first is a 3,500-horse-power, vertical, cross-compound Allis engine, running at 75 revolutions per minute, driving a 2,500-kilowatt, double-current generator, giving 170-volt, 6-phase, 25-cycle alternating current or 300-volt direct current. The output of this machine is "stepped up" to 9,000 volts by means of two banks of three 450-kilowatt, single-phase, air-blast transformers.

The second large unit is a 5,000-horse-power, vertical, cross-compound Allis engine, running at 75 revolutions per minute, driving a 3,500-kilowatt, 9,000-volt, 25-cycle, 3-phase alternator.

In the annex there is a 3,000-horse-power horizontal tandem compound, old type, Corliss engine, running at 60 revolutions per minute, and driving through a rope transmission two 1,000-kilowatt, 25-cycle, 9,000-volt, 3-phase generators; and a 2,500-horse-power, vertical, cross-compound Allis-Chalmers engine direct connected to an 1,800-kilowatt General Electric, 25-cycle, 9,000-volt, 3-phase generator. These alternating current generators are controlled from the panels installed on the operating gallery in the main engine room.

In the North Annex of the building there is installed a battery for service on the three-wire system on the Chicago Edison Company. It consists of 160 H.-61 cells with discharge rate of 4,500 amperes at one hour rate. There is also a three-unit booster set for charging the battery, which consists of a motor driving two generators of 1,500-ampere, 70-volt capacity, with necessary controlling panels for booster and batteries.

The high-tension bus and line system is taken care of in rooms which have been added on the interior of the station. In these structures the different compartments are known as "Switch Rooms," and cable running on insulators beneath the oil switches or practically in the floor of these rooms is employed in the construction of the bus. In these various "Switch Rooms" there have been installed many high-tension solenoid operated switches necessary for control of the generators and of the outgoing lines.

WASHINGTON STREET STATION

Until six months ago this station was second in importance to the Harrison Street Station. It formerly contained a greater variety of electrical generating apparatus than any other station of the company. First the series arc equipment of about 2,000-light capacity was disposed of, the arcs being changed over to constant potential system; next the load carried by a single-phase, alternating-current equipment of about 500 kilowatts was taken over by other stations, until now the last remaining 500-volt power load is being changed over to the three-wire system and nothing remains except the direct-current equipment.

The building, rather irregular in outline, constructed of brick in a plain manner characteristic of stations of the earlier type, is situated on the Chicago river at Washington street, and nearer the center of the downtown district than any other generating station. This plant has been operated continuously for the fifteen years preceding May 1st, 1904. Formerly there were three floors to this station, the bottom being the engine room with the direct connected direct current units; the second floor contained the direct current switchboard and other switchboards and all the series arc and 60-cycle alternating machinery, while the floor above was used as a counter-shaft room for the belted units on the second floor.

The boiler room at the north end still contains six Edgemoor boilers, with a total of 3,250 horse-power, and four Climax boilers of 500 horse-power each. The engines and generators still in service are the following:

One 1,500-horse-power Tandem Compound Southwark engine, running at 120 revolutions per minute, direct connected to a 1,000-kilowatt, General Electric, 300-volt, direct-current generator.

One 1,000-horse-power, cross-compound Williams engine, 120 revolutions per minute, driving a 700-kilowatt, 300-volt, direct-current generator.

Four Porter Allen tandem compound engines, 550 horse-power each, driving eight 225-kilowatt, 135-volt, direct-current generators, half being on the positive and half on the negative side of the system.

Three 500-horse-power tandem compound Williams engines, 132 revolutions per minute, driving six 250-kilowatt, 135-volt generators.

The contemplated operation of this station, with its 5,000 kilowatts of generating capacity, as an annual "Peak" plant, gives a striking illustration of the extent to which it is permissible to carry the principle of "Peak" operation of plants when the more modern and economical plants are available.

It is of interest to note that owing to the high cost of coal conveyance to this plant the boilers have been equipped for gas burning, and for several seasons the station has been operated in this manner very satisfactorily.

### CHICAGO EDISON SUBSTATIONS

Prominent among the features of these substations are the switchboards of the company's design, well built, handsome in appearance and as safe as electrical apparatus can be made with every detail thoroughly worked out. Special attention is given to the back of the switchboards with respect to both the wiring and the provision for working space and also to the protection of cables leading from them. On the switchboard itself are installed the best operating devices procurable and every panel is laid out with a view toward simplicity of control, so essential to successful routine and emergency operation.

Throughout the direct-current substations, with only a very few exceptions, all rotaries and their auxiliaries are counterparts, the principle type of rotary being the six-phase, diametrically connected, 500 or 1,000 kilowatt unit, with a three-phase, air-cooled transformer. These rotaries operate from a 9,000-volt, 25-cycle transmission system, while current is delivered to the direct-current system at 250 volts. The center of the low-tension side of the three-phase transformers furnishes a neutral connection to the system.

The transformers are usually three-phase delta connected on the high-tension side and six-phase diametrically connected on the low-tension side; the parts being all in one case, with an ample opening in the bottom for air blast from below. The six-phase regulators are of the induction type remote controlled and provided with an open base for air blast. The rotaries are also installed in such a manner as to permit the upward passage of cooling air. The regulators used with the 500-kilowatt rotary installation are of a capacity of 44 kilowatts, while those used with the 1,000 rotaries are of 88 kilowatt capacity. Copper bar usually furnishes a neat and efficient means of connection between transformer and regulator and between regulator and rotary.

All rotaries are equipped with speed limit devices, while reverse current attachments to the direct current ammeters open the circuit breakers of the rotaries upon a reversal of current. Some of the speed limit devices are those of the centrifugal type, while others are a purely electrical variety which operate upon increase of frequency.

A few details of the standardized rotary and feeder panels serve to illustrate the general high standard of construction. On the rear of the board the bus construction is such that the positive and negative connections are kept entirely apart, the positive bus occupying the upper and the negative the lower half of the board. Copper bars connect the rotary cables to the buses, while small, well-ordered wires form a continuation of the multiple control cables from the terminal boards to the instruments or controlling apparatus. Thus all cables are kept off the back of the board, making it easily accessible.

On the front of the switchboard uniformity in operation of switches and unmistakable indicating and signal devices furnish all that is necessary for reliable operation.

Transmission lines are usually brought into the substations by different routes from different sections of the generating station. The high-tension bus at the substation is usually sectionalized so that immunity against a complete shut-down is obtained. This is further illustrated by the study of the individual installations, wherein the large proportion of storage batteries add their reserve strength to the bulwark against interruption of service.

The installation of cranes, wherever there is revolving machinery and sufficient head room, is a valuable feature of these substations, which greatly facilitates the rapid installation or removal of apparatus in cases of emergency.

### DOWNTOWN SUBSTATIONS

In the "downtown," or most thickly built up, business district of the city, bounded on the north and west by the river, on the east by the lake, on the south by 12th street, known to the company as District No. 1, six substations operate to maintain the three-wire, direct-current service, and since the varying load conditions here affect all of these substations similarly, they will be considered together.

The proportion between revolving machinery and battery installations is very carefully maintained, and a study of this district, regarding its load factor, its connected load, the time of the daily maximum and the amount of the maximum load, with respect to the system as a whole, could be made the subject of a most interesting treatise. One feature of similarity among the substations, all located on expensive real estate, is the fact that five of the six are located in basements of office buildings. The one exception, the Market Street Substation, occupies the lower floors of a building owned by the Chicago Edison Company.

The substations known as "Randolph Street," "Dearborn Street," and "Jackson Boulevard," the names in each case being derived from the streets upon which they are located, are equipped with rotaries only. The "Adams Street" and "Haddock Place" substations are equipped with batteries only, while the new "Market Street" Substation combines both equipments.

EDISON BUILDING

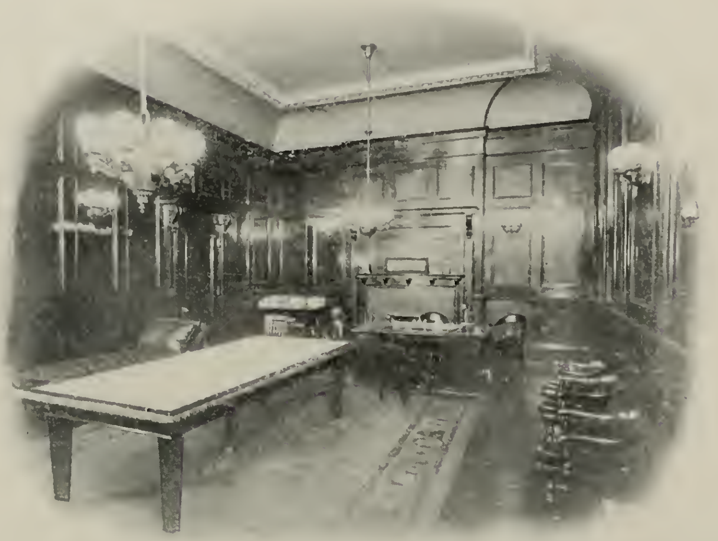
*Edison Building*

By no means least in importance among the company's downtown properties is the handsome and substantial Edison Building, containing the General Offices of the company. The basement and rear portion of the first floor contain the Adams Street Substation. The site of the present building, 139 Adams street, marks the location of one of the company's earliest endeavors in the field of electric lighting, although nothing of that historic plant now remains.

The Edison Building, of moderate height and with large, towering office buildings on either side, presents the strong yet refined forms of the French Renaissance, and has a facade of strong individuality, commanding attention by its richness and beauty of detail, rather than by its bulk. This facade is of Milford pink granite, the surface for the first two stories being highly polished, while the upper portion to the top of the parapet wall is ten-cut work. Above this is a cresting and a large central motive of terra cotta, and, crowning all, a Mansard roof of red tile.

The walls and ceiling of the entrance hall are of English vein Italian marble, and the floors of marble mosaic. The stairs to the second story are of marble, with a heavy wrought-iron balustrade.

The executive offices of the company are located in the front portion of the building, on the fourth and fifth floors. The Directors' Room, on the fifth floor, is in Italian Renaissance style, with panels of mahogany wainscoting twelve feet high and coved ornamental stucco ceiling. A feature of the company's general office building is the Employes' Library and Meeting Room, which is wainscoted five feet high in dark English Oak, with green walls above, and has a floor of quartered oak. The entire building is occupied by the offices of the various departments of the company, among which might be mentioned the Contracting, Inspection and Construction Departments on the second floor, the Accounting Department on the fourth floor, the Pur-



DIRECTORS' ROOM, EDISON BUILDING

chasing and Supply Departments on the fifth floor, the Operating and Engineering Departments on the sixth floor, and various other departments located throughout the building, with particular reference to their co-operation with the foregoing and their work and relations with the public.

*Adams Street Substation*

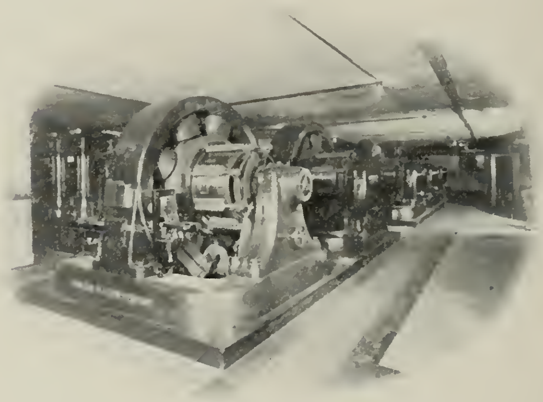
The "Adams Street" Substation, located at the heart of the business district, ranks first by reason of its seniority and the amount of output that it distributes.

DISTRIBUTION ROOM, ADAMS STREET

It was originally intended as a distributing center for the direct-current generators at Harrison street, which office it has maintained through the epoch of modernizing which the system has undergone. Current is supplied to the bus bars of the distributing switchboard by a trunk line from the Harrison Street Station, of a circular millage amounting to 63,000,000 c. m. and a length of 3,400 feet, and is distributed by means of feeders, 47 in number, and of sizes varying from 350,000 to 1,000,000

c. m. Page 49 shows the arrangement of the switch boards in this substation.

Three batteries, averaging 154 cells per battery, with a united capacity of 27,000 amperes at 1½-hour discharge rate, or 8,400 amperes at the 8-hour rate, have been installed in this substation, making a battery installation of unusually large size. A three-unit booster set with a 300-horse-power motor, driving two 100-kilowatt generators for charging the batteries, completes the equipment.



INTERIOR OF RANDOLPH STREET SUBSTATION

*Randolph Street Substation*

A 3,000-kilowatt substation in the basement of one of the city's largest office buildings, with headroom preventing the installation of any units larger than 500-kilowatts and with a single consumer, just across the street, having a connected load of 40,000 lamps and 3,000 horse-power in motors—such are the unusual conditions defining the Randolph Street Substation. An interior view of this substation is shown above.

Installed about three years ago, and containing at present five 500-kilowatt rotary converters, with a 100-kilowatt, 125-volt balancing set arranged to be thrown to either side of the three-wire system, this substation operates to maintain the service in the northeastern part of the downtown district. The plans admit of an increase to an ultimate capacity of 6,000 kilowatts in rotary converter units.

### *Dearborn Street Substation*

While really a modern plant in every detail of equipment, this is the oldest of the company's downtown rotary substations. Like the Randolph Street Substation, it is installed in a basement, and it required a great deal of ingenuity to get all the desired apparatus in place. At present five 500-kilowatt rotary converters supply the central portion of District 1, this station being very centrally located. This substation was installed about four years ago, and has reached its limit in capacity.

### *Market Street Street Substation*

One of the most important, the most recently installed, and the finest in point of structural ensemble is the Market Street Substation. This plant is located in the basement and on the first and second floors of a fine eight-story steel building, which, with an imposing plate glass and stone front, makes the building by far the handsomest structure in the vicinity. An exterior view of this building is shown on page 52.

Four 1,000-kilowatt rotaries and a 1,200-kilowatt battery (one-hour rate of discharge) furnish current to the northwest part of the downtown district. Part of the output is also passed under the river, by tunnel, to the West Side.

The high-tension switching installation is located in an air chamber in the roomy basement, which is also reserved for blowers, and cable connection to the old, previously described Washington Street Station.

On a gallery above the main floor and directly over

MARKET STREET SUBSTATION BUILDING

the rotary and feeder panel, a switchboard for the operation of the 4,500-kilowatt auxiliary steam plant in the adjoining building has been installed.

Provision has been made for increasing the capacity and present arrangement to four 1,000-kilowatt converter units, two of which will have additional transformer and regulator capacity to give a range of 240–360 volts at the commutator, permitting their use for the charging of batteries without the intervention of boosters.

*Jackson Boulevard Substation*

This station occupies space in the basement of the magnificent new Railway Exchange Building on Jackson Boulevard, in the southeastern part of the downtown district. Here we have headroom permitting installation of 1,000-kilowatt units, two of which are now being installed. The ultimate arrangement contemplates six 1,000-kilowatt rotary converters with all accessories.

Two 500-kilowatt units have been in service for about nine months in a temporary location during the construction of the building. The load conditions in the vicinity indicate that a rapid increase in the capacity of the substation will be necessary. The larger and more improved type of converter units with three-phase transformers lend themselves readily to the excellent arrangement of apparatus. A noteworthy feature of this installation is the provision for an air supply consisting of a large duct running under the floor of the basement and having its intake, which is provided with a filter, opening at the sidewalk.

*Haddock Place Substation*

This substation is installed in the extreme northeasterly section of the downtown district, near commission houses and a large number of elevator power consumers. It is connected by a heavy tie line to the bus bars of the Randolph Street Substation, about 800 feet distant.

Two 1,000-kilowatt batteries (one-hour rate of discharge) and a 100-kilowatt, three-unit booster set comprise the electrical equipment of this substation. The first of these two storage batteries is notable in that it was installed in record-breaking time, the entire installation of battery, booster, switchboards and all underground connections in street ready for one-hour rate of discharge, covering a period of only 57 days, from the date on which expenditure was authorized and apparatus and material ordered.

The battery proper was installed by the Electric Storage Battery Company of Philadelphia, and all other work by the company's own organization.

### SOUTH SIDE SUBSTATIONS

The old South Side of Chicago, known to the company as District No. 2, is bounded on the north by 12th street, on the east by Lake Michigan, on the south by 39th street and on the west by Armour avenue. Three substations supply this district with current for business and residence purposes. Their locations are such as to form the electrical vertebrae of this rather attenuated branch of the system. The maximum load in this district occurs somewhat later in the evening than that of District 1 and is, therefore, no additional strain on the machinery at the generating stations, upon which these substations are dependent, at the time of "Peak."

#### *State Street Substation*

Located just south of the northern boundary of District No. 2 on State street, near 12th street, is the State Street Substation. Need for a substation in this locality was felt long before a location could be secured, for selection of a site was confined to a small radius. The immediate vicinity of the substation is developing rapidly with a class of commercial buildings requiring a considerable amount of general power as well as elevator power and lighting.

This substation is notable in that it was erected on a 20-foot lot, which is rather narrow for substation purposes. However, the substation is a complete one, containing two 500-kilowatt rotary converters, one 275-kilowatt battery (one-hour rate of discharge), with a 30-kilowatt, 3-unit booster set, capable of use as a balancing set. The high-tension apparatus is located on a gallery in the front over the rotary room, the battery being located in the basement. Living rooms for the operator are provided above the rotary room.

The building, though rather small, is made conspicuous by the striking contrast which its neat pressed brick front presents to the somewhat sordid surroundings. It is entirely of brick and steel construction, and is altogether a very attractive and interesting little substation.

### *Twenty-First Street Substation*

Located about midway between the State Street Substation and the Twenty-seventh Street Substation is the Twenty-first Street Substation. This plant is installed on the site of an old generating plant, one part of the building being used as a storeroom, another as a substation. The load in this district is mixed business and residence lighting in its character.

The substation contains two 500-kilowatt and one 250-kilowatt rotary converter, and is capable of extension considerably beyond this capacity, as a large amount of additional floor space is yet available in the old plant.

### *Twenty-Seventh Street Substation*

Six years ago this plant was a generating center of the southern district of the Chicago Edison Company. It is located on Wabash avenue and 27th street, and about 2½ miles distant from Harrison Street Station. Being in a residence district and without railway or river facilities, all coal has to be hauled by wagons. The engines are run non-condensing. The building is of brick and contains, at the front, living rooms for the engineer and a lamp exchange room for the district.

In 1898 rotary converters began to creep in and fires began to be banked. The little central station became a dependency upon the Harrison Street Station. There remains, however, a generating plant of about 920-kilowatts capacity. Four Heine boilers, with a total of 1,700 horse-power, furnish steam for one 135-horse-power tandem compound and two 250-horse-power tandem compound McIntosh and Seymour engines, and one vertical, cross-compound, 600-horse-power Ball & Wood engine. Belted to the first three mentioned are six 100-kilowatt Edison bi-polar shunt machines and to the last mentioned two 200-kilowatt General Electric multi-polar, direct-current, 140-volt generators. One generator in each of these sets of two is connected on the positive and the other on the negative side of the three-wire system. This station, which has been in operation for 12 years, still does regular duty as a subsidiary steam plant.

In the same building with the generating plant, and in reality in the engine room of the station, there are two 200-kilowatt and one 250-kilowatt rotary, also a 30-kilowatt, 3-unit booster set. At the north side of the station a 275-kilowatt battery occupies a separate room.

The rotaries are all of the older type, as this was the first rotary converter installation of the Chicago Edison Company, they being started in service when the transmission line pressure was but 2,250 and later 4,500 volts. Some of these machines have been installed for six years, having been in continuous service during that time. In this substation were installed the first rotary converters ordered for lighting service in America.

### NORTH SIDE SUBSTATIONS

In the northern district of the City of Chicago, a territory of about two and one-half square miles, bounded on the north by North avenue, on the east by Lake Michigan, on the south and west by the Chicago river, are four substations. The load in the eastern portion of this district is principally a lighting load, but in the western and particularly southwestern portion a heavy motor load is being developed. Submarine cables afford a tie between the direct current network of this district and that of District No. 1, just south of the river.

*North Clark Street Substation*

On the north side of the city the Edison Company has one subsidiary steam plant, formerly known as the "Newberry Library Plant," a name derived from its proximity to the above-named building. The proximity in location is, in fact, almost identity, for the station appears to be a part of the same structure. This plant is rather small, but deceptive in appearance, for it is quite well filled with apparatus, there being both generators and rotary converters installed.

In its history and present capacity it is very much like the Twenty-seventh Street Station, previously described. Twelve hundred and seventy-five horsepower in Heine boilers supply four vertical, cross-compound Lake Erie engines, one of one hundred and fifty horse-power and three of two hundred and twenty-five horse-power each. To these engines are coupled two 50-kilowatt, 135-volt, direct-current generators and six 75-kilowatt, 135-volt, direct-current generators. These generators are balanced on the two sides of the three-wire system and are employed in their present capacity as "Peak" machinery.

This is one of the few substations where there are to be found remnants of the original rotary converter installation, the company's first venture in converting apparatus and high-tension transmission. Two 100-kilowatt, 125-volt rotaries, one operating on each side of the three-wire system, also operating in parallel with the 250-volt, 500-kilowatt rotary, complete the substation equipment.

*Sedgwick Street Substation*

On Sedgwick street, near North avenue, the northern boundary of the Edison Territory, there was erected about two years ago one of the company's typical modern substations—two buildings of fireproof construction, one in the rear of the lot, being a separate battery structure, while facing the street is the rotary converter building. This substation contains two 500-kilowatt rotaries at present, and a 425-kilowatt battery. A 30-kilowatt, 3-unit booster set furnishes a means of charging the battery from the system.

In this station we find a high-tension gallery with the rotaries on the main floor. This type of substation is installed quite extensively by the company where building lots are of inconsiderable width. The installation of the battery in a separate building leaves the basement of the rotary converter building free for the installation of air ducts and cable runs.

### *Kinzie Street Substation*

The Northwestern Railway Company requires a large and unfailing source of electrical energy for operating air compressors which furnish compressed air for its signal system, as well as for lighting its passenger depot and terminal equipment and yards. For this purpose the Chicago Edison Company has installed in one of the Railway Company's buildings on Kinzie street one 250-kilowatt and two 100-kilowatt rotaries of the older type. In addition to furnishing direct current for the air compressor motors and railway company's lighting, three feeders from this substation supply the Edison System in the vicinity.

### *Ohio Street Substation*

This substation represents all that is modern in the development of substation construction. The building is of brick and steel, equipped with a crane, and the basement free for use as an air chamber and for cable runs. The second floor is occupied by a 600-kilowatt battery, while the main floor is planned for five 1,000-kilowatt rotaries, to be installed as the district develops. The present equipment consists of a 500-kilowatt rotary converter and a 30-kilowatt, 3-unit booster set.

This substation also represents another phase in the development of the company's property, in that real estate of continually enhancing value is secured while still within reasonable cost, and a commercial building of such nature is erected on rear of lot as will fulfill present requirements, permit extension to front, and such additional stories, up to eight in height, as future rental requirements may make advisable.

### *Illinois Street Substation*

This little substation was installed in this particular part of the district only after it was found that it was impracticable to maintain pressure here by feeders from existing stations.

The building, a small brick structure on an alley, is located on a strip of land which permits of enlargement and more permanent structure should the necessity arise. The present equipment is two 100-kilowatt, 125-volt rotaries, operating on either side of the three-wire system, and one 500-kilowatt, 250-volt rotary installation.

## WEST SIDE SUBSTATIONS

The West Side, known officially as District No. 3, is the newest territory invaded by the Chicago Edison Company. Five years ago there was practically no business in this section of the city and to-day five substations are kept busy supplying the electrical needs of the district. This district, bounded on the north by North avenue, on the east by the Chicago river, on the south by 39th Street and on the west by Ashland avenue, covers an area of about four square miles, the Chicago river separating it from Districts 1, 2, and 4.

Harrison Street Substation, which has already been referred to in the description of the generating station of the same name, due to its location on the north side of the plant, consists simply of two large batteries, each of 1,000-kilowatt capacity, at the one-hour rate. Its only piece of rotating machinery, a 100-kilowatt booster, enables its batteries to be charged.

The rather distant location of this battery from the load centers of either District 1 or District 3 renders it serviceable for either district, and therefore it seemingly partakes more of the nature of a station reserve than a district battery.

Similarly the Market Street Substation, although located on the east side of the river and therefore in the downtown district, also supplies current to the three-wire system on the West Side.

*Lydia Street Substation*

About two years ago one rotary converter was hastily installed on the rear of a lot facing Lake street and extending through to Lydia street, near Union street. The load increased at such a rate that work on a large substation was soon begun. The present Lydia Street Substation, the result, is in some respects like the Market Street Substation, being located on expensive real estate. The foundation provides for a future seven-story building of brick and steel, with cut stone and plate glass front, only two floors of which have so far been built. The future upper floors, when erected, may be rented to outside tenants, since the basement and first floors only are occupied by the substation.

In the basement there is a storage battery with a capacity of 1,000 kilowatts, on the first floor are two 1,000-kilowatt rotaries and above on a gallery is the high-tension equipment of line switches and buses, from which leads are taken directly to the converter transformers on the first floor.

A 100-kilowatt, 3-unit booster set, capable of use as a balancing set, on the three-wire system, completes the electrical equipment of this substation, which has come to be recognized as a most important one and bears much the same relation to District 3 as the Randolph Street Substation does to District 1.

*West Division Street Substation*

This substation, an exterior view of which is shown on page 61, is located on West Division street near Ashland avenue and is within one-half mile of the northwestern operating limit of the Edison Company; it bears the distinction of being the only combination station of the company, that is, a substation distributing both direct current and 60-cycle alternating current. The building is of brick and steel, with a basement battery and a high-

WEST DIVISION STREET SUBSTATION

tension gallery above the rotary converter room. Living rooms for the operator are provided on the upper floor of the substation, and the front of the lower floor is used partly as a district supply office. This structure is of rather greater width than the average substation, being 50 feet wide and making a double equipment possible. Two 500-kilowatt motor generator sets, supplied with

25-cycle current, deliver 60-cycle alternating current to portions of the northern and of the western districts of the Commonwealth Electric Company. Two rotary converters, a 425-kilowatt battery and a 30-kilowatt, 3-unit booster set are at present also in operation here. Both rotary and motor generators are fed from common transmission lines.

### *West Fourteenth Street Substation*

This substation was installed in a new brick and steel structure on 14th street near John street about three years ago. It supplies the southern part of District 3. The building faces the street and is of sufficient size to accommodate three 500-kilowatt rotary converter sets. Future extension to a capacity twice this amount is possible.

At present this station contains one 500-kilowatt rotary converter, one 250-kilowatt rotary and one 275-kilowatt battery with two 15-kilowatt booster sets, an equipment ample for the present needs of this district.

## LOW TENSION DISTRIBUTION SYSTEM

In view of the fact that the low-tension distribution system of a large Central Station Company, especially where conditions obtain which necessitate its position under ground, represents a large investment and that on its proper installation and operation the success of the company depends, a general description will be given here. Inasmuch as the part consisting of rotaries, storage batteries and their necessary accessories, switchboards, bus bars, etc., have already been described under the substation headings, the underground portion only will receive our attention.

Formerly the "Edison Tube," an iron pipe containing three conductors, was laid directly in the ground for use as feeders from station bus bars to the junction boxes in street and also for mains between these junction boxes. The junction boxes were circular, cast-iron shells, with three copper rings, positive, negative and neutral, on the interior, to which the copper of the tubes connected. But that system has been very largely superseded. Instead we have a conduit and cable system, with roomy manholes at the street corners and junction boxes installed within the manholes. Glazed tile conduit lines, consisting of ducts from 4 to 24 in number, enclose the cables from manhole to manhole or to substations, as the case may be. Between the manholes, where services enter the customers' buildings,

REPRESENTATIVE CONDUITS AND MANHOLE, SHOWING ISOLATION OF CABLES

handholes are provided for a lateral connection of tile or iron pipe.

Most of the cable in this system at present is single conductor paper and lead covered, varying in size from 250,000 c. m. to 2,000,000 c. m. A large amount of 1,000,000 c. m. concentric cable for feeders is now being installed on account of the better economy in duct space. Cables are carefully trained through manholes to avoid crossing, and great care is taken in providing against communication of trouble from one cable to another.

The cables are usually laid in ducts on the side walls of the manholes and covered with split tile. In cases where the use of this protection is impossible an asbestos covering, held in place with steel tape, is provided. Page 63 shows the usual manhole and conduit construction.

The manholes are usually constructed of brick and concrete, and vary in size from the so-called "handhole," about 2 x 3 x 3 feet, to the large manholes at street

TUNNEL CONSTRUCTION AND CABLE PROTECTION

intersections, a common size being 6 x 8 x 6 feet. Ventilated iron covers are put on the concrete tops, and sewer drains are provided in the bottom. These manholes assume somewhat irregular shapes in some cases, for it is often found that on account of obstructions in the street the company has to utilize whatever space is left under ground.

At the river crossings provided recently, of which there are quite a number, the company has installed tunnels. These tunnels, usually of elliptical cross section, having a bore of about five feet, with the major axis horizontal, are constructed of concrete and sunk to a depth which eliminates possibilities of entrance of foreign bodies, such as piles, etc. Page 64 shows tunnel construction. One of the oldest tunnels carries the "Trunk Line" from Harrison Street Station to Adams Street Substation, and it has done duty for twelve years, despite the damage done by an occasional pile driven through its roof. This tunnel is about 65 feet below grade, while later tunnels are sunk to a depth of 85 feet and through the bed rock under the river.

The substations and feeders are well disposed throughout the network and the objective "constant potential" is rigidly maintained. Pressure wires run back from certain junction boxes to the operator in a particular substation, indicating to him any departure from the "standard pressure" that he is required to preserve. The potential of 117 volts on each side of the three-wire system is maintained at the feeder end junction boxes, thus producing a pressure of 113 volts at the lamps. The earlier mains between junction boxes were of varying sizes, depending upon the density of the load connected. In the more recent installations these mains have been limited to a few standard sizes, the three conductors in any one main being always the same cross section. Cables of 200,000 c. m. and 350,000 c. m. for this purpose predominate very largely.

In the earlier developments of the company, with comparatively few feeders supplying a large area, the size of the mains was largely fixed by the drop in potential between junction box and customers' service. The very great increase in density of load over given areas and the resultant necessary increase in number of feeders has changed this consideration so that the sizes of mains are now very often fixed by the carrying capacity required. This makes it possible to have a much higher average current density in all mains. The usual development, therefore, is simply to connect up additional feeders to the existing network of mains.

Similarly, when the density of load in any particular locality increases beyond the point where it is no longer economical to carry it by means of feeders from existing stations or substations, a new substation is installed and the existing system of feeders connected thereto. In this manner a feeder from an existing station is often rearranged to perform the functions of three feeders: namely, a shortened feeder from the existing station and two feeders running in opposite directions from the new substation established. Such a feeder is sometimes also utilized as a tie line between the old and the new substations. In brief, therefore, the carrying capacity of the network of mains is reinforced by the installation of additional feeders, and the carrying capacity of copper in feeders is reinforced by the installation of additional substations. An idea of the immensity of this system may be conveyed by the fact that there are 124 miles of low-tension mains and 69 miles of feeders supplying the Edison customers.

Incandescent lamps, having an efficiency of 3.1 watts per candle power, are used for all except the lamps of 10 candle-power or less. The losses at 113 volts in incandescent lamps, arc lamps and meters are considerably less than those on systems using 250-volt incandescent lamps.

The stability of this system has been put to severe tests in some instances, but the storage batteries and the interconnected network have for several years operated very effectively against a total incapacitating of the system, a condition so dreaded by all central station companies.

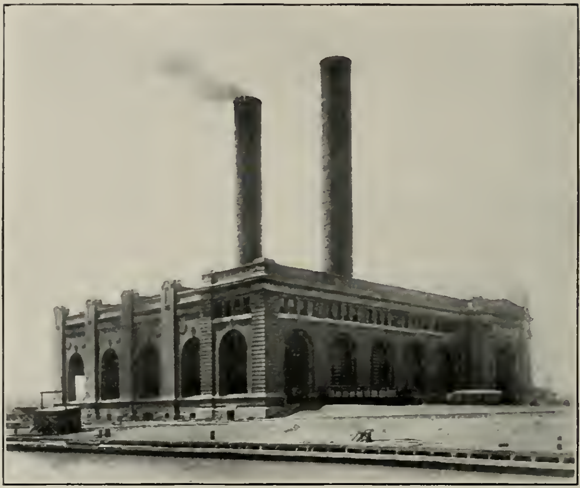
## *Commonwealth Electric Company*

The Commonwealth Electric Company has three sources of electrical energy: the Fisk Street Station, preeminent with a capacity of 18,000 kilowatts; the 56th Street Station, a 3,000-kilowatt, 60-cycle generating plant, built four years ago, and a subsidiary steam plant, the Lake View Station. Besides supplying its own six substations, it furnishes current to the Chicago Edison Company and also to the Chicago & Oak Park Elevated Railway. The transmission is effected in a 9,000-volt, 3-phase, 25-cycle system, while the distribution is a 3-phase, 4-wire, 2300/4000-volt, 60-cycle, overhead system, which serves the more recently developed residential districts and suburbs of Chicago. In three of its substations there are installed frequency changing sets of 4,500-kilowatt capacity, while the remainder are static transformer installations.

While its own patronage of 11,000 customers, with a connected load of 728,000 incandescent lamps and 9,220 horse-power in motors, calls for about 6,500 kilowatts of generating capacity, the Chicago Edison Company demands the remainder for the supply of its numerous substations. The twofold aspect of the company is thus apparent—as generating a supply for the substations of the Chicago Edison Company; as a generating and distributing agent supplying its own independent territory.

### FISK STREET STATION

This station is located at the juncture of Fisk street and the South branch of the Chicago river, about three miles from the center of the downtown business district of Chicago. It stands nearly in the center of a plat of land of an area of fourteen acres, with a mean width of



FISK STREET POWER HOUSE
COMMONWEALTH ELECTRIC COMPANY

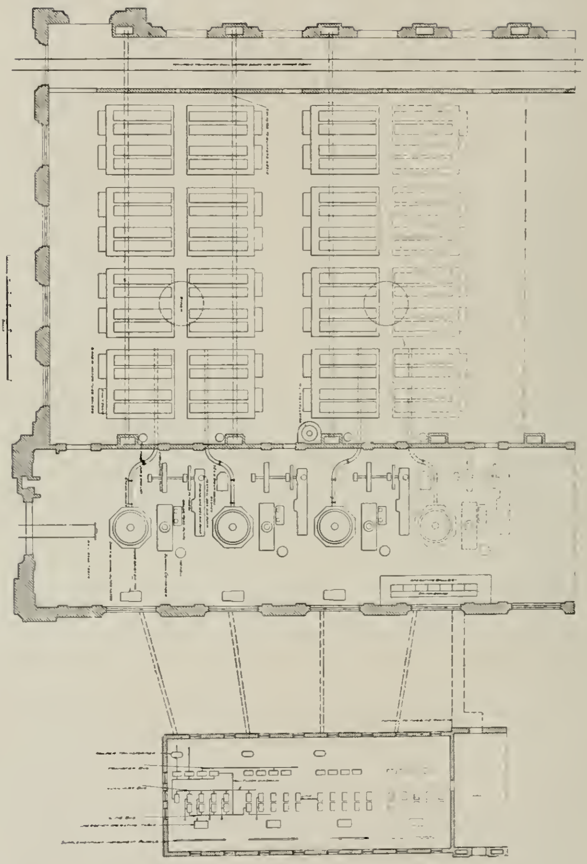
about six hundred feet, bounded on the south by the river. On either side of this plat of land a slip extending north from the river about thirteen hundred feet provides an inexhaustible supply of circulating water for the huge condensers. The river furnishes an excellent coal conveying medium, and at the north end of the property a spur of the Chicago, Burlington & Quincy Railroad facilitates bringing coal directly from the mines.

The Fisk Street Station buildings, as at present constructed, consist of the boiler house, 190 x 165 feet, the turbine house, 225 x 65 feet, both of steel, and the separate switch house, 140 x 50 feet. These buildings are designed for future extension to three and one-half times the present capacity. Of the French style of architecture, with red pressed brick walls and cut stone trimmings, they form a delightful contrast to the ordinary river front property.

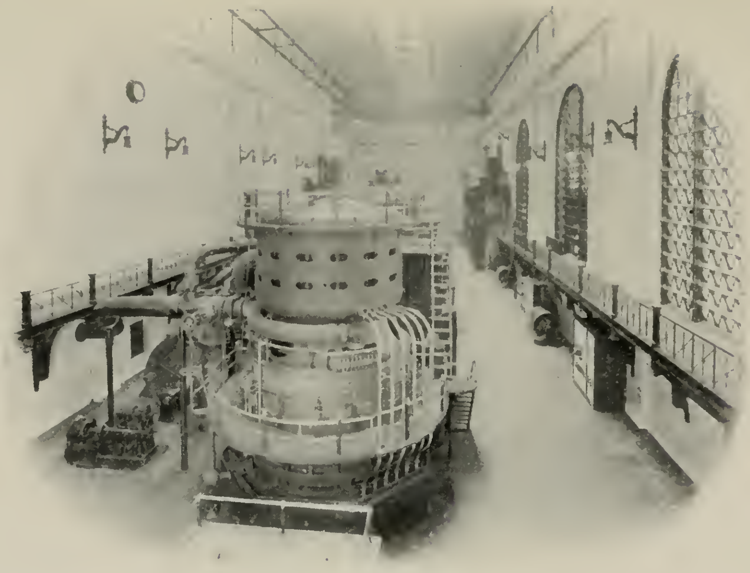
The unit idea pervading this whole plant makes itself evident at first sight. Every unit from the coal conveyor to the last group of outgoing line switches is complete in itself, and the value of this idea in the localizing and confining of trouble will be at once apparent to the operator of large central stations. Page 68 shows a plan of the station.

There are now installed three complete units, consisting of coal conveyors, boilers, Curtis turbo-generators, steam and electrical auxiliaries and switching apparatus. The ultimate installation contemplates fourteen units.

Each boiler unit consists of eight Babcock & Wilcox 512-horse-power boilers, equipped with automatic stokers and Meade conveyors. Coal is dumped directly from cars into hoppers in the basement of the train shed and from there conveyed to bunkers of 1,000 ton capacity above each unit of eight boilers. A steel stack 20 feet in diameter and 215 feet above the earth furnishes draught for each 2-boiler unit. In the yard there is also track capacity for 50 cars of coal of 35 tons each, and further dock space for 20,000 tons. A four and one-half foot



PLAN OF FISK STREET STATION

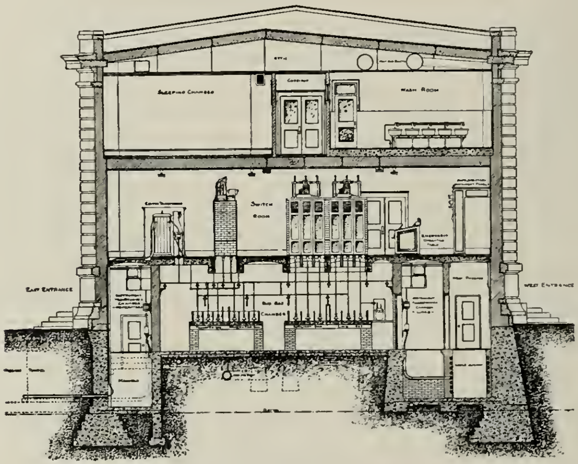


INTERIOR OF TURBINE ROOM NORTH END

injection canal conveys circulating water from the east slip to each set of condensers, and an 8-foot discharge tunnel conveys the condenser discharge to the west slip.

The 5,000-kilowatt turbo generators operate at 500 revolutions per minute at 180 pounds boiler pressure with 150 degrees super-heat, the potential being 9,000 volts delta with the neutral brought out and grounded.

Regulation of the turbines is effected automatically by the operation of the governor, which opens or closes

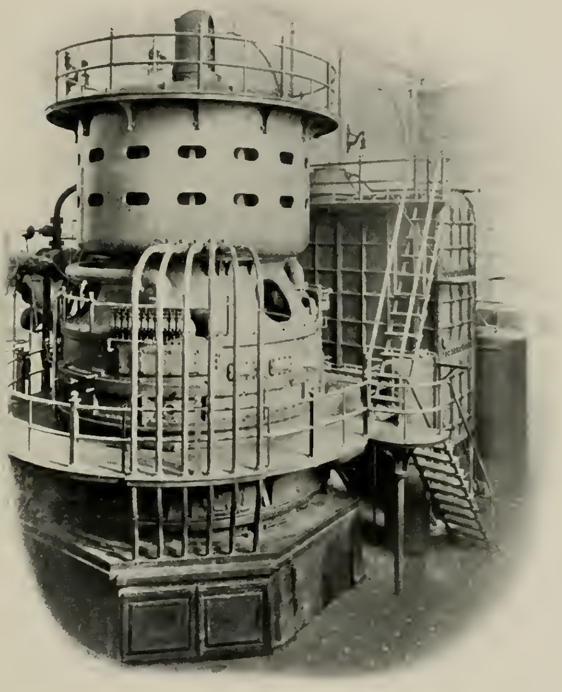



CROSS-SECTION OF SWITCH HOUSE, FISK STREET STATION

individually 36 small valves, delivering steam to the nozzles.

Essential to the successful operation of these turbines is an unfailing supply of oil for the step bearing of the shaft which carries the weight of the revolving field and steam bucket wheels, a total of 70 tons. Oil at about 1,000 pounds per square inch pressure must be supplied constantly to keep the shaft off its bearing, and to that end individual motor-driven oil pumps force oil at this pressure into the bearing continuously while the turbine is in service. An "accumulator" or oil pressure reservoir operates in parallel with the pumps.

In the turbine room, an interior view of which is shown



DETAIL VIEW OF TURBINE

on page 71, the steam auxiliaries are all located at the base of the Alberger surface condenser. They consist of a 140-horse-power horizontal Corliss engine, which drives the wet air and dry air pumps and the centrifugal pump, which is capable of supplying 140,000 cubic feet of water per hour to the condensers. Two separate steam-driven feed pumps supply the boilers with feed water, which is passed through a heater after leaving the hot well. All of these auxiliaries are within easy reach of the attendant, whose duties do not therefore require his presence in the boiler room.

Operating control in this station is provided in the main turbine room on a specially constructed operating gallery of a capacity sufficient to control seven units. In addition, emergency operating tables and instrument panels are provided in the switch house. In the exciter system we have further illustration of the unit system of operation, as each turbo generator is provided with an induction motor exciter set (220-volt, 3-phase motor and 50-kilowatt, 125-volt generator). These sets are fed from the respective generators and are interconnected by common exciter busses. A battery operates in parallel with the motor-driven exciter units, and a 75-kilowatt steam-driven exciter is also available whenever occasion demands.

A special electrical feature worthy of a more detailed description is the main operating switchboard on the operating gallery. This board is a combination of the instrument panel and the operating table. Complete equipments of indicating instruments for the generators and the outgoing lines occupy the instrument panel, while on the operating table portion are the controlling switches for oil switches, rheostats, etc. All control switch contacts are made on the under side of the table, the handles only projecting through the marble. A special synchronizing plug completes the closing circuit of the oil switch control switch, and causes on the synchronizer an indication of a synchronous or non-synchronous relation of the two points about to be connected by the closing of the oil switch. Special pilot lights with prismatic lenses furnish signals to the operator of the proper working of the remote control apparatus.

On the rear of the board all the control and instrument multi-conductor cables end at a terminal board, carefully

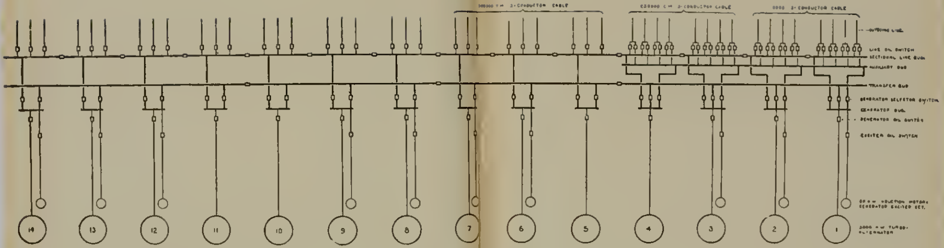



Diagram of High-Tension Connections—Fisk Stret Station, Commonwealth Electric Company lettered, and the wiring from that point to the control apparatus and instruments is a feature of the construction. All cables leading from this board to the various points of control are lead-covered and are installed in individual iron pipes, which render communication of trouble to adjacent circuits impossible.

On the turbine room floor each exciter has its switchboard with controlling devices, while at the turbine the operator is provided with a wattmeter indicating the total output of the turbine, a frequency indicator, and an electrical signal device which puts him in communication with the operator on the main operating switchboard.

The high tension system is taken care of by carefully insulated open bus construction, with the buses of each unit in a separate chamber; all being separated from the oil switches on the floor above and the whole being installed in the separate and especially constructed switch house, forty feet from the turbine house. The high-tension connections are best understood by reference to the diagram of generator, bus and line connections shown herewith. The output of the generator is conducted to the bus, in the switch house, in single-conductor, lead-covered, 600,000 c.m. cables, drawn in vitrified clay tile ducts, oil circuit breakers of the most modern type being used throughout for high tension switching. No cable is used in the bus chamber; copper bars and rods insulated to withstand 20,000 volts have been used, these conductors being mounted on porcelain insulators. The outgoing lines, all three-conductor, lead-covered cables, convey the energy through an underground duct system to the various substations.

One corner of the basement under the boiler room of Fisk Street Station is utilized as a substation. This is only a temporary arrangement, as it is intended later to construct a suitable substation building on the north end of the grounds surrounding the Fisk Street Station.

At present this substation contains one 500-kilowatt rotary converter and one 250-kilowatt motor generator set composed of a D. C. 250-volt motor and a three-phase, 4,000-volt, 60-cycle generator mounted on a common shaft, this machinery being entirely reversible in its operation. The principal output of this substation is a direct current supply to District No. 3 of the Edison Company, although four 60-cycle circuits are carried by this plant, for a period during the evening.

### FIFTY-SIXTH STREET STATION

Situated just west of the Chicago & Eastern Illinois tracks is the 56th Street polyphase generating plant of the Commonwealth Electric Company. Page 77 shows an exterior view of this station. This plant is a notable one in many ways; for example, its location near a fashionable boulevard in the heart of a residence district. Its history as a pioneer in the three-phase, four-wire generating service, and its unique engineering features, combine to make it, although installed five years ago, a most interesting central station.

The station building proper, 112 x 120 feet, is an attractive one in appearance. The style of architecture of the building is such that none of its beauty is lost in the attainment of structural solidity.

The boiler room, about 46 x 110 feet, contains six 400-horse-power Babcock & Wilcox boilers with superheating coils. A Meade conveyor carries the coal from the hoppers, into which cars are unloaded, to the bunkers of 1,000 tons capacity above the boilers. All boilers are equipped with automatic stokers, and above the boilers is a large space reserved for a possible future installation of an economizer.

Three large Worthington cooling towers, 80 feet in height and 20 feet in diameter, containing 10,000 cooling tiles each, cool the injection water supplied to the jet condensers used with the several generating units.

In the engine room, 55 feet in width, 120 feet in length, 57 feet in height in the clear, there are three polyphase generating units, two 1,000-kilowatt sets and one 400-kilowatt set. These units are identical in design, being of the vertical cross-compound type of the Southwark Foundry Machine Company's design, and the generator of the revolving field type, giving three-phase, 60-cycle, 4,000 volts delta pressure, 2,300 volts, phase to neutral. Two steam-driven exciter sets, each of 30 kilowatts capacity, and one induction motor-driven set of the same capacity, furnish the necessary exciting and auxiliary operating current for the station.

The switchboard is of liberal double-deck design, very handsome in appearance, and extends along the west wall toward the north end of the building. All line

EXTERIOR OF THE FIFTY-SIXTH STREET STATION

oil switches on this board are hand operated, the generator and bus tie switches only being of the remote control compartment type. The upper section of the board comprises the operating panels, while on the lower panels are the selector knife switches used in connection with the duplicate busses. Pressure compensators are provided on all lighting circuits, thus obviating return pressure wires.

At the north of the new plant stands the old arc-light plant, the only remaining series arc-light plant owned by the company. This plant was one of the original acquisitions of the company at the time of the general consolidation of electric light interests which gave rise to the Commonwealth Electric Company.

This plant contains about 700 horse-power capacity in boilers, with two Porter-Allen engines and three Williams engines, all aggregating about 750 horse-power. Twenty arc-light machines of various types supply a load of eight hundred and forty 1,200-candle-power and six hundred and eighty 2,000-candle-power arc lights. Most of the arc-light machines are driven from a 45-foot jack shaft, formerly direct connected at each end to a 500-horse-power engine, but now motor driven. The series arc-lamp load is decreasing at a rate of about 10 per cent annually, and the ultimate displacement of this system by the low-tension arc is anticipated by the company.

Between the old and the new plant of the generating station there has been built an intermediate structure for the accommodation of compartment oil switches of the solenoid operated type; but the substation frequency changing machines occupy the north end of the engine room, and their location defines the extent of the present and future 56th Street Generating Station.

The unoccupied floor space in the new plant is sufficient for the accommodation of four 1,000-kilowatt motor generator sets, but there are contemplated at present two 500 and two 1,000-kilowatt sets, the two 500 sets being already installed. At the south end of the station there has also been installed one 50-kilowatt induction motor-driven exciter set, there being space for additional installation of these units. The frequency changing motor generating sets consist of two machines of 600 and 500-kilowatt capacity respectively, mounted on the same shaft and with a common base. The motor requires a supply of 25-cycle, 9,000-volt, three-phase energy, while the generator delivers 3-phase, 60-cycle energy at 4,150 volts delta pressure. The neutral for the 60-cycle machine is brought out and connected to the neutral of the system, both being grounded.

In the old arc plant, as previously mentioned, there are two motors, one of 600-kilowatt and the other of 300-kilowatt capacity, connected at the ends of a long jack shaft driving the arc machinery. One of these is a complete motor generator set similar to those described above and is so connected as to enable it to do duty either as a motor, driving the shaft, or as a frequency changing set.

The switching facilities for the substation have been provided for in the intermediate structure built especially for that purpose, and the control of these switches is afforded by an extension to the original switchboard, located in the engine room. The generating machinery in this plant will probably remain intact and operate, at least for a time, as daily "Peak" machinery, thus giving another illustration of the policy of centralizing generating capacity, particularly during long-time light-load periods.

COMMONWEALTH ELECTRIC COMPANY'S SUBSTATIONS

The substations, with the exception of those located in the generating stations, are all detached, fireproof structures, of handsome architectural design and distinctive appearance. In the more modern, all wires enter and leave the building underground, thus obviating a feature which always detracts from an otherwise pleasing exterior.

In the interior of these substations we find a standard of construction equal to that of the Chicago Edison Company. There is the same uniformity of converting apparatus and auxiliaries and also of operating appliances. The frequency changing sets, all of the revolving field type, are of two sizes, 500 and 1,000 kilowatt capacity, and consist of a 9,000-volt, 3-phase, 25-cycle motor mounted on the same shaft and base with a 2300/4000-volt, 3-phase, 60-cycle generator, with neutral connected to neutral of system. No transformer is used with this set and all regulation is effected by means of individual regulators on the 60-cycle distribution feeders.

The starting of these machines is accomplished by means of a starting compensator used in connection with several machines. A double dial synchronizer is used for synchronizing, the method being to throw in the machine when both 25 and 60 cycle synchronism is indicated. The dial synchronizer really consists of two General Electric synchronizers mounted in the same case; one synchronizer indicating 25-cycle synchronism while the other denotes 60-cycle synchronism.

The motor generators are equipped with oil switches, electrically controlled, while outgoing 60-cycle lines are operated by means of hand-controlled oil switches. These feeder switches in the later substations have overload attachments, thus dispensing with fuses. The special double-throw oil switches are wired for transferring the motor from the starting compensator bus to the transmission line and also for transferring the single phase 60-cycle circuits from one phase to another for balancing the load on the 60-cycle generator.

### *Lake View Substation*

This plant, a brick building located on an alley near Lincoln and Diversey avenues, was acquired some five years ago by the company and was gradually modified until now there remains only one engine-driven generator, the other electrical equipment of this plant being entirely new. One battery of two National boilers of 75 horse-power each and one of two Standard boilers of 375 horse-power each, furnish more than sufficient boiler capacity for the only remaining engine, a 500-horse-power, cross-compound Buckeye, which is belted to a 500-kilowatt, 3-phase generator. This generator delivers energy at 4,150 volts delta, 60 cycles, the distribution system voltage of the Commonwealth Electric Company. The generator is really a half of a frequency changing set, similar to those installed in the other substations of the company. A large pulley, belted back to the engine, which plays the part of a motor, will ultimately be displaced by a motor, and the substation, which at present occupies seventy-five per cent of the present station building, will be the only occupant.

The output of the generators is distributed along with the output of the frequency changing sets over the same buses, and the two are sometimes operated in parallel. Five hundred volt service is supplied from a small machine, but the load is fast disappearing and is altogether insignificant. Some exhaust steam heating is also done from this plant, for the station is run non-condensing, being remote from both river and rail facilities.

Installed in the engine room of the subsidiary steam plant is the substation portion of the plant, which has attained dimensions greater than the steam plant. It is the principal distributing center of the northern district. The equipment of this plant consists of one 1,000-kilowatt and one 500-kilowatt motor generator frequency changing set. These two units operate in parallel on both the 25 and the 60 cycle ends. A 50-kilowatt induction motor exciter set, fed by the transmission line, furnishes exciting current for the two frequency changing sets.

The 25-cycle switchboard is installed on a gallery, and the 60-cycle switchboard is on the main floor of the station. This plant is notable in that the first frequency changing set (of 250 kilowatts capacity and since removed) was installed here, and displaced two engine-driven, two-phase generators.

*West Madison Street Substation*

This substation is the only one containing frequency changing sets exclusively, and is the principal distributing center for the western district. It is located in the rear of a handsome office building which faces West Madison street, as shown on page 82. The office building is three stories in height, with living rooms on the top floor, a district repair office on the second floor, and a district Superintendent's and supply department on the first floor. Beyond the substation, in the rear, is a storeroom designed for the extension of the substation.

On the main floor of the substation are the frequency changing sets, one 500 and one 1,000 kilowatt motor generator with two 50-kilowatt induction motor-driven

WEST MADISON STREET SUBSTATION

exciter sets. All oil switches are in the basement, the controlling and instrument panels only being on the first floor. All lines enter and leave this station underground.

*Morgan Street Substation*

A modern rotary converter installation, distributing direct current entirely to a Chicago Edison District, and combined under the same roof with a group of high-tension oil switches for controlling a number of the 25-cycle, high-tension transmission lines. The building is located on an alley and is capable of extension to a capacity of five 1,000-kilowatt rotary converters. At present one 1,000-kilowatt rotary unit and a battery with a capacity of 370 kilowatts furnish most of the current for this, the extreme western portion of the Chicago Edison Company's territory.

The upper floor of the building is occupied by the storage battery, the rotary converter and the switchboard being on the first floor, while a three-unit, 30-kilowatt booster set and the high-tension buses of the transmission system occupy the basement. A thoroughly modern open bus construction similar to that at the Fisk Street Station, and the provision of means for using the booster as a balancing set on the system, are among the features of this station.

### *South Chicago Substation*

About nine miles southeast of the 56th street Station, which supplies it with current, as described in another place, the South Chicago Substation is located on South Chicago avenue. This is a small brick building, containing three 100-kilowatt transformers, into which the three-phase lines are led, the pressure being reduced to 4,000 volts delta. The lines are brought into the building and taken out on pole lines, as the district is well out in the suburbs. All pressure regulating is done back at the generating station.

### *Hyde Park Substation*

Purely a distributing and regulating center, this plant is in a class by itself. It contains no converting machines of any kind, the only equipment being indicating instruments, regulators and oil switches. It is located about two and one-half miles from 56th Street Station, upon which it depends for its supply of energy.

The building itself stands on an alley just north of 50th street and east of Cottage Grove avenue, in the middle of a residence district. The exterior of the building in no way betrays its purpose, and it much resembles a detached two-flat building of the type so often seen in the nicer residence districts.

The incoming transmission lines from Station A are led into a switchboard bus and from there the three-phase, four-wire and single-phase circuits are led out through oil switches and pressure regulators to the district for distribution. Excellent regulation and great facility in handling trouble is thus attained.

### OVERHEAD SYSTEM

Operating under a franchise permitting the employment of an overhead transmission and distribution system, the Commonwealth Electric Company supplies the outlying districts of the City of Chicago, a territory of about 150 square miles, with 60-cycle alternating current service. The nucleus of this system was the combination of the different alternating current systems of varying pressures and frequencies in vogue at the advent of the Commonwealth Electric Company, and whose only feature of similarity was the overhead transmission. Upon combination, however, a grand unification in the form of a three-phase, four-wire, 4,150-volt delta, with 2,300 volts to neutral system, was effected.

Two-wire, single-phase circuits, with pressure regulators and pressure compensators, take care of the bulk of the lighting business. All pressure regulation refers to the feeder ends, at which points recording voltmeters show any departure from constant pressure. Single-phase motors ranging in size up to 5 horse-power, and in special cases somewhat larger ones, are permitted on these circuits. Four-wire, three-phase circuits, with one-phase wire and the neutral equipped as a single-phase lighting circuit, take care of the power and isolated lighting business, many elevator motors being included.

The transmission to the Hyde Park Substation, the more important distributing center, is effected by duplicate, three-phase, four-wire lines carried on poles through the residence district for a distance of about two and one-half miles. These lines are run underground at boulevard crossings, the pole lines being supported by poles from 30 to 50 feet in height. The pressure is not raised on this transmission, the energy delivered being simply distributed and regulated at this substation. The pressure on the transmission line to the South Chicago Substation, about nine miles distant, is raised to about 8,000 volts by means of step-up transformers, and lowered again at the substation to the normal system pressure.

Alley pole lines eliminate the unsightliness so often the basis of popular prejudice of urban property owners against overhead systems in streets, and afford a means of service entrance into the rear of buildings. Transformers mounted on the cross arms of the pole supply the district with service, the secondary mains being carried on the same poles. All transformers on power circuits are connected in star on the high-tension side and in delta on the low-tension, with neutral grounded on all secondaries. A block of customers is usually supplied from one or more individual single phase transformers feeding secondaries, the employment of large interconnected secondaries feeding a network being comparatively rare. Primary taps are fused in many instances, and all phase wires on the circuits are fused back at the station.

Some very large customers are connected to this system, notably the Sans Souci Park, a very extensive and profusely illuminated amusement garden located about two and one-half miles from the 56th street plant. This park has a connected load of 5,000 16-candle-power incandescent and 60 arc lights.

The distribution system in the Northern and Western districts is effected by means of substations equipped with 25/ 60-cycle frequency changing sets; but in general the distribution system is identical with that of the Southern district. The same variety of service, business and residence, with their sub-classes, is taken care of here as elsewhere, and with equal success.

At this writing approximately 1,000 miles of wire are used on the primaries of the alternating circuits and 300 miles on the secondaries. Triple braid weather-proof wire of the best quality is used in all cases.

On the same pole lines are carried about 400 miles of series arc circuits, which have suffered a great reduction in number during the past five years and are now all localized in the southern district and fed from an old arc plant adjacent to the 56th Street Station. About 20 miles of 500-volt conductors, also finds a place on the overhead transmission system; but this service, like that of the series arc, will soon be abandoned.

At a very early date, therefore, absolutely all distribution in the outlying and scattered suburban districts of Chicago will be by means of the 2,300/4,000-volt, 60-cycle overhead system, which is so admirably adapted for this condition. Likewise also the distribution in the heavy business and older residential districts will be exclusively by means of the 115/230-volt underground system, particularly adapted for such service, while the transmission from large power houses is 25-cycle, 3-phase current at 9,000 volts.

## ORGANIZATION

Although the Chicago Edison and Commonwealth Electric companies are two separate and distinct corporations as to financial organizations, securities, boards of directors, operating territory, contracts and accounts, they have executive officers and heads of departments who hold the same positions in both companies, and occupy general offices in common.

The Chicago Edison Company, as previously stated, operates a territory practically coincident with the old city, covering approximately 15 square miles, with the present business center as a nucleus. It transacts all of its general office business in its downtown office, known as the Edison Building.

The Commonwealth Electric Company maintains, in addition to its general offices in the Edison Building, three branches or district offices, located north, west and south of the main offices, each answering as a local headquarters for its respective district. Each of the three district organizations is presided over by a District Superintendent, who has direct charge of men of all departments reporting at his district office.

In general all dealings with customers that pertain to immediate income, collection of bills, complaints and similar matters of local character, are expeditiously handled under the immediate supervision of the District Superintendent. All questions of policy in soliciting new business, all disbursements, all engineering and operating and similar matters which affect directly the entire company are handled by Heads of Departments under the supervision of the executive officers of the company.

A Contract or Soliciting Department, consisting of about seventy persons, solicits for and receives applications and contracts for the sale of electrical energy. This work is somewhat subdivided and specialized, covering incandescent lighting, power, arc lights, wiring construction and signs. Electricity is sold for incandescent lighting on meter basis at a list price of 20 cents per kilowatt hour, using the Wright Demand system, the maximum indicators being read monthly, and the first 30 hours' use of the maximum demand consumed in each month being sold at list price, secondary or excess hours at 10 cents per kilowatt hour, with a schedule of extra discounts for quantity only.

Power is sold on a similar maximum-meter basis, with a list price of 10 cents per kilowatt hour. Considerable arc light and sign business is sold on a flat-rate basis—so much per week—the companies controlling such lighting by locked switches operated by their patrolmen, so no advantage can be taken of them. This department also contracts for wiring construction to be done by the companies, sells motors, heating appliances, and so on. The Edison Company furnishes free, and the Commonwealth Company a limited number, of incandescent lamps for original installation, while both companies furnish free incandescent lamps for renewals. Arc lamps, and, under certain conditions, signs, are furnished free by the companies. Solicitors are employed on the salary basis, with small commissions for special and excess work.

Contracts, upon being obtained, are first submitted to the Accounting Department for credit approval, with as few deposits as possible. After approval of credit, advices are sent to the Inspection Department, which passes upon the wiring installation; to the Line and Service Construction Department if service wires are required, and to the Meter Department to prepare meters. After approval of the wiring, the Inspection Department advises the Operating Department to install meters and lamps and to connect the service. The latter, after executing order, returns advices through the various departments to the Accounting Department, where an account is opened for the new customer on the books, and the order slip is filed.

The Accounting Department, with branches at the district offices, makes out all bills for service and construction work, keeps and collects all accounts, and has the custody of all contracts. The mails are used for the distribution of bills, and such money as is not paid at the companies' offices is attended to by collectors. Modern labor-saving devices for accounting work are used as far as possible, such as addressographs, sealers, etc., and the loose-leaf type of ledgers and records prevail. Employees are all paid by check, the office force being paid semi-monthly, and the station operatives, construction men, street laborers, and others, weekly.

The Meter Department, as its name implies, has entire charge of all meters on customers' premises. Mechanical meters, principally Thomson-Houston and Fort Wayne, are used. The meters are generally read monthly, but a very considerable portion of business is handled on a weekly basis.

The Inspection Department examines and keeps a record of all customers, lighting and power installations, and also a record of all transformers and alternating current service connections. In addition, this department checks the character of service rendered to customers and investigates all cases of lost and stolen current.

The Interior Wiring Department employs more men than any wiring concern in the city; does a large volume of business, is more than self-supporting, and is looked upon as a valuable adjunct for securing new business. The policy of the company as to this department is not to sharpen competition, but rather to encourage and maintain the highest standard of interior wiring construction, so essential to the best lighting and power service.

A Supply Department combines with the companies' stores a Sales Department for selling of supplies to contractors and the general public. It is also directly profitable, and an aid in business-promotion work by displaying lighting devices and selling apparatus.

The Operating Department has charge of the generation and distribution of all electrical energy to the companies' patrons. Among its duties might be mentioned the operation of the various stations and substations, the extension and maintenance of all underground and overhead lines, all meter work, customers' repairs, and the trimming and patrolling of arc lamps.

The Engineering Department, employing a considerable number of engineers and draughtsmen, is in direct charge of the erection and equipment of all stations and substations, and has general charge of all the engineering work of the two companies.

A Statistical Bureau collects and preserves in accessible and useful form all general and department data of every kind.

In addition to these various working departments, the employees sustain a library supplied with all the technical and many of the standard magazines, and a good and growing collection of standard technical books.

A magazine called the Electric City, with a monthly circulation of 25,000 copies, having for its object the complete electrification of the city, is published in the interests of the two companies.

This entire organization has been the growth of a dozen years under the present administration, and is, with the growth of the companies, constantly being elaborated and extended. During the past six years, being the period covered by the operations of both of the companies, the combined connected load of the central stations has increased from 600,000 16 candle-power equivalents in 1898 to a conneeted load at date of 2,000,000 16 candle-power equivalents.

Single customers consuming 500,000 kilowatt hours of energy annually are common, and over ten times this consumption has been reached in individual cases. The companies are making special efforts to obtain this large business and remove or prevent the installation of isolated plants, but at the same time in no way neglecting the smaller business.

The field for the extension of business seems to increase with the facilities for supply. Especially does this seem to be true in the matter of electric power. The policy of the present administration is, and has been, one of liberality and aggressiveness, utilizing the highest economies of production which the most modern apparatus can give, keeping the condition of the property up to a high standard, and selling the product at the lowest priee consistent with a fair return to the shareholders.

*ELECTRIC TRANSPORTATION AND TELEPHONE SERVICE*

## *The Elevated Railways of Chicago*

The Chicago elevated railway systems are operated by electricity and are all run over the so-called Union Loop, making a circuit of about two miles through and around the business center of the city. There are eleven stations on the Loop from which each road receives and discharges passengers. The Loop is a two-track railroad built in the center of the streets, the north side of the Loop being on Lake street from Fifth avenue to Wabash avenue, the east side being on Wabash avenue from Lake street to Van Buren street, the south side being on Van Buren street from Wabash avenue to Fifth avenue, and the west side being on Fifth avenue from Van Buren street to Lake street.

In the year 1903 the elevated railroads of Chicago carried 114,873,652 passengers. Average number carried per day, 314,722.

Thirty-five per cent of the daily passengers carried are received and discharged during the rush hours morning and evening. In the evening rush hours the Loop loads 38,600 passengers per hour. During this period there are from 48 to 53 trains of four and five cars each on the Loop at one time. The time required to make a circuit of the Loop, stopping at each station to discharge and receive passengers, is from 13 to 15 minutes.

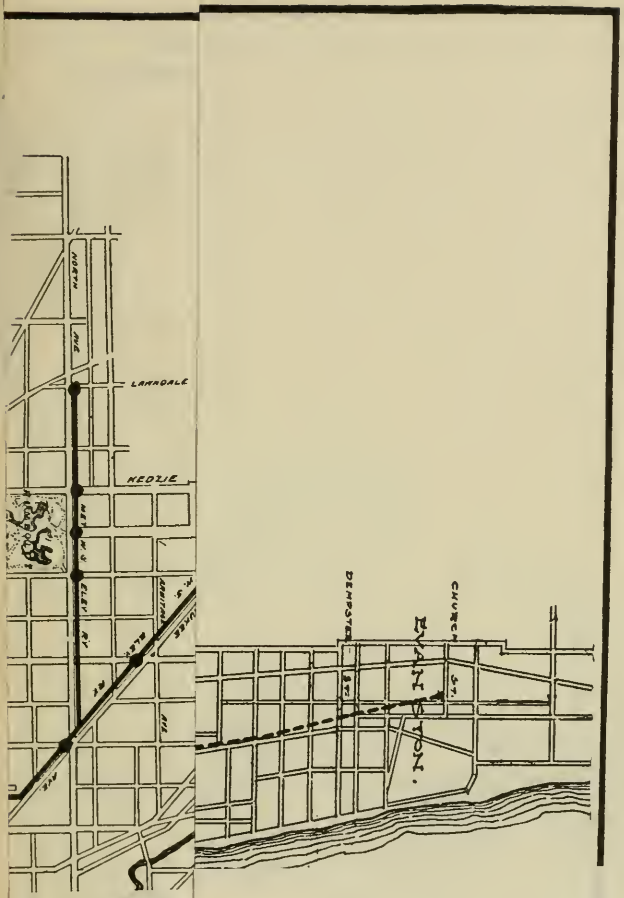
The accompanying sketch shows the Loop and the various roads leading to and from it, together with location of stations on the various lines.

Chicago's elevated railroads are the Metropolitan West Side Elevated, the South Side Elevated, the Northwestern Elevated and the Chicago and Oak Park Elevated.

The Metropolitan West Side Elevated Railway Company has 38.7 miles of single track, built on its own right of way. It is a four-track line west to Marshfield avenue. From Marshfield avenue the road branches into three separate lines: the Douglas Park line, the Garfield Park line, and the Humboldt Park line; the Logan Square branch leaves the Humboldt Park line at Robey street and North avenue. This company has 87 motor cars and 262 coaches. It at present is operating the locomotive system, but is transferring to the multi-unit system. The power house is located at Throop and Van Buren streets, the nearest elevated station thereto being at Center avenue on the Garfield Park and Douglas Park lines. The capacity of the power plant is 10,100 kilowatts.

The South Side Elevated Railroad Company's road runs south and east from the Union Loop to Stony Island avenue and Sixty-third street, a distance of 8.6 miles. It is built on its own right of way except about one and one-half miles on Sixty-third street. It has 18.8 miles of single track. It was the first road to equip electrically with the multi-unit system. The rolling stock consists of 220 motor cars and 30 coaches. Its power house, located on State street between Thirty-ninth and Fortieth streets, has a capacity of 7,700 kilowatts. In its power system this road has two storage battery plants floating on its line, one at Twelfth street and the other at Sixty-third street, each having a capacity of 750 kilowatts.

The Northwestern Elevated Railroad Company's road runs from the Union Loop to Wilson avenue, a distance of 6.37 miles, built on its own right of way, except the distance from the Loop to Chicago avenue. This latter portion of the road is a two-track road, and from Chicago Avenue to Wilson avenue it is a four-track road, the two outer tracks being used for local service and the two inner tracks for express service. This road has 23.7 miles of single track. It is at present using the locomotive system, but is transferring to the multi-unit system. Its rolling stock at present consists of 59 motor cars and 160 coaches. The power house is located at Southport and Fullerton avenues and has a capacity of 8,100 kilowatts. This power house lies 2,000 feet west of the structure and is conveniently reached from the Fullerton


LAWNDALE
KEDZIE
NORTH AVE
DEMPSTER ST.
CHURCH ST.
EVANSTON.

MAP SHOWING
THE ELEVATED RAILROAD SYSTEM
CITY OF CHICAGO
SURFACE EXTENSION OF CHICAGO & OAK PARK LINE
HARLEM RACE TRACK
OAK PARK
AUSTIN
EVANSTON
ROGERS PARK
LAKE MICHIGAN
SCALE OF MILES

avenue station. At the Wilson avenue terminal is a modern storage battery plant of 1,500 kilowatts capacity.

The accompanying map shows in dotted lines a proposed branch of the Northwestern Elevated, known as the Ravenswood line, which will be a three-track structure 3.48 miles long. This line will connect with the center or express tracks of the main line, and all trains will run express from the junction to and from the Loop. The dotted line near the lake shore from Wilson avenue to Evanston shows a proposed extension. This will be a two-track railroad 6½ miles long, which will run express service from Evanston to Chicago, a distance of 12.7 miles.

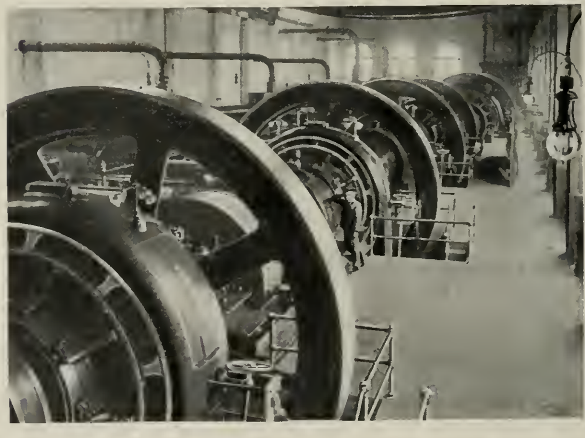
The Chicago and Oak Park Elevated Railroad Company has a two and three track structure, built on Lake street and running west on an elevated structure from the Loop to Fifty-second avenue and from that point on an incline to the surface paralleling South boulevard and the Chicago & North-Western steam road to Harlem avenue, the west line of Oak Park, a distance of 8.82 miles. It has 20.57 miles of single track. Its third or express track, running from Rockwell street west to Fortieth avenue, enables it to operate express trains to the city in the morning and from the city in the evening. This road has two modern sub-stations taking alternating current from the Commonwealth Electric Company's plant. The transmission line to the Lombard avenue sub-station is 9 miles in length, and from the power house to the Rockwell street station is 5.18 miles in length. These two sub-stations are equipped with six 1,000-kilowatt, six-phase, 25-cycle, rotary converters. The rolling stock of this road consists of 44 motor cars and 122 coaches, using the locomotive system, four cars per train.

### THE SOUTH SIDE ELEVATED RAILROAD COMPANY POWER PLANT

The power house of the South Side Elevated Railroad Company, designed by Messrs. Sargent & Lundy of Chicago, presents an example of the use of a power house containing a number of large engine type direct current railway generators, especially designed for flexibility and reliability in handling a fluctuating power load of wide limits.

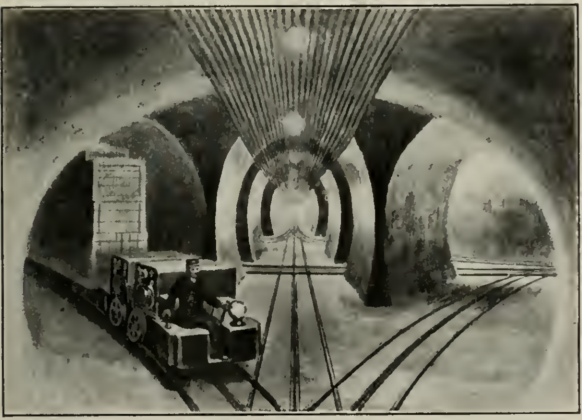
The power house began operation on May 1st, 1898. Up to the present date there has at no time been any failure of necessary supply of current, either in whole or in part, though the conditions of overload have been unusually severe. For the period November 12th to 26th, 1903, the twenty-four-hour average output from the station was 4501 kilowatts; the normal full load rating of generators then installed being 6,200 kilowatts. The twenty-four-hour average load November 17th was 4,981 kilowatts, with a three-hour period during which the average load was 7,578 kilowatts, and a one-hour load of 8,028 kilowatts, the maximum peak being about 12,500 kilowatts. It is only fair to state that such an overload record is creditable to the engineer in charge as well as to reliability of the installation in every detail.

The present normal full-load capacity is 7,700 kilowatts, all in direct current generators, at 630 volts.



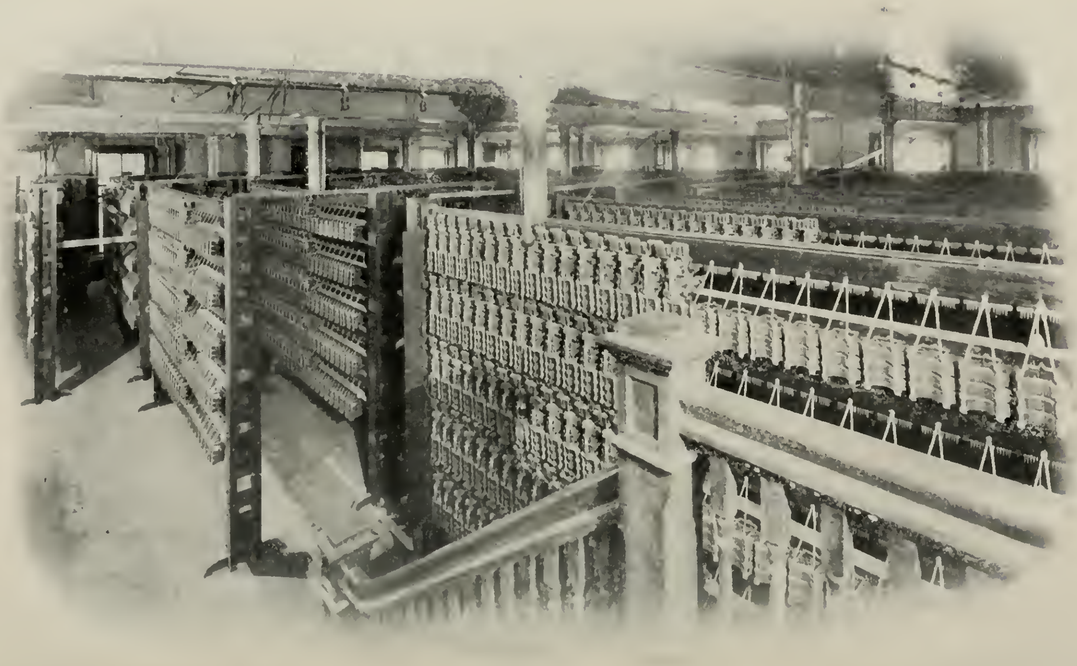
POWER HOUSE, SOUTH SIDE ELEVATED RAILROAD COMPANY

Transportation and sanitation—these are the great problems of Chicago. The solution of the first is the removal of the tremendous congestion upon the surface of the streets, caused by the immense congregation of people and vehicles in a small space. To understand this it must be known that the great mass of traffic and



STREET INTERSECTION OF TUNNEL

teaming for business purposes is practically confined to a square mile in the heart of the business district, "the loop," as the resident designates the space bounded by the elevated structure occupying Van Buren street on the south, Lake street on the north, Wabash avenue on the east and Fifth avenue on the west. Over this structure are operated all the cars of all the elevated roads,



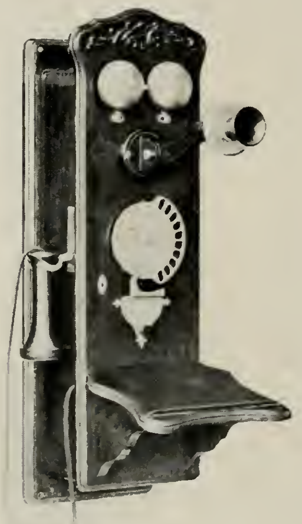
ILLINOIS TELEPHONE & TELEGRAPH COMPANY SWITCHBOARD each of them, through a score of stations, discharging thousands of pedestrians hourly into this district. This, in a community of 2,241,000 souls, all of them at some time or other drawn into the "loop" for business or pleasure, presents a phase in transportation difficult even to appreciate unless understood through experience. Again, it must be realized that within this so-called "loop" are the great retail shops, the hotels, the theaters, the newspaper offices and the sky-scraping office buildings, some of the latter sheltering 10,000 people in their daily vocations, and visited each twenty-four hours by as many more. And all this time within the "loop" is the traffic—street cars, trucks, delivery wagons, the carriages of the pleasure seekers, and those most essential vehicles, the ambulances, police and fire apparatus.

In the problem of sanitation are two important considerations—purity of water and purity of air. In the building of its great sanitary canal and its work upon a vast system of intercepting sewers, Chicago promises to solve the first question. As yet but slight progress has been made towards clearing the atmosphere. Soft coal is burned in this city. The gigantic office buildings use thousands of tons of screenings in their furnaces, and not only do the chimneys belch forth darkening clouds of oily smoke and cinders, but the dusty loads of coal are trucked along the thoroughfare in open wagons, while the residue of ashes is taken away and carried through the streets, a goodly proportion to be blown into the eyes and nostrils of the pedestrians before it is dumped at some outlying point.

Surrounding this "loop" section and situated as if for the purpose of accentuating the gloom, are the termini of the railroads. East, west, north and south, the visitor is confronted with depots and yards. Belching volumes of soft coal smoke, the locomotives add to the nuisance, and no matter which way the wind blows, Chicago, in its business district, the habitation of its energy and its spirit, is smoky, gloomy, dirty.

But the solution is at hand, and, like every solution to a great problem, it is simple, as simple as a hole in the ground. As a matter of fact, a hole in the ground is the solution. In exact truth it is just this—the conduit of the Illinois Tunnel Company.

By authority of an ordinance passed by the city council of Chicago, February 20, 1899, a franchise was granted to the Illinois Telephone and Telegraph Company permitting it to construct and maintain a conduit for telephone purposes. From this has been the expansion which to-day means that the successor of the original corporation, the Illinois Tunnel Company, not only has the first granted privilege, but the right to construct tunnels which may be utilized for freight-carrying on a basis which is a marvel to the world.



Aside from all else, the telephone operations of the Illinois Tunnel Company are marvelous even in this day of perfection and progress along the lines of mechanical ingenuity. Already installed and in working order within the business district of the city are ten thousand automatic instruments, furnishing subscribers instantaneous service, absolutely secret and without the intervention of human operators. It is, in a phrase, "a girlless, cussless, out-of-orderless" system, enabling patrons of the telephone to secure immediate communication without the intervention of a third party. It is a conversation-carrying device which protects the user. It makes possible the secrecy of a long-distance talk, for with this system there is no "breaking in," no "cutting out," no "listening in," none of the annoying features of the manual board system. It insures a conversation against the eavesdropping of a third person, and its operation is quicker and simpler than that of the telephone with which it competes. In addition to this, it is capable of unlimited expansion, is never out of order and during the period of its installation has received no adverse criticism from its users. It is a factor, too, in solving the problem of transportation, because it enables people to conduct the most important conversations between distant points, assured of accuracy of transmission, and so removes the necessity of travel when an important confidential conference is desired. It is a further factor in the manufacturing world, for the company controls the great factory wherein the telephones and telephonic devices are produced. And this output is not confined to the operating territory in Chicago alone, for in many cities of the country automatic exchanges have been established, while there is a constantly growing demand throughout the land—so much of a demand that the present capacity of the works, already large, is unable to keep pace with unsolicited orders.

But this sphere of the work of the Illinois Tunnel Company, important as it is, interesting as it appears, valuable as it may be in the commercial sense, is pygmy when contrasted with the stupendous principal undertaking of the corporation.

Beneath Chicago, their tops 24 feet 6 inches below the surface, are the tunnels. With walls of concrete, fashioned after the shape of a horseshoe, they form a network of subterranean streets under the surface in the business district of the metropolis. More than this, the tunnels go beneath the river to the north and west divisions of the city, and, under the terms of the grant from the municipality, may be extended until the entire territory of Chicago is undermined for the furtherance of the useful purposes set forth in the license. With the methods of building this work, which is at once a wonderment to layman and engineer alike, it is not the purpose of this article to deal. The exigencies of time and space prohibit a narration of the manner in which the first shafts were sunk, how thousands of men and hundreds of teams were employed on the work, which was pushed to completion almost before the citizens of Chicago knew what was being done. It is the purpose to set forth the accomplishment and to tell something of the ends which are to be attained. For when it is all completed, and the work of the projectors is finished, the great problems of transportation and sanitation in Chicago will have been solved.

After the tunnels were constructed under every street, with the necessary connections beneath the river so that all divisions of the city may be reached in the expanding system, permission was granted the Company by the municipality to conduct a general transportation business. This comprehends the carrying of mail, newspapers, packages, merchandise, coal, lumber, grain and every conceivable sort of freight. The additional license or grant also permits the company to use the tunnels as termini for the transfer of freight from the steam railroad cars to the cars of the tunnel company, and deliver this freight through the tunnels and into the basements of the buildings throughout the city.

The magnitude of this latter phase may be better understood when it is realized that Chicago is the greatest railroad center in the world. More than thirty-five per cent of the entire mileage of the United States terminates in the mile and one-half square which includes the business center of the city. The cost of teaming to and from the railroad terminals in this territory was, in 1903, considerably in excess of $50,000,000, this sum representing a much larger expenditure than is earned by any of the railroads entering the territory.

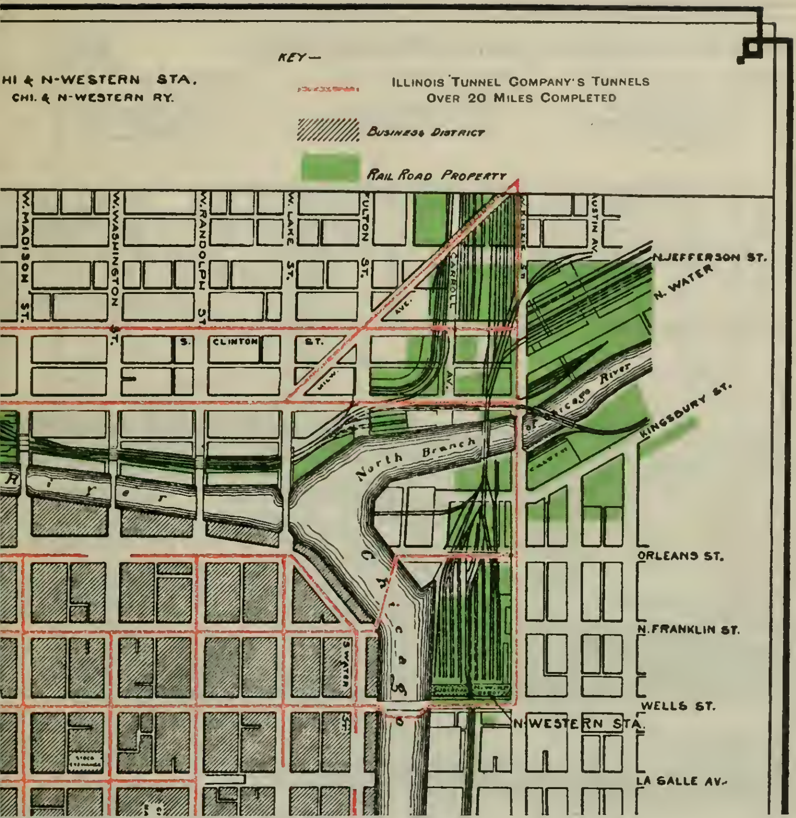
An examination of the plat (included herein) will show that the railroads have acquired practically all the property that may be secured for terminal uses. Because of the terminal locations in the congested districts of a great city and the consequent accidents, many of them of a serious, if not fatal character, constantly occurring at grade crossings, the city council of Chicago forced the elevation of the tracks, and this almost immediately reduced the capacity of these terminals from twenty-five to fifty per cent. With the reduction of terminal capac-

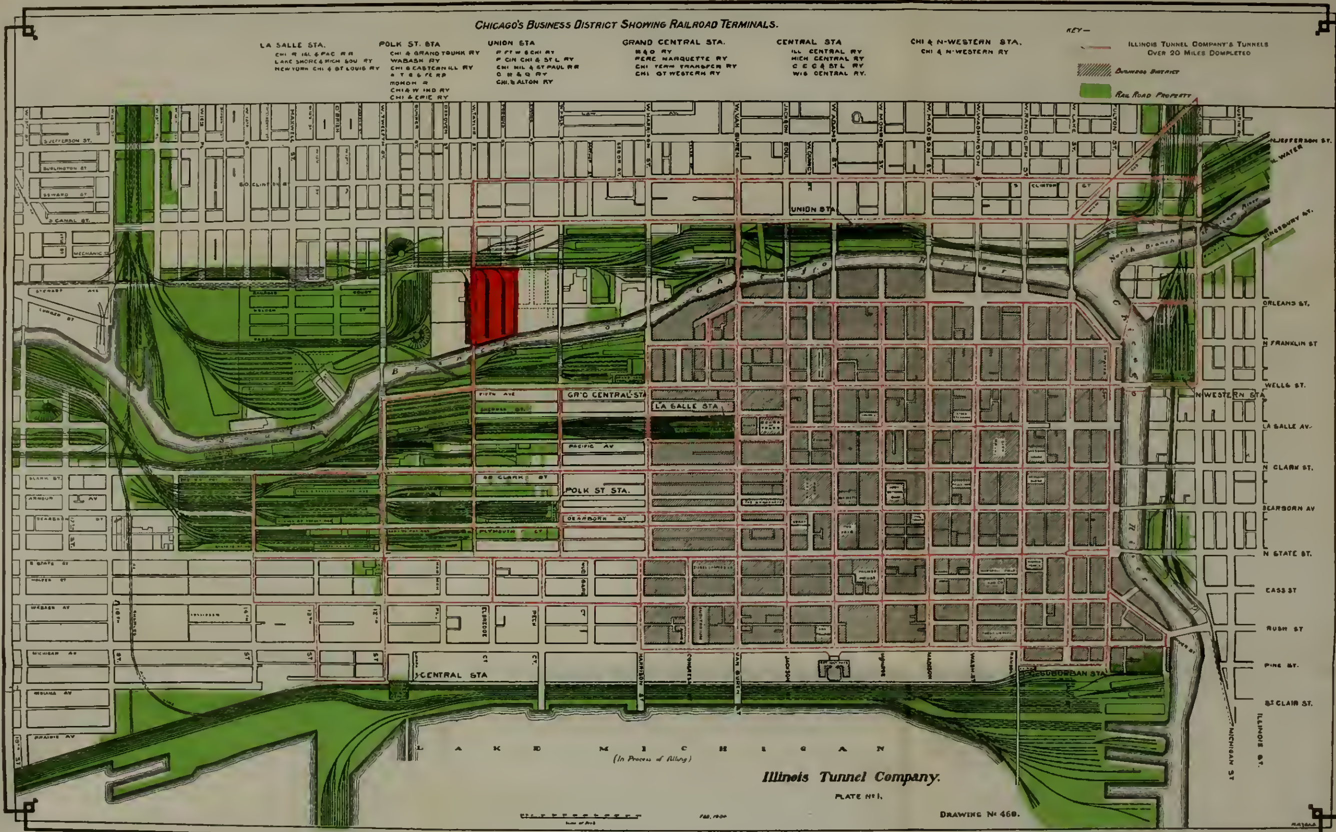

ELECTRIC LOCOMOTIVE AND LOADED FREIGHT CAR

ity comes the increase of trucking requirements, and to-day it may be safely estimated that 30,000 teams are in use within the already over-congested business district. It must also be understood that the teaming and trucking service is practically crowded into a time limit of from eight to nine hours, and this in the busiest part of the city's busy day. Furthermore, this service may not be depended upon entirely, for while it is endurable and fairly satisfactory when weather conditions are good, a great proportion becomes useless in bad weather, delays are incurred, and long, annoying detentions are resultant, thus inviting further confusion and congestion on the following fair days.

This, however, is not all. The cost of operating and maintaining the trucking business in the streets is of vital importance. On the estimate of a conservative statistician the total investment in trucking rigs within the city is placed at $57,000,000. The cost of maintaining this immense establishment is becoming too expensive, and merchants are seeking a relief which involves a fixed charge per year on the handling of their tonnage, without investment on their part. The teaming interests have, without question, reached their limit. They have taken the streets, they have placed every horse in service that it is possible to use, they have advanced their charges, they have co-operated with every one with whom co-operation is possible, until pedestrian and merchant, receiver and shipper, find themselves not only helpless but utterly swamped.

It is this condition that the Illinois Tunnel Company will change. To begin with, the service is increased from ght or nine hours a day in fair weather to twenty-four hours in all kinds of weather. Instantly the capacity of the terminals is increased by at least one hundred per cent. But this is not all, nor the most important from the point of view of good government. The first consideration is the welfare of the people. In New York and other cities the solution of the transportation problem is to put the people underground and reserve the surface for traffic. The saner and more desirable way is to reverse this and keep the people, who wish quick and safe locomotion, in the air and in the light. The mechanical and commercial side of life should be put underground. The streets ought to be preserved to the pedestrians. In the plan of the Illinois Tunnel Company the ungainly, unsightly and awkward things, the parcels, freight, coal, and merchandise, are sent underground, to the advantage of the general public, which is given the sunshine and freedom of the thoroughfares.


KEY—
HI & N-WESTERN STA.
CHI. & N-WESTERN RY.
ILLINOIS TUNNEL COMPANY'S TUNNELS
OVER 20 MILES COMPLETED
BUSINESS DISTRICT
RAIL ROAD PROPERTY
W. MADISON ST.
W. WASHINGTON ST.
W. RANDOLPH ST.
W. LAKE ST.
FULTON ST.
CARROLL AV.
AUSTIN AV.
N. JEFFERSON ST.
N. WATER
S. CLINTON ST.
KINGSBURY ST.
Chicago River
North Branch
River
Chicago
ORLEANS ST.
N. FRANKLIN ST.
WELLS ST.
N. WESTERN STA.
LA SALLE AV.

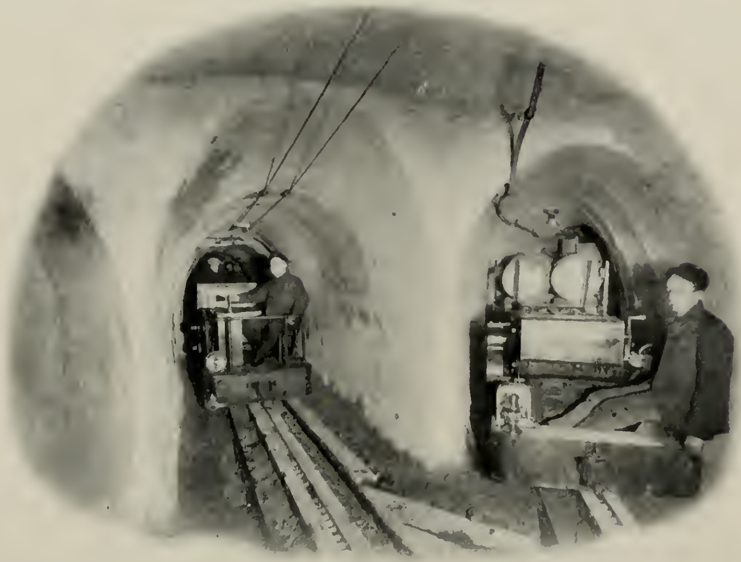

CHICAGO'S BUSINESS DISTRICT SHOWING RAILROAD TERMINALS.
LA SALLE STA.
LAKE SHORE & MICH SOU RY
NEW YORK CHI & ST LOUIS RY
POLK ST. STA
CHI & GRAND TRUNK RY
WABASH RY
CHI & EASTERN ILL RY
MONON R
CHI & W IND RY
CHI & ERIE RY
UNION STA
P CIN CHI & ST L RY
CHI MIL & ST PAUL RR
C B & Q RY
CHI & ALTON RY
GRAND CENTRAL STA.
B & O RY
PERE MARQUETTE RY
CHI TERM TRANSFER RY
CHI GT WESTERN RY
CENTRAL STA
ILL CENTRAL RY
MICH CENTRAL RY
C C C & ST L RY
WIS CENTRAL RY.
CHI & N-WESTERN STA.
CHI & N-WESTERN RY
KEY—
ILLINOIS TUNNEL COMPANY'S TUNNELS
OVER 20 MILES COMPLETED
Business District
Rail Road Property
UNION STA
GR'D CENTRAL STA
LA SALLE STA
POLK ST STA.
CENTRAL STA
N-WESTERN STA
ORLEANS ST.
N FRANKLIN ST
WELLS ST.
LA SALLE AV.
N CLARK ST.
DEARBORN AV
N STATE ST.
CASS ST
RUSH ST
PINE ST.
ST CLAIR ST.
MICHIGAN ST
ILLINOIS ST.
L A K E M I C H I G A N
(In Process of Filling)
Illinois Tunnel Company.
PLATE No 1.
DRAWING No 468.

In the designing of a proper system for the transportation of merchandise through the tunnels so as to care for any increased business and relieve congestion, these facts had to be considered:

First—The strength of any railroad as to the tonnage which may be handled by it depends upon its side tracks. Therefore, as the Illinois Tunnel Company is limited as to the space it could occupy in the streets with absolute safety to the buildings, a size was adopted which woutd permit, if necessary, a side track to be constructed on each side of the main tunnels, which are built in the middle of the streets, forty feet below the surface. From a glance at the plat it will be observed that there are nine streets leading north and south and ten streets leading east and west in the business or congested district. As the tunnels are constructed, this makes a railroad of nine tracks wide north and south, with room to place two sidings on each track, while east and west the tunnels are similar to a railroad ten tracks wide, each track being sufficiently apart from every other to permit two sidings in each street. In the picture showing an intersection of two streets it will be seen that at least one hundred loops may be utilized by trains in which to pass around every block, thus multiplving the carrving capacity of the tunnel trains.

Second—It must be remembered that ninety per cent of the freight the railroads carry has to pass through the car door, and that everything which passes through the freight car door can be taken through these tunnels. Next it becomes important that the standard car adopted should go into the basements of any building without cost of alteration to the property holders, if they are to receive freight through the tunnels.

The tunnels are equipped with a No. 56 rail, laid in a concrete roadbed and cast-iron chairs, without ties, over which steel cars, each having a capacity of seven tons of coal, or twenty-four barrels of flour or sugar, may be transferred by electric locomotives, having a capacity of 8,000 pounds, draw bar pull.



FREIGHT TRAINS AT STREET INTERSECTION

The connections with buildings where freight is to be received and delivered is made by means of an elevator on which the cars are run and then elevated to the basements of the buildings from the level of the tunnel. The same method is to be adopted with many of the railroad terminals, while other railroad terminal connections will be through an incline with a nine per cent grade, where the rack system, used by railroads in mountainous countries, will be used. There is a difference in the system, however, in that the cogwheel used on this rack system will transmit the electric current from the rack to the electric locomotives. The trains will run direct from the tunnel up the incline to the railroad yards and transfer freight from the railroad cars across the platform to the cars of the tunnel company.

But very few of the buildings of Chicago have been built on pile or caisson foundations, but since these tunnels have been built the leading architects of the city have directed their attention to designing all new buildings so that they will go down to the floor level of the tunnels. This lower space is to be used as sub-basements or underground freight yards for the buildings. As new buildings are being constructed at the present time, one of the very practical uses to which the tunnel system may be put is being daily demonstrated. In the making of excavations, instead of lifting the earth to the street and carrying it away in wagons to the discomfort of all pedestrians in the vicinity, the soil is being passed down into the tunnel, loaded into the electric cars and transferred through an incline shaft to the Lake Front, where it is used to fill in the new Grant Park. A moment's consideration of this feature will satisfy any one of the great advantage to be obtained. Not only is a great public improvement materially assisted, but the streets are relieved of the unsightliness, the dirt and the disorder usually attending a considerable work of excavation. Another most important feature of this character is that comprehended in the carrying of coal. In 1902 there were delivered by horse power in Chicago

8,000,000 tons of coal, most of it bituminous and all of the deliveries attended by the discomfort incident to the carriage of such freight through the streets. With the old trucking system but one day's supply was delivered to the big office buildings, and, as is well known, the streets are frequently choked by the coal traffic alone. Under the tunnel system this will all be done away with, the coal will be delivered underground, the ashes will be removed in the same way, and the health of the municipality subserved by the removal of much of the dirt and dust unavoidably connected with such deliveries. On the score of economy alone this method of transportation will appeal to the owners of buildings, for the coal will be delivered direct to the furnaces and the ashes taken away with the minimum cost for handling.

In Chicago approximately 100,000 tons of freight are handled daily. It will be put underground in a manner that is at once economical to the merchant and satisfactory to the pedestrian. Already the newspapers are editorializing upon the relief to be effected when the system is in complete operation. There is a cry against the ear-splitting and nerve-racking hubbub which envelopes the business district throughout the day. Heavy trucks upon cobblestone pavements are a prolific source of racket, and so long as they remain upon the surface will continue to be a nuisance. This nuisance the underground tunnel system of the Illinois Tunnel Company will eliminate. And the system, capable of an expansion which can hardly be dreamed of at this time, will do more towards the relief from congestion and noise and dirt. It will enable the railroads to move their freight terminals to the limits of the city, affording them opportunity to utilize the present terminals for passenger and express service, the freight being brought to the distributing center underground. It will practically solve the smoke problem, for with the changing conditions, the railroads entering the business districts will eventually do away with the steam locomotive, that most fruitful source of smoke, and substitute electric motive power.

Better suburban service will be provided, and with the streets cleared of traffic wagons, the dust and dirt and smoke largely abated, the unsightly functions of commercialism transacted beneath the surface, Chicago will present a new aspect and become a city celebrated for its cleanliness and beauty, as it is now famous for its grime and street congestion. And all of this will tend to increase commercial activity, because the business of transportation will be conducted at the minimum cost, without delay and without the annoying features with which it is now attended.

With the longest tunnel system in the world, with a plan of operation which will relieve the streets of traffic congestion, with a telephone system which assures absolute secret service and instant communication, the Illinois Tunnel Company stands before the world to-day as the most remarkable of the public service corporations.

# *The Aurora, Elgin and Chicago Railway*

The above road, one of the first high-speed, third-rail inter-urban lines installed in this section of the country, runs from the 52d avenue terminus of the Metropolitan Elevated Road on the West Side, in a southwesterly direction to Aurora, 37 miles distant, passing through a number of Chicago's important suburbs and furnishing a high-speed service in competition with the Chicago & North-Western steam road.

The road is double track from Chicago to Wheaton, about 20 miles, where it divides, one branch running northwest to Elgin, another to Aurora, and still another to Batavia, 35 miles west of Chicago, where the Power House is located. The service is furnished by three 1,500-kilowatt, 25-cycle, engine-driven alternators at 2,300 volts three-phase. The current is stepped up to 26,000 volts and distributed from six rotary stations. Each car is equipped with four 125-horse-power motors, with the multiple system of control. The motors are geared for a speed of 65 miles per hour, which is frequently attained.

The company owns its right of way, and as the country through which the road runs is very level and curves are few, the conditions are ideal for high speed. The track is laid with 100-lb. rail. The schedule time is 33 miles per hour, and trains run every quarter hour during the busy hours of the day, with a thirty-minute service during the remainder of the time.

The unprotected third rail has not been found to cause any trouble, even in the most severe winter weather.

*CHICAGO TELEPHONE COMPANY*

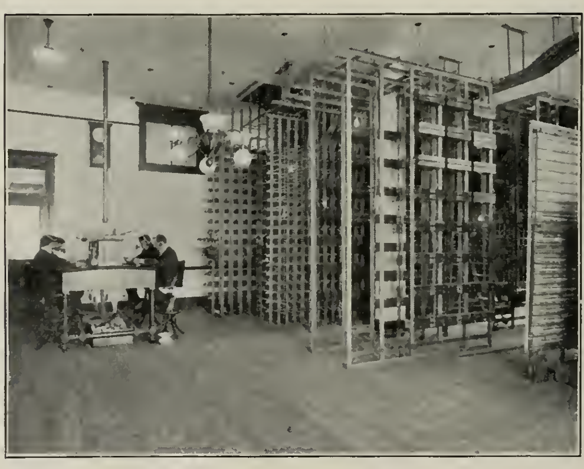
MAIN OFFICE, CHICAGO TELEPHONE COMPANY.

## *The Chicago Telephone Company*

The Chicago Telephone Company has been for the past twenty-five years furnishing telephone service in the City of Chicago and the surrounding territory embraced within a radius of about forty miles, and is operating at this time a total of 104,000 telephones, of which 82,000 are in the Chicago city exchange, the remainder being operated in about 150 suburban exchanges. In the outside territory the service is furnished by means of equipment which is modern in every respect, metallic circuits, relay common battery switchboards and modern apparatus being used throughout. Toll lines extend throughout the territory in every direction, and in the country surrounding nearly all of the exchanges farmers' lines have been developed, furnishing not only a neighborhood service between the farmers and nearby villages and towns but direct toll line service to Chicago and to the entire country by means of the long distance lines of the American Telephone and Telegraph Company.

The exchange in the City of Chicago has always presented most interesting problems to telephone engineers and operating men. For more than twenty years it has been recorded of it that more service per instrument is furnished than in any other exchange in the world. In Chicago the telephone is availed of constantly during the business hours of the day by the busiest of Chicago's business men, and is found ready at his hand as an indispensable article of desk furniture. Records have been made of telephones in business places which have been used more than 300 times in one day. This pressure of traffic at an early date brought out features in the service which have since been found indispensable, not only in Chicago, but in the large exchanges throughout the world. The first private branch exchange was estab-

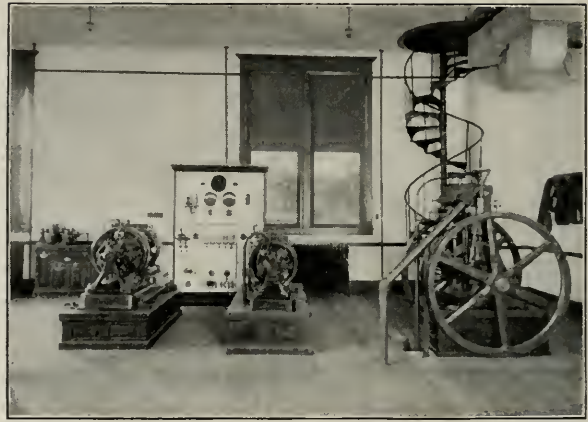
A LARGE PRIVATE EXCHANGE BOARD



TERMINAL ROOM

lished to fit the peculiar requirements of a large and busy manufacturing establishment in Chicago. To-day there are more than 1,200 private branch exchange switchboards in business places, one establishment requiring the service of thirteen trained operators to handle its business. Electric lights as signals on telephone lines were first used in Chicago, and the development which has led to their general introduction in all large exchanges was started by their use in several of the Chicago Exchange offices. The so-called automatic ringing was first used in a downtown Chicago office and has since been generally used throughout the country where inter-office trunking is necessary.

The general introduction of underground conduits began in Chicago in 1890, and has continued steadily each year until at the present time the Company is operating 235.36 miles of underground conduit, comprising 1,372.28 miles of duct. The wire in underground cables at this time aggregates 149,233.68 miles, and of aerial wires in the Chicago Exchange 40,480.05 miles. In the downtown district the telephone wires operated by the Company are buried throughout. Cables are led from the exchange offices through the underground conduits and directly to the buildings or particular business blocks to be reached. In the large buildings, direct cable terminals are established in basement rooms near the elevator or wire shafts which have been provided. Distribution is made by lead-covered cable to terminal boxes on each floor of the building and thence by individual wire led in behind moldings extended throughout the halls, so that in this way any particular office or room may be reached, the wiring being concealed throughout its entire length. Behind these moldings and in the underground runs, low tension wires only are provided for, it being arranged that electric lighting, power or other high tension wires are separated from them at all points. The standard of 200 pairs for underground cables was adopted in 1893, which has since been increased to 300 pairs and 400 pairs for



TYPICAL POWER PLANT

OPERATORS AT LUNCHEON

certain portions of the business district, all insulation being of paper encased with the usual lead cover. In the outlying districts the distribution of wires to the premises of subscribers is accomplished by means of pole lines, built in alleys. Underground cables are led directly to terminal boxes located upon poles in such lines, distribution being made by overhead wire for a distance of one or two blocks in either direction, so-called

TYPICAL SUB-EXCHANGE BUILDING

"drop wires" extending from these poles to the rear of the residence or place of business to be reached. There are very few pole lines located in the streets. The territory of the Chicago Exchange being about eighteen miles long by six miles wide, many long lines in the outlying portions were inevitably involved. This territory is now covered by fourteen sub-exchange districts.

In 1894, a four-party line service was introduced for the accommodation of private residences, a system of non-interfering signaling being provided which has continued to meet successfully all requirements in this respect.

By ordinance requirements in 1889 the rates for service in the Chicago Exchange were based on an annual sum for which the subscriber might use the telephone to any extent desired. Later on the requirements of very heavy users necessitated private branch exchange systems, and the requirements of private residences were such that one circuit might readily accommodate a number of subscribers, which made variations in this plan inevitable. The injustice of this so-called flat rate plan continued to be more and more apparent. The very small business user under it must of necessity pay just as much as the greatest. The storekeeper who used his telephone five times a day paid just as much as one whose use might be fifty or more calls. Measured rates were introduced in 1896, and immediately these were adopted to a large extent. It was not, however,

until 1900, when the measured service plan was introduced upon what is known as the "nickel" basis, that the Chicago Exchange took on a tremendous growth, which has since continued. Upon this plan the user of the telephone pays for the service at the time it is rendered, depositing a nickel or 5c piece in the coin box provided for that purpose. Upon this plan service is furnished, not only upon direct lines but in private exchanges, two-party and four-party lines, and also, for very small users, upon ten-party lines. In the latter class the telephone is installed in a residence upon a guarantee by the subscriber that the earnings shall not be less than 5c per

A SUB-EXCHANGE INTERIOR

day or in a place of business 10c per day. Nearly 50,000 telephones are now operated in Chicago on the nickel plan, and it is used by all classes of customers. The ten-party lines are separated from the general body of exchange lines and operated on special switchboards so that they may not in any way delay the general service of the exchange, other classes of service being operated in the usual manner, the type of coin box making it possible to accomplish this without retarding the service.

Twelve of the fourteen Chicago Exchange offices are operated in buildings owned by the Company, the two remaining being provided for by perpetual leasehold in fireproof office buildings. Relay multiple switchboards, accompanied by the usual storage battery and power plants, are operated in all of the offices, the system of trunking for intercommunication comprising a total of 3,658 trunks or junction circuits.

In the territory outside of the Chicago Exchange the Company owns eleven buildings in which its switchboards are operated.

The annual statistics for the past ten years, showing

MAIN OFFICE INTERIOR

in a general way the growth of the Company's business, are indicated in the following table.

The entire plant of the Chicago Company, including cables, switchboards and instruments, is now of the most modern class. Its efficiency is attested in the very large amount of traffic successfully handled. The engineering plans of the Company are based on an ultimate capacity for 250,000 telephones, and the widespread and increasing use of the service makes it appear not unlikely that this number may be reached even earlier than has been anticipated.

## TABLE SHOWING GROWTH OF CHICAGO TELEPHONE COMPANY'S PLANT DURING THE PAST TEN YEARS

| | 1894 | 1895 | 1896 | 1897 | 1898 | 1899 | 1900 | 1901 | 1902 | 1903 |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of Exchanges. | 15 | 22 | 31 | 42 | 58 | 70 | 84 | 95 | 112 | 114 |
| Toll Stations .... | 71 | 72 | 68 | 82 | 86 | 101 | 101 | 97 | 93 | 81 |
| No. of Exch. Telephones ....... | 12,049 | 13,869 | 15,384 | 16,909 | 21,188 | 27,663 | 36,414 | 53,511 | 79,043 | 101,187 |
| Undergro'nd Con. St. Miles. ..... | 49 | 52 | 54 | 58 | 61 | 104 | 121 | 156 | 197 | 235 |
| Undergro'd Duct Miles. ........ | 160 | 171 | 185 | 234 | 267 | 527 | 874 | 1,019 | 1,192 | 1,372 |
| Miles of Wire Underground. . | 18,820 | 19,050 | 20,548 | 24,324 | 30,259 | 41,757 | 68,593 | 87,685 | 123,708 | 149,234 |
| Miles of Wire Aer. Cables. ....... | 5,802 | 6,991 | 7,189 | 7,864 | 11,225 | 14,445 | 19,194 | 25,976 | 32,570 | 40,480 |
| Miles of Wire on Poles. ........ | 11,900 | 12,127 | 12,713 | 13,932 | 15,629 | 18,692 | 22,818 | 32,124 | 38,742 | 41,484 |
| Total Miles of Wire. ........ | 36,522 | 38,168 | 40,450 | 46,120 | 57,113 | 74,894 | 110,605 | 145,785 | 195,020 | 231,198 |
| Capital Stock. ... | $3,796,200 | 3,796,200 | 4,336,500 | 4,336,500 | 4,336,500 | 5,000,000 | 7,000,000 | 9,000,000 | 11,993,400 | 14,000,000 |

*ELECTRICAL MANUFACTURES*

## *Western Electric Company*

The observer of large and powerful machinery marvels at the manufacturing establishment which is able to turn out such apparatus in the ordinary course of its business. The observer of the small telephone instrument or of the inter-communicating exchange equipment marvels perhaps at the engineering and the delicacy of the mechanism, but seldom realizes the present magnitude of establishments manufacturing such comparatively small devices. And yet a consideration of the development of the telephone for commercial use and the present enormous extent of the telephone systems of this and foreign countries, where standardization of equipment is so important an element, points at once to the necessity for concentration of this work in the hands of large manufacturers.

In 1869, in a little shop on the top floor of what is now an old and dilapidated building in Cleveland, Ohio, Elisha Gray and Enos M. Barton set up a small instrument shop and this became the seed from which has grown the Western Electric Company. The firm of Gray and Barton, manufacturers of annunciators, telegraph instruments, and handling a small electrical repair business, moved the following year to Chicago and established themselves in an unpretentious shop in the center of town on La Salle street, performing the same line of work that they had done in Cleveland. Moving to State street the following year, they escaped the big Chicago fire of 1871, but when the city was rebuilt, they set up again on Kinzie street near State street. In this shop they began the manufacture of telephone instruments for commercial operation, as well as extending their telegraph instrument manufacture, and becoming affiliated with the Western Union Telegraph Company, incorporated themselves under the name of the Western Electric Manufacturing Company. Later, when a closer relationship developed with the American Bell Telephone Company, then in its infancy, the company again reorganized under the name of Western Electric Company, of which Mr. Barton of the original firm of Gray and Barton is now President.

While most of the large electrical manufacturers have established their works in small country towns or suburban places, it naturally followed that the Western Electric Company, from its start a city concern, should have its growth in the city, and when in 1883 the Kinzie street shop of the Company became inadequate, a new building was erected on South Clinton street. It is a notable fact, as showing the possible success of city factories, that to-day with twenty-two establishments in various parts of the world, and with eight of those establishments manufacturing, all are located in large commercial centers.

Since its very beginning, the growth of the Company has kept step with the development and popular usefulness of the telephone; in addition to its telephone business, it has successfully taken up the manufacture of power and lighting apparatus, and has also carried on a jobbing business in electrical supplies, which is to-day the largest in America.

It is to the telephone business, however, that the magnitude of the Company is to be attributed. As sole manufacturer for the American Bell Telephone Company's interests, its shops have always been filled with telephone work. A glance at the American Telephone and Telegraph Company statement of operations for April, 1904, indicates something of the demands made upon the manufacturing company supplying the entire equipment. The total number of outstanding instruments on that date was over 4,000,000, an increase of approximately one quarter of a million over the previous year, while five years before the system had 1,125,000 instruments outstanding and ten years before less than

600,000, an increase in five years amounting to nearly 300 per cent and in ten years to nearly 600 per cent.

This evident success of the American Bell system can be attributed in a degree to the superiority of workmanship in the Western Electric factories, a superiority which has been achieved and is maintained largely by the extensive inspection methods employed. The influence of the factory inspector is felt everywhere. The workman realizes that his product will be rejected if not up to standard; the foreman is continually reminded that he must maintain the high quality of his output. The factories are literally policed by inspectors who stand for the superiority of the product and the rights of customers.

To guarantee the quality of the apparatus, the inspection begins with the receipt of the raw material, every particular class of material being tested under specifications issued in advance from the engineering departments, and each lot of material receiving the approval of the chief inspector before it becomes a part of the general stock.

All machines on which raw material is to be worked are set up by expert machinists, and sample products are gauged and inspected by the department inspector before the work is actually begun. The inspector exercises such a supervision over the work as may be needed to guard against faults and he may order the complete output held for his final approval if that seems desirable or necessary.

When manufactured parts are finished by any department, the foreman turns them into the combination Counting and Inspection Department, which keeps a card record of special instructions for each kind of piece made. Under this inspection, the pieces are counted, sorted and all that are perfect are credited to the foreman and turned into the piece parts stockroom. In the assembling of parts, the various operations are followed by the necessary tests and accurate gauges are used in making adjustments; when the apparatus is completed, it is delivered to the Department of Final Inspection, where each piece is inspected, gauged, tested and in some cases specially adjusted. This final inspection is supposed to be as critical as is practicable to apply to the thousands of pieces of apparatus turned out daily, and on the approval of this inspection, apparatus is placed in stock.

As a further check to insure care in manufacture, as well as to test the reliability and durability of the output, an Engineering Inspection Department is maintained. This department, provided with complete files of drawings and specifications and accurate testing devices, as well as with a knowledge of the requirements and use of the apparatus, inspects complete installations, investigates complaints, and studies, both in the laboratory and in the systems of customers, the effect of wear and of service conditions. The engineering inspection puts a check on the entire series of routine inspections. It watches the lists of apparatus approved by the Department of Final Inspection, and continually draws from stock various types of apparatus supposedly ready for shipment to customers. The inspection of this stock material is of the most searching character; tests, gauges and wearing processes are devised to show failure, unreliability or inefficiency in service. Each type of apparatus is taken apart or worn out for the purpose of developing any possible weakness, inconvenience or inaccessibility of parts, or concealed faults. Any unsatisfactory workmanship is noted and in case of discovery of actual defects, the entire supply may be ordered back into the shop for repairs and re-inspection. This high efficiency in the inspection work is one of the secrets of success in manufacturing which has carried the Western Electric product into all the markets of the world.

But it is not the purpose to dwell upon the telephone apparatus or the telephone installations of the Western Electric Company, nor to tell of its output of power and lighting apparatus which is scattered throughout the states, nor to point to the acknowledged efficiency of that portion of the business covering the distribution of supplies. The development of electrical engineering and the growth of the demands made upon manufacturers have been so rapid that few have found the time to devote to the perfection of factories; on this account the perfected factories of the Western Electric Company are of special interest.

In erecting the buildings, it has always been the policy of the Western Electric Company to use the best material and construction. At the time the first buildings were erected on South Clinton street in 1883, the interior construction was with cast-iron columns and iron girders, steel beams not being made at that time. Wooden joists were used, with double floors of pine and maple. As additions were made to the buildings, the construction was improved, and the next step was the use of mill construction. Then came the use of flitch beams, these beams resting on iron girders and being composed of channel irons with small joists between, to serve as a nailing for the floors. In 1896, when further buildings were erected, fireproof construction was used throughout, and when metallic window frames and wire-glass came into vogue, this construction was adopted, and in some cases, in order to reduce the fire risk, all of the woodwork used in sections devoted to office use was rendered fireproof by a patented process. All of the buildings recently erected have been of the highest class of fireproof construction, all elevators and stairways being enclosed within brick walls, sprinkler systems installed throughout and every precaution taken against loss of life by numerous fire escapes and fireproof bridges connecting buildings.

There are at present three separate works of the Western Electric Company in Chicago. One of these occupies nearly all of the two blocks bounded by Clinton, Van Buren, Jefferson and Harrison streets; another located at Polk street on the west bank of the Chicago river, and at third, the erection of which is now about complete, at Hawthorne, five miles west of the center of Chicago.

The Clinton street works, which represents a gradual growth on property acquired from time to time as more space was needed, and which represents an assembly of buildings rather than a carefully designed and united whole, consists of twenty-four separate structures, nearly all of which are of solid fireproof construction and connected by bridges and subways. There are 915,037 square feet or more than twenty-one acres of floor space available for manufacturing and office use; in this plant alone, are employed between four thousand and five thousand men and women. The electrical equipment consists of seven generating units of Western Electric manufacture, with a capacity of over 2,500 kilowatts for factory use. There are about 325 telephone stations, which, in combination with the thoroughly modern telephone exchange, connect all buildings and departments.

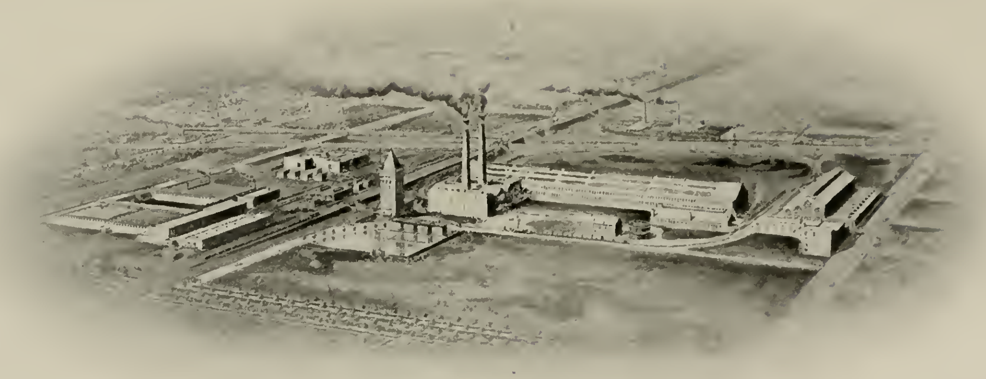
On the eighth floor of one group of these buildings are arranged the offices, many of them rich in their appointments and all designed for economy in the routine of office work.

One of the most interesting features of the Clinton street plant is its system for fire protection. At the pumping station, which is amply protected against falling buildings, there are two 1,500-gallon pumps, discharging under a pressure of 100 pounds into eleven street hydrants, and into nineteen 6-inch standpipes, which extend from basement to roof at each principal stairway and which have fifty feet of 2½-inch hose at each floor with 2½-inch connections at the roof; liquid fire extinguishers, sand buckets and water pails are well distributed over the entire plant. The private fire alarm system consists of 136 boxes, a box being located upon each floor at each stairway and connecting directly with the Fire Department headquarters, where is located the switchboard arranged both to register all fire alarm calls and give notice of the action of the sprinkler system at any particular section of the plant. For protection at night there are 111 watch service boxes, so distributed through the factory that a registration is made by watchmen every two

CHICAGO CITY WORKS, CLINTON STREET, WESTERN ELECTRIC COMPANY minutes from 5:30 P. M. to 7:30 A. M. The entire factory is equipped with automatic sprinklers, receiving water direct from headers supplied from pumps and from high pressure and gravity tanks located upon the roofs of the different buildings. The fire station is a two-story brick building, similar in design to the standard fire engine house. Upon the second floor are beds for a captain and nine men, with abundant lavatory and locker facilities. A pole connects with the floor below. The fire house equipment consists of two hose carts, each carrying 500 feet of hose, extra nozzles, ladders, pike poles, axes, tarpaulins and all connections for a 2½ and 3½-inch hose. The day force of the Fire Department consists of one chief, two assistants and sixteen men, all of the latter being employed in a department adjacent to the fire station. The night force consists of the chief, one assistant and sixteen men, these men comprising the force of night watchmen, eight of whom are patrolling the factory while the other eight are stationed in the fire house. The fire brigade is given each week a practice drill, and in case no fire alarm is turned in, a false alarm is given at least once a week for a practice run. A systematic course of instruction as to the proper use of apparatus in case of fire is given periodically to a large number of employees, some being selected from each department for this purpose.

The Polk street plant, which at present is devoted to the manufacture of lead-covered telephone cables and to warehouse purposes, covers 220,000 square feet of ground and has railroad and dock facilities. This is the most complete cable factory in the West, but as all the work carried on there is about to be transferred to Hawthorne, where superior facilities have been provided, and the vacant space devoted to storage of material, the construction and description of buildings will not be given.

Early in the year 1903 the Company commenced the erection of a new plant now known as "Hawthorne Works," on property acquired in the southwest portion



HAWTHORNE WORKS, WESTERN ELECTRIC COMPANY of the city, bounded by 22d street on the north, South 48th avenue on the west, the Chicago, Burlington & Quincy Railway and 26th street on the south, and 44th court on the east, the area being about 125 acres and divided nearly in the center, north and south, by the Belt Railway. To this point will be moved first the large machinery business of the Company which is at present located at the Clinton street plant, second, the cable work now done at Polk street, and in addition a factory has been made ready for the manufacture of insulating material. Occupancy will commence some time in October or November of this year. The buildings erected consist of foundry, machine shop, blacksmith shop, pattern shop, pattern storage, office building, gas plant, water tower, pump house and power plant—all west of the Belt Railway, and a group of one-story buildings for the manufacture of telephone and power lead-covered cable, insulating material and wood working, on the east side of the Belt Railway. Provision has been made for future expansion in all lines of work, the present construction work being carried out under a general plan providing for some fifty buildings.

There are ample railway facilities, including connections with the Belt Line, Chicago, Burlington & Quincy, Chicago Terminal Transfer and Illinois Central railroads. A general system of underground tunnels in connection with sub-ways under the Belt Railway permits of the easy transfer of material and distribution of pipe, cable and intercommunicating equipment from one part of the plant to another.

Water for general use is raised by means of compressed air from deep wells. A large excavation has been made to retain this water in reserve.

The foundry, the first building in the group, is located on 48th avenue. It is of standard steel construction, about 400 feet long and 175 feet wide, and is divided into three sections. The center section has a span of about 72 feet and is devoted to the manufacture of heavy castings. The west side is for light work, and the east contains sand bins, a charging floor, core ovens and provision for flask making and pattern storage. Coke is delivered direct from the cars into a brick enclosure which is outside of the east wall, and all material is carried to the charging floor upon an elevator in suitable cars provided for that purpose. The cupola capacity is thirty tons per hour. Blast is provided from positive pressure blowers, direct connected to motors mounted upon the same bed plate. The foundry equipment consists of two 4-motor 30-ton cranes, one 15-ton crane, a complete system of industrial tracks for distribution of material, friction-driven tumbling mills with dust exhaust, crucible furnaces for brass, and air furnaces for semi-steel. Heat and ventilation are cared for by the general hot-blast system. Toilet rooms containing shower baths are provided for the use of the foundrymen.

The machine shop, directly east of the north end of the foundry, is of the standard one-story steel construction type, about 825 feet long and 150 feet wide. The center span of 75 feet and the north span of 50 feet are designed for the use of traveling cranes, while the south section of 25 feet has an intermediate floor or gallery for light work, and on this side are three two-story wings, 50 feet by 60 feet, in which are located toilet rooms, elevators and heating apparatus. These wings are so designed that they may with ease be connected with a second machine shop, a duplicate of the one now erected, which may at some time be put up parallel to and south of the present shop. An abundance of light is furnished from skylights in the tile roof and from windows in the south and end walls. The general illumination is from arc lights, while incandescent lamps are used for bench work. Blast apparatus supplies heat to the upper parts of the building and direct radiation is given from coils upon the walls under the windows. Broad-gauged tracks cross both east and west ends of the building, on which castings may be brought from the foundry, an industrial railway for lighter work connecting with pattern shop, pattern storage building, foundry and blacksmith shop.

All heavy machines used in this shop are direct connected to individual motors, and speed control is obtained electrically by means of the Western Electric three-wire system. At the west end of the building there is a cast-iron testing floor 120 feet long, and at the east end a similar floor for testing generators and motors. The shipping platform is at the rear railway track, east of this testing floor.

The blacksmith shop, separated from the machine shop at the north only by a system of railway tracks, is 200 feet long and 76 feet wide and is 18 feet high to the lower chord of the roof truss. The building is of brick, with a roof of Ludowicic tile, having a monitor extending the full length of building, containing swinging windows and a wire-glass top. Oil is used for fuel with which to heat the furnaces. A complete exhaust system provides ample ventilation, and heat is obtained by direct radiation from coils upon the walls. The toilet rooms contain shower baths for the use of the men.

The office, pattern shop and pattern storage buildings are located on 48th avenue just north of the foundry and are of standard fireproof office building construction, about fifty feet wide, and are so designed as to be available for general manufacture when it becomes necessary to make a change at that point in order to provide for future expansion. The office building contains rooms for draughting and blueprinting and for the accommodation of the shop clerical departments. All machines in the pattern shop are driven by motors directly applied.

The gas plant, consisting of one building and one holder, is north of the machine shop just east of the pattern shop. This plant furnishes 450,000 cubic feet of uncarbureted water gas in a day of ten hours, the apparatus consisting of two generators, two washers, a scrubber, purifier and oxide conveyor, blowers, motors and the necessary pipe connections. Provision has been made, not only for future growth, but also for changing to the manufacture of carbureted water gas, should it become necessary at some future time. The gas produced is used to furnish heat only.

The water tower is of ornamental design of brick, about 50 feet square and 175 feet high to the top of the Ludowicic tile roof. Steel tanks are placed at different levels in this tower, to contain water for fire protection and for shop service. The fire station and pumping plant, providing a high pressure system for fire protection, are located in a brick building south of and connected with this tower.

The power plant is adjacent to and directly north of the east end of the machine shop, the boiler house being in the north portion. Provision has been made for two brick chimneys, each with a flue 12 feet in diameter, 250 feet high from the ground, although but one of these chimneys, connecting with eight boilers, has as yet been erected. Each chimney is designed to take care of 4,000 horse-power of horizontal water tube boilers equipped with chain grate stokers. The center line of the boiler room runs east and west between the two chimneys. Coal is delivered to the power house direct from cars into steel bunkers above, at the center of the building, and is fed through chutes to the grates below, the ashes being collected in a pit in the basement and carried away in cars designed for that purpose, so that from the time the coal leaves the mines until it leaves the plant as ashes, it is never handled except by machinery. The boilers are designed to receive super-heaters and carry steam at 150 pounds pressure. A broad-gauged track enters the east end of the engine room and delivers material under a 20-ton, 4-motor traveling crane. The power equipment, a part of which only is now in place, consists of two horizontal engines of 500 and 750 horse-power and two vertical engines of 1,500 horse-power each, all direct connected to Western Electric 250-volt direct-current generators, the current being controlled from a switchboard consisting of eighteen 30-inch panels located in the gallery on the north wall of the engine room. Centrifugal pumps deliver water from the reservoir to three surface condensers. Cooling towers are to be installed at the water reservoir. Small lighting units, air compressors and other auxiliary apparatus, together with the condensers, are located in a room below and between the engine room and the machine shop. Compensator sets are placed in buildings of the plant wherever it is necessary to obtain speed regulation by means of the three-wire system.

For the yard lighting, alternating current is used in connection with Western Electric series enclosed arc lamps. Exhaust steam from the power plant is used for the general heating system.

The cable plant, just east of the Belt Railway, contains approximately 182,000 square feet of floor space, the buildings being of one-story, brick and steel construction with tile roofs and north exposed skylights. All material is received at the east end of the plant near 45th avenue, where a track enters the building, and the manufacturing is worked west to the shipping platform near the Belt Railway. The equipment consists of paper insulating machines, wire twisting machines, stranders, drying ovens, furnaces, lead presses, high pressure pumps and reeling machines. The pressure delivered by the lead presses in the cylinders is in some instances as high as 20 tons per square inch. Practically all machines are driven by direct connected motors and are worked on the three-wire, variable speed system. Special provision is made for the convenience of women employees, who constitute a large percentage of the working force of the Cable Department. Toilet rooms, wash rooms, lockers, a modern hospital 33 feet by 22 feet, a dining-room 87 feet by 49 feet and a completely equipped kitchen 40 feet by 16 feet are operated in connection with the cable plant.

The insulating material shop lies between the cable plant and the wood-working shop, the latter being a small building about 100 feet square. The wood-working machinery, complete in its detail, is all driven by direct connected motors. Such rough wood-working only as the manufacture of cable reels and packing boxes is to be performed in this plant, the finer work being confined as yet to the Clinton street works. The land south of this group of buildings and east of the Belt Line is now used for the storage of lumber.

The structural detail of the "Hawthorne Works" represents the highest and most advanced state of the art, and it is expected that, when the plant is placed in full operation, it will in its electrical and mechanical equipment be one of the most complete in America.

But the Chicago plants are not the only manufacturing stations of the Western Electric Company which are of interest. The factories in foreign cities, while small in comparison with the works of Chicago and New York, are designed and managed with the same care and efficiency as are those in America.

A glance at the New York factory will suffice to show that, in its extension beyond Chicago, the Western Electric Company has not been unmindful of the benefits and economies resulting from efficient factory construction and organization. In 1896 the Company moved from a building which it owned and occupied on Thames street just off Broadway, and began the erection of a system of buildings on West and Bethune streets directly opposite the docks of the White Star Line, and at that point there are to-day employed over 4,000 men. From the New York factory the output is almost entirely fine work, such as instruments, telephone receivers, transmitters and bells, the only coarse work being the making of lead-covered cables; the cable output, however, is only large enough to take care of certain business in the East which it is not convenient to handle from Chicago.

This factory was planned in its entirety before construction was begun, so that as it now stands it is a consistent and homogeneous arrangement of shops, with none of the disadvantages which necessarily exist in such a plant as the Clinton Street Works in Chicago, which have greatly outgrown their original plans and have

NEW YORK WORKS, WESTERN ELECTRIC COMPANY been enlarged by additions and extensions. The general design of the buildings is a hollow rectangle, having a solid rectangular court about 150 feet long, which aids in admitting light to the shop floors. Structurally, the building is of the most approved fireproof construction, with a steel framework and floors supported throughout on brick arches. To reduce the fire risk, the building is divided into four parts by fire walls running from cellar to roof and extending from a central court to the four fronts of the building and cutting each floor into four sections, the ten floors of the shop thus being divided into forty sections. The fire walls are double, and contain between them the elevators and stairways, the openings through the walls being provided with fire doors with fusible links. All buildings are sprinkled automatically. The isolated plant which supplies electric current for lighting and power in the building, although installed some years ago, is still one of the largest independent installations in New York. Current is generated and distributed entirely on a two-wire, 120-volt system, this voltage being adopted on account of the short distance from plant to the load. The buildings are heated by means of hot water, which is in turn heated by the exhaust steam of the auxiliary engines, or live steam in case this exhaust is not sufficient. All water used throughout the building except that for boiler feed is obtained from artesian wells sunk under the property. The offices cover about one-half of the 10th floor and the whole of the 11th, 12th and 13th floors, and are unusually elaborate.

Within the past five years the Western Electric Company has rebuilt its plants at London, Antwerp and Berlin, and is at present increasing its facilities for foreign manufacture. In American cities it has added steadily to the number of its selling and warehouse buildings, and aside from the construction work now in process at Chicago, is just finishing a new plant at Philadelphia. Over 67 acres of floor space are now occupied by Western Electric houses.

*WATER POWER AND ELECTRICAL TRANSMISSION*

## *The Sanitary and Ship Canal*

The Sanitary District of Chicago is organized under the general law for the creation of Sanitary Districts enacted by the Legislature of the State of Illinois in 1889 and in force July 1st of that year.

The first Board of Trustees was elected December 12, 1889, and served, barring resignations, until December 2, 1895. Since that period the regular term of service has been five years.

The primary object of the work undertaken by the Sanitary District is the protection of Lake Michigan—the great reservoir from which the city of Chicago and its urban and suburban neighbors draw their drinking water—from sewage pollution due to the discharge directly into it, or into the rivers which empty into it, of the sewage of the city of Chicago and its aforesaid neighbors.

The first work undertaken was the construction of a great canal, whose characteristics are described in the body of this report, from Robey street to Lockport. That done, the logical sequence was the improvement of the Chicago river by deepening and widening and removing bridge obstructions so as to make it possible to secure an adequate flow of water through it without injury to navigation.

While the Sanitary District of Chicago has been carrying on its great work, the city of Chicago has been reversing, wherever practicable, sewers which discharged into the lake and discharging them into the Chicago river, and by building on 39th street, from the lake to the east end of the Stock Yards Slip at Halsted street, a conduit twenty (20) feet in diameter. Along Stony Island avenue and the Lake Shore from 73rd street north to 39th street, the city is building and has far along toward completion an intercepting sewer, increasing progressively in size from 12½ feet in diameter at the south end to 16 feet at the north end, which will take all of the sewers between 73rd street and 39th street which now discharge into the lake. At 39th street the city is constructing four sewage pumps, two having each a capacity of 75 cubic feet per second, and two having each a capacity of 250 cubic feet per second. These pumps are to be operated by the Sanitary District of Chicago, and the said District will erect as a part of the same plant two pumps having each a capacity of 667 cubic feet per second (40,000 cubic feet each per minute), to pump pure lake water. The total pumping capacity of the plant, namely, 120,000 cubic feet per minute, will be discharged into the 39th street conduit, from whence it will flow on through the south fork of the south branch and unite with the flow from Lake Michigan of 480,000 cubic feet per minute, and give the ultimate flow of 600,000 cubic feet per minute through the main channel of the Sanitary District.

What has been described, however, does not embrace the whole problem of sewage and water supply; on the south there is a large urban and suburban population fouling the Calumet river, which discharges into the lake within 3⅝ miles of the Hyde Park Four Mile Water Supply Crib; on the north, beyond the limits of the original Sanitary District, still other urban and suburban populations are discharging their sewage into the lake.

The Legislature of 1903 enacted laws for the annexation of these adjacent territories. On July 14, 1903, this legislation became operative, and the original Sanitary District, which contained 185 square miles, was enlarged by the annexation of the North Shore District, 78 6-10 square miles, and the Calumet District, 94 48-100 square miles, so that the total area of the Sanitary District of to-day is 358 8-100 square miles. The topography and hydrography of the North Shore District precludes a gravity channel, and therefore it is proposed to cut a channel from the lake at some point north of Evanston southward to a connection with the northern extension of the

Chicago river at Lawrence avenue. The water to flow through this channel must be supplied by pumping, and a plant having a capacity of 60,000 cubic feet per minute will be erected near the lake and operated by the Sanitary District. When completed this channel will become the outlet of sewers. Surveys for the purpose of locating the channel have been made.

The typography and hydrography of the Calumet District admit of treatment that will secure a reversal of the current of the Calumet river and a gravity flow therefrom into the main channel of the Sanitary District through the depression known as the Sag Valley. Surveys have been made and a channel partially located, which will accomplish the purpose outlined above. The tentative plans for this channel contemplate that its cross section shall be 70 feet wide at the bottom in the earth and 90 feet wide in the rock, with side slopes in the earth of five feet in three feet and a depth below hydraulic grade line of 22 feet.

The work of the Sanitary District has created valuable possibilities in the way of water-power development, and the same Legislature which passed the annexation laws enacted a law which enables the Sanitary District to realize in part these possibilities by giving it the authority to develop the water power at Lockport. This work is now under contract, and construction is in progress. The plans for it provide for an extension of the channel now in use between concrete walls and earth and rock embankment southward for a distance of about 10,700 feet to the site selected for the erection of the power plant. From this point on, a tail race is to be excavated for a distance of about 6,800 feet to a junction with original Section 17; this tail race is to be 160 feet wide, and be deep enough to afford a minimum depth of water of 22 feet. Section 17 is a wide channel, and the minimum depth of water therein, until it enters the Upper Basin at Joliet, will be ten feet. The mean head for power development resulting from this improvement will be 32 feet, and the net horse-power, figured on an

SECTION OF EARTH AND ROCK CHANNELS

efficiency of 75 per cent and a flow of 600,000 cubic feet per minute, will be 27,000 horse-power. The power is to be housed in a structure of concrete and brick construction and will have ten turbine chambers, three for exciter units and seven for power units. The power units are designed to pass 100,000 cubic feet at 8-10 discharge. They consist of turbines on horizontal axes, capable of generating 6,500 horse-power at full gate under 34 feet of head at 150 revolutions per minute. Each power unit is to drive one 3,750-kilowatt, 3-phase, 2,200-volt generator. The ultimate discharge of the channel will, under present plans, reach 800,000 cubic feet per minute.

This outline of the work shows that its primary purpose is sanitation, and that in attaining that vital object it provides an artificial waterway of great utility and develops water power of immense value. Sanitation, navigation, and industrial development are the visible results of the vast expenditure made by the Sanitary District of Chicago.

### MAIN CHANNEL

The Main Drainage Channel of the Sanitary District of Chicago is now completed from its confluence with the south branch of the Chicago river, at Robey street, in the city of Chicago, to Lockport, in Will County, Illinois, a distance of 28.05 miles, as shown upon the accompanying map. Water from Lake Michigan was let into the main channel via the Chicago river, and through the auxiliary channel which connects the main channel with the west Fork of the south branch, on January 2, 1900. It took thirteen days to fill the channel from Western avenue to the Controlling Works. On the morning of the 17th of January, 1900, by permission of the Governor of the State of Illinois, the Bear Trap Dam was lowered and the westward flow of water from the lake was commenced. At the end of Section 15 of the channel the Controlling Works are located. Beyond these works the construction completed by the District covered the

BROWN CANTILEVER CONVEYOR, ROCK SECTION

work necessary for conducting the flow from the channel in conjunction with the waters of the Desplaines river down the declivity to and through the city of Joliet, and the making of such changes in the Illinois and Michigan Canal as the new conditions developed rendered necessary.

The first work put under contract extended southwesterly from the Willow Springs road, and these sections were numbered consecutively Numbers 1 to 14. Average length of sections, nearly one mile. Easterly from Willow Springs road the sections are lettered from A to O, omitting J. The lettered sections are, except for a short distance near Summit, entirely in glacial drift, defined in the specifications thus: "Glacial drift shall comprise the top soil, earth, muck, sand, gravel, clay, hard pan, boulders, fragmentary rock displaced from its original bed and any other material that overlies the bed rock."

The sections from 1 to 14 were put under contract in July, 1892; those from A to F were put under contract late in 1892 and early in 1893; and those from G to M, inclusive, were contracted for in December, 1893. Sections N and O were put under contract May 2d, and Section 15, August 27th, 1894.

Earth was first broken on "Shovel Day," September 3, 1892, on the rock cut below Lemont.

The Desplaines Valley is traversed by the river from which it takes its name—a stream of wide fluctuations, with no constant and reliable fountain supply. During some seasons its whole discharge would pass through a six-inch pipe, and at others its volume reaches 800,000 cubic feet per minute. Then it rolls majestically along, flooding the whole valley. Such being the situation, control of this stream was a condition precedent to the successful prosecution of the work upon the main channel. This control has been secured by the outlay of $1,000,186 (exclusive of bridges) in constructing what is known as the "River Diversion Channel."

About thirteen miles of new river channel had to be

CONTROLLING WORKS, DOWN-STREAM SIDE

excavated, parallel with the location of the main drainage channel, and about nineteen miles of levee built to divorce the waters of the Desplaines watershed from the channel which is to receive the waters of Lake Michigan and pass them on to the Mississippi river via the lower Desplaines and the Illinois rivers. The width of the River Diversion Channel on the bottom is 200 feet, side slopes one and one-half to one, grade generally 12-100 per 1,000 feet.

At the head of this River Diversion it was necessary to provide a safety valve in the form of a spillway, to allow surplus water to flow toward Chicago, pending the completion of the work necessary for carrying the entire flood waters of the Desplaines through Joliet.

This spillway is a concrete dam capped with cut stone, and its wings faced with stone masonry; it is 397 feet long and its crest is 16.25 feet above Chicago datum (this datum is referred to the low water of Lake Michigan of 1847, and is 579.61 feet above sea level at Sandy Hook). No water flows over this spillway until the water passing the water gauge above it reaches 300,000 cubic feet per miinute.

The cross-secton of the earth sections from A to E inclusive, a distance of 5.3 miles, is 202 feet on the bottom, side slopes two to one. This section extends for about 500 feet into the west end of F and then reduces to 110 feet on the bottom, preserving the same side slopes for a distance of 7.8 miles. The explanation for this change of cross-section is as follows: Throughout the rock sections, and those sections in which there is a preponderance of hard material, or where rock may appear, the section adopted is designed according to law for a flow of 600,000 cubic feet of water per minute, which means provision for a population of 3,000,000 people. The narrower channel provides for the flow of 300,000 cubic feet per minute, or for about the present population of Chicago. The enlargement of the narrow channel can be made by the easier methods of excavation, such as dredging, whenever the needs of the city require it. The grade throughout the lettered sections is one foot in 40,000 (.025 per 1,000 feet) and the bottom of the Channel at Robey street is 24.448 feet below datum. The numbered sections, from No. 1 to No. 6 inclusive, are underlaid with solid rock. The width of the bottom, in rock, is 160 feet, and walls of masonry laid in cement have been built upon the rock surface to a height of five feet above datum. Sections 7 to 14, inclusive, are in solid rock, width at bottom 160 feet, sides vertical, prism taken out in three stopes with offsets of six inches on each side for each cut, making top width 162 feet; grade in rock, one foot in 20,000 (.05 per 1,000 feet).

Section No. 15 is also in rock and its cross-section is enlarged at its south end so as to form a "windage basin," in which large vessels may be turned around. The Controlling Works are located on this section. These works consist of gates and a movable dam by which the flow of water from the main channel into the tail race, which is to deliver the outflow into the Desplaines river, can be controlled.

This river below Lockport follows the trough of the valley down a steep declivity to the canal basin in Joliet. The fluctuations in Lake Michigan, by varying slope of water surface, will be felt at the controlling works, and provisions have been made to meet these fluctuations within a range of five feet above datum and twelve feet below, or an extreme oscillation of seventeen feet. The fall from datum at the Controlling Works to the level of the upper basin is about forty-two feet, in a distance of about four and one-third miles.

The Controlling Works comprise seven sluice gates of metal, with the necessary masonry bulk heads and one bear-trap dam. The sluice gates may be considered as a modification of what is known as the Stoney gate type, gates having a vertical play of twenty feet and openings of thirty feet each. The bear-trap dam has an opening of 160 feet and an oscillation of seventeen feet vertically. This dam is essentially two great metal leaves hinged to-


DU PAGE CO.
WILL COUNTY
COOK COUNTY
CHICAGO
LAKE MICHIGAN
LAKE CALUMET
LOCKPORT
JOLIET
ROMEO
LEMONT
SAG
WILLOW SPRINGS
SUMMIT
EXECUTIVE
SANITARY DISTRICT OF CHICAGO STATE OF ILLINOIS
SANITARY DISTRICT OF CHICAGO.
MAP
SHOWING
THE SANITARY AND SHIP CANALS
OF THE
DISTRICT.
AUG 1903.

gether and working between masonry bulk heads. The down-stream leaf is securely hinged to a very heavy foundation, and the up-stream leaf is so placed as to present the barrier to the water. This structure is operated by admitting water through properly constructed conduits, controlled by valves, beneath the leaves just described. To raise the crest of the dam, water is admitted from the up-stream side and the discharge shut off until the desired height is obtained, and then the valves are adjusted so that the volume of water beneath the leaves shall be constant. To lower the crest, the water beneath the leaves is drawn off until the desired height is reached, when the valves are again arranged so as to maintain a constant volume of water.

All the bridges on the main channel are movable structures. There are six bridges for public highways. One was built for the use of the Southwest Boulevard and Western avenue. It has double roadways—one being for heavy and the other for light traffic. There are seven railway bridges, one being an eight-track rolling lift structure, with a channel span of one hundred and twenty feet. One is a four-track swing bridge, and the others are double-track structures. The bridges on the walled and solid rock sections of the channel are all "bob-tailed" (or have arms of unequal length), counter-weighted structures, with pivot piers on the right bank, and long arms spanning the entire channel, thus avoiding any obstruction to the flow from center and protection piers. These bridges are of latest design, conforming to the heaviest modern specifications. The entire weight of the iron and steel used in their construction was 22,862,-454 pounds.

The work of the District south of the Controlling Works consisted of straightening, widening and deepening the Desplaines river, to give it a flowage capacity of 1,500,000 cubic feet of water per minute. This involved, in the city of Joliet, the rebuilding of Dam No. 1, the removal of Dam No. 2 (both structures belonging to the Illinois and Michigan Canal), and the removal of the

BEAR TRAP DAM, LOOKING DOWN THE STREAM

Adam dam, the rebuilding of Lock No. 5, and the removal of the Guard Lock. At Jefferson street, the stone-arched bridge has been removed to make way for a steel bridge of greater span and width, equal to that of the street. The Cass street bridge also gave place to a modern steel structure of greater span and width. From Lock No. 5 to Jefferson street a massive concrete wall has been constructed to separate the Illinois and Michigan Canal from the river, and on the east side of the river a concrete wall has been constructed, extending from Cass street to Jefferson street. At Jackson street a great deal of costly excavation has been made to admit of an extensive water power development, which is the property of the State.

The total amount of excavation involved in the construction of the main channel is 26,693,000 cubic yards of glacial drift and 12,265,000 cubic yards of solid rock, or an aggregate of 38,958,000 cubic yards, to which must be added the material excavated from the River Diversion; glacial drift, 1,810,652 cubic yards; solid rock, 258,659 cubic yards; total River Diversion, 2,069,311. The work between Lockport and Joliet, including the Controlling Works, involves 1,201,724 cubic yards of excavation; grand total main channel, River Diversion and Joliet Project, 42,229,035 cubic yards. All of this work is now completed and in addition thereto 457,777 cubic yards of retaining wall and bridge masonry. The retaining wall is all laid in cement mortar. The rock when broken up expands about 80 per cent, and therefore the volume of the rock spoil banks will be nearly 22,542,586 cubic yards. The whole volume of spoil (earth and rock), if deposited in Lake Michigan in forty feet of water, would make an island one mile square, with its surface twelve feet above the water line. In addition to these quantities the work of the main Channel extension and water power development involves 105,000 cubic yards of earth, 1,274,000 cubic yards of rock and 145,000 cubic yards of masonry and concrete.

### CHICAGO RIVER

The distance from the mouth of the Chicago river to Robey street (the junction of the artificial channel of the Sanitary District of Chicago with the west fork of the south branch of the Chicago river) is six miles. From Lake street to Robey street the channel is to be widened to 200 feet and given a depth of 26 feet for a mid-channel width of 100 feet, shallowing up to 16 feet at the dock lines. The standard docks are of timber secured to anchor piles 38 feet back from the dock face. The Board of Trustees has authorized the construction of a concrete dock on the west side of the river, extending from Randolph street to Madison street, and it is now in process of construction.

Much work has been accomplished in executing the plans of the District for river improvement. Up to the 31st of December, 1903, 488,650 square feet of land has been acquired for widening, nearly all of which has been excavated by dredging and the frontage docked. The dredging thus far aggregates 2,935,691 cubic yards and the docking 10,822 lineal feet. Seven bascule bridges have been completed, one of which is a double-track railway bridge of 275 feet span between points of support. Two others are now under contract and plans are authorized and in process of preparation for four more. The bridge at Ashland avenue is a trunnion bascule, of a type invented by John W. Page; all of the others are of the Scherzer Rolling Lift type.

### DIMENSIONS AND COST OF CHANNEL

The distance from the mouth of the Chicago river to the junction of the main channel with the west fork of the south branch at Robey street is about six miles.

The length of the main channel proper, from Robey street to the Controlling Works at Lockport, is 28.05 miles—making a total of 34.05 miles.

The dimensions of the channel are: Robey street to Summit, 7.8 miles; 110 feet wide at bottom; 198 feet at water line, with minimum depth of water 22 feet. Summit to Willow Springs, 5.3 miles; 202 feet wide at bottom, 290 feet wide at water line, with 22 feet depth of water; grade of earth channel one foot in forty thousand feet, or $1\frac{5}{8}$ inches per mile. The side slopes in earth are one foot vertical to two feet horizontal. At Willow Springs the channel narrows to the walled and rock cross-section, extending 14.95 miles to Lockport, 160 feet wide at bottom, 162 feet at top; grade in rock one foot in twenty thousand, or $3\frac{1}{4}$ inches per mile.

The velocity in earth is figured for $1\frac{1}{4}$ miles per hour and in rock 1.9 miles per hour. For table of costs, see page 162.

METHODS OF WORKING

On the earth sections some novelties were introduced. On sections L and M, cars, specially constructed, were loaded by steam shovels and drawn by steam hoists up a steep incline to a proper height, where they ran on to a tipple and were automatically dumped. Each incline was equipped with two four-yard cars, which loaded and dumped alternately. On sections I and K, the contractors erected bridges spanning the spoil bank at proper height, their supporting piers being carried on trucks which traveled on tracks parallel with the channel. From the channel end of the bridge, an inclined track ran down into the cut. In connection with this device two eight-yard cars were used, which were successively loaded by steam shovel, drawn up the incline on to the bridge by steam hoist, and then automatically dumped and immediately returned to the pit. An output of 100 yards per hour was probably sustained by this combination of devices.

On Section H, a conveying machine, designed by Messrs. Hoover & Mason, was constructed on a mammoth scale. It was essentially a bridge, spanning the channel, with cantilever arms projecting far enough beyond on each side to overhang the spoil area. On this structure were mounted the necessary sprocket wheels

COST OF MAIN CHANNEL AND AUXILIARY WORK UNDER CONTRACT, AND EXPENDITURES TO DECEMBER 31, 1903

CONSTRUCTION

| | | | |
|---|---|---|---|
| *Diversion of Desplaines River—* | | | |
| Excavation, etc | $ 1,000,186.38 | | |
| Bridges | 142,391.94 | | |
| | | $ 1,142,578.32 | |
| *Main Channel—Robey Street to Lockport—* | | | |
| Excavation, etc. | $18,553,181.57 | | |
| Bridges | 1,993,446.23 | | |
| | | 20,546,627.80 | |
| *Controlling Works—* | | | |
| Sluice Gates and Bear-Trap Dam | $ 333,438.94 | | |
| Bridge | 7,873.35 | | |
| | | 341,312.29 | |
| *Desplaines River Improvement—Lockport to Joliet—* | | | |
| Excavation, etc. | $ 1,306,760.98 | | |
| Bridges | 271,161.66 | | |
| | | 1,577,922.64 | |
| *Chicago River Improvement—* | | | |
| Dredging, docking, by-passes, etc. | $ 1,792,709.64 | | |
| Bridges | 2,237,306.40 | | |
| | | 4,030,016.04 | |
| Illinois and Michigan Canal improvement at Bridgeport | | 77,016.08 | |
| Water Power Development | | 1,938,072.67 | |
| Thirty-ninth Street Pumps | | 243,300.00 | |
| Total estimated cost of construction contracts | | $29,896,845.84 | |
| Capitalization and maintenance of bridges | | 413,076.11 | |
| Total estimate of construction and capitalization contracts | | | $30,309,921.95 |

and other machinery for carrying a series of steel pans which form the conveyor belt. The structure was 640 feet from end to end, mounted on trucks traveling upon tracks parallel with the channel, and its capacity was 500 cubic yards per hour. This capacity, however, was that of the conveyor only; the arrangements for excavating the earth and loading the conveyor were never perfected to an extent which secured recognition for the device as one of the successful inventions applicable to great public works. On Section F the material was taken from the steam shovel by cars fitted with pneumatic dumping apparatus, the power for which was supplied from the locomotive. The engineer operated these dumps just as he would apply the air brakes. Sections A, B and a portion of C are located in the old channel of the Desplaines river, and were overlaid with muck to a considerable depth. This muck was removed by hydraulic dredges. Each of these dredges has a capacity of about 2,500 cubic yards in ten hours, and this output in solid matter represents about eight per cent of the capacity of the pumps. One great advantage of the hydraulic method of removal is that the material can be removed to any desired dumping ground within a distance of 3,000 feet without adding anything to the contract price of the excavation.

On those sections which are partly in earth and partly in rock, all of the usual methods of removing earth were employed, varied to suit peculiar conditions or to meet the ideas of the contractors doing the work. On section No. 6 a large amount of muck had to be removed, and a very ingenious contractor improvised a hydraulic dredge at a small cost, and did the work at a very moderate expense.

On the rock sections the sides were cut down vertically by channeling machines, and the merits of several devices were satisfactorily demonstrated on this work. Of course, steam drills were used, and on the sections which were best planted these were worked from a central power station by compressed air. The top lifts were removed by the use of carts and tramcars, the traction for which

METHOD OF WORKING ON SECTIONS I AND K

latter was usually supplied by steam-hoisting engines. The lower lifts were taken out by the use of cable-ways, high power derricks and cantilever conveyors.

The cable-ways as first constructed were not very successful, but experience gained upon this work resulted in improvements from time to time, until by the adoption of a simple improvement, devised by Mr. H. C. Locher, one of the contractors, they were brought to a stage of efficiency which made them worthy competitors of the cantilever conveyors. The high power derricks used upon two of the sections did not come up to the expectations of the builders, and their use was confined to the machines already in place. The revolving derricks on Section 14, after a great deal of costly experimentation, developed considerable merit. The cantilevers are probably the most perfect devices now known for hoisting and disposing of material from rock cuttings such as these.

The average daily output of rock for the month of June, 1895, reached 21,365 cubic yards, requiring the use of eight tons of dynamite.

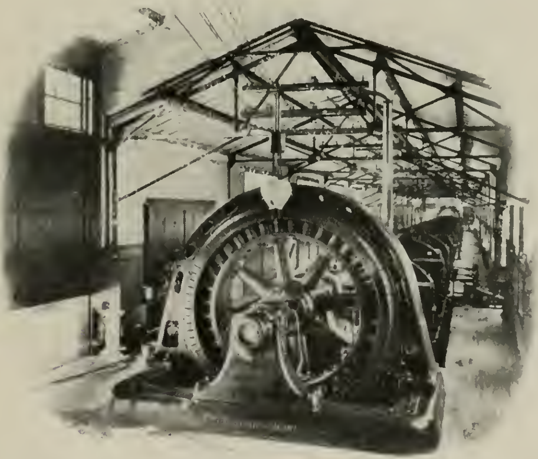
Although all of the bridges on this channel are movable structures, yet the law allows the District to keep them closed and operated as fixed structures for a period of seven years dating from January 17, 1900. At the expiration of that period they must be equipped with operating machinery and go into service as movable bridges, and then this channel will be a free water-way, navigable for any craft drawing less than twenty-two feet of water. The work performed by this District constitutes nearly two-thirds of the entire cost of creating a channel from Chicago to the Mississippi, which would be navigable for the largest boats which will be able to ply between St. Louis and New Orleans, after the present plans for the improvement of the Mississippi will have been completed. The creation of such a channel seems to be inevitable; a commercial necessity sooner or later to be recognized and undertaken by the general government, which must carry out the enterprise, if it is ever executed.

# *SOME INTERESTING APPLICATIONS OF ELECTRICAL POWER*

# *Bridgeport Pumping Station*

AN ELECTRIC PUMPING PLANT PROVIDING PART OF THE POWER TO DRIVE ITSELF

The above pumping station is located in the southwestern part of Chicago, on the south branch of the Chicago river, near Archer avenue. Its function is primarily to maintain a sufficient depth of water in the



INTERIOR OF ECONOMY LIGHT AND POWER PLANT AT JOLIET, ILLINOIS

Illinois & Michigan Canal for the operation of canal boats. The water is lifted from the river into the canal, a height varying from three to seven feet, according to the height of the river. Incidentally, also, this pumping station keeps the water in the south branch of the Chicago river in circulation, thereby greatly improving the sanitary conditions.

The pumping station consists of a long, narrow building, through the length of which is the wheel pit, in which are located five impeller pumps manufactured at Connersville, Ind., each having a capacity of 7,000 cubic feet per minute when running at 70 revolutions per minute, and designed to pump at a head varying between three and seven feet. A line shaft extends the entire

MOTOR AND CONNECTION, MAIN SHAFT OF BRIDGEPORT PUMPING PLANT

length of the building, being in three sections, a short section at the center and two long sections extending in each direction to the end of the building. By means of friction clutches the three sections can be thrown together, or the center section can be operated in conjunction with either end section. To the outer end of each of the long sections is belted a General Electric, 14-pole, 300-horse-power, 514-revolutions-per-minute, 2,080-volt, three-phase, 60-cycle induction motor. To each of the long sections of shafting are belted two of the pumps, and to the center section, one pump; the arrangement being such that the latter may be driven from either motor by properly manipulating the clutches above referred to.

The power for operating the motors is received over a long-distance transmission line from the Economy Light & Power Company's plant, which is located on and receives power from the Drainage Canal, at Joliet, Ill., thirty-five miles distant. The current is three phase,

POWER HOUSE AND DAM, ECONOMY LIGHT AND POWER COMPANY

60 cycle, and the line voltage 31,000. The three transmission wires enter the end of the building through suitable openings, and are tied to insulators on each side thereof, the lightning arresters being located on the wall of the building immediately below. The conductors are led from the insulators into the primary windings of three water-cooled, 200-kilowatt, General Electric single-phase transformers, having primaries wound for 31,000 and 29,000 volts, and the secondaries for 2,300 volts. Reactance coils are placed between the transformers and the point at which the lightning arrester

connections are made. The secondary conductors from the transformers are led to the motor panels, one for each motor. Each panel contains an automatic oil switch, voltmeter, ammeter, and the necessary current and potential transformers for these instruments.

The motors are provided with polar wound armatures

INTERIOR OF BRIDGEPORT PUMPING PLANT

and starting resistances mounted in the spiders of the rotors and are connected directly to the panels.

Since the pumps are of a type having an initial suction and at times must be started against a head of as much as seven feet, and as no clutches are provided on the shafting to enable the motors to be started without load, it is necessary that the motors should start at least two of the pumps under full load, which they readily do, coming up to normal speed in something less than a minute. By reason of the starting resistance and the polar windings of the rotors, they accomplish this without an abnormal rush of line current or appreciable drop in the line voltage.

A novel feature about this installation is that the water which is pumped by it into the Illinois & Michigan Canal finds its way into the water wheels of the generating plant at Joliet, thirty-five miles away, and is utilized in producing power for the operation of the pumps. In other words, the pumping plant provides part of the power to drive itself. It is estimated that the water utilized in this way, after deducting all losses (including the evaporation and seepage generator, line and motor losses), is in the neighborhood of 200 horse-power of the 600 horse-power needed to do the pumping. Or, to put it in another way, the motors furnish 600 horse-power at their pulleys with an actual net consumption of approximately 400 horse-power.

The cut on page 172 illustrates the interior of the pumping plant and shows the tops of the pumps, and at the farther end, one of the motors. The motor at the opposite end is shown in the cut on page 170. This cut also shows the three step-down transformers, the openings on the wall for bringing in the transmission wires, and just below the latter the lightning arresters.

The Economy Light & Power Company's dam and power house, at Joliet, are shown in cut on page 171, and the interior of the power house, with one of the generators in the foreground, is illustrated on page 169.

## *Packing by Electricity*

The packing industry of Chicago is conceded to be one of the most interesting and important commercial establishments in the world. The Stock Yards proper, covering an area of a mile square, form an example of the scale upon which this business is conducted. The packing houses west of the Stock Yards cover an area of one-half mile by one mile.

Swift & Company occupy a portion of this area, their plant covering forty-seven acres of land, with a floor space of eighty-seven and three-quarter acres. The different branches of the industry are here conducted on the most modern lines, approved for the quickest and best conversion of live animals to finished food products and their various by-product accessories.

Cattle are slaughtered in their Chicago plant at a rate of 240 per hour, hogs 700 per hour and sheep 620 per hour.

The refrigerating plant has a daily capacity equal to that furnished by 2,500 tons of ice. They employ 23,000 people, and their distributive sales for 1903 exceeded $200,000,000.

At present, besides several outlying steam-power plants, they have a central electrical generating station, which furnishes power to motors throughout the packing establishment.

The boiler house contains 6,400 horse-power in Babcock & Wilcox boilers, delivering steam to the engines at 150 pounds pressure. These are equipped with Murphy stokers and with coal and ash handling machinery. The stack is built of brick and is 265 feet high.

In the engine room are installed three General Electric, three-phase revolving field, 240-volt, 60-cycle generators. One of these generators, of 300 kilowatts capacity, is direct connected to a 13 x 26 x 48 Filer & Stowell cross compound Corliss engine; another, of 600 kilowatts capacity, is direct connected to a 19 x 38 x 42 engine of the same make, and a 1200-kilowatt generator to a 27 x 54 x 42 engine of the same make. All three units operate at a speed of 120 revolutions per minute.

There are installed a total of about 3,600 horse-power in induction motors of the General Electric Squirrel Cage Motor type, and about twelve thousand 230-volt incandescent lamps, besides a large number of series alternating current arc lamps. The motors range in size from 1 to 140 horse-power, the average horse-power per motor being 14.37. Many of these motors are in odd and unusual places, some in coolers at zero temperature, others in dusty, dry rooms at over 125 degrees temperature, and numerous and novel special constructions have necessarily been developed in connection with the motor installation and wiring system.

This plant offers a striking example ot the advantages possessed by induction motors, as the conditions in many parts of the plant are too severe to admit of the satisfactory and economical use of direct current motors. Little or no advantage is derived from the use of the multiphase system in respect to saving in conductors, as it will be noted that the voltage is low. There were originally several separate plants driving direct current generators furnishing lights and power, all of which were abandoned when the alternating current system was installed. This radical and extensive change was long contemplated before being made and was the result of long and careful investigation and the previous installation of a smaller multiphase plant in one of Swift & Company's other packing houses, which afforded an opportunity for actual and practical experience with both systems. A few synchronous motors are used which tend to help the power factor; one of these is a 100-kilowatt machine, driving pumps.

# *International Harvester Company*

## McCORMICK DIVISION

This plant, devoted to the manufacture of complete harvesting machines, covers a large area, cut in half by the Chicago river, at Blue Island and Western avenues. Electric power is distributed for all purposes, from the driving of shafting in the twine mill to the operation of cranes in the foundry.

An interesting application of motors at the plant is the driving of a coal pulverizer by a 75-horse-power Westinghouse induction motor, and also a coal crusher by a 15-horse-power Westinghouse induction motor, using a Morse chain.

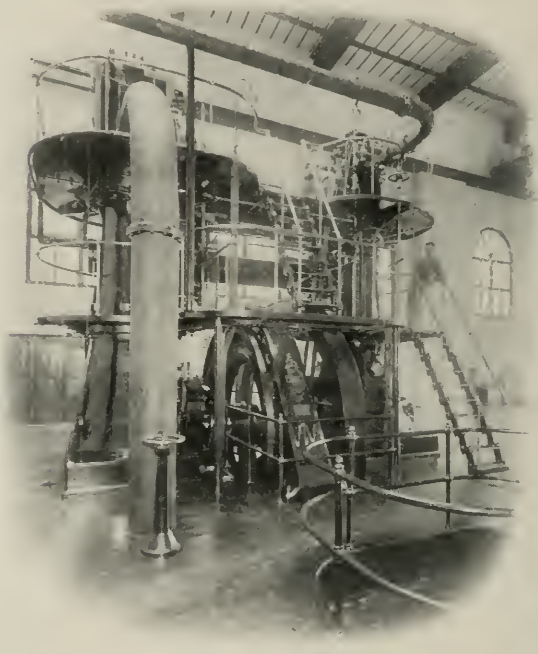
Both alternating and direct current is used; 550-kilowatt alternating current generating capacity in two units, three-phase, 7,200 alternations, 440 volts, one of which, a 300-kilowatt Westinghouse, is shown in the accompanying illustration. There is approximately 900-kilowatt direct current generating capacity in seven units, 250 volts, two motor-generator sets, one 200-kilowatt and one 100-kilowatt, consisting of induction motors driving direct current generators.

Another illustration shows a direct connected exciter unit at this plant.

## DEERING PLANT

One of the largest of Chicago's great manufacturing institutions is that of the International Harvester Company's Deering plant, which was founded by William Deering in December, 1880. The intervening period of less than twenty-four years, which has witnessed the gigantic development of the electrical industry, has also seen an enormous growth in this particular factory.

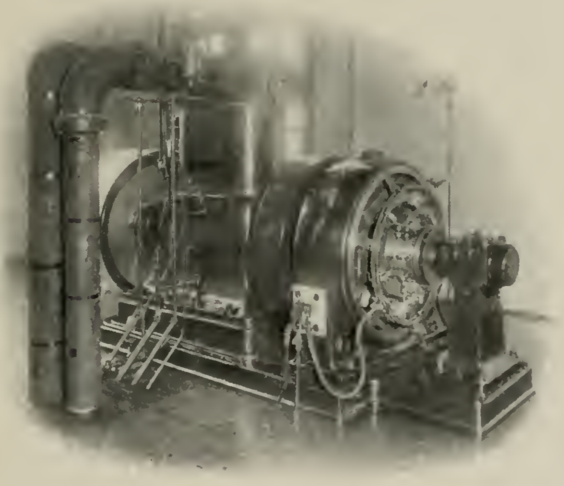
Starting in with kerosene oil lamps and a 300-horse-power, belted, non-condensing engine, 500 horse-power in tubular boilers, one night watchman, an errand boy, and a few hundred men, this industry has grown until at present



300-KILOWATT, ALTERNATING CURRENT WESTINGHOUSE GENERATOR

there are 12,000 incandescent lamps, 10,000 horse-power in compound condensing engines (of which 6,500 horse-power is electrically connected), 9,000 horse-power of watertube boilers, 1,000 horse-power of air hoist, twenty-four watchmen, 7,000 men, a plant covering 85 acres of ground, and, last but not least, 100 telephones to replace the solitary errand boy.

In 1897, in building a new twine cordage mill, the question whether another large steam plant, directly driving lines of shafting, should be installed, or whether electricity should be used, was decided, as would be expected from a progressive management like the Deering, in favor of the latter; and in taking up with the new



DIRECT CONNECTED EXCITER SET

order of things, the Deerings became pioneers in extending the use of the most effective system of electrical drive, namely, the multiphase induction motor.

The first multiphase installation was put into operation in the spring of 1898, with about 1,000 horse-power in motors and one 750-kilowatt, 100-revolution, 600-volt, three-phase, 40-cycle, General Electric generator, direct connected to an Allis Corliss horizontal cross-compound engine. This engine was installed in the same power house with the engine installed originally for driving the machinery in the first twine mill through the intermediary of belting and shafting, and was found eminently satisfactory, reducing fire risk at the mills, increasing greatly the flexibility of the system and showing an even-up economy with the belt driven mill, which was located closely adjacent to the engine room, whereas the electrically operated mill was 500 feet away.

The success of this installation led the management, later on, in the fall of 1899, and throughout the year 1900, to centralize the power for the rest of the plant. Old steam plants and obsolete apparatus were abandoned and sold, and in their place were installed modern revolving field, direct connected, three-phase, General Electric generators and Allis Corliss vertical cross-compound condensing engines. The voltage and frequency maintaining in the twine mill plant was made standard, and induction motors of the squirrel cage armature type installed for driving the different line shaft sections throughout the works. An old power plant, in which were a number of bipolar Edison generators, single-phase alternators, direct current power generators, and series arc light generators, belted to a common shaft, which in turn was driven by a belted engine, was not abandoned, but a 250-kilowatt synchronous motor was installed and belted to the line shafting to drive it during the day time and to be utilized, if necessary, as a generator, by starting up the engine driving into this shafting. This machine, running as a synchronous motor during the day time, operates with a light actual load, but with full ampere load as a condenser, which materially helps the power factor of the system, which, without the condenser, is about 83 per cent and with it over 91 per cent.

The equipment of the new power house embraces the following:

Two 1,100-kilowatt, 3-phase, 40-cycle, 600-volt, 90½ revolutions per minute, General Electric revolving field generators, direct connected to Allis vertical cross-compound engines with cylinders 28 x 60 x 48.

One 750-kilowatt, 3-phase, 40-cycle, 600 volt, 90½ revolutions per minute, also direct connected to Allis vertical cross-componud engine.

One 60-kilowatt, 125-volt, 280 revolutions per minute exciter, direct connected to General Electric vertical compound engine.

A Weiss condenser, Cochrane feed water heater, Green mechanical stoker and Hoppes water purifiers are used.

There are four Edgemoor boilers, each having 6,666 square feet of heating surface; two Stirling boilers each having 3,750 square feet of heating surface; one Stirling boiler having 4,500 square feet of heating surface; one Heine boiler having 3,750 square feet of heating surface.

The chimney is 16 feet 3 inches inside diameter, and it is 250 feet high.

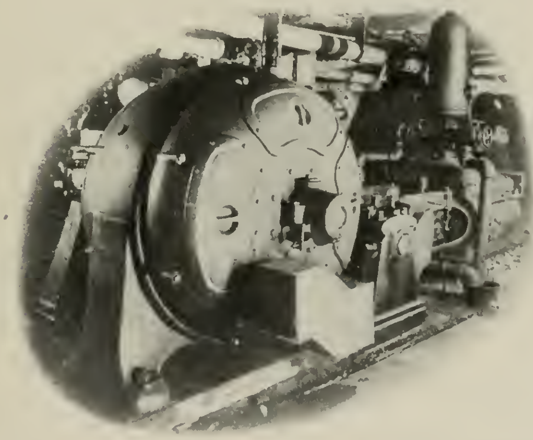
In this plant it is customary to stop and start a large portion of the factory from the throttle of the engines, which is rendered possible by energizing the field of the generators, before starting, from the independently driven exciters.

The lighting is taken care of by transformers located at convenient and economical points about the plant.

The induction motor sizes range from 10 horse-power to 100 horse-power, 75's and 50's predominating.

# *Electric Fire Pump*

The accompanying cuts illustrate an application of the electric motor in a field which is somewhat new, namely, the operation of fire pumps. The outfit shown in the cuts is installed in the mammoth wholesale establishment of the firm of Marshall Field & Company, Chicago

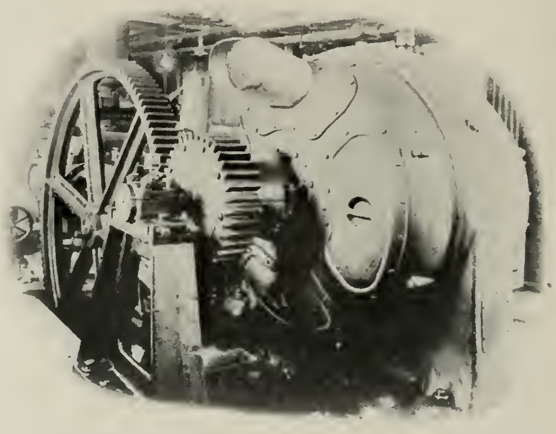


ELECTRIC FIRE PUMP MOTOR, MARSHALL FIELD & CO. WHOLESALE BUILDING

whose reputation is world-wide, and may be briefly described as follows:

The motor is enclosed and waterproof, of General Electric make, 100 horse-power capacity, 230 volts, shunt wound, and has a fan mounted on a shaft inside the frame between the armature and pinion end bearing, the purpose of which is to ventilate the windings by drawing air through a large wrought iron pipe screwed into a flange on the front side of the motor casing. The air passes through the motor and is discharged through a similar opening at the opposite end, thus keeping the windings at a safe temperature and materially reducing the size of the motor.

The electric conductors to the motor are let in through a pipe screwed into the casing and the construction is



ELECTRIC FIRE PUMP MOTOR, MARSHALL FIELD & CO. WHOLESALE BUILDING

such that a fire stream of water can be played upon the motor, or it can be completely submerged without injury.

The pump is a Laidlow-Dun-Gordon, $8\frac{1}{2}$ inch by 12 inch duplex, 60 revolutions per minute, and is geared to the motor through a single reduction gearing. The pump is connected to the sprinkler system with which the entire building is equipped. The pressure of the system is maintained at 100 pounds per square inch by means of a pressure gauge, so constructed that when the pressure drops below 100 pounds, the needle, or hand of the gauge, completes an electric circuit through a controller, which starts the motor automatically. When the pressure increases to the desired amount, the gauge hand completes another circuit through the controller and stops the motor.

The controller is also waterproof and the whole installation is so designed that its operation will not be interfered with in case the basement in which it is located should become filled with water. The outfit was designed to meet the specifications of the Underwriters Bureau of Fire Protection, which is coming to favor installations of this nature, after having investigated the subject very thoroughly during the past two or three years.

The current for operating the above-described electric fire pump is obtained from the circuits of the Chicago Edison Company through its underground system of conductors, so that the operation of the pump would not be interfered with by a shutting down of the steam plant of the Marshall Field Building due to fire in the building or other causes; nor would a shut-down of operations in any one of the Chicago Edison stations or substations deprive the pump of its source of power, as the Chicago Edison Company's system is so arranged that the current could be supplied through their other stations.

# *Electrically Operated Lift and Draw Bridges in Chicago*

EFFECT A GREAT SAVING OVER STEAM

In its industrial applications electricity is especially valuable in the operation of lift and draw bridges. The power necessary to open and close these bridges is not required all the time, but may be wanted at any moment, and in installations where steam is used for this purpose,

ASHLAND AVENUE BRIDGE, OPEN

it is necessary to keep the fire going at all times to meet the demands. Continually maintaining a proper steam pressure necessitates a large consumption of coal and consequently a high operating cost.

The City of Chicago has found by actual experience that the cost of operating bridges has been greatly reduced by the substitution of electricity for steam, and a considerable saving in the time required to open and close the bridges has also been effected. As the electric power is consumed only when the bridge is in actual operation, the cost is small as compared with coal; the maintenance is also much less than with steam engines and boilers.

Before the advent of steam operated bridges, the heaviest ones required several men to handle them, and the service was slow and unsatisfactory. Speed and control are the requisites of modern methods, and the

ASHLAND AVENUE BRIDGE, CLOSED

old method of hand operation is unsuitable for the larger bridges.

Chicago now has twenty bridges operated by electricity, four operated by steam and twenty-four by hand

CLYBOURN PLACE BRIDGE, CLOSED

power. The increase in speed obtained in turning the bridges electrically is estimated by the City Bridge Engineer to be 25 per cent over steam operation, and at least 75 per cent over hand operation. In some cases the old hand-operated bridges required from ten to twelve minutes to make a quarter turn, which can now be made in from thirty-five to forty seconds.

Among the bridges operated by electricity are the following, and over some of them flows an enormous traffic:

Adams St.; Clybourn Place; Loomis St.; Clark St.; Dearborn St.; North Halsted St.; 18th St.; Jackson St.; Randolph St.; Rush St.; Van Buren St.; Washington St.; Lake St.; North Western Ave.; and Wells St.

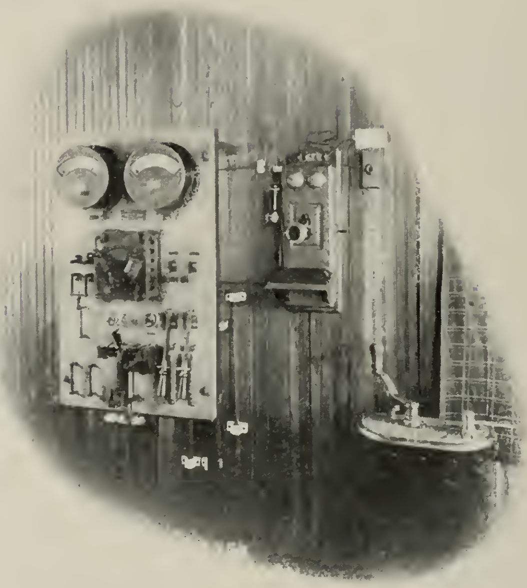
For these bridges the street and elevated railway companies whose tracks cross them furnish the current at a cost of $50 per month or less, in some cases no charge

CLYBOURN PLACE BRIDGE OPEN

being made; excepting in the case of the Rush street bridge, for which current is obtained from the Chicago Edison Company at a cost of about $100 per month.

The coal only for the steam-operated bridges averages about $63 per month, and the coal bill for the South Halsted street bridge alone amounts to over $200 a month.

Some interesting data regarding a number of the electrically operated bridges was published in the Twenty-third Annual Report of the Department of Public Works for 1898, and the extract from this report tabulated herewith is of considerable interest.



MOTOR CONTROLLING PANEL AND K-10 CONTROLLER FOR OPERATING CLYBOURN PLACE BRIDGE

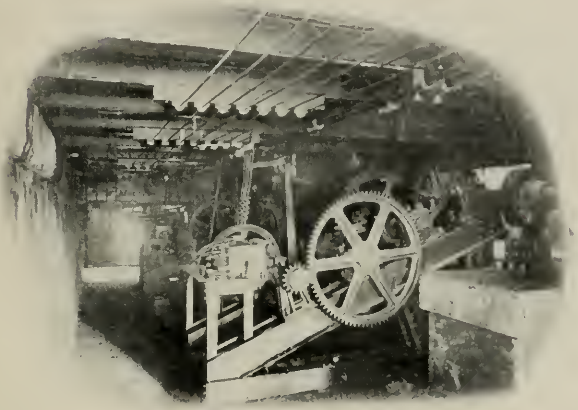
# ELECTRICALLY OPERATED LIFT AND DRAW BRIDGES

| Name | Type | Approximate Weight of Movable part of Bridge Tons | Average Time of Each Swing in Minutes | Average Number of Swings Each Month | Total Number of Swings Annually | Equipment | Make |
|---|---|---|---|---|---|---|---|
| Adams Street | Draw | 500 | 5¼ | 618 | 1688 | 1 GE–800 Motor<br>1 R–11 Controller | General Electric |
| Ashland Avenue | Bascule | . . . | | . . . | . . . | 4 GE–57 Motors<br>3 K–11 Controllers | General Electric |
| Clark Street | Draw | 500 | 2¼ | 699 | 6289 | 2 GE–800 Motors<br>1 K–10 Controller | General Electric |
| Division Street (River) | Bascule | Each Leaf 500 | | | . . | 4 GE–58 Motors<br>2 K–10 Controllers | General Electric |
| Division Street (Canal) | Bascule | Each Leaf 400 | | | | | |
| Dearborn Street | Draw | 175 | | | . . . | 1 No. 6 Motor with Rheostatic Controller | Sprague |
| North Halsted Street | Bascule | Each Leaf 250 | 3¾ | 137 | 825 | 4 GE–1000 Motors<br>2 K–10 Controllers | General Electric |
| Jackson Boulevard | Draw | 500 | 2 | 474 | 4744 | 2 GE–800 Motors<br>1 K–10 Controller | General Electric |
| Lake Street | Draw | 700 | 3 | 516 | 4647 | 2 GE–800 Motors<br>1 K–10 Controller | General Electric |

## ELECTRICALLY OPERATED LIFT AND DRAW BRIDGES—*Continued*

| Name | Type | Approximate Weight of Movable part of Bridge Tons | Average Time of Each Swing in Minutes | Average Number of Swings Each Month | Total Number of Swings Annually | Equipment | Make |
|---|---|---|---|---|---|---|---|
| Metropolitan Elevated | Bascule | . . . | . . . | . . . | . . . | 4 GE–2000 Motors<br>2 L–2 Controllers | General Electric |
| 95th Street | Bascule | Each Leaf 450 | . . . | . . . | . . . | 4 GE–58 Motors<br>2 K–10 Controllers | General Electric |
| Randolph Street | Bascule | . . . | . . . | . . . | . . . | 6 GE–58 Motors (3 on each leaf)<br>3 R–16 Controllers | General Electric |
| Rush Street | Draw | 500 | 2½ | 902 | 8118 | 1 F–40 Motor<br>T–H Rheostatic Controller | General Electric |
| Van Buren Street | Bascule | Each Leaf 450 | 3¾ | 467 | 4441 | East Side<br>2 No. 10 Motors<br>1 No. 14 Controller<br>West Side<br>2 GE–67 Motors<br>1 K–10 Controller | <br>Westinghouse<br>Westinghouse<br><br>General Electric |
| Washington Street | Draw | 150 | 2¾ | 478 | 4782 | 1 No. 6 Motor, old type Rheostatic Controller | Sprague |
| Wells Street | Draw | 700 | 2½ | 666 | 5995 | 2 GE–800 Motors<br>1 K–10 Controller | General Electric |

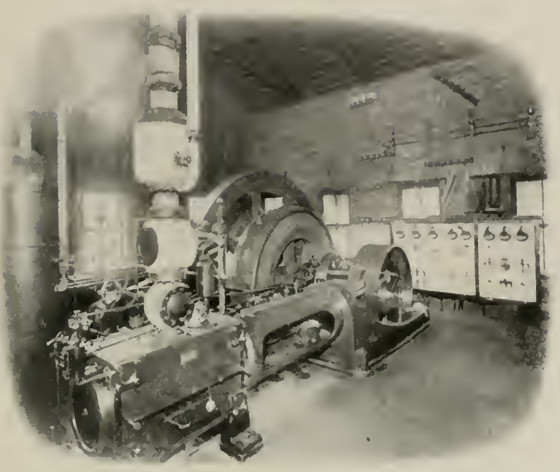
It will be noted that the bridges on which the data is given in this tabulation have an average weight of over 600 tons, while each bridge swings on an average



MOTOR SUSPENSION, CLYBOURN PLACE BRIDGE

nearly 5,000 times a year, three minutes being the average time required for each swing.

The accompanying cuts illustrate the Ashland avenue bridge open and closed, and the Clybourn Place bridge open and closed, also a portion of the operator's room and the operating machinery below the bridge.



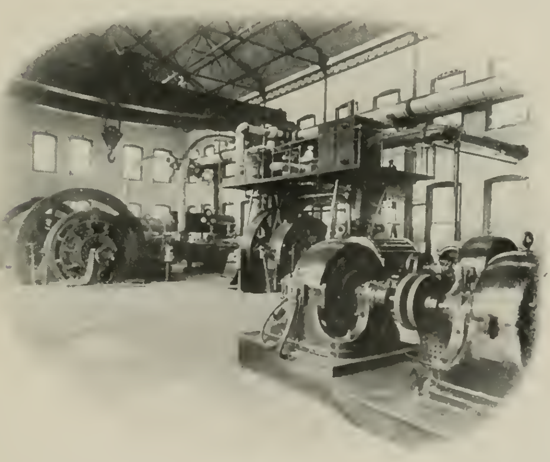
400-KILOWATT WESTINGHOUSE GENERATOR AT FACTORY OF W. W. KIMBALL COMPANY

## *W. W. Kimball Company*

In the manufacture of pianos and organs the Kimball Company use electric power throughout their factory. A 400-kilowatt, Westinghouse, three-phase, 7,200-alternation, 440-volt generator, 100 revolutions per minute, as illustrated in the view, carries a load of 500 horse-power of induction motors in various sizes, which are used to drive line shafting and various kinds of machinery peculiar to this industry.

## *The Illinois Steel Company*

Among the most interesting of all manufacturing plants in which electric power is used are those engaged in the manufacture of iron and steel. The magnitude of the electrical equipment required for large plants of such character, and the wide divergence of uses to which electric power is put, together with the somewhat peculiar



VIEW OF DIRECT CURRENT STATION BEFORE REMODELING

features of application, afford the interest to the electrical engineer. The plant of the Illinois Steel Company at South Chicago perhaps may be taken as typical of this class of works. In that plant, the use of electric power began about the year 1894, by the installation of a 100-kilowatt generating station. Many difficulties were met, some of which were successfully overcome at that time, and some of which caused much prejudice in the minds of some of the mill operatives, which operated to restrain the rapid increase in the use of electric power. Notwithstanding these obstacles, however, in a couple of years it was found necessary to have generating capacity five times as great as that originally installed. Within two years more, it was necessary to build a new station of 1,100-kilowatt capacity. By 1901 this had been doubled again. By 1903 it was again increased, and, at the

PRESSING REVOLVING FIELD OF 2,000-KILOWATT WESTINGHOUSE GENERATOR ON ENGINE SHAFT

present time, a new station of 4,000-kilowatt capacity is being added to the present station of 3,000 kilowatts. During the time covered by these various extensions, the attitude of steel men toward electric power rapidly changed from opposition to enthusiastic encouragement.

At first it was thought necessary always to provide a steam reserve for every electric motor installed, and also to be careful in installing motors to see that no department would be shut down by the crippling of the source of electric supply. The continued use of motors, however, demonstrated this type of machinery to be fully as reliable as any other type and, in fact, considerably more so. Within a very few years it was found that the condition had practically been reached where cutting down the source of electric supply would seriously disable all departments of the steel plant. When it was found that this condition existed, it was evident to all that the proper method was to extend the use of electric power as widely as possible and to provide ample reserve in generating capacity. In pursuance of this idea, the Illinois Steel Company has taken every precaution possible to insure the continuity and reliability of service.

To insure absolute continuity of service, there are two separate generating stations. In one there are four

ORE BRIDGE, SOUTH CHICAGO

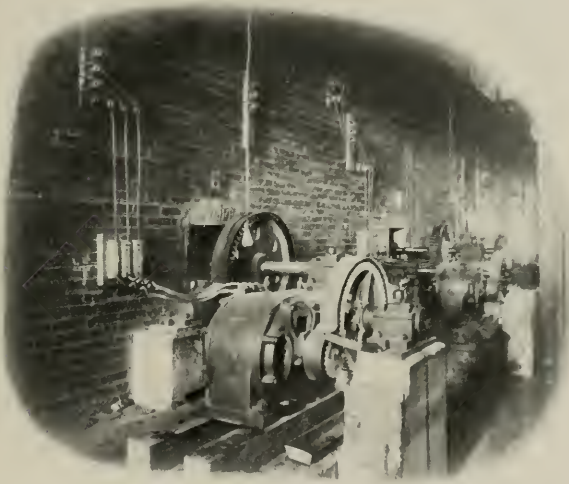
direct current units, aggregating 2,800 kilowatts, and in the other, under process of construction, there are two alternating current units, each 2,000 kilowatts. The two electric stations are connected by means of one 1,000-kilowatt and two 500-kilowatt rotary converters, which float on the system, being connected to both alternating current and direct current sides. Through them, when needed, power can be supplied to the direct current mains from the alternating current station, or to the alternating current mains from the direct current station. Further reliability is secured by reason of the fact that the boilers furnishing steam to the engines in both stations are fired by blast furnace gases from separate sources of supply, whose mains are connected together, with the further provision that either battery of boilers can be fired with coal, should the gas fail.

The accompanying illustrations show the direct cur-

SKIP HOIST, ILLINOIS STEEL COMPANY

rent station and give a view of the new alternating current station, taken during the interesting process of pressing the revolving field of a 2,000-kilowatt Westinghouse generator on the shaft of the engine by which it is to be driven.

The current, both alternating and direct, is transmitted throughout the plant by overhead construction. The alternating current generated at 2,200 volts 3-phase, 25-cycle, is stepped down at various points, through banks of static transformers, for use in motors of comparatively small size, 440 volts. Large motors are operated at 2,000 volts; 3,000 horse-power



MOTOR CEMENT PLANT, ILLINOIS STEEL COMPANY

is stepped up in the alternating current station by static transformers to 20,000 volts, and transmitted ten miles down the lake shore to a cement plant having daily output of 4,000 barrels. There is no power generated at the cement plant, which, therefore, depends entirely upon the transmission line. There are here used induction motors of the short-circuited secondary type, aggregating 3,000 horse-power.

At two points in the yards of the Steel Plant proper there are located two rotary converter substations, each containing a 500-kilowatt rotary converter, transforming alternating current to direct current.

This comprehensive plant, coupled with first-class construction, precludes break-downs of any extent and enables any small break-down to be isolated, so that its effect is limited to the smallest degree.

The electric motor is used in almost every process, and among such uses there are a number of interesting applications. The accompanying illustration gives a view of a large ore bridge which spans the ore yard. This bridge is operated electrically in all of its movements, and resembles a huge traveling crane.

Another accompanying view illustrates the application of motors to skip hoists, the control being automatic and affording safeguards against exceeding the limits of travel when dumping ore into the blast furnaces.

By means of the electric motor used in driving a cold saw for cutting steel rails, it has been found possible to so adjust the speed of the saw that maximum cutting capacity, minimum wear and minimum power expended can be secured with each size of rail cut, a condition which could not be attained when the cold saw was driven by a steam engine.

Motors are used extensively throughout the plant for traveling cranes, Gantry cranes, hoists, elevators and blowers; they are used to drive line shafting, machine tools, incandescent and arc lighting generators, and, in fact, are put to every purpose within the capacity of an electric motor. In fact, the use of electrically transmitted power is so extensive in this plant that after the gradual growth to the present condition, it is found that every essential process in the manufacture of iron and steel is dependent, either directly or indirectly, upon the continuity of service rendered by the machinery employed, which is absolutely insured by the arrangement of the stations in the circuits.

At the works of the Illinois Steel Company at Joliet, Illinois, there is used a 500-kilowatt Westinghouse rotary converter (which is shown, together with station switchboard, in the accompanying photograph), for the purpose of transforming alternating currents purchased from the local power company into direct current for use in the mills.

500-KILOWATT ROTARY CONVERTER AND STATION SWITCHBOARD

At the North Works of this company there is a direct current plant of approximately 300-kilowatt capacity, furnishing current for motors throughout the plant; and at the Milwaukee Works there is a direct current plant of approximately 700-kilowatt capacity, carrying large loads of various sizes for use in the works.