THE SCHENECTADY ELECTRICAL HANDBOOK

Electrical Engineers' Handbook

American Institute of Electrical Engineers.

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Schenectady
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Schenectady Electrical Handbook

THE history of Schenectady begins properly in 1621, when the Dutch West India Company was chartered by the States-General of Holland, following Henry Hudson's memorable voyage of discovery up the river that bears his name. It was not until 1661 that the first settlers purchased a tract of land in the lower valley of the Mohawk River, including the present site of Schenectady; the name being derived from the Iroquois Schau-naugh-ta-da, meaning "over the pine plains" (from Albany).

Its history from the earliest time is interwoven with that of the Indians, especially the warlike Mohawk tribe of the Iroquois nation. These Indians traded furs with the Dutch and English settlers in exchange for firewater, trinkets and firearms, and aided them against the French in the contest for possession of the country. European wars were here, as elsewhere in the New World, reflected by raids and reprisals in which the use of hostile Indians as allies meant cruelty and massacre. The most memorable of these occurred in 1690, when the expulsion of James II from England gave rise to an attack by French and Indians from Canada, in which the little town was surprised and burned and nearly a hundred of the inhabitants killed or made prisoners.

But the importance of the site in transportation, situated as it was at the foot of navigation on the Mohawk River, insured the continuance of a garrison, notwithstanding discouraging wars; and this importance was later heightened by increasing immigration. Schenectady became the natural depot for the products of the great West, and was incorporated a city in 1798. The fire of 1819, the completion of the Erie Canal in 1825, and the beginning of railroad communication in 1831 changed the face of the city and began its later history as a great railroad and general transportation center.

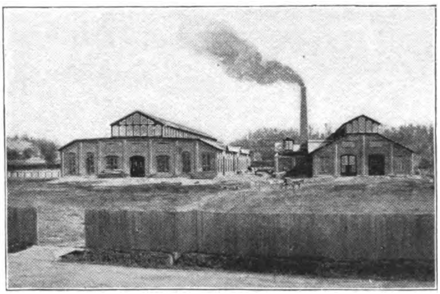
Schenectady claims the honor of the first steam passenger railroad in the country, a locomotive having made a trip on the railroad from Albany, August 3, 1831. By the beginning of 1832 the road was in regular running order.

The advantages of the city as a distributing center have always promoted its manufacturing interests and brought a steady increase in population and in real estate values. The great rise in the city's importance, however, began in 1886, with the coming of the Edison Machine Works, which eventually became the largest works of the General Electric Company. The Schenectady Works of the American Locomotive Company, established in 1848, has also grown into a large modern plant.

The present population of 57,000 supports 18 public schools, a savings bank having $4,300,000 deposits, three other banks having aggregate deposits of $3,500,000, and 50 churches and missions. Post-office receipts are $125,000 annually. There are well equipped fire and police departments, and about 40 miles of paved streets, lighted entirely by enclosed arc lamps.

The General Electric Company

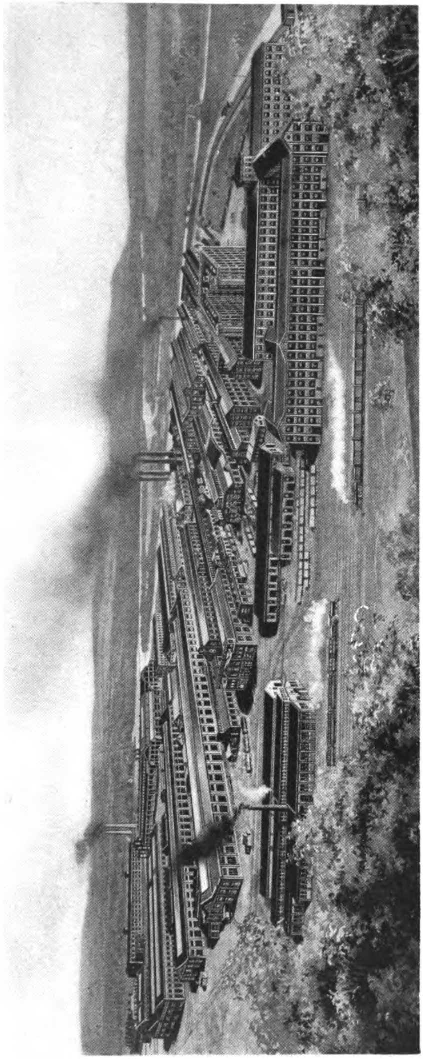
THE General Electric Company was incorporated in 1892, acquiring at its formation all the capital stock of the Edison General Electric Company, of the Thomson-Houston Electric Company, and of the Thomson-Houston International Electric Company. The previous twelve years in the history of electrical industries was an era of invention and preparation; incandescent and arc lighting and electric traction were growing arts, but were so clouded and delayed



Schenectady Works in 1886

up to 1892 by the clash of divergent methods, that only a few realized their vast future utilization.

The General Electric Company was founded by men who felt that the time was ripe to amalgamate the large existing companies and to harmonize competing patents and engineering talents into one great concern; one that should not only manufacture all appliances and develop all promising inventions, but should also advise prospective customers as to best methods and apparatus—in a word, a vast manufacturing and engineering company deserving the name General Electric.



General Electric Company
Schenectady Works

Never in the industrial world did organization effect a more magical change in releasing pent energy. Guided by master hands, electrical arts leaped into industrial pre-eminence; volume of manufacture of appliances, progress of invention, public confidence in electricity, and its general utilization, all took long strides forward. The development of electrical arts, not only in the United States but throughout the civilized world, became the history of the General Electric Company.

Isolated inventions and the talents of inventors reacted on each other to produce perfected systems. Among these were the high tension electric light systems of Elihu Thomson and Chas. F. Brush, which had been owned by the Thomson-Houston Company, and the low tension incandescent lamp system of Edison, which had been owned by the Edison General Electric Company. Although Sprague, whose patents had been purchased by the Edison General Electric Company, had shown that the electric street car was a practical possibility in Richmond in 1887, it was not until Van DePoele, whose patents were purchased by the Thomson-Houston Company, had, in 1889, utilized the now familiar under-running trolley, and the carbon brush for motors, in the West End Railway of Boston, that the electric street railway was assured of permanent success.

The expansion of each department of electrical engineering has been signalized by achievements utterly undreamed of when the General Electric Company was started.

Generators have grown from 200 or 300 H.P. at the largest to an ordinary standard of 5000 H.P., with a rapidly growing demand from costumers of the General Electric Company for sizes up to 10,000 H.P. In 1882 the total number of incandescent lamps manufactured in this country was about 100,000; in 1903 the Harrison Works of the General Electric Company manufactured 28,000,000. Electric railways have not only totally displaced horse cars, but have, by their growth in volume and evolution of transportation methods, opened up a field that has profoundly affected our urban and suburban life. From the early work of Sprague and Van DePoele, the great amalgamated General Electric Company has nursed and tended the electric railways of the country and of the world to a giant's growth. Power transmission by electricity has grown from a mere problem for discussion to the reaching of 50, 100 and even 150 miles with good efficiency. The flexibility and economy of electric power for driving machine tools is replacing line shafting in all modern factories; in textile mills alone, the General Electric Company has installed 70,000 H.P. in motors. In mines everywhere, electric locomotives, hoists and pumps have replaced steam and compressed air. On board ship, and especially in the navy, the use of electricity was early extended from lighting to power; in nearly every vessel of the United States Navy, General Electric apparatus is relied upon today for ordinary and searchlight illumination, for fans, hoists, turret turning, and numerous uses that it has made for itself in superseding steam. Electro-metallurgical and electro-chemical progress, expressed by General Electric Company apparatus and methods, has built up along the Niagara Falls frontier a long line of factories run by Niagara Falls power. These instances are among hundreds that were totally unrealized previous to the General Electric Company era, and which that Company has fostered to a marvelous development.

The following approximate figures indicate the relative sizes of the General Electric Company's works at Schenectady, New York; Lynn, Massachusetts; and Harrison, New Jersey:

Works	Sq. Ft. of Floor Space	Employees
Schenectady	2,519,000	10,000
Lynn	1,081,000	5,000
Harrison	345,000	2,000
	3,945,000	17,000

The Schenectady Works of the General Electric Company

Offices

Buildings Nos. 2 and 4

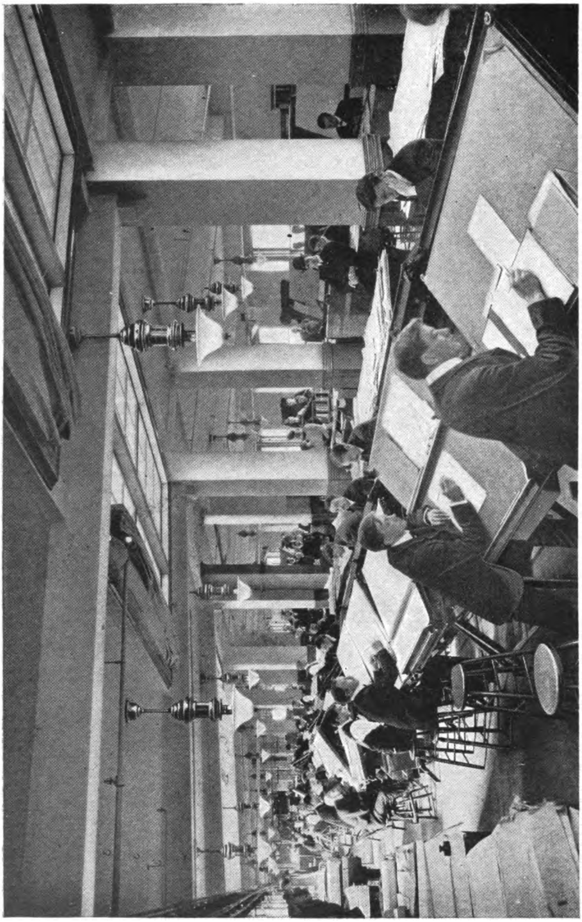
The principal offices of the General Electric Company comprise the executive offices and the offices of the Engineering, Commercial, Law, Patent, Auditing, Production and Purchasing Departments. The present office building, a five-story brick structure, was first

Office Building

occupied in the summer of 1902. It is equipped with elevators, mail and telegram chutes, telegraph stations, pneumatic tubes and telephone exchange, including more than 500 instruments, and a restaurant. The offices require about 96,000 square feet in the office building, and an additional 28,000 square feet in an adjoining building.

Drafting Room

The main drafting force occupies the fifth floor of the office building and the third floor of the adjoining building, but for some classes of work squads of drafts-



A Section of the Drafting Room

men are located directly in the factory buildings. More than 300 skilled draftsmen are employed; nearly 200,000 drawings are filed in the fireproof vaults, and these drawings are classified and cross indexed by the use of approximately 900,000 cards. About 25,000 new drawings are added each year, and on each drawing from 5 to 50 parts are specified.

Drawings and tracings made in the Drafting Room are transmitted by a carrier system to the Blue Printing Department on the second floor of Building No. 4. The annual output of this department is more than 1,000,000 blue prints, which are easily produced without regard to sunlight by the interesting electric printing frames and automatic washing and drying machinery. A receipt is required for each print delivered and a record is kept of its location.

The Pattern Shop

Building No. 77

Nearly two hundred men are employed in this three-story building, which contains 52,000 square feet of floor space. The shop has an annual output of about 14,000 patterns. Close attention is paid to molders' requirements, and every resource looking towards the economy of pattern making is brought into service.

The Brass Foundry

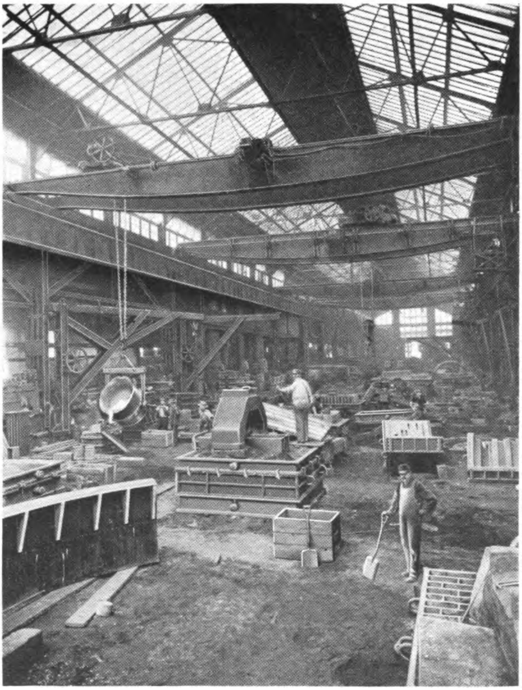
Building No. 7

This building has an equipment of sixteen compressed air molding machines and the usual arrangement of pit furnaces in which are molded the smaller amounts of the various mixtures used in brass founding. Continuous furnaces are used for the bulk of the work, where a large number of castings are poured from the same mixture. About 150 men are employed, and the annual output at the present time is about 2100 tons of castings.

The Iron Foundry

Building No. 83

The main building contains a total floor area of about 150,000 square feet, and there is in addition the usual equipment of sheds for storing foundry supplies



A View in the Iron Foundry

of sand, coke, facings, etc. The main portion of the building is well lighted by 41,500 square feet of windows and skylights.

The heating of the building is accomplished by the use of the warm blast system, with steam coils fed by exhaust steam from the power house and motor driven blast wheels. Much attention is paid to the comfort of the men, and a room containing a full equipment of lockers, lavatories and shower baths is provided.

The building is well equipped with cranes, there being five large travelers in the main bay, six in the cleaning room wing, and eight side bay cranes. All columns in the main bay are fitted with pintles for placing of jib cranes, which can be transferred from one column to another by means of one of the large traveling cranes. There is also one 40-ton crane, which covers the casting storage yard.

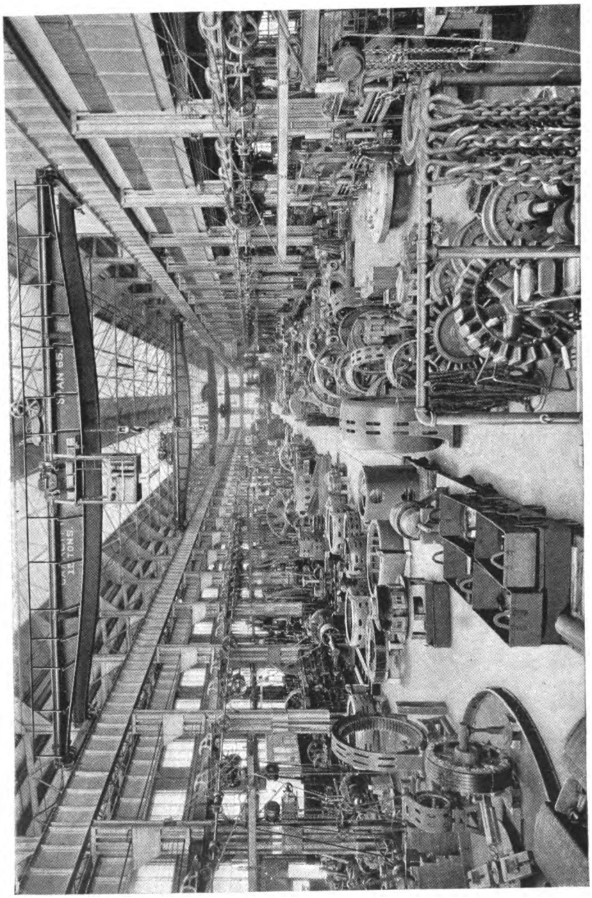
The system of cranes is supplemented by tracks connecting portions of the main building with sand and coke sheds, pig and scrap piles, and flask storage.

There are six cupolas of the Colliau type, and two rotary pressure blowers supplying the necessary air blast. The pig iron, scrap and coke are conveyed to the charging floor by electric hydraulic elevators, and the material is weighed on scales just in front of the elevators.

The core oven equipment is complete, there being a number of the well-known Millet ovens for baking small cores and six ovens of medium size, the cars of which are operated by compressed air. There are also three ovens for baking the large cores which require especially careful handling.

In one of the side bays and a portion of the main bay 100 molding machines are in daily use. Several of these are used very successfully in making cores. The cleaning room wing is fitted up with exhaust rumblers, sand blast for cleaning castings, scales for weighing them after they have been cleaned and chipped, and all facilities for the proper distribution of these castings to the various departments of the works.

The weekly output of the foundry at present is about 600 tons of finished castings.



One of the Large Machine Shops (Building No. 16)

Machine Shops

Buildings Nos. 9, 16 and 8

The large machine shops at the Schenectady Works are well equipped with modern machine tools. Building No. 9, containing 32,000 square feet of floor space, is devoted to the manufacture of induction motors, bearings, and medium sized generators. Two cranes, of 10 tons and 15 tons capacity, serve the center bay, and several bridges are used in the side bays.

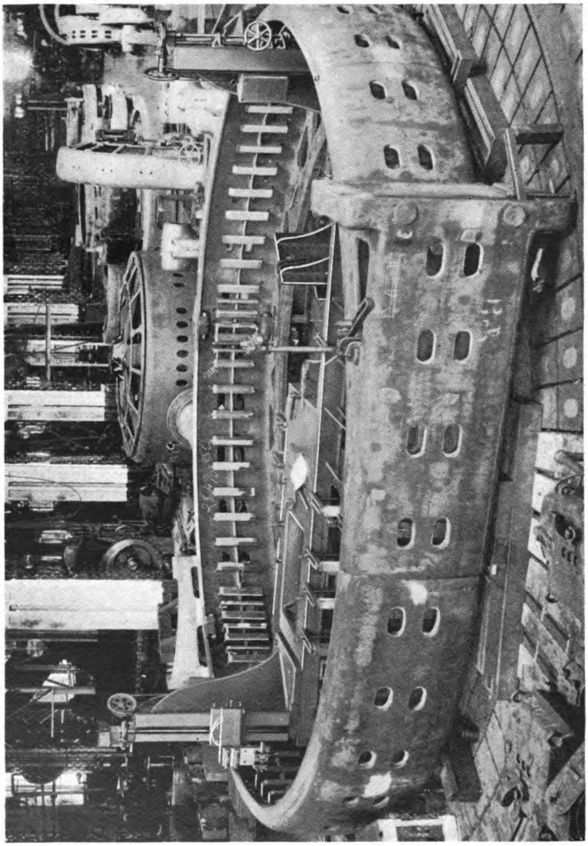
Building No. 16, 850 feet x 160 feet, with its 3½ acres of floor space and modern equipment, affords excellent facilities for handling the largest castings. Twelve thousand square feet of iron floor plate is provided on which castings may be set up and worked upon with electrically driven portable tools. The equipment of portable tools includes four milling machines, five milling and drilling machines, two drilling machines, one shaper, two 60″ slotters, five 48″ slotters, one special slotter, two 96″ slotters, and two 144″ radial drills.

Electric drive is used, and there is therefore a striking absence of line shafting and belts. The design of apparatus built in this shop requires a large amount of boring mill work, and there are 30 boring mills ranging in size from 36″ up to 65′. The last mentioned is one of the largest of its kind in the world.

The handling of castings is facilitated by a complete crane equipment. There are here installed one 50-ton electric crane, three 40-ton, one 15-ton, and one 10-ton, besides some smaller auxiliaries.

Considerable space in the lower end of the building is devoted to the testing of large generators and rotary converters, which are assembled, painted and shipped in this building.

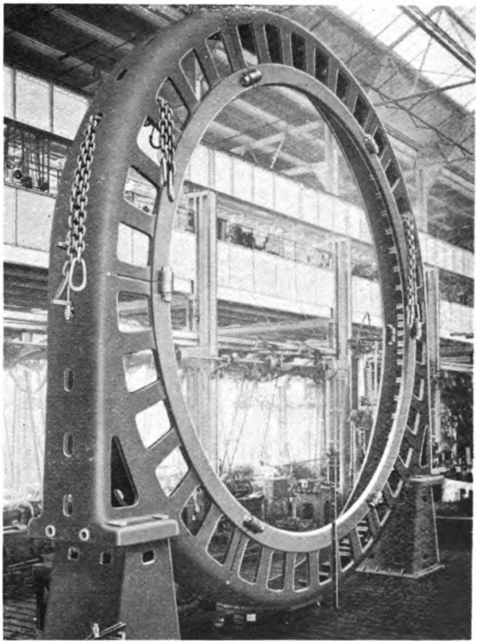
In Building No. 8 about seventy men are employed in making bolts and nuts and in miscellaneous machine work, such as fitting pulleys and making gear cases and rails.



65 Ft. Boring Mill in Building No. 16 at work on Armature of 5000 Kw. Generator

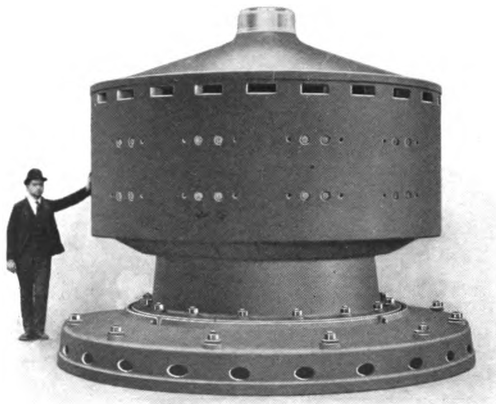
Large Units

Some of the most interesting work which has been done by the General Electric Company in recent years has been in the production of very large machines, many of which are designed for very high voltages.



Stationary Armature Frame of 3500 Kw. Three-Phase Alternator

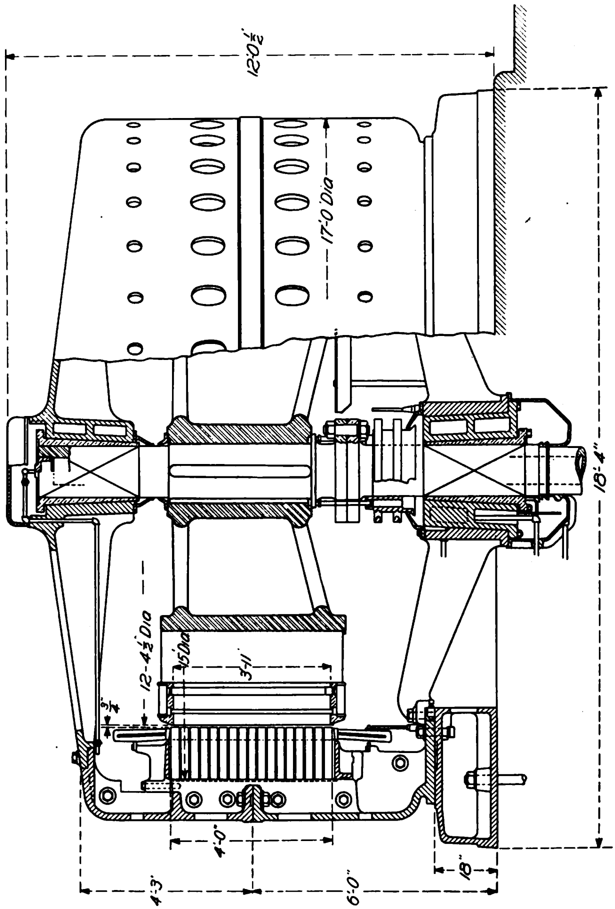
The 10,000 H.P., 10,000 volt generators now in production for the Canadian Niagara Falls Power Company are the largest electrical machines ever produced. These machines operate at 250 revolutions per minute, an unusually high speed for a machine of such large capacity. Their over all dimensions are consequently much less than those of many generators of much smaller capacity which operate at lower speeds. Contrary to the regular practice of the Company to test each machine before shipment, these machines are not assembled at Schenectady, the weight of assembled parts—the 141,000 pound motors, for example—being too great for shipment. Accordingly, the parts are made in Schenectady and are put together at Niagara Falls.



3750 Kw. Four-Phase Alternator
Built for Niagara Falls Power Co.

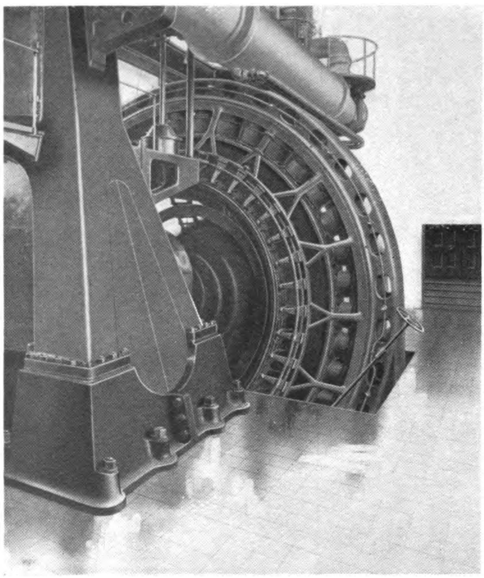
The generator of largest dimensions so far completed at Schenectady, was recently shipped to the Philadelphia Electric Company. It is 33 feet in diameter, has 96 poles and generates 5000 Kw., at 6000 volts, 60 cycles and 75 revolutions per minute.

Among other very interesting machines recently produced may be mentioned the 2700 Kw. direct current machine built for the Boston Elevated Railway Company, and a 2500 Kw. double current generator built for the Chicago Edison Company. The former machine is 27 feet 8 inches in diameter, operates at 575 volts and 75 revolutions per minute, and is de-



Cross-Section Assembly of 10,000 H.P., 10,000 Volt Generator Building for Canadian Niagara Falls Power Co.

signed for heavy overloads. The double current generator in Chicago delivers its full output and heavy overload either in alternating or direct current, the direct current voltage ranging from 250 to 300. Its over all diameter is 28 feet 8 inches. Both of these machines are highly efficient and operate at low temperatures with very perfect commutation. Among large motor-generators may be mentioned a 1000 Kw.



2700 Kw. Railway Generator
Built for Boston Elevated Railway Co.

unit driven at 300 revolutions per minute by an 11,000 volt, 1400 H.P. induction motor. An 800 H.P. induction motor for 180 revolutions per minute has recently been supplied to the Anaconda Copper Mining Company.

Four 2500 Kw., 240 volt rotary converters, 17 feet in diameter over all, and having 13-foot armatures running at 115 revolutions per minute, have recently been completed.

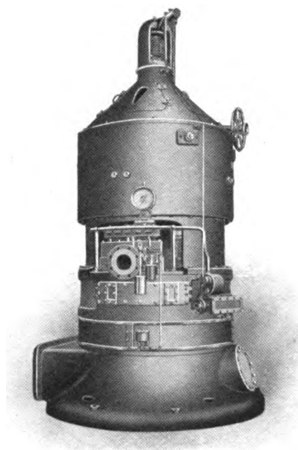
Steam Turbines

Buildings Nos. 20 and 86

The principal advantages of steam turbines for generating electricity are so well known that they need only be mentioned here:

Small floor space per Kw. capacity, reducing to a minimum the cost of real estate and buildings.

Uniform angular velocity, thus facilitating the synchronizing and paralleling of alternators.



500 Kw. Direct Current Curtis Turbine-Generator

Simplicity in operation and low expense for attendance.

Entire freedom from vibration, and approximate noiselessness.

Small oil consumption.

High steam economy at all loads.

High steam economy with rapidly fluctuating loads.

Steam economy is not appreciably impaired by wear or lack of adjustment in long service.

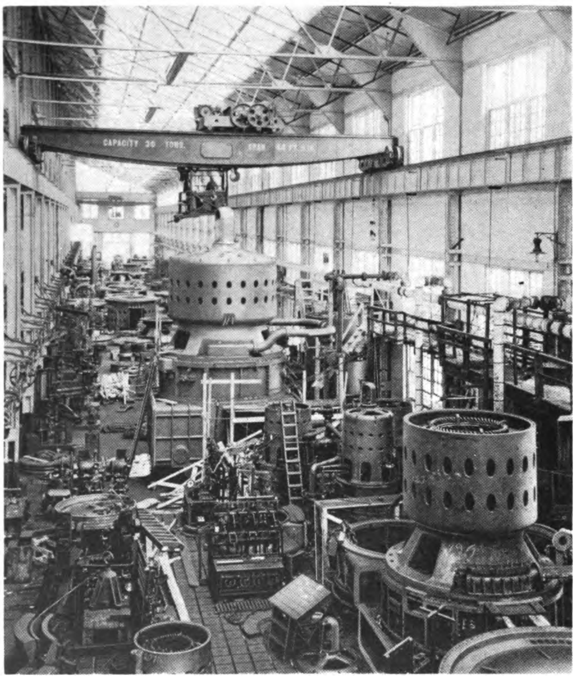
Adapted to high steam pressure and high superheat without practical difficulty and with consequent improvement in economy.

Condensed water is kept entirely free from oil and can be returned to the boilers.

Ability to use steam from any stage of the turbine for heating without the troubles that such use on a large scale brings with compound reciprocating engines.

The steam turbines built by the General Electric Company are based on the inventions of Charles G.

Curtis, developed by experimental work in Schenectady. Mr. Curtis' general idea is susceptible to varied application; machines of different forms have been



Turbine Testing and Erecting Shop (Building No. 20)
Showing Turbine-Generators from 500 Kw. to 5000 Kw. Capacity

built and experimental developments are constantly proceeding. Much of this experimental work is done in Building No. 11 with machines designed for the purpose and readily adaptable to a variety of conditions.

Over 250,000 H.P. of steam turbines, to be direct connected to electrical generators, are now on order.

Among these are eight 5000 Kw. units for the Edison Electric Companies of New York, Chicago and Boston. The New York Central & Hudson River R.R. has ordered eight units of the same size. The largest turbine yet manufactured has a capacity of 7500 H.P., but even larger ones are in prospect. The enormous demand for steam turbines has resulted in the construction of Building No. 86, devoted to their manufacture. The various floors and galleries of this building have a total floor space of nearly six acres. The different stages in turbine manufacture may be followed here and in Building No. 20.

The commercial steam turbines now being produced at Schenectady are all of the vertical shaft type, and range from 5000 Kw. to 500 Kw. capacity; turbines of smaller capacities, operating with shafts in a horizontal position, are being built at the Lynn Works of the General Electric Company, together with some 500 Kw. and 1500 Kw. vertical shaft machines.

Most of the turbines now being built at Schenectady are of the four-stage type. In some of them the valves are operated by electro-magnets controlled by the governor, and others are so arranged that the governor operates the valves without the use of the magnets.

In the larger turbines, the buckets a recast gun metal finished to the proper surface and form. In the smaller machines buckets are cut from steel disks or rings by special machinery designed for the purpose. In machines of smaller diameter, operating at high speeds, steel is in many cases desirable for mechanical reasons.

The generators for steam turbines are necessarily designed and constructed with great care to meet the peculiar conditions of their service. The high speed imposes very great centrifugal strains, and a perfect and unchanging balance is essential. The speed of General Electric turbines is low, however, as compared with that of other steam turbines, making possible the adoption of generators of the most perfect electrical design; in fact, the turbine speeds have,

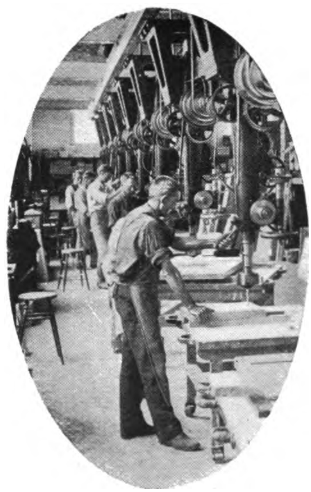
5000 Kw. Curtis Turbine-Generator

generally speaking, been chosen with a view to obtaining ideal generating conditions. In this respect turbines of the Curtis type have an important advantage especially in the operation of direct current machines when such moderate speeds are particularly desirable, inasmuch as they insure low peripheral speeds for the armature and freedom from sparking or other commutator difficulties.

Switchboard Department

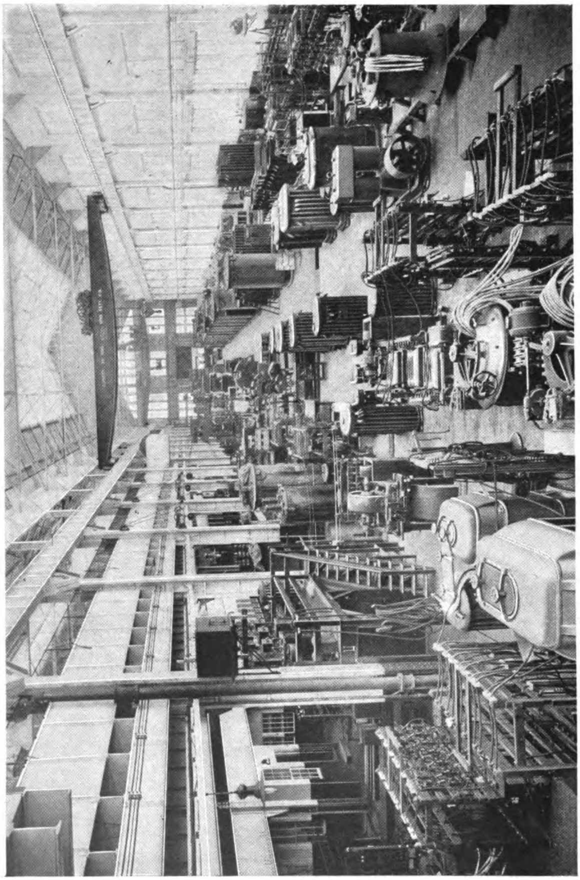
Building No. 23

The rapid extension of this department well illustrates the progress of electrical arts. Fifteen years ago when the central station switchboard comprised a few primitive switches arranged with measuring instruments on a wooden framework, twenty or thirty men in one small shop were able to keep pace with the demand. The factory now employs about 800 hands and occupies a floor space of more than 100,000 square feet.



As an illustration of the large sizes and capacities of some modern switchboards, the one recently supplied to the Elevated Division of the Interborough Rapid Transit Company may be mentioned. The current from nine 5000 Kw., 10,000 volt, three-phase generators is connected to the various panels of this board, and is there measured and distributed through forty connecting lines to as many 1500 Kw. rotary converters in seven separate sub-stations. A switchboard of similar capacity is now in course of construction for the Subway Division of this road.

The modern practicability of high voltage transmission is due largely to the General Electric Company's splendid development of oil switches, which are manufactured in this department. The plan of setting up and testing completed apparatus before shipment is rigidly followed.



Main Floor of Transformer Building

Transformers

Building No. 84

All General Electric transformers of over 50 Kw. capacity are built at Schenectady in Building No. 84, one of the newest and largest shops (160 feet x 855 feet), devoted to transformer manufacture.

In this department, the de-centralization plan is adopted; that is, instead of depending on the central engineering, drafting and production offices and on the other factories for manufacturing and shipping, the whole organization is contained within the one building. Moreover, all transformer parts, except the castings and punchings, are made in the building.

A spacious storage yard for castings, covered by a 20-ton gantry crane, adjoins the building. The engineering office, in the front end of the second story, receives an order from the general office and then proceeds with the work independently, except for necessary conferences with other departments. Adjoining are the drafting room, the offices of the shop foremen, the production clerks and cost clerks, and a stock room for insulations and copper.

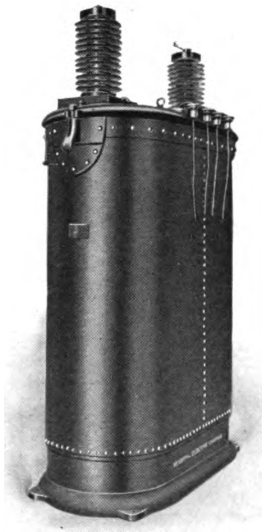
Every department of the building is equipped to co-operate in turning out the immense output of 75,000 to 80,000 Kw. per month in units ranging from 50 to 3000 Kw. The great aim of the organization is to simplify the work from engineering to shipment, dividing responsibility as little as possible and preserving the closest relations throughout. A 4″ pneumatic tube will shortly be installed to the central office building.

The factory portion of the second floor is devoted to the winding of coils, which is done exclusively by machines with individual motor drive. The abundant light and the absence of any belting or shafting are noteworthy. Nearly all winding is done on forms rather than directly on the transformer cores. The application of varnished wrappings to high potential portions is done by hand in a small building adjacent, to avoid fire risk.

Beyond the winding machines are appliances for clamping the finished coils into compact form for treatment with insulating compound by the interesting "Vacuum Drying and Compound Filling Process." This is done in a fireproof annex building. All ovens are heated by steam, ventilated by electric blowers, and equipped with recording thermometers, and special doors for saving time and heat. Many coils are subjected to over 30 successive coats of varnish, and it is therefore important to provide facilities for hastening the process of drying. The insulated coils are held ready for assembly in a large storeroom with racks.

For shell type transformers the coils are stacked up with special insulating diaphragms between the high and low potential sections and built into a finished structure ready to be assembled within the iron core, which is finally mounted in the lower casting that is to support the transformer. The sheet iron that forms the core is then assembled and pressed together by the aid of two large hydraulic presses and the cap bolted in place.

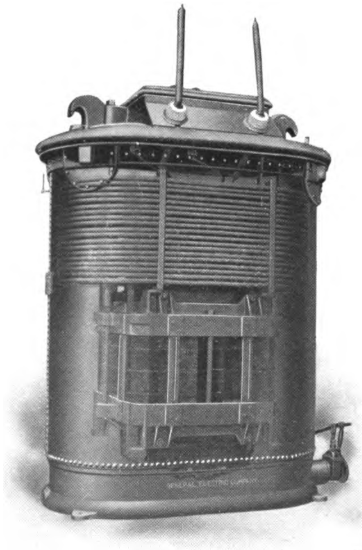
Self-cooling transformers are enclosed in oil-filled cast-iron cases having corrugated surfaces of very large area for their size. These are difficult castings to make, especially in the larger sizes, some of which weigh over 12,000 pounds; but they are much superior to the customary thin sheet iron tanks with soldered seams, which are liable to leak. Oil-immersed transformers designed for cooling by water circulation are enclosed in heavy boiler plate tanks with cast iron bases. In high voltage transformers, this tank and cover make an air-tight joint which permits the air to be exhausted as an aid in thoroughly removing moisture without having to unduly heat the windings. Transformers cooled by "air blast" are enclosed in open top and bottom frames connected by sheet iron casing, the transformers being designed to be placed over a duct or chamber furnishing fresh air. The top of the case contains a sliding damper.



50 Kw., 100,000 Volt, Type H Transformer

Under the gallery at the front end of the building is a space devoted to the assembly of starting compensators used with nearly all General Electric Form K induction motors, and having a function analogous to that of the starting resistance of a direct current motor. In addition to transformers and compensators, several forms of feeder regulators are built in this department and may be seen in various stages of completion.

The entire product of the Transformer Department is tested in the same building and a large amount of floor space is set aside for this purpose. The cement floor for oil transformer tests is sunk slightly below the main floor, and that for air blast transformers con-



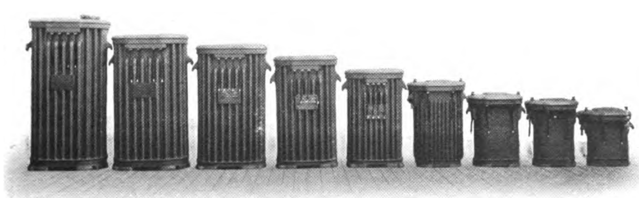
"X-Ray" View of 2000 Kw. Water Cooled Oil Transformer
60,000, 50,000, or 40,000 Volts Primary
3800, 4000, or 4200 Volts Secondary

tains large chambers with blowers for supplying air at varying pressures. All tests under load are made by the "motor-generator method," the power furnished being only sufficient to supply the losses of the apparatus under test. High voltage transformers for testing insulation are provided, including one large transformer capable of producing 500,000 volts.

After the transformers have been tested and the results approved by the Engineering Department, they are packed for shipment in the large Shipping Department on the main floor. Standard gauge tracks and three large traveling cranes, including one of 50-ton capacity, facilitate handling in manufacture and shipment.

Maintaining the proper standard of excellence in an insulating oil is very important in building large high voltage transformers. Traces of moisture, hard to keep out, will reduce its insulating qualities fifty or even ninety per cent. At the Transformer Department, oil that passes the tests is stored in steel tanks in the adjacent oil house, whence it is piped direct to the Testing Department as needed, to be returned when tests are complete. Oil for extra high voltage insulation is specially treated by a patented drying process.

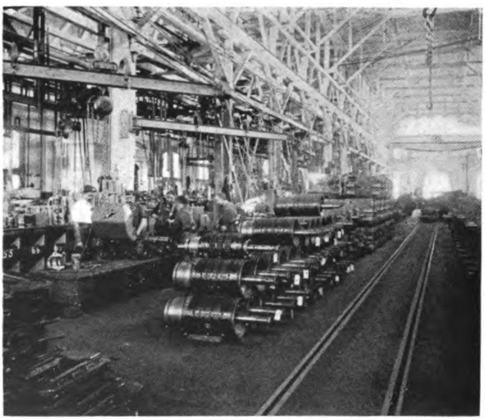
Among the largest sizes of transformers we may mention those supplied to the power transmission plant "Puyallup River in Pierce County to Tacoma, Seattle, Wash." The insulation includes eighteen transformers rated at 2333 Kw. but standing without excessive temperature rise 25% overload, or 2916 Kw. They are used with a primary voltage of 2300 volts and supply high tension of 22,500 to 55,000 volts. The height is 12 feet 3 inches, and the weight of each transformer is 37,650 pounds without oil. In this transformer the oil transfers the heat developed to a water cooling coil placed in the top of the case.



Railway Motor Department

The General Electric Company were pioneers in the building of railway motors. Twenty years' experience and large manufacturing facilities have made their product a recognized standard throughout the world.

Two of the General Electric Company's large plants (Schenectady, N. Y., and Lynn, Mass.) are fully



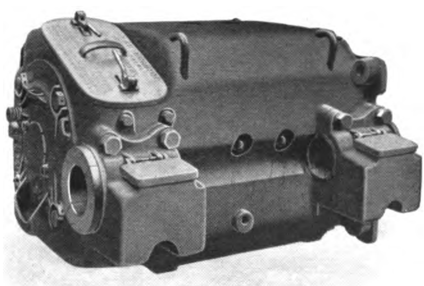
Section of Railway Motor Department (Building No. 10)

equipped for the manufacture of railway motors complete in every detail. The work includes making castings, cutting gears, winding armatures and fields, assembling and testing and a variety of general machine work which is naturally distributed among several shops.

The factories are building over thirty types of railway motors, ranging from 18 to 550 H.P. A number of these motors are built in several forms to meet different styles of suspension, track gauges, etc., and most of them have a variety of windings to meet the varied conditions of railway service. In addition to the large number of combinations which can be secured with standard capacities and speeds, a considerable amount of special designing is carried on.

The majority of the General Electric railway motors of large capacities are of the box type, which most readily lends itself to compact, accessible and durable construction.

At the present time, a number of locomotives to be used on the New York Central & Hudson River Railroad are being equipped with General Electric motors embodying novel and special features. These motors, known as the GE-84 type, are bipolar gearless machines rating about 550 H.P. The locomotive frame acts as a part of the magnetic circuit, thus greatly simplifying the design of the complete locomotive. The large air-gap permits the armature to pass between the pole-horns for removal and insures ample clearance in operation. The laminated pole pieces and field coils are supported on three intermediate and two end transoms of the locomotive frame. One hundred and twenty of these motors are on order at the present time.



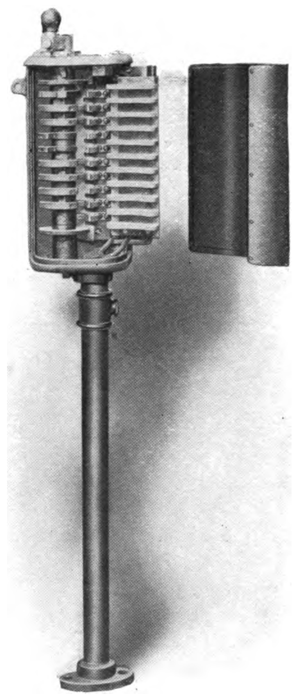
GE-66 Railway Motor

Used by Interborough Rapid Transit Company, New York

Controllers and Air Brakes

Building No. 23

The General Electric Company has manufactured to date over 139,000 controllers, embracing about 400 different forms, an evolution the history of which would form an exceedingly interesting story of research, experimentation, continual improvements, and final success in turning out a device which does its work thoroughly and can be entrusted to unskilled hands under exceedingly severe conditions of service.



Master Controller (C-26) for Sprague-General Electric Train Control

Controllers manufactured for railway service are of two general classes. The first is the cylinder type of platform controller in which the main leads from the motors enter the controller, and a manually operated handle rotates a cylinder making the requisite resistance and motor combinations. The second form of control is the Sprague-General Electric multiple unit type, which was designed primarily for that class of service requiring the coupling together of a number of motor cars, with means for simultaneous control of all cars from the leading car.

The multiple unit control has been in general use for several years, and has been adopted and over 800 equipments purchased by the four great underground electric railroads of the world, namely, the Interborough Rapid Transit, New York; the Boston Elevated, Boston; the Underground Electric Railway, London; and the Metropolitan Railway, Paris. In addition to these equipments, there are over 2000 operating in many different places. The flexibility of this form of control is strikingly shown by its application to the Baltimore & Ohio locomotives described elsewhere.

Controllers are manufactured for the operation of direct current motors varying over the usual commercial voltages, and also for single-phase, two-phase and three-phase alternating circuits, for various classes of work.

Other purposes for which the controllers manufactured by this Company are used, include:

Electric launches and automobiles.

Hoists and cranes.

Coal mining machinery.

Mining locomotives.

Shop tool motors.

Printing presses.

Motors on warships, for boat cranes, turret turning, ammunition hoists, gun carriages, etc.

Electric pumps.

Operation of draw bridges.

And many other uses.

General Electric controllers are used with motors ranging in power from that required for the delicate operations of silk spinning to the control of locomotives capable of hauling the heaviest freight trains, and the controllers vary in weight from seven or eight pounds to nearly three tons each. The Controller Department manufactures and tests annually about 17,000 controllers, and a variety of special switches used in connection with them.

The General Electric Company manufactures complete air brake apparatus, including motor driven compressors, for the equipment of electrically propelled cars and trains for operation under all possible conditions and embodying many practical improvements. This apparatus includes both the "Straight Air" system for use on single cars and "Automatic Air" system which has become standard for use in regular train service. All this apparatus has been thoroughly standardized and much of it is interchangeable with similar pieces of apparatus manufactured by other companies.

Controller Department

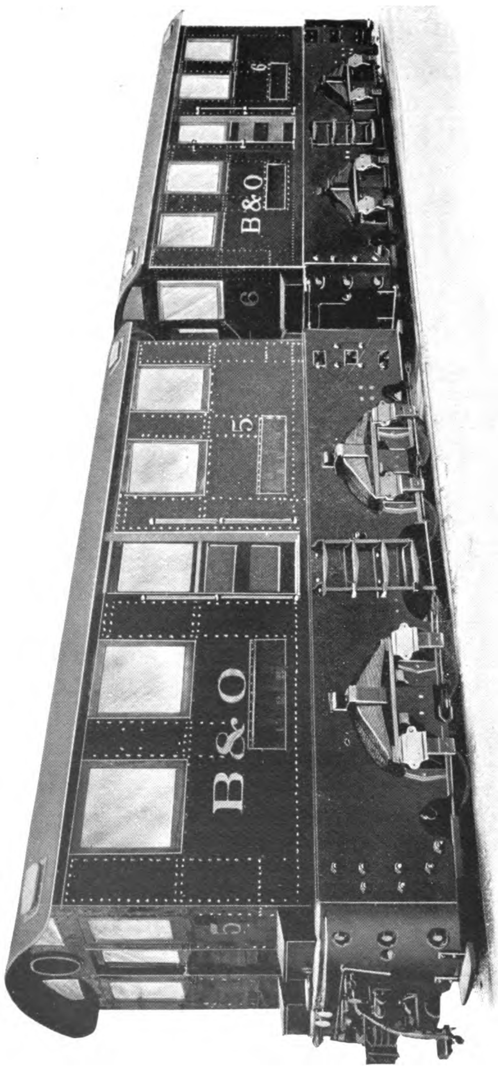
Electric Locomotives

Building No. 16

The General Electric Company has developed nearly all the modern apparatus for heavy electric traction, and the various types, manufactured at the rate of 200 a year, show a complete history of the development of electric locomotives, from the small mining locomotives intended to work in low galleries to huge machines designed for handling the heaviest freight or passenger service. In addition to the large four-motor equipments designed for freight haulage, the Company manufactures a complete line of smaller locomotives suited to power and mining and inter-factory transportation.

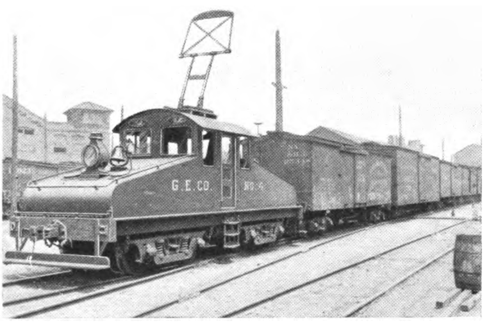
One of the early locomotives equipped with four 125 H.P. motors, was built in 1894, and has been in continuous operation since its installation, doing freight service at the Ponemah Mills at Taftville, Conn.

Among the first of the steam railroads to place electric locomotives in regular service was the Baltimore & Ohio. Three 96-ton electric locomotives were originally built for this road, each equipped with four 400 H.P. motors, for handling the terminal traffic, passenger and freight, through a tunnel entering the city of Baltimore. It was found that one of these locomotives could accelerate a loaded train equivalent to 52 freight cars having a total weight of 1900 tons on a grade of .8 of 1%, the draw-bar pull exerted during acceleration being 63,000 pounds. So satisfactory was their operation that an order was placed for two more larger locomotives which are now in commercial service. These are two of the most powerful locomotives in the world, having a weight of 320,000 pounds on the drivers, built in two separate units of 80 tons each. Each locomotive has a draft gear of approved design, which will withstand a maximum draw-bar pull of more than 100,000 pounds. The electrical equipment



160-Ton Electric Locomotive Built for B. & O. R. R.

of each unit consists of four 225 H.P. geared motors, giving a normal rating of 1800 H.P., or maximum temporary output of 3000 H.P., for the complete locomotive. In order to convey some idea of the tractive power of these locomotives, it may be noted that at the nominal rating of the motors, each locomotive is capable of accelerating on the level a train weighing 8000 tons.

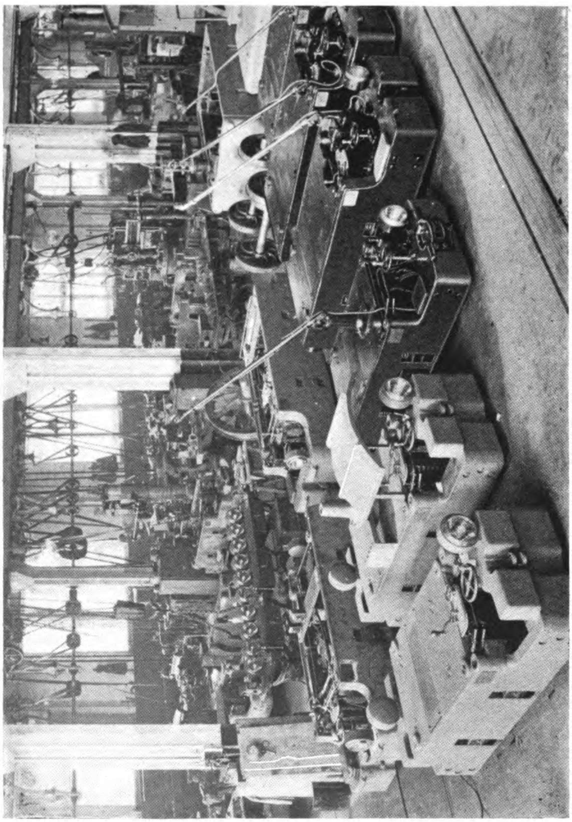


Electric Locomotive Hauling Freight Cars at Schenectady Works

The General Electric Company has at present in use in its yards, for the purpose of switching freight cars between factories, two locomotives, one weighing 30 tons, the other 40. These take current from the line through a specially constructed self-reversing bow trolley.

The New York Central & Hudson River R.R. has recently placed an order with the General Electric Company for 30 powerful electric locomotives for their New York terminal service. These locomotives will be of special design, weighing 85 tons and equipped with four 550 H.P. gearless motors, as described on page 37. Their maximum speed when hauling trains will be approximately 75 miles per hour.

There are 650 General Electric mining locomotives in operation in various mines throughout the world.



A View in the Locomotive Department

Wire and Cable Department

Buildings Nos. 93, 95, 97, 99, 101 and 103

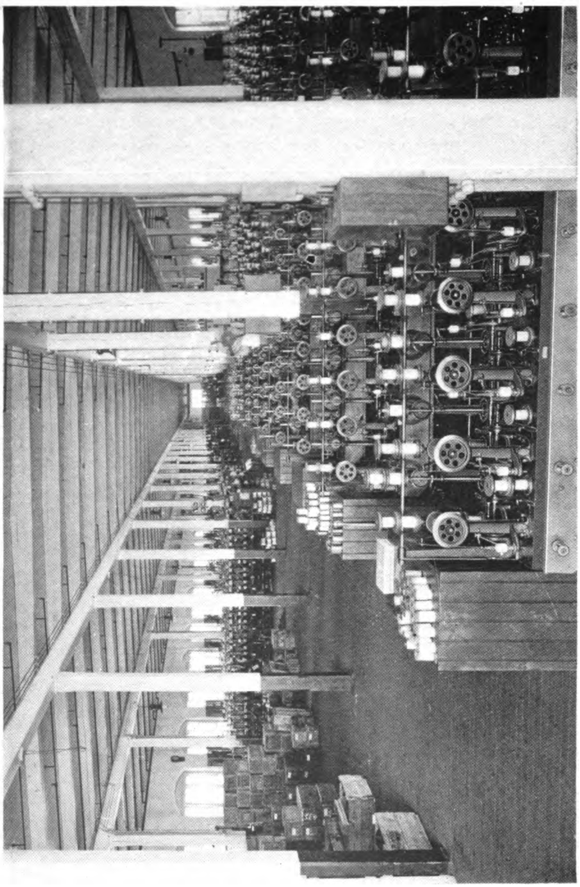
The Wire and Cable Department comprises a group of six buildings, having a total floor space of about 175,000 square feet and employing about 500 operatives.

The principal building, No. 93, three stories high and 460 feet x 90 feet, is of the type known as "Standard New England Mill Construction." All the stairways and the powerful elevators are in towers independent of the main building, so that the floors in the main building are unbroken by any opening.

The third floor is devoted to the manufacture of cotton and silk wrapped magnet wire ranging in size from .003″ (.8 millimeter) to .325″ (8 millimeters). The machines for the manufacture of this wire are driven in groups by shafts running across the building, the shafts being actuated by three-phase induction motors driven through high-speed silent chains. The machines are located so as to permit ready inspection and allow the maximum of light from the windows to reach the center of the room.

The second floor is devoted almost entirely to braiding or plaiting machines, which are arranged and driven in the same manner as those on the third floor. They are all fitted with automatic stop motions, so that a few operators are sufficient for a large number of machines. The rubber wire for interior use and rubber cables for the wiring of electric cars are braided on this floor. It will be noted that, contrary to European practice, practically all rubber insulated wire is finished with a braid, little or no tape finished wire being used in the United States.

On the first floor of the building, on the right-hand side, are the washers, mills, calenders, and other machinery for the manufacture of rubber insulating compounds. The direct electric drives, with which all



Section of Wire and Cable Department

this machinery is fitted, render the plant extremely compact, and do away with all noisy high-speed gearing and belts. The sheet rubber is cut into strips of various widths and delivered to the rubber covering machines, whose capacity is 1,500,000 feet weekly. On the opposite side of the building stranding machinery manufactures cable cores, which are afterwards insulated by various methods. Next to the stranding machinery is the special paper insulating machinery for applying paper to the copper cores.

The apparatus for drying and impregnating paper cables, the lead presses for leading all classes of cables, and the testing department which is fitted with various transformers for obtaining potentials up to 50,000 volts for purposes of test are located in Building No. 95. From the Testing Department the product proceeds to the packing department and is then loaded by means of overhead electric cranes into freight cars for transportation.

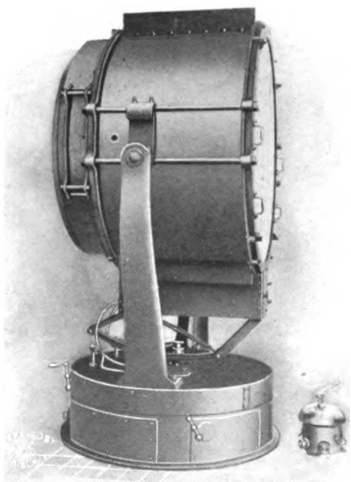
The pots for compounding and finishing braided wires, the annealing furnace for annealing special forms of cable, and the machine shop where are built the various types of underground fittings are among the interesting features of this building.

The Wire and Cable Department also includes buildings for the manufacture of special varnishes, japans and similar materials.

Searchlights

Building No. 23

The Searchlight Department employs about 125 men and about 200 large searchlights are annually manufactured here. The building has a tower with trackage and switchboard for practically testing its product. Projectors of General Electric Company make have come rapidly into use by the Government for coast defense and upon warships, and upon merchant ships as well. The largest projector ever built in the United States was made at Schenectady for use at the St. Louis Exposition. This projector is 80″ in diameter, and has a positive carbon 2¼″ in diameter. It consumes nearly 17 Kw. at the arc.



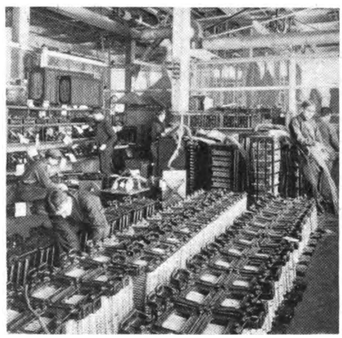
60-Inch Projector

In addition to searchlights from 9″ in diameter up, controlled by hand or from a distance by electric motors operated through a cable, steam turbine operated locomotive headlights, and complete portable searchlight outfits, this department manufactures a keyboard manipulated "Night Signal System" in use by the United States Government, a telltale board for the control of running lights on board ship, and similar apparatus.

Rheostat Department

Building No. 26

On the entire second floor of this building rheostatic controlling devices are made for nearly every conceivable duty: Field rheostats, starting, battery charging, projector, and motor regulating rheostats, as well as controlling rheostats of various types for use with machine tools, printing presses, etc. The sizes of the field rheostats vary from the little hand operated device used in the field of a small exciter or motor, to the large rheostat with cast grid resistance and motor driven dial switch used to regulate a 5000 Kw. alternator.



A Portion of the Rheostat Department

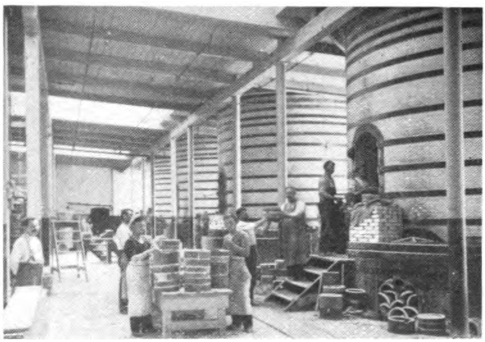
Motor panels for the United States Government are also made here in various styles and capacities as well as motor panels for the general trade. Both types of motor panels are made with all practical combinations of field control, armature regulation, no voltage and overload release, and interlocking devices to prevent the operator from misusing the motor.

The Rheostat Testing Department is located on the same floor and every device is carefully tested for resistance, insulation and operation before being sent to the Shipping Department. One year's work consisted in manufacturing and testing about 32,000 rheostats of various classes, 450 special controlling panels and 1600 air pump governors.

Sockets, Receptacles and Small Supplies

Buildings Nos. 26 and 94

On the third floor of Building No. 26, about 280 employees are at work making up sockets, receptacles, snap switches, cut-outs, fuse plugs and fuses. Automatic machinery and systematic methods are of vital importance to the enormous output of this department.



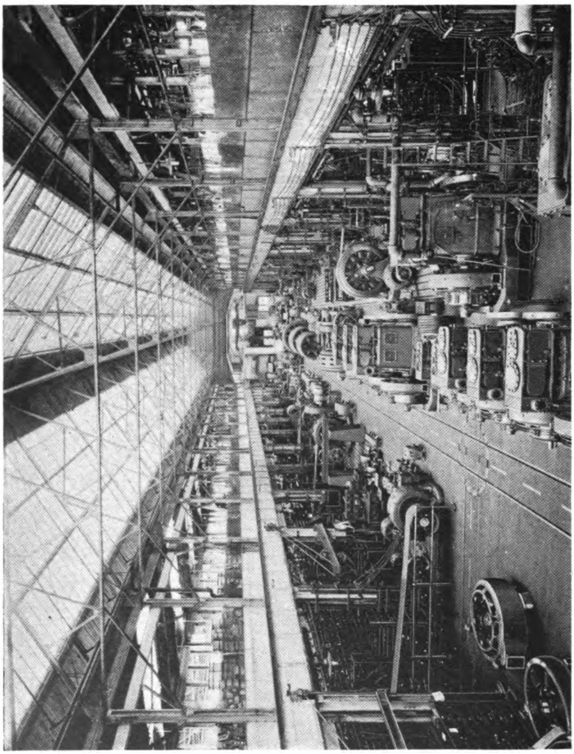
The Porcelain Works

The Porcelain Works, Building No. 94, where insulators and porcelain parts for many other devices are manufactured, is believed to be the most modern and best equipped plant of its kind in this country. It employs 160 men, has 7 kilns, 52,000 square feet of drying racks, and 16,700 square feet of floor space. Last year it manufactured more than 1000 tons of porcelain products. The processes of mixing the clay, molding it into shapes, firing and glazing it in the kilns are all of interest. While nearly all porcelain pieces are molded in presses, high potential insulators, to secure perfect homogeneity, are formed on a potter's wheel similar to those used by the Egyptians 4000 years ago.

Testing Department

Buildings Nos. 11, 16, 20, 23, 26 and 84

The success or failure of any machine is definitely determined when it has been in operation for a term of years, but the manufacturer, with a reputation to uphold, and the purchaser, with exacting requirements to be fulfilled under heavy penalty for failure, cannot wait for time's decision. Before any part of the product takes its place in the machinery of industry, the manufacturer and purchaser want positive assurance that there will be no failure and no disappointment. Such assurance can be obtained only by reproducing the conditions of actual service and giving every appliance a thorough test. To conduct such tests is manifestly impossible without a vast amount of available power and an expensive equipment of appliances and experienced men, such as cannot be maintained except in connection with a works large enough to insure their constant employment. The Testing Department at the Schenectady Works occupies all of one large building (No. 11) and large spaces in several others. When any machine is set up and connected for test, calibrated instruments are secured from the Standardizing Laboratory. All readings of the test are set down on a record sheet provided for the purpose, and forwarded to the calculating room in the Testing Department offices. Here the calibration curve of each instrument is applied and corrected readings are entered in a parallel column on the sheet. The results



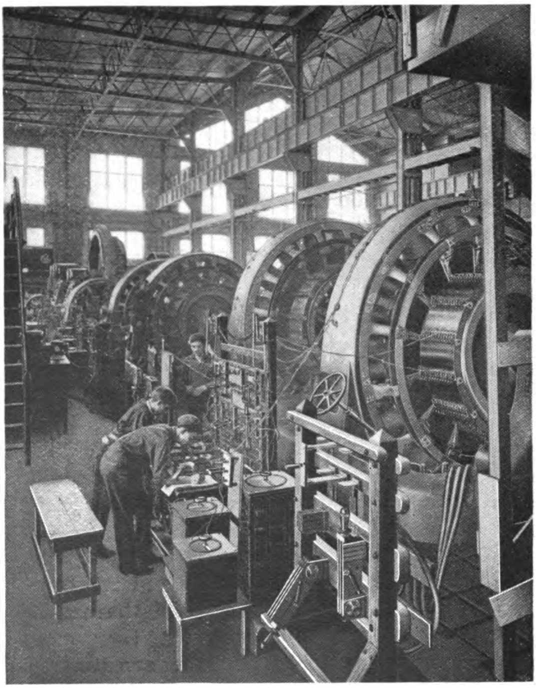
Main Floor of Testing Department (Building No. 11) of all tests are forwarded to the Engineering Department for approval or comments.

Steam power for driving large generators and steam for testing turbines and direct connected marine engine-generator sets are provided. The principal source of the electric power used in the Testing Department is a 1200 Kw. direct current machine, which is direct connected to a 1500 H.P. tandem compound engine. This generator has two commutators and two separate armature windings, so that 250 or 500 volts may be obtained. For general use the commutators are connected in series, thus giving from 500 to 600 volts. Feeders from this machine are brought out to the main switchboard provided with suitable circuit breakers and switches and from there distributed to the switchboards in the various tests. Each of these switchboards has its own circuit breakers and switches, so that in case a short circuit occurs in a section it will not necessarily shut down the entire department. All of the shop motors in the department are run from this circuit also. In addition the department is equipped with a 250 volt three-wire system from which power may be taken at either 250 or 125 volts. This circuit is obtained from the double commutator rotary converters in the Power Station.

In the center of the annex building, a bank of generators constituting the exciter plant run continuously. The fields of all exciters and the armatures are brought to one board so that they may be excited from any voltage and the armatures connected to any part of the department where an exciter is required.

The general method of testing all generators is to belt them to motors of sufficient capacity to drive the generator at its full load. This load is obtained in various ways: by absorbing the power in water rheostats, by pumping it back into the driving circuit and thus supplying only the losses, etc.

The large steam engine in Building No. 12 is used in tests of generators up to 1000 Kw. Not infrequently a direct current generator is assembled in the pit and direct connected to the engine while two

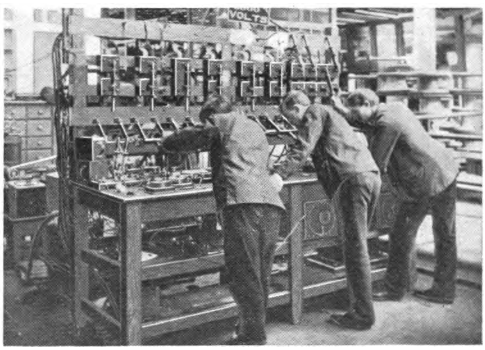


A View in the Testing Department

motors are belted to the engine, one on either side of the large fly-wheel. By this plan the engine supplies only the losses and a 600 Kw. generator may be tested by belting two 300 Kw. machines on either side of the fly-wheel and driving them as motors from the generator in the pit.

In the Railway Motor Test, motors of the box type are also operated under load by this "pumping back" method, and owing to the severe usage which railway motors are likely to receive, the tests are unusually thorough.

An interesting feature of the Induction Motor Test is the measurement of slip by the arc lamp method. On the shaft of many of the motors in test will be seen

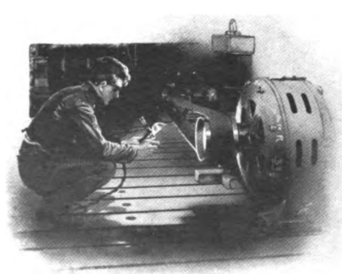


Making Simultaneous Readings
Testing Department

a disk which has as many black and white sectors as there are poles on the motor. The arc lamp is operated from the alternating current generator which drives the motor. When the disk is rotating with the motor and observed by the light of this arc lamp, the black sectors appear to be slipping backward, because of the difference in speed of the motor and generator. In this test the tables and the arrangement of switches for reading current in all legs by means of one meter only are also of interest.

In general, the tests applied to all lines of apparatus are of far greater severity than the apparatus will be likely to meet in its commercial use, and in case any special guarantees are made as to temperature rise, or overload runs, the Testing Department is always very particular to see that the machines fully meet these guarantees.

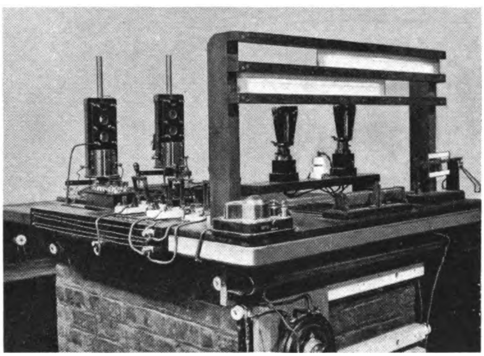
The working force of this department is chosen with great care and includes representatives of nearly all of the leading technical schools of the world. At the present time the 575 men employed in the testing force include graduates of 67 colleges and universities of 18 different nations. Nearly every civilized country in the world is from time to time represented in this remarkable force of experts. A man is seldom allowed to stay permanently in any one department, but after being thoroughly trained is passed along to another where under experienced guidance he becomes a specialist for the time being, and is then transferred again for further training. The Testing Department thus has a double value in that it provides for tests by very high grade men, and also provides properly equipped men for important positions in the Company's Engineering and Commercial Departments.



Standardizing, Testing and Research Laboratories

Building No. 4

The Standardizing Laboratory is completely equipped for electrical measurements of every kind, and employs about thirty-five experts engaged in the accurate calibration of the 1800 electrical measuring instruments used in the Works. These instruments when in regular use are calibrated at least once a week,



Apparatus for Measuring Hysteresis

and where extraordinary precision is required, once a day.

The scope of this laboratory now covers the design of new measuring and indicating instruments to meet the growing requirements of electrical engineering.

The Testing Laboratory was organized to assist the Purchasing Department in the selection of the various materials, including metals, required in electrical manufacture, by scientific investigation and analysis. This work has led to the testing of all materials used and to the tabulation of results; thus providing accurate data on which new designs and calculations are based, and from which exact specifications are drawn stating necessary qualifications of material to be purchased. These are used for the guidance of the Purchasing Department and also by the factories in their inspection of raw material.

A number of mechanical testing machines, varying in capacity from a few pounds up to 100 tons, are provided for making the usual tension and compression tests; also special apparatus for determining the magnetic quality of iron and steel, and for the testing of insulating materials under high potential strains up to 200,000 volts.

A complete equipment of chemical apparatus facilitates all kinds of exact analytical work, both qualitative and quantitative, and a number of gas and electric furnaces, together with all kinds of pyrometers and apparatus for standardizing them, supplement the resources of this department. Much of this apparatus was designed especially for the investigations carried on here, and no expense has been spared to secure efficient results.

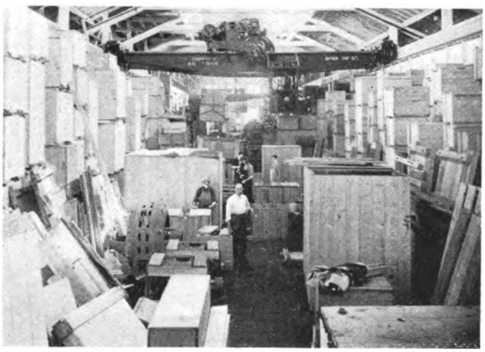
The Research Laboratory was established about three years ago for purposes of original investigation. It is fully equipped with all kinds of chemical and physical apparatus, and employs a well trained corps of chemists, electro-chemists, and engineers who devote their entire time and energies to pioneer research. Work tending to the improvement of the factory product and to the development of new apparatus and methods is constantly under way.

The work is divided into different classes and the laboratory is given careful and scientific supervision by engineers of international reputation. The development of new methods for producing light by electricity is naturally receiving a large amount of study and attention, and results thus far obtained in this direction are very promising.

Shipping Department

Building No. 12

The finished products of the Works are all shipped from the Shipping Department except when unusual size or other special considerations indicate advantages in shipping from the building of manufacture. Some large machines are shipped in pieces for muleback transportation, or for lowering into mines; others are assembled in part or entirely and shipped on large flat

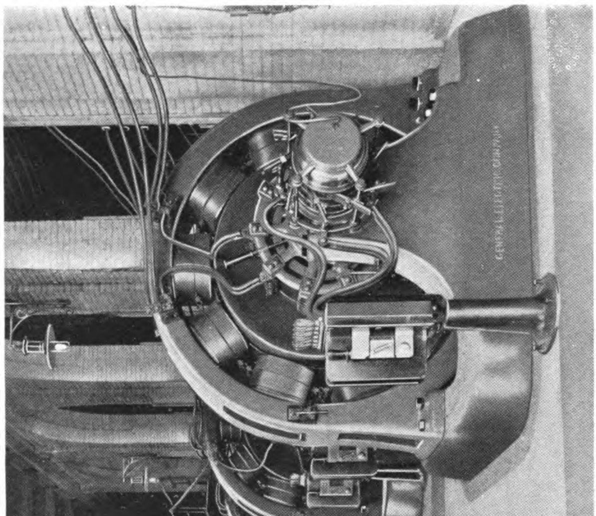


Shipping Department

cars, or in packing cases. In the year 1903, the total shipments, amounting to about 100,000 tons in 320,000 separate packages ranging in weight from an ounce to 137,500 pounds, required 8730 freight cars. Some of the larger pieces required extra large and heavy cars specially constructed for the purpose.

Building No. 12 contains standard gauge tracks, electric cranes, and every facility for painting, handling and boxing the various products of the Works, brought in on an elaborate system of interfactory tramways.

Shipping boxes are put together by nailing machines in the Carpenter Shop (Building No. 74), where about 16,000,000 feet of lumber are worked up annually for all uses.



Rotary Converters in Power Station (Building No. 13)

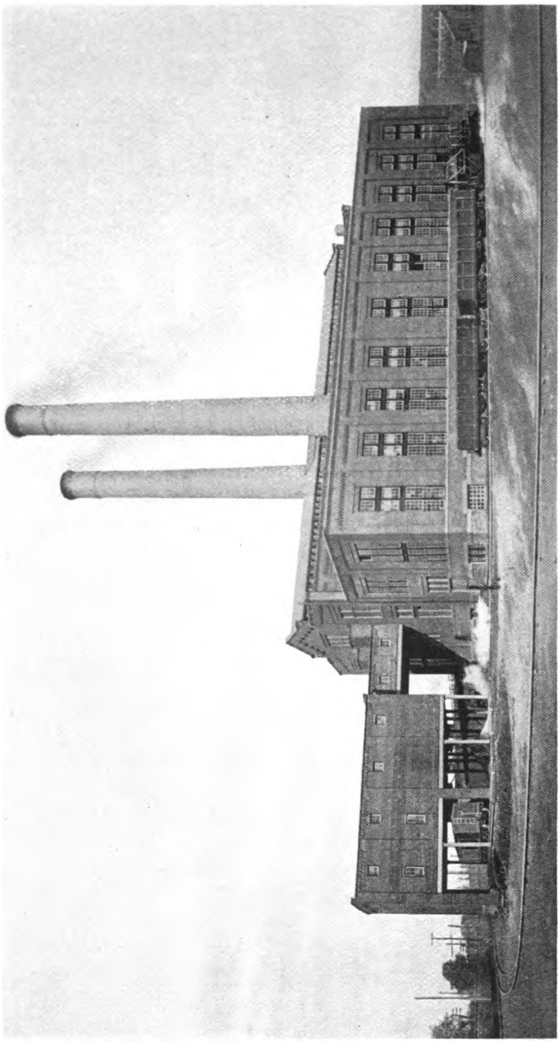
Old Power Station

Buildings Nos. 13 and 12

The Power Station (Building No. 13) is both a generating station and a rotary converter sub-station. Power is received from Spiers Falls, forty miles away, at a potential of 25,000 volts and is stepped down to 10,000 volts and distributed through a double circuit switchboard (giving separation of lighting and power circuits) to the various factories of the General Electric Works and to the Schenectady Railway Company. All switching is done at 10,000 volts by means of remote control switches. Five double commutator converters supply direct current to the shops at 125, 250 and 500 volts, and one three-phase 250 Kw. step-down transformer supplies current at 120 volts for the alternating current system of the Testing Department.

The station contains 16 Babcock & Wilcox boilers, equipped with American and Roney stokers with forced draft, and with coal and ash conveyors. A pumping plant draws water from the Mohawk River, about 1600 feet distant. The boilers supply steam for general manufacturing and testing purposes and for fire pumps as well as to the engines. Building No. 13, and Building No. 12 nearby, contain nine engines direct connected to various alternating current and direct current generators. In Building No. 13 is the first General Electric turbine-alternator, a 500 Kw. unit.

Four distinct circuits supply the factories from this station. The direct current switchboard is so arranged that any machine or machines may be placed upon any circuit. The generators are all double commutator machines and the two ends are connected in series or in parallel, as the demand may require. The normal load on this station is about 6000 Kw. The Works' installation includes 1300 motors, 2200 arc lamps and numerous incandescent and Meridian lamps.



New Power Station

New Power Station

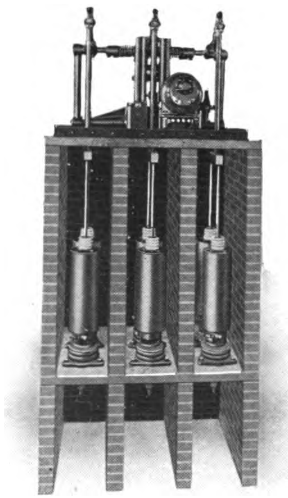
Building No. 85

This station is designed for a capacity of 12,000 Kw., in eight 1500 Kw. turbine-generator units. It furnishes current for motor driving and general testing in the Works and is also a reserve for the Schenectady lighting plant and railway system which it supplies through the Dock Street Sub-Station. Three-phase transmission at 10,000 volts is used, as most readily applicable to these conditions. The station has been designed to produce power at minimum cost under the widely varying demand set by the conditions, and is in every way a good demonstration of the capabilities of the Curtis turbine applied to electric power generation. The following units have been installed: A 1500 Kw. turbine for permanent service in the plant, a 2000 Kw. and a 500 Kw. unit for experimental purposes.

The building is 200 feet long and 80 feet high, and is divided by a lengthwise partition into two main rooms. The boiler room is 80 feet wide and is equipped with eighteen 513 H.P. water tube boilers, each comprising three groups of tubes of which one constitutes a superheater capable of giving 200 degrees of superheat. They are fed with clean, soft, oil-free water from the turbine overflow. There are two 200-foot brick stacks, and forced draft is provided for bringing up the fires quickly. Automatic stokers of the underfeed type are used, and labor and attention in the boiler room are further reduced by the use of motor driven coal and ash handling machinery.

The main steam gate valves are also operated by small electric motors.

The turbine room (50 x 200 feet) is spanned by a 50-ton crane and contains, without crowding, the above turbine-generator equipment and auxiliary machinery, such as condensers, electric driven air, circulating and water pumps. Mounted on a gallery overlooking the turbines are two 250 Kw. double commutator rotary converters for 250 volt, three-wire direct current distribution, and the switchboard for the whole plant. The Form H high tension oil switches are of the same type used by the Metropolitan and Manhattan Railway Companies, the New



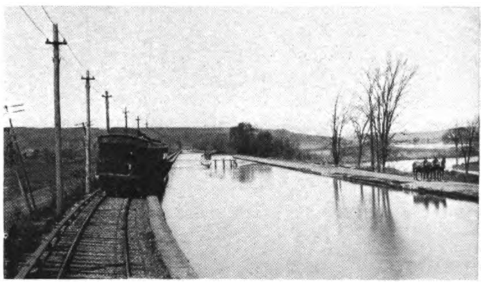
High Potential Oil Switch

York Gas, Light, Heat, and Power Company, the New York Edison Company, the Niagara Falls Power Company, etc. They are mounted in fireproof switch cells, operated by small direct current motors, and automatically controlled by overload and time limit relays.

There are two sets of high tension and low tension busses, subdivided by sectionalizing switches to be used simultaneously as required. All alternating current instruments and apparatus are energized by low tension obtained through current and potential transformers.

General Electric Railroad

In the development of electric traction apparatus the knowledge to be gained from experiments under practical operating conditions is of special value. One of the most interesting equipments at the Schenectady Works is the General Electric Railroad, built in 1896 on the banks of the Erie Canal close at hand. On this track most of the experimental and testing work of recent years has been done. When a new railway motor, control system or other part of railway equipment has been designed, it is thoroughly tested here



General Electric Railroad

and perfected before it is put on the market, the test often extending over several months. The General Electric Railroad thus affords the means of detecting and eliminating defects, besides enabling new ideas to be investigated for their practical worth.

The plant consists of a car shop, in which cars are stored and equipped, a switching yard, and about 1⅓ miles of 85-pound rail, standard guage, single track laid in stone ballast, and equipped with both third rail and overhead trolley. The third rail has a simple but effective protective covering for its entire length, and a special third-rail shoe is used. A portion of the track is also equipped with the General Electric surface contact system.

The tests are almost as varied as the railway apparatus itself and include operating tests on electric locomotives, heat runs on railway motors, tests of brakes, controllers and control systems, of train resistance and wind effect, besides investigations of the causes of all troubles that arise in actual operation. Ample power is available for any test that may be required, so that there is no difficulty in completely realizing service conditions. Some interesting tests recently made to determine the relative merits of steam locomotives and electric motors for heavy traction work showed that the electric motor could accelerate a given train more quickly than a steam locomotive with the same weight on drivers.

The rolling stock equipment of the road consists of six different sized cars that can be equipped with the various types of apparatus for commercial tests. Two of these cars are full sized, completely equipped passenger coaches, used principally for exhibition purposes and for heavy railroad investigations. The particulars of the operation of a train or motor are accurately recorded by automatic instruments specially designed for such work.

Workmen Leaving at 5.30

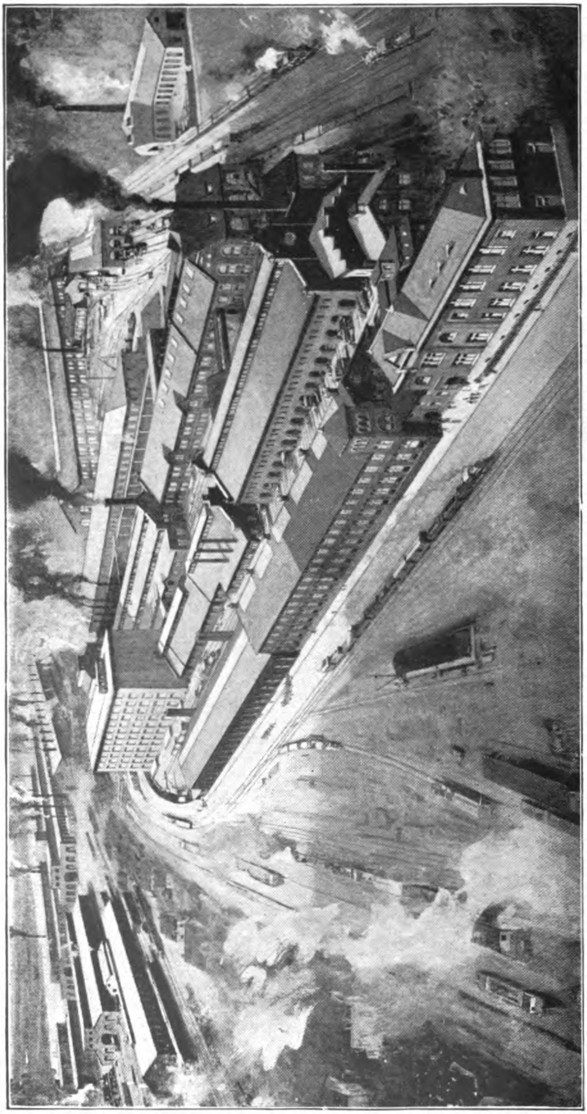
The American Locomotive Company

Schenectady Works

PRIOR to 1901 this Works was known as the Schenectady Locomotive Works, and as such was incorporated in 1851. It was built in 1848 by citizens of Schenectady, and equipped by the Norris Brothers, of Philadelphia, who were among the pioneer locomotive builders of this country. The Works ever since it was started has contributed to the development of the American locomotive and has built engines of all styles for both the domestic and foreign trade. The total number of engines built by this shop now amounts to 7800. In the sixties, this shop was widely known as the home of the McQueen engine. The name was taken from Mr. McQueen, who was superintendent of the Works from 1851 to 1876. For many years the plant was commonly known as the Ellis Locomotive Works, being owned and managed by different members of the Ellis family from 1863 to 1901. In 1901 the Works was purchased by the American Locomotive Company and has become the largest of the nine plants operated by this company which have a capacity of 3000 engines a year; 750 of these being produced at Schenectady.

The idea is often expressed by people who are not familiar with railroad work that the locomotive is a finished product both in design and size and that it is not capable of much further development. It is true that long experience has established certain limitations in locomotive work, but the styles of locomotives are continually changing and each year brings new developments both in size and in style.

There are now 33 well defined classes of locomotives, all of which are subject to endless change in size, weight and detail which are made to suit the specified requirements of the various railroads. In addition to the modification of details, locomotive designers are

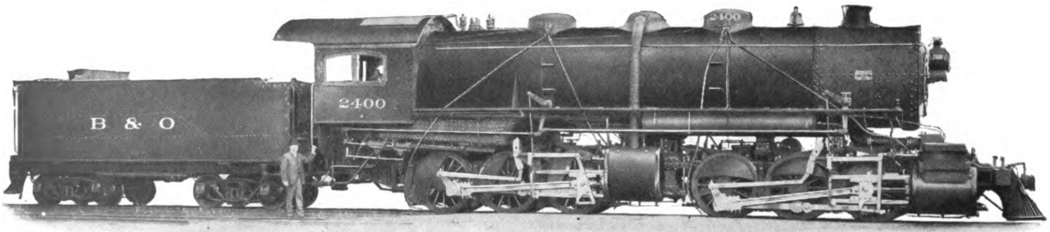


American Locomotive Company
Schenectady Works

confronted with demands for higher economy, higher speed, and greater working capacity than have yet been obtained and are considering the use of electric power to meet these demands where the traffic conditions will warrant its use. Visitors at the St. Louis Fair will find the product of this company well represented by 13 engines of different classes and those who can stop at Schenectady will be interested in the construction of the electrical locomotives which are being built for the New York Central Railroad after designs prepared by engineers of the General Electric Company and the American Locomotive Company.

The following general description may be of service to those who can visit the Works and look over in detail the methods which are used in producing the modern locomotive. The Works covers 62 acres, and employs 5000 men when running full. It is divided in two parts: The old part east of the canal contains the Offices, Storeroom, Frame Shop, Cylinder Shop, Wheel Shop, General Machine Shops, Erecting and Finishing Shops. All the finishing and assembling of the locomotives will be found in this part of the Works. The new part of the Works west of the canal contains the Foundry, Boiler Shop, Forge Shop, Blacksmith Shop, Drop Forge Shop and the Tank Shop, in which buildings the rough material is received and made ready for finishing and assembling in the Machine and Erecting Shops. The Works in its present condition is capable of turning out 750 engines a year, but when improvements now under way have been completed, the capacity will be 1000 engines a year.

Many interesting features will be found here by the student of shop design and management and it may be of special interest to electrical engineers to note the method of group driving of tools by motors, which has been found very satisfactory. Within the last few years, all the shop engines have been replaced by motors which are driven from central stations;



LARGEST LOCOMOTIVE IN THE WORLD
BUILT BY
AMERICAN LOCOMOTIVE COMPANY

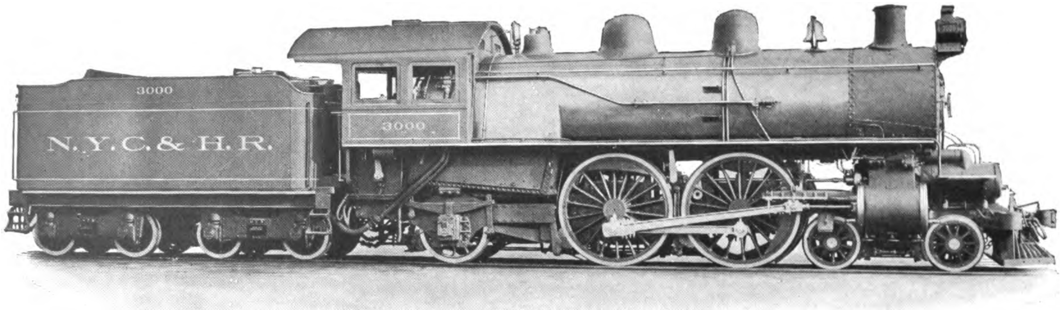
Four Cylinder Articulated Compound Locomotive

Weight of Engine	*334,500 Lbs.*	*Max. Tractive Power*	*71,500 Lbs.*
Weight of Tender	*143,000 "*	*Wheels, Driving*	*56"*
Wheel Base, Driving	*10' 10"*	*Wheels, Tender*	*33"*
Total of Engine	*30' 8"*	*Cylinders*	*20" and 32" x 32"*
Total of Engine and Tender	*64' 7"*		

there being two such stations in the Works, one for the new portion west of the canal located in Building No. 23, and one for the old portion of the Works located in Building No. 15. These two stations have an aggregate of 3000 Kw. in electrical generators, so connected to the switchboards at the two stations that any circuit in any part of the Works can be connected with any generator. In making improvements in the Works, the electric motor drive has been found very convenient in eliminating all trouble of building new engine foundations and running steam pipes; and further, as the tools are moved from one building to another, or rearranged in the same building, the motor driving a particular group of tools has been moved with them, thus doing away with costly foundations and expensive lines of pipe.

Visitors at the American Locomotive Company's Schenectady Works will be especially interested in the methods of making forged engine frames and in the boiler work; the forge work being done in Buildings Nos. 21 and 22, and the boiler work in Building No. 23. Another very interesting part of this work is that done on the flanging machines, examples of which can always been seen in Shop No. 23. In Building No. 25, tanks, tender frames and trucks are built and the tender is sent complete from this building ready for the Erecting Shop. In Building No. 3, rod work and general machine work will be found. In Building No. 4, cylinders are finished complete from the rough castings ready for the Erecting Shop. In Building No. 11, frames are finished complete from the rough forgings and made ready for assembling. The engines are assembled in Building No. 7 and finished in Building No. 30. The drafting room will be found in Building No. 28 on the upper floors, the lower part of the building being used as a storeroom.

Engineers visiting Schenectady will be welcomed at this Works and given every opportunity to see in detail the work of producing and assembling locomotives.



Four Cylinder Balanced Compound Locomotive

Weight of Engine	200,000 Lbs.	*Max. Tractive Power*	27,500 Lbs.
Weight of Tender	122,500 "	*Wheels, Engine Truck*	36"
Wheel Base, Driving	7'	*Driving*	79"
Total of Engine	27' 9"	*Trailing*	50"
Total of Engine and Tender	53' 8"	*Tender*	36"
		Cylinders	15 1-2" and 26" x 26"

Schenectady's City, Suburban and Interurban Electric Railway Facilities

The rapid growth of the electric railway industry has no better example than that afforded by the growth of the Schenectady Railway Company. Ten years ago, in 1894, this system consisted of two miles of single track with an equipment of four closed cars. Today it is operating over 144 miles of track and has in course of construction ten additional miles, while its equipment has increased to over 160 cars, with traffic during the year ending June 30, 1904, of 10,000,000 passengers.

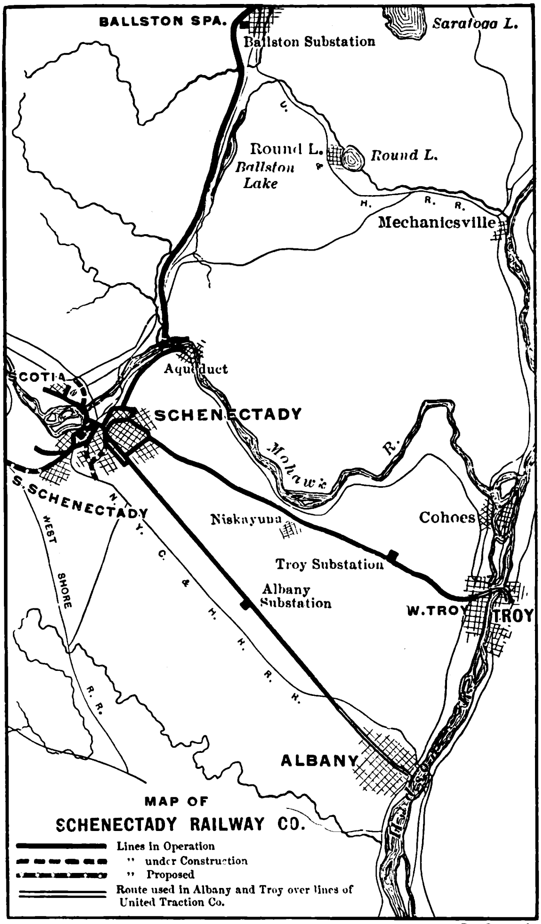
The extraordinary growth of this system may be attributed to the rapid increase in the population of the City of Schenectady, which has doubled twice since 1880, due to the development of its two large industries, the General Electric Company and the American Locomotive Company.

Operation

In the City of Schenectady six lines are operated under 10 and 15 minute headways. These lines cover 26 miles within the city limits.

Interurban Lines

Three interurban divisions are now operated: To the north, a double track road to Ballston Spa, a distance of 16 miles, operated on a 30 minute schedule (at Ballston Spa connections are at the present time made with the Hudson Valley Railway to Saratoga); to the east, a double track road to Troy, a distance of 16 miles; to the south-east, a double track road to Albany, a distance of 15 miles. Both the Albany and Troy divisions are operated on a 15 minute headway from 8:00 A. M. until 8:00 P. M. and on a 30 minute headway at other hours of the day. On the hour a special service has been established between Schenec-



Street Ry. Journal

tady and Albany, called the "Schenectady-Albany Limited." The trip is made in 45 minutes, without stops outside the city limits, and no extra fare is charged.

In order to accommodate the large number of employees who live in the neighboring towns, special cars are run, directly to and from the works, over all interurban divisions, both morning and night.

Rolling Stock

The rolling stock of the company is of the most modern type, equipped throughout with electrical

Interurban Car — Ballston Division

apparatus manufactured by the General Electric Company. A brief description follows:

City Cars

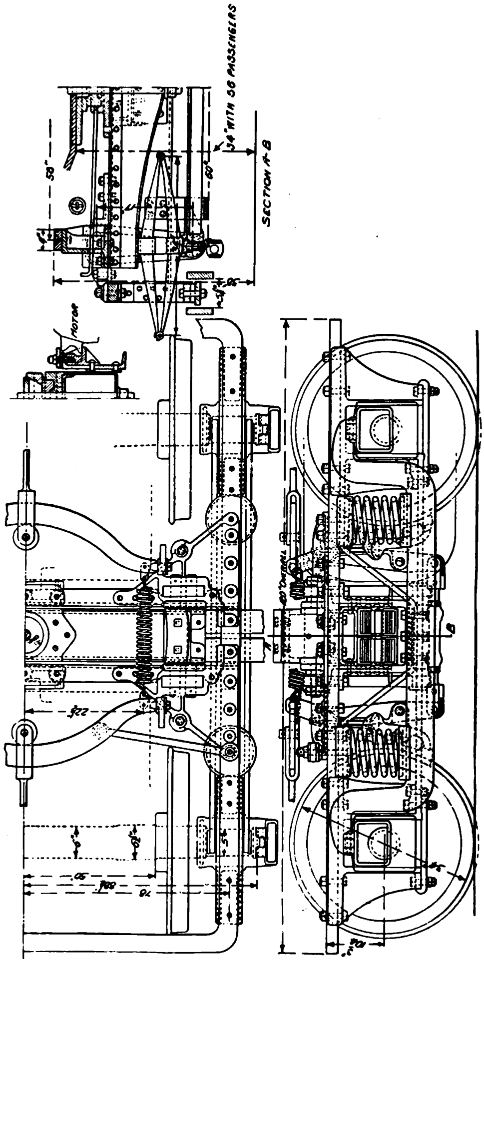
Twenty-nine single-truck closed cars equipped with two GE–67 motors.

Eight single-truck closed cars equipped with two GE–57 motors.

Four double-truck closed duplex cars equipped with four GE–52 motors.

Six eight-bench and twenty nine-bench single-truck open cars equipped with two GE–67 motors.

Twelve thirteen-bench double-truck open cars equipped with four GE–67 motors.



Truck of Ballston Car

Interurban Cars

Twelve 40-foot double-truck closed cars equipped with four GE–57 motors.

Ten 47-foot double-truck closed cars, with smoking compartment, equipped with four GE–57 and GE–73 motors.

Six 51-foot double-truck semi-convertible cars equipped with four GE–73 motors.

Six 51-foot double-truck closed cars equipped with four GE–66 motors.

Miscellaneous Equipment

Twelve flat cars equipped with four GE–57 motors.

Twenty-five dump cars without motors.

Six 4-motor express cars equipped with GE – 57 and GE–67 motors.

Three rotary snow plows without propelling motors.

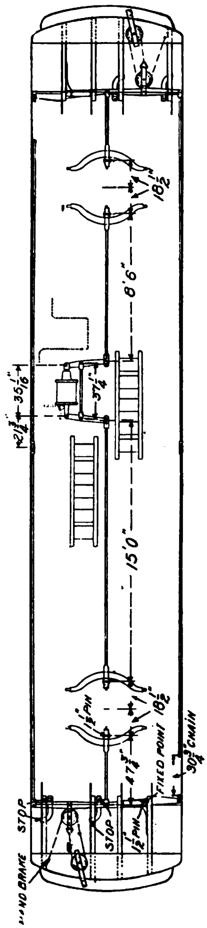
Four small snow plows without motors.

One sprinkling car equipped with two GE–67 motors.

One sand car without motors.

Ballston Cars

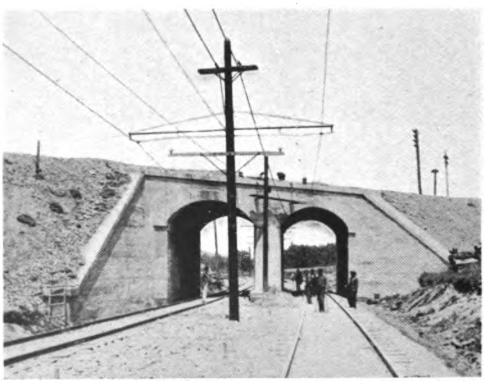
The Ballston cars were constructed after general plans prepared by the Schenectady Railway Company and embody some interesting features.



Brake Mechanism
Ballston Car

There are two separate and independent electric equipments which may be operated individually or together. The bottom of the car is covered with boards made of a fireproof material. The car bodies are mounted on double trucks.

The electric equipment is the General Electric Type M control with four GE-66 motors, each having a rated capacity of 125 H.P. and geared for 70 miles per hour. The motors are oil lubricated by means of wool



Concrete Bridge — Ballston Division

waste which is packed in the oil well cast in the frame heads.

The master controllers have dead man's handles, and a release of the emergency button also applies the air brakes.

Track and Line Construction

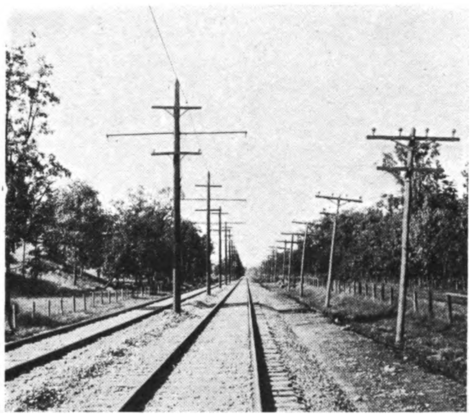
All interurban tracks are laid with 75-pound T rails, thoroughly ballasted with either gravel or stone under the ties and filled up even with base of the rail.

The overhead work on the present system is all span construction with 35-foot and 40-foot chestnut poles set 100 feet apart. Center pole, double bracket construction has been installed on the Ballston division, 35-foot octagonal yellow pine poles set in concrete being used. The tracks on the latter division are on 13-foot centers and the roadbed is graded 29 feet wide.

The trolley wire on interurban lines is 0000 grooved and on city lines is 000 grooved.

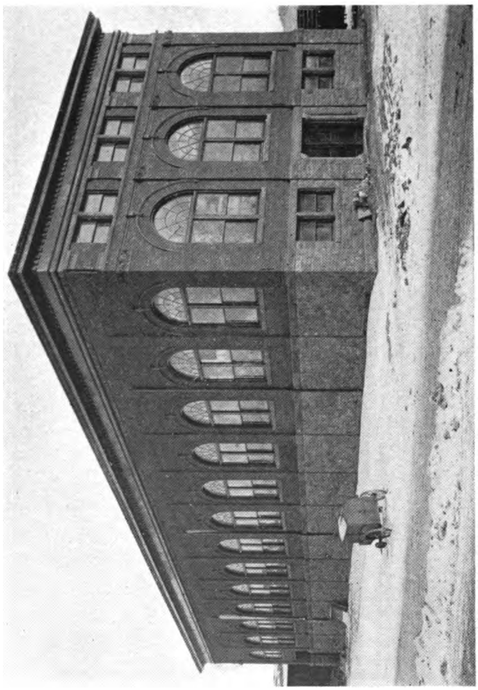
Power Supply

The power used for operating the Schenectady Railway is furnished mainly by the Hudson River



Track and Line—Ballston Division

Power Company from the large water power plant at Spiers Falls, transmitted at a voltage of 30,000 and a frequency of 40 cycles; augmented at times by the steam plant of the General Electric Company (old Power House, Building No. 13). Another source of supply for the railway company is the large steam turbine station of the General Electric Company (new Power House, Building No. 85), which contains at present three Curtis steam turbine sets of 500, 1500 and 2000 Kw. capacity but is designed for a much larger ultimate capacity.



Dock Street Sub-Station, Schenectady Railway Company

The New Dock Street Sub-Station

This building covers an area 166 feet by 45 feet, and is of brick, concrete and steel construction. The basement is divided off by means of brick partition walls into air-blast, bus-bar and switch compartments. The machine floor is served by a 15-ton crane so arranged that teams driving into the station may be unloaded directly by it. All railway apparatus is arranged in one half of the building, all power and lighting apparatus in the other half.

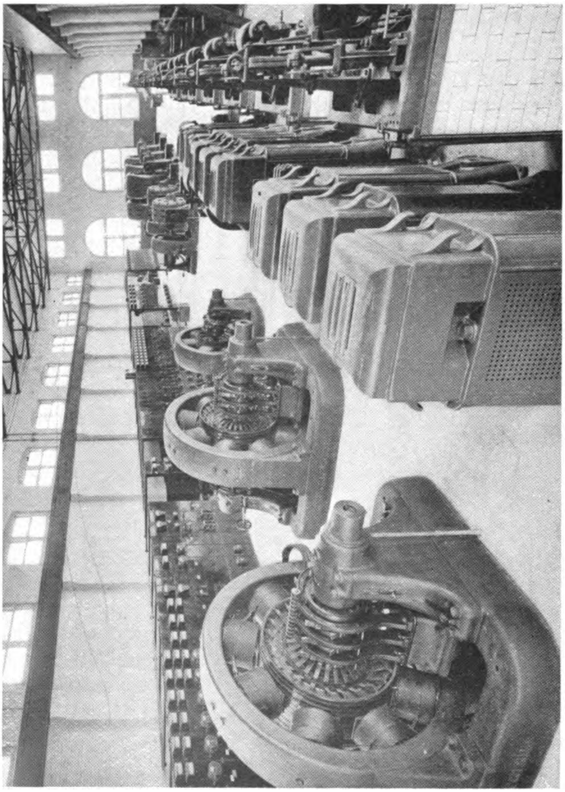
Power is delivered from the Spiers Falls and Mechanicville plants to the General Electrie Company's Power House at 30,000 volts, 40 cycles, and is stepped down to 10,000 volts for the sub-station. Three incoming lines are provided for railway, lighting and reserve; all entering over motor-operated oil switches controlled from three panels having 4000 Kw. capacity each.

Care is taken to avoid shutdowns by enclosing the main busses in brick housings; by the free use of sectionalizing switches; by enclosing the main leads in heavy iron pipes and the small leads in conduits; and by the use of overload relays on the alternating current side and circuit breakers on the direct current side. The station lighting is provided for by two reserve systems independent of the ordinary arc lamp system.

All high tension switches are motor driven and operated from the switchboard, which is equipped with alternating current instruments fed with low tension only.

There are installed two 300 Kw. and three 600 Kw., 600 volt rotary converters, together with air-blast transformers, reactive coils, blowers, 10 rotary and 12 railway feeder switchboard panels. The converters are compound wound and are started with reduced voltage from the alternating current side.

The power and lighting part of the station contains three 500 Kw. frequency changers: 10,000 volt, 40 cycle synchronous motors direct coupled to 2300 volt, 60 cycle, three-phase generators. Excitation



Interior of Dock Street Sub-Station

current is supplied by two induction-motor-driven, 75 Kw., 125 volt, direct current generators. The frequency changers are started with half voltage by means of a compensator, their excitation being regulated by the well-known General Electric Type TA regulator.

Space is provided for one additional 75 Kw. motor-generator and for three 250 Kw. frequency changers. The switchboard contains 28 panels.

The commercial lighting load in July, 1904, was equivalent to 125,455 16-C.P. incandescent lamps, and the motor load to 26,818 16-C.P. incandescent lamps. Current for motors and incandescent lamps at 118 volts is distributed through small transformers placed at feeder points all over the city. Eight 75-light constant current transformers, controlled by nine switchboard panels, supply current for 471 arc lights for street lighting.

A feeder panel is provided for the Schenectady City Water Works in Rotterdam, N. Y., which has been recently equipped with two electrically driven pumps each having a capacity of 12,000,000 gallons per day.

Troy Sub-Station

The Troy sub-station of the railway company, located on the Troy-Schenectady turnpike, ten miles from Schenectady, is of brick, with concrete floor and a granolithic top.

The apparatus consists of three 300 Kw. rotary converters operating at 760 R.P.M., each provided with a reactive coil in the alternating current side for the purpose of regulating the voltage. There are two transformers of the three-phase air-blast type, each of 330 Kw. capacity. Part of the cellar is made into an air blast chamber for the transformers, while in the other part the cable work and wiring are carried on insulators fastened to the walls and converter foundations. The switchboard is of black enameled slate and is made up of three direct current feeder panels, two direct current rotary panels, two alternating current rotary panels, and three 10,000 volt panels. The low tension panels are all of the General Electric standard pattern provided with circuit breakers, ammeters, etc.

The 10,000 volt panels are provided with single-pole oil break switches, mounted in separate brick cells about 10 feet back of the panels themselves. The switches are provided with overload relays and on the panels themselves are mounted horizontal edge-wise black oxidized finish ammeters, voltmeters, and power factor indicators, and one round pattern induction recording wattmeter. The bus-bars back of the panels are heavily insulated and carried on an insulated iron framework. All of the 10,000 volt feeders enter the station overhead and are connected with a suitable number of General Electric lightning arresters. At this station there is also an air compressor operated by a 20 H.P. induction motor belted to it, for charging car reservoirs.

Albany Sub-Station

The Albany sub-station is a one-story frame structure, with cellar, occupying a space 46 feet square. The apparatus installed in this sub-station is similar to that in the Troy sub-station.

Ballston Sub-Station

This new plant supplies current for the operation of the Ballston division of the railway company. The following General Electric Company apparatus is installed:

Two 300 Kw., 40 cycle, compound wound rotary converters running at 800 R.P.M.; three 220 Kw. air-blast transformers provided with double secondary windings; one blower set consisting of a 2 H.P., three-phase induction motor direct coupled to a 35″ fan; two 45 kilo-volt-ampere, air-blast reactive coils, one 20

H.P., three-phase induction motor having two pulleys for operating an air compressor, and the necessary switchboard panels for the above apparatus.

Freight and Express

The freight and express business of the company, practically all "through business" between Albany and Schenectady, is very extensive. It is divided

Special Express Car

into three classes and conducted by the Electric Express Company, a distinct organization. Class A, at 30 cents per cwt., includes handling by wagon service at both ends; Class B, at 10 cents per cwt., goods which are not thus handled; Class C, at 20 cents per cwt., goods which require wagon service at only one end. The company maintains three double and three single teams in Schenectady, and two double teams and one single team in Albany. The cars make four round trips daily, and have a running time between the cities of an hour and fifteen minutes. The cars are equipped so that they may be run two or more together in multiple unit. Recent figures on freight business are shown herewith:

May — 1,272,173 pounds incoming to Schenectady, 366,587 outgoing. June — 1,431,444 pounds incoming to Schenectady, 315,901 outgoing.

Employees

Promotion is by order of seniority. The men start as extra employees on the city cars and are moved up to regular cars, then "extra" on local interurban cars and finally to "regular" on a limited interurban car.

Benefit Association

In the Fuller Street car house an unusually complete club room is provided for the employees. The dues of the association are 50 cents per month, which is deducted from the pay of the men each month. Disability by reason of accident or sickness insures the member an income of $1.00 per day for a period not to exceed ninety days. The death of a member provides an insurance of $150.00.

Organization

It may be said that the character of service required of the Schenectady Railway Company makes it an unusually interesting study and that the results of its operation have been a revelation to experienced transportation men. This is especially true of the express and freight department, in which the facilities of the company have been overtaxed from the beginning. One important feature of this service is the handling of fruit and "garden truck." The quickness of transit and the relative freedom from the jolting incident to hauling by teams brings small fruit to the market in good condition.

The company maintains a complete system of records and accounts. The General Manager has constantly before him tabulated statements of all equipment, and these statements are brought up to date at frequent intervals. All operating expenses and receipts are figured on a basis of eighteen hour cars per day.

The Hudson River Power Company

ON the northwesterly side of the Schenectady Works there may be observed several towers 67 feet high and 700 feet apart. Tracing the wires which these towers support in a northerly direction for a distance of 38 miles will lead one to Spiers Falls on the Hudson River about 10 miles from the village of Glens Falls.

At this point the Hudson River Power Company built a dam 115 feet in breadth, 22 feet thick and 1570 feet from shore to shore. The effective head on the water wheels is 80 feet and the available power varies from a minimum of 15,000 Kw. to a maximum of 25,000 or 30,000 Kw.

Ten penstocks, each 12 feet in diameter, enter the wheel house and feed the water wheels. The generators are of 2500 Kw. capacity and were furnished by the General Electric Company. They operate at 240 revolutions and furnish three-phase current at 40 cycles and 2000 volts which is stepped up by transformers to the line potential of 30,000 volts.

The Schenectady Works has contracted for 1875 Kw. at a flat rate for the entire twelve months of the year and all additional power required at a rate per kilowatt-hour, but from April to September inclusive, 1875 Kw. additional is taken at a flat rate. The total amount of energy contracted for is 7500 Kw.

The energy is transmitted to Schenectady by two circuits, one of No. 0 and one of No. 000 wire, passing through switch houses at Saratoga and Alplaus, and entering the terminal house located on the canal bank in the rear of the Works' Power House. The terminal house is equipped with lightning arresters, Type H oil switches and metering apparatus and from it six conductors are carried across the street to the tower of the transformer house, where six step-down transformers reduce the pressure from 25,000 to 10,000 volts. The normal rating of this bank of transformers is 7500 Kw.

and on them depends the supply of transmitted power for the Works and the Schenectady Railway Company.

From these transformers two underground cables conduct the energy to a switchboard in the old Power House, Building No. 13, for distribution.

In addition to the Power Plant at Spiers Falls the Hudson River Power Company now owns the power plant at Mechanicville, which was completed in 1898. The effective head at this plant is 16 feet. The power house contains seven 750 Kw., 12,000 volt, three-phase, 40 cycle generators, running at 114 revolutions. To provide for contingencies of low water or accident, two 500 H.P. water tube boilers and one 1000 H.P. tandem engine have been installed. The engine can be connected by rope drive to the nearest generator. Three circuits, each of No. 000 wires, leave the Mechanicville plant; two of them go to Watervliet and one to the Alplaus switch house so that energy can be fed in either direction from the latter circuit. One circuit of No. 0 wire runs from Watervliet to Lathams Corners where a sub-station of the Schenectady Railway is located.

Switch houses and sub-stations through which the trunk lines pass are equipped with lever switches so connected that any incoming line can be transferred to any outgoing line in case of trouble or repairs.

The following companies receive power from the generating plant at Spiers Falls:

Schenectady Works of General Electric Company.
United Traction Company (of Albany and Troy).
Hudson Valley Traction Company.
Albany Light Company.
Troy Light Company.
Watervliet Light Company.
Glens Falls Light Company.
Saratoga Gas, Electric Light & Power Company.
Ballston Spa Light & Power Company.

Union College

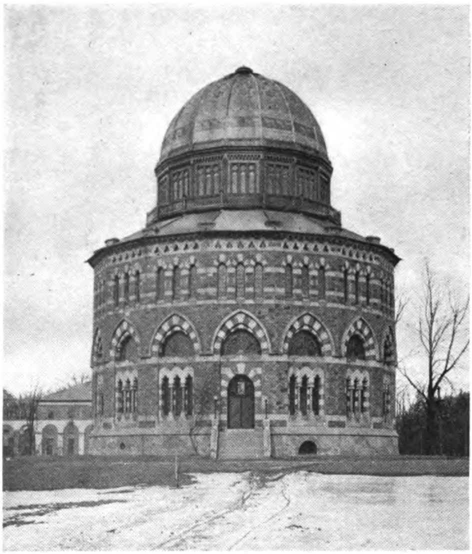
UNION College holds a distinctive place among the older colleges of America. It was distinctive in its origin, and has been distinctive in many features of its development.

Rev. A. V. V. Raymond, D.D., President of Union College

While each of its predecessors was founded in the interests of some ecclesiastical organization, Union, as its name indicates, was founded to represent all denominations.

Its undenominational character was due to the fact that it came into existence as the result of a citizens' movement. In 1779, during the War for

Independence, 850 citizens of Northern and Eastern New York petitioned the Legislature for a college to meet the growing "demand for men of learning to fill the various offices of church and state." In 1785



Union College Library

the charter of an academy was granted, which was supplemented ten years later by the charter of a college.

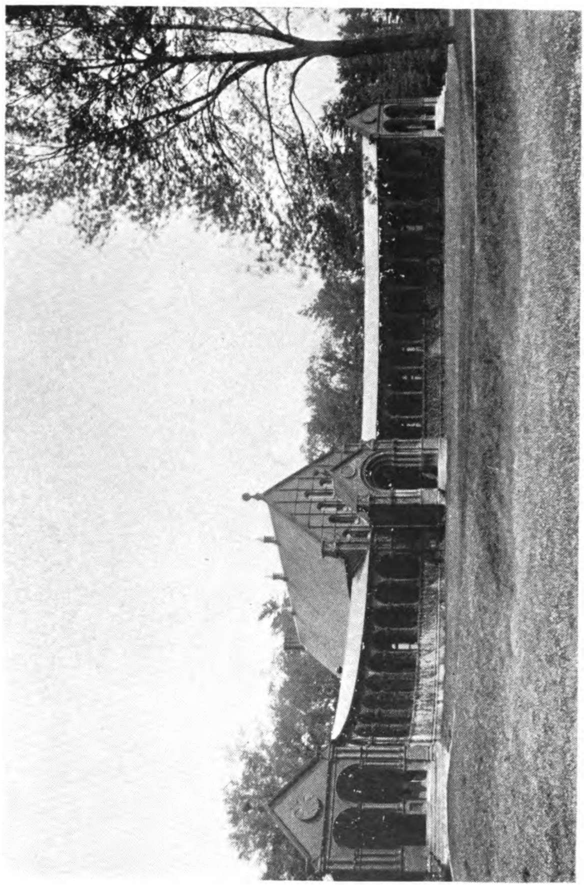
Grounds and Buildings

The present site is the third the college has occupied, and was purchased in 1812. The work of transforming what was then a wilderness into a beautiful and commanding college domain was begun in 1813 under the direction of Jacques Rameé, who prepared an elaborate plan which included not only the artistic treatment of the grounds, but also the grouping of the buildings, and even the designs of the buildings, This accounts for the fact which has often been noted that Union College alone among the older American institutions of learning, with the exception of the University of Virginia, shows the early adoption of a consistent and comprehensive plan. The characteristic features of this plan are essentially foreign, with a suggestion of an Old World monastery in both the architecture and the arrangement of the buildings.

President Eliphalet Nott

Fortunately for Union College and for the cause of American education, the Trustees elected as the fourth president of the college the Rev. Eliphalet Nott, who assumed office in 1804, just one hundred years ago, and who continued in service until his death in 1866, a period of sixty-two years, exceeding by several years the official life of any other American college executive. Dr. Nott was a man of original genius, of independent thought, and vigorous action—a natural leader and administrator.

The first innovation introduced by President Nott was the establishment in 1806 of a Chair of Modern Languages. This was followed almost immediately by the establishment of the first full professorship of Natural Science, and it is a fact of scientific interest that the man called to this new professorship was F. H. Hassler, who later, in 1811, left the college to undertake for the Government the organization of the United States Coast Survey. In many respects, however, the most significant departure from college traditions occurred in 1833, when an alternative course of study was introduced in which Modern Languages and the Natural Sciences were substituted for the Ancient Languages and other required subjects of the old-time Classical Course. Naturally, such a wide departure from prevailing standards provoked criticism and aroused opposition in the educational



Washburn Hall, Union College

world; but Dr. Nott was too independent to be affected by this, and in 1845 he went still further and introduced an Engineering Course, the first connected with any American college. With characteristic wisdom in the choice of men, he called to the Professorship of Engineering Dr. William M. Gillespie, one of the most thoroughly educated and proficient men in the engineering world at that time. From the beginning, this department has maintained a high rank, and among its graduates have been many of the leading engineers of the country. The present Professor of Engineering is Olin H. Landreth, consulting engineer of the New York State Board of Health.

Scientific Equipment

In further recognition of the increasing importance of scientific studies, Union College provided what was at the time the most complete equipment for the Department of Physics and the Department of Chemistry. The Professor of Physics, Dr. John Foster, was sent to Paris to purchase the physical apparatus, which was made under his personal supervision. The development of the Department of Chemistry was under the direction of such men as Dr. Charles A. Joy, Dr. Charles F. Chandler, and Dr. Maurice Perkins.

While thus emphasizing scientific and technical instruction, Union has always maintained its place as a classical college. Its distinction lies in having been the first to anticipate the broader scope of modern education.

University Organization

In 1873 Union University was incorporated, and now consists of the following institutions and Departments of Instruction:

- Union University
  - Union College
    - Academic Departments
    - Engineering School
      - Civil
      - Sanitary
      - Electrical
  - Albany Medical College
  - Albany Law School
  - Dudley Observatory
  - Albany College of Pharmacy

Engineering School

For many years Civil Engineering only was taught. Then, when the principles of sanitary science came to be better understood, and their importance realized, a course in Sanitary Engineering was established, and in 1895, a course in Electrical Engineering was added. The School of Engineering has stood for broad, fundamental training, rather than narrow specialization; and during recent years increased time and attention have been given to culture studies and a larger proportion of academic training.

Local Advantages

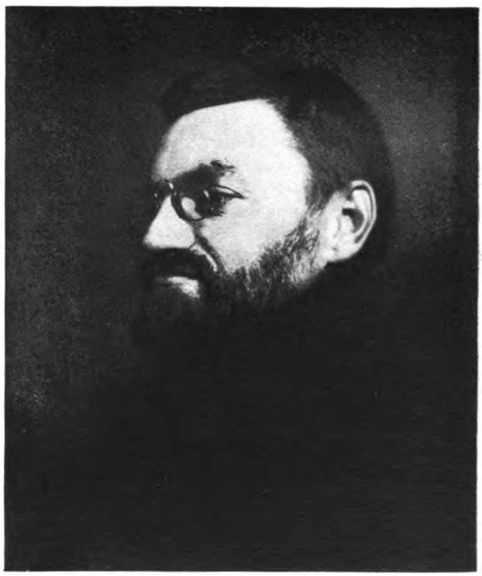
Schenectady is a peculiarly favorable location for an engineering school. The city is on the Mohawk River, and is intersected by several steam railroads, a number of interurban electric trolley lines, and the Erie Canal. In the city are located the works of the General Electric Company and of the American Locomotive Company. The Scientific Departments of the State Government at Albany, the United States Arsenal and gun factory at Watervliet, the water power developments and electric power transmission plants at Mechanicville and Spiers Falls, the hydraulic cement works at Glens Falls and Howe's Cave are all easily accessible.

Engineering Courses Now Offered

Three courses of Engineering are offered, each extending through four years: (1) a course in General Engineering, which is intended to give the basis of a broad engineering education, including the fundamental principles underlying all special branches of the profession; (2) a course in Sanitary Engineering; and (3) a course in Electrical Engineering in which the last two years are devoted almost entirely to strictly Electrical Engineering subjects. The degree of Bachelor of Engineering is given for the successful completion of any one of these courses.

Electrical Engineering

The work of the Department of Electrical Engineering is carried on under the direction of Prof. Charles P. Steinmetz, to whom the College is indebted for the great progress which the department has made since its reorganization in 1902.



Charles Proteus Steinmetz, Ph.D.
Head of Department of Electrical Engineering, Union College

The course of studies aims at a broad and thorough training of the prospective engineer, rather than the narrower training of the specialist. The culture studies such as languages, literature, history, etc., essential to every educated man, are followed by a thorough scientific training in mathematics, physics, chemistry, descriptive geometry, theoretical and applied mechanics, and allied sciences.

In laying out the course of technical studies special efforts have been made to first familiarize the student with the practical aspect of the machine or phenomena to be studied, following this with a theoretical lecture course with parallel laboratory work.

The men are equipped with a broad foundation in the underlying principles of electrical engineering, which is absolutely essential to a comprehensive study of the more intricate and special departments of the profession.

Among the electrical studies of the Senior year are: Alternating Current Phenomena, using Steinmetz's treatise on this subject as text book; Alternating Current Laboratory work consisting of complete tests and investigations of characteristic curves, etc., of transformers, synchronous machinery, rotary converters, induction motors, multiphase and single-phase repulsion motors, etc.; Alternating Current Design; Electric Transmissions; Electric Railways; Electric Lighting; Electro-Chemistry, and Technical French and German.

Throughout the course special efforts are made to keep as closely as possible in touch with actual progress made in manufacturing and professional electrical engineering work. The works of the General Electric Company and of the American Locomotive Company are of inestimable value in this respect and trips to these plants are part of the regular college work.

Through the courtesy of many of the most prominent engineers of the General Electric Company a course of lectures is provided on electrical engineering subjects by specialists from the practical field.

Graduate Course in Electrical Engineering

A one year's graduate course is offered to those students who, after graduating from the four years' electrical engineering course, desire to continue their studies.

Schenectady to Montreal

MONTREAL, Quebec, is almost directly north of Schenectady, a distance of about 225 miles. The route includes the world renowned Saratoga Springs and skirts the western shore of historic Lake Champlain. Between Schenectady and Ballston (16 miles) the first commercial single-phase alternating current railway system was put into service August 17th, this year, on the Schenectady Railway Company's Ballston division and has since been in regular operation. The entire equipment was designed and

United States Hotel, Saratoga, N. Y.

built by the General Electric Company, and the commercial possibilities of the system are largely due to the fact that the motors operate with alternating current power outside of city limits, and with direct current power within city limits.

Saratoga is 22 miles by electric car from Schenectady *via* Ballston. Tradition says that the Indians, to whom we owe the name "Saratoga," first discovered the medicinal values of the waters of the locality, and led the white man thither. There are now as many as thirty-five separate mineral springs which furnish water of widely different compositions for table and medicinal use. Natural carbonic acid gas, from a vein discovered some years ago, is here compressed and shipped in steel tanks. The curative powers of the waters have attracted health seekers from all over the world, and the city of to-day, with its beautiful parks and boulevards, its great hotels and its famous race course, owes its origin to the natural mineral springs.

The present United States Hotel, located in the center of the town, was erected in 1874. The building and its court cover seven acres of ground.

Lake George, with its beauties scarcely equalled by those of the Italian Lakes, is not far away to the north, and some of the most attractive of the Adirondack Lakes and Mountains are within a few miles' ride.

Leaving Saratoga, the night train crosses the Hudson River at Ft. Edward, passing east of Lake George and through Whitehall on its way north. Threading the neck of land at the southern end of Lake Champlain at old Fort Ticonderoga — the historic gate between the Hudson River and the great northern waterways — and following the western shore of this lake, through Crown Point, Port Henry, and Plattsburg, it crosses the international frontier just beyond Rouse's Point and shortly arrives at Montreal.

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