STREET RAILWAY JOURNAL

THE CONVENTION CITY.

Atlantic City is unique among the pleasure resorts of this country in that it receives and entertains guests during the entire year. Annually between 6,000,000 and 8,000,000 people visit Atlantic City expecting to be amused or to find benefit in the climate. The city has no factories or no shipping and none of the large industrial enterprises to which other communities lay claim. It tries to forget the existence of those institutions in which men toil and labor. In doing so it the more successfully succeeds in affording relief to those who wish to escape business cares and worry.

But Atlantic City does boast of its hotels, and it may rightfully do so, both as to number and quality. Of the hotels there are twenty-two that have a capacity of more than 500 people each, and these, together with the 900 other licensed hotels and boarding houses, have a total capacity for about 300,000 guests. Few cities can boast of better accommodations than they afford.

But the hotels and even Atlantic City itself are incidental to the Boardwalk. This cosmopolitan thoroughfare, which varies in width from 20 ft. to 60 ft. and which stretches for five miles along the beach, has an inexplicable fascination for and leaves an indelible impression on every visitor to Atlantic City. Probably the explanation lies in the fact that the proximity of so many others, all on pleasure bent, the large shop windows in which everything is enticingly arranged to attract the attention of the purchaser, and the wide expanse overhead, and eastward in the direction of the ocean, combine to turn one's thoughts from himself and drive dull care away.

The roller chair is a feature of the boardwalk to the same extent that the walk itself is a feature of Atlantic City. These chairs are always in readiness for those who have spent too much of their energies in battling with the waves while in bathing or in keeping their place for several hours in the continuous promenade along the ocean. There are more than 1300 roller chairs licensed by the city, and to the observer it appears that the entire number passes him during an evening promenade. The boardwalk, it may be added, was constructed by the municipality at a cost of $300,000.

One cannot help but reflect on the amount of money left in Atlantic City annually by the horde of visitors. An official estimate places it at $110,000,000. Assuming that there are 6,000,000 visitors annually, this would allow of each visitor spending about $18. The estimate has every appearance of being a conservative one. The amount in the aggregate seems a prodigous sum, but no doubt it would be much less than the money value of the benefits derived by the visitors could a price be placed on improved health, clearer brains and rested nerves.

Atlantic City of course owes its existence to the ocean and to the gradually descending beach which causes the surf to roll in a manner which is peculiarly fascinating to the observer. Almost every visitor during the summer season comes with firm resolution to spend at least a portion of the time each day in the water, and usually does so. During the height of the season there are often as many as 40,000 people on the beach in bathing suits at one time. A few bathers may be found in the water during the early morning hours and some venture into the ocean after dark, but the throng begins to appear about 10 o'clock in the morning. From this time on the beach is crowded until evening, when all return to their hotels, to sally forth soon afterward on the boardwalk or to patronize some of the many amusement features which are to be found on the several steel piers.

Those who care to stray from the influences of the beach, the boardwalk and the piers will find many other pleasant and wholesome ways of spending their time.

In the inlet at the northern terminus of the boardwalk are small steamboats, sailboats and tugs which can be engaged for excursions along the shore or for fishing trips out into the ocean, while those who are too timid for either of these pastimes may enjoy a sail over the waters of the Thoroughfare, which divides the island on which Atlantic City is located from the mainland. Still others prefer to drive on the Speedway, which continues seven miles from Albany Avenue to Seaview, or on the several highways which extend to Longport, South Atlantic City, Lighthouse and other nearby points of interest.

A very pleasant trolley trip may be had by taking the electric cars which traverse the ocean front and extend from the Inlet at the northern end of the island through Chelsea, Ventor and South Atlantic City to Longport, where the trolley is met by a steamboat on which the trip may be continued across an inlet to Ocean City. Another trolley trip may be taken across the Thoroughfare to Pleasantville and to Somers Point on the mainland, and thence to Ocean City over a long trestle which has recently been completed. The Country Club, located at Northfield seven miles away, affords every opportunity for golf and other outdoor sports at all seasons and can be reached by trolley at any hour.

Many visitors undoubtedly leave Atlantic City under the impression that it consists wholly of the boardwalk, the beach, the hotels, the bathing pavilions and souvenir stores. But such is not the case. Behind what can be seen from the shore there is in fact a well planned and carefully built city with 40,000 permanent inhabitants who have their work and their business institutions just as do residents of other cities.

The city has five national banks and three trust companies with aggregate deposits of $8,500,000. There are ten public school buildings with about 150 teachers and 5800 pupils. Of churches of all denominations there are thirty. The police department consists of 100 members, the fire department of 140 men and the city beach patrol or life saving corps is composed of 55 guards.

The city's water supply is obtained partly from fifteen artesian wells, which supply 4,000,000 gallons of water per day, and partly from a cedar-grown protected watershed on the main land. In August the daily consumption is over 10,000,000 gallons, exclusive of that of many of the larger hotels, which obtain their water from private artesian wells.

Sixty miles of sewer pipes carry sewage to a common station, from which it is pumped up into the Thoroughfare several miles back of the city. By this method the water of the bathing beach is kept pure, as has been proven by repeated analyses.

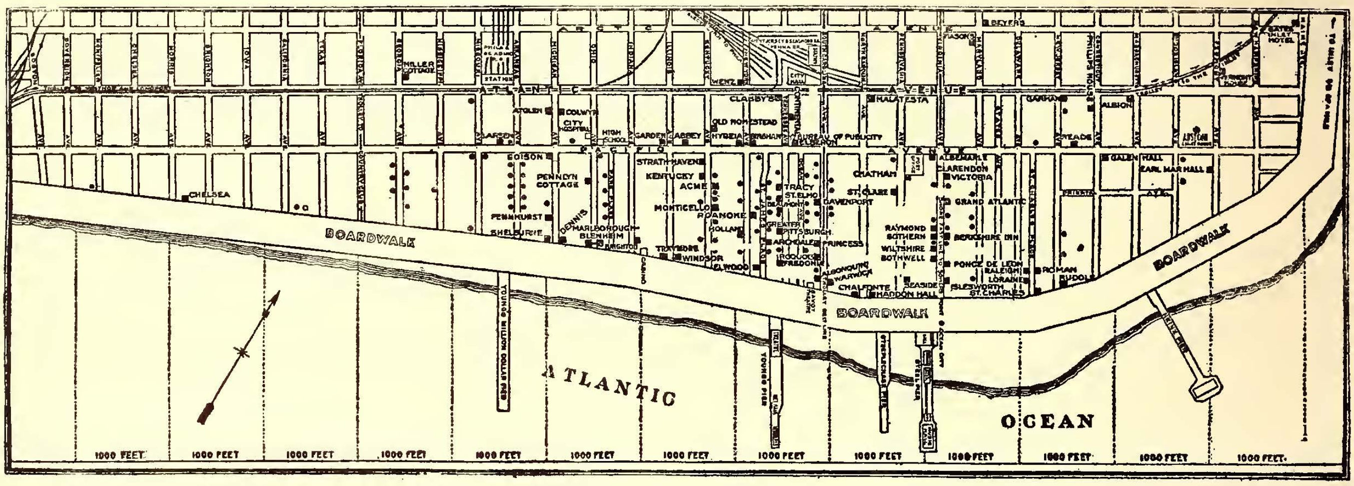
ELECTRIC RAILWAYS

Exclusive of the West Jersey & Seashore Railroad, which is owned by the Pennsylvania Railroad Company, there are three electric railway systems in and about Atlantic City.

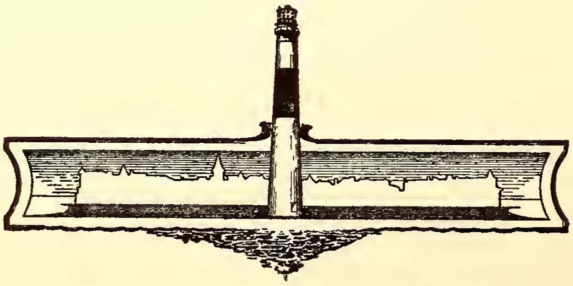
The Atlantic City Electric Railway extends the full length of the island on which Atlantic City is located, from the inlet on the north to the landing opposite Ocean City on the south. It is owned and operated by the Pennsylvania Railroad. There are seventeen miles of track and the passenger equipment consists of twenty semi-convertible and thirty-five open cars. The repair shops are at Main and Arctic Avenues.

The Atlantic City & Shore Railroad extends from Virginia and South Carolina Avenues across the Thoroughfare to Pleasantville and thence to Somers Point. An extension under the name of the Atlantic City & Ocean City Railroad is being built across Egg Harbor to Ocean City. For a portion of the distance between Pleasantville and Atlantic City the cars are operated over the tracks of the West Jersey & Seashore Railroad, and for this reason the cars are equipped with third-rail shoes. On the mainland catenary construction overhead is used. Current for operating the line is purchased from the West Jersey & Seashore Railroad. The high tension lines from the power station at Westville are carried to a rotary converter sub-station belonging to the Atlantic City & Shore Railroad at Somers Point. The run between Atlantic City and Somers Point, a distance of fourteen miles, is made in thirty minutes.

The Atlantic City & Suburban Traction Company also operates between Atlantic City, Pleasantville and Somers Point. The road has seventeen miles of track and twenty-two cars. The power station and shops are at Pleasantville.



MAP OF THE HOTEL DISTRICT, ATLANTIC CITY



THE BOARD WALK AS SEEN FROM THE MARLBOROUGH-BLENHEIM

EASTER SUNDAY AT ATLANTIC CITY

Plate II

THE BATHING HOUR AT ATLANTIC CITY

THE STEEL PIER AND STEEPLECHASE PIER

Plate III

VIEWS IN AND AROUND ATLANTIC CITY

Plate IV

THE INLET, THE STARTING-POINT FOR BOATING TRIPS

TERMINAL AT VIRGINIA AVENUE AND BOARDWALK OF THE ATLANTIC CITY & SHORE RAILROAD

THE SCOPE OF THIS ISSUE

It seems a far cry from the Richmond road of 1888, with its two 7½-hp motors per car hung on the underframing, to the powerful electric locomotives which are now hauling trains of twelve or more heavy Pullman sleepers out of the Grand Central Station in New York—to the high-speed motor trains which are carrying more passengers between Camden and Atlantic City and on the electrified portions of the Long Island Railroad than were ever transported by their steam predecessors—to the single-phase leviathans of the New Haven and Pennsylvania railroads, and to the latest developments in electric traction locomotives in England and on the continent of Europe. The past nineteen years, which have been crowded with developments in other branches of engineering, have consituated practically the entire history of the modern electric road. Starting almost as a toy at an exposition it soon developed into the street railway as we know it now, then into the suburban extension of the city system, then by almost insensible gradations into the interurban road which is familiar to readers of this paper. From this point the advance to heavy electric traction was a rapid one.

Practically all of the electrified steam railroads in this country have been described in the technical press at the time or soon after they were placed in operation. A list of the most important of these articles which have appeared in the Street Railway Journal is presented below. In this table the elevated railways which have been converted from steam to electricity, like those in Brooklyn and New York, have been omitted.

	Present Length of		Reference to Street Railway Journal.
Name of Company.	Route.	Track.	
TRUNK LINE RAILWAYS FOR TRUNK LINE CONDITIONS			
N. Y. Central (N. Y. Zone)	17	85	Vol. 26, 336, 609, 837, 872, 920.
N. Y., N. H. & H.	22	100	Vol. 27, 558; Vol. 30, 242, 278, 308.
Baltimore & O. (Belt Line)	4	8	Vol. 21, 398, and earlier issues.
Long Island Railroad......	42	97	Vol. 27, 323, 536, 896, 936, 968.
TRUNK LINE RAILWAYS FOR BRANCH LINE CONDITIONS			
Pennsylvania Railroad—			
West Jersey & Seashore.	74	150	Vol. 28, 928.
N. Y., N. H. & H.—			
New Canaan Division....	8	8	Vol 14, 540.
Providence-Warren-Bristol	24	44	Vol. 19, 225.
Middletown-Berlin	17	17	Vol. 30, 412.
Erie R. R.—Port Morris Br.	34	34	Vol. 28, 1091.
West Shore R. R.—			
Utica-Syracuse	44	105	Vol. 29, 996.
Boston & Maine—			
Concord & Manchester...	16½	16½	Vol. 20, 921.
INDEPENDENT LINES, OPERATED BY STEAM OR ELECTRIC RAILWAY COMPANIES			
Albany & Hudson..........	37	37	Vol. 17, 141.
Cincin., Geo'twn & Portsm'th	53	56b	Vol. 21, 286.
Evansville, Sub. & Newburg.	28	28	Vol. 29, 446.
North Shore, California...	12	24	Vol. 23, 4, 56.
Lockport Line—International Railway, of Buffalo...	13½	13½	Vol. 14, 535.

b, partly operated by steam.

These articles, as well as most of those which have appeared elsewhere in the technical press, have described the engineering features of the roads as they were when completed and turned over to the operating department of the railroad company. There has been a dearth of information, however, as to the practical operation of these roads. It is as if the constructional features only are of interest to the engineer and manager and that the question of operation is a minor detail.

This is very far from the fact and it is the intention of this paper to supply this omission so far as the most conspicuous examples of the recent changes from steam to electric traction are concerned.

For this reason a careful study has been made of the electrical engineering operating practice of the New York Central & Hudson River Railroad, the Long Island Railroad, the West Jersey & Seashore Railroad and the West Shore Railroad. As the New York, New Haven & Hartford Railroad was described so recently in these columns no attempt has been made to take up the electric operating practice of this company so completely as in the case of the other roads mentioned, but the use of single-phase locomotives adds such an interest to the practice of this company that it has been deemed wise to take up this matter in considerable detail. Additional information is also presented of the electrified division of the Erie Railroad between Rochester and Corning to supplement the article on this subject in the second section of this issue, and of the Interborough Rapid Transit Company in its power station department. It is thought that this account will be of interest in this connection because of the similarity between its conditions and those of the electrified steam railroads already mentioned.

Finally an article from the pen of Philip Dawson discusses the progress being made abroad in heavy electric traction, particularly in the field of single-phase motors. As will be seen from Mr. Dawson's review of the subject, European engineers and managers are fully alive to the possibilities of electric power on their steam roads. Probably the most ambitious plans at present being formulated in this direction are those of the Swedish Government, whose extensive trial of electric power receive ample discussion in Mr. Dawson's paper. Germany, Switzerland, Italy and England, however, are not far in the rear of their Northern neighbor and are engaged in electric traction work of the greatest importance.

In many respects it is believed that this compilation will be of great value not only to the steam railroads which are contemplating or have contracted for electrical equipment but also to the electric railway companies of the country. The managements of the latter have worked out their problems along certain lines, but as the high-speed electric road is the outgrowth of the city line it is not surprising that the conclusions reached should have been different from those obtained when the same question is taken up from the steam railroad standpoint, and when the electric road in question is operated as a part of a large trunk line system.

The editors and publishers of this paper take this occasion to express their sincere thanks for the courtesy and co-operation of the engineers and managements of the different lines whose practice is described, in the preparation of these articles and the compilation of the data contained in this issue.

GENERAL FEATURES OF THE NEW YORK CENTRAL ELECTRIFICATION

The New York Central & Hudson River Railroad Company's terminal electrification at New York City, including the northern suburban zone tributary to the metropolis, involved the solution of engineering and operating problems of unprecedented magnitude before commercial electric train service could become a reality. The far-reaching scope of the changes required in the physical equipment of the road has already been outlined by the design and construction articles printed from time to time in the columns of the Street Railway Journal. Nothing less than the complete reconstruction of the Grand Central terminal as a whole is required, with the building of a new double-level station for the reception and dispatch of trains; the construction of new streets over depressed electrified tracks; the installation of a complete system of power plants, transmission lines and sub-stations arranged for reliable and flexible operation, and the placing in service of a third-rail distribution system capable of meeting the demand for continuous service under all conditions and emergencies which can be anticipated. The substitution of the electric motor for the steam locomotive in the local and through train service of the road demands the solution of numerous problems in rolling stock design, operation and maintenance—problems which in many instances can be settled only by the test of service. The fundamental necessity in the construction period has been to carry out the momentous changes at issue with a minimum interference with traffic, and the essential requirement in the present period of initial operation is to give as good service, if not better, than was given with steam locomotives, leaving the accomplishment of minor economies to be worked out in a gradual way as each month goes by.

Although at this writing the electric train service of the New York Central extends only as far as High Bridge on the Hudson River Division and to Wakefield on the Harlem Division, the general operating features of the electrical zone are well determined. The organization has been built up with the idea of giving safe, reliable service under all possible anticipated conditions. The ample provisions made for emergencies can be followed through every root and branch of the system. While some of these provisions are doubtless of a tentative nature, the magnitude of the traffic demands a fixing of responsibility in the operating organization, a definite apprehension of limits of authority, and a crystallized knowledge of the proper course in emergencies and in routine duties which would be entirely out of place in a small system.

It must be borne in mind by the reader that the operating methods described in the following articles are not necessarily final in themselves. The temporary terminal facilities now in use at the Grand Central Station and at Lexington Avenue cannot be selected as a basis for estimates of the operating situation in the permanent terminal station, but from the standpoint of the electric railway engineer, the temporary solutions of such problems are as interesting as the final ones.

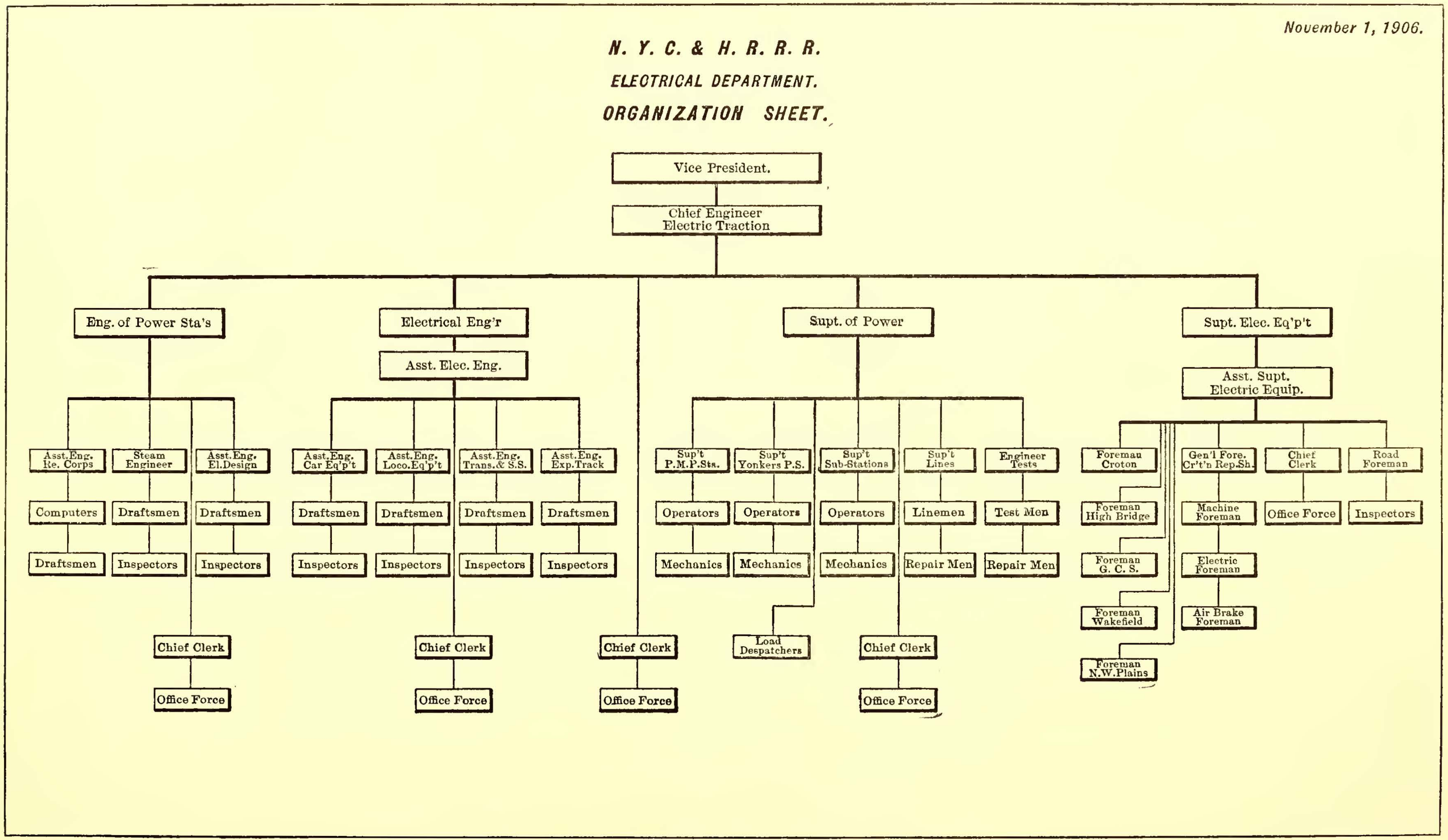
Construction and train operation in the electrical zone, which will ultimately extend from the Grand Central Station to Peekskill on the Hudson River Division and to North White Plains on the Harlem Division, are in charge of the Electrical and Operating Departments of the company. In so far as the operating routine comes under the head of train movements and service, it falls under the immediate jurisdiction of the operating department; and in so far as the operating routine concerns the provision of adequate power and the maintenance of electrical rolling stock in proper condition for service, it falls within the jurisdiction of the Electrical Department.

ORGANIZATION OF ELECTRICAL DEPARTMENT

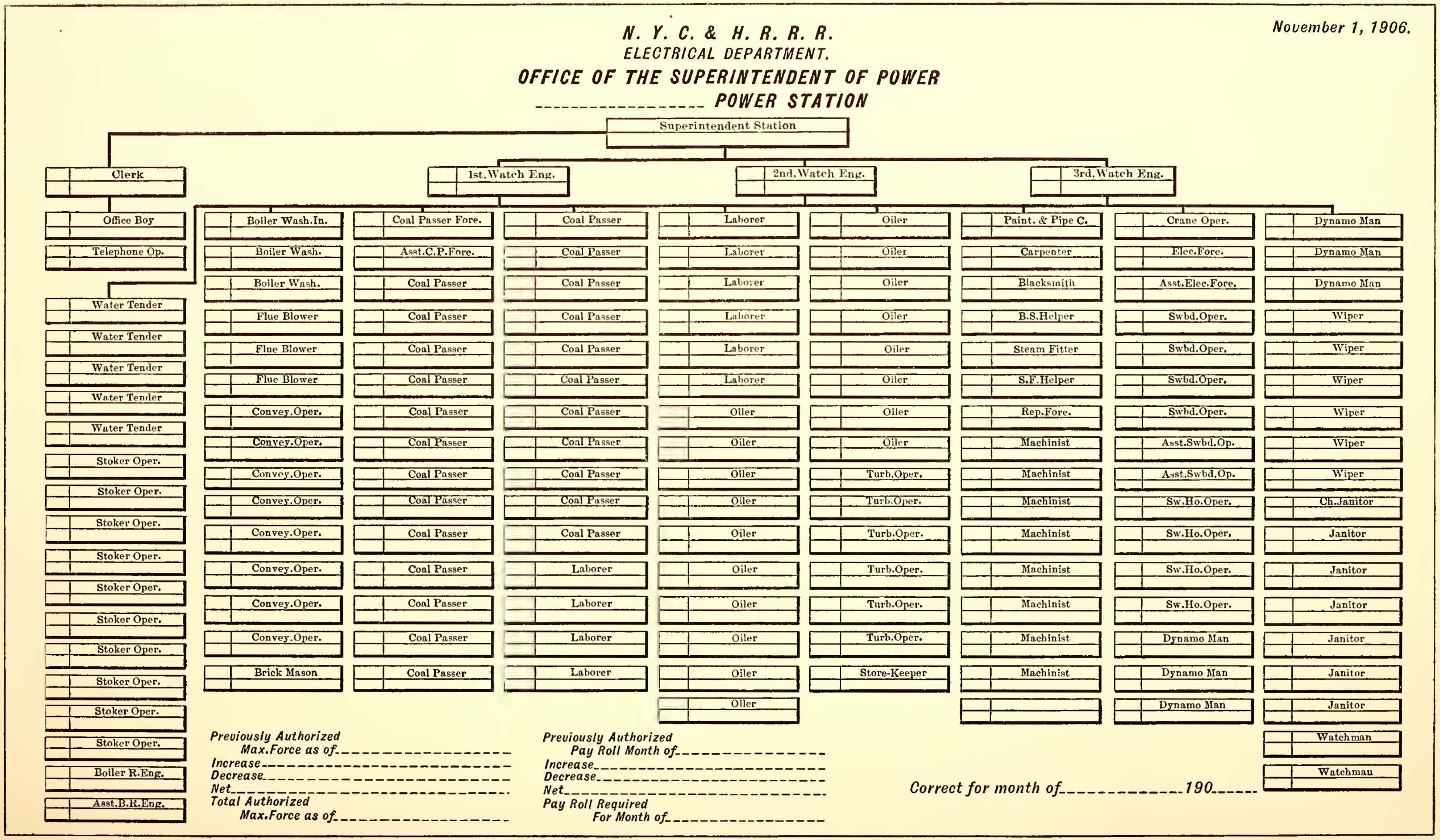
The chart published on the opposite page shows the general organization of the Electrical Department as developed by Mr. William J. Wilgus. A Vice-President of the company is in charge of the work of the Department and next in command is the Chief Engineer of Electric Traction. Four heads of departments report directly to the Chief Engineer of Electric Traction, namely, the Electrical Engineer, the Engineer of Power Stations, the Superintendent of Power and the Superintendent of Electrical Equipment. The work of the Electrical Engineer is largely of a designing and constructional nature, as can be seen by the make-up of his subordinate force. The Engineer of Power Station's duties in a similar manner cover the field of power station design and construction. The Superintendent of Power is responsible for the supply of electricity to the third-rail and his jurisdiction begins at the coal pile and ends with the delivery of power to the rolling stock at the third-rail. The Superintendent of Power has charge of operating matters rather than construction work. The Superintendent of Electrical Equipment is responsible for the maintenance of electric rolling stock and operation of repair shops and inspection sheds. The employees reporting to him include an Assistant Superintendent and a clerical force in addition to men on the road and in the shops.

The chart published on page 542 illustrates the organization of the force at each power station. Reporting to the superintendent of the station are a small clerical force and three watch engineers. The functions of the different subordinate employees are clearly shown in the diagram.

Detail organization sheets covering each subdivision of the electrical department have been prepared to enable the Chief Engineer of Electric Traction and the other heads of departments to keep a continuous and simple record of the status of their working force. Three of these are shown on page 543 and one other is reproduced later in this issue in connection with the discussion of "Maintenance of Rolling Stock." An important feature of these detail organization sheets is a tabulation made up each month, summarizing the force on the pay rolls as compared with the force of the previous month and showing the authorized number of employees, their total salaries and the number of employees who are estimated as necessary for the month to follow. This method is described in detail in the chapter on maintenance of rolling stock.



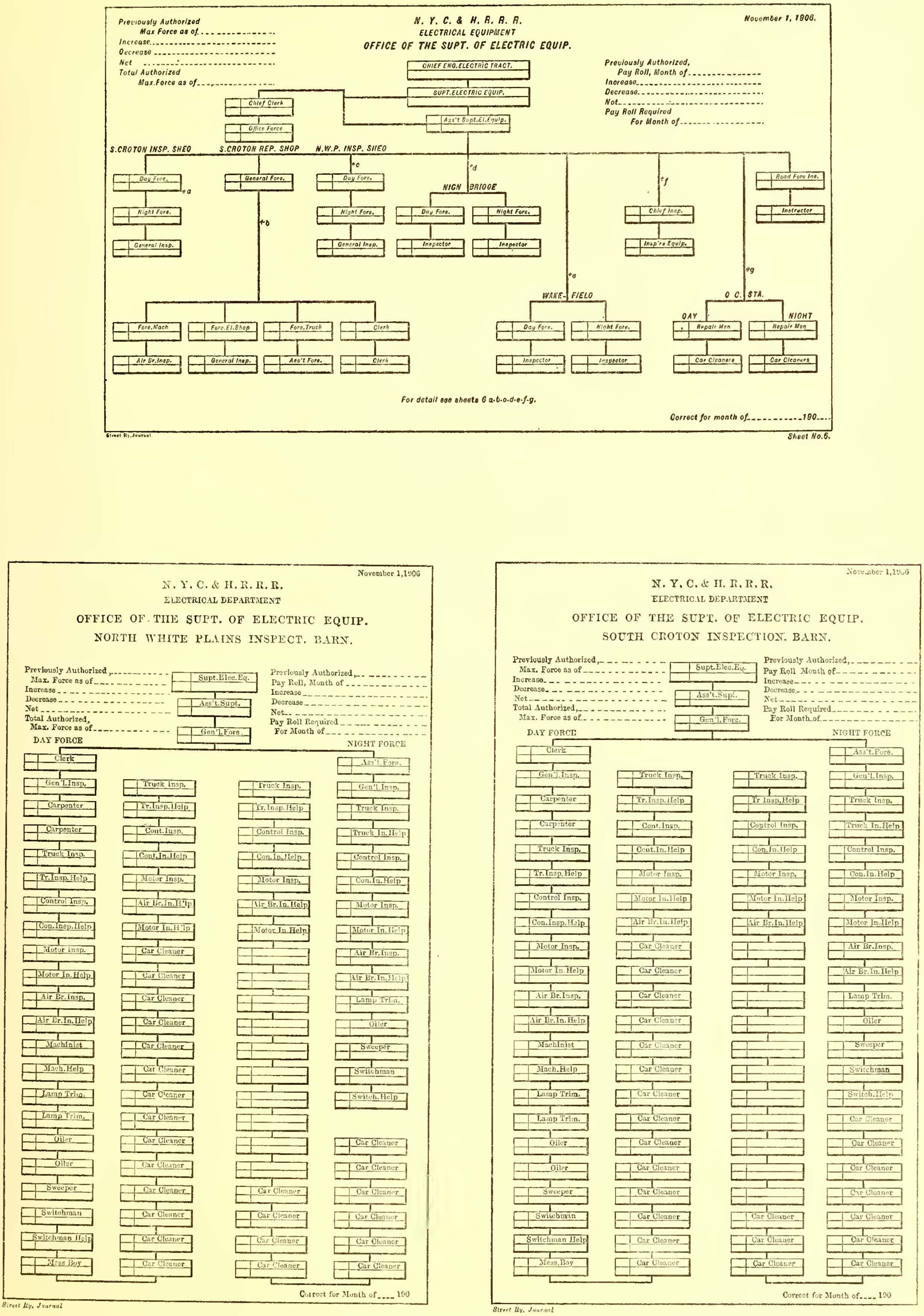
ORGANIZATION CHART OF THE ELECTRICAL DEPARTMENT OF THE NEW YORK CENTRAL RAILROAD



Street Ry.Journal

Sheet No._5(___)

ORGANIZATION OF OFFICE OF THE SUPERINTENDENT OF POWER AND FORCE AT EACH POWER STATION



TYPICAL ORGANIZATION CHARTS OF DIFFERENT DEPARTMENTS OF THE NEW YORK CENTRAL RAILROAD

POWER STATION PRACTICE OF THE NEW YORK CENTRAL

Two power plants have been built to furnish current to the electrical zone of the New York Central, one being located at Port Morris and the other at Yonkers. In salient features these stations are duplicates, each having an ultimate capacity of 30,000 kw normal output at full rating. The Port Morris and Yonkers stations were described in the Street Railway Journal of Nov. 11, 1905, and Nov. 3, 1906. The operating organization of each plant provides for an elastic service capable of current supply separately or in multiple to the various transmission lines and rotary converter substations, meeting routine and emergency conditions with positive assurance of successful cooperation. The distribution of power and to some extent the operation of the main generating plants are supervised by a highly developed load despatching system, described under the caption "Distribution System." This feature of the work and the scientific methods of analysis practiced in the power plant production processes are of peculiar interest in connection with the general reliability and economy of the power supply. So far as the generation of power is concerned the station routine follows practice accepted in the heaviest central station work, but at every stage the question of continuous service is paramount.

The Port Morris power station was started in May, 1906, and it has thus far supplied all the current necessary for train service, both preparatory and commercial. The first trial train was operated in July, 1906, and the first regular electric train was run into the Grand Central Station on Dec. 11, 1906. Since July 1, 1907, all the New York Central trains have been electrically operated into and out of the Grand Central Station and the Lexington Avenue temporary terminal. The Yonkers station is practically in readiness for operation.

Sixteen 625-hp boilers have now been installed at Port Morris, the ultimate capacity of the station being twenty-four boilers of this size. Four 5000-kw turbines have been installed, each machine consisting of a Curtis-General Electric five-stage, three-phase, 25-cycle, 11,000-volt unit of the revolving field type. Six turbines constitute the ultimate station equipment at each plant. The Port Morris station is 237 ft. long, 167 ft. wide and 105 ft. high. It has the Custodis stacks, each 250 ft. high above the grates and 15 ft. 6 ins. in diameter. The turbine room at Port Morris is 231 ft. 8 ins. long by 69 ft. wide, the boiler room being 88 ft. wide. All high-tension switching at each power station is effected in a separate switch house. This building is 100 ft. long by 50 ft. 10 ins. wide at Port Morris, and at Yonkers, on account of the fact that it is combined with a rotary converter substation, the switch house is 255 ft. 4 ins. by 37 ft. 4 ins.

COAL HANDLING

The coal burned at Port Morris is of the semi-bituminous variety from Clearfield County, Pa. A typical analysis is presented under the caption "Work of the Engineer of Tests." This coal is delivered at the power station by water, although in case of necessity it can be delivered by rail, and the same conditions apply at Yonkers. The capacity of the coal barges which deliver at Port Morris varies from 400 to 700 tons each. Aside from the hoist for unloading coal from the boats, which is handled by steam, the coal handling apparatus is all driven by electric motors. The conveyors are driven by 220 volt three-phase induction motors varying in capacity from 7½ hp for the ash conveyor to 40 hp for the coal crusher and conveyors.

Coal delivered by boat is elevated by means of a hoisting tower to a hopper over the car tracks, whence it is delivered to the crushers. From the crushers the coal is fed to an elevating conveyor of the bucket type which carries it to a point above the bunkers, whence it is distributed by four scraper conveyors acting independently. From the coal bunkers the coal is discharged to the hoppers of the stokers through cast iron chutes and distributing aprons. The ashes fall from the grates to hoppers below, which discharge into hand push-cars of one ton capacity. These dump their load into conveyor hoppers in the basement underneath the boiler room and the ashes are carried up by malleable iron bucket conveyors to storage bins over the trestle where they are loaded into cars. A gang of ten men is busy looking after the coal and ashes all the time. The coal conveying system is run about 10 per cent of the time.

There are three coal bunkers above the boilers, the capacity being 4800 tons, and in addition there is ample yard room for storage in case it is needed. About 2500 tons are usually kept in the bunkers. In case of fire in a bunker the coal is used from that bunker as quickly as possible and, if necessary, the coal is run out of the bunker, wet down and returned to the bunker; however, there has been but little trouble from bunker fires.

Calorimeter tests and chemical analyses are made in the testing department laboratory of the fuel used, four or five samples being taken from each barge load. A Parr calorimeter is employed, and both proximate and ultimate analyses are made if necessary.

STACK AND FUEL GASES

Each of the two chimneys is of the Custodis radial brick type, and is 250 ft. high above the grates and 15 ft. 6 ins. in diameter. Twelve boilers are operated on one stack and four on the other. The draft averages about ¾ in. An automatic CO_2 recorder is used in the boiler room; frequent analyses of flue gas are also made with the Orsat apparatus.

BOILERS

Each of the sixteen boilers at the Port Morris station has 6250 sq. ft. of heating surface and 112 sq. ft. of grate surface, with a total superheating surface of 1230 sq. ft. The boilers are equipped with Roney stokers and each stoker engine operates four stokers in normal operation, but eight can be run per engine in case of emergency. The boilers have an overload capacity of 50 per cent for 24 hours and 175 lbs. per square inch pressure is used in regular operation. Superheated steam is employed for the turbines and all the auxiliaries, the average superheat being about 150 degs. F.

The boilers are usually operated on a common header, but if desired, when the load increases the station can be operated on the unit system. To take care of the latter procedure the apparatus in the station is divided into groups. Each group consists of four boilers, one feed pump and feed water heater and a complete condensing plant.

The maximum load of the plant so far is carried on six boilers. Only one turbine is operated at present, except at times of peak load, when two machines are in service. Twelve hundred and fifty kw per boiler can be carried on the turbine continuously.

FEED WATER

The feed water enters the boilers at a temperature of 212 degs. F. Croton water is used for boiler feed and very little scale forms. The boiler drums are cleaned about twice a year and the tubes once in three months; a turbine cleaner is used for cleaning the tubes. No oil is allowed to enter the water supplied the boilers.

COAL AND WATER CONSUMPTION

The usual rate of combustion varies from 28 to 29 lbs. of coal per square foot of grate surface per hour at times of heavy load. The monthly coal consumption under present load conditions averages 2.9 lbs. per kw-hour. About 100 tons of coal are burned daily at present, the amount of ashes averaging about 15 per cent to 20 per cent in weight.

The water consumption of the plant averages about 8 lbs. per kw-hour. This includes the water required for auxiliary and general uses, exclusive of lavatories. It is estimated that from four to five pounds of water per kw-hour are required for make-up in connection with the turbine operation, when the condensing system is tight.

OUTPUTS

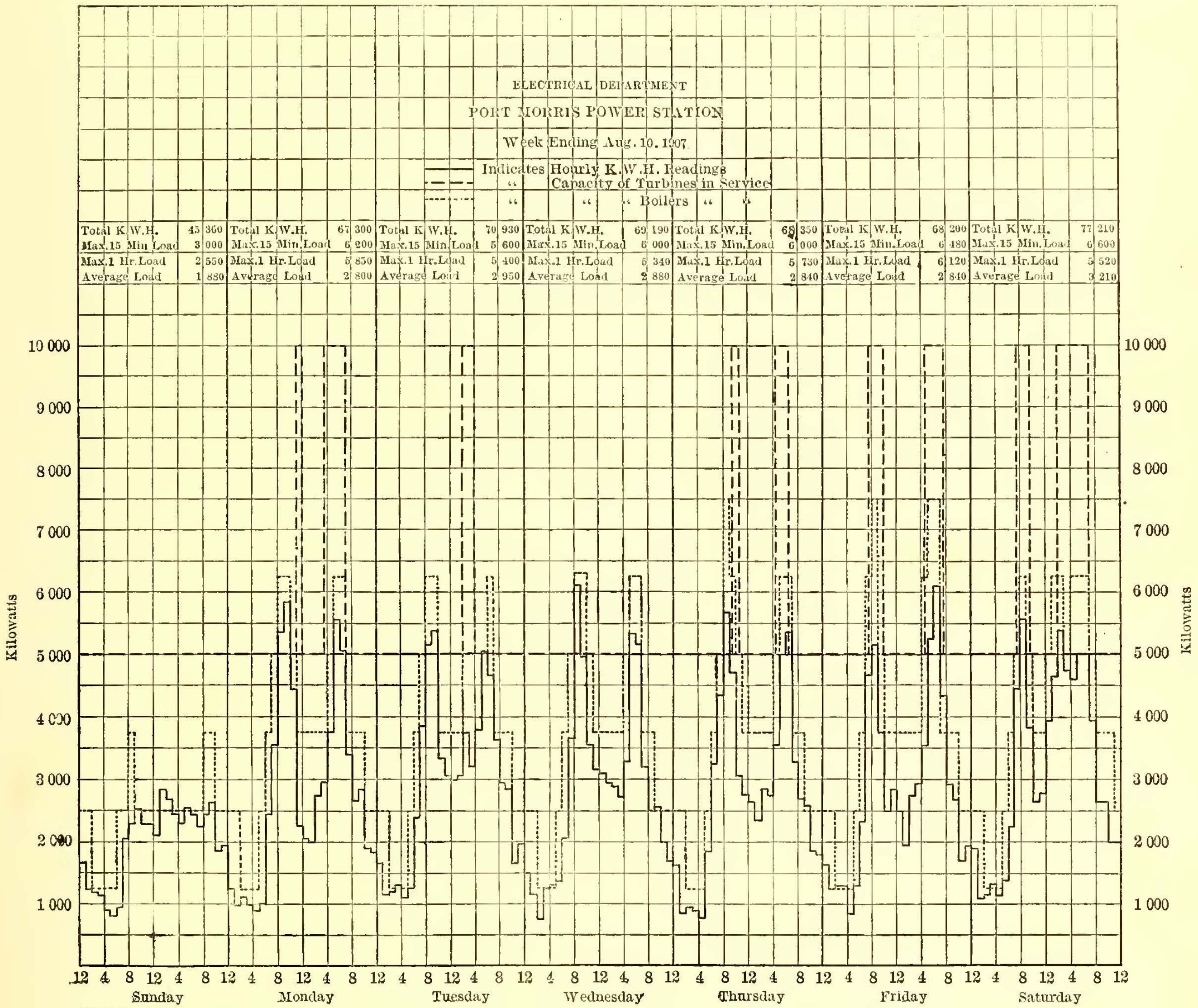
The total kw-hour output of the Port Morris plant from March, 1907, to July, 1907, was as follows:

March	1,687,730
April	1,693,950
May	1,790,990
June	1,717,020
July	1,936,960

The load factor of the station in July, 1907, averaged 44.4 per cent on a 15-minute peak assumption. At time of writing this article the load on the plant was increasing on account of the addition of electric trains on the New York, New Haven & Hartford Railroad.

TURBINE AUXILIARIES

The concrete intake line for the circulating water of the condensing system is protected by a double screen at the outer end. No trouble was experienced with ice at this point last winter. The intake racks are cleaned once daily and the screens three times a week. In starting the centrifugal pumps which supply the circulating water to the condensers the pumps are primed from the dry air pump. The circulating and dry air pumps are steam driven, but the hot well pumps are motor driven. Practically the only head against which the circulating pumps work is that due to the pipe friction, as the discharge is below the water level. The capacity of each pump is 18,000 gals. per minute against a head of 20 ft. at 250 r. p. m. The minimum temperature of the circulating water during last winter was from 30 to 31 degs. F. and the maximum summer temperature is about 65 degs. F. The average temperature of the discharge is from 6 to 9 degs. higher than that of the intake.



Street Railway Journal

TYPICAL WEEKLY POWER STATION LOAD, PORT MORRIS STATION

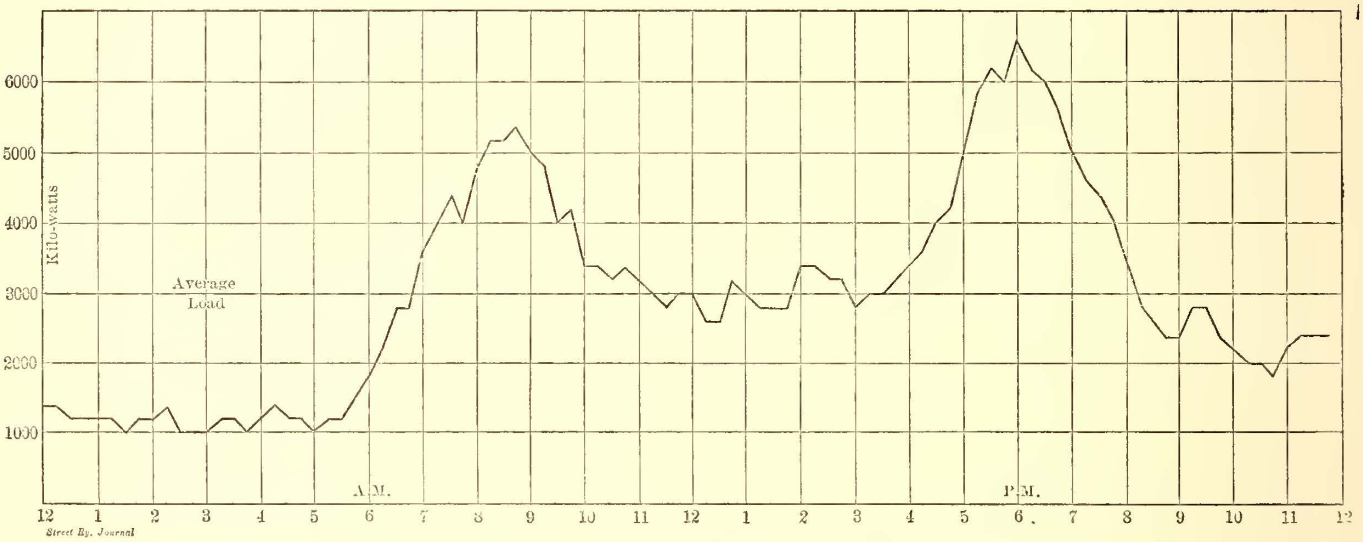
OIL

Three grades of oil are used in the plant; first, a high temperature cylinder oil adapted to operation at 175 lbs. steam pressure and 200 degs. superheat. This is used in reciprocating engine cylinders; second, ordinary engine oil used generally in the bearings, and third, crank case oil used in the stoker engines. The oil consumption in July, 1907, was 216 gals. of cylinder oil, 101 gals. of engine oil and 10 gals. of crank-case oil. A gravity oiling system is in use, two storage tanks being located at the roof level. Each machine is separately piped for both cylinder oil and engine oil. The oil is cooled mainly by circulation through the power house and is filtered by two Turner oil filters which both strain and wash it.

TURBINE OPERATION

The turbines are warmed up previously to starting if there is time. About fifteen minutes are required for this work. In case of emergency a turbine can be brought up to speed in two minutes from the cold state and placed in service in three minutes, all told.

In starting a turbine, the switchboard operator notifies the watch engineer in charge of the shift when another unit is needed. An emergency machine is kept standing ready all the time with water circulating through the condenser at half speed in the pump. One short blast on the turbine room whistle calls the turbine operator's attention to the switchboard, and by means of a speaking tube, which connects the operating gallery with the main floor of the power station, he learns what is wanted. The turbine operator is then ordered to bring the machine up to speed, by the watch engineer, and this is done by opening the throttle to 10 or 15 lbs. pressure, as indicated by the first gauge.



TYPICAL WEEK-DAY LOAD, PORT MORRIS POWER STATION

In addition to the speaking tube and whistle, pilot lamps are provided for connection between the switchboard gallery and the operating gallery of the turbines, a bell calling the attention of the attendant at either end, to the lamps. The whistle signals are as follows:

One short blast	Calls turbine operator
One long blast	Calls watch engineer
Two short blasts	Indicate machine phased in or out
Three short blasts	Call dynamo man
One short and one long blast	Call electrical operator
Two short and one long blast	Call boiler-room foreman
Four short blasts	Call all hands for emergency

The machine, after being started, is synchronized at the switchboard and placed in service. Two whistles are then blown, notifying the turbine operator that the machines are tied together, and immediately the throttle is opened wide, the new turbine taking its share of the load. Normal excitation is used in starting.

In shutting down, one whistle calls the attention of the watch engineer or the turbine operator. The number of the machine to be withdrawn from service is struck on the bells at the turbines from the switchboard. The throttle is partially closed and at the same time the switchboard operator lowers the load by means of the field rheostat and also by the motor-controlled governor. When the throttle is nearly closed the turbine operator signals the switchboard operator and the generator switch is opened.

When the load is above 5000 kw for one hour, a second turbine is cut into service and the same thing is done after the load is above 6000 kw for a few minutes. The maximum sustained overload usually permitted is about 20 per cent for one hour.

The turbine step bearings each require from 8 to 10 gals. of water per minute for lubrication. It takes about three-quarters of an hour for a turbine to come to rest after steam is cut off, with full field on and two hours without the field.

The repairs of the turbines as compared with reciprocating engines have been very much lower. None has been required to the wheels or wheel casing; the bearings also have given little trouble. Spare armature coils, valve fittings, governor parts, field-ring brushes and similar small supplies for the turbines are carried in storage against emergencies.

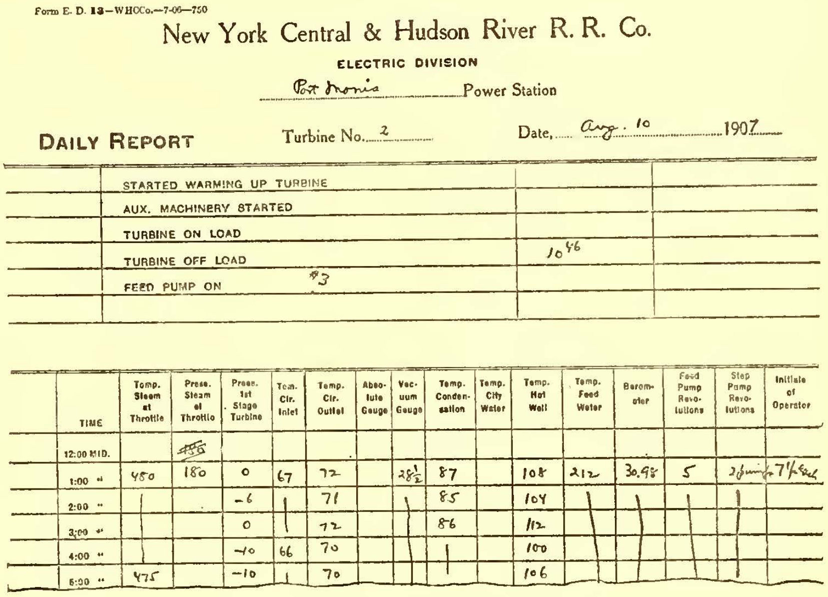
EXCITER SYSTEM

The exciter system operates at 125 volts, power being furnished from two 150-kw Curtis turbines and one 150-kw motor generator. In addition to these a battery having a capacity of 1200 amps. at the one-hour rate is provided. The exciter turbines are of the horizontal type, two-stage, 2000 r. p. m., and operate non-condensing, the exhaust from them being used for heating the feed water. Two direct-current bus-bars are provided so that the crane motors and any other direct-current load can, when desired, be operated on a separate machine from that used for field excitation. A 200-hp, 220-volt, three-phase induction motor is used for driving the motor generator set. The exciter battery consists of seventy-four cells, each containing 21 type "R" plates and has a capacity of 1200 amps. for one hour. It will furnish sufficient current for exciting the fields of four 5000-kw generators for about four hours.

SWITCHBOARD

The entire electrical equipment in the station is controlled from the switchboard gallery on one side of the generator room. Enclosed in a glass booth in the center of the gallery is the main operating board, on either side of which are separate boards for controlling the exciters. The lamp and motor circuits in the station are controlled from smaller switchboards situated at either end of the operating gallery and the field panels are located outside the operating booth on each side.

In the switch house two sets of high-tension bus-bars are provided, one being divided into two and one into three sections by tie switches. The high-tension bus-bars are connected to the generators through a main switch and selector switches. Each feeder is provided with two selector switches which connect to the two respective high-tension bus-bars below them. Overload relays are connected with the feeder circuits and the generator circuits have reverse current relays connected to indicator lamps. The switchboard equipment in the switch house is such that the main operating board in the station may be out of service for cleaning or repairs and the equipment could be then controlled from the switch house. With a few exceptions, all the incandescent lamps in the station, about 1000 in number, are fed with alternating current, although the lamp circuits are arranged so that they can be thrown on the exciter bus-bars should occasion require.



Form E. D. 13—WHCCo.—7-06—750

New York Central & Hudson River R. R. Co.

ELECTRIC DIVISION

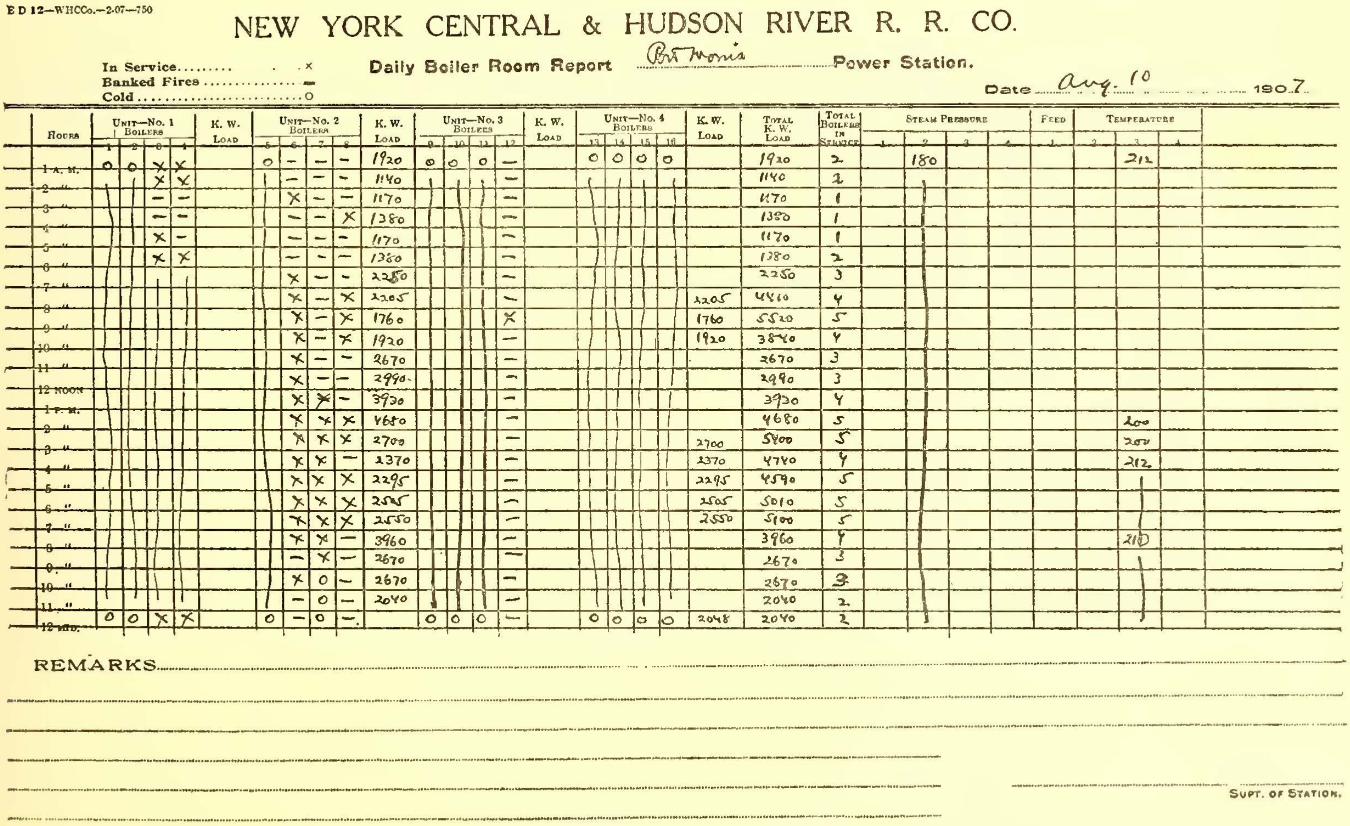
Port Morris Power Station

DAILY REPORT Turbine No. 2 Date, Aug. 10 1907

	STARTED WARMING UP TURBINE		
	AUX. MACHINERY STARTED		
	TURBINE ON LOAD		
	TURBINE OFF LOAD	10^{46}	
	FEED PUMP ON #3		

TIME	Temp. Steam at Throttle	Press. Steam at Throttle	Press. 1st Stage Turbine	Tem. Cir. Inlet	Temp. Cir. Outlet	Absolute Gauge	Vacuum Gauge	Temp. Condensation	Temp. City Water	Temp. Hot Well	Temp. Feed Water	Barometer	Feed Pump Revolutions	Step Pump Revolutions	Initials of Operator
12:00 MID.		~~456~~													
1:00 "	450	180	0	67	72		28½	87		108	212	30.98	5	2 pumps	7½ [illegible]
2:00 "			-6		71			85		104					
3:00 "			0		72			86		112					
4:00 "			-10	66	70					100					
5:00 "	475		-10		70					106					

UPPER PART OF TURBINE RECORD



E D 12—WHCCo.—2-07—750

NEW YORK CENTRAL & HUDSON RIVER R. R. CO.

In Service.......... x
Banked Fires.......... —
Cold.......... o

Daily Boiler Room Report Port Morris Power Station.

Date Aug. 10 1907

Hours	Unit—No. 1 Boilers 1	2	3	4	K. W. Load	Unit—No. 2 Boilers 5	6	7	8	K. W. Load	Unit—No. 3 Boilers 9	10	11	12	K. W. Load	Unit—No. 4 Boilers 13	14	15	16	K. W. Load	Total K. W. Load	Total Boilers in Service	Steam Pressure 1	2	3	4	Feed 1	Temperature 2	3	4	
1 A. M.	o	o	X	X		o	—	—	—	1920	o	o	o	—		o	o	o	o		1920	2		180					212		
2 "			X	X			—	—	—	1140				—							1140	2									
3 "			—	—			X	—	—	1170				—							1170	1									
4 "			—	—			—	—	X	1380				—							1380	1									
5 "			X	—			—	—	—	1170				—							1170	1									
6 "			X	X			—	—	—	1380				—							1380	2									
7 "							X	—	—	2250				—							2250	3									
8 "							X	—	X	2205				—						2205	4410	4									
9 "							X	—	X	1760				X						1760	5520	5									
10 "							X	—	X	1920				—						1920	3840	4									
11 "							X	—	—	2670				—							2670	3									
12 NOON							X	—	—	2990				—							2990	3									
1 P. M.							X	X	—	3930				—							3930	4									
2 "							X	X	X	4680				—							4680	5							200		
3 "							X	X	X	2700				—						2700	5400	5							200		
4 "							X	X	—	2370				—						2370	4740	4							212		
5 "							X	X	X	2295				—						2295	4590	5									
6 "							X	X	X	2505				—						2505	5010	5									
7 "							X	X	X	2550				—						2550	5100	5									
8 "							X	X	—	3960				—							3960	4							210		
9 "							—	X	—	2670				—							2670	3									
10 "							X	o	—	2670				—							2670	3									
11 "							—	o	—	2040				—							2040	2									
12 MID.	o	o	X	X		o	—	o	—		o	o	o	—		o	o	o	o	2048	2040	2									

REMARKS..........

SUPT. OF STATION.

DAILY BOILER-ROOM REPORT

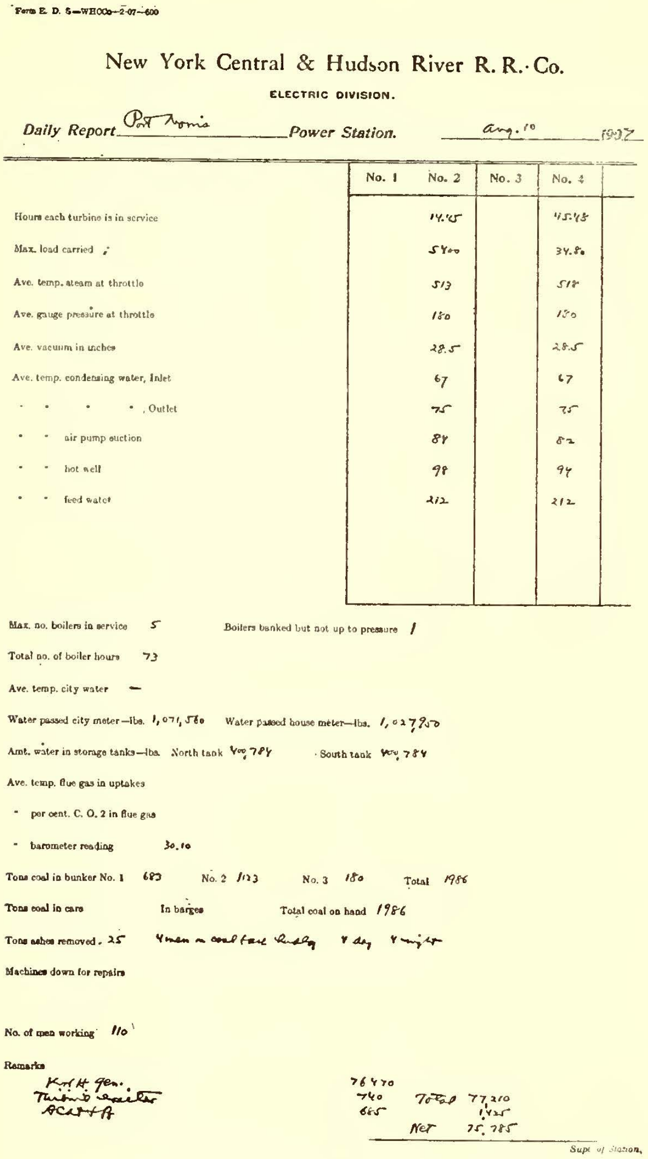
AUXILIARY MOTORS

A large number of small motors is in use in the Port Morris plant for auxiliary purposes. These include one 15-hp elevator motor; four crane motors of 25, 50, 7½, 25 hp; four condenser hot well-pump motors, 10 hp, each run on the exciter-bus as a provision against shutdowns; four 1/6-hp governor motors; two ½-hp motors driving battery end cell switches; forty-five motors of .9 hp each for operating oil switches; and four motors of ¼ hp, each for operating generator field rheostats. All of these motors are 125-volt direct-current machines.

The alternating current motors in the plant are wound for 220 volts and are all of the three-phase induction type; these consist of two 30-hp coal crusher motors, one 15-hp and two 20-hp motors driving scraper conveyors, and one 7½-hp ash conveyor motor; one 15-hp motor for driving winch used in hauling cars along coal trestle, one 40-hp and one 7½-hp motor driving air compressors; four 1-hp driving sump pumps; one 3-hp driving house pump, and one 7½-hp motor driving fan in connection with heating and ventilating of the switch house, also several small fan motors.

MACHINE SHOP

The Port Morris power station is equipped with a first-class machine shop located on the north gallery of the turbine room below the main operating switchboard. All the machine tools in this shop are driven by direct connected motors. The shop is well lighted by north windows and is accessible from the main traveling crane of the station. The equipment consists of one 48-in. Prentiss radial drill driven by a 5-hp 125-volt motor; one 24-in. Gould & Eberhardt shaper, driven by an 8-hp motor; one Blount emery wheel, and one 24-in. Davis drill, driven by a 2-hp motor; one 30-in. Lodge & Shipley lathe, driven by a 10-hp motor; one 16-in. Lodge & Shipley lathe, driven by a 4-hp motor; and one National bolt cutter, driven by a 3-hp motor. Speed controls are provided for each machine on the machine frame and the lathes are provided with controls on the carriages. On the north side of the shop is a bench where hand work is carried on. Three regular machinists devote their time to the work of the shop in the day time. At night one man is on duty in case emergency repairs are necessary. This shop has been of considerable value in making the final adjustments and slight changes required in the plant during the construction period, and in the early months of regular operation.



Form E. D. 5—WHCCo—2-07—600

New York Central & Hudson River R. R. Co.

ELECTRIC DIVISION.

Daily Report Port Morris Power Station. Aug. 10 1907

	No. 1	No. 2	No. 3	No. 4	
Hours each turbine is in service		14.45		45.45	
Max. load carried ;		5400		34.80	
Ave. temp. steam at throttle		513		518	
Ave. gauge pressure at throttle		180		130	
Ave. vacuum in inches		28.5		28.5	
Ave. temp. condensing water, Inlet		67		67	
" " " " , Outlet		75		75	
" " air pump suction		84		82	
" " hot well		98		94	
" " feed water		212		212	

Max. no. boilers in service 5 Boilers banked but not up to pressure 1

Total no. of boiler hours 73

Ave. temp. city water —

Water passed city meter—lbs. 1,071,580 Water passed house meter—lbs. 1,027,950

Amt. water in storage tanks—lbs. North tank 400,784 South tank 400,784

Ave. temp. flue gas in uptakes

" per cent. C. O. 2 in flue gas

" barometer reading 30.10

Tons coal in bunker No. 1 683 No. 2 1123 No. 3 180 Total 1986

Tons coal in cars In barges Total coal on hand 1986

Tons ashes removed. 25 4 men on coal face hndlg 4 day 4 night

Machines down for repairs

No. of men working 110

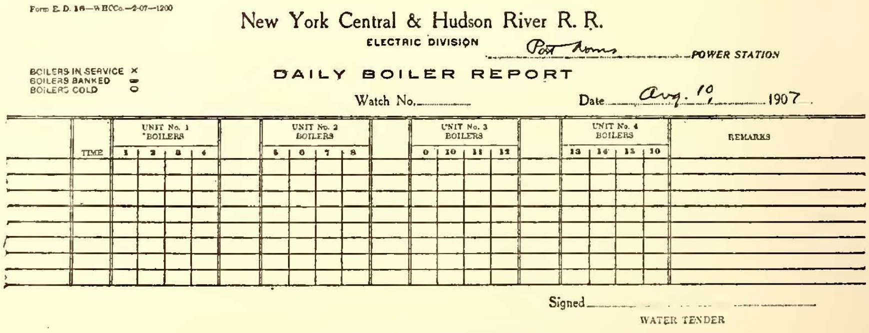
Remarks

Kn H gen.
Turbine heater
ACA&F

76470
740 Total 77,210
665 1,425
Net 75,785

Supt. of Station.

DAILY REPORT OF BOILER AND TURBINE OPERATION



Form E. D. 16—WHCCo.—2-07—1200

New York Central & Hudson River R. R.

ELECTRIC DIVISION Port Morris POWER STATION

DAILY BOILER REPORT

BOILERS IN SERVICE ×
BOILERS BANKED ▬
BOILERS COLD ○

Watch No. Date Aug. 10 1907

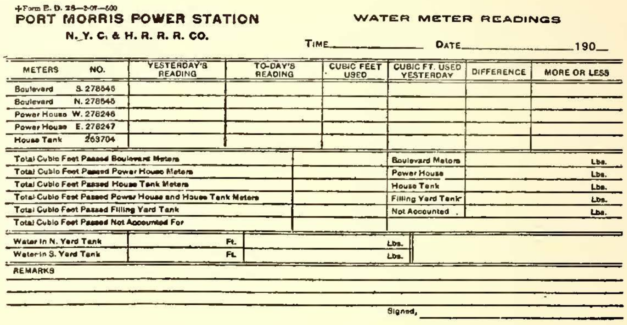
		UNIT No. 1 BOILERS					UNIT No. 2 BOILERS					UNIT No. 3 BOILERS					UNIT No. 4 BOILERS				REMARKS
	TIME	1	2	3	4		5	6	7	8		9	10	11	12		13	14	15	16	

Signed
WATER TENDER

DAILY BOILER REPORT

STORE ROOM

On the gallery near the shop is a store room where pipe fittings, valves, packing, gaskets, nuts, bolts, cutters and tools are kept. Each machinist is provided with several numbered brass checks which he exchanges for tools when he wishes to draw them out of the store room for use. At a conspicuous place in the store room is a check board fitted with numbered hooks, each number representing a specific tool. In borrowing a tool from the store room the machinist leaves his brass check on the corresponding hook. By this arrangement the total number of tools out at any one time, the number of tools of the same kind which are out, and the numbers of the men who are using them, can be observed at a glance. There is also another store room on the turbine-room gallery which contains electrical supplies, including lamps, fuses, carbon, brushes, and wiring fittings, compactly disposed in tiers of labeled compartments. Beneath the boiler room is a storage compartment for heavy spare parts and supplies.



+Form E. D. 28—2-07—600

PORT MORRIS POWER STATION
N. Y. C. & H. R. R. R. CO.

WATER METER READINGS

TIME DATE 190

METERS	NO.	YESTERDAY'S READING	TO-DAY'S READING	CUBIC FEET USED	CUBIC FT. USED YESTERDAY	DIFFERENCE	MORE OR LESS
Boulevard	S. 278546						
Boulevard	N. 278545						
Power House	W. 278246						
Power House	E. 278247						
House Tank	263704						

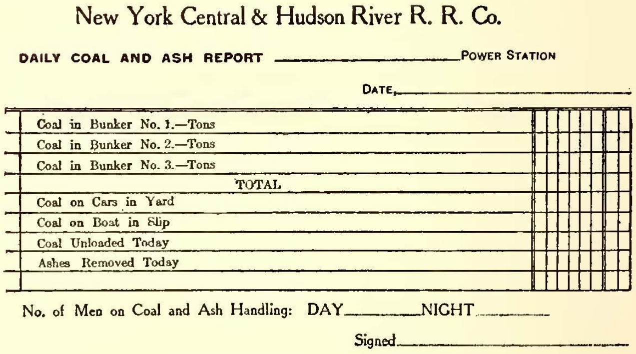
Total Cubic Feet Passed Boulevard Meters		Boulevard Meters	Lbs.
Total Cubic Feet Passed Power House Meters		Power House	Lbs.
Total Cubic Feet Passed House Tank Meters		House Tank	Lbs.
Total Cubic Feet Passed Power House and House Tank Meters		Filling Yard Tank	Lbs.
Total Cubic Feet Passed Filling Yard Tank		Not Accounted	Lbs.
Total Cubic Feet Passed Not Accounted For			

Water in N. Yard Tank	Ft.	Lbs.
Water in S. Yard Tank	Ft.	Lbs.

REMARKS

Signed,

WATER METER RECORD



New York Central & Hudson River R. R. Co.

DAILY COAL AND ASH REPORT POWER STATION

DATE

Coal in Bunker No. 1.—Tons								
Coal in Bunker No. 2.—Tons								
Coal in Bunker No. 3.—Tons								
TOTAL								
Coal on Cars in Yard								
Coal on Boat in Slip								
Coal Unloaded Today								
Ashes Removed Today								

No. of Men on Coal and Ash Handling: DAY NIGHT

Signed

DAILY COAL AND ASH REPORT

LOAD CURVES

A typical weekly load curve of the Port Morris plant for the seven days ending Aug. 10, 1907, is given on page 545, together with capacities of generators and boilers in service.

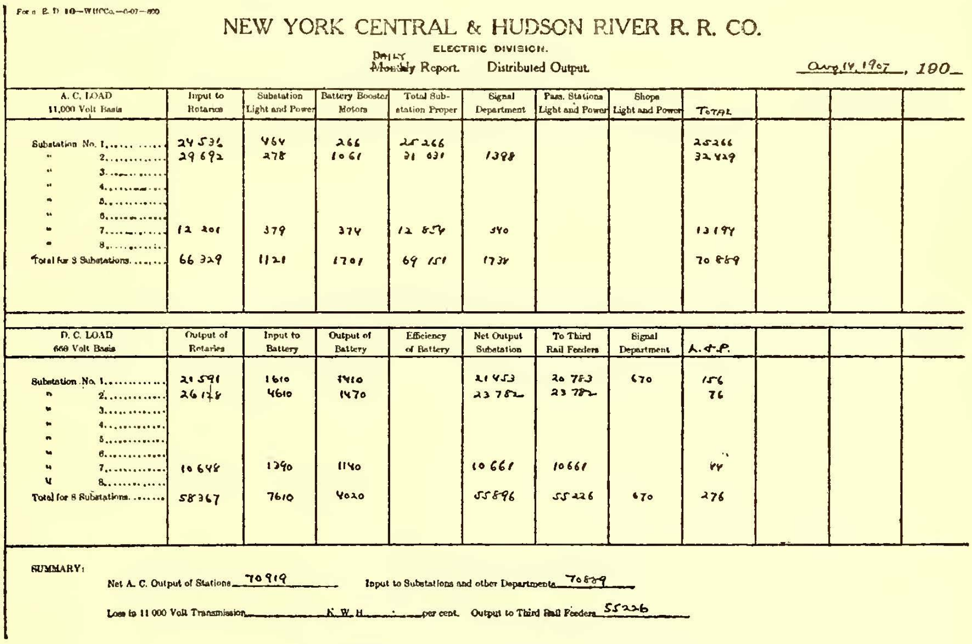
The full line indicates the hourly load, the dotted line the boiler capacity and the dashed line the generator capacity. By examination of these curves it will be seen that there are two prominent peaks upon each week day, with prominent depressions at noon, and in the small hours of the morning. The maximum load during the week was about 6100 kw. The minimum load upon the station occurred between 4 and 5 o'clock a. m. on Thursday, being 750 kw. The maximum output of the station during any single day of the week was 77,210 kw-hours, on Saturday, Aug. 10. The Sunday load was light in the early morning, and extremely regular during the day. The load variations on Monday, Tuesday, Wednesday, Thursday and Friday resemble each other quite closely, but on Saturday a large and sustained afternoon and evening load reflects the conditions of the weekly half-holiday. The minimum output of the station during the week was 45,360 kw-hours, which occurred on Sunday. The turbine capacity in service reached 10,000 kw nine times during the week. The boiler capacity in service follows the fluctuations of the load quite closely.

The diagram on page 546 illustrates a typical week-day load curve at the Port Morris power station. The day taken was Monday, Aug. 7, 1907, and the average load during this day was 3000 kw. The minimum load was 1000 kw, and the maximum load of the day, 6600 kw, occurred at 6 p. m. The morning peak reached a value of 5400 kw. The morning peak, as a whole, lasted for about three and a half hours, and the afternoon peak, as a whole, was of practically the same duration. The minimum load lasted for about five hours.

BLANKS AND FORMS

A considerable number of specially devised blank forms are in use in the operation of the stations.

The daily electrical log sheet of the plant, size 20 ins. x 15 ins., shows the bus-bar voltage, average load in kw during fifteen-minute periods as derived from recording wattmeter readings on each generator, the total load on the plant every fifteen minutes, average hourly load on the plant, power factor of the generators in service and miscellaneous notes. In view of the fact that the station is at present operating at less than one-fourth of its continuous capacity it must be borne in mind that figures of operation given in the following paragraphs do not carry the same significance that they will when the electrical zone is completed. On a typical day's run, taken for Saturday, Aug. 10, 1907, the bus-bar voltage averaged 10,800 all day. Turbine No. 2 was in operation from midnight until 10:45 p. m. During the morning peak load turbine No. 4 was placed in service at 7:25 a. m. and cut out at 9:32 a. m. As this was Saturday, the afternoon load necessitated the use of turbine No. 4 again between 1:59 p. m. and 7:00 p. m., and this latter machine carried the entire station load from 10:45 p. m. until the close of the day. The total output of the station on this day was 77,210 kw-hours, of which 740 kw-hours was consumed in exciting the turbine, and for direct-current light and power, and 685 kw-hours for alternate current light and power service. Deducting this auxiliary power consumption of 1425 kw-hours from the gross output of the turbines the net output of the station figures 75,785 kw-hours. This is an average commercial output of 3150 kw. The load factor from the station for the day was 58 per cent, defining the former as the ratio of the average load to the maximum hour load. The maximum momentary output recorded was 6800 kw at 8:27 a. m. and the minimum 1000 kw at 4:45 a. m. The maximum fifteen-minute load occurred between 8:30 and 8:45 a. m., being 6600 kw.



Form E. D. 10—WHCo.—6-07—500

NEW YORK CENTRAL & HUDSON RIVER R. R. CO.

ELECTRIC DIVISION.

~~Monthly~~ Daily Report. Distributed Output. Aug. 14, 1907, 190_

A. C. LOAD 11,000 Volt Basis	Input to Rotaries	Substation Light and Power	Battery Booster Motors	Total Substation Proper	Signal Department	Pass. Stations Light and Power	Shops Light and Power	Total			
Substation No. 1	24 536	464	266	25 266				25266			
" 2	29 692	278	1061	31 631	1398			32429			
" 3											
" 4											
" 5											
" 6											
" 7	12 201	379	374	12 854	540			13194			
" 8											
Total for 8 Substations	66 329	1121	1701	69 151	1738			70 869			

D. C. LOAD 660 Volt Basis	Output of Rotaries	Input to Battery	Output of Battery	Efficiency of Battery	Net Output Substation	To Third Rail Feeders	Signal Department	A. & P.			
Substation No. 1	21 591	1610	1410		21 453	20 753	670	156			
" 2	26 178	4610	1470		23 782	23 782		76			
" 3											
" 4											
" 5											
" 6											
" 7	10 648	1290	1140		10 661	10661		44			
" 8											
Total for 8 Substations	58367	7610	4020		55896	55226	670	276			

SUMMARY:

Net A. C. Output of Stations 70919

Input to Substations and other Departments 70869

Loss to 11 000 Volt Transmission ______ K. W. H. ______ per cent.

Output to Third Rail Feeders 55226

DAILY REPORT OF DISTRIBUTED OUTPUT

The daily boiler-room report used, original size 13⅝ ins. x 8 ins., is reproduced on page 548. This shows at a glance the condition of each one of the sixteen boilers in the station at every hour of the day, the load on the station at those times, total number of boilers in service, steam pressure and temperature of the feed water. On Aug. 10 boilers Nos. 1 and 2 were cold all day; boilers Nos. 3 and 4 were in service a large part of the day, though both were banked at 3 and 4 a. m.; boiler No. 5 was not in service during the day; boiler No. 6 was in service during one of the early morning hours and from 7 a. m. throughout practically the rest of the day; boiler No. 7 was banked until noon and then used until 9 a. m. and boiler No. 8 was banked and in use irregularly during the day. Boilers Nos. 9, 10, 11, 13, 14, 15 and 16 were cold throughout the day; boiler No. 12 was banked all day except during the morning peak load, when it was cut in service to help the others. The chart shows at a glance just how the boilers were handled as the load varied, and as it is filled out by means of simple symbols it is a very easy matter to keep it correctly. Variations of the load require from one to five boilers in service at different periods of the day.

The daily report of the boiler and turbine service, original size 13¾ ins. x 8 ins., also on page 548, shows the total number of hours each turbine is in service, the maximum load carried, various temperatures and pressures, water consumption, coal on hand, ashes removed, and number of men on duty. On Aug. 10 turbine No. 2 was in service 14.45 hours, and No. 4 15.48 hours. The average temperature of the condensing water on that day was 67 degs. at the inlet and 75 degs. at the outlet. The average temperature of the hot well was 98 degs. F. for turbine No. 2 and 94 degs. F. for turbine No. 4. The total number of boiler hours required was 73 and the water used inside the house meter 1,027,950 lbs. The total coal on hand during this day was 1986 tons and eight men were required for coal and ash handling, four being on day work and four on night work. The number of men working in the plant on this day was 110.

TESTING DEPARTMENT

The headquarters of the testing department are located at the Port Morris power station, and this work is in charge of a department head called the engineer of tests, with nine subordinates reporting to him. The work of the power house chemical laboratory is included in this department. In addition to the chemical tests outlined on the next page, the engineer of tests makes all electrical tests on the machines in the power stations and substations, tests of energy consumption on locomotives and motor cars, switchboard meter tests, rail bond tests, locomotive ammeter calibrations and tests on underground and overhead lines. The routine tests of the department include monthly insulation measurements on high tension and low tension lines, monthly readings of ground potentials relative to track rails and negative conductors, and semi-annual meter tests.

BOND TESTS

Two men are working continually on bond testing. There are about 30,000 bonds to be maintained in the electrical zone as at present installed. It takes about two minutes to test a bond on the running rail, 200 bonds being a fair average day's work of eight hours. Greater care is necessary in testing the bonds on the third-rail, and here 100 bonds per day is a fair average.

A differential voltmeter is used for bond testing, the zero being in the middle of the scale and the total deflection being fifteen millivolts each way from the center. By means of a special contact device one of the coils is connected across the rail joint, the distance between contact points being 8 ins.; one terminal of the second coil is connected to one of the contact points referred to above and the other end of the coil is connected to the rail by means of an adjustable contact, this contact being moved until the drop in the rail equals the drop in the joint, this being indicated by the needle on the voltmeter coming to zero. A scale on the contact device indicates the length of third-rail equivalent in resistance to the 8-in. length at the joint. Average results show that on the third-rail 18 ins. and on the track-rail 20 ins. is equivalent to an 8-in. length at the joint. The average maximum and minimum variations for the third-rail are from 24 to 14 ins. and for the track-rail from 27 to 20 ins. If the resistance is equivalent to 36 ins., bonding of the joint is repaired.

INSULATION TESTS

The initial tests on 11,000-volt, three-conductor cables are made with a pressure of 22,000 volts between conductors and also from each conductor to ground; subsequent tests which may be necessary are made at 15,000 volts, although no regular break-down tests are made on these cables unless they have been out of service for repairs. Monthly insulation resistance measurements are made on these cables, as well as on the armature windings of the turbo-generators. A special transformer is installed in the power station for use in high voltage tests; the primary of this transformer is connected to the 11,000-volt bus and the secondary to the line to be tested. The secondary voltage can be varied from 2000 to 30,000 volts by means of moving a section of the iron core of the transformer.

Daily insulation tests are made by the substation operators on the 660-volt feeders and on the rotary converters. The overload relays and speed limit devices on the substations are tested at regular intervals.

FORMS

The form shown below, original 8 ins. x 10½ ins., is that used in reporting the results of bond tests. It shows the number of bonds tested in a day on the east running rail, the west running rail and the third-rail of each track, with the totals. The location of bonds having an equivalent of over 36 ins. of continuous rail is specified, as are the maximum and minimum bond resistance values noted during the day by the tester.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD CO.
ELECTRIC DIVISION
BOND TESTER'S DAILY REPORT

August 15, 1907.

Bonds inspected from ***Sta. 105 + 30***
To ***Sta. 154 + 50***

NUMBER OF BONDS TESTED

Track No. 1			Track No. 2			Track No. 3			Track No. 4			Total No.
Run Rail		3d Rail	Run Rail		3d Rail	Run Rail		3d Rail	Run Rail		3d Rail	
E.	W.		E.	W.		E.	W.		E.	W.		
150	150											300

Bonds having an equivalent of over 36 inches of continuous rail.

Location ***Sta. 130 + 25, E. Rail***.......................... = ***40*** inches
Location .... = "
Location .... = "
Location .... = "
Maximum = ***24*** inches of continuous rail.
Minimum = ***14*** " " " "
Remarks and General Inspection:

....
Bond Tester.

The next, original 8 ins. x 13 ins., illustrates a transmission line test made for the purpose of locating a ground. In making this test the cable was cut at two points, and with one phase grounded readings were taken for the standard Murray

TRANSMISSION LINE TEST

Reason for test: *To locate how far from Shore, Ground exists under Harlem River at Drawbridge. Cable cut at both ends of Bridge, measured at No. End of Draw.*

TEST FOR GROUNDS. Date, 2/19/'07. Time..........

Phases Grounded, *One Phase Grounded.*
Insulation Resistance by Voltmeter. A..........................
B..........................
C..........................

READINGS FOR MURRAY LOOP TEST. Date, 2/21. Time, 4.45 P.M.
Length of Line: 720 feet. *Fig. used by Contractors.*

Clear Phase	Grounded Phase	Readings				
		A.	B.	A^1	B^1	
		40.6	59.4	59.1	40.9	
		40.8	59.2	59.0	41	
	Average	40.7	59.3	59.05	40.95	
						40.825

Calculated Distance from *End of Cable on S. Side of River* to Ground = 139.2 feet.

This indicates Manhole No....................Found........................

....

POTENTIAL TEST. Date.................Time..........

Three } Phase
Single }

Between Phases ....Volts........Amps. Charging Current......Time
Cable to Ground ....Volts........Amps. Charging Current......Time
Remarks...

....

loop test. As shown by the readings, the calculated distance of the ground from the end of the cable was 139.2 ft.

CHEMICAL LABORATORY

The chemical laboratory is located on the upper floor of the switch house and it contains a standard line of reagents. In one corner of the room is a small shop driven by a ½-hp motor, the equipment of the shop consisting of a grinder and a lathe belt-driven from a countershaft. The routine work consists of a daily coal analysis and a daily gas analysis. Other work includes tests of engine, cylinder and transformer oils, insulating compounds, acid and water. The importance of the chemical laboratory in the economy of the modern power plant is well illustrated by the character of the work done here. Several analyses are given below to show the scope of the work:

EXAMPLE OF A FLUE GAS ANALYSIS, ORSAT APPARTUS, JUNE 21, 1907

No. Boiler.	Co_2	O.	C. O.	N.	Draft.	Doors.
7	12.20	7.70	0.10	80	¾ in.	Open
7	10.60	9.30	0.25	79.85	"	"
7	11.85	8.10	0.30	79.75	"	"
7	13.50	6.30	0.25	79.95	"	"
7	13.80	6.10	0.10	80.00	"	"
7	14.20	5.60	0.35	79.85	"	"
9	13.60	6.30	0.25	79.85	"	"
9	14.20	5.80	0.00	80.00	"	"
9	14.10	5.60	0.20	80.10	"	"
9	12.70	7.10	0.10	80.10	"	"

SAMPLE COAL ANALYSIS

	Per cent moist coal.	Per cent dry coal.	Per cent combustible.
Moisture	.334	......	......
Volatile combustible matter	22.166	22.24	24.122
Fixed carbon	67.924	68.15	73.917
Ash	7.776	7.802	......
Sulphur	1.8	1.808	1.961

B. T. U. per pound moist coal by calorimeter, 13,955.
B. T. U. per pound moist coal by proximate analysis, 14,500.
B. T. U. per pound conbustible, 15,136.
Boiler No. 10, draft ½ in. Co_2 12.7 per cent, 3:10 p. m.
Boiler No. 13, draft ½ in. Co_2 12.3 per cent, 3:30 p. m.

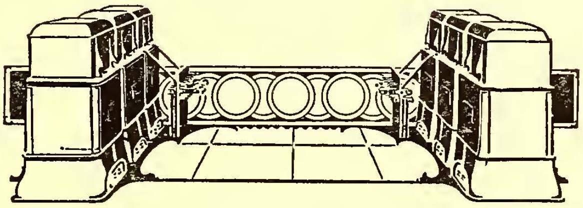
EXAMPLE OF AN ANALYSIS OF ANTI-FRICTION METAL FOR BEARINGS, JUNE 15, 1907

Lead	60.39	per cent
Copper	37.95	"
Iron	00.05	"
Tin	00.58	"
Zinc	00.01	"
Other impurities	1.02	"

The main constituents of this metal are seen to be lead and copper.

EXAMPLE OF AN OIL TEST, JUNE 5, 1907

	Cyl. Oil.	Air Comp. Oil.	Air Comp. Oil.	Cyl. Oil.	Cyl. Oil used.
Flash point	560° F.	460° F.	413° F.	569° F.	529° F.
Burning point	617° F.	497° F.	456° F.	628° F.	611° F.
Specific gravity	.895	.875	.9025	.8875	2.00 water
Resinous matter	27%	7%	13%	23%	1%
Acidity	no	no	no	no	slightly
Alkalies	trace	trace	present	trace	none



POWER DISTRIBUTION SYSTEM OF THE NEW YORK CENTRAL

In no branch of the terminal electrification has greater provision been made to insure continuous service than in the high and low tension distribution systems. The use of alternating current generators with three-phase transmission and the distribution of direct-current from rotary converter substations require a very complete operating organization to handle the routine and emergency work, in view of the large number of separate lines, switches, feeders, jumpers, rotaries, transformers and auxiliary apparatus in service. The responsibility of each employee in the power department is definite, and his duties under all anticipated conditions have been mapped out with great care. In the following section on the New York Central distribution system a number of points on power house and substation operation are included for the reason that it is difficult to draw arbitrary lines separating the different parts of the transmission, conversion and distributing equipment into distinct operating sections. The system as a whole, from the bus bars to the third-rail shoes, is an organized group of apparatus with inter-related and not separated parts.

The transmission lines and substations of the electrical division were described in the Street Railway Journal of Nov. 19, 1905, and only a brief resume will therefore be given at this time of the construction features. When the work is completed eight substations will be in operation, viz., No. 1, Fiftieth Street and Lexington Avenue; No. 2, Mott Haven; No. 3, Kings Bridge; No. 4, Yonkers; No. 5, Irvington; No. 6, Ossining; No. 7, Bronx Park; No. 8, Scarsdale.

Nos. 1, 2 and 7 are now in service, and Nos. 3 and 4 are ready for service at any time. The present equipment of all the substations is three 1000-kw rotary converters each, with the exception of Nos. 1 and 2, which have three 1500-kw rotaries each. Each substation may be fed from either power station, and the lines are so disposed that no ordinary accident can cut off a substation from its power supply. The system is designed to give the greatest protection against interruptions of all kinds, and the transmission lines are partly overhead and partly underground. Throughout the Park Avenue tunnel, along the viaduct, and also through the Harlem Division depression the conductors are carried in steel pipes, and in crossing the Harlem River the conductors are submarine cables laid in the bed of the river. The transmission line voltage at the power house is 11,000.

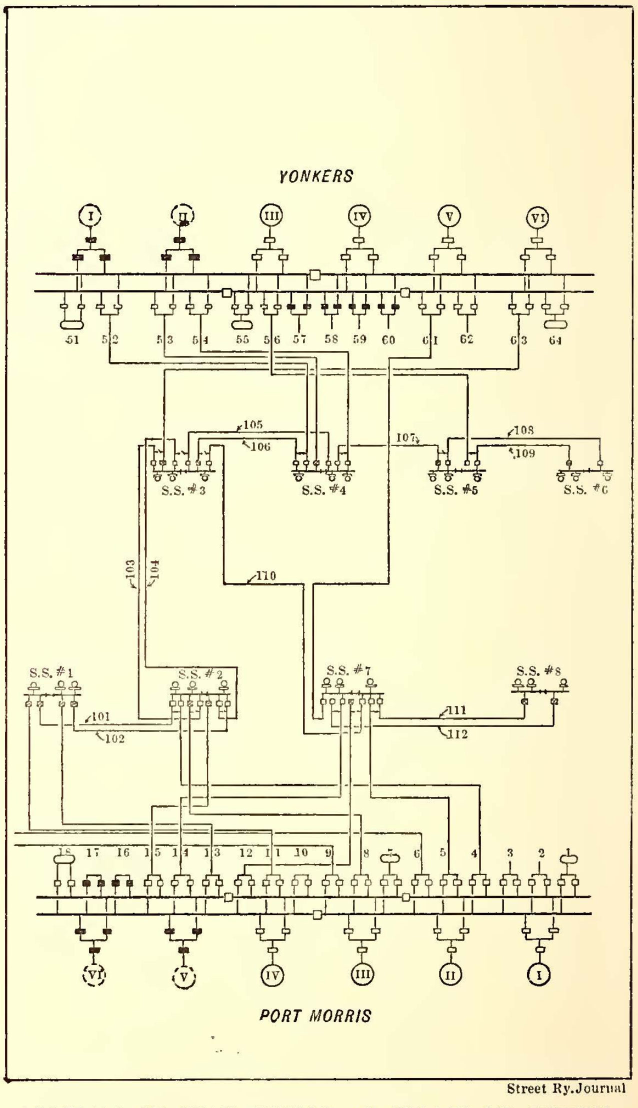
HIGH TENSION CIRCUITS

The diagram herewith shows the connections of the transmission lines with the power stations and substations. As stated, each power station has an initial equipment of four turbo-generators. Each station is provided with two sets of main high tension bus-bars. Each generator and each high tension line is provided with two selector switches and can be connected to either bus. The generators have an additional main switch in series with the selector switch. The testing transformers and the light and power transformers in each station can be operated from either set of high tension buses. Each substation is supplied by at least two high tension lines, and in the majority of cases special switches are provided in the substations, so that if desired the high tension current entering the station by one line can by-pass the substations and feed the next substation directly without going through the high tension bus of the first substation. The substation bus bars can be separated in two sections if necessary. The general flexibility of the scheme is clearly shown in the illustration.

The next cut shows the substation and power station high tension circuits a little more in detail as regards the bus bars and oil switches. Line oil switches and machine oil switches, both present and future, are shown, together with the tie switches, which enable the 11,000-volt power on any circuit to be fed past the substation if desired. All the high tension lines leaving Port Morris power station are carried underground. Both overhead and underground circuits will be run out from Yonkers power station.

LOAD DESPATCHER'S BOARD

The load despatcher's indicator board contains a skeleton diagram of the high tension system. At the Port Morris load despatcher's office, for example, the Port Morris high tension bus bars are shown near the bottom of the board, and the Yonkers buses at the top. The board is mounted against the wall close by the load despatcher's desk. The pilot lamps indicate the condition of the 11,000-volt oil switches in the station, and are operated in harmony with the oil switch movements by relay currents. A green light burning at any point on the diagram indicates that the oil switch at that point is open, and a red light indicates that it is closed. Similarly, red disks hung on the appropriate hooks indicate that the corresponding rotaries are running in the substations, and green



Street Ry.Journal

DIAGRAM OF HIGH-TENSION TRANSMISSION SYSTEM disks show that the corresponding machines are shut down. The high tension lines are shown in red on a slate background. The load despatcher's office also contains a direct current feeder dummy board showing the condition of each feeder and third-rail in the electrical division. Pegs are used to indicate whether switches are open or closed. A similar board is located in the office of the superintendent of power.

LOW TENSION DISTRIBUTION

The general connections of the direct current wiring in a typical circuit breaker house are shown on page 554. The four third-rails of the main line opposite each circuit breaker house are connected at the middle points of double throw single pole switches, by means of which they can be thrown upon either the main 660-volt current bus of the house, or an auxiliary bus used in emergencies. In this figure an auxiliary feeder cable running from substation to substation is also shown. A main circuit breaker is provided for the substation connection and the circuit breaker house as a whole, and each one of the four cables leading to the third-rail is also provided with a circuit breaker, as shown in the diagram. A spare breaker is included in the circuit breaker house outfit for use in case of emergencies.

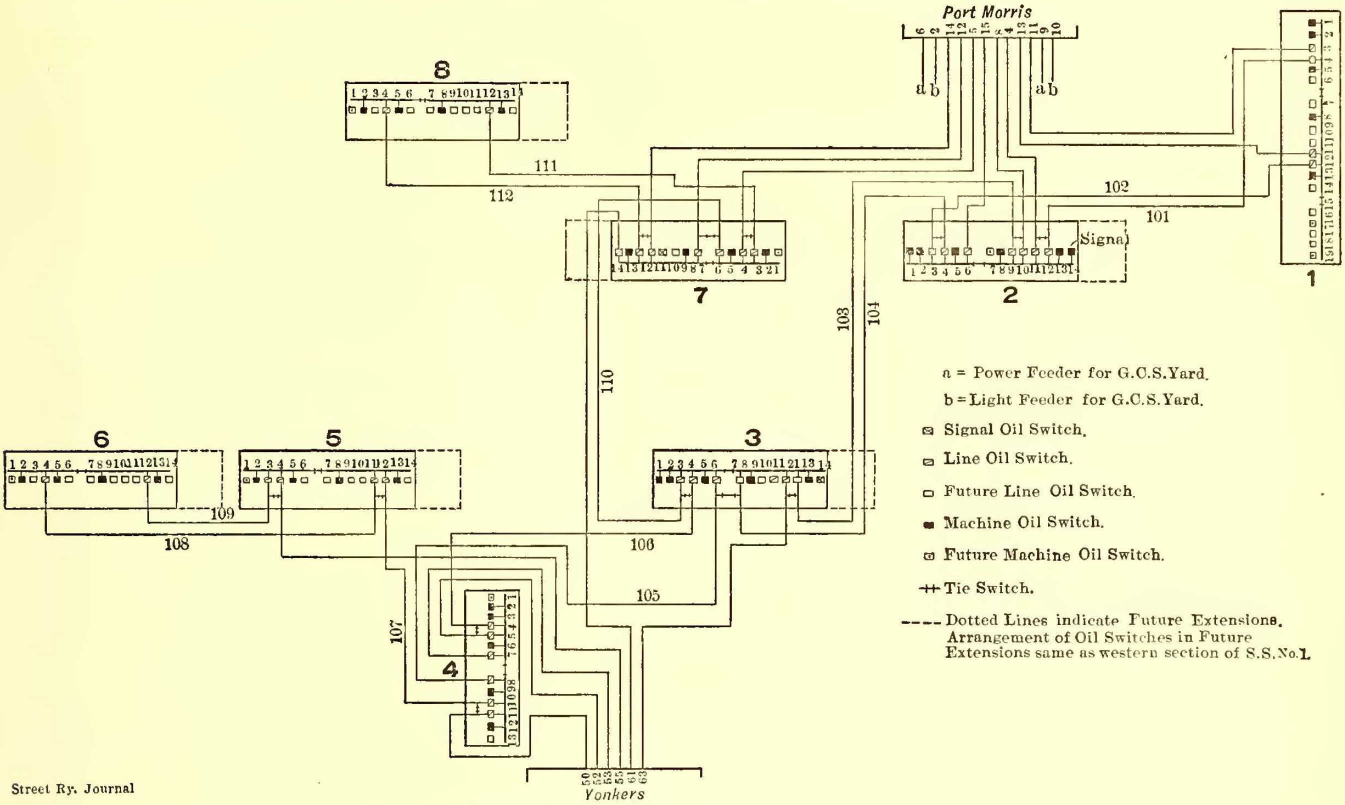


DIAGRAM OF HIGH-TENSION CIRCUITS

5, 6 and 8 entirely overhead. 1, 2, 4 and 7 entirely underground. 3, composite

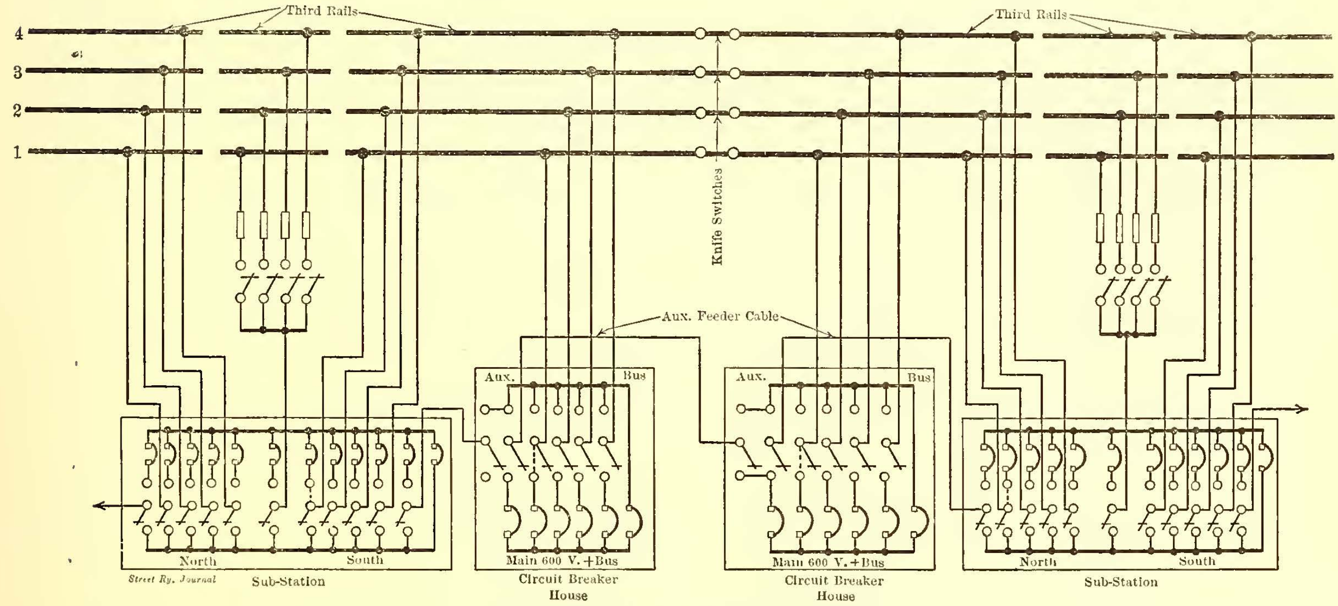
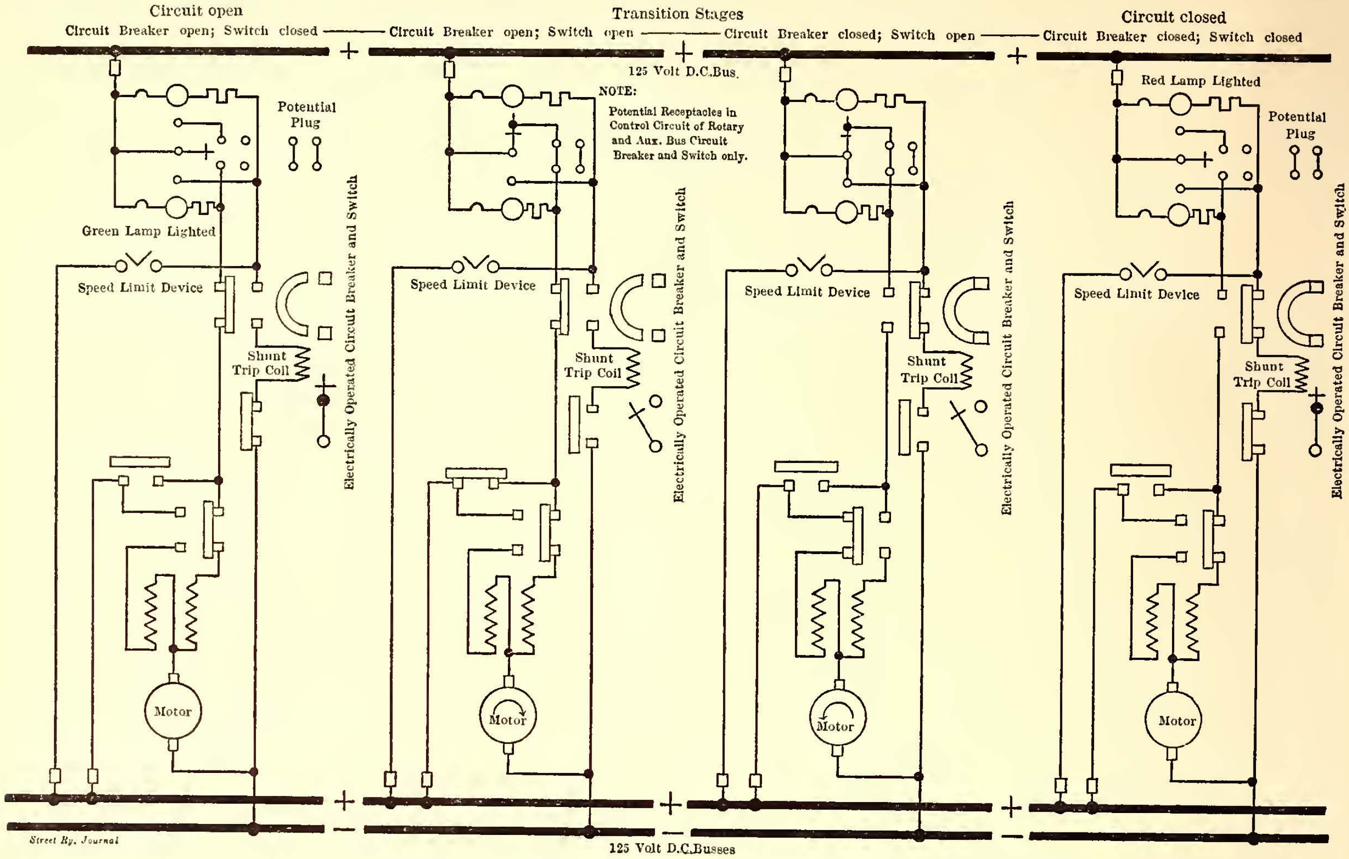


DIAGRAM OF DIRECT-CURRENT CIRCUITS

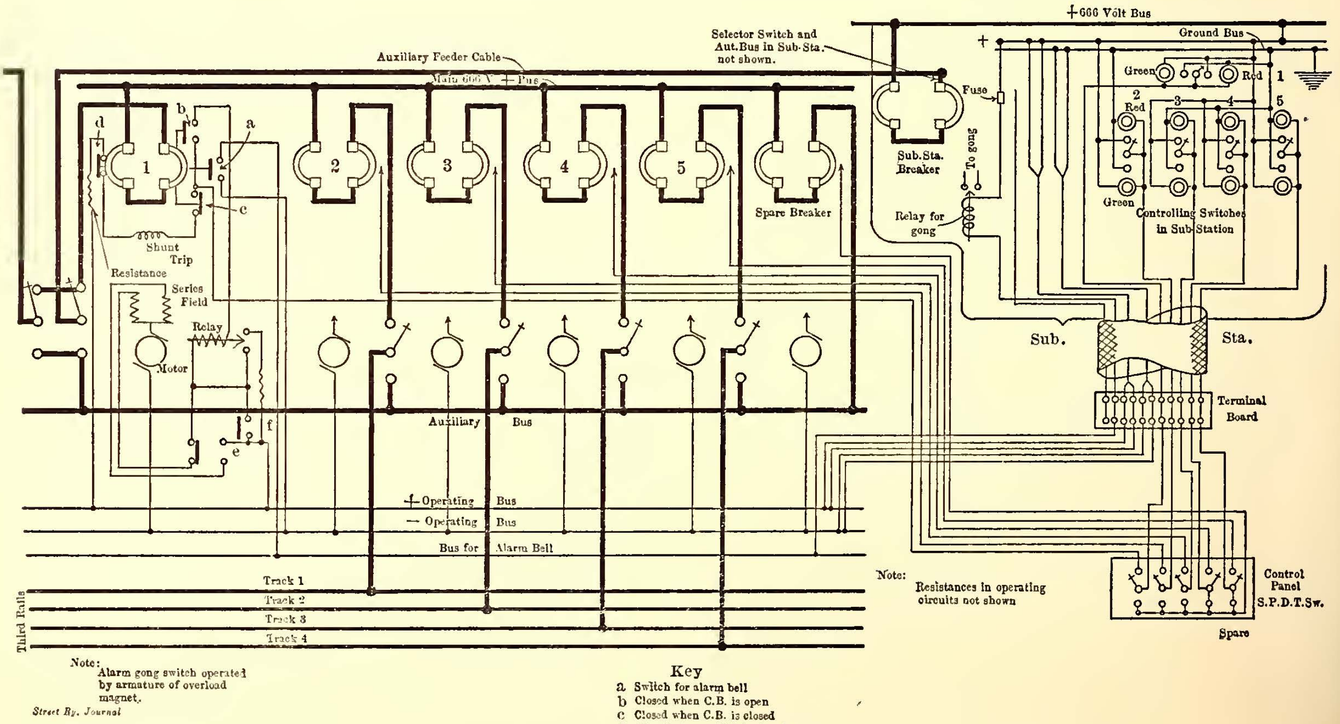
CIRCUIT BREAKERS

All the circuit breakers in the substations are operated by small motors, these being of the series wound type to assure sufficiently quick acceleration. A switch is in series with each circuit breaker, this switch also being operated by the same motor which operates the circuit breaker proper. In closing the circuit breaker the breaker proper is first closed and then the auxiliary switch, so that in case the feeder is closed on a short circuit the breaker can immediately open. The connections for operating these circuit breakers are shown herewith. The two elevations of the circuit breaker are shown on page 555.

The upper diagram on page 555 gives in schematic form the d. c. connections between four typical substations and their circuit breaker houses. The isolated sections of third-rail in front of each substation are 800 ft. long. The flexibility of the third-rail supply from either the main or auxiliary substation bus or circuit breaker house buses is evident from the diagram.



CIRCUIT BREAKER AND SWITCH CONTROL FOR SUBSTATIONS



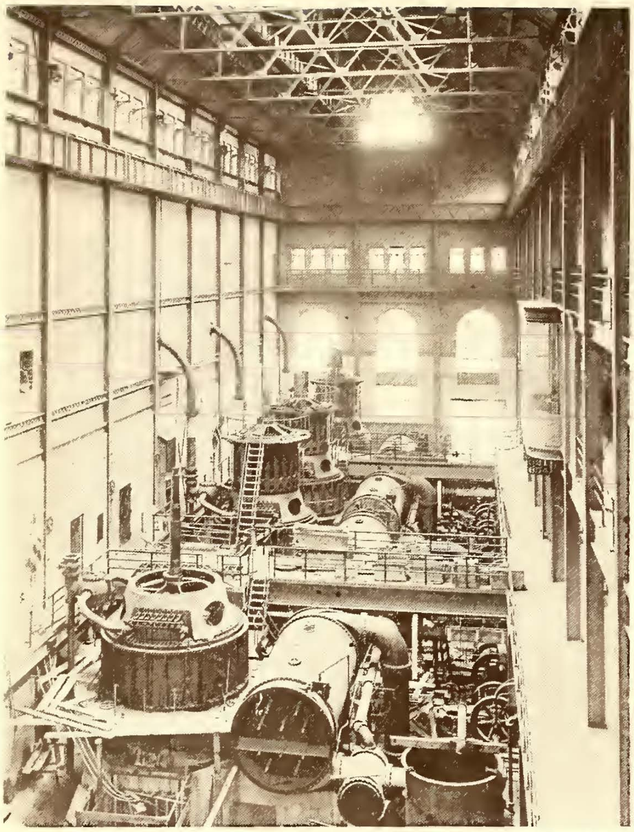
Key
a Switch for alarm bell
b Closed when C.B. is open
c Closed when C.B. is closed
d Closed when switch is closed
e D.T. Switch for reversing direction of rotation of Motor. In position as shown when Motor is at rest
f Master switch closes after C.B. has begun to close

CIRCUIT BREAKER HOUSE WIRING

EXTERIOR OF YONKERS POWER STATION (UNDER CONSTRUCTION)

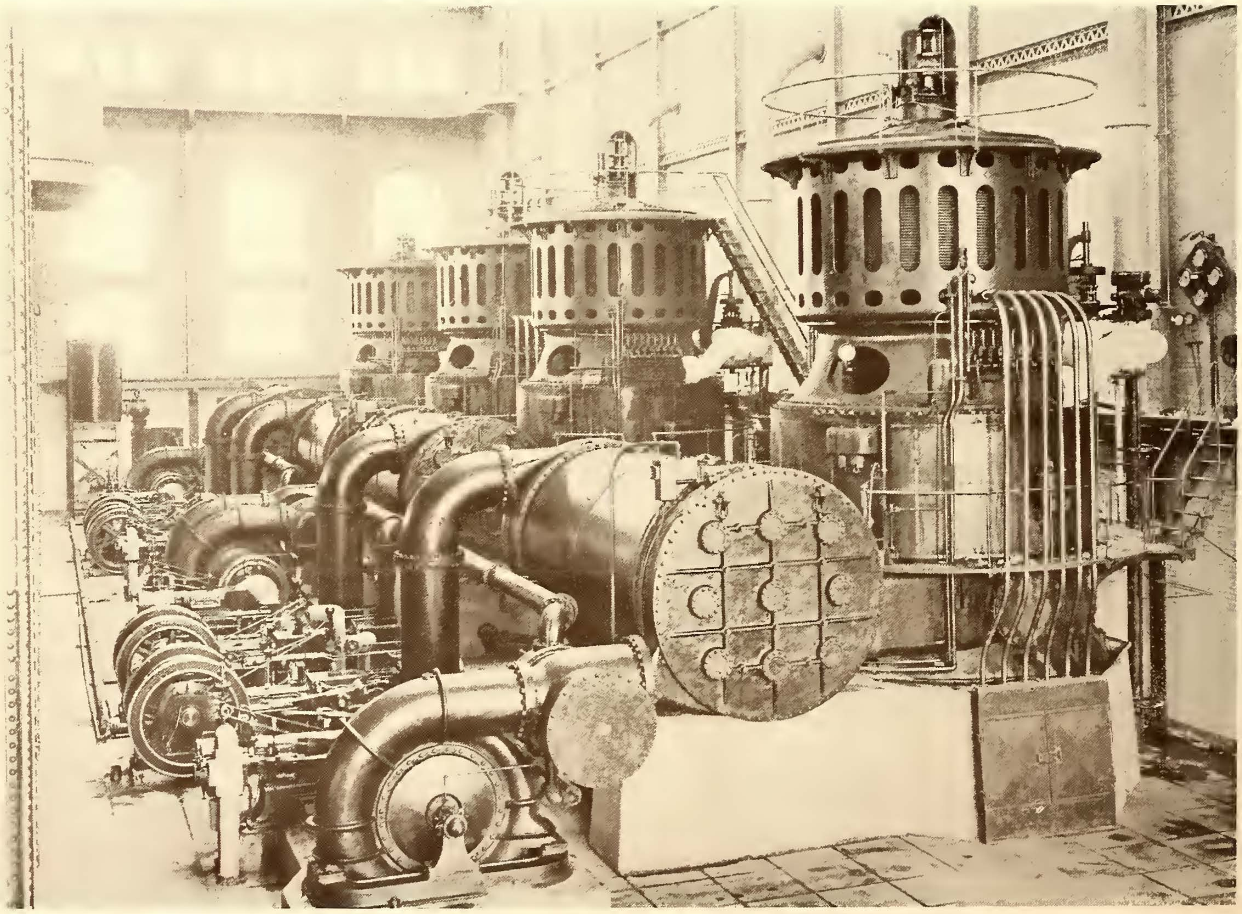
EXTERIOR OF PORT MORRIS POWER STATION

VIEW FROM RIVER OF PORT MORRIS POWER STATION OF NEW YORK CENTRAL RAILROAD, SHOWING RELATION OF POWER STATION AND SWITCH-HOUSE



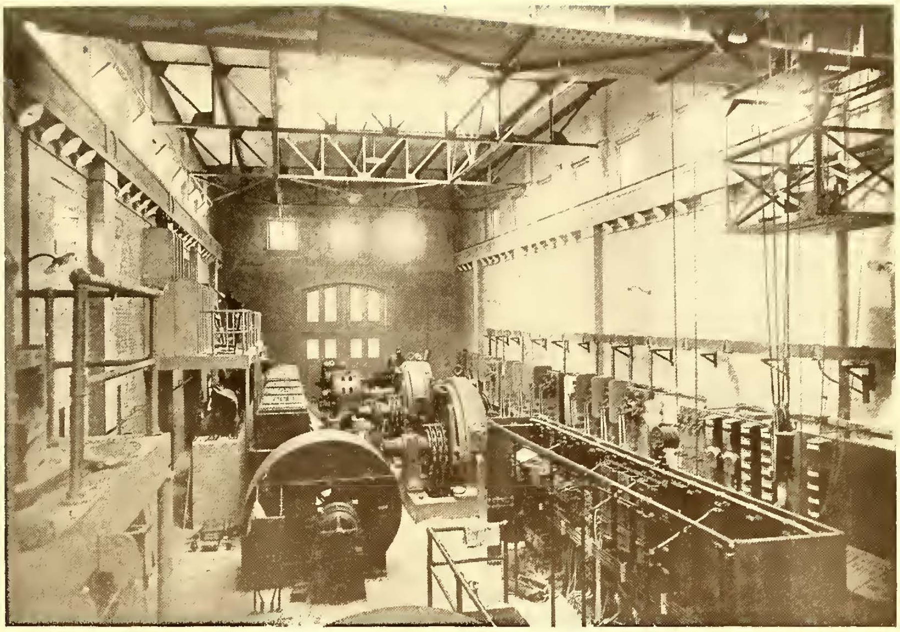
TURBINE ROOM UNDER CONSTRUCTION—YONKERS POWER STATION

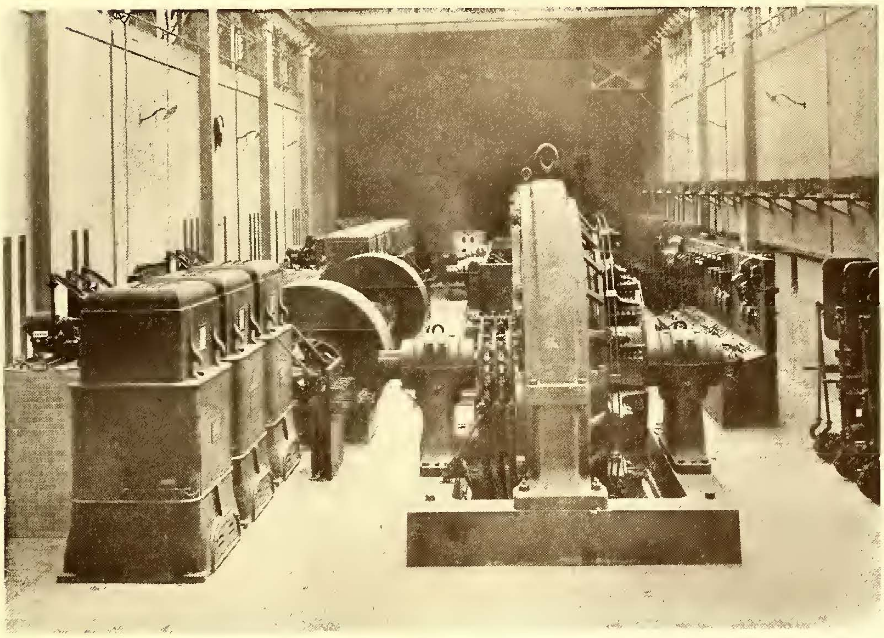
BOILER ROOM, PORT MORRIS POWER STATION



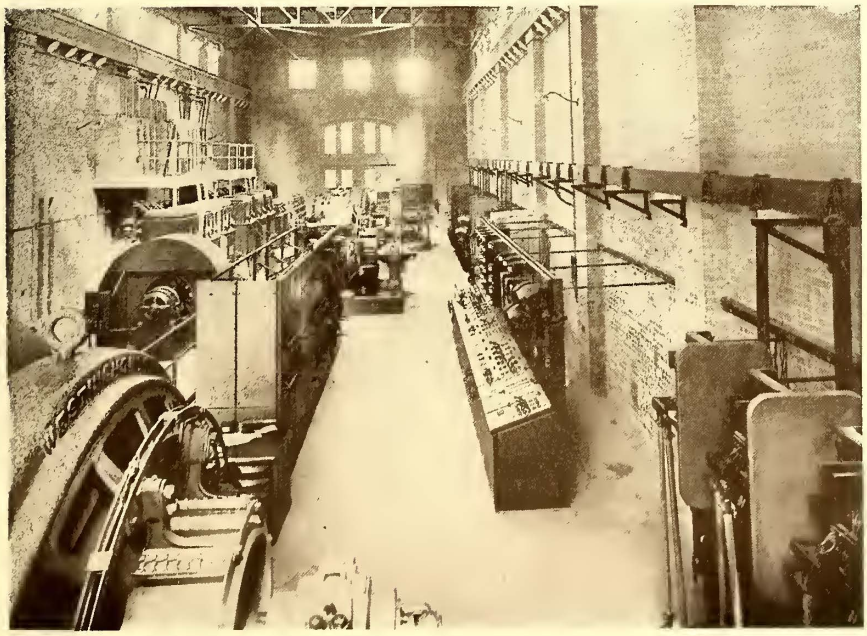
TURBINE ROOM, PORT MORRIS POWER STATION, NEW YORK CENTRAL RAILROAD

KINGSBRIDGE
SUBSTATION
(NO. 3),
LOOKING
WEST,
NEW YORK
CENTRAL
RAILROAD

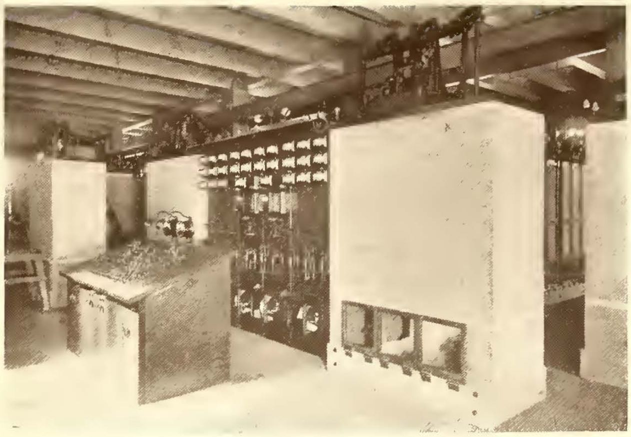




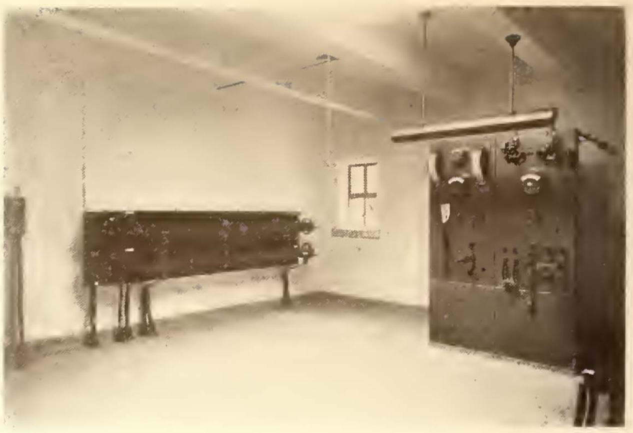
SUBSTATION NO. 1, NEW YORK CENTRAL RAILROAD



KINGSBRIDGE
SUBSTATION
(NO. 3),
LOOKING
EAST,
NEW YORK
CENTRAL
RAILROAD



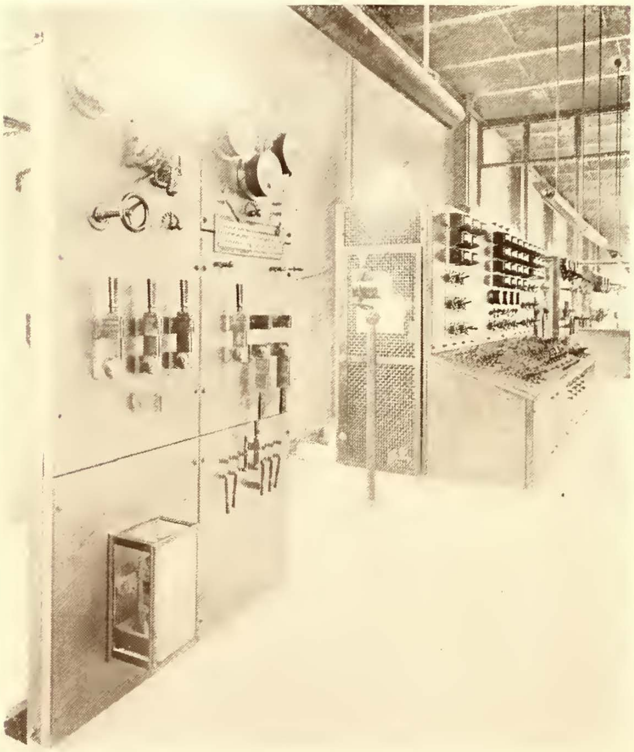
INSTRUMENT BOARD AND AUXILIARY OPERATING BOARD



BOOSTER ROOM SHOWING BATTERY END CELL SWITCH

SWITCH-HOUSE LABORATORY

BATTERY-ROOM LOOKING SOUTH

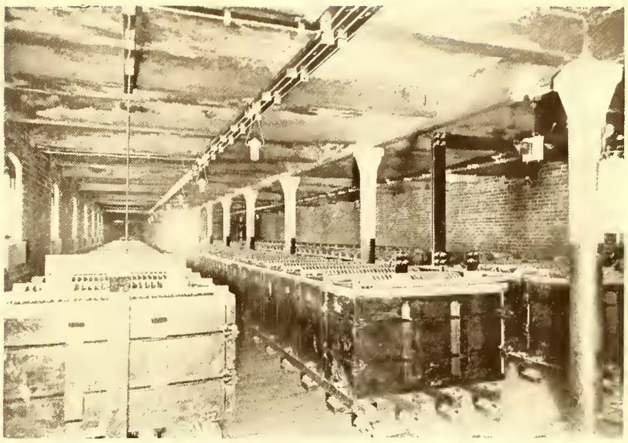


REMOTE CONTROL SWITCHBOARD

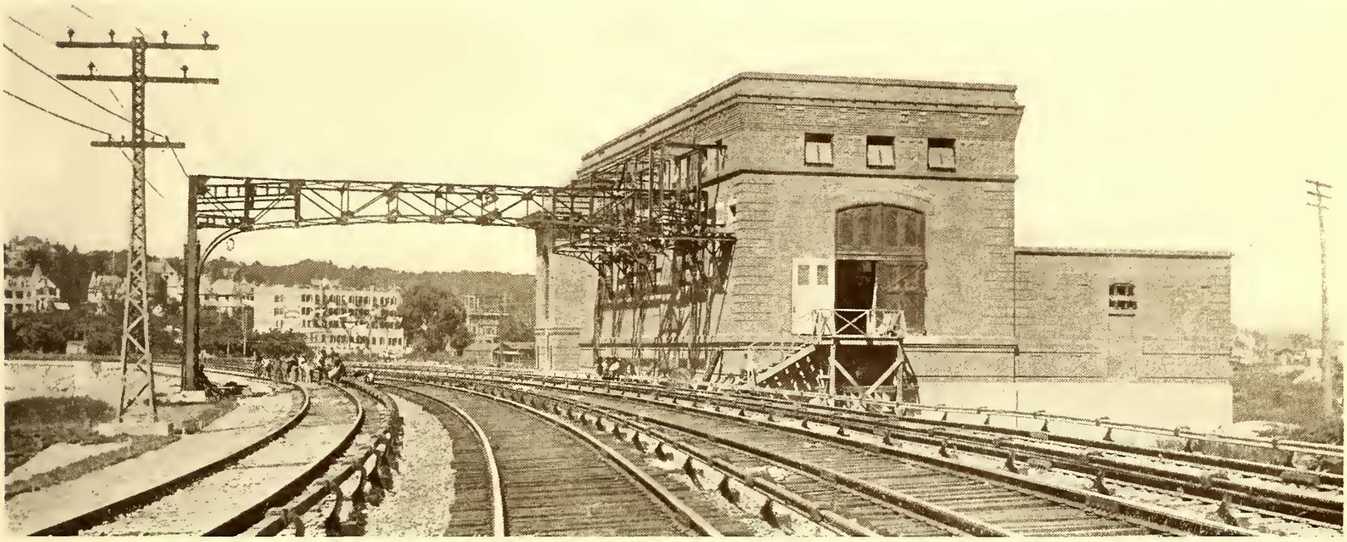
LOAD DISPATCHER'S OFFICE

VIEWS IN PORT MORRIS POWER STATION NEW YORK CENTRAL RAILROAD

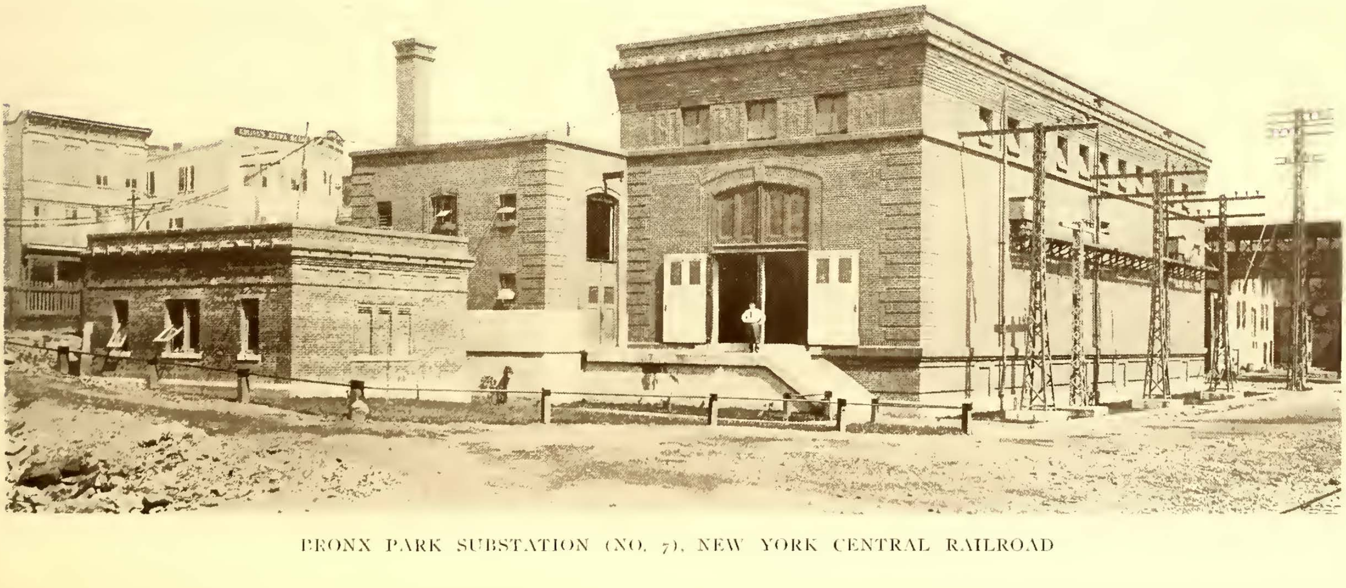
BATTERY ROOM, BRONX PARK SUBSTATION



BATTERY ROOM, KINGSBRIDGE SUBSTATION



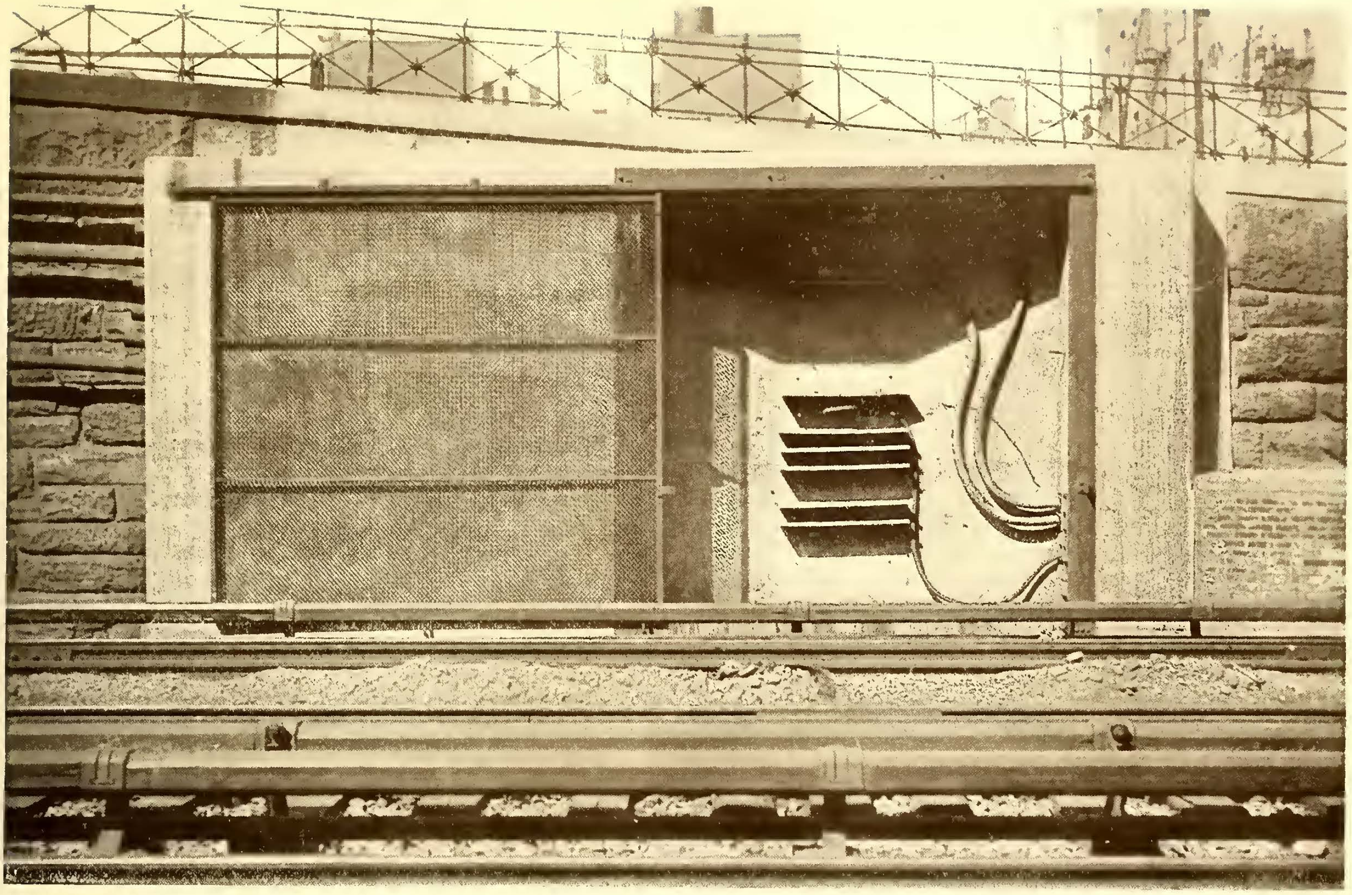
KINGSBRIDGE SUBSTATION NO. 3, NEW YORK CENTRAL RAILROAD



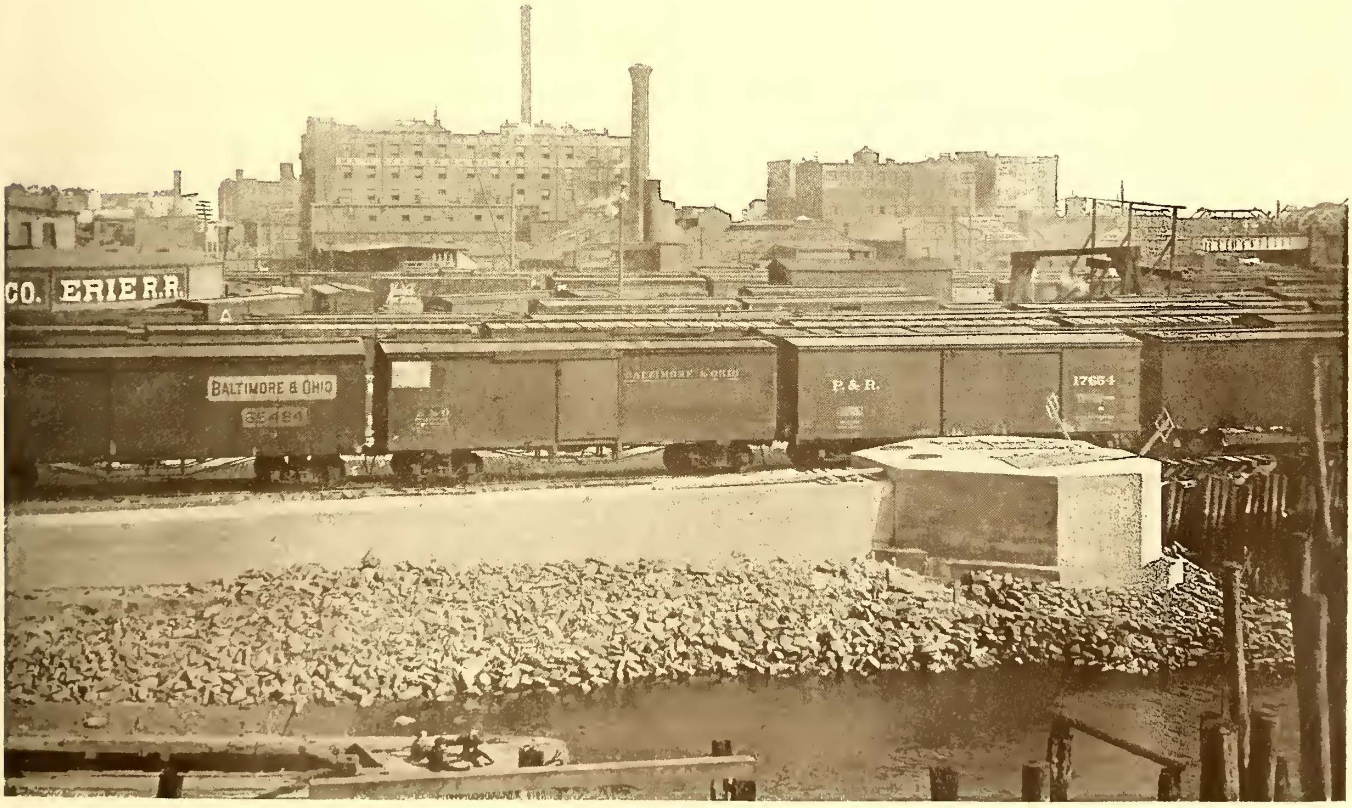
BRONX PARK SUBSTATION (NO. 7), NEW YORK CENTRAL RAILROAD

SIGNAL BRIDGE AT 108TH ST., LOOKING NORTH, NEW YORK CENTRAL RAILROAD

TYPICAL PIPE CONDUIT, LOOKING NORTH FROM 100TH ST., NEW YORK CENTRAL RAILROAD



SPLICING CHAMBER AT 99TH ST. WEST SIDE OF RAILROAD TRACKS, NEW YORK CENTRAL RAILROAD



MOTT HAVEN SPLICING CHAMBER AT HARLEM RIVER, NEW YORK CENTRAL RAILROAD

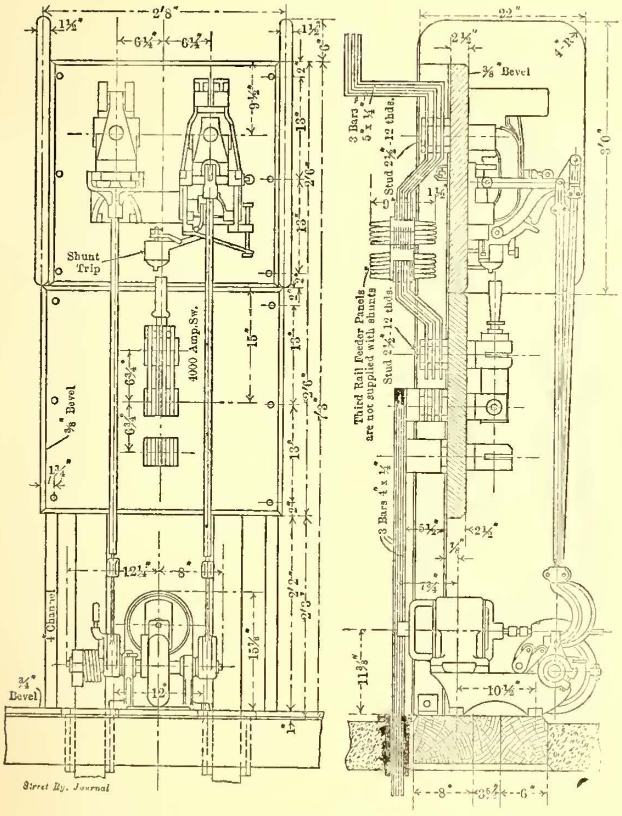
TYPICAL CIRCUIT BREAKER HOUSE, NEW YORK CENTRAL RAILROAD

HIGH-TENSION OVERHEAD POLE LINE, HUDSON DIVISION, NEW YORK CENTRAL RAILROAD

YARD DIAGRAMS

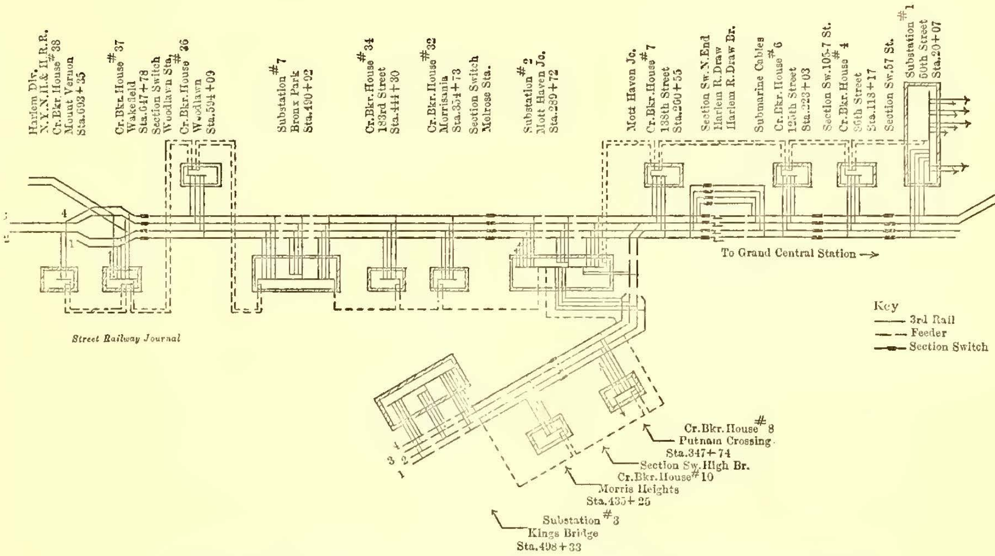
The cut on page 556 shows the scheme of third-rail connections throughout in the Grand Central yard and in the vicinity of substations 1, 2, 3 and 7. The long lines projecting from each rectangle representing a circuit breaker house or substation indicate the substation bus bars. Fourteen train tracks and a ladder connection in the Lexington Avenue terminal for suburban trains are shown, as well as twelve tracks for through trains in the Grand Central Station itself. The various third-rail jumper connections between the different yard tracks are also indicated.

The diagram on page 558 illustrates the track layout at the Grand Central terminal, and that on page 557 the layout at the Mott Haven yard, the overhead contacts in each case being shown by cross dotted lines. The lower part of the former figure represents the Lexington Avenue terminal, and the upper part the Grand Central Station tracks. The arrangement of these tracks will, of course, be greatly changed upon the completion of the construction work for the new terminal as planned by the company and now in process of execution.



4000 AMP. MOTOR OPERATED CIRCUIT BREAKER AND SWITCH

An interesting feature of the yard practice at Mott Haven is the provision of remote control switches at eleven points in the yard. In case any section of the third-rail is cut out, it is not necessary for the employee responsible for closing the circuit breaker corresponding to his section to go back to the circuit breaker house on foot and thereby lose time. Each section of the yard is provided with a separate circuit breaker in the circuit breaker house and the remote control switches control these switches as desired.



SIMPLIFIED DIAGRAM OF D. C. FEEDERS—MAIN LINE, THIRD-RAIL

In case repairs are necessary on any section of the third-rail at this point the circuit breaker corresponding can be electrically locked against closing by a suitable connection on the yard switch.

SUBSTATIONS

Each substation converts the high tension current to direct current of 666 volts for delivery to the third-rail, and each substation is provided with a storage battery equipment of sufficient capacity to operate the maximum train load for about one-half hour. In order to provide against interruptions in the substations the following general principles of design were followed: (1) The path of the current was made as short and direct as possible from the transmission lines to the d. c. feeders; (2) the wiring is as little exposed as possible and yet is readily accessible; (3) all machinery is on the same floor as the operating switchboards; (4) the principal apparatus is under the direct control of the operator while standing at the boards; (5) all equipment is so arranged that the effects of an accident will be confined to the place where it occurs; (6) risk of accident to the operator is as slight as possible, and finally (7) the stations are of fireproof construction.

All overhead lines are provided with knife switches to disconnect them from the substation apparatus. The oil switches are provided with pilot lamps to indicate at the control board whether they are open or closed. There are two controlling switchboards situated in a part of the station which will be the center when the station is extended to its final limits. The substation batteries have capacities varying from 2250 amps. to 4200 amps. for one hour.

The direct current feeder system is designed to provide duplicate paths for the current from the substation to the third-rail. Opposite each substation is a section of the third-rail 800 ft. long separately fed from the substation. In case of trouble this isolated section can be killed to prevent a train bridging between the main sections each way from the substation.

BOOK OF RULES

The following paragraphs are taken from the book of instruction and rules for the electric power department:

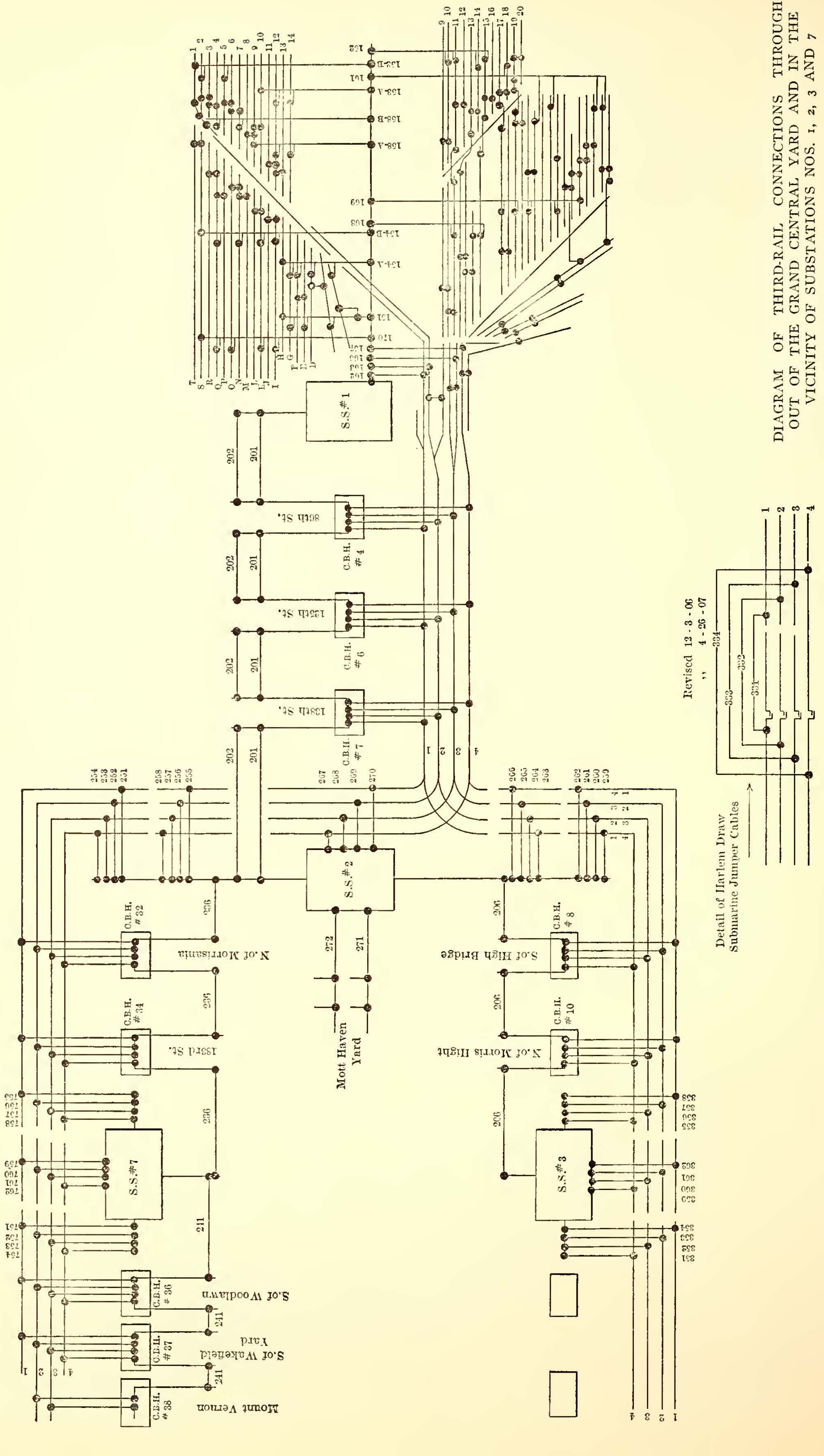


DIAGRAM OF THIRD-RAIL CONNECTIONS THROUGHOUT OF THE GRAND CENTRAL YARD AND IN THE VICINITY OF SUBSTATIONS NOS. 1, 2, 3 AND 7

NORMAL OPERATION OF THE ELECTRIC POWER SYSTEM.

A. ELECTRIC POWER SYSTEM.

1. The "electric power system" consists of the power houses, 11,000 volt lines, substations, 660 volt feeders, circuit breaker houses, the third-rail, overhead working conductors, and track rail return.

B. LOAD DESPATCHER.

2. The general operation of the electric power system is under the immediate supervision of the Load Despatchers, reporting direct to the Superintendent of Power. For the initial operation there is one Load Despatcher's office, located on the second floor of the Port Morris switch house. This is connected by a private telephone line known as the Load Despatcher's telephone system with the different substations, the two power stations and such offices as are necessary. There are also telephone connections through the public service to the Load Despatcher's office and to the stations and substation. Also through the railroad company's general service and substation party line systems as explained in emergency directory.

3. All cases of trouble, which are likely to affect the operation of the electric system, occurring in or reported to the power house or substations, must be promptly reported to the Load Despatcher on duty. The Load Despatcher will then communicate with the proper department or person and will take such further steps as may be necessary to insure continuity of operation.

C. POWER STATIONS.

4. Each power station is in charge of a Superintendent, reporting direct to the Superintendent of Power. Reporting to the Superintendent of the Power Station are three watch engineers, one of whom is always on duty. The watch engineers have immediate charge of the operation of the power house, and are responsible for having sufficient capacity in boilers, turbines and auxiliary apparatus to carry the normal load, ready as needed. They will also, under instructions from the Load Despatcher, carry such additional load as may be needed.

5. The watch engineer on duty must see that the Load Despatcher is kept posted as to the number of turbines in service and the number of boilers under steam and banked.

6. Any trouble, actual or impending, which is likely to interfere with the operation of the station must also be promptly reported to the Load Despatcher, so that arrangements can be made with the other station to carry additional load.

D. POWER SUBSTATIONS.

7. The substations containing rotary converters and storage batteries are called "power substations" to distinguish them from those for furnishing current for signals, which are known as "signal substations."

8. All substations are in charge of the Superintendent of Substations, reporting direct to Superintendent of Power, and each power substation and its adjoining signal substation is in charge of a Substation Foreman. In case the foreman is not on duty the power substation and also the signal substation will be in charge of the Power Substation Operator on duty.

9. The substation operators will run such rotaries as may be needed to carry the load, and will operate their storage batteries as may be directed from time to time by the Superintendent of Substations.

10. No 11000 volt line switches shall be operated without instructions from the Load Despatcher, except in case of extreme emergency, and if so operated the Load Despatcher must be promptly advised. This also applies to the 2200 volt signal circuit switches.

11. The substation foremen or operators will take instructions from the Load Despatcher in regard to switching all outgoing or incoming circuits.

12. The Load Despatcher must be kept advised of the number of rotaries running and also, in a general way, as to the amount of power left in the storage batteries.

13. Any trouble occurring or impending in the substations must be reported to the Load Despatcher as soon as possible, also any trouble occurring or impending near the substation on the lines or third-rail which may be brought to the attention of the substation foremen or operators must be reported at once to the Load Despatcher.

E. SIGNAL SUBSTATIONS.

14. The signal substations furnish single phase alternating current at a frequency of 25 cycles for supplying the signal system. All signal substations furnish this current at 2200 volts pressure, except at signal substation No. 1, where 300 volt signal circuits are used for supplying the Grand Central yard. A 2200 volt signal circuit also runs from No. 1 signal substation, supplying the main line signals north of 57th Street.

15. In signal substations Nos. 2, 3 and 7 current is furnished normally by a static transformer, stepping down from 11,000 to 2200 volts. Motor generators with 660 volt direct current motors and 2200 volt alternating current generators are also provided. In case of failure of the 11,000 volt supply of current, the motor generators will be operated, current for them being furnished from the storage batteries in the power substations.

16. In substation No. 1 no static transformer is provided for stepping down from 11,000 volts. Motor generators are used for generating alternating current at a pressure of 300 volts. A static transformer is provided for stepping up from 300 to 2200 volts.

17. The operators in the signal substations will report to the foreman of their respective power substations, or to the operators on duty in the power substations.

18. The circuits running from the signal substation must not, except in case of emergency, be opened without instructions from the office of the Engineer of Signals, these instructions to be given to the Load Despatcher. The Load Despatcher will, before ordering circuit opened, obtain permission from the Train Despatcher of Electric Division.

F. CIRCUIT BREAKER HOUSES.

19. Two circuit breaker houses are located between each two adjacent power substations, and between substations No. 1 and No. 2 there are three. Each circuit breaker house contains, as a rule, six circuit breakers, one for the connection to each of the four third rails, one for the auxiliary feeders and one for a spare, in case of the failure of either of the other five.

20. The circuit breakers will open on an overload automatically, and can also be opened or closed from the nearest power substation, pilot lamps in the power substations indicating whether the breakers are opened or closed.

21. The Superintendent of Substations is responsible for the operation and maintenance of the circuit breaker houses.

G. CABLE DEPARTMENT.

22. The cable department is under the general direction of the Superintendent of Cables, reporting direct to the Superintendent of Power. Two assistants, Foreman of Overhead Lines and Foreman of Underground Lines, report to the Superintendent of Cables.

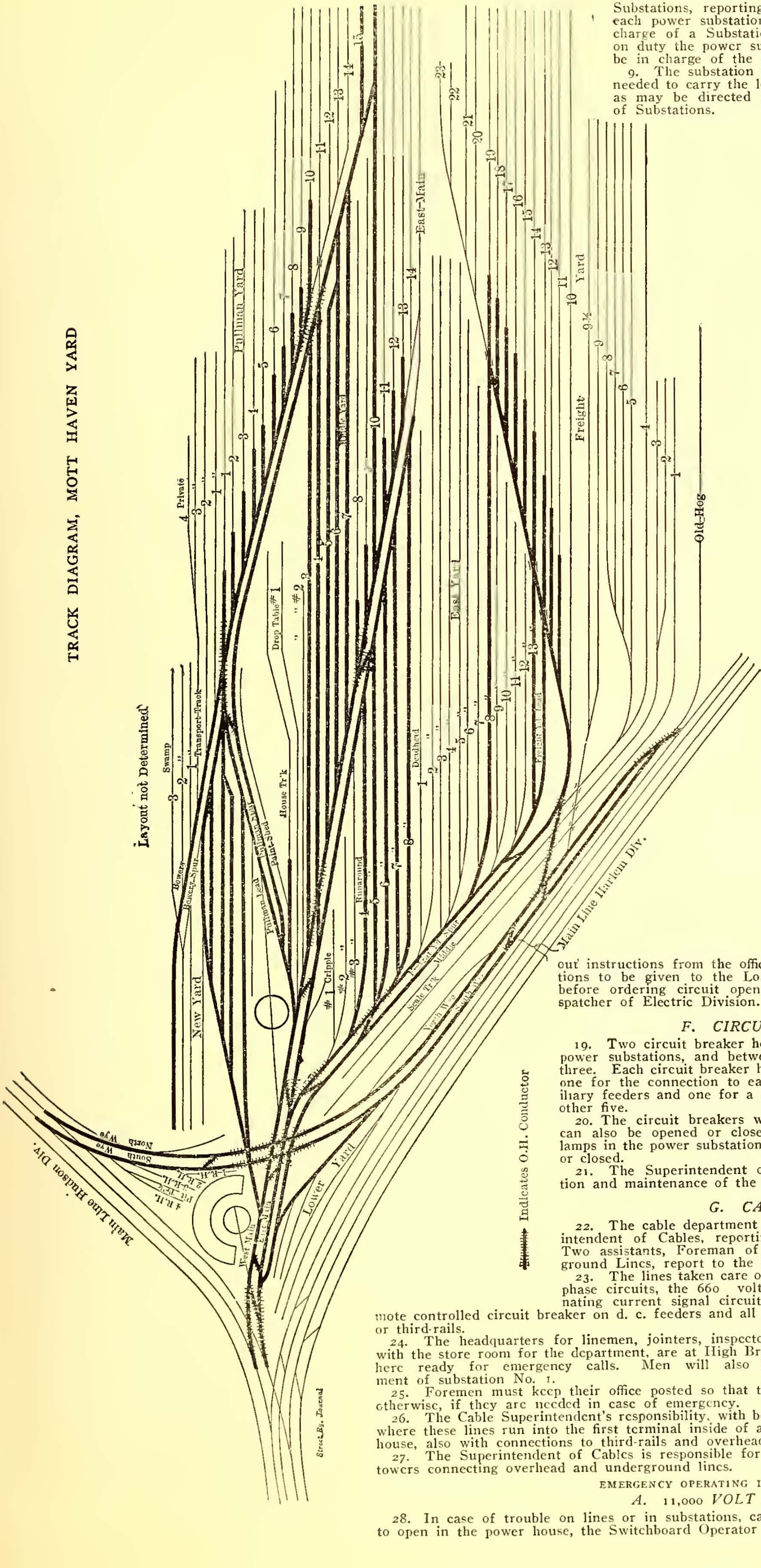
23. The lines taken care of by this department are the 11,000 volt, three-phase circuits, the 660 volt direct current feeders, the 2200 volt alternating current signal circuits, the control circuits for operating the remote controlled circuit breaker on d. c. feeders and all jumpers connecting isolated sections of track or third-rails.

24. The headquarters for linemen, jointers, inspectors and helpers in this department, together with the store room for the department, are at High Bridge. Men will be on twenty-four hour duty here ready for emergency calls. Men will also be on twenty-four hour duty in the basement of substation No. 1.

25. Foremen must keep their office posted so that they can be reached readily by telephone, or otherwise, if they are needed in case of emergency.

26. The Cable Superintendent's responsibility, with both overhead and underground lines, will end where these lines run into the first terminal inside of a power station, substation, or circuit breaker house, also with connections to third-rails and overhead working conductor.

27. The Superintendent of Cables is responsible for the operation and maintenance of the cable towers connecting overhead and underground lines.



TRACK DIAGRAM, MOTT HAVEN YARD

EMERGENCY OPERATING INSTRUCTIONS.

A. 11,000 VOLT LINES.

28. In case of trouble on lines or in substations, causing one or more 11,000 volt line switches to open in the power house, the Switchboard Operator will report at once to the Load Despatcher,

giving information as to switches that open. If any damage has been caused, either to the turbines or to the oil switches, he will report the same, and will advise the Load Despatcher as to the station's ability to carry the load which has been dropped.

29. The Switchboard Operator will prepare to test the feeders which have opened, but will not put current on them until instructed by the Load Despatcher to do so.

30. If an idle bus is available the feeders to be tested will be thrown to this bus and the test made by means of one of the turbo generators or by the testing transformer in the switch house.

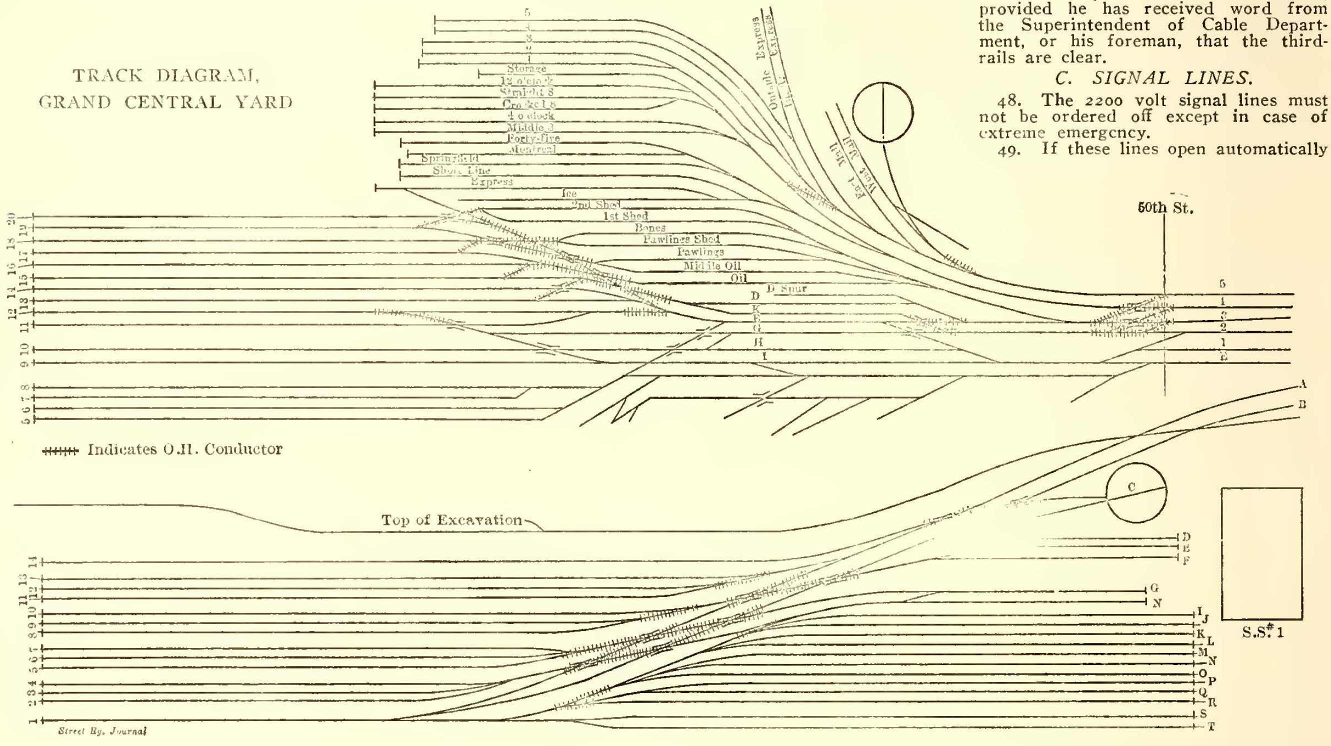
31. This test should be made beginning at not more than 2500 volts. If no trouble develops inside of one minute, advise the Load Despatcher, who will then notify the substations to put load on line or lines which have been tested.

32. If an idle bus is not available, either a section of one of the two buses will be killed or temporary connections will be made from the testing transformer.

33. If but one line is out of service, and if both buses are in use, the test may be postponed for a short time if the line is not needed immediately. Instructions from the Load Despatcher will govern.

34. If test shows there is trouble on a feeder, endeavor to isolate it in case it is possible to open the feeder in a substation or cable tower.

35. These tests, as covered by paragraphs 29, 30, 31, 32, 33 and 34, will be made under the direction of the power station electrical foreman or his assistants, under instructions from the Load Despatcher.


TRACK DIAGRAM, GRAND CENTRAL YARD

36. Further tests to determine the exact location of trouble in any given feeder will be made under the direction of the Engineer of Tests.

37. In case of a 11,000 volt line switch opening in a substation, the substation operator will report the trouble at once to the Load Despatcher, and instructions for testing this feeder will be given by the Load Despatcher.

38. As soon as possible after trouble occurs on the 11,000 volt lines the Load Despatcher will notify the office of the Superintendent of Cables, so that arrangements can be made to assemble men for repair work. This must be done at once without waiting for tests to be made to locate trouble.

39. The Superintendent of Cables, or his assistant on duty, will immediately send out one or more men to look for the trouble, and will hold his other men to await further reports from the men sent out, or from the Load Despatcher's Office.

40. If the trouble is found by the men sent out by the Superintendent of Cables they must not start work on the line without first getting permission from the Load Despatcher's Office, as there is a possibility of current being on for testing purposes.

41. As soon as repairs have been made on an underground 11,000 volt line, both insulation and phase tests must be made before the line is again put in service, this test to be made by the Engineer of Tests, who may call upon the Electrical Foreman of the Power Station, or his assistants, to make the test if necessary. The Engineer of Tests will, however, be held responsible for the test.

42. At the discretion of the Load Despatcher an overhead 11,000 volt line may be put in service after repairs have been made, without any tests.

B. 660 VOLT DIRECT CURRENT FEEDERS.

43. The four direct current feeders to the isolated section of the third-rail opposite each substation are connected to one circuit breaker. In case this circuit breaker opens, close it immediately. If it opens the second time isolate the trouble by opening first one knife switch and then another until the trouble is found, then leave the knife switch open on the section of track on which the trouble is located, reporting the same at once to the Load Despatcher. If a man is available in the substation, send him to examine the isolated section, and if the trouble is found report at once to the Load Despatcher the nature and extent of same. If a man is not available, the Substation Operator will report trouble to Load Despatcher, who will refer same to office of Superintendent of Cables.

44. In case of circuit breakers opening on the feeders other than to the isolated section of third-rail, close them immediately. If they open the second time, wait thirty seconds and close again. If they open the third time, notify the Load Despatcher, who will report the trouble to the office of Superintendent of Cables. The feeders must not be closed again without orders from the Load Despatcher.

45. The Load Despatcher may at his discretion order the feeders closed for further test. He must not, however, order this done after the feeders have been turned over to the cable department, without first receiving advice from the foreman on the work.

46. In the case of a general short circuit, causing all or part of the d. c. line circuit breakers to open in the lines feeding either to the north or south from his substation, a substation operator will first see that all or part of the d. c. line circuit breaker are open in the circuit breaker houses controlled from his substation to the north or south, whichever way the trouble may be. He will then proceed to make alive in his substation first one third-rail and then another of those which have been killed until either all are alive or until the trouble is isolated. He will then notify the Load Despatcher, who will, after talking with the adjoining substation, advise him in regard to closing the circuit breakers in the circuit breaker houses.

47. In case of current being held off from one or more third-rails on account of a wreck, it must not be put on without orders from the Load Despatcher, and the Load Despatcher must not give such orders without first receiving corresponding orders from the Train Despatcher or Superintendent of the Electric Division. As soon as notice is given by the Train Despatcher or Superintendent to the Load Despatcher to have current put on, the Load Despatcher will so notify the substations affected, provided he has received word from the Superintendent of Cable Department, or his foreman, that the third-rails are clear.

C. SIGNAL LINES.

48. The 2200 volt signal lines must not be ordered off except in case of extreme emergency.

49. If these lines open automatically in the signal substations they must be immediately closed, and if they open the second time close them again. If the trouble still holds on, report at once to the Load Despatcher, who will advise as to further tests and who will report the trouble to the Train Despatcher, to the Superintendent of Cable Department and to the Engineer of Signals.

50. The Line Foreman working under the direction of the Superintendent of Cables will, as quickly as possible locate the trouble, and if it cannot readily be removed will isolate as much as necessary of the signal circuit in order to clear trouble. He will then report to Load Despatcher, stating condition of lines and request that such parts as he has cleared, be made alive.

51. Further repairs will be made as directed by Superintendent of Cable Department.

52. Failures of 2200 volt signal transformers on overhead or underground lines will be reported from the office of the Engineer of Maintenance of Way to the Load Despatcher's Office and by the Load Despatcher to the line trouble men on duty. These men, working in pairs, will locate trouble, and will repair or replace whatever is necessary as quickly as possible.

53. The 50 volt signal circuits will be maintained by the maintenance of way department, the dividing line being at the 50 volt terminals of the transformers.

54. Trouble with the transformers, even though it be with the 50 volt winding, will be taken care of by the electric power department.

55. The 300 volt signal circuits from signal substation No. 1 will be taken care of by the maintenance of way department. The maintenance of way department will also replace 2200 volt transformer fuses.

D. SUBSTATIONS.

56. In case of loss of 11,000 volt power on substation bus bars, the substation operator will immediately open the high tension oil switches, both on the rotaries, boosters and the feed to the signal substations, leaving the high tension line switches as they are, and then throw the battery switch direct to the negative bus.

57. The operator or his assistant will next call up the Load Despatcher, stating that he has lost the 11,000 volt power and that all machines are clear from the high tension bus.

58. After this, call the operator in the adjoining signal substation and see that he has started the motor generator and is maintaining current on the signal circuits.

59. If the battery is discharging at more than the twenty minute rate, bring the discharge down to the twenty minute rate by opening feeders to one or more tracks.

60. If at the end of ten minutes a. c. power has not been restored,

open sufficient feeders to bring the discharge down to the half hour rate. The substation operator will then advise the Load Despatcher as to the situation in his substation and as to the probable length of time he can carry what load he has on the battery.

61. As soon as a. c. power is restored, start up from the a. c. end as many rotaries as were running previous to the trouble, being sure that the polarity of each rotary is right before starting the next machine. As soon as these rotaries are running, close them one after another to the direct current bus.

62. Be sure that the signal substation operator is notified before closing the rotaries to the direct current bus, so that he can watch his motor generator closely when the increased direct current bus pressure comes.

63. If the battery has been discharged to such an extent that it takes an excessive charge, open battery circuit breaker and leave battery off until provisions can be made for charging through the booster.

64. If the battery has received an excessive discharge it should be at least partially charged as soon as possible.

65. As soon as a. c. power is restored, and substation is operating normally, notify the signal substation operator so that he can shut down his motor generator and throw his signal circuits to the static transformer.

E. GENERAL INSTRUCTIONS.

66. The superintendent of cable department will see that a sufficient force of men is kept on duty night and day to handle ordinary cases of trouble, and will see that all of his men can be readily reached by telephone, or otherwise, at any hour, either nights, Sundays or holidays.

67. Notices have been sent to the agents in the passenger stations, and have been posted at various points along the right of way, giving the power station and substation telephone numbers, so that in case of an emergency, instructions can be telephoned asking to have the power cut off from the third-rail. Party line telephones with direct connections to substations are installed in all passenger stations and at other points along the right of way.

68. In case such telephone messages are received at the power houses or substations definite information should be asked as to the nature and location of the trouble, and the name of the party asking to have current cut off should be ascertained.

69. A substation operator upon receiving such a call will immediately cut off current from the track or tracks as requested, providing his substation feeds the place from which current is asked to be cut off, and he will also call Load Despatcher so that the adjoining substation can be notified to open their feeders to the same place.

70. If a substation operator receives a request to have current cut off from track not fed from his substation he will notify Load Despatcher, who will transmit the request to the proper substation. Such a call should be put down in writing as soon as possible after it has been received.

71. After the third-rail has been killed in this manner, it will not again be made alive until the Load Despatcher has received word from the Superintendent of Cables, his foremen or some other responsible party, that it is safe to put current on. If the trouble has been due to a wreck, permission must be received from the Superintendent or Train Despatcher of the Electric Division before putting current on.

F. LOSS OF TELEPHONE COMMUNICATION.

72. Ordinarily telephone communication between the power stations, the substations and the Load Despatcher will be on the private system known as the Load Despatcher's telephone system. A New York Central general telephone system is installed and connections made from this system to the Load Despatcher's office, power stations and substations. There are also connections from the New York Telephone Company's exchanges to the Load Despatcher's office, all power stations and substations. Telephone numbers will be found in the emergency directory.

73. In case of the failure of the Load Despatcher's system, use the general system, and in case of failure of this, use the New York Telephone Company's Lines.

74. In case of trouble occurring during a time that all telephone systems are out of order, the following rules should be observed:

75. If 11,000-volt line switches open at the power station two minutes will be allowed substations to clear their buses, when power will be thrown on again or as soon thereafter as the power station is ready.

76. If the switch or switches open the second time they will be left off until communication is re-established by telephone or otherwise with the substations affected.

77. If a 11,000-volt line switch opens in a substation on a line which runs beyond the substation, the operator will after an interval of two minutes close this line switch, first cutting the line clear from the substation bus bars, if there is such a connection. If it opens the second time he will leave it open until communication by telephone or otherwise is established with the Load Despatcher's office.

RULES TO INSURE SAFETY OF EMPLOYEES AND OTHERS.

A. GENERAL INSTRUCTIONS.

78. Visitors will not be allowed in power stations or substations without properly signed permits.

79. Visitors will not be allowed on switchboard gallery or in bus bar chambers of power stations, nor in basements of substations unless such permission is specifically given on their permit to visit station or substation.

80. If a visitor's pass allows him to visit switchboard gallery, or the vicinity of high tension work, he must be accompanied by a responsible employee of the station or substation.

81. No employee shall touch either with or without rubber gloves any switch, current or potential transformer, cable, bus bar or conductor or any other apparatus which ordinarily carries current at a potential higher than 700 volts, until he has positively ascertained that such conductor or apparatus is disconnected from all sources of such potential.

82. Before starting work on any high or low tension cables or bus bars which are supposed to be dead, the foreman in charge of the work will make his own tests to ascertain if they are dead. Test lamps or a light fuse to be used on low tension work and electroscopes or other suitable devices for high tension work.

83. Foremen must confer with head of department to whom they report in regard to approved methods of testing to ascertain if cable or bus bars are alive.

84. In replacing potential transformer fuses either in power stations, substations or on signal transformers rubber gloves must be used and in addition the fuse must be held in wooden tongs. In case of signal transformers on aerial lines a suitable insulated holder for the fuse block must be used in place of the wooden tongs.

B. WORK ON HIGH TENSION LINES.

85. When work is to be done upon any high tension lines, either overhead or underground, written permission must be obtained from the Load Despatcher for killing the same, unless the work is of an emergency nature so that there is not time for getting written permission. In such cases permission must be obtained by telephone.

86. After the Load Despatcher has granted permission for work on these lines, before the work is started he will arrange with the station and substations affected for having the line or lines killed, and will instruct the operators in the station and substations to tag the feeder or feeders upon which work is to be done. A regular tag (Form E. D. 18) is provided for this purpose.

87. The name of the foreman who will have charge of the work to be done on the line in question must appear on this tag, and the line cannot again be put in service after repairs have been made until released by the foreman whose name appears on the tag.

88. A tag must be placed upon each end of the line and a "not clear" card (Form E. D. 37) must be placed upon the control switches for operating the oil switches at each end of the line and also upon the corresponding dummy switches on the Load Despatcher's indicator board.

89. At the same time the Load Despatcher notifies the power station and substation operators to tag the line he will also notify them to open the knife switches in series with the oil switches at each end of the line, and also short circuit and ground at least one end of the line. In case of a line running from the power station this short circuiting and grounding must be done at the power station end. If the line is to be cut it must be short circuited and grounded at both ends.

90. When the Load Despatcher receives information from the power station or substation operators that the line has been short circuited and grounded, and that the necessary tags and "not clear" cards have been placed he will release the line to the foreman, at the same time advising him of the places where tags have been installed and also where short circuiting and grounding has been done.

91. Upon completion of the work the foreman will personally sign the tag from at least one end of the line, stating that the work is completed, and so advise the Load Despatcher. The Load Despatcher will then order off the short cicuiting and grounding connections and have the tags and "not clear" cards removed.

92. If the work has been such that there is a possibility of the connections being changed a phase test must be made before the line is put in service.

93. All tags are to be removed as soon as possible after the completion of the work, and no lines are to be left tagged when work is not being done upon them if they are in condition to be used.

94. Tags which have been removed must be sent to the Load Despatcher after removal.

C. WORK ON DIRECT CURRENT FEEDERS.

95. Permission must be obtained from the Load Despatcher for any work on the direct current feeders which makes it necessary to put them out of service, and the same rules in regard to tagging as used for high-tension cables will govern in the case of low-tension cables, except that it will not be necessary to ground the feeders before working on them.

96. In case of direct current feeders which are to be killed to permit of work being done on them, tags must be placed on all switches in either the circuit breaker houses or substations from which it is possible to make these feeders alive.

97. If a third-rail is killed on account of work to be done on it, all control switches by which it is possible to throw current to the section of the third-rail to be killed must have tags placed on them in the same manner as specified for direct current feeders in the preceding paragraph.

98. In case work is to be done on low tension apparatus in stations or substations the switches controlling said apparatus must be tagged in the same manner as for high tension lines, and the foreman who is to do the work must obtain written permission from the Load Despatcher before starting the work, and must also release the apparatus as soon as the work is completed and must sign the tag stating that the work is completed and must then so advise the Load Despatcher.

99. Men working on the overhead or underground lines, or any other work along the right of way, must be careful not to leave any tools, scrap, loose wires or other material between track rails or which might lie so as to short circuit the third-rail, or foul third-rail shoes. Foremen must use great care to enforce this rule and inspectors will report violations to the Superintendent of Cables.

VI. SPECIAL RULES.

A. WORK IN POWER STATIONS AND SUBSTATIONS.

100. When work is to be done upon any piece of apparatus in a power station or substation which will prevent any turbine, rotary, motor generator or booster from being ready for service on short notice, the Load Despatcher must be so advised by the Superintendent or Watch Engineer of the Power Station, or by the foreman or operator of the substations.

101. Exciter storage batteries in the power stations, and the main and auxiliary storage batteries in substations, must not be put out of service unless absolutely necessary, and not until permission has been received from the Load Despatcher. The Load Despatcher will, before granting permission to put a battery out of service, confer with the Superintendent of Power.

B. WORK ON THIRD-RAILS.

102. If it is necessary to take current off from the third-rails which are in actual service, for other than emergency causes, arrangements must be made with the Train Despatcher or Superintendent of the Electric Division. The Division Superintendent will notify the Load Despatcher in regard to the track to be killed and also as to the time current is to be taken off and put on again. After a track has been cut dead at the request of the Train Despatcher or Superintendent, it will not be again made alive until so ordered by them.

103. The Engineer of the Testing Department shall upon request of the Engineer of Maintenance of Way, the Division Engineer, or of the third-rail foreman working under the Division Engineer, make conductivity tests to determine if track or third-rail bonds are in proper condition.

C. FIRE APPARATUS.

104. A sufficient number of fiber pails, filled with clean, dry sand, must be kept in all power stations, power substations, signal substations and circuit breaker houses.

105. A sufficient number of chemical extinguishers must be kept in all power stations, power substations and signal substations.

106. A monthly report in writing must be sent to the Superintendent of Power from the Superintendent of each Station and the Superintendent of Substations, giving the number and condition of fire pails, chemical extinguishers and other fire extinguishing apparatus, including fire pumps, hose and fire lines.

D. SAFETY DEVICES.

107. Safety apparatus, such as speed limit devices, reverse current and overload relays on power station and substation apparatus must be tested at frequent intervals to be sure that the same are kept in working order.

108. Each substation foreman, and also the electrical foreman of each power station, must make up a monthly list of spare fuses on hand, this list to also state the total number of each kind of fuses needed for the full complement of the power station or substation.

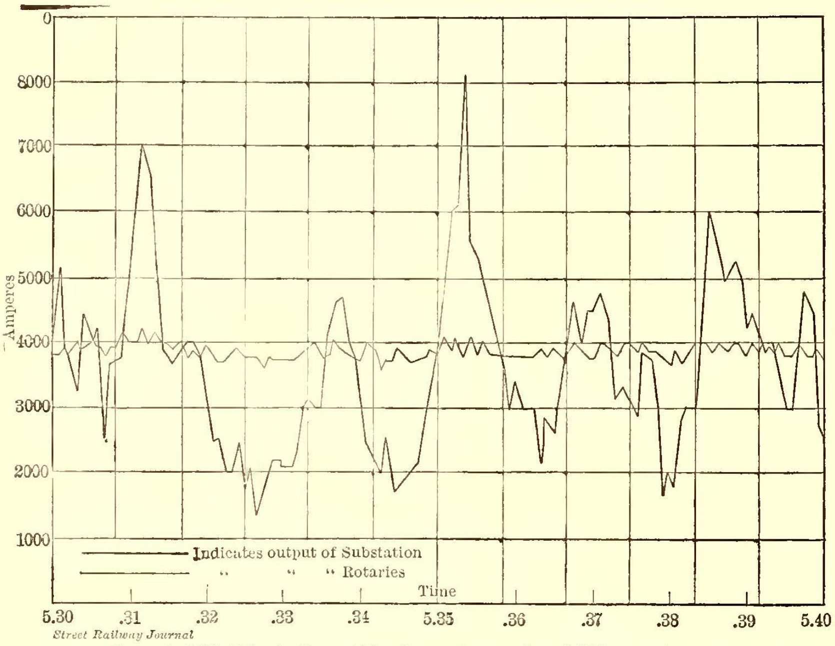
E. ADDRESS OF EMPLOYEES.

109. Each employee who is likely to be called for emergency work must keep his foreman or superintendent posted as to his residence and the number of the nearest available telephone. Foremen and superintendents will see that they have complete lists of the names and addresses of all men whom it may be necessary to call for emergency work.

SUB-STATION PRACTICE OF THE NEW YORK CENTRAL

The sub-station practice of the New York Central resembles in many of its general features that of large street railway companies as regards the handling of individual machines, but the variety of equipment installed and the importance of the service given broaden the duties of the employees in a marked degree. It is not too much to say, however, that the work of these sub-stations measures close in quantity and quality to the operating duties essential in many good sized power stations.

Careful provision through regular records of the behavior of the equipment, special arrangements for the use of auxiliary connections in case of trouble, well established methods of handling the machinery, switchboards and batteries, and the widespread adoption of the remote control principle on both a. c. and d. c. sides of the installation combine to illustrate the importance of detailed planning of operating arrangements in the electrification of a large terminal service.



Street Railway Journal

CURVES SHOWING DIVISION OF LOAD BETWEEN ROTARIES AND BATTERY—READINGS TAKEN AT INTERVALS OF 5 SECONDS

OPERATING SHIFTS

All sub-stations which are in service are operated on three eight-hour shifts daily. Each sub-station is in charge of a foreman who works from 8 a. m. to 6 p. m., and under him are three sub-station operators, three dynamo men, three signal station operators and one batteryman. One sub-station operator is on duty per shift, the shift hours being 8 to 4 p. m., 4 p. m. to 12 midnight and 12 midnight to 8 a. m. The batteryman's hours are from 8 a. m. to 5 p. m.

The sub-station forces as a whole are under the jurisdiction of the superintendent of sub-stations, whose headquarters are at Port Morris power station. In addition to the regular operating force there is a circuit-breaker inspector who makes a daily inspection of all circuit breakers in circuit-breaker houses. There is also one oil switch inspector who makes repairs on oil switches and inspects all switches at least once a month. Both the circuit breaker and the oil switch inspectors are included in a repair gang. This force of men spends its entire time in repairs and construction work in the sub-stations and circuit-breaker houses.

The sub-station operators are in direct charge of the operation of the sub-station, the dynamo men look after the commutators and collector rings on the machines in service and clean up all apparatus; they also assist operators when necessary. Each rotary and motor generator is cleaned at least four times a week. The static transformers are cleaned weekly. Compressed air at 35-lbs. pressure is used for this work. The batteryman keeps the battery room clean, replaces evaporation of cells with water, and takes the necessary readings on battery. The sub-station batteries are in direct charge of the sub-station foreman. General supervision of all batteries is kept by a battery foreman reporting to the superintendent of sub-stations.

STARTING AND SHUTTING DOWN ROTARIES

Rotaries are started up ordinarily from the d. c. side, but can be started from the a. c. side. In starting up from the d. c. side the first operation is to throw the field circuit to bus excitation. The field resistance is then adjusted and the starting switches closed and rotary brought up to speed by cutting out resistance in the armature circuit. Immediately after the rotary starts the switch which connects the transformer secondary to the rotary slip rings is closed. The rotary is then thrown upon its own excitation and synchronized, at which time the d. c. switch opens automatically. The d. c. bus and machine voltage is then compared and the remote controlled circuit-breaker closed, putting the machine in service. The entire operation usually takes about a minute.

To start from the a. c. side taps are brought out from the secondary of the transformer giving one-third and two-thirds voltage. On starting, the field circuit is split up so that but two field coils are in series, thus reducing the inductive voltage when the current is first thrown on. If the machine builds up with wrong polarity, provision is made to reverse the direction of the current in the field circuit until the right polarity is established.

In taking a rotary out of service the load is first cut off by adjusting the field rheostat. The circuit breaker connecting the d. c. side of the rotary with the main bus-bar of the station is then opened; the high-tension oil switch is next opened, after which the secondary switch and the selector switch are opened. This takes about ten seconds.

BATTERY OPERATION

The largest battery on the system is the one at sub-station No. 1, near the Grand Central terminal. This consists of 318 cells of chloride accumulators, type R-71. The charging rate of this battery is as follows:

	Amperes.
Continuous normal 8-hour rate........................	894
" maximum battery not over 90 per cent full..	1,200
" maximum battery not over 85 per cent full..	1,500
" maximum battery not over 75 per cent full..	2,000
Maximum for one minute under normal conditions of operation with battery in normal state of charge......	4,020

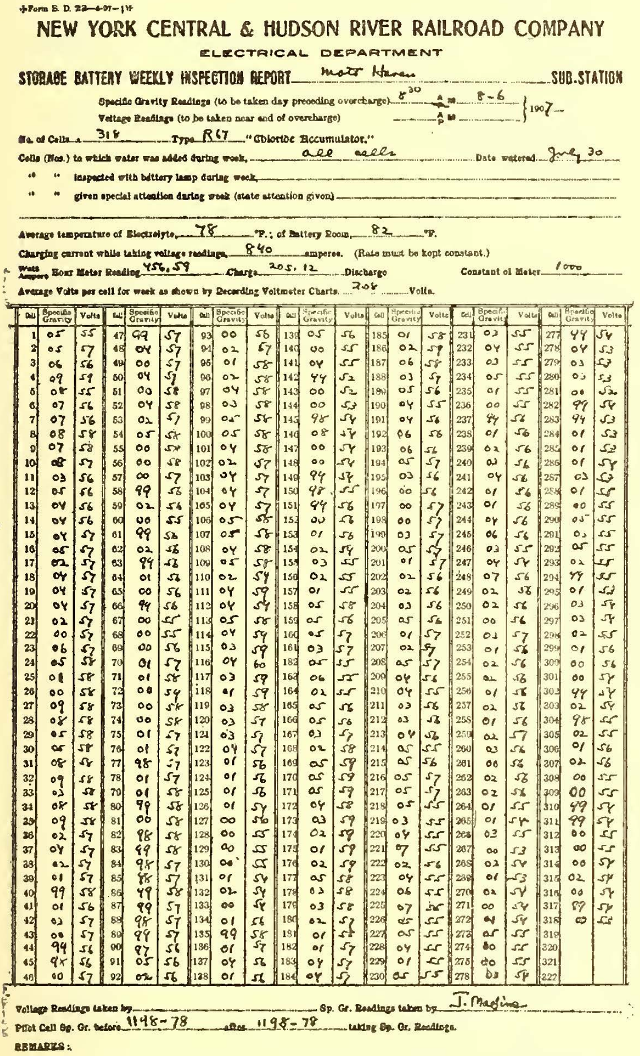
Discharging rate—

Maximum for one hour	4,020
" for thirty minutes	6,030
" for twenty minutes	8,040
" for one minute	12,060

CARBON REGULATOR

The storage battery is connected to the bus-bars at all times, but the boosters are not used excepting when the battery is being discharged at time of the peak, or when it is being charged. In order to get the proper use of the battery for taking sudden variations in load, the carbon regulator is used in connection with the booster.

The normal function of the battery is to regulate the momentary fluctuation of the load falling on the batteries, the adjustment being such that the total amount of the charge compensates for the discharge, such operation being known as floating. By adjusting the tension of the spring on the carbon regulator the amount of the discharge can be made to exceed the amount of the charge producing a net discharge or vice versa.



Form E. D. 22—4-07—1M

NEW YORK CENTRAL & HUDSON RIVER RAILROAD COMPANY

ELECTRICAL DEPARTMENT

STORAGE BATTERY WEEKLY INSPECTION REPORT Mott Haven SUB.STATION

Specific Gravity Readings (to be taken day preceding overcharge) 8^30^ A.M. 8-6 } 1907

Voltage Readings (to be taken near end of overcharge) A.M. P.M.

No. of Cells 318 Type R 67 "Chloride Accumulator."

Cells (Nos.) to which water was added during week, all cells Date watered July 30

" " inspected with battery lamp during week,

" " given special attention during week (state attention given)

Average temperature of Electrolyte, 78 °F.; of Battery Room, 82 °F.

Charging current while taking voltage readings, 840 amperes. (Rate must be kept constant.)

Watt / Ampere Hour Meter Reading 456.59 Charge 205.12 Discharge Constant of Meter 1000

Average Volts per cell for week as shown by Recording Voltmeter Charts. 208 Volts.

Cell	Specific Gravity	Volts	Cell	Specific Gravity	Volts	Cell	Specific Gravity	Volts	Cell	Specific Gravity	Volts	Cell	Specific Gravity	Volts	Cell	Specific Gravity	Volts	Cell	Specific Gravity	Volts
1	05	55	47	99	57	93	00	56	139	05	56	185	01	58	231	03	55	277	44	54
2	05	57	48	04	57	94	02	57	140	00	55	186	02	59	232	04	55	278	04	53
3	06	56	49	00	57	95	01	58	141	04	55	187	06	58	233	03	55	279	03	53
4	09	59	50	04	57	96	02	58	142	44	52	188	03	57	234	05	55	280	03	53
5	08	55	51	00	58	97	04	58	143	00	52	189	05	56	235	01	55	281	00	52
6	07	56	52	04	58	98	03	58	144	00	53	190	04	55	236	00	55	282	99	54
7	07	56	53	02	57	99	05	58	145	98	54	191	04	56	237	94	56	283	94	53
8	08	58	54	05	58	100	05	58	146	08	54	192	06	56	238	01	56	284	01	53
9	07	58	55	00	58	101	04	58	147	00	54	193	06	56	239	02	56	285	01	53
10	08	57	56	00	58	102	02	57	148	00	54	194	05	57	240	03	56	286	01	54
11	03	56	57	00	57	103	04	57	149	94	54	195	03	56	241	04	56	287	03	53
12	05	56	58	99	56	104	04	57	150	98	55	196	00	56	242	01	56	288	01	55
13	04	56	59	02	56	105	04	57	151	94	56	197	00	57	243	01	56	289	00	55
14	04	56	60	00	55	106	05	58	152	00	56	198	00	57	244	04	56	290	05	55
15	04	57	61	99	56	107	05	58	153	01	56	199	03	57	245	06	56	291	03	55
16	05	57	62	02	56	108	04	58	154	02	54	200	05	57	246	03	55	292	05	55
17	02	57	63	94	56	109	05	58	155	03	55	201	01	57	247	04	54	293	02	55
18	04	57	64	01	56	110	02	54	156	02	55	202	02	56	248	07	56	294	44	55
19	04	57	65	00	56	111	04	59	157	01	55	203	02	56	249	02	56	295	01	53
20	04	57	66	94	56	112	04	54	158	05	58	204	03	56	250	02	56	296	03	54
21	02	57	67	00	55	113	05	58	159	05	56	205	05	56	251	00	56	297	03	54
22	00	57	68	00	55	114	04	54	160	05	57	206	01	57	252	01	57	298	02	55
23	06	57	69	00	56	115	03	59	161	03	57	207	02	57	253	01	56	299	01	56
24	05	58	70	01	57	116	04	60	182	05	55	208	05	57	254	02	56	300	00	56
25	01	58	71	01	58	117	03	59	163	06	55	209	04	56	255	02	56	301	00	54
26	00	58	72	00	54	118	01	59	164	02	55	210	04	55	256	01	56	302	44	54
27	09	58	73	00	58	119	03	58	165	05	56	211	03	56	257	02	56	303	02	54
28	08	58	74	00	58	120	03	57	166	05	56	212	03	56	258	01	56	304	98	55
29	05	58	75	01	57	121	03	57	167	03	57	213	04	56	259	02	57	305	02	55
30	05	58	76	01	57	122	04	57	168	02	58	214	05	55	260	03	56	306	01	56
31	08	58	77	98	57	123	01	56	169	05	59	215	05	56	261	00	56	307	02	56
32	09	58	78	01	57	124	01	56	170	05	59	216	05	57	262	02	56	308	00	55
33	03	58	79	01	58	125	01	56	171	05	59	217	05	57	263	02	56	309	00	55
34	08	58	80	99	58	126	01	54	172	04	58	218	05	55	264	01	55	310	99	54
35	09	58	81	00	58	127	00	56	173	03	59	219	03	55	265	01	54	311	99	54
36	02	57	82	98	58	128	00	55	174	02	59	220	04	55	266	03	55	312	00	55
37	04	57	83	99	58	129	00	55	175	01	59	221	07	55	267	00	53	313	00	55
38	02	57	84	98	57	130	00	55	176	02	59	222	02	56	268	03	54	314	00	54
39	01	57	85	98	57	131	01	54	177	05	58	223	04	55	269	01	53	315	02	54
40	99	58	86	99	58	132	02	54	178	03	58	224	06	55	270	02	54	316	00	54
41	01	56	87	99	57	133	00	54	179	03	58	225	07	56	271	00	54	317	97	54
42	03	57	88	98	57	134	01	56	180	02	57	226	05	55	272	04	54	318	00	55
43	00	57	89	99	57	135	99	58	181	01	57	227	05	55	273	05	55	319		
44	94	56	90	97	56	136	01	57	182	01	57	228	04	55	274	00	55	320		
45	98	56	91	05	56	137	04	56	183	04	57	229	01	55	275	00	55	321		
46	00	57	92	02	56	138	01	56	184	04	57	230	05	55	278	03	54	222		

Voltage Readings taken by Sp. Gr. Readings taken by J. Magina

Pilot Cell Sp. Gr. before 1198-78 after 1198-78 taking Sp. Gr. Readings.

REMARKS:

WEEKLY STORAGE BATTERY INSPECTION REPORT

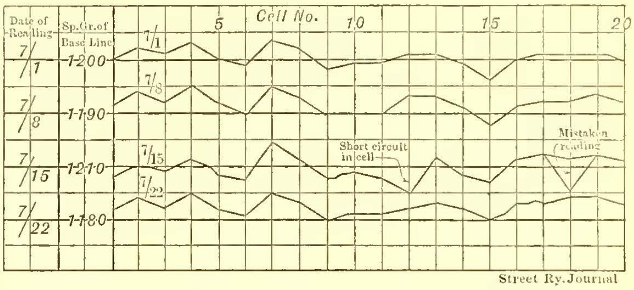
PILOT CELL

A convenient cell has been selected as a pilot cell. The automatic cell-filling apparatus keeps the height of the electrolyte constant in the pilot cell. An accurate specific gravity reading of this cell is taken every hour with the compensating hydrometer and the readings recorded on a form provided for the purpose and also on the recording voltmeter charts opposite the corresponding hours, at the time the chart is removed from the instruments. The temperature of the room and of the electrolyte is taken twice each day and recorded with other readings on a form provided.

To make sure that the automatic cell filler is always in order, the level of the electrolyte is noticed every time the other readings are taken, and any indication that it is out of order is reported immediately to the storage battery foreman. The compensating hyrometer is used in the pilot cell only.

FLOATING

Charts are figured usually by noting the average voltage for each hourly division separately and then averaging the whole twenty-four hours; the result is divided by the number of cells in circuit which gives the average voltage per cell for the day. The average is noted on the chart, together with the date and number of cells in circuit, any irregularities being noted on the back. The charts are mailed daily to the storage battery foreman.



FORM FOR KEEPING SPECIFIC GRAVITY RECORDS

In daily operation the pilot cell's specific gravity is not allowed to go higher than 0.005 below the maximum specific gravity reached on the previous weekly overcharge, and when the battery is merely regulating, charge and discharge being the same, the specific gravity of the pilot cell is maintained as near 0.005 below the maximum as possible. For instance, when doing the regulating work only, if the maximum specific gravity of the pilot cell as shown by the previous weekly overcharge is 1207, the battery would be operated with the pilot cell reading 1202, but no higher. The average voltage while floating as shown by the Bristol voltmeter should then be between 2.06 and 2.10 per cell in circuit. If the average is above this the battery is receiving a net charge, and if lower, then a net discharge. For instance, if there are 318 cells in circuit the average voltage for floating as shown by the records should be 661 to 668.

DISCHARGING AND CHARGING

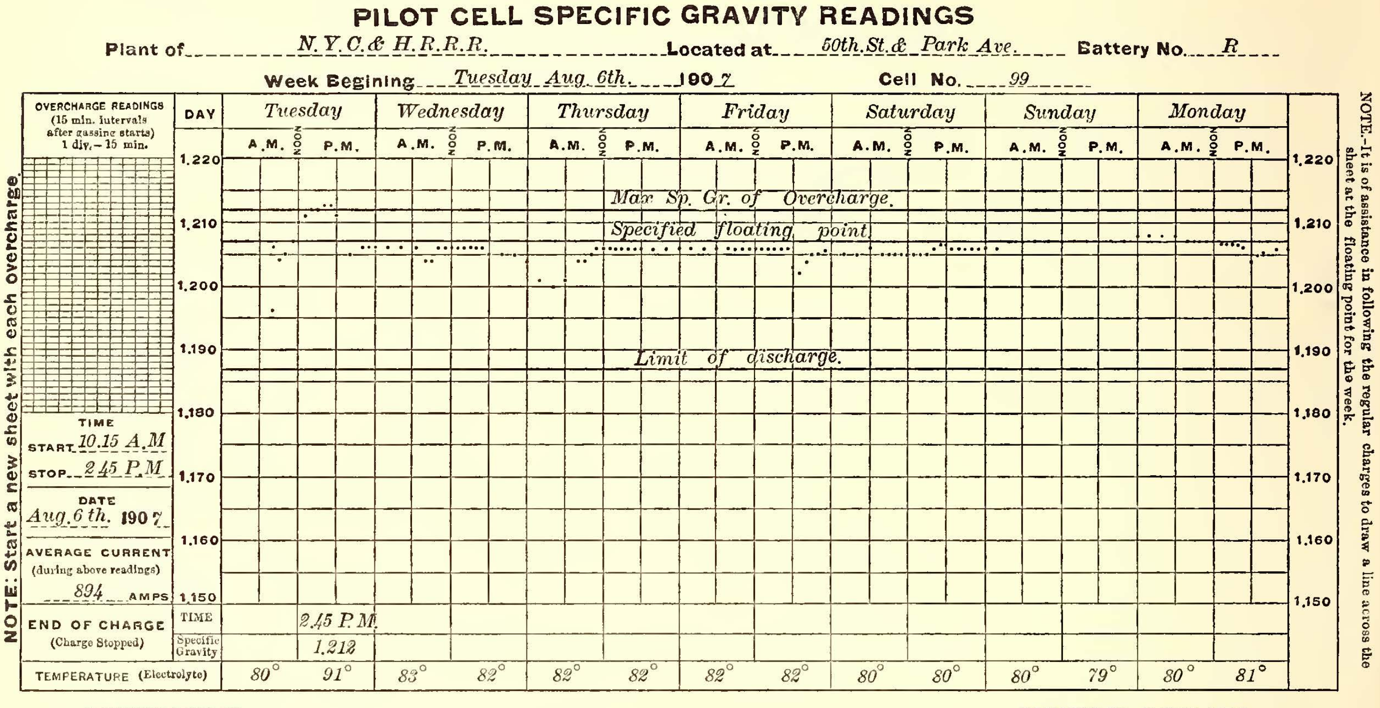
On discharging, the specific gravity of the pilot cell is not allowed to fall below the maximum by more than 0.025, attained on the previous week's overcharge; for instance, if the preceding weekly overcharge maximum specific gravity of the pilot cell is 1207, the discharge would be stopped when it has fallen to 1182. If the discharge is at the eight-hour rate the voltage would not be allowed to go below 1.75 per cell; if the current is less than the eight-hour rate the voltage is not allowed to go so low; if at the one-hour rate the voltage is not allowed to go below 1.6 per cell. Thus, if there are 318 cells in circuit the discharge would be stopped when the voltage has fallen to 556 with the eight-hour rate flowing; and to 509 with the one-hour rate flowing.

As soon as practicable after the discharge the battery is re-charged. The continuous charging rate of the average of net charge while regulating is not allowed to exceed, under ordinary operating conditions, the eight-hour rate, except in a case of emergency, and then the maximum is not allowed to exceed the one-hour rate. The charging lasts until the specific gravity of the pilot cell has risen to a point which is 0.005 below the preceding weekly overcharge maximum. With constant charging rate the recording voltmeter is used to check the cutting off point, and the curve is allowed to just pass over the bend after the rapid rise characteristic of the end of the charge and before the voltage has ceased rising. In case of an overcharge the battery is charged until the pilot cell specific gravity has shown no further rise for a period of thirty minutes with normal eight-hour charging current flowing.

On one day each week, which is determined by the storage battery foreman, the batteries are given an overcharge at a rate as near the eight-hour rate discharge as possible. This overcharge lasts until five consecutive fifteen-minute specific gravity readings of the pilot cell are obtained at the same value similar to those used by the company in its other operating departments to instruct employees in the use of apparatus.

REPORTS TO SUB-STATION FOREMEN

The recording voltmeter charts after the average cell voltage has been carefully figured and noted on the back are sent in daily to the sub-station foreman, also a report covering the condition of the gassing on all the cells, together with the maximum specific gravity of the pilot cell during the last overcharge and maximum and minimum specific gravity of the same during the day. Pilot-cell readings for the week which ends the day preceding an overcharge are promptly sent in also.



PILOT CELL SPECIFIC GRAVITY READINGS

Plant of *N. Y. C. & H. R. R. R.* Located at *50th. St. & Park Ave.* Battery No. *R*

Week Begining *Tuesday Aug. 6th.* 190*7* Cell No. *99*

OVERCHARGE READINGS (15 min. intervals after gassing starts) 1 div. – 15 min.

TIME

START *10.15 A. M*

STOP *2.45 P. M*

DATE *Aug. 6 th.* 190*7*

AVERAGE CURRENT (during above readings) *894* AMPS

DAY	Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Monday	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
END OF CHARGE (Charge Stopped) TIME		*2.45 P. M.*												
Specific Gravity		*1.212*												
TEMPERATURE (Electrolyte)	*80°*	*91°*	*83°*	*82°*	*82°*	*82°*	*82°*	*82°*	*80°*	*80°*	*80°*	*79°*	*80°*	*81°*

NOTE: Start a new sheet with each overcharge.

NOTE.—It is of assistance in following the regular charges to draw a line across the sheet at the floating point for the week.

READINGS TAKEN BY REMARKS ON OTHER SIDE

Street Ry. Journal

CHART OF PILOT SPECIFIC GRAVITY READINGS

or until five consecutive fifteen-minute readings of the voltmeters across the battery terminals show no further rise in voltage, the current being kept constant while these voltage readings are being taken. The recording voltmeter charts are made use of to determine the point of maximum voltage and the curve is run flat for an hour after the maximum is reached with the eight-hour rate current flowing. Just before finishing the overcharge, with as near constant current rate as possible, a voltage reading of all the cells is taken on a form provided for the purpose.

VENTILATION

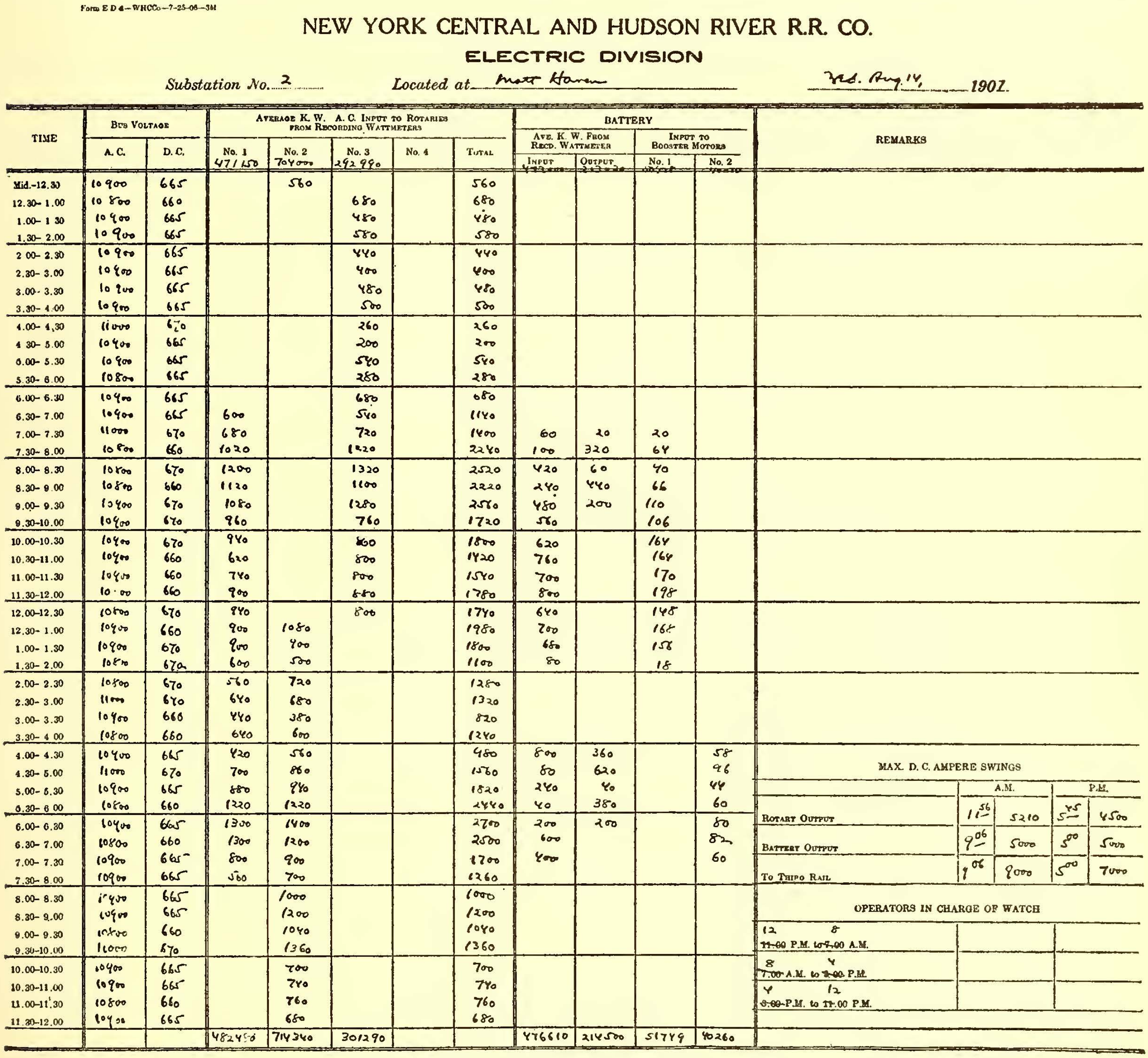
Care is taken at all times to have the battery rooms freely ventilated, as it is of the utmost importance when charging. Care is also taken never to bring an exposed flame into the battery room during or immediately after the gassing period of charge. Trouble of any description is promptly reported to the storage battery foreman.

STIMULATING INTEREST IN BATTERY WORK

In order to stimulate the interest of the batterymen in their work, and to encourage them to attain a broad knowledge of the behavior of batteries in the service of the electrical division, a set of over one hundred questions has been prepared. These questions raise a large number of practical points with which the men are expected to familiarize themselves. They are not reproduced here, but the questions are

The form on page 561, original 13¾ ins. x 8 ins., is the storage battery weekly inspection report which is made out at each sub-station and submitted to the battery foreman. The specific gravity and voltage of each one of the 318 cells at Mott Haven sub-station (No. 2) are shown, together with the temperature of the electrolyte, battery room, average voltage of the battery per cell for the week and charging current while taking voltage readings. To save the trouble and time of writing 12 before the figures in the specific gravity columns the 12 is omitted, and the figures are understood to mean either 1205 or 1206, 1199, etc., as the case may be. The figure 2 is also omitted from the voltage per cell columns for the same reason.

The form on page 563, 14 ins. x 15 ins., shows the sub-station daily log in use at this writing. It gives a half-hourly record of bus-bar voltage a. c. and d. c. rotary inputs, battery performance and inputs of booster motors. Maximum swings of the ammeters reading rotary output, battery output and third-rail output are also given. On Aug. 14, the day shown, the high-tension voltage varied from 10,800 to 11,000 at the Mott Haven sub-station, and the voltage on the sub-station d. c. bus varied from 660 to 670. Rotary No. 1 was in service from 6:30 a. m. to 8 p. m.; rotary No. 2 from midnight to 12:30 a. m. and from 12:30 p. m. to midnight, and rotary No. 3 from 12:30 a. m. to 12:30 p. m. Two rotaries were in service between 6:30 a. m. and 8 p. m. The maximum average kw load on the a. c. side of the sub-station was 2500 kw, occurring from 6:30-7 p. m. The battery was discharged only in the hours of peak load in the morning and afternoon, i. e., from 7 to 9:30 a. m. and from 4 to 6:30 p. m. The maximum d. c. ampere swings were 5210 amps. on the rotary output, 5000 amps. on the battery output, and 9000 amps. to the third-rail, the latter occurring at 5 p. m. The battery carried 5000 amps. of this momentary fluctuation. The company expects in the future to modify the form of this log somewhat, retaining the important features and adding several new ones. The new log will be about the same sized sheet, but will show kw-hour readings on the a. c. sides of the rotaries and boosters, with space for daily insulation tests of rotaries and auxiliary apparatus, and hourly readings of the maximum swing of the sub-station main d. c. ammeter. There will also be space for wattmeter readings at midnight of the preceding day and midnight of the day charted, with the difference. Power-factor readings will also be included.



Form E D 4—WHCCo—7-25-06—3M

NEW YORK CENTRAL AND HUDSON RIVER R.R. CO.

ELECTRIC DIVISION

Substation No. 2 Located at Mott Haven Wed. Aug. 14, 1907.

TIME	Bus Voltage		Average K. W. A. C. Input to Rotaries from Recording Wattmeters					Battery				Remarks
								Ave. K. W. From Recd. Wattmeter		Input to Booster Motors		
	A. C.	D. C.	No. 1 471150	No. 2 704000	No. 3 292990	No. 4	Total	Input	Output	No. 1	No. 2	
Mid.-12.30	10900	665		560			560					
12.30- 1.00	10800	660			680		680					
1.00- 1 30	10900	665			480		480					
1.30- 2.00	10900	665			580		580					
2 00- 2.30	10900	665			440		440					
2.30- 3.00	10400	665			400		400					
3.00- 3.30	10900	665			480		480					
3.30- 4.00	10900	665			500		500					
4.00- 4,30	11000	670			260		260					
4 30- 5.00	10400	665			200		200					
5.00- 5.30	10900	665			540		540					
5.30- 6.00	10800	665			280		280					
6.00- 6.30	10400	665			680		680					
6.30- 7.00	10400	665	600		540		1140					
7.00- 7.30	11000	670	680		720		1400	60	20	20		
7.30- 8.00	10800	660	1020		1220		2240	100	320	64		
8.00- 8.30	10800	670	1200		1320		2520	420	60	40		
8.30- 9.00	10800	660	1120		1100		2220	240	440	66		
9.00- 9.30	10400	670	1080		1280		2560	480	200	110		
9.30-10.00	10400	640	960		760		1720	560		106		
10.00-10.30	10400	670	940		860		1800	620		164		
10.30-11.00	10400	660	620		800		1420	760		164		
11.00-11.30	10400	660	740		800		1540	700		170		
11.30-12.00	10·00	660	900		880		1780	800		198		
12.00-12.30	10800	670	940		800		1740	640		148		
12.30- 1.00	10900	660	900	1080			1980	700		168		
1.00- 1.30	10900	670	900	900			1800	680		158		
1.30- 2.00	10800	670	600	500			1100	80		18		
2.00- 2.30	10800	670	560	720			1280					
2.30- 3.00	11000	640	640	680			1320					
3.00- 3.30	10400	660	440	380			820					
3.30- 4 00	10800	660	640	600			1240					
4.00- 4.30	10400	665	420	560			980	800	360		58	
4.30- 5.00	11000	670	700	860			1560	80	620		96	
5.00- 5.30	10900	665	680	940			1820	240	40		44	
5.30- 6 00	10800	660	1220	1220			2440	40	380		60	
6.00- 6.30	10400	665	1300	1400			2700	200	200		80	
6.30- 7.00	10800	660	1300	1200			2500	600			82	
7.00- 7.30	10900	665	800	900			1700	400			60	
7.30- 8.00	10900	665	560	700			1260					
8.00- 8.30	10400	665		1000			1000					
8.30- 9.00	10900	665		1200			1200					
9.00- 9.30	10800	660		1040			1040					
9.30-10.00	11000	670		1360			1360					
10.00-10.30	10400	665		700			700					
10.30-11.00	10900	665		740			740					
11.00-11.30	10800	660		760			760					
11.30-12.00	10400	665		680			680					
			482450	714340	301290			476610	214500	51749	40260	

MAX. D. C. AMPERE SWINGS

	A.M.		P.M.	
Rotary Output	11^{56}	5210	5^{45}	4500
Battery Output	9^{06}	5000	5^{00}	5000
To Third Rail	9^{06}	9000	5^{00}	7000

OPERATORS IN CHARGE OF WATCH

12 8 ~~11.00~~ P.M. to ~~7.00~~ A.M.		
8 4 ~~7.00~~ A.M. to ~~3.00~~ P.M.		
4 12 ~~3.00~~ P.M. to ~~11.00~~ P.M.		

DAILY LOG OF SUBSTATION

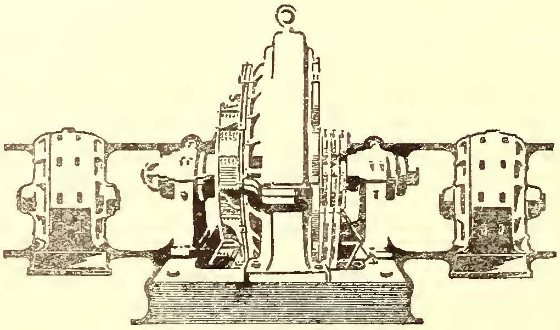
BATTERY PERFORMANCES

The diagram on page 560 at the beginning of this chapter illustrates the division of load between the rotaries and the storage battery in sub-station No. 2 on Aug. 7, 1907, between 5:30 and 5:40 p. m. Two 1500-kw rotaries were in operation, and the readings of the battery and rotary d. c. ammeters were taken every five seconds. Inspection of the curves shows that the rotaries carried an average load of about 3900 amps. during the time covered, with an extreme fluctuation per rotary of about 2500 amps. The sub-station output varied from a maximum of 8000 amps. to a minimum of 1300. Practically all fluctuations about the 4000-amps load on the sub-station were carried by the battery, and when the load fell below 3800 amps. the rotaries charged the battery. The maximum rate of automatic charging was about 2500 amps. The maximum sustained peak load on the sub-station lasted for nearly one minute, reaching 8000 amps. total, and during this fluctuation the combined output of the two rotaries, with carbon regulator in operation varied from but 3800 to 4100 amps., or but 150 amps. per rotary.

The form on page 549 (13¾ ins. x 8 ins.) shows the distributed output of the electric division for Aug. 14, 1907. As only three sub-stations out of eight are in operation as yet, and the loads are small, the figures given reflect preliminary rather than completed service. The outputs shown cover the train service between the Grand Central Station, High Bridge and Woodlawn, including in the latter about twenty-four New York, New Haven & Hartford trains, which at this writing are being electrically operated. As shown on the report, the total a. c. input of the three sub-stations was 70,889 kw-hours, the largest input being taken by the Mott Haven sub-station (No. 2). Less than two per cent of the a. c. input of the sub-station was required for sub-station lighting and local power service. The total d. c. rotary output was 58,367 kw-hours, of which the third-rail feeders took 55,226 kw-hours. Each sub-station can be lighted from the a. c. 11,000-volt lines through step-down transformers, from the motor-generator control battery charging set or from the control battery itself at 110 volts. The control battery is installed as a reserve of 55 small cells to insure the operation of oil switch and circuit-breaker motors at all times. In case the a. c. supply fails at night in a sub-station, a switch can be thrown which will light a row of reflector lamps at the top of the upright board, illuminating by current from the control battery the instruments at the bench board.

The small diagram on page 561 illustrates the method adopted by the company of keeping the specific gravity records of the individual cells in the storage battery. The vertical lines represent the various cells of the battery in proper order from one to any number of cells. The horizontal black lines are taken as base lines, one for each reading, and dated and named according to the condition of the battery at the time the reading was taken: for instance, 7/1-1200, meaning that for the reading taken July 1 the base line represents a specific gravity of 1200. Each horizontal line then at the point of the intersection with the cell line represents a certain specific gravity with relation to the base line. In the case of the reading taken July 1, beginning at cell No. 1, the readings were as follows: 1200, 1202, 1201, 1203, 1199, 1204, etc. Connecting the points of these readings, we have a line crooked or straight, according to the evenness of the electrolytes' specific gravity. The principle of the method is that other readings of the same cells, if taken correctly and if the battery is in uniform condition, completed and connected in the same manner, should form a line similar in direction as shown by comparison of the lines formed by readings taken July 1, July 8 and July 22; but if anything is wrong with any cell or if a reading is not taken correctly, it will be shown up in the manner indicated in the line by readings taken July 15. Thus, in cell No. 12, a short circuit occurred July 15, the specific gravity falling to 1205. Such other data as temperature of the electrolyte, temperature of the room, the name of the party taking the reading, etc., may be noted on the base line of the reading to which they belong. This record gives at a glance the specific gravity readings at various days, a comparison of various readings showing, in a way that cannot be overlooked. trouble in any cell or changes in specific gravity caused by any other reason, or readings taken incorrectly, and a line showing the evenness of the specific gravity throughout the battery.

The chart on page 562 (6 ins. x 11 ins.) illustrates the readings for a single week on the pilot cell of the battery located at Fiftieth Street and Park Avenue. The variation in specific gravity corresponds closely to the condition of the battery as regards charge or discharge. The temperature of the electrolyte is also shown in each day, the average charging current and the specific gravity during the time of charge.



ELECTRIC ROLLING STOCK OF THE NEW YORK CENTRAL

The general features of the rolling stock used in the electrical zone of the New York Central & Hudson River Railroad have been described in previous issues of the Street Railway Journal and need not be repeated here. Both the motor cars and the electric locomotives are equipped with multiple unit control. In general the motor car control does not differ materially from that installed on previous systems, but the high power of the electric locomotives renders their control of special interest. In view of the care taken by the company to forestall troubles, the course followed in handling both the motor car and the locomotive control under normal and abnormal conditions is given in the following paragraphs at considerable length, and the essential details of locomotive control, arrangement and operation have also been included. A special feature of the motor-car equipment is the use of graduated release air brakes, and as comparatively little has thus far been printed in regard to the handling of this improved apparatus, a liberal space has been allotted to the discussion of this subject. Among the detailed tasks which accompany the electrification of a steam railroad, few are of greater importance than the training of the enginemen in the handling of the revolutionized rolling stock. The preparation of instruction books for this purpose is a problem of no small moment, and for this reason extracts from the work of the New York Central along this line have been fully utilized. Flexibility and safety in operation are apparent in all the details of the rolling stock design and service.

The company now operates thirty-five electric locomotives, 131 motor cars for suburban service, and fifty-five trailers. Six of the motor cars are combination baggage and passenger cars, Electric locomotives are operated as far as High Bridge and Wakefield, but the motor cars are at present hauled by steam locomotives from these points north to Croton and North White Plains. The Peekskill local trains consist of motor cars and trailers, and are hauled through to Peekskill by steam locomotives.

INSTRUCTION BOOK

In anticipation of the beginning of operation in the electical zone, an exhaustive Instruction Book was prepared by the Equipment Department for the use of employees in the train service. This book describes the electrical and mechanical features of the motor cars and locomotives in detail, the phraseology being carefully selected with the object of making the electrical equipment details clear to train-service employees familiar with steam locomotive practice. In addition to the description of the apparatus incorporated in this book, instructions were included to meet emergencies, and the course to pursue in overcoming troubles and in handling the equipment most effectively was given in considerable detail. In view of the fact that the rolling stock of the Electrical Division has been described in previous issues of the Street Railway Journal, only such particulars will be given in the following paragraphs as throw additional light upon the actual operation of the cars and locomotives.

MOTOR-CAR ELECTRIC CONTROL

Two master controllers are provided for each motor car. Four points are indicated on the cap plate for forward direction and two for reverse. The first point in either direction is called the "switching" or "lap" position, the second "full series." The third point forward is called the "parallel lap," and the fourth the "full parallel."

The train cable is composed of seven conductors, each being covered with different colored braiding for identification. These conductors are attached to numbered plugs in the coupler sockets at the ends of the car and branch wires extend to the master controllers. Each motor car is provided with two circuit-breaker setting and tripping switches. Moving the handle in one direction makes connection from the master controller switch through the train cable to the various setting coils of the circuit breakers, and moving the handle in an opposite direction completes a circuit through the tripping coils on the various circuit breakers throughout the train. An emergency air-brake attachment is fitted to each master controller. The panel board at the end of each car contains vestibule and headlight fuses, car-lighting fuses, fan-motor fuse, vestibule and headlight switch, heater switches, car-lighting switch, fan-motor switch, heater fuses, main switch, control cut-out switch and fuses, current-limit relay, air-compressor switch, and air-compressor fuse. The concentration of fuses and switches at one point greatly adds to the operating convenience of the car.

Before attempting to start a train the motorman closes the air-compressor switches located on the panel boards of the various cars and waits until the train line and reservoir are properly charged, following the air-brake instructions in regard to testing brakes. He then sees that all main switches are closed and all master-controller switches open, with the exception of the one near the controller which he is to operate. He also moves the circuit-breaker switch to its "on" position, allowing about one second for the circuit breakers throughout the train to close.

To start the train the motorman presses down the button in the controller handle, inserts the handle key and gives it a quarter turn. It is necessary to hold down the knob in the top of the handle to prevent the pilot valve in the controller from operating and applying the brakes. This is not necessary while in any running position, as the air brakes will not be applied automatically unless the controller handle is at its "off" position and the knob released. The main or motor current flows from the third-rail shoes to the main switch, through the circuit breaker and main fuse to the contactors, then through the reverser and No. 1 motor to a set of rheostats, then through another set of rheostats and No. 2 motor to ground. The controller handle is then gradually advanced until the full series position is reached. A "bridge" connection is established by the contactors. The motors are then connected in parallel with rheostats connected in series with each, after which all the resistance is cut out of circuit by means of the contactors, and the motors are in full parallel.

The arrangement of apparatus is such that the train may be operated in either direction from any master controller in the train. It is necessary, however, in order to operate in a reverse direction at full speed, to operate from a master controller at the end of a car toward the direction in which the train is to be moved.

Should the train break apart the control couplers pull out, cutting off current from the train cable on the section of train behind the break. This drops out all the contactors on the rear section, while the front section continues under the control of the motorman.

OPERATING QUESTIONS

The following questions and answers have been issued by the company to assist the motormen in understanding the operation of the electric control system:

Q. 1.—If train fails to move after instructions under train operation have been followed, what should be done?

A.—Light circuit switches should be cut in to ascertain if there is power in the contact rail, or motorman should note if trains in neighborhood are moved by power.

Q. 2.—If it is found that there is current in operating car, what should be done?

A.—Master controller handle should be moved to first point, then master controller switch opened to ascertain if the master control circuits are closed, which will be indicated by the sound of slight arcing at master controller switch.

Q. 3.—What would cause the failure of train cable circuits?

A.—First, imperfect master controller fuse; second, grounded train cable; third, imperfect contact in master controller; fourth, loose coupler jumper.

Q. 4.—What should be done to detect imperfect fuse?

A.—Insert new fuse, and if this fails it is evident that the trouble is elsewhere.

Q. 5.—What should be done when a grounded train cable occurs?

A.—The master controller fuse should be replaced and the controller moved to the "on" position to determine if fault lies in construction of fuse. If this fails, an attempt should then be made to locate the ground in the train cable. The first thing to do is to throw the control cut-out switch on the operating car to "off" position. If this proves ineffective, this operation should be repeated back through the train, cutting out, however, the train cable jumper between car tested and one to be tested.

Q. 6.—What should be done to detect imperfect contact in master controller?

A.—Motorman should remove cover from controller and note the movement of contact fingers. The action of the train is dependent upon the contact of these fingers, and if it is found that the contact is imperfect he should endeavor to readjust the contacts, and if he fails in this it is then necessary to operate the train from the next car.

Q. 7.—What should be done to detect a loose jumper?

A.—Motorman should lose no time in going back through his train to determine if the coupler plugs are properly inserted in the sockets, and, if not, he should insert them properly.

Q. 8.—What are the other causes that would prevent the operation of a train or reduce the speed?

A.—First, the blowing of third-rail shoe fuses; second, the blowing of main motor circuit fuses; third, the blowing of circuit breakers or main fuses; fourth, an imperfectly acting triple valve causing brakes to remain set on one or more cars in train.

Q. 9.—How can enclosed fuse that is blown be detected?

A.—If an enclosed fuse has blown there is a deposit or collection of grayish powder at the ends of the box.

Q. 10.—What should be done in the event of a third-rail shoe fuse blowing?

A.—This fuse will blow only when there is a short-circuit on the car equipment, and fuse should not be replaced but train continued in the regular manner, and report promptly made to the train despatcher or person in charge of nearest terminal.

Q. 11.—If a circuit breaker acts or blows, what should be done?

A.—The circuit breaker setting switch should be moved to the "on" position.

Q. 12.—What should be done when a triple valve acts imperfectly?

A.—Air-brake instructions should be followed, *i. e.,* valves should be cut out and auxiliary reservoir cock opened to release brakes.

Q. 13.—If a train is standing on crossover and current cannot be obtained on the operating car, although the other cars of the train and trains in the neighborhood have current, what does this indicate?

A.—This indicates that the bus-line fuses between the operating and adjacent cars have blown, or that bus jumper is loose or disconnected.

Q. 14.—What should be done to continue operation of train?

A.—Motorman should go back to the first motor car where current can be obtained and move train through crossover, then go back to the first car again and proceed in the usual manner until a point of inspection can be reached and inspector notified.

Q. 15.—If a fire occurs in any car in the train, what should the motorman do?

A.—Open all circuit breakers by moving the circuit-breaker switch to the "off" position, and if this fails he should then open the main or motor circuit and the main cut-out switch on the car on which the trouble occurs.

Q. 16.—If smoke or fire is observed by the trainmen in any of the light or heater circuits within the car, what should be done?

A.—The trainman should immediately cut out the light or heater switches, whichever the case may be, and the trouble be reported to the despatcher in charge of the nearest terminal.

Q. 17.—If an unusual noise is observed in the movement of the train, what should be done?

A.—To prevent delay the motorman should have the conductor stand beside the train to locate the noise while he moves the train, after which if the trouble is with the brake rigging, same should be tied up.

Q. 18.—If the noise is located within the motors, what should be done?

A.—Motorman should open the cut-out switch on the car affected, and proceed after reporting trouble to despatcher in charge of terminal.

Q. 19.—If a third-rail shoe support is broken, what should be done?

A.—Motorman should first pull the bus-line jumpers at both ends of the car, insert wooden insulating slippers between the contact shoe and rail, and then proceed to detach or tie up remnants of device, exercising extreme care that the contact device is kept clear of the truck frame, contact rail, structure, or any grounded parts to prevent injury to himself.

Q. 20.—If either pilot or emergency air-brake valve leaks badly, what should be done?

A.—First try applying brakes by releasing the knob in the controller handle several times, and if this does not remedy the difficulty cut the valves out by means of a cut-out cock located in the pipe leading to them from the train line.

LOCOMOTIVE ELECTRIC CONTROL

The general features of the Sprague-General Electric type "M" control, as used on the suburban motor cars, also apply to the electric locomotive control, except that the train cable in the locomotive control has twenty wires, seventeen of which are connected to the master controller and to the motor-control apparatus. Of the remaining three wires two are used for the sander device and one is an extra bus ground. This control, in the same way as on the suburban motor cars, comprises two distinct sets of circuits, namely, the main or motor-control circuits and the master-control circuits, the former being governed by the latter. Each locomotive has four motors, the control being arranged for operating the motors first, all in series, then in series parallel, and then in parallel relation. The two ends of locomotives are designated the "A" end and the "B" end, the main switch being located on the "B" end.

The motor control on each locomotive consists of the following apparatus:

Contactors.
Reversers.
Rheostats.
Main switch.
Main motor cut-out switches.
Individual motor fuses.

In addition to these pieces of apparatus there are four sets of third-rail contact shoes—two shoes in each set—and two overhead contact shoes, with the necessary main cables connecting them to the control apparatus on the locomotive. There is also a main cable extending through the locomotive terminating with couplers at the ends, so that the third-rail shoes and the overhead shoes of any two or more locomotives may be connected together. This cable is termed the "bus-line." The circuits from the contact shoes—both third-rail and overhead—are protected by fuses, a set of two fuses in multiple being located near each shoe to protect the circuit of that shoe. From the third-rail shoes or from the overhead shoes the main circuit is carried through the respective fuses of each to bus line, to the main switch and through the motor fuses to the contactors and thence to motors.

There are forty-three contactors, located in the end compartments of the cab, one group on each side of the end compartment. The contactors are numbered progressively around the cab, No. 1 being nearest the No. 1 reverser. Each contactor has a plate with its number, which is attached in front above the arc chute.

There are two reversers—one in each end compartment. The No. 1 reverser, which is on the main switch end of locomotive, has the armature and field leads of the two motors on that end connected to the studs of its contact brushes. The connections of armature and field leads for producing forward and backward movement of locomotives are established by means of copper bars pressed against spring-contact brushes, through a toggle mechanism.

The handle for the main switch, which is a knife-blade, quick-break switch, is located in the "B" end compartment of the cab. It is never opened while the current is on the motors, except in an emergency, but is opened before the individual motor fuses or contactors and reversers are examined.

The main motor cut-out switches are for the purpose of cutting out the individual motors in case of any ground or defect in a motor which renders it inoperative. There are four of these cut-out switches, one for each motor, and they are located on the sides of the cab, the switches for No. 1 and No. 2 motors being just over the No. 1 reverser and for No. 3 and No. 4 motors over the No. 2 reverser. The number of the motor to which it is connected is marked on each switch. Each switch also has a small auxiliary control cut-out switch which opens and closes with the larger switch for opening the circuit of the series contactor. These switches are normally kept closed, except in case of individual motor trouble. They are kept well closed, so that the small auxiliary switches make good contact. When one of these switches is opened on account of motor trouble, the locomotive will not move until controller handle reaches the eleventh notch.

There are four motor-fuse boxes, each motor having its individual fuse. These boxes are located one over each third-rail shoe, just above the shoe-fuse boxes. A copper ribbon fuse of 1000 amps. rating is used in these boxes. Each box has marked on it the number of the motor whose circuit it protects.

The third-rail shoe fuse boxes are similar to the motor fuse boxes, but somewhat larger. There are two of these arranged in multiple for each pair of third-rail shoes. A copper ribbon fuse of 1200 amps. rating is used in each of these boxes.

The overhead shoe fuse boxes are practically the same as those for third-rail shoe, but are mounted on the roof, two in multiple near each shoe. A copper ribbon fuse of 1200 amps. rating is used here also.

The third-rail contact shoes are of the slipper spring actuated under-running type. The shoe bracket is mounted on a wooden insulating beam. There are two shoes in multiple on each bracket.

OVERHEAD CONTACT

The overhead contact device is a pneumatically operated shoe. There is a valve near each master controller in the cab, by means of which the shoe may be raised or lowered. When air is applied the shoe is lifted so as to make contact with the overhead rail. When air is released the shoe drops; also if the shoe runs off the rail it is tripped automatically and drops. Moving the handle forward operates the pilot valve, by means of which a slide-valve is thrown to admit air from reservoir to cylinder of contact shoe device. Pulling the handle back operates another pilot valve and the slide-valve is thrown over to connect air chamber of contact device to exhaust. The handle will spring back to the middle position from either direction. There are two of these overhead contact shoes, which are controlled in common by either valve in the cab. They are mounted on wooden insulating blocks. It is very important that these shoes are not raised when they will come in contact with overhead obstructions.

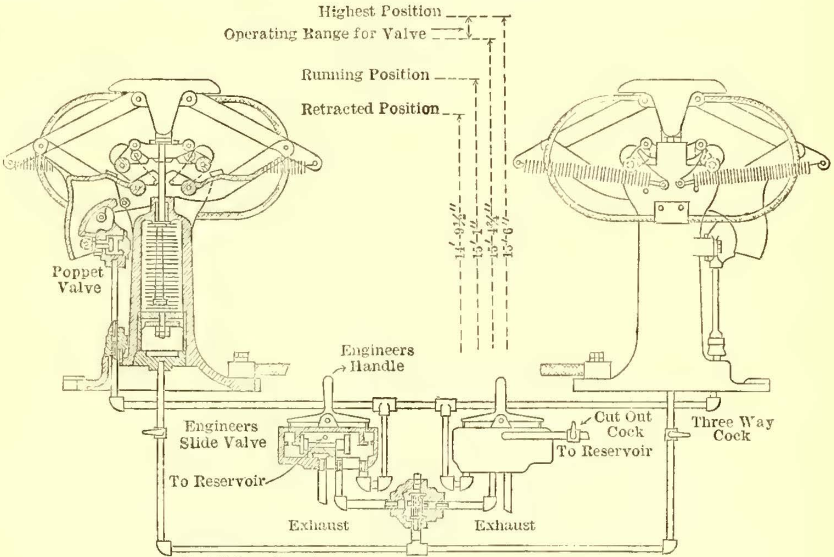
TRACK SANDER CONTROL

The track sander control comprises the following pieces of apparatus:

One main sander switch.
Two sander operating switches.
Two electro-pneumatic valves.

The main sander switch, located in the "A" end compartment of cab, is for the purpose of admitting or cutting off current from the sander operating switches. This switch contains a 10-amp. fuse. The switch is opened on inspecting fuse. This switch has plate marked "Sander."

Sander operating switches are located on one side of cab near each master controller. These are double-throw switches and are marked "Sand Forward," "Sand Reverse." Moving the handle to the "Forward" position energizes the valve which applies sand to rail for forward direction. "Reverse" position of handle applies sand for the reverse direction.



Street Railway Journal

LOW PANOGRAPH TROLLEY AND PNEUMATIC CONTROL ON NEW YORK CENTRAL LOCOMOTIVES

The electro-pneumatic valves are located one in each end compartment. One valve operates a sander for one direction of movement, the other valve operates a sander for the other direction, only one valve being operated at a time. The valve is operated by a magnet, which is energized by current applied in the sander operating switch.

ELECTRIC LOCOMOTIVE OPERATION

Before attempting to start the locomotive, the motorman first closes the pump switch, then he closes the main switch and sees that the main control switch and all the cut-out switches are closed. After the reservoir and train line are charged, the overhead control switch over the controller from which locomotive is operated is closed and the reverser handle thrown in the direction of desired movement of locomotive. The motorman then proceeds on the signal. After releasing the latch on controller handle he pulls the controller handle to the first notch, then to the second notch, and so on, until the desired speed is attained. For coupling with the locomotive, light, the first and second notches are ordinarily sufficient. If it is desired to get up to speed as soon as possible the handle is moved around notch by notch, allowing the latch to take each notch until the last notch is reached. If the motorman feels, at any point, the further movement of the controller checked, he does not exert undue pressure on handle—no more than is ordinarily required to move the handle from one notch to the next. Whenever the current through the motors is higher than a certain amount the automatic governor acts and stops the further movement of handle. When the current falls to a certain amount the governor releases controller cylinders and another notch may be taken, and so on.

Every notch on the controller must invariably be taken by latch in moving controller on, whether in accelerating or in throwing controller on with motors already up to speed. In throwing off, the notches need not be observed. The off notch of the controller is called the zero notch. The first closed position of the controller is the first notch and so on.

If the reversers are not already thrown to the position corresponding with the position of the reverse handle when the controller is thrown to the first notch, current will pass through the proper operating coil to ground. After the reversers have reached the correct position interlocking contacts on each reverser cut off current to ground and establish a circuit through three contactor coils. Moving the reverse handle does not operate the reversers, but simply arranges the contacts, so that when the controller is turned to the first position the reversers will be thrown in the proper direction. The operating coil for one direction on one reverser is in multiple with the corresponding coil on the other reverser, these two coils being controlled by one wire from the master controller and protected by one fuse.

On the first notch the main or motor current flows from the third-rail shoes or from the overhead shoes through the shoe fuses to the main switch, then through the No. 1 motor fuse, through the reverser and No. 1 motor, through a set of rheostats, then through another set of rheostats to reverser and No. 2 motor, then through the other reverser and No. 3 motor through a set of rheostats, then through another set of rheostats to reverser and No. 4 motor, and then to ground. The four motors are here all in series, with all the resistance in circuit, and the locomotive, if light, may start, or if coupled to a train may simply take up draw-bar slack. Each of the next three steps cuts out one complete set of motor resistance, and on succeeding steps, until full series is reached, the remaining set is cut out in six more steps. After full series, between the tenth and eleventh notches, bridge connections are established, and then on the eleventh notch motors are thrown in series parallel relation. Resistance is cut out in six steps to full series parallel, the seventeenth notch. Bridge connections are then established and the motors are thrown all in parallel, the resistance being cut out again in six steps. When motors are in parallel each is protected by its own fuse.

When it is necessary to reverse the direction of train movement, leaving controller handle in the off position, the reverser handle is thrown in the opposite direction and then move controller handle on in the same way. The reverser handle is thrown in the direction corresponding to direction of movement required. The motors are not reversed while the locomotive is moving, except in case of emergency, and then if speed is more than a few miles per hour the wheels would probably slip. If it is necessary to reverse while moving, the motorman is not allowed to throw the controller handle beyond the first notch, if all the motors are cut in, or beyond the eleventh notch, if one motor is cut out.

OVERHEAD SECTIONS

When operating on an overhead rail section the overhead contact shoe is tripped and will drop on leaving this section. The motorman, however, as an extra precaution, throws the valve handle back. Either for raising or lowering the overhead shoe it is necessary to hold handle in position only long enough for the shoe to start movement.

To sand the rails the sander operating switch is moved over in the direction of movement of the locomotive. To stop the sand the handle of this switch must be brought back to the middle position.

The control cut-out switch, if open, disconnects the operating parts of contactors and reversers on the locomotives from the train cable, but does not affect the operation of the other locomotive if two are connected together, although it is cut out on the locomotive whose master controller is being operated. The control connections for the reverser are so arranged that unless it is at the proper position current is cut off from contactors, so that motors on that locomotive will receive no current. In case of electrical trouble within the master controller train cable, couplers, or connection boxes, the single fuse in the master control switch will protect them. In case of local trouble on contactors or reversers the fuses in the cut-out switch will protect the circuit.

ELECTRIC LOCOMOTIVE CATECHISM

The following catechism has been issued by the company to instruct the locomotive motormen in the operation of the system:

Q. 1.—If locomotive fails to move after instructions under train operation have been followed, what should be done?

A.—First, after making sure that the overhead and main master controller switches are closed, throw controller on two or three points and off, and observe by the sound whether any contactors are operating.

Q. 2.—If none of the contactors operates, what should be done?

A.—Turn on light circuit switches to ascertain if there is power on the third-rail or overhead rail.

Q. 3.—With current on the locomotive, what would cause the failure of contactors to operate?

A.—First, an imperfect master control fuse; second, imperfect contact in master controller on some of the fingers of the primary cylinder; third, two or more imperfect 4-amp. fuses in the control apparatus circuits.

Q. 4.—What should be done to detect imperfect master controller fuse?

A.—Open main master controller switch and renew fuse, and if there is still no operation of contactors the trouble is evidently elsewhere.

Q. 5.—How can enclosed fuse that has blown be detected?

A.—A small circle in center of table is charred and turned black when fuse is blown. This is termed the "Telltale" of fuse.

Q. 6.—What should be done to detect imperfect contact in master controller?

A.—Cut out master controller switch, then remove controller cover and open arc deflectors; first on the right-hand side. Turn on controller and see that the controller fingers make good contact with their respective cylinder segments. If any contact is imperfect endeavor to readjust, if there is time. Failing in this, go to the other controller and operate from that, after cutting in its overhead switch and the main master controller switch again.

Q. 7.—What should be done to detect imperfect fuses in the control apparatus circuits?

A.—Remove cover from the cut-out switch on back of No. 2 controller and inspect the five top fuses and the eighth and ninth from top. If any one of these fuses shows signs of being blown, from the telltale being black, renew the blown fuses.

Q. 8.—If some of the contactors close on the first test without giving main current, what should be done?

A.—After opening main switch throw reverser handle back and forth two or three times, throwing controller to first notch at each reversal and note whether both reversers respond, throwing over at each reversal.

Q. 9.—If neither reverser responds, what should be done?

A.—Renew fuses eighth and ninth from top on cut-out switch and then try.

Q. 10.—If one reverser responds to reversals on controller and other does not, what should be done?

A.—Throw over by hand the reverser that is not operating, making sure after throwing that the reverser is properly locked by toggle. It would require considerable force to lock reverser, but it is absolutely essential that it be locked, and no attempt should be made to operate before making sure of this.

Q. 11.—What contactors should close on the first notch of controller?

A.—1, 2, 4, 19, 22, 25, 33, 41 and 42. Contactors 1, 4 and 19 close after No. 1 reverser throws; 25, 33 and 41 close after No. 2 reverser throws. Contactors 2, 22 and 42 are governed by the No. 1 circuit on master controller.

Q. 12.—If contactors 2, 22 and 42 do not close, what should be done?

A.—First, renew top 4-amp. fuse on cut-out switchboard; second, examine main motor cut-out switches. See that they are well closed, so that auxiliary contacts are closed.

Q. 13.—If this is not effective, what should be done?

A.—After closing main switch again, throw controller to eleventh notch, moving slowly from tenth to eleventh, and begin operation in series multiple. Motorman should here move handle more slowly than ordinarily, as the automatic feature may thus be cut out. Motorman should watch meter and should not exceed 1000 amperes in series multiple and 2000 amperes in multiple.

Q. 14.—If two locomotives are being operated together and the master controller fuse blows again, after being renewed, what should be done?

A.—Pull 20-point jumper between locomotives and try renewing fuses, and then operate from locomotive on which fuse does not blow again. If a new 20-point jumper is available this may be substituted and tried.

Q. 15.—If motors do not take current between eleventh and seventeenth notches or between the eighteenth and twenty-fourth notches, what should be done?

A.—Renew the second and fifth fuses for the first case and the second and fourth fuses for the second case. If this is not effective, examine contact fingers for the primary cylinder and adjust if any of these fingers are not making good contact. Failing in this operate from the other controller.

Q. 16.—What are the other causes that would prevent the operation of locomotives?

A.—First, the blowing of the third-rail shoe fuses. Example for this, if lights are not obtainable in turning on light switches (See Q. 2). Second, the blowing of an individual motor fuse.

Q. 17.—What would tend to reduce the speed?

A.—First, in operating with two locomotives, if either locomotive is inoperative from any of the causes referred to, or if there is a loose 20-point jumper, or the bus line jumper is loose or out, and the shoe fuses blow on either locomotive, of course, one locomotive would be dead load; second, imperfectly acting triple, as would be indicated by meters showing excessive current.

Q. 18.—What should be done in the event of third-rail shoe fuses blowing?

A.—These fuses will ordinarily blow only when there is a short circuit on locomotive equipment. If the cause of fuses blowing is evident, however, as from the temporary grounding of some part of the third-rail shoe circuit or from the breaking off and grounding of a shoe, the fuse may be renewed after the ground has been removed. To do this put slipper boards under all the contact shoes of both locomotives and pull bus line jumper between locomotives and release overhead shoes from overhead rail. In removing slippers from under shoes, after renewing fuses, do not stand nearer the fuse box than is absolutely necessary. If one locomotive is grounded and the other is not, leave out bus line jumper and operate from locomotive which is free from ground.

Q. 19.—What should be done in case of an individual motor fuse blowing, as indicated by contactors 1, 2, 4, 19, 22, 25, 33, 41 and 42 closing properly on first notch without taking current?

A.—After making sure that the motor cut-out switches over reversers are all closed, open main switch and see which motor fuse is blown, renew this and proceed. If this fuse blows again, open cut-out switch for this motor and start train from the eleventh notch.

Q. 20.—If a third-rail shoe support is broken, what should be done?

A.—Motorman should first pull bus line jumper if two locomotives are coupled together, insert wooden insulating slippers between the contact shoes and rail on the crippled locomotive and retrieve overhead shoe if upon rail and then proceed to detach or tie up remnant of device, exercising extreme care that the contact device is kept clear of the contact rail and kept clear of truck or any grounded part to prevent injury to himself.

Q. 21.—What should be done in case air pump fails to operate?

A.—Renew fuse in pump switch which is located in "A" end cab. Open the pump switch before doing this. If this does not remedy the trouble inspect the governor contacts and adjust them if necessary.

While many of the conditions referred to are somewhat imaginary and may never arise in practice, the questions and answers given serve to give the motormen familiarity with the circuits and the operation of the control.

After the motormen have acquired familiarity and experience in electrical operation they are allowed on occasions to exercise their own judgment and common sense to better advantage.

LOCOMOTIVE AIR-COMPRESSOR CONTROL

The air-compressor control comprises the following pieces of apparatus:

A pump motor switch.
A pump governor.
A pump motor circuit contactor.

The pump motor switch is located on side of passage "A" end compartment. This switch is for the purpose of opening the pump motor circuit when locomotive is not in service.

This switch contains a 40-amp. fuse, which protects the pump motor circuit.

The pump governor is located in "A" end compartment on side opposite No. 2 reverser. The governor is of the diaphragm type of construction, the movement of the diaphragm, as air pressure falls or rises, operating a lever mechanism which serves to give a quick make and break to a small switch of the contactor type. This switch does not close the pump motor circuit itself, but closes the circuit through the pump motor circuit contactor, which has higher current capacity on its contacts than the governor. This contactor is located to the left of the governor. When the air pressure in the reservoir falls to 125 lbs. the governor closes its contacts, thereby energizing the contactor coil, which in turn closes its contacts; the pump motor circuit being thus completed, the pump starts. When the air pressure reaches 135 lbs. the governor opens the circuit of the contactor coil, which in turn opens and breaks the pump motor circuit and the pump stops. Both the governor and the contactor have strong magnetic blow-outs at their contacts, sufficient to handle any current which they may take in this service.

AIR-BRAKE EQUIPMENT ON MOTOR CARS

The air brakes on the cars and locomotives in electric service are essentially the same as those on the other passenger equipment, except that the steam driven air pumps on the locomotives are replaced by electrically driven air compressors, one on each electric locomotive and each motor car, and the design of the air brakes is such that their release, as well as application, can be graduated.

The use of an air compressor and main reservoir on each motor car necessitates the use of an additional train pipe to connect all the main reservoirs together and to the motorman's brake valve. This extra train pipe is called the control pipe.

The graduated release feature of the brakes makes it desirable to provide a double cut-out cock, which controls at the same time communication between the triple valve and brake pipe and between the triple valve and control pipe.

A safety valve is placed in the end of the main reservoir on each motor car to prevent overcharging the brake system in case the electric pump governor fails.

In suburban service it is highly important not to block the road. Therefore, motormen are required to remember, in case anything gets out of order, that the first important thing is to get out of the way; and to learn carefully just what to do in order to make the proper move quickly; for example:

1. In case of a burst hose, if it be the control pipe hose, the cut-out cock on both sides of it should be closed; but if it should be the brake pipe hose, then it is necessary to close the cut-out cock ahead of the brake and the double cut-out cocks on each of the cars back of it; then open, and leave open, the auxiliary reservoir bleed cocks on all of the cars that are cut out. In a case of this kind some one is designated and prepared to operate the hand brakes on the cars that are cut out in case a car coupling should break and cause the train to separate.

2. In case of inability to release a brake, caused, for instance, by the emergency valve remaining unseated after an emergency application, close double cut-out cock and open, and leave open, bleed cock of auxiliary reservoir on this car and proceed.

3. In case of brake sticking after service application make about a 10-lb. reduction and place the handle of the brake valve in release position. This will usually release the brake. If not, or further trouble is had with this brake, do as recommended in preceding case 2. It will be seen by these three examples that by a knowledge of the operation of the air brake the motormen and trainmen can formulate rules for themselves that, in case of trouble, will enable them to get out of the way with little or no delay.

To gain time the brake-pipe reduction for application of brakes is adapted to the speed. For example, for high speed make a full application and graduate off when a short distance from the stop. To handle train smoothly make the application heavy and soon enough, so that if held on the train would stop a car length or so short of the mark. Then as the stop or mark is approached graduate the pressure out of the brake cylinder so that little remains when stop is made. If on a level, complete the release; if on a grade, hold until the signal to start is given, then release. As the pressure has been graduated down so that little remains in the cylinder, it will be seen that the start can be made promptly.

As the automatic brake is applied by a reduction of the brake-pipe pressure, no matter how produced, it is plain that leaks will produce results not intended or desired by the motorman, and sometimes interfere with the accuracy and smoothness of the stop.

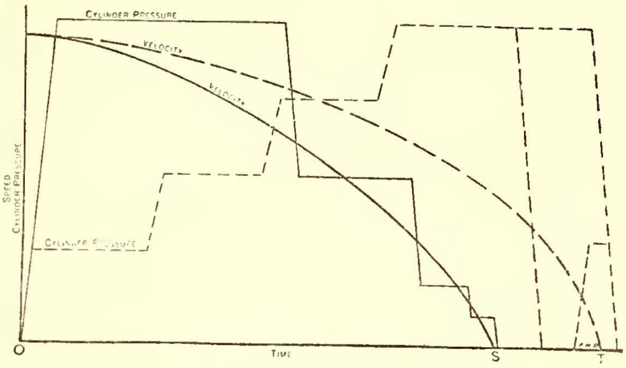


DIAGRAM OF STOPS

Therefore, they are kept down and reported as surely and promptly as any other defect. Motormen observe as carefully as possible the action of the governor, feed valve and gages; that is, their adjustment, etc., as much better operation can be obtained if all are approximately uniform.

One of the things that the motorman learns carefully regarding the automatic brake is that after a certain reduction of pressure in the brake pipe, say, 18 to 20 lbs., the auxiliary reservoir and brake cylinder have equalized. Therefore, no greater braking power can be obtained, and to further reduce the brake-pipe pressure wastes a great amount of air which must be restored to the brake-pipe before a release can be made, and interfere with that release to such an extent that a rough stop is usually the result.

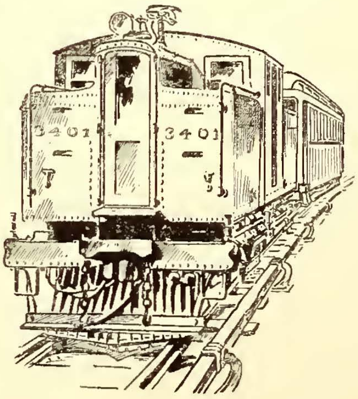
Properly handled this brake possesses all the flexibility of the straight-air brake, while the safety and reliability of the automatic brake has been greatly increased.

For instructing its employees in the use of the air brakes there is a catechism with questions and answers very similar in style to those employed with the electrical equipment. Accompanying these questions and answers are illustrations which emphasize the rules enjoined. No attempt will be made here to reproduce the text of these instructions, but the accompanying diagram and explanation are reproduced from the discussion in the hand book on good and bad braking.

The brakes are applied at 0 and the train comes to a stop at S or T. The curve shows the decreasing velocity after the brakes are applied. The diagram shows the variations of cylinder pressure during the stop. The full lines show the proper method of handling, and the dotted lines the improper. It will be seen by the dotted diagram and curve that the retardation of the train during the first part of the stop is comparatively small. The motorman is afraid to put on his brakes, and as a result applies them little by little, till at the end of a stop he has full cylinder pressure, and the retardation of the train is very sudden and dangerous. Often a motorman will find, when using such a method, that he has to make full release of the brakes and then reapply, as shown on the diagram, in order to keep the train from stopping short of the station. This causes jerks and uneven motion throughout the train and a great waste of air, resulting in overworking the compressor and causing unnecessary wear on the brake apparatus. On the other hand, if the motorman throws full pressure at once into the cylinder the retardation during the first part of the stop is much greater, and, as the speed gradually decreases, the motorman gradually releases the cylinder pressure in such a way as to keep the retardation of the train at a maximum. The amount gained in retardation during the first part of the stop by the proper method of braking makes the time required for the entire stop much less than in the other case, the time saved being represented by the distances S T.

The air compressors used on the electric locomotives each consists of a duplex, single acting vertical air pump, motor driven. The piston displacement is 75 cu. ft. per minute when operating at 600 volts, and against a tank pressure of 130 lbs. per square inch.

The air compressor is intended to operate on 600 volts, and for such operation the motors are always connected in series.

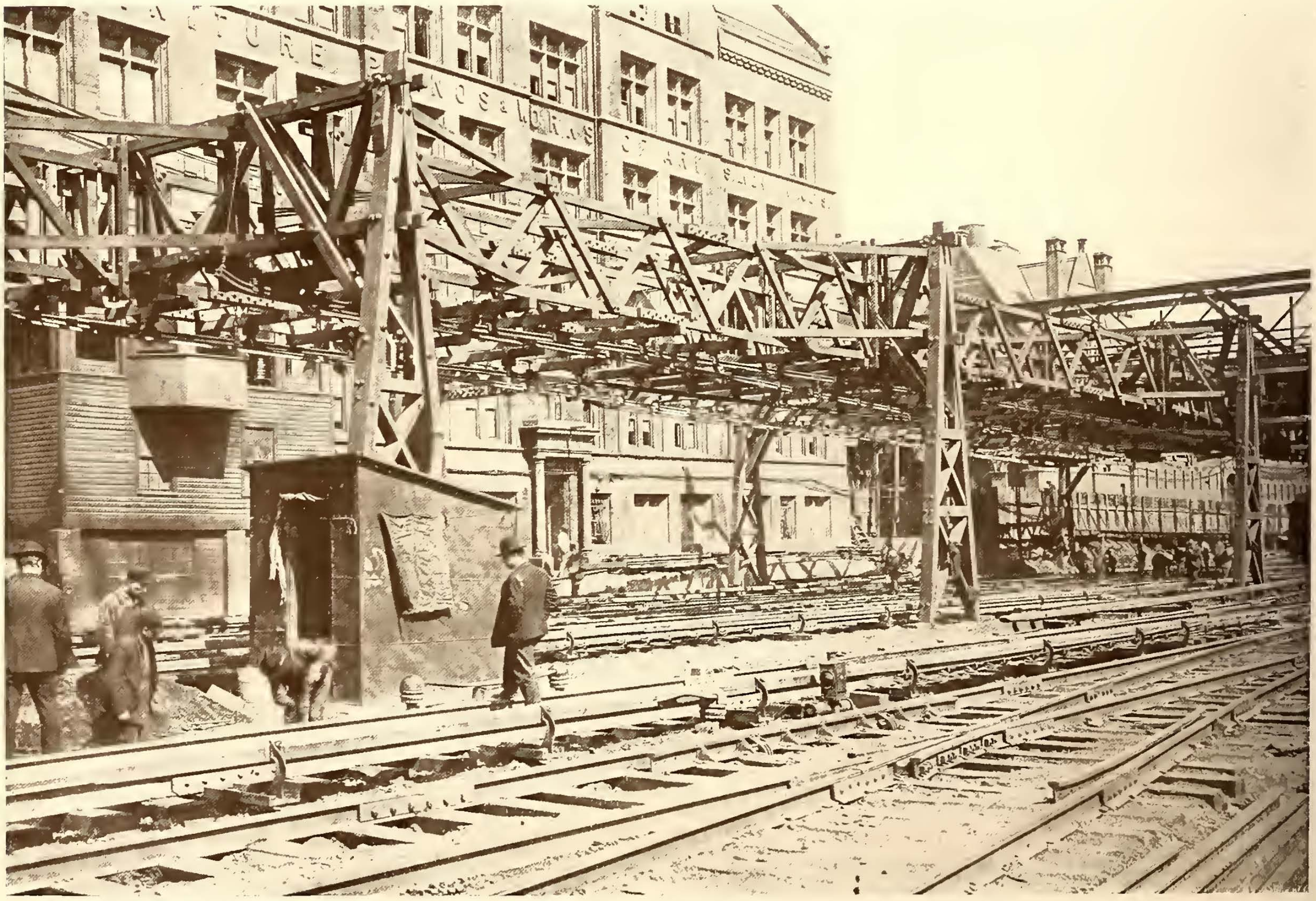


TYPICAL SECTION OF ELECTRIC ZONE, HARLEM DIVISION, NEW YORK CENTRAL RAILROAD

TYPICAL SECTION OF ELECTRIC ZONE, HUDSON DIVISION, NEW YORK CENTRAL RAILROAD

Plate XIV

THIRD-RAIL CONSTRUCTION IN HARLEM CUT, NEW YORK CENTRAL RAILROAD



TEMPORARY OVERHEAD CONSTRUCTION IN GRAND CENTRAL YARDS BETWEEN 49TH AND 50TH STS.

FIRST ELECTRIC TRAIN ON NEW YORK CENTRAL RAILROAD, LEAVING HIGH BRIDGE

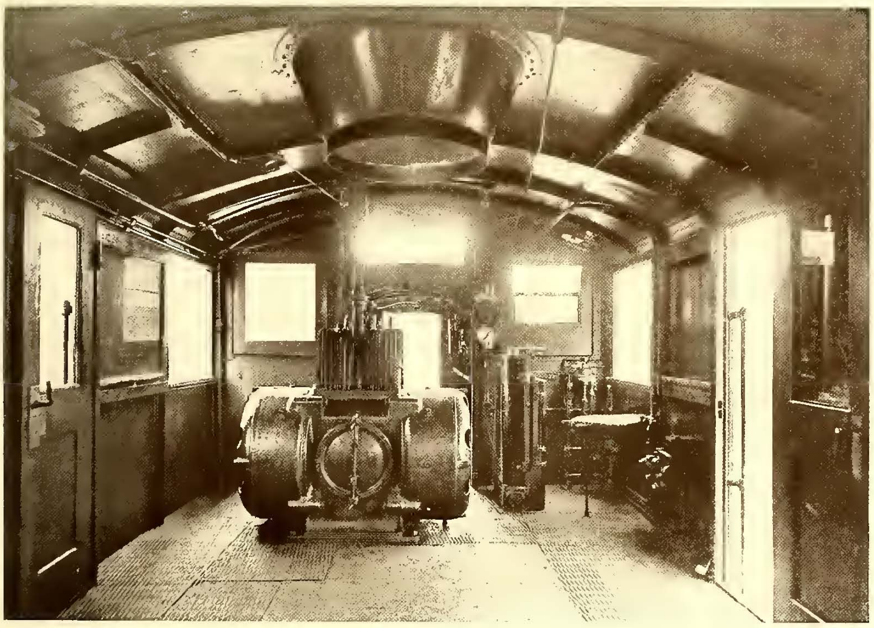
FIRST ELECTRIC TRAIN ON NEW YORK CENTRAL RAILROAD, LEAVING GRAND CENTRAL STATION ON RETURN TRIP

Plate XVI

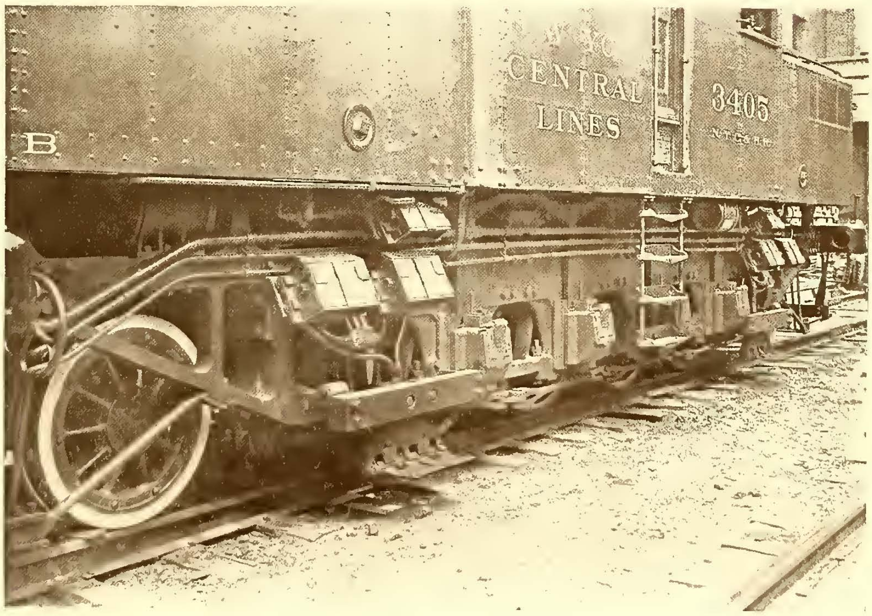
SIDE VIEW OF ELECTRIC LOCOMOTIVE, NEW YORK CENTRAL RAILROAD

GROUP OF NEW YORK CENTRAL ELECTRIC LOCOMOTIVES IN EAST YARD AT 50TH ST.

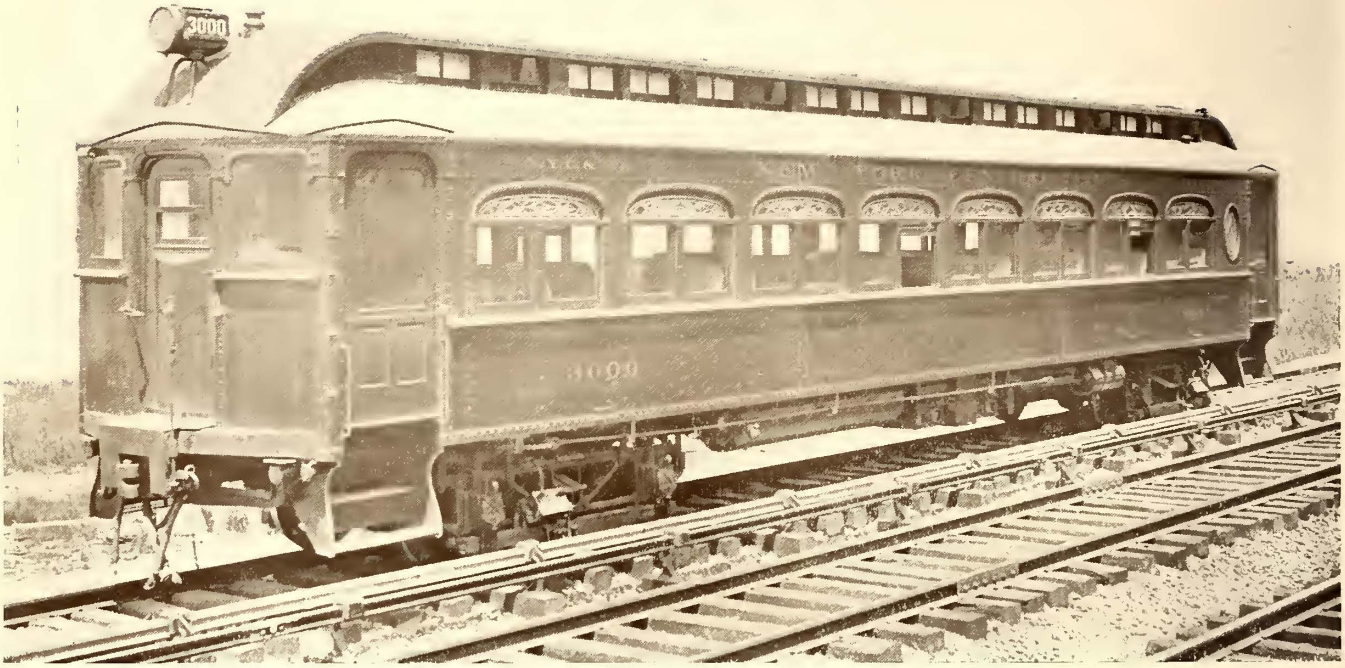
INTERIOR OF NEW YORK CENTRAL ELECTRIC LOCOMOTIVE



INTERIOR OF NEW YORK CENTRAL ELECTRIC LOCOMOTIVE



VIEW OF TRUCKS, NEW YORK CENTRAL ELECTRIC LOCOMOTIVE



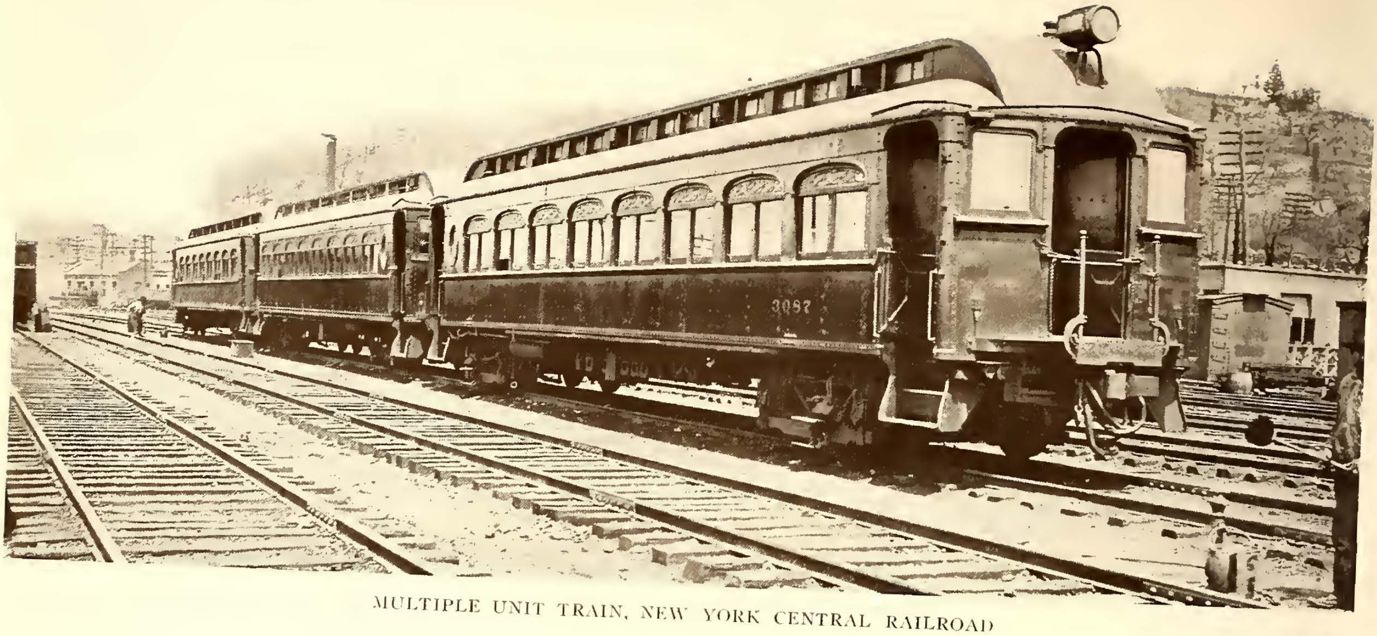
STANDARD STEEL MOTOR CAR, NEW YORK CENTRAL RAILROAD

INTERIOR OF STEEL MOTOR CAR, NEW YORK CENTRAL RAILROAD

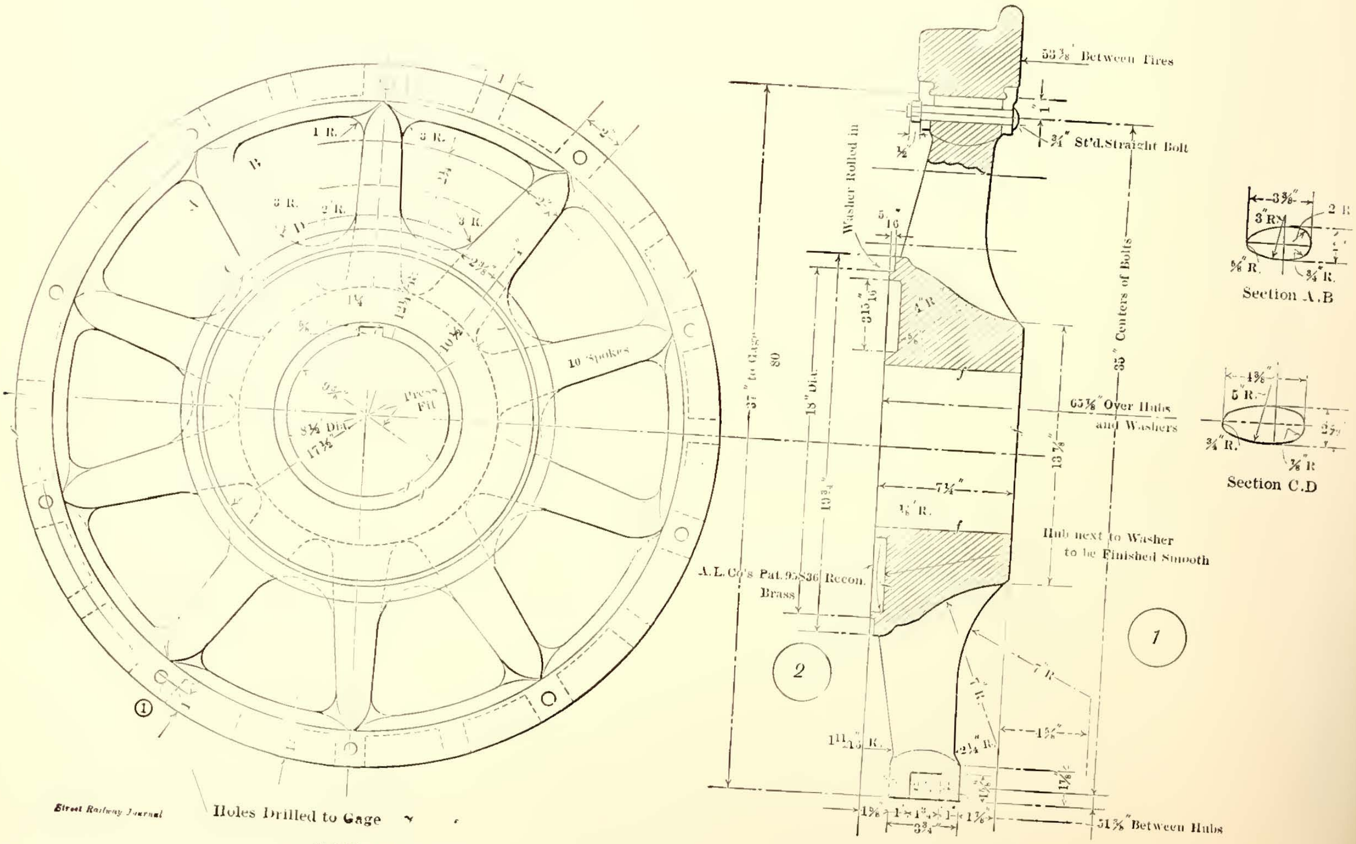
Plate XIX

VIEW OF PART OF EXCAVATION FOR NEW ELECTRIC RAILWAY TERMINAL AT GRAND CENTRAL STATION, NEW YORK. VIEW TAKEN OCT. 12, 1906

Plate XX



MULTIPLE UNIT TRAIN, NEW YORK CENTRAL RAILROAD



Street Railway Journal

DRIVING WHEEL USED ON NEW YORK CENTRAL LOCOMOTIVE

MAINTENANCE OF ELECTRIC ROLLING STOCK ON THE NEW YORK CENTRAL

The comparatively short time during which the New York Central electric train service has been in operation has been insufficient to bring out data of value regarding the wear of rolling stock, and in the equipment department as in others the fundamental problem has been to forestall all possible troubles and improve upon the old service. Inspection has been essential from the first, and repair facilities have in no degree been lacking. At the same time the maintenance has been of a light character and the work so far necessary has not taxed the company's facilities for repairs. A strong organization has been created, and careful records of mileage and inspection are being gathered to form bases of future policies in reference to the overhauling of the equipment. The excellent behavior of the equipment thus far has been gratifying to all concerned, and this freedom from trouble in service has contributed to keep the repair work from assuming proportions of any special magnitude. An account was published in the Street Railway Journal for June 8 of the design of the Harmon and other shops of the company and in the accompanying description the methods only in the operation of its shops will be considered.

INSPECTION

At the present time the Harmon shops of the company are in operation to only a limited extent and the third-rail has not been carried as far as this point. Both electric locomotives and cars are inspected at Wakefield, locomotives only at High Bridge and motor cars only at North White Plains. Locomotives make 750 miles each between thorough inspections and motor cars 900. Two locomotives are usually inspected at the same time. The only repairing which motormen are expected to make on the road is the replacement of fuses. Motormen do not always have the same equipment in operation. All the rolling stock has thus far shown remarkable immunity from trouble. In the case of a breakdown, the succeeding train pushes the stalled train to the nearest inspection point rather than attempting to make emergency repairs on the spot. The density of traffic is so great in the electric zone that it is not feasible to make other than the slightest adjustments on the main line tracks. The only tool carried on each electric locomotive is a No. 4 alligator wrench and no tools whatever are carried by the motormen.

The inspection of the electric locomotives takes about two hours, and the inspection of a multiple-unit train three hours. Cars are not detached from trains when an inspection is to take place, but the train is inspected as a unit. This eliminates an enormous amount of switching and train movements which would otherwise be costly and obstructive. After about 200 miles of running a new electric locomotive or motor car generally runs smoothly. The principal adjustments required are to secure proper lubrication of journals. No trouble has been experienced through the flashing over of locomotive or motor car armatures. The center of gravity of the electric locomotives is much lower than in the case of a steam locomotive and the former rides much more easily and engineers are able to work with less fatigue than in steam practice. Practically no inspection except of lamps, the oil in the journal boxes and the main switches is required of the locomotive and motor car train men. Very few modifications in the details of the rolling stock have been necessary as yet, with the exception of the locomotive control contactors. The contactors have been subdivided by means of a new interlocking arrangement to facilitate the breaking of heavy arcs. Idle contactors on the motor cars have also been used for this purpose.

Every locomotive coming to Wakefield is inspected, as is every one which reaches High Bridge. At Lexington Avenue shoes and air hose are inspected, but only a limited examination is made of rolling stock at this point. The motor-car trains are made up in units of two, three, four, five or six cars each, so that any reasonable combination of cars can be obtained to supply the necessary elasticity in handling the traffic. No fires have occurred on account of the car wiring in any rolling stock and no changes have been required in the wiring as a result of the company's experience in handling locomotives and motor cars. Sand is blown off the locomotive commutators every 750 miles and a considerable amount of sand is required on the locomotives on account of the present dampness in the Park Avenue tunnel and under the viaducts. The electric locomotives are daily handling trains weighing from 750 to 800 tons and in approaching the Grand Central Station there is a 1 per cent temporary grade which requires sanding in order to accelerate upon it.

At the time that the locomotives are inspected the gage of the third-rail shoes is also measured. In addition at 110th Street a check on the gage of the third-rail shoes is automatically maintained and an inspector, who is on duty all day, takes the numbers of the cars or locomotives upon which the shoes are too high or too low. A special device is provided at this point which rings an electric bell of one tone in case a shoe is too high and sounds a bell of another tone in case it is too low.

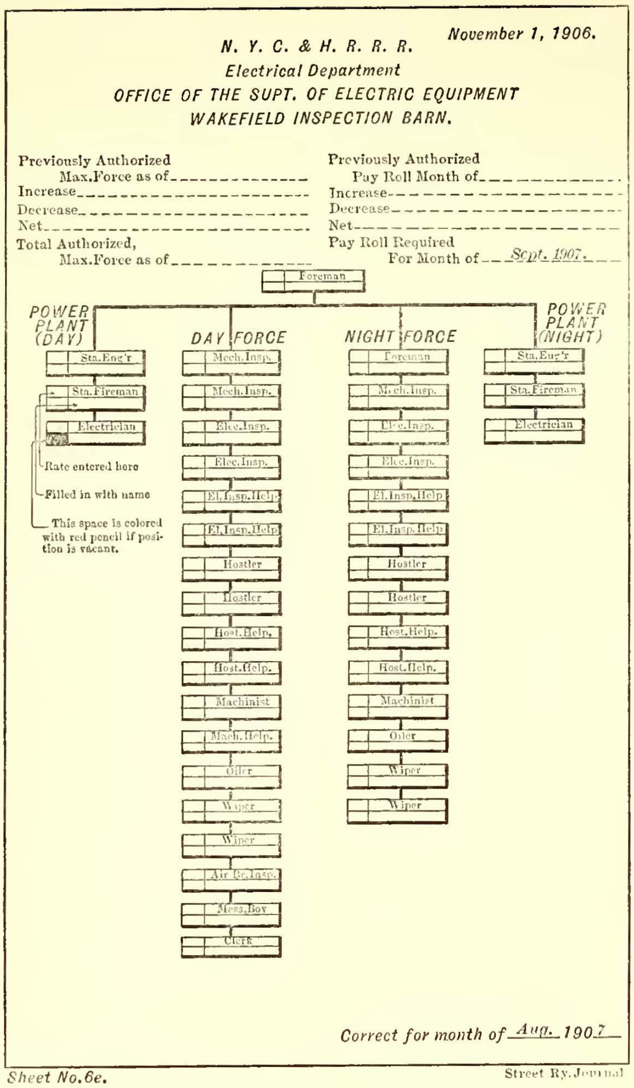
GENERAL OVERHAULING

The heavy repairs on all the rolling stock will be made at the Harmon repair shops. It is planned to put one motor car in the shops for a thorough overhauling after it has made from 35,000 to 40,000 miles, but the mileage which should be made between overhaulings is as yet undetermined. The rolling stock will be gradually passed through the shop until the last car or locomotive is in at the conclusion of the mileage which the company's experience shows is desirable between overhaulings. A locomotive will also be run 35,000 to 40,000 miles before a thorough overhauling for the purposes indicated above.

The company's practice is to carry extra trucks, extra wheels and extra armatures instead of holding a locomotive out of service a long time while repairs are made upon a single part of it. Thus, the electric locomotive might be out of service a week or two in case of a burned-out armature, whereas to substitute a new armature does not keep it out of service more than twelve hours. Not a single locomotive armature has burned out because of the service, and almost the only repairs on the locomotives thus far have been the replacing of brushes, contactor-wearing parts and other light maintenance work.

WEAR

Very little wear of the contact shoes has been experienced. It was found quite difficult at first to educate the trackmen to the point of giving the proper clearance for the shoes, but this has come by practice. About 40 lbs. pressure is carried by the shoe against the underside of the third-rail.



November 1, 1906.

N. Y. C. & H. R. R. R.
Electrical Department
OFFICE OF THE SUPT. OF ELECTRIC EQUIPMENT
WAKEFIELD INSPECTION BARN.

Previously Authorized
Max.Force as of______________
Increase______________________
Decrease______________________
Net___________________________
Total Authorized,
Max.Force as of______________

Previously Authorized
Pay Roll Month of____________
Increase______________________
Decrease______________________
Net___________________________
Pay Roll Required
For Month of ___Sept. 1907.___

Correct for month of __Aug. 1907__

Sheet No.6e. Street Ry. Journal

ORGANIZATION OF OFFICE OF THE SUPERINTENDENT OF ELECTRIC EQUIPMENT, WAKEFIELD INSPECTION BARN

TELL-TALE REPORT

....1907.

Car No.	Gage E. Bd. W. Bd.	Car No.	Gage E. Bd. W. Bd.	Loco. No.	Gage E. Bd. W. Bd.
3000	..	3060	..	3400	..
3001	..	3061	..	3401	..
3002	..	3062	..	3402	..
3003	..	3063	..	3403	..
3004	..	3064	..	3404	..
3005	..	3065	..	3405	..
3006	..	3066	..	3406	..
3007	..	3067	..	3407	..
3008	..	3068	..	3408	..
3009	..	3069	..	3409	..
3010	..	3070	..	3410	..

TELL-TALE REPORT, SHOWING THE LOCOMOTIVES OR CARS HAVING HIGH OR LOW SHOES

....190....

Mr. J. G. BAUKAT,
Ass't Sup't Electric Equipment,
New York.

Dear Sir:

Subject to your approval:

I have this day employed Mr. .... key No..........as .... Rate..........per..........at ...., in place of Mr...............................who ....

I have this day transferred Mr...................... .... key No..........employed at......................as .... rate..............per. . ..., to take the place of Mr............. .... key No...........employed at . ...as.......................... rate..............per............, who............ ....

Yours truly,

....Foreman.

....190....

Mr..

Foreman....................................

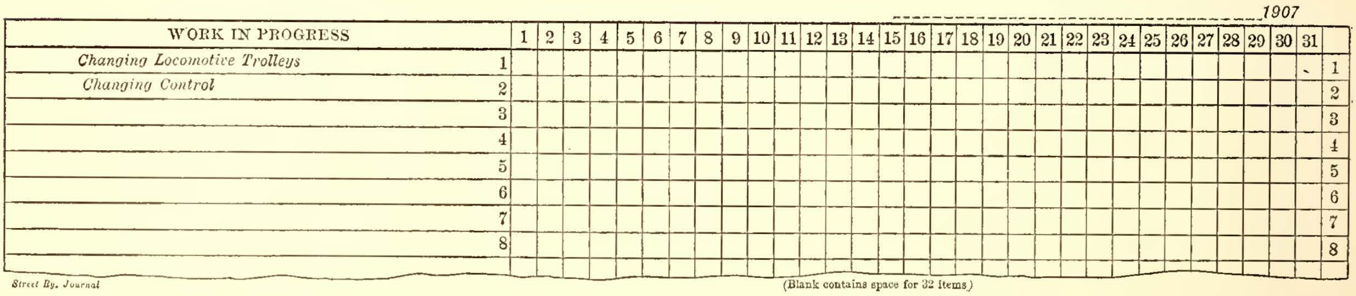
Dear Sir:

Your request of................to employ Mr............................ as..............................at........per........meets with my approval

Yours truly,

....
Ass't Sup't Elec. Equip.

LETTER USED IN EMPLOYING AND TRANSFERRING MEN BY REPAIR-SHOP FOREMAN

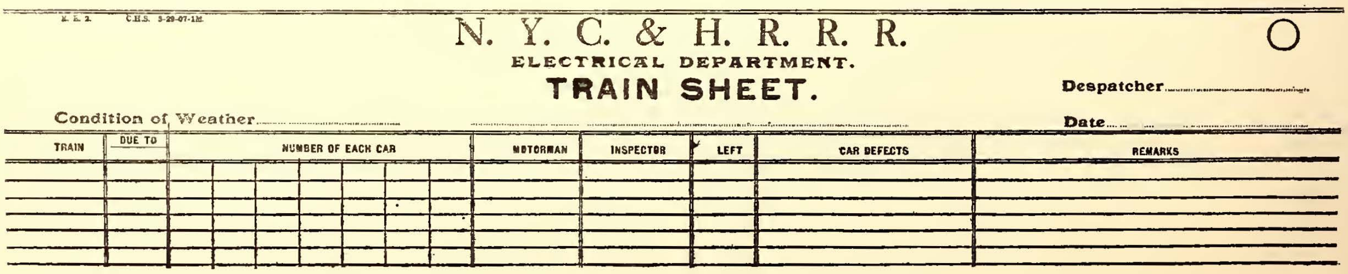


____________________1907

WORK IN PROGRESS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Changing Locomotive Trolleys	1																																1
Changing Control	2																																2
	3																																3
	4																																4
	5																																5
	6																																6
	7																																7
	8																																8

Street Ry. Journal (Blank contains space for 32 items)

UPPER PART OF EQUIPMENT SHEET SHOWING WORK IN PROGRESS



E. E. 2. C.H.S. 5-29-07-1M.

N. Y. C. & H. R. R. R.
ELECTRICAL DEPARTMENT.
TRAIN SHEET.

○

Despatcher..............................

Condition of Weather..............................

Date..............................

TRAIN	DUE TO	NUMBER OF EACH CAR							MOTORMAN	INSPECTOR	LEFT	CAR DEFECTS	REMARKS

UPPER PART OF TRAIN RECORD

FORCES AND ORGANIZATION

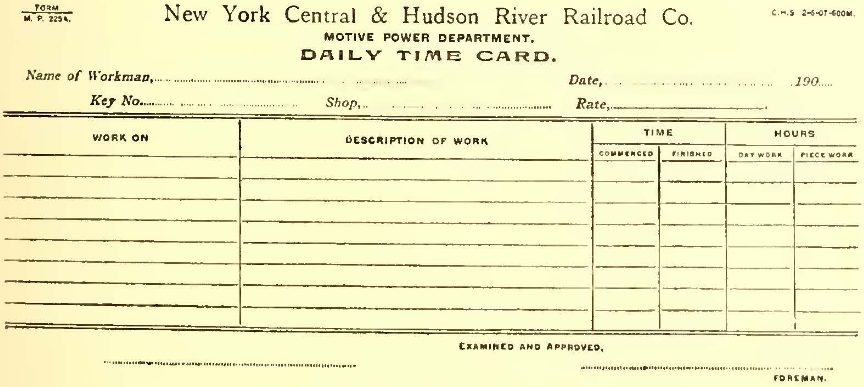
The chart on page 572 gives the organization of the inspection force at Wakefield and is reproduced from one of the standard organization charts of the company (original size 13½ ins. x 7¾ ins.), to which reference has already been made on pages 540 to 543. In this diagram, as in the other organization diagrams in the preceding pages referred to, each position is shown with space for the number of men doing that kind of work, to be filled in, and their rates of pay. The sheet illustrated is submitted each month to the superintendent of equipment and in case a position is vacant the blank space in the lower left-hand corner is filled in in red. If it is occupied the number of men is written beneath the title of the position, and in any case the rate of pay remains in the upper left-hand corner.

OTHER FORMS

Another cut on the opposite page is a reproduction of the upper part of a sheet, original size 12¾ ins. x 8⅞ ins., used to show at a glance all work in progress in the equipment department at any time. Squares are provided for each day of the month and spaces for thirty-two different jobs on each sheet if necessary. When a piece of work is started on a car or set of cars, or on any of the locomotives, the title of the work is inscribed in the left-hand space and the number of pieces of rolling stock changed over or attended to each day is placed in the smaller squares at the right. Thus at a glance the superintendent of equipment can tell just what work should be hastened in case a delay occurs anywhere along the line.

The tell-tale report is also reproduced in part on the opposite page. This form, original size 13 ins. x 8 ins., is kept by the inspector at 110th Street, and shows the shoe-gage of the different cars, if above or below the proper gage. This report is sent to the office of the superintendent of equipment.

Another form, original 13 ins. x 7 ins., is a letter devised to save extra correspondence in connection with the employing or transferring of new men. One of these notices is sent to the assistant superintendent of electrical equipment by the foreman of the shop or inspection barn when he employs or transfers a man. The sheet is arranged with a stub at the bottom which is returned to the foreman in case the employment or transfer is approved. If it is not approved no return notice is sent.



FORM M. P. 2254.

New York Central & Hudson River Railroad Co.

C.H.S 2-6-07-600M.

MOTIVE POWER DEPARTMENT.

DAILY TIME CARD.

Name of Workman,............ *Date,*............190....

Key No............. *Shop,*............ *Rate,*............

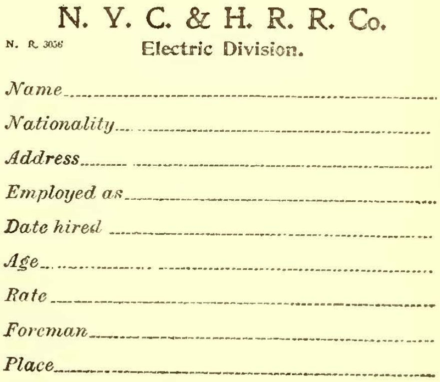
WORK ON	DESCRIPTION OF WORK	TIME		HOURS	
		COMMENCED	FINISHED	DAY WORK	PIECE WORK

EXAMINED AND APPROVED.

....

FOREMAN.

WORKMAN'S DAILY TIME CARD



N. Y. C. & H. R. R. Co.

N. R. 3056

Electric Division.

Name............

Nationality............

Address............

Employed as............

Date hired............

Age............

Rate............

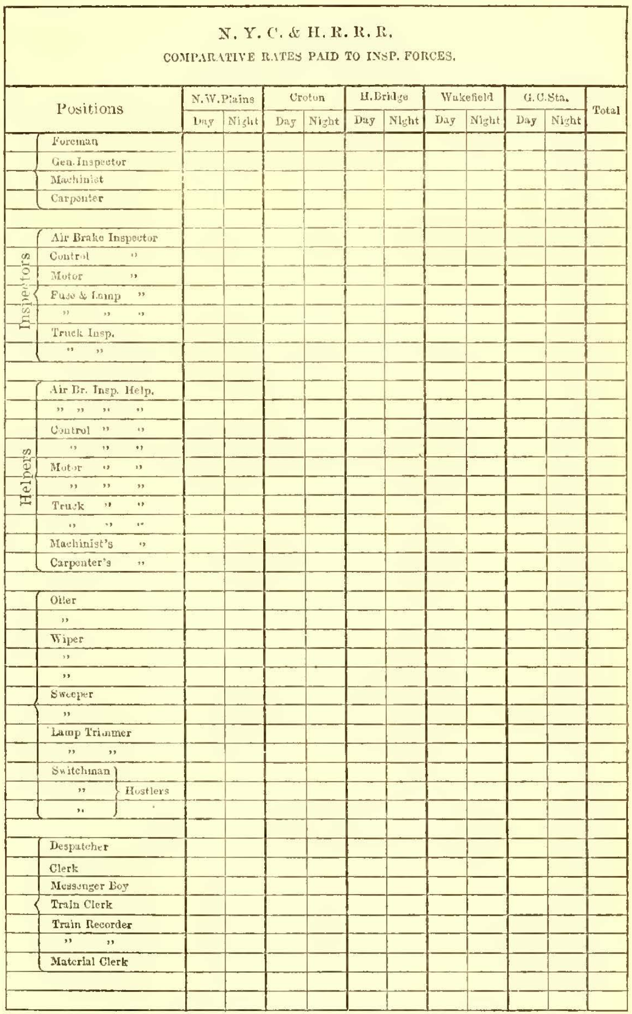
Foreman............

Place............

FORM GIVING EMPLOYEE'S RECORD

The time-card blank shown above, original size 9¼ ins. x 4¼ ins., is filled in by each workman in the shop or inspection barn and transmitted to the main office by the foreman at the conclusion of each day's work. Inspectors and repair men all use this blank, which discusses the character of the work, the location where it is performed, the time required to complete it and the man's pay.

The chart below, original 13¾ ins. x 8 ins., gives the classification of the inspection force at North White Plains, Croton, High Bridge, Wakefield and the Grand Central Station. At each one of these points are a foreman, general inspector, machinist and carpenter and a group of inspectors, helpers and miscellaneous employees as listed. The inspection of the equipment is performed in groups; that is, one force of men inspects the air brakes while another inspects the control. Similarly the motors, the fuses, the lamps and the trucks are inspected separately. No particular order is followed in this inspection work with the exception of the fact that the



N. Y. C. & H. R. R. R.

COMPARATIVE RATES PAID TO INSP. FORCES.

	Positions	N.W.Plains		Croton		H.Bridge		Wakefield		G.C.Sta.		Total
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
	Foreman											
	Gen. Inspector											
	Machinist											
	Carpenter											
Inspectors	Air Brake Inspector											
	Control "											
	Motor "											
	Fuse & Lamp "											
	" " "											
	Truck Insp.											
	" "											
Helpers	Air Br. Insp. Help.											
	" " " "											
	Control " "											
	" " "											
	Motor " "											
	" " "											
	Truck " "											
	" " "											
	Machinist's "											
	Carpenter's "											
	Oiler											
	"											
	Wiper											
	"											
	"											
	Sweeper											
	"											
	Lamp Trimmer											
	" "											
	Switchman											
	" Hostlers											
	"											
	Despatcher											
	Clerk											
	Messenger Boy											
	Train Clerk											
	Train Recorder											
	" "											
	Material Clerk											

Street Ry. Journal

CHART OF INSPECTION FORCES

work is kept from overlapping as far as possible. The blank is designed to show the number of men at work during the day and during the night at each one of these inspection points.

The third form on page 573, original size 4⅜ ins. x 4 ins., is used to summarize the particulars of each man's employment in maintenance work. Full records are, of course, kept of all applicants and employees, but this blank is designed to show at a glance the salient points. A duplicate of this blank is retained by the foreman under whom the man works.

This Car Sent in for REPAIRS

Equtpment No.________ Date________

Defects________

____

____

Signed________

THIS CARD TO BE SENT TO THE OFFICE OF SUPERINTENDENT ELECTRIC EQUIPMENT.

No.________ Date________

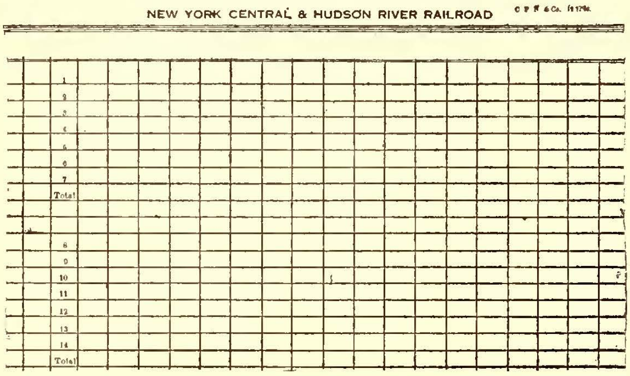
Defects________

Signed________

RED TAG ATTACHED TO CAR REQUIRING REPAIRS DUE TO ACCIDENT

The tag shown above, original size 8¾ ins. x 3⅛ ins., is attached to any car or locomotive requiring repairs and the stub at the end of it is sent to the office of the superintendent of electrical equipment. When the stub reaches the office it is placed in a rack with a numbered slot corresponding to the number of each car and locomotive, so that the number of cars and locomotives in the shop can be seen at any time without trouble.

The record of miles run is kept in a loose-leaf book with leaves ruled as shown below. The mileage figures are not secured from the conductors' reports but are computed in the main office as follows: All trains arriving at the station are met by a platform man who puts down in a notebook the train number, individual car numbers, points of departure and time of arrival. This book is turned over to a mileage clerk who enters the data on the train sheet, reproduced on page 572, original size 15¼ ins. x 13¼ ins. This train sheet illustrates the number of trains, the leaving time, the number of each car making up the train, who the motorman was, the inspector, the time of leaving, any defects noted, whether the car was north-bound or south-bound, the despatcher, the date. At the end of the day this train sheet is submitted to the chief mileage clerk who proceeds to compute the mileage from the run data given.

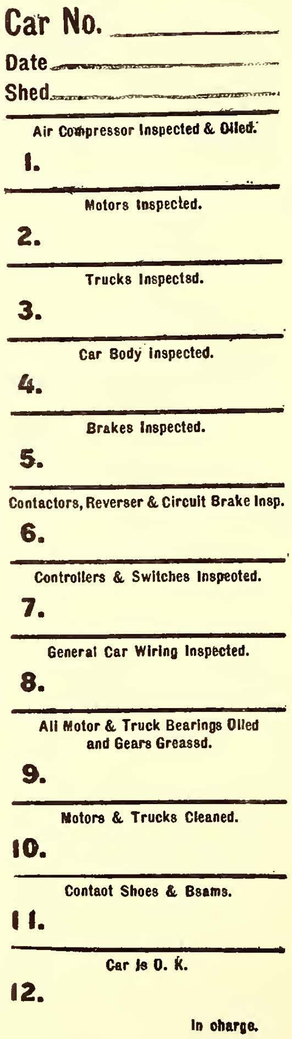


NEW YORK CENTRAL & HUDSON RIVER RAILROAD

1
2
3
4
5
6
7
Total
8
9
10
11
12
13
14
Total

PART OF LOOSE LEAF MILEAGE BOOK, WITH PAGES RULED FOR 31 DAYS, WEEKLY TOTAL AND GRAND TOTALS

When several cars have reached the 750-mile limit a list of their numbers is sent to the proper car-house foreman. This list is turned over to the clerk who immediately copies all car numbers on delivery inspection cards which are slipped into metal holders and tied to the controller handles. These cards are 8½ ins. long by 2¼ ins. wide, original size, and as shown below, call for inspection under one general heading and eleven special headings. This scheme is more convenient than separate signed reports on a car for all the signatures are on one card, and before the final inspector adds his final o. k. he can see at a glance whether every part of the inspection process has received attention. The name of the employee who makes the particular inspection designated is always written on this card and any defective work can be traced with ease. One of these cards is kept in the foreman's office in each inspection shop, for each car upon which work is done.



Car No. ________

Date ________

Shed ________

Air Compressor Inspected & Oiled.

1.

Motors Inspected.

2.

Trucks Inspectsd.

3.

Car Body Inspected.

4.

Brakes Inspected.

5.

Contactors, Reverser & Circuit Brake Insp.

6.

Controllers & Switches Inspeoted.

7.

General Car Wiring Inspected.

8.

All Motor & Truck Bearings Oiled and Gears Greassd.

9.

Motors & Trucks Cleaned.

10.

Contaot Shoes & Bsams.

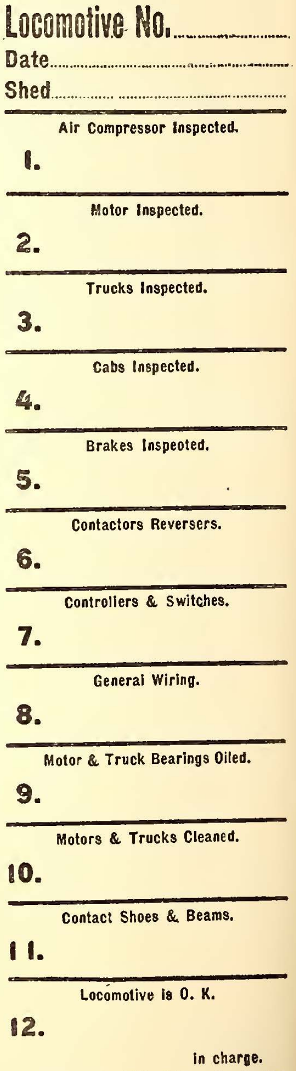
11.

Car Is O. K.

12.

In oharge.

CARD PLACED ON CAR TO BE INSPECTED



Locomotive No. ________

Date ________

Shed ________

Air Compressor Inspected.

1.

Motor Inspected.

2.

Trucks Inspected.

3.

Cabs Inspected.

4.

Brakes Inspeoted.

5.

Contactors Reversers.

6.

Controllers & Switches.

7.

General Wiring.

8.

Motor & Truck Bearings Oiled.

9.

Motors & Trucks Cleaned.

10.

Contact Shoes & Beams.

11.

Locomotive Is O. K.

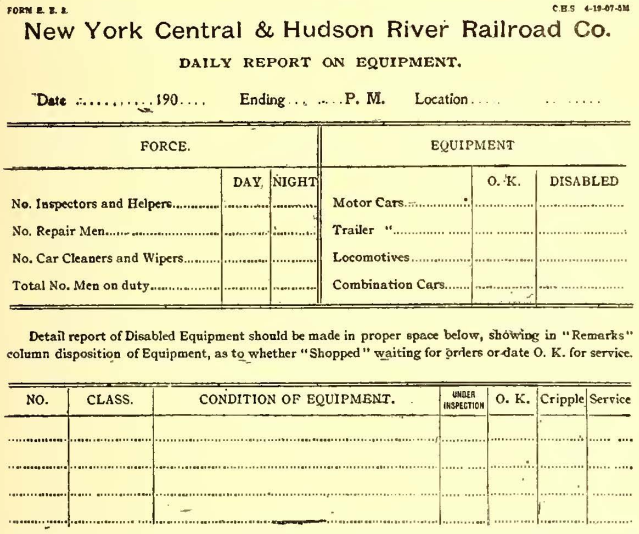
12.

In charge.

CARD PLACED ON LOCOMOTIVE TO BE INSPECTED

Each inspector has two small books in which he makes notes of the different items found. One of these books is used on Mondays, Wednesdays and Fridays, and the other the remaining days of the week, to enable the men to turn in their books every day for record by a clerk, who also keeps the original inspection tag. Should a car later become crippled before the next regular inspection it is an easy matter to trace the trouble due to careless work. In case a car is turned in due to some accident, such as a broken brake beam, the red tag is tied to the controller handle, the stub is torn off and sent with a statement of defects to the superintendent of equipment for his information. The car then goes through the usual inspection process before it is allowed to go into service again.

The daily report, original size 8 ins. x 13 ins., which is submitted by the car-house foreman on the equipment in hand and the number of employees caring for it, is shown below. The total number of inspectors, helpers, repair men, car cleaners, wipers on both day and night work are shown together with the total number of motor cars, trailers, locomotives and combination cars which are o. k. or disabled, the number of the car or locomotive, its class and condition with respect to inspection, availability for service. One of these reports is sent to the superintendent's office daily from Harmon, High Bridge, Croton, North White Plains, Wakefield and the Grand Central Station.



FORM E. E. 1. C.H.S 4-19-07-5M

New York Central & Hudson River Railroad Co.

DAILY REPORT ON EQUIPMENT.

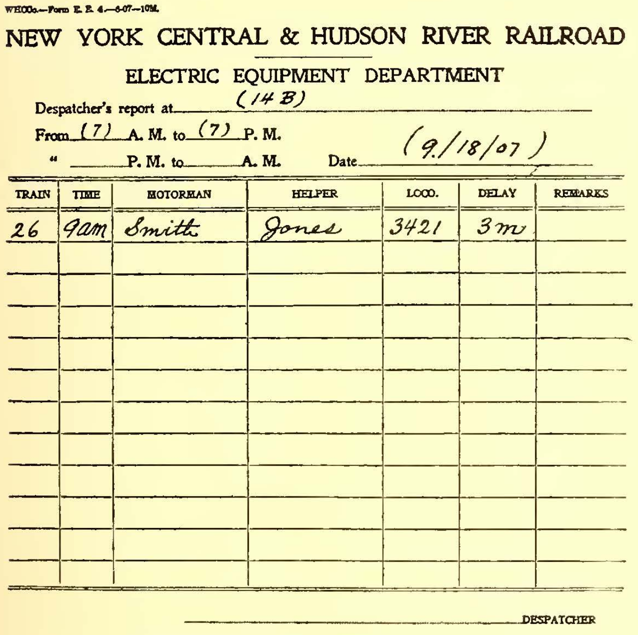
Date ....190.... Ending...........P. M. Location............

FORCE.			EQUIPMENT		
	DAY	NIGHT		O. K.	DISABLED
No. Inspectors and Helpers..........			Motor Cars..............		
No. Repair Men..........			Trailer "............		
No. Car Cleaners and Wipers..........			Locomotives..........		
Total No. Men on duty..........			Combination Cars..........		

Detail report of Disabled Equipment should be made in proper space below, showing in "Remarks" column disposition of Equipment, as to whether "Shopped" waiting for orders or date O. K. for service.

NO.	CLASS.	CONDITION OF EQUIPMENT.	UNDER INSPECTION	O. K.	Cripple	Service

FOREMAN'S DAILY REPORT OF EQUIPMENT UNDER CARE AND NUMBER OF EMPLOYEES



WHCOo.—Form E. E. 4.—6-07—10M.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD

ELECTRIC EQUIPMENT DEPARTMENT

Despatcher's report at (14 B)

From (7) A. M. to (7) P. M.

" ______P. M. to ______A. M. Date (9/18/07)

TRAIN	TIME	MOTORMAN	HELPER	LOCO.	DELAY	REMARKS
26	9am	Smith	Jones	3421	3 m	

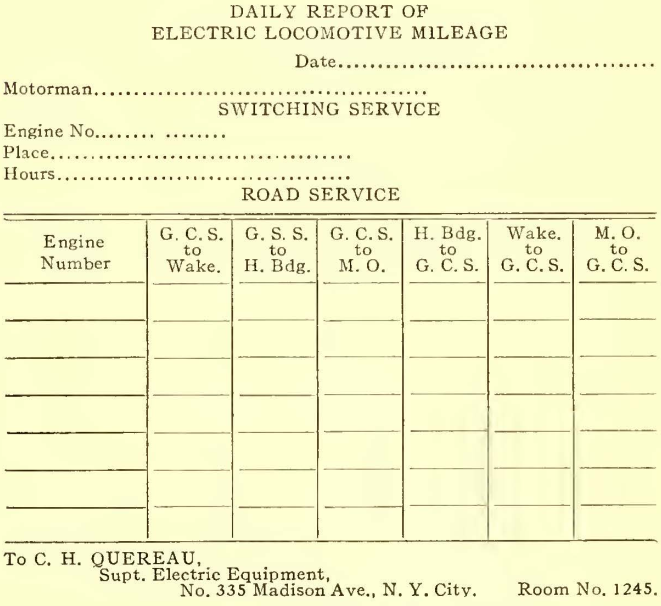
______DESPATCHER

DESPATCHER'S RECORD OF DELAYS

The next form, original size 5¼ ins. x 8 ins., shows a slip giving a daily report of the electric locomotive mileage. One of these reports is filled out at the end of each day by each motorman and the trips which he makes and the number of his locomotive between the Grand Central Station, Wakefield, High Bridge, are shown by check marks. These sheets are figured up in the office and the mileage of the different locomotives checked by their indications.

The next, original size 13 ins. x 8 ins., illustrates the report of a despatcher at either High Bridge, Wakefield, Lexington Avenue or the Grand Central Station. This report shows the number of each train, the time of its leaving or arrival, the name of the motorman, his helper, the number of the locomotive and any delay in case such occurred.

The despatchers in charge of the movement of the electrical equipment are responsible for the make-up and the manning of all trains. There are eight of these men, four being on day work and four on night work. They supervise the supplying of men for the runs designated on the time table in the electric division and are in general charge of the provision of electric locomotives and motor cars to meet the schedule. It requires about three minutes to make the change from steam to electricity at the High Bridge and Wakefield terminals. In changing locomotives, two men are required. As soon as the train pulls in these two men uncouple, and the locomotive, which is to be cut off, moves out of the way as quickly as possible. The new locomotive immediately backs down, is coupled to the train and the air brake test is made from the rear of the last car.



DAILY REPORT OF
ELECTRIC LOCOMOTIVE MILEAGE

Date..

Motorman..

SWITCHING SERVICE

Engine No........ ....

Place....................................

Hours....................................

ROAD SERVICE

Engine Number	G. C. S. to Wake.	G. S. S. to H. Bdg.	G. C. S. to M. O.	H. Bdg. to G. C. S.	Wake. to G. C. S.	M. O. to G. C. S.

To C. H. QUEREAU,
Supt. Electric Equipment,
No. 335 Madison Ave., N. Y. City. Room No. 1245.

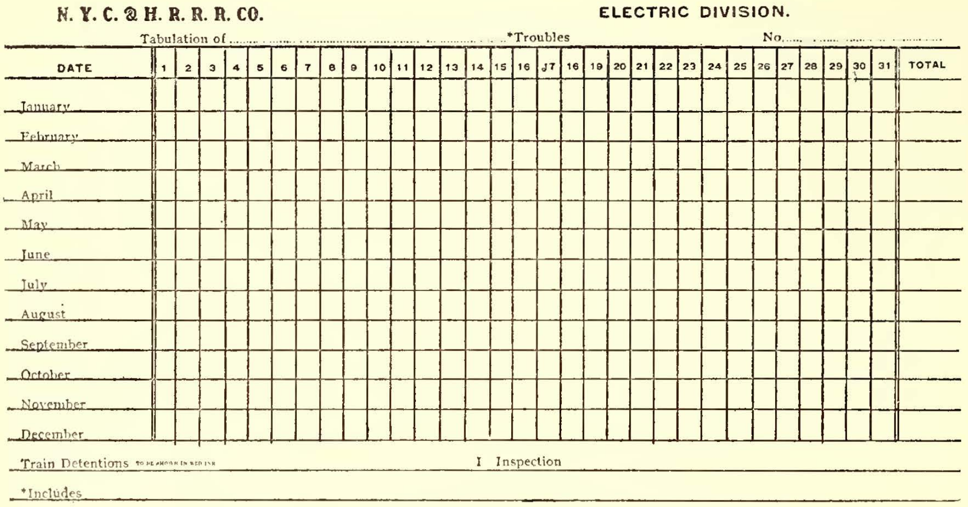
DAILY REPORT OF LOCOMOTIVE MILEAGE

The card on page 576, original size 5 ins. x 8 ins., is used in summarizing the troubles of each motor car throughout the year. Space is given for a summary of the troubles occurring on each day in the year, the total number of defects being recorded in a small square corresponding to the day. The frequent occurrence of any trouble or the frequency of any inspection can be told at a glance by examining this card. A white card is used in the same way for keeping track of locomotive troubles. Both sides of the cards are used.

The next form, original size 5 ins. x 8 ins., is a card used for keeping armature records. The number of the car or locomotive on which the armature is placed is given with the date of application, removal, mileage made between shop visits and notes of general repairs made. This record is kept in the office of the superintendent of equipment and is compiled from repair reports sent in from the inspection sheds and shops.

The third form on page 576, original size 5¼ ins. x 8 ins., gives the number of employees required for the maintenance of equipment on day work and night work at the various inspection stations and at the Harmon shops. It shows at a glance when filled out the total number of each class of men at work on a given day and is compiled from the sheets which are sent in to the office daily from the different inspection and maintenance points.

The form opposite, original size 8⅞ ins. x 4¾ ins., is used in keeping records of wheel applications. A sheet of the same size takes account of wheel renewals, and is also reproduced.



N. Y. C. & H. R. R. R. CO. **ELECTRIC DIVISION.**

Tabulation of ....*Troubles No.............

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	J7	16	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL
January																																
February																																
March																																
April																																
May																																
June																																
July																																
August																																
September																																
October																																
November																																
December																																

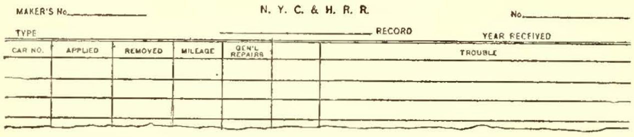
Train Detentions to be shown in red ink I Inspection

*Includes

CARD RECORD OF TROUBLES DUE TO A PARTICULAR PART OF THE EQUIPMENT

GENERAL RULES

Employees of the Maintenance of Way Department in the electrical zone are governed by the book of rules of the Maintenance of Way Department of the road in effect Aug. 1, 1906. In addition to this book other detail instructions have been prepared for the men in this department. In every telephone booth there is posted a list of the names and addresses of men who are to be called in case of emergency; this list is revised monthly by the superintendent.



MAKER'S No.________ N. Y. C. & H. R. R. No.________

TYPE ________________ RECORD YEAR RECEIVED

CAR NO.	APPLIED	REMOVED	MILEAGE	GEN'L REPAIRS		TROUBLE

ARMATURE RECORD CARD

REPORT ON HELP AND MAINTENANCE OF EQUIPMENT

Location	DAYS						NIGHTS						Total
	Fore-man	Inspec-tors	Rep. Men	Car Cleanrs	Oilers	Host-lers	Fore-man	Inspec-tors	Rep. Men	Car Cleanrs	Oilers	Host-lers	
High Bridge..													
Wakefield.....													
Harmon Insp.													
No. W. Plains.													
Harmon Rep..													
G. C. Station..													
Total.........													

OBSTRUCTIONS

No hand car or push car or any obstructions which may not be easily removed within sight of an approaching train is allowed upon the tracks without permission of the superintendent. No ballast, ties, tools, ladders, refuse or construction material of any sort is allowed to lie within the clearance lines of a track in service. The track and road bed are kept clear of scrap, loose wire, and all material which might cause a short circuit. Special care is also taken to keep divergent track rails in the same plane for a distance of 33 ins. between divergent rails in order to prevent the contact shoes from touching the track rails, causing short circuit.

In no case are any planking, ballast, or other obstructions allowed to come above the plane of the tops of the running rails for a distance of 33 ins. out from the gage line. Special care is used to keep this clearance where tracks have a superelevation. The distance between the third-rail and track is tested frequently with a template so that the proper gage can be maintained and the templates are frequently compared with the division standard. The division standard is checked with that of the superintendent of electrical equipment at least once a year.

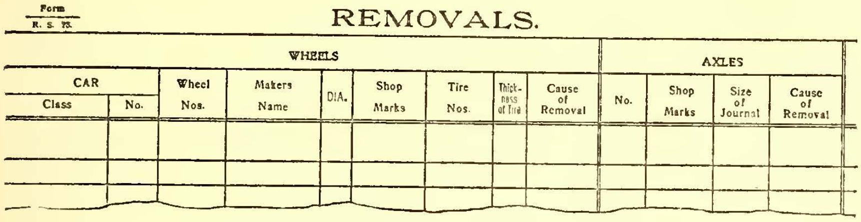
GENERAL PRECAUTIONS

Where work is to be done close to the third-rail, foremen are obliged to provide themselves with a special insulating form to be placed or held so that there will be no possibility of contact with the third-rail. All employees are obliged to know that metal tools or wooden tools that are wet coming in contact with the third-rail may injure them or others, or interrupt train service. Special instructions are given to the employees to avoid stepping, sitting, walking upon, or brushing against the third-rail. Unless it is definitely known that current has been turned off for a definite period it is required to be understood that current is turned on at all times on all third-rail and overhead conductors. Absolutely no change is allowed in the location or construction of the third-rail or third-rail appliances without an approved plan and letter of authority.

ORGANIZATION OF THE DEPARTMENT

The supervisor of third-rail reports to and receives instructions from the division engineer. He has charge of and is responsible for the safe and economical maintenance of all third-rail, all overhead conductors, and all rail bonding. He employs such foremen, mechanics and laborers as may be authorized and is required to know that foremen are sober, trustworthy men with knowledge and experience in the work. He instructs them as to their duties as occasion may require and sees that all his men understand their duties and faithfully perform them. He is also required to see that the men are supplied with the proper tools and that they use and care for them properly. The supervisor of third-rail employs ordinary laborers for all work which it is possible for such men to perform, and advises the supervisor of track of any track construction or method of work which improperly affects the third-rail or overhead conductor.

The third-rail foreman reports to and receives instructions from the supervisor of third-rail. He has charge of and is responsible for third-rail and track bonding, cross bonding and frog bonding and all third-rail and overhead conductor construction in his territory. He has jurisdiction over foremen, mechanics, patrolmen, helpers and laborers in his employ. He is required to personally examine at least three times a week all construction under his jurisdiction and to take immediate action to prevent damage from exposed third-rail and other conductors, defective sheathing, inadequate clearance or defective construction of third-rail, overhead conductors or other appliances. He notifies the superintendent of power whenever there is doubt of the proper condition of any bond, jumper, cross bond or other connection. The third-rail foreman is required to see that each patrolman has a complete set of tools in good condition for the work he may have to perform and that a sufficient reserve is kept in stock and in prescribed places. He receives from patrolmen and forwards to the supervisor of third-rail daily reports showing what defects were discovered and what action was taken. He is obliged to respond to any request from the superintendent of power or superintendent for emergency repairs and is charged to give special attention to inclines to see that they do not become loosened or displaced.

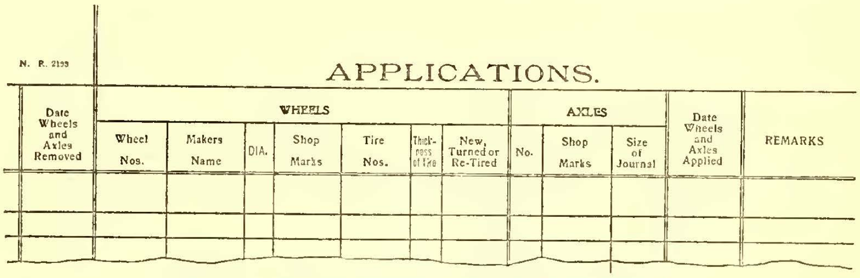


Form
R. S. 75.

REMOVALS.

WHEELS									AXLES			
CAR		Wheel Nos.	Makers Name	DIA.	Shop Marks	Tire Nos.	Thickness of Tire	Cause of Removal	No.	Shop Marks	Size of Journal	Cause of Removal
Class	No.											

UPPER PART OF WHEEL REMOVAL SHEET



N. R. 2193

APPLICATIONS.

Date Wheels and Axles Removed	WHEELS							AXLES			Date Wheels and Axles Applied	REMARKS
	Wheel Nos.	Makers Name	DIA.	Shop Marks	Tire Nos.	Thickness of Tire	New, Turned or Re-Tired	No.	Shop Marks	Size of Journal		

UPPER PART OF WHEEL APPLICATION SHEET

The section foreman or his assistant foreman is required to be constantly with the gang. He gives such oversight to the work of track workers and special watchmen as may be possible from the time they enter upon the tracks until they leave them. He advises the patrolmen of any defects in the third-rail insulators, sheathing, track bonds, cross bonds, jumpers, and any other connections and telephones or telegraphs the information to the third-rail foreman. He also assists the patrolmen or third-rail men in emergency.

The section foreman sees that the relation between the top of running rails and the under side of the third-rail is carefully maintained so as to give proper contact at all points between the under side of the third-rail and the contact shoes on the locomotives and cars, and after every leveling or lining of tracks, replacing of rails, changes of switches or frogs, he has the patrolmen test the third-rail as to height above the top of the running rail and clearance of overhead conductors and distance from the gage line. Except in emergency the removal or renewal of rails, frogs, or switches that are in tracks which are bonded is allowed only after the co-operation of the signal forces and third-rail forces has been secured.

Each patrolman reports to and receives instructions from the third-rail foreman. Two patrolmen have immediate charge of such section of the third-rail, the bonds of the track rail and overhead conductors as the third-rail foreman may direct and are responsible for its safe and economical maintenance. Each day patrolman is in charge from 7 a. m. to 7 p. m. and each night patrolman from 7 p. m. until 7 a. m. At least twice in his trick each patrolman is required to examine the construction assigned to him and see that everything is safe. He reports by telephone or telegraph to the nearest sub-station any defects noticed in the transmission cables, supports or other connections and also reports any defects in track or roadbed to the section foreman.

Patrolmen or any persons requiring power cut off a third-rail are obliged to obtain permission of the superintendent who notifies the superintendent of power, giving the details as to the track and length of time required and the name of the person who will be in charge of the work. The superintendent of power is responsible for the handling of jumpers and switches. Immediately before cutting power off the third-rail the load despatcher advises the chief train despatcher. When the work is completed or the time has expired the person who asked to have the power cut off is obliged to report the third-rail ready for current to the chief train despatcher. The chief train despatcher then notifies the load despatcher that the third-rail is ready for current. The load despatcher then orders current turned on and notifies the train despatcher as soon as this has been done. Patrolmen are required to be familiar with all rail circuits and to report at once to the third-rail foreman any defects which cannot be corrected without assistance. Each patrolman is obliged to see that the despatchers, agents, and signal men on his section have his address and to promptly notify them in case of a change. He is obliged to respond to all calls from the despatchers for emergency work or repairs of any kind and forwards a copy of his report to the third-rail foreman. He also complies with requests of section foremen to bond the track rail and calls upon the section foreman to help him in times of emergency.

THIRD-RAIL MAINTENANCE

Broken or defective insulators are replaced at once and six 33-ft. lengths of third-rail, properly prepared for bonds, are kept in rail racks not more than one mile apart. Duplicates of all special sections of third-rail are stored on rail racks at suitable places and at yards and terminals an adequate reserve of materials for erection and repair of third-rail are stored at convenient places. Tool boxes marked "Third-rail maintenance" are kept at twenty-one places enumerated in the instruction book. Each tool box contains the following material:

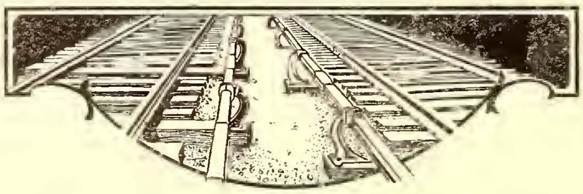
1 adze.
1 template for X bracket.
1 template for Y bracket.
1 template to gage dapping out of ties.
1 5/8-in. ship auger.
1 2-lb. No. 2 bull point hammer.
1 1¼-in. square socket lag screw wrench.
1 flogging chisel.
1 4-lb. double-face hammer.

1 hacksaw frame.
1 dozen hacksaw plates.
1 square taper shank, No. 4 packer sleeve ratchet.
6 1-in. square taper shank twist drills.
1 center punch.
2 ¾-in. bolts 20 ins. long, threaded and fitted with nuts on each end for clamp.
1 ¾-in. backing-out punch.
2 drift pins for opening bond terminals.
1 dozen sheets emery cloth.
2 track bolt wrenches.
3 14-in. flat bastard files.
1 pair 6-in. clamps.
1 Sievert blow torch.
3 small acid brushes.
5 yds. cheese cloth.
6 lbs. 2-in. insulating tape.
4 pairs rail tongs.
1 cross-cut hand saw.
1 claw hammer.
1 1½-in. wood chisel.
1 1-in. cold chisel.
1 5-gal. can gasoline.
1 1-qt. can neutral acid.
12 brackets.
3 Y brackets.
3 dozen ¾-in. x 6-in. lag screws.
3 dozen ¾-in. x 4½-in. lag screws.
1 dozen ¾-in. x 2-in. machine bolts.
1 dozen ¾-in. lock washers.
½ dozen channel extensions.
1 dozen pairs (No. 1) insulators.
3 pairs (No. 2) insulators.
1 dozen (No. 1) hook bolts.
3 (No. 2) hook bolts.
1 lb. Hydrex felt.
2 dozen solder bolts.
2 dozen track bolts.
½ dozen twin terminal bolts.
6 pairs third-rail splice bars.
36 pairs ¾-in. x 2½-in. track bolts.
6 pairs half-and-half solder bolts.
3 lbs. drive screws.
2 pairs rubber gloves.
2 rubber mats, 18 ins. x 36 ins.
1 box "first aid to the injured."

Each took box is in charge of the patrolman on whose district it is located, but tools are for the use of any one who properly has a master key. The person using the tools is responsible for their condition and prompt return.

TRACK WORK

No track jack is ever allowed between the third-rail and the track. Bracket ties are thoroughly tamped under and for 16 ins. each side of each running rail; the remainder of the tie has a uniform bearing and is lightly tamped. These ties are placed and maintained at right angles with the track and where possible are put in the track from the side opposite the third-rail. Lining bars are not allowed between the third-rail and track, but when it is necessary to line adjacent rail away from the third-rail a hook and jack are used.



EFFECT ON TERMINAL OPERATION OF THE NEW YORK CENTRAL ELECTRIFICATION.

The New York Central electric trains are being operated upon the same schedules as were formerly used with the steam trains, so that the effect of their more rapid acceleration in reducing the maximum speed is hardly perceptible to the ordinary passenger, however evident it may be at the time of starting the trains. It is in the atmosphere in the tunnel that the greatest difference from former conditions is apparent. The primary reason for the adoption of electricity on the New York Central Railroad was to eliminate locomotive smoke and gases of combustion, and the results have certainly justified expectations. The Park Avenue tunnel, which is some two and one-half miles in length, is now almost clear.

Formerly the entrance of a train into this portion of the route was the signal for the closing of all the windows and doors. Then followed a ride of some five minutes in a stifling atmosphere. It is difficult for any one who has not had the actual experience to realize the immense improvement effected in this respect. Passengers on the trains which run observation cars now occupy the rear or observation platform in traveling from Forty-Second Street to 125th Street. This was not possible a year ago.

The New York Central Railroad has changed over its equipment entirely, but 80 per cent of New Haven trains are still drawn by steam locomotives. When these are finally eliminated and electric locomotives are substituted for them, it is the intention of the management to thoroughly clean and whitewash the tunnel and possibly introduce some system of lighting.

Another reason why the full benefits have not yet been secured by the New York Central from its electrical equipment is that the work of reconstructing its Forty-Second Street terminal is still under way. Plans showing the proposed improvements were published in the Street Railway Journal for Nov. 18, 1905. The excavation east of the old station has largely been completed and all New York Central suburban and Harlem Division trains are being dispatched from the Lexington Avenue station. Others still leave and enter the old station on Forty-Second Street. As the excavation gang progresses with its work, trains are changed from one track to another and new portions of the excavation are attacked. The smoothness with which the operation of the trains is carried on is remarkable.

In spite of these facts it is already possible to determine some of the results which have followed the electrification of the New York Central terminal and it is proposed to describe them in the following paragraphs.

EFFECT ON STATION LABOR

From an operating standpoint the first question which might be raised is whether the terminal service requires less help than when steam was used as a motive power. There has been a marked reduction in this item of expense, although its extent is difficult to determine as yet. Thus, practically the entire engine house force is dispensed with, such as the turntable men, ash men, water men, etc.

This absence of attention necessary to the locomotive at the terminal is one of the marked features of the electrical machine. Formerly when a train was pulled into Forty-Second Street by a steam locomotive it would require from one to two hours to prepare the locomotive for use again. This time was taken up in dumping the ashes, receiving a fresh supply of water and the necessary attention of the inspectors. With electricity this work is of course entirely eliminated. Electric locomotives come into Grand Central Station, uncouple from the inbound train and couple to an outbound train ready to start on the return trip in a very few minutes. This has permitted the pooling of locomotives at Forty-Second Street to a greater extent than heretofore, and consequently has resulted in a considerable reduction in train movement.

The total number of movements in the yard on July 2, not only for regular trains, but also of switches, showed a decrease of about 33 per cent due to the use of electricity. This decrease in movements, combined with the enlargement of the terminal, has increased its efficiency to such an extent that on July 2 the delays had been reduced from a total of 443 minutes per day to 122 minutes per day. On July 2, 1907, the New York Central Railroad alone was handling a total of 350 trains in the Grand Central tunnel, of which 327, amounting to 94 per cent, were handled by electricity. The New Haven Company on the same day was handling 145 trains, all its motive power being steam. On Aug. 20 all New York Central trains and twenty-four New Haven trains were being handled by electricity, leaving 133 New Haven trains hauled by steam.

STORAGE AT SUPPORTING YARDS

The conditions at the Grand Central Station at present do not permit of very much storage of either cars or locomotives, and for this reason the practice is still followed of storing most of the locomotives and motor cars at the Mott Haven yards between 150th and 160th Streets. The empty trains passing between the Grand Central Station and these supporting yards are run on the same schedule as regular trains to unify train movement. From one to two electric locomotives, however, and about the same number of motor car trains are usually held at the Forty-Second Street yards.

When a train reaches the incoming platform assigned to it the duty of the crew is over. The men leave the locomotive or car and it is run to its siding or to the Mott Haven yards by a special switching motorman.

LOADS HAULED

The heaviest train under normal conditions which is hauled in or out of the Grand Central Station is made of from eleven to fourteen Pullmans with occasionally a maximum of eighteen Pullmans. There is no doubt, however, that the electric locomotives could haul longer trains. In fact, on one or two occasions, when steam locomotives have broken down in the tunnel, an electric locomotive has hauled the dead locomotive and train as well as its own.

EMPLOYEES

The electric trains are operated by the former steam engineers and firemen, and two men are kept in the cab, both with the electric locomotives and the motor cars. On the locomotive, the fireman and on the motor cars an inspector acts as an assistant. No change has been made in the wages paid to the crews, but the work is undoubtedly very much simpler than with the steam locomotives, as well as cleaner and more pleasant. Employees of the electric division are governed by the book of rules of the operating department of the New York Central & Hudson River Railroad Company.

YARD OPERATION

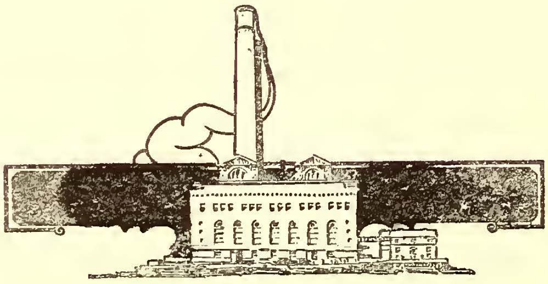
In coupling up locomotives to trains the electric locomotive has an advantage over the steam locomotive because with the latter the blowing off of steam makes it more difficult for the engineer and fireman to hear and see the brakemen doing the coupling, and in winter this is frequently a serious matter. There is also a difference in the sensitiveness of the control of the two machines in favor of the electric locomotive.

The yards are safer with electric power on account of the reduction in noise and the absence of smoke and escaping steam. The yard men have had to adapt themselves to the new conditions, however, because the electric locomotives do not give the same noisy warning of their approach as their steam predecessors.

INCREASE IN CAPACITY AND COMPARISON OF COST

It is practically impossible at the present time to determine how great will be the increase in the capacity of the Forty-Second Street terminal resulting from electric operation. The limiting feature of the capacity of the Grand Central terminal is of course the tunnel, and any increase in the capacity of the tunnel can be secured only by shortening the blocks. At present, during the rush hours, trains are run three minutes apart, the same schedule as employed in steam days. This headway corresponds to twenty trains an hour on each track, or forty trains an hour each way for the four tracks. After the New Haven steam locomotives are finally banished from the tunnel and all smoke and steam removed the blocks will be shortened. The trains during rush hours may then be run on a headway of two minutes, or even one and one-half minutes, which would correspond to an increase of 50 to 100 per cent in the capacity of the tunnel, measured in trains per hour. The figure is of course the theoretical capacity, based upon absolutely no detensions from open draws, switches, crossings or other causes.

Very careful observations of the comparative cost of operation by steam and electric power are now being made by the railroad company, and the results will soon be ready for announcement. Enough has already been learned to indicate that electricity has even other attractions than the elimination of nuisances incident to steam power, and greater efficiency.



ELECTRICAL OPERATION ON THE WEST SHORE RAILROAD

The operation of the electrified section of the West Shore Railroad between Utica and Syracuse, N. Y., illustrates a combination of urban and interurban service that is unique in the present development of heavy electric traction. The novelty of the service lies in the fact that it is a combination of street and steam railroad service. The cars use the steam tracks between Utica and Syracuse, a distance of some forty-four miles, and are also operated on local tracks in the streets of both cities, giving at the terminal cities a house-to-house distribution and collection of passengers which is out of the question in either suburban or interurban steam railroad service. For some time past transportation experts have sought to develop a system of this character which would be sufficiently free from restrictions to enable its economic value to be determined. The electrified section of the West Shore has been in operation only since Sunday, June 16, 1907, but from the company's experience thus far in this particular field there seems to be no question about the attractiveness of the combined urban and through service offered.

The regular electric service now in operation between Syracuse and Utica provides facilities which were not in existence before, and aside from offering cheaper through and round trip rates than were in force in connection with the old steam service, it affords means of tying the rural regions to the business centers in a way which was formerly impossible. This result is usually attained in the building of an interurban trolley line, but in the case of the West Shore the permanent way was already established, with low grades and long radius curves permitting a much higher schedule speed than is ordinarily the case. The increase in the frequency of the service has proved a great boon to the population tributary to the line, and journeys from the country-side to the city which hitherto consumed a large part of a day on account of the small number of local steam trains scheduled are now completed with the minimum of time consumption, easily less than half a day in many instances.

In its engineering features, the West Shore electrification illustrates standard practice in alternating current supply to rotary converter substations with third-rail direct current distribution. The construction details of the work were described in the Street Railway Journal of June 8, 1907, and only such reference will be made to them in this article as is closely related to the operation of the road. Briefly, the operating problem has been simplified as far as possible, and the remarkable differences in conditions between the West Shore situation and the electrified terminal work in the vicinity of New York are reflected in the manner of handling the service in each case. High density of traffic has yet to appear on the West Shore electrified section, and the resemblances to interurban conditions are apparent at many points. The electrified service has not been in use long enough for its operating details to become fully settled, but it is interesting to note the influences of both the steam and the street railway in the scheme as it is thus far developed.

SUMMARY OF PHYSICAL CHARACTERISTICS

The electrified section of the West Shore extends from the westerly limits of Utica to the easterly limits of Syracuse, the distance between terminals being about forty-four miles. There are 30.515 miles of double track, 8.843 miles of triple track section and 4.582 miles of four track line, the total electrified mileage being 105.887. Power is purchased at 60,000 volts from the Hudson River Electric Power Company, and delivered by that company to a substation at Clark Mills. The railroad service is supplied from Clark Mills and from three other substations, located respectively at Vernon, Canastota and Manlius Centre, which are connected with Clark Mills by a 60,000 volt three-phase transmission line carried on steel towers. Each substation contains the usual step-down transformer and switching equipment, with two 300 kw rotary converters and space for a third. The oil switches are motor-operated, current being supplied to the motors by a storage battery of fifty-five cells. The third rail is of the bullhead type, weighing seventy pounds per yard, and of the same cross section as that employed in the terminal work of the New York Central, arranged for an under-running contact. No direct current feeders are required. The rolling stock consists of fifteen cars equipped each with four General Electric "73" motors and multiple unit control.

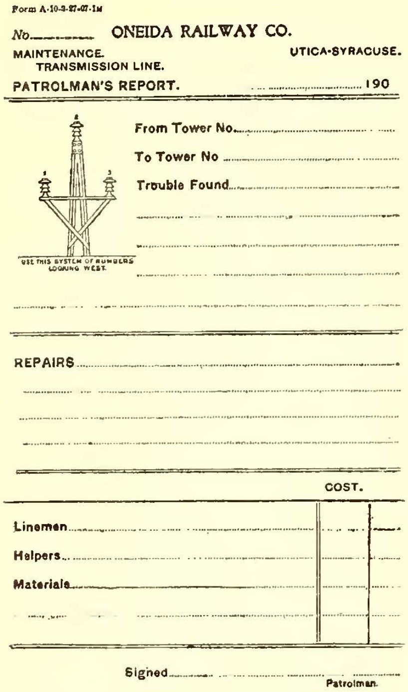
GENERAL OPERATING ORGANIZATION

An agreement between the New York Central and Hudson River Railroad Company and the Oneida Railway Company provided that the latter should lease the West Shore Railway between Utica and Syracuse, and equip its tracks for electrical operation and conduct the passenger business between these two points; while on the other hand the New York Central agreed to abandon the local trains on these tracks, reserving the right to continue its through steam trains and to haul freight over the section by means of steam locomotives.

The operation of the electrified section is in general charge of the vice-president and general manager of the Oneida Railway Company, C. Loomis Allen, of Syracuse. Operation in details falls under the jurisdiction of W. J. Harvie, electrical engineer, and F. J. Gerdon, superintendent of transportation, of the Utica & Mohawk Valley Street Railway, a property closely associated with the Oneida Railway Company. The train movements over the West Shore tracks are directed by the regular New York Central train despatchers at Utica, who are responsible jointly to the Oneida Railway Company and the New York Central. Maintenance of the transmission line between Clark Mills and Manlius Centre is handled by the Oneida Railway Company, this line belonging to the West Shore, and not to the Hudson River Electric Power Company. Maintenance of rolling stock on the electrified section of the West Shore is performed under the jurisdiction of the Oneida Street Railway Company in the Utica shops of the Utica and Mohawk Valley Street Railway Company. The Oneida Railway Company is now building a repair shop in Syracuse, which will be jointly used by the Oneida company for the maintenance of West Shore rolling stock and by the Syracuse Rapid Transit Company.

Reporting to the electrical engineer is an assistant electrical engineer, H. S. Williams, who has general supervision of the work done on the West Shore cars at the Utica repair shop, with the co-operation of the master mechanic of the Utica and Mohawk Valley Street Railway; a subordinate clerical and drafting force; a chief substation operator, and general foreman of maintenance and construction. Reporting to the superintendent of transportation are an assistant superintendent, F. L. Van Slyke, who has charge of all train crews; a clerical force, and in part the New York Central train despatchers.

All electrical and mechanical construction on the West Shore electrified section is under the jurisdiction of the electrical engineer, the work being charged to the Oneida Railway Company under the lease of this section of the former steam road. At the present time the construction work has nearly all been completed, the principal work remaining being the building of concrete platforms at each regular stopping point on the West Shore private right of way. Each of these platforms will be 100 ft. long and 7 ft. wide. The general foreman of maintenance and construction is in direct charge of this work and about half his time is devoted to each of the branches designated in his title. Three subforemen report to the general foreman and the working force includes about forty men. At the completion of the construction work this organization will be discontinued.



Form A-10-3-27-07-1M

No.______ ONEIDA RAILWAY CO.

MAINTENANCE. UTICA-SYRACUSE.
TRANSMISSION LINE.

PATROLMAN'S REPORT. 190

From Tower No.............
To Tower No ....
Trouble Found.............

USE THIS SYSTEM OF NUMBERS LOOKING WEST.

REPAIRS.............

COST.

Linemen.............
Helpers.............
Materials...........

Signed............. Patrolman.

PATROLMAN'S REPORT ON LINE TROUBLE

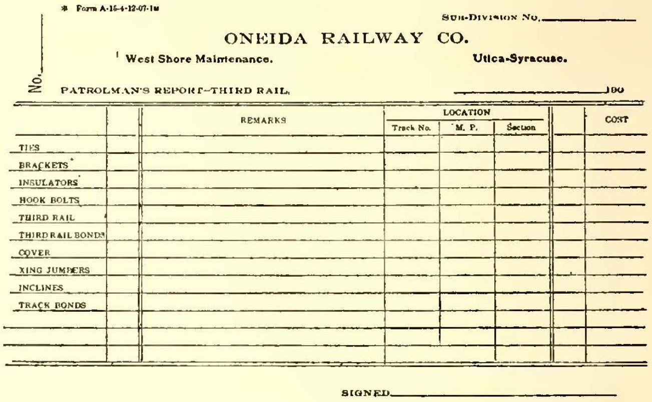
The New York Central & Hudson River Railroad maintains all the track on the West Short electrified section. The maintenance of the third-rail is handled by an organization of nine third-rail patrolmen responsible to the general foreman of maintenance (and construction). Eight of these patrolmen are regular inspectors, and each man patrols about twelve miles of single track per day on foot, making minor adjustments and repairs. The ninth man is a relief inspector. The third-rail patrolmen make their headquarters at the various substations along the line and can be reached by telephone at these points rather than at other points along the right of way. It has not yet been considered necessary to install telephones at other points than the substations and company offices. The third-rail patrolmen inspect ties, insulators, hook bolts, the third-rail itself, third-rail bonds, covers, crossing jumpers, inclines and track bonds. They replace broken parts, maintain the third-rail in the proper alignment and elevation, including inclined approaches and recessions. Thus far it has not been necessary to make any electrical tests on either the bonding of the running rails or of the third-rail. In case a third-rail bond should work loose it would result in the heating of the cover. A visual inspection suffices at present, but later it is probable that some form of regular bond test will be inaugurated.

REPORTS OF THIRD-RAIL PATROLMEN

Each third-rail patrolman makes out a daily report on a blank illustrated on this page, original size 5 in. x 7½ in. This form is kept in a book with provision for a duplicate carbon, colored yellow, which is kept by each patrolman for future reference. The original blank is a blue sheet and these are sent regularly to the Oneida company's office in Utica. The third-rail patrolman records the subdivision of the line on which he is at work, the date, the character of repairs made, the number of the track, the nearest mile post and the section number where the work was done. The cost of the work is figured in the office from the known rates and material quantities consumed as indicated on the back of the report by the general foreman of maintenance. Spare crossing jumpers are kept in cable form at each substation and bonds with line material are kept at the substations. No bracket or third-rail insulator tests are made on the road, but these were handled at the factory. It has not yet been necessary to make any resistance tests on either the third-rail or track.

LINE MAINTENANCE

Line maintenance is handled by two high tension patrolmen who report to the chief substation operator. They each cover from eight to ten miles of line per day on foot, but on Sunday mornings the trip over the line is made on a regular car. The high tension line parallels the tracks of the electrified section all the way from Clark Mills to Manlius Center, and can be inspected in a general way from a car platform without difficulty. These patrolmen report at each substation as they walk over the route, so that the office can give them special instructions if necessary. There are about thirty-three miles of 60,000 volt line maintained by the Oneida Railway Company in connection with the West Shore service.



* Form A-16-4-12-07-1M

SUB-DIVISION NO.________

No.

ONEIDA RAILWAY CO.

West Shore Maintenance. Utica-Syracuse.

PATROLMAN'S REPORT—THIRD RAIL. ____________190

		REMARKS	LOCATION				COST
			Track No.	M. P.	Section		
TIES							
BRACKETS							
INSULATORS							
HOOK BOLTS							
THIRD RAIL							
THIRD RAIL BONDS							
COVER							
XING JUMPERS							
INCLINES							
TRACK BONDS							

SIGNED________________

PATROLMAN'S REPORT ON THIRD-RAIL TROUBLES

REPORTS OF LINE PATROLMEN

Since the road was placed in electrical operation only one insulator has failed, and this, it is thought, was broken by a stone or other missile. The factory tests on the insulators were described in the Street Railway Journal of June 8, 1907, and at that time reference was made to the plan followed in specifying a certain duty for the insulators rather than attempting to settle detail dimensions and shapes. The company's experience seems to justify the former practice. In case it is necessary to change insulators on the 60,000 volt line the line is shut down for the purpose, the work being done at night if possible. Each patrolman uses a blank form like the one shown on this page, original size 4½ in. x 7½ in., in making his daily inspection and maintenance report. The line is carried on steel towers, No. 0 wire being used to give the requisite mechanical strength for the spans, which are 480 ft. in average length. The circuit is of the three phase star connected type, with grounded neutral. The inspection report is provided with a tower diagram in the upper left hand portion, the top insulator being numbered 2 and the left and right hand insulators being numbered 1 and 3 respectively, looking west. The report indicates the location of the line trouble, the nature of repairs, number of linemen, helpers and quantity of material required, the cost being figured in the office at the conclusion of the work. A gasoline motor car is used for emergency repairs on both the transmission line and third-rail. It has a maximum speed of about twenty miles per hour and is ordinarily kept at the Oneida Castle station, which is twenty-two miles from Utica. This car is never used in routine inspection, but is held in readiness for prompt movement over the line in case of trouble, particularly in emergencies when power for operating the motor cars might be shut down.

LINE OPERATION

Thus far no shutdown from lightning has been experienced on the high tension line. Power is at present supplied at 60,000 volts from the steam plant of the Hudson River Electric Power Company at Utica, but this company's transmission line from the Spier Falls station on the Hudson River, about 100 miles distant, is being pushed westward with the view of ultimately operating the West Shore from the hydro-electric plant at Spier Falls. No line short circuits have thus far been experienced on the West Shore. The towers are thirty-nine feet high and are provided with steps to facilitate inspection and repairs. Two men are required to replace an insulator, the time expected being about thirty minutes with the use of tackle. Not enough of this work has had to be done as yet to fix a minimum time for its performance under usual conditions. The country paralleling the line is all of open character. No breaks have as yet occurred on the line. Telltale papers are not as yet used to record lightning arrester discharges, but probably will be soon. The arresters have made an excellent record thus far, one having handled four severe discharges in twenty-two minutes. Danger signs have been installed on all the West Shore high tension towers. The minimum clearance of tree sections from the line is about twenty-five feet. A few troubles have occurred in the low tension distribution on account of mechanical injury to third-rail jumpers, but these have become largely matters of experience.

SUBSTATION OPERATION

The chief substation operator on the electrified section of the West Shore Railroad has direct control of the handling of the transmission line and the four substations. The operation of the latter is effected by nine substation employees, including a helper. There are two daily shifts in each substation, the day shift being eleven hours long and the night shift thirteen hours in duration. The headquarters of the chief operator are at Clark Mills. The helper takes care of the thirteen-hour run on a change-over which occurs once in two weeks, and the rest of the time is occupied in small repairs and maintenance.

The third-rail is kept continuously alive, one rotary being run during the night in some one substation. The other substations are started at 5:30 a. m. and are operated until 1 a. m.

The inspection of the substation machinery falls under the jurisdiction of the chief operator. The apparatus is blown out once in two weeks and the switchboards wiped down daily. Oil switch motors and contacts are inspected weekly. As far as possible, inspection and repairs are confined to the daytime. The third-rail potential is 600 volts, and the sectionalizing at substations is of the simplest character. The third rail of each track is broken opposite each substation and a cable connection carried from the end of the third-rail through a switch and circuit breaker to the D. C. 600-volt positive bus bar. This enables each track to be independently fed each way from each substation, there being four feeder panels on a two-track section, as shown in the accompanying sketch. By keeping the east and west-bound tracks entirely distinct except through the bus bars an interruption on one track has no effect on the other. In one or two instances, where there are long passing sidings equipped with third-rail, there has been added an extra panel to the switchboard to supply current for this section.

In starting the rotaries half voltage taps on the a. c. sides are used. The full load on the direct current side of each machine is 500 amperes. The half-voltage taps prevent the starting current from exceeding full load and the machines are brought up to synchronism quickly and smoothly. Should the d. c. polarity chance to come up in the wrong direction, it is readily changed by means of the field-reversing switch provided for this purpose. By this method, in any circumstances, a rotary can be started, run up to full speed and be delivering power to the line inside of a minute. The rotaries are operated with their series and shunt windings both in service. The maximum continuous overload allowed per rotary is 50 per cent.

MISCELLANEOUS OPERATING NOTES

The high-tension line is continuous through each substation, and no maintenance work has as yet had to be done on the 60,000-volt circuits within the substation buildings. Each transformer and hence each rotary can be cut off from the bus bars by oil switches without interfering with the operation of the substation beyond the one where the particular transformer and rotary are located. The voltage of the remote control motor circuits is 125. It was not considered necessary to provide motor-driven direct current circuit breakers in this installation. Totalizing wattmeters are used on the individual rotaries in the substations. The high-tension voltage is measured by multiplying the indications of a secondary voltmeter by the proper constant. Fifteen minute readings are taken on the indicating instruments in the substation switchboards during each shift. No curve drawing instruments are in service as yet, and it has not yet become necessary to make regular tests on the transmission line from any of the substations, either in sections or as a whole. Supplies for the substations are ordered through the purchasing department of the Oneida Railway Company at Utica.

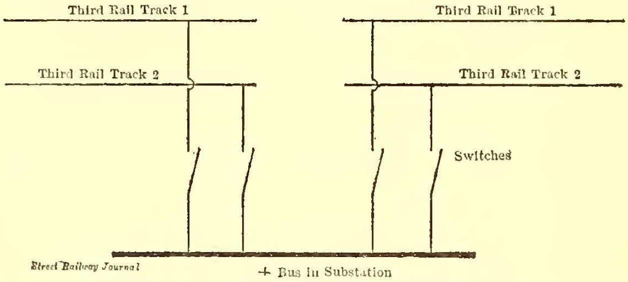
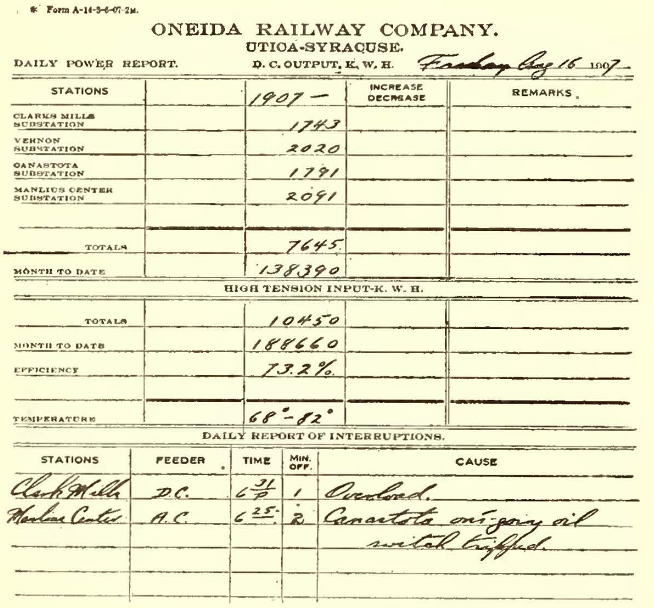


DIAGRAM OF THIRD-RAIL CONNECTIONS

The substation batteries are charged and discharged by floating on the live wire a suitable resistance between them and the 600-volt d. c. bus. Records of specific gravity and cell voltage are kept by the chief substation operator. Compressed air is used regularly in all the substations for cleaning. No trouble has been experienced with hunting in the operation of the rotaries, which are 40-cycle machines. The chief substation operator has full power to order in or out of service any machine at any time. Two rotaries are regularly used in each substation.

TELEPHONE SERVICE AND EMERGENCY OPERATION

As stated in a previous paragraph, there are as yet no telephones located along the road except at the substations, where a leased private line of the Bell Company between Syracuse and Utica enters. This connects with two private branch exchanges in the offices of the Utica & Mohawk Valley Street Railway Company and the Syracuse Rapid Transit Company. For commercial company service another line is shortly to be added, but it is not planned to carry this into the substation. No interference with telephone service has been caused by the high potential transmission line thus far. No telephones are carried on the cars. The movement of rolling stock on the electrified section of the West Shore is handled entirely by telegraph, in the routine work of the New York Central despatches. An emergency telephone connection is in service between the Clark Mills substation and the steam plant of the Hudson River Electric Power Company at Utica, so that if any trouble occurs in the substation which relates to the high-tension power supply, immediate communication can be had with the generating station. In case of a short circuit on the third-rail, when the breakers keep coming out, the substation operator on duty at that particular moment tries to close the line three times, then waits three minutes, and then tries to close the circuit once a minute for five minutes more, after which he tries to establish a power flow once every three minutes. No outdoor line switches are in service on the electrified section of the West Shore, and no branch tracks of the road are equipped electrically as yet. No fires have as yet occurred on account of trouble on the 60,000-volt transmission line or its connections. There are no machine shops in the substations, and only minor substation supplies, like rotary brushes, spare cable and tools, are stored at these points.



* Form A-14-3-6-07-2M.

ONEIDA RAILWAY COMPANY.
UTICA-SYRACUSE.
DAILY POWER REPORT. D. C. OUTPUT, K. W. H. Friday Aug 16 1907

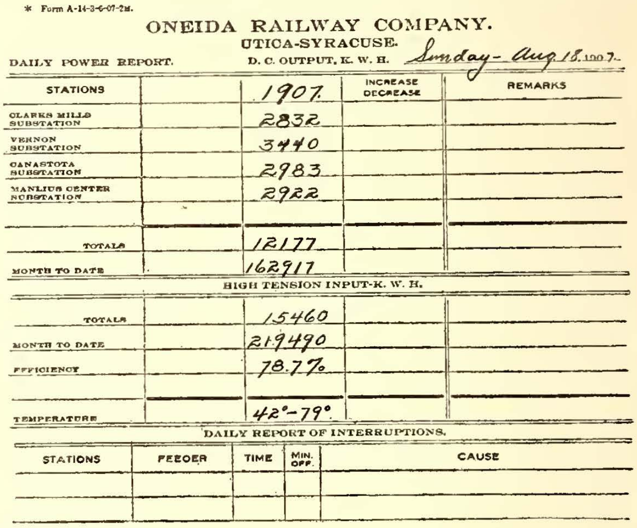
STATIONS		1907 —	INCREASE DECREASE	REMARKS
CLARKS MILLS SUBSTATION		1743		
VERNON SUBSTATION		2020		
CANASTOTA SUBSTATION		1791		
MANLIUS CENTER SUBSTATION		2091		
TOTALS		7645		
MONTH TO DATE		138390		

HIGH TENSION INPUT-K. W. H.

TOTALS		10450		
MONTH TO DATE		188660		
EFFICIENCY		73.2%		
TEMPERATURE		68°-82°		

DAILY REPORT OF INTERRUPTIONS.

STATIONS	FEEDER	TIME	MIN. OFF.	CAUSE
Clark Mills	D.C.	$6\frac{31}{P}$	1	Overload.
Manlius Center	A.C.	6^{25}	2	Canastota out-going oil switch tripped.



* Form A-14-3-6-07-2M.

ONEIDA RAILWAY COMPANY.
UTICA-SYRACUSE.
DAILY POWER REPORT. D. C. OUTPUT, K. W. H. Sunday- Aug 18. 1907.

STATIONS		1907.	INCREASE DECREASE	REMARKS
CLARKS MILLS SUBSTATION		2832		
VERNON SUBSTATION		3440		
CANASTOTA SUBSTATION		2983		
MANLIUS CENTER SUBSTATION		2922		
TOTALS		12177		
MONTH TO DATE		162917		

HIGH TENSION INPUT-K. W. H.

TOTALS		15460		
MONTH TO DATE		219490		
EFFICIENCY		78.7%		
TEMPERATURE		42°-79°.		

DAILY REPORT OF INTERRUPTIONS.

STATIONS	FEEDER	TIME	MIN. OFF.	CAUSE

FORMS SHOWING SUBSTATION OUTPUTS FOR AUG. 16 AND AUG. 18

SUBSTATION LOG SHEETS

The cuts on Plate XXVIII (originals 14 ins. x 25½ ins.) illustrate two log sheets of the Clark Mills substation of the West Shore Railroad for Friday, Aug. 16, and Sunday, Aug. 18, 1907. These log sheets are kept in every substation and are sent to the office in Utica daily and bound as parts of a loose leaf book. The voltage and load records are plotted on the logs in the form of curves, and special occurrences are tabulated also. Wattmeter readings on both the incoming and outgoing circuits are recorded in figures.

On Friday, Aug. 16, single-car trains were in service all day except for a few hours in the morning and afternoon, when two-car trains were operated. The increased load due to this is plainly evident upon the curves. Rotary No. 1 was in service from 7 a. m. to 1 a. m. on Saturday and again at 6 a. m. Saturday, the 24 hours beginning at 7 a. m. Friday. Rotary No. 2 was in service throughout the same period, except that it was shut down at 11:50 p. m. Friday instead of at 1 a. m. the next morning. Between 1 a. m. and 6 a. m. Saturday the line was kept alive by some substation beyond Clark Mills. The d. c. voltage (practically at the third-rail) varied from 595 to 620, the average for the day being about 610, the readings being taken every 15 minutes. The high-tension current passing through the 60,000-volt bus bars at Clark Mills varied during the 24 hours from 3 to 20 amperes. The maximum loads at different substations do not occur at the same time, which explains the occurrence of the transmission line maximum current of 20 amperes at 11:30 a. m. instead of at 5:30 p. m. Friday, the time of maximum load at the Clark Mills substation. The average a. c. line load for the 24 hours was about 9 amperes at 60,000 volts, three phase. The voltage on the a. c. side of the substation rotaries at Clark Mills was held closely at 365 practically the entire day.

The direct current load curve of the substation on 15-minute readings shows an output varying from 0 to 1800 amperes, momentarily in swings and an average of about 400 on swings. The actual load on the station from hour to hour as deduced from the recording wattmeter readings averaged 92 kw throughout the day, with an average maximum of 140 kw between 5 and 6 p. m. It will be seen that the fluctuations are very severe in proportion to the average output of the substation. This arises from the small number of trains at present required to maintain the schedule, four cars being sufficient to hold up the present intervals, although eight cars are operated during hours of heavier traffic. The log shows that the two rotaries divided the day's load almost evenly, the d. c. kw-hour output of No. 1 being 868, and of No. 2, 875, making a total d. c. output from Clark Mills of 1743 kw-hours. The log sheet also shows the time of breaker openings in connection with the different rotaries and tracks.

SUNDAY LOG

On Sunday, Aug. 18, two-car trains on an hourly schedule were run throughout the day, and the load peaks on maximum swings were very much higher, reaching an extreme of 2000 amperes twice, and exceeding 1750 amperes eight times. The average d. c. load on the substation at Clark Mills during the 19 hours in which it was operated between 7 a. m. Sunday and 7 a. m. Monday, the 19th, was 149 kw, or 62 per cent more than on Friday. The average maximum load on the substation during any hour as determined from the recording wattmeter readings was 200-kw. The average amperes output on swings was about 800. The maximum sustained loads occurred between 9 and 10 a. m.; 1 and 2, and 6 and 9 p. m. Both rotaries were in service throughout the 24 hours, except that between 1 and 6 a. m. Monday the substation was shut down. The rotaries divided the load evenly with 1412 and 1420 kw-hours d. c. output respectively.

The a. c. secondary voltage at Clark Mills varied from 345 to 365 with a well sustained average of 360 during the hours of machine operation. The high tension 60,000-volt current varied from 4.5 to 20 amperes during the 24 hours, the average being about 11 amperes. The influence of two-car trains on the line as a whole is reflected in the higher and more frequent maximum readings. Direct current voltage was held between 600 and 630 during the day with an average of about 610.

TOTAL SUBSTATION PERFORMANCE

The forms on page 48, original 6½ ins. x 7½ ins., shows outputs of the different substations. These are designed to show the direct current output, the increase or decrease compared with any previous time decided upon, the high tension input per day and for the month, and the interruptions to the service. On Friday, Aug. 16, 1907, the total alternating current input at the substation was 10,450 kw-hours. The d. c. outputs totalled 7645 kw-hours, giving a substation efficiency of 73.2 per cent. The outputs were divided well among the substations, Manlius Center handling the largest load, 2091 kw-hours, and Clark Mills the smallest, 1743 kw-hours. The average d. c. output per substation was 1911 kw-hours. The interruptions to service were slight during the day. The efficiency of the substations to Aug. 17 for the month averaged 73.5 per cent.

WATTMETER READINGS

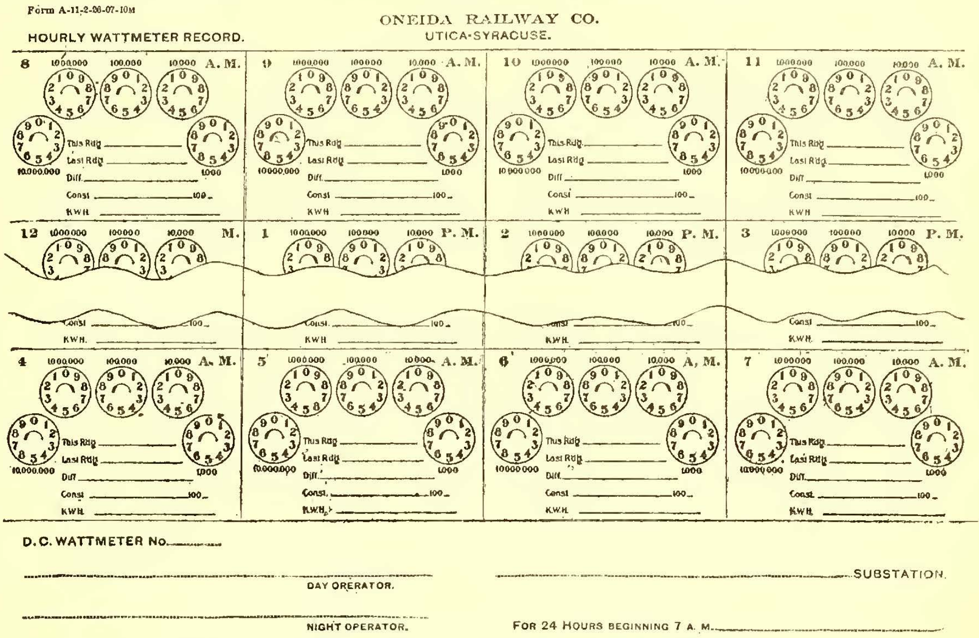
The hourly wattmeter readings at the substations are taken on a blank 9⅛ ins. x 11¾ ins. herewith, space being provided for the recording of the individual dial readings at each hour of the twenty-four. The exact position of the pointers on the dials are sketched into the dial blanks, space being left for the subtraction of previous readings later. One sheet is used for each wattmeter and the report is signed by both the day and the night operator.

A typical Saturday load was that of Aug. 17, 1907, in which the substation efficiency reached 80.4 per cent. The total a. c. input at substations was 15,370 kw-hours, and the total d. c. output 12,350 kw-hours. The individual substation d. c. outputs to the third-rail were:

Clark Mills,	3074 kw-hours.
Vernon,	3075 kw-hours.
Conastota,	3260 kw-hours.
Manlius Center,	2941 kw-hours.

TRAIN SERVICE

Train service in Utica is handled over the Utica & Mohawk Valley Company's lines, the car movements being locally directed until the electrified section of the West Shore is reached. In Syracuse the Oneida Railway Company directs the movement of the cars. Each train service man is under the rules of the New York Central and the two local companies en route. Crews are not changed en route, and all cars make through runs between Main Street, Utica, and James and Salina Streets, Syracuse. Cars are held in the Utica Park house when not in operation. Transfers are given to connecting cars on all local lines in Syracuse and Utica. The fare from Syracuse to Utica is 75 cents, the round trip costing $1.40. Before the electrified service began, the fares were $1.08 and $2 respectively, so that the reductions by electric service are 32.6 per cent and 30 per cent. No season tickets are sold on the electrified sections, but through tickets originating on the electrified section are sold to all points as in steam railroad days. There are still four daily through trains hauled by steam locomotives and carrying passengers over the electrified section, in addition to the motor car service.


Form A-11-2-06-07-10M

HOURLY WATTMETER RECORD.

ONEIDA RAILWAY CO.
UTICA-SYRACUSE.

D.C. WATTMETER NO.

DAY OPERATOR.

NIGHT OPERATOR.

SUBSTATION.

For 24 Hours beginning 7 A. M.

FORM FOR RECORDING HOURLY WATTMETER READINGS

DISTANCES AND RUNNING TIME

The following table shows the distances between stations and the running time of electric trains at present scheduled:

Station.	Miles.	Hours.	Min.
Main Street, Utica	.00	0	0
Genesee and Bleecker Streets	.41	0	3
Oneida Square	1.16	0	9
West Shore—Genesee Street	2.26	0	15
New York Mills	3.54	0	19
Clark Mills	8.39	0	30
Hecla	12.18	0	38
Vernon Grade	13.69	0	41
Vernon	17.04	0	48
Sherrill	20.02	0	55
Oneida Castle	22.23	1	00
Wampsville	25.61	1	06
Canastota	27.92	1	10
Sullivan	31.72	1	17
Chittenango	34.13	1	21
Kirkville	38.08	1	28
Manlius Center	40.75	1	33
Eastwood	45.63	1	40
Syracuse Line	46.56	1	43
Oak Street	47.59	1	49
James and Townsend Streets	48.24	1	53
James and Salina Streets	48.63	1	57

CHARACTER OF SERVICE

Electric train service begins at each end of the line at 6 a. m. and is continued on an hourly schedule both ways until 11 p. m. At present the cars are handled on the telegraph block system while on the West Shore, there being ten stations between Utica and Syracuse. The regular normally operated block signal system used on the main line of the New York Central is shortly to be installed, and when this is in service limited cars will be run between the two cities. As outlined in the June 8 issue of the Street Railway Journal, three classes of service will be given:

1. Limited cars or trains, two stops en route, hourly headway, 1 hr. 28 min. schedule.

2. Local cars or trains, highway stops en route, hourly headway, 1 hr. 58 min. schedule.

3. Through steam service, infrequent passenger, and freights.

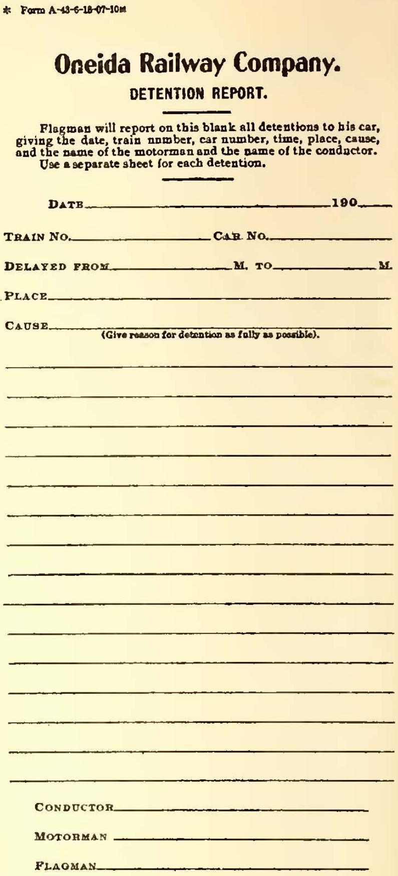
The limiteds in class I will cover the West Shore right of way in 1 hour. For local trains there are a possible 39 stops all told aside from railroad crossing stops and two stops at the city line to turn the third-rail shoes up if the cars are inbound and down if they are outbound from the city. The total distance between terminals, including local street railway tracks, is covered in a shorter time than would formerly have appeared to be feasible in view of the urban running involved. Out of 19 half trips timed by the company it was found that in the Utica portion of the route the average number of urban stops was 6 in 2.26 miles, aggregating 90 seconds; and on the local tracks in Syracuse, about 2.5 miles, the average number of stops was 4, aggregating 108 seconds. About 15 minutes are required at each end in running over the urban sections.

CARS

No freight service is electrically handled on the West Shore, and no trailers are operated. The maximum speed of each car is 52 miles per hour, and the maximum grade on this section of the West Shore is 0.57 per cent. The shortest curve is a 3-degree arc. Crouse-Hinds arc headlights are used on the West Shore right of way, but in the city streets the arcs are cut off and incandescents used. No advertisements are allowed in the West Shore cars. The car signs are of the simplest character, the names of the terminal cities being the only designations used. Girder rails are in use in Utica and tram girder rails in Syracuse. Chemical extinguishers, a screwdriver, hammer, wrench, tape, section of cable 25 ft. long, fuses and one spare third-rail shoe are carried on each car. The current per car during acceleration is about 525 amperes, and the rate of acceleration 1.25 miles per hour per second. The usual axes, bars and sledges are carried on the cars; the cars weigh about 38 tons each, and are 48 ft. over all. Graduated release brakes are used on each car.

TRAINMEN

The trainmen required to handle the service number 44 regular and 16 extra men. The men like the West Shore runs better than city service and are selected from experienced employees of the Syracuse and Utica companies. Before the road was electrically operated about three weeks of practice runs were completed under the oversight of a New York Central pilot and experts from the General Electric and Westinghouse companies. The only repairs expected of trainmen on the road are the replacement of fuses, shoe adjustments and air hose replacements when necessary. The West Shore can run any steam trains it desires over the line as long as they do not interfere with the service of the Oneida company or handle local passenger business. Trunks, mail and other baggage are not as yet handled by the motor cars, with the exception of one baggage car, which carries National Express matter. No special switch is required for slow speed city running. Car crews get correct time from Western Union clocks at the ends of their runs. Inside the cities the cars are run as double headers. In case the dog holding the third-rail shoe in place gets out of adjustment, the shoe automatically returns to its vertical position.



* Form A-43-6-18-07-10m

Oneida Railway Company.

DETENTION REPORT.

Flagman will report on this blank all detentions to his car, giving the date, train nnmber, car number, time, place, cause, and the name of the motorman and the name of the conductor. Use a separate sheet for each detention.

Date________________190___

Train No.__________ Car No.__________

Delayed from__________M. to__________M.

Place____________________

Cause____________________

(Give reason for detention as fully as possible).

Conductor____________________

Motorman____________________

Flagman____________________

DETENTION REPORT USED ON THE WEST SHORE RAILROAD

INSPECTION AND MAINTENANCE

Each car in service makes about 250 miles per day. The mileage is figured from the conductors' trip reports by the auditing department of the Oneida company. At each end of the route and after every trip each motor car has a layover of one hour. Air brakes, trucks, control parts and shoes are inspected then, and an inspector is constantly on duty for this purpose. The repairs so far have been running repairs only, with very light maintenance. The Utica & Mohawk Valley organization handles the shop repairs in detail, as outlined before. Minor cleaning is done at the car house at the end of each trip. About one week is required before a new car runs smoothly. The gage of the third-rail shoes is tested at the end of every trip. No inter-terminal inspection takes place. Spare armatures, control, air brake and truck parts are kept in the shops to enable a car to be put back in service promptly if it is needed. Very little wear of rolling stock has thus far occurred, and it is too early to present any life records. Axle and armature bearings on the cars are lubricated every two weeks.

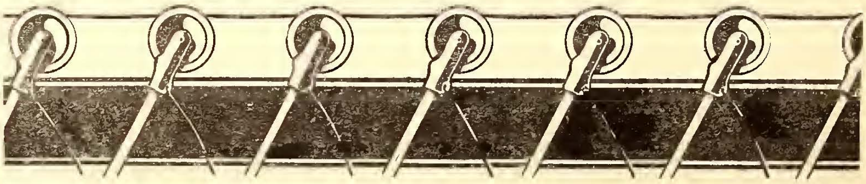
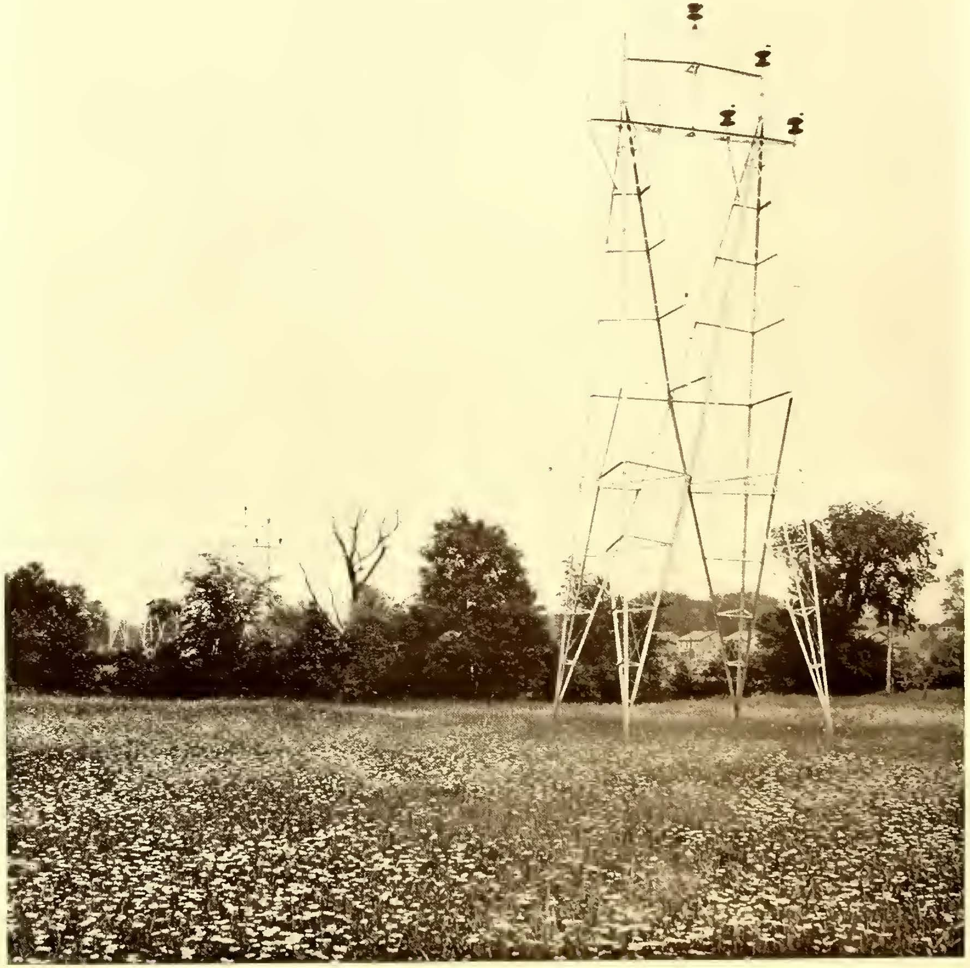
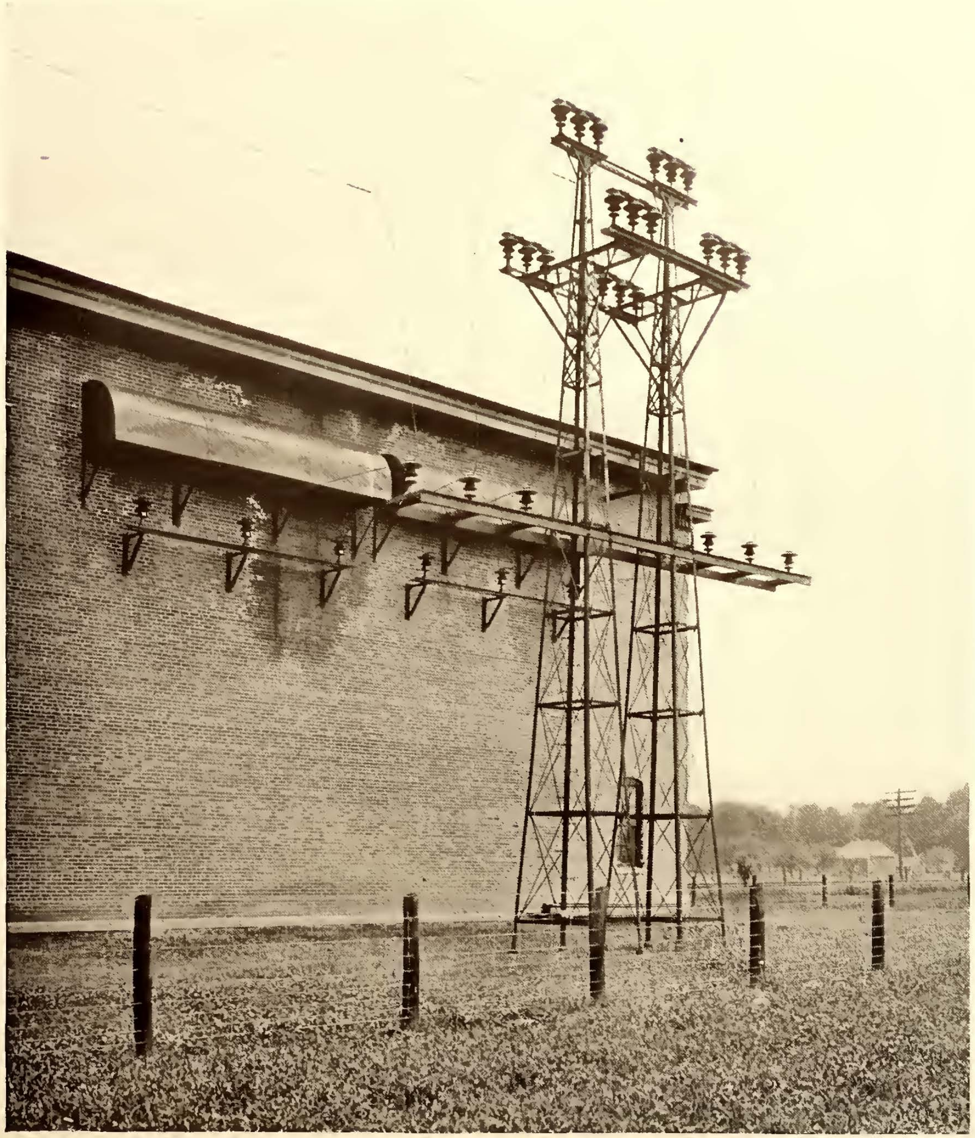


Plate XXI

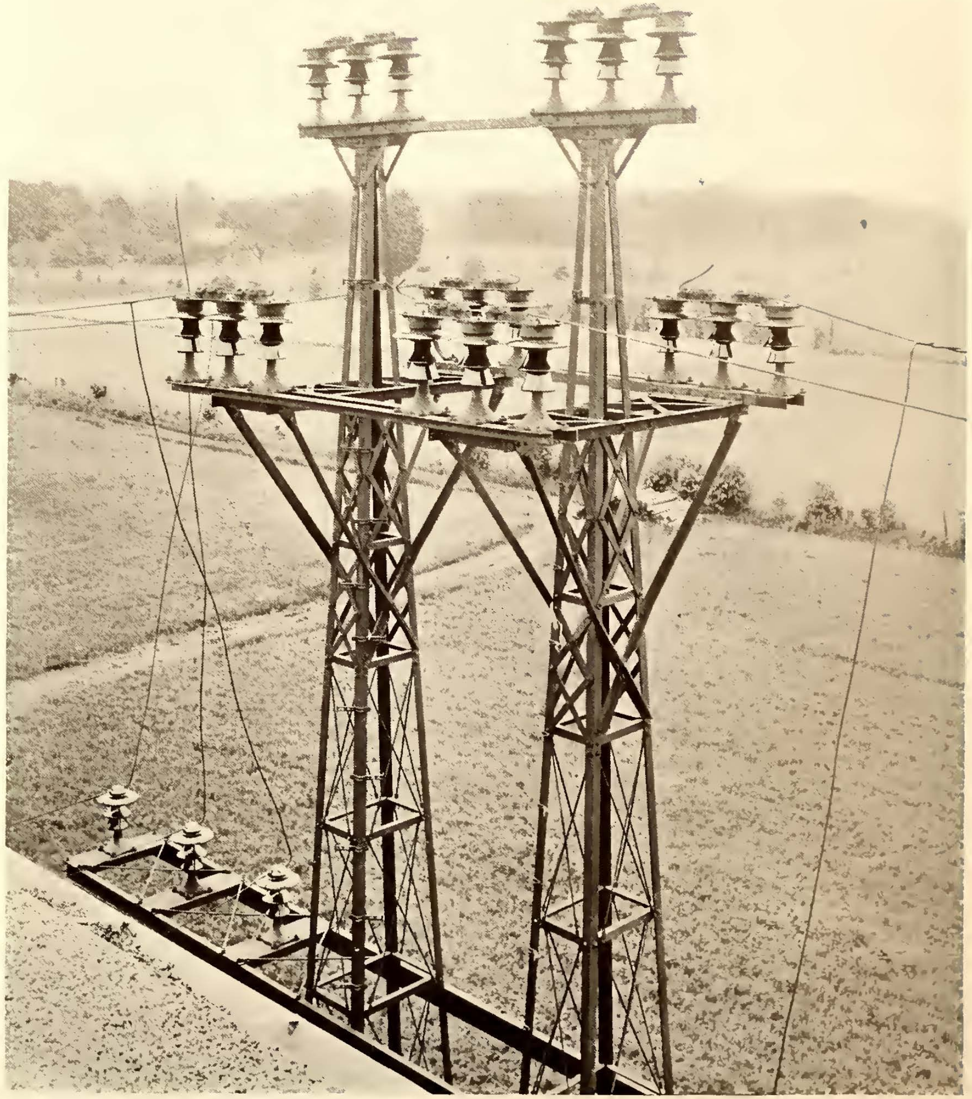
VIEW OF RAILWAY COMPANY'S TRANSMISSION LINE NEAR VERONA, WEST SHORE RAILROAD



VIEW OF HUDSON RIVER POWER COMPANY'S TRANSMISSION LINE NEAR CLARK'S MILLS



BACK OF CLARK'S MILLS SUB-STATION, SHOWING TRANSMISSION TOWER AND ARRANGEMENT OF INCOMING AND OUTGOING FEEDERS, WEST SHORE RAILROAD

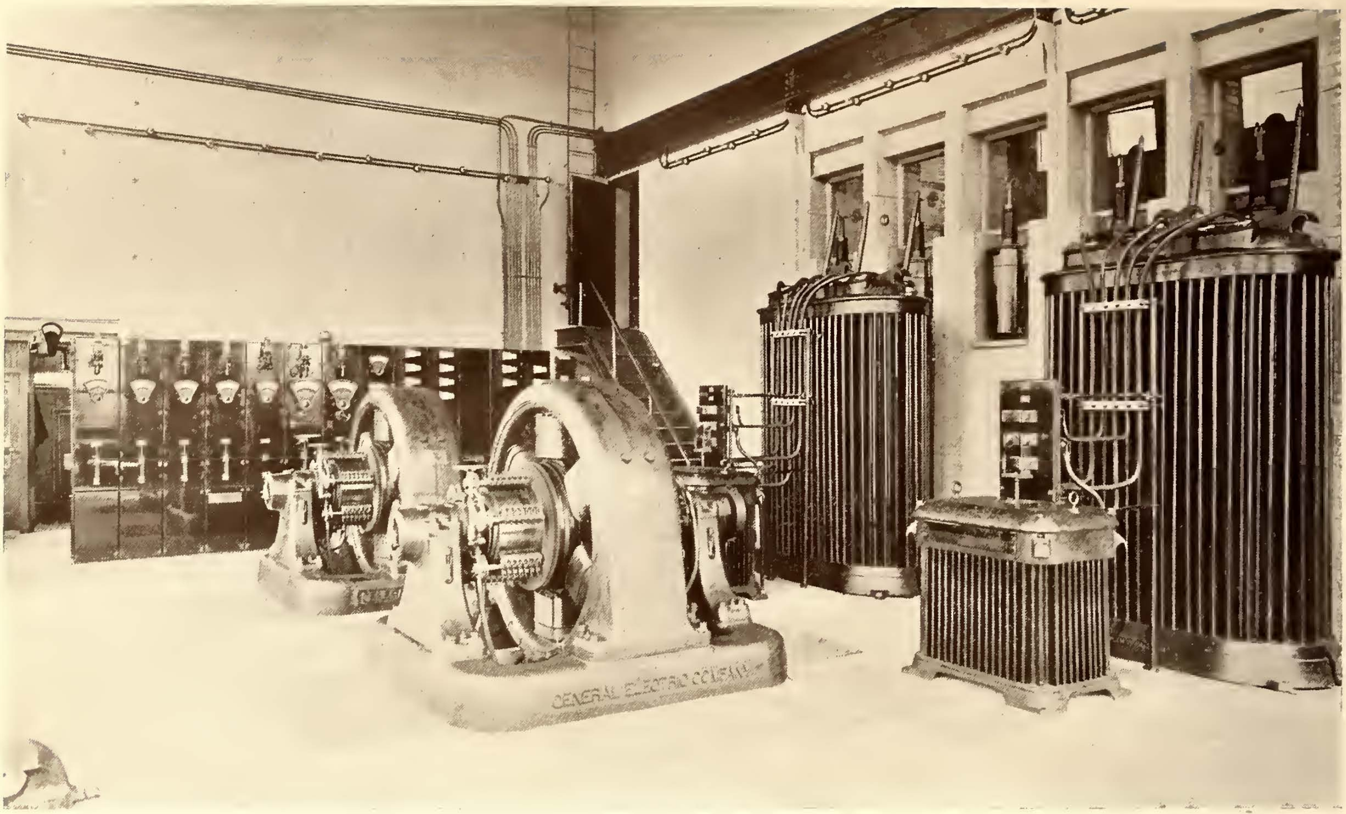


TOP OF TRANSMISSION POLE AT SUB-STATION, WEST SHORE RAILROAD

VIEW TAKEN IN HIGH-TENSION COMPARTMENT, SHOWING CHOKE COILS AND TOP OF LIGHTNING ARRESTERS, WEST SHORE RAILROAD

SECOND FLOOR OF HIGH TENSION COMPARTMENT, CLARK'S MILLS SUB-STATION, WEST SHORE RAILROAD

BATTERY OF CHLORIDE ACCUMULATORS FOR OPERATING OIL SWITCHES IN CLARK'S MILLS SUB-STATION, WEST SHORE RAILROAD



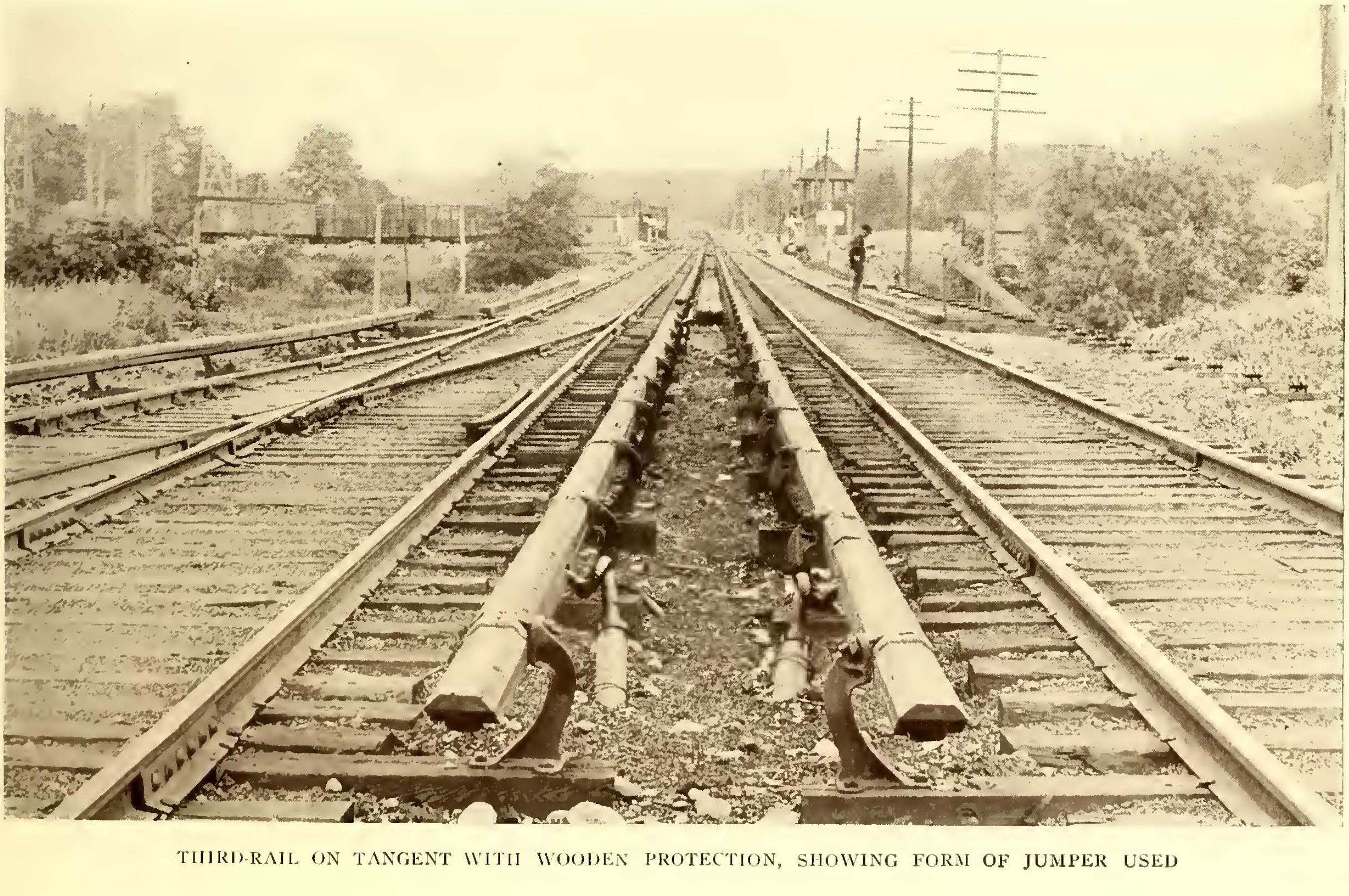
INTERIOR OF CLARK'S MILLS SUB-STATION, WEST SHORE RAILROAD

EXTERIOR OF CLARK'S MILLS SUB-STATION, WEST SHORE RAILROAD

WEST SHORE TRACKS WITH THIRD-RAIL AND FIBRE PROTECTION

TELL-TALE USED FOR GAGING TRAINS BEFORE PASSING ON TO THIRD-RAIL SECTIONS, WEST SHORE RAILROAD

EXTERIOR OF CLARK'S MILLS SUBSTATION



THIRD-RAIL ON TANGENT WITH WOODEN PROTECTION, SHOWING FORM OF JUMPER USED

INTERIOR OF STANDARD PASSENGER MOTOR CAR, WEST SHORE RAILROAD

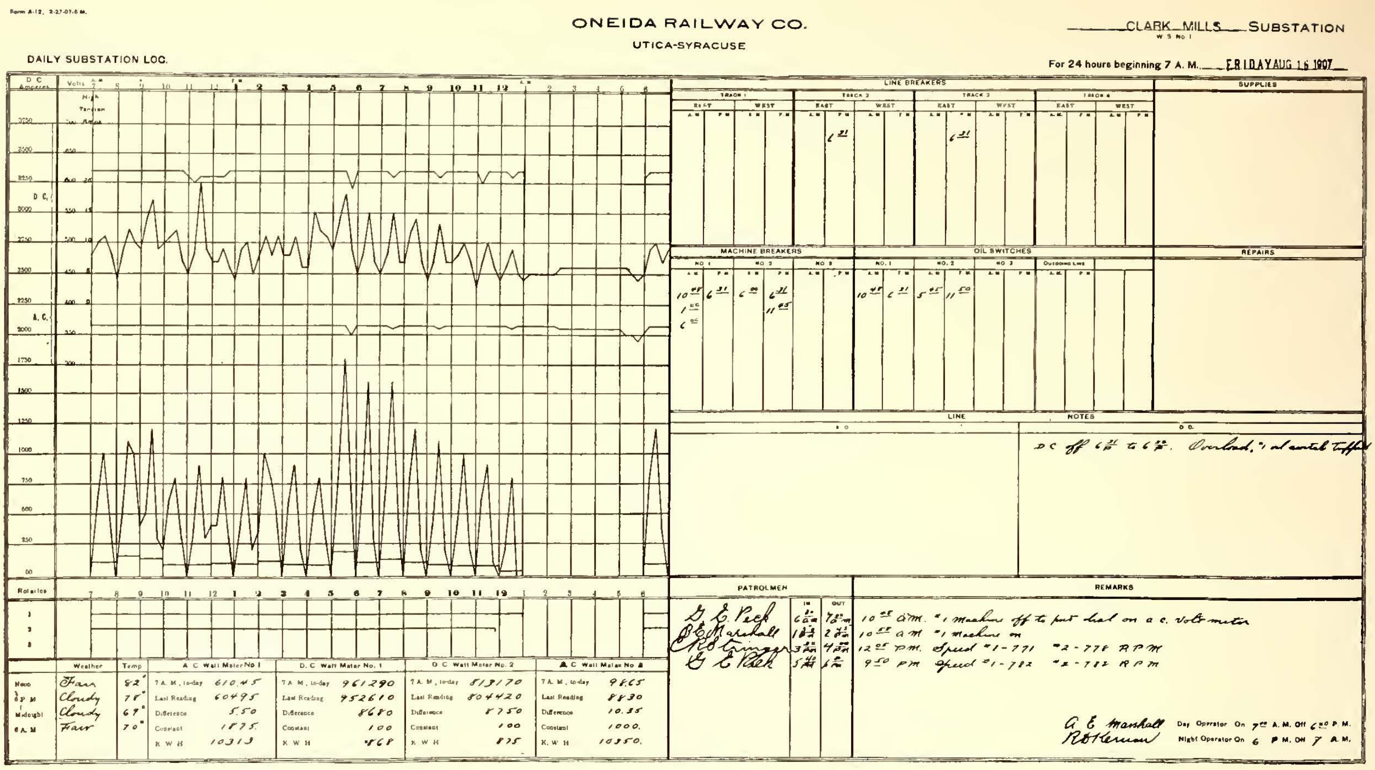
TRAIN OF THREE MOTOR CARS, EACH WITH FOUR-MOTOR EQUIPMENT, WEST SHORE RAILROAD

Plate XXVII


JUNCTION OF TRACKS OF WEST SHORE RAILROAD AND UTICA CITY TRACKS


VIEW OF WEST SHORE TRACKS, SHOWING TYPICAL GRADE CROSSING

Plate XXVIII



Form A-12. 2-27-07-5 M.

ONEIDA RAILWAY CO.
UTICA-SYRACUSE

CLARK MILLS SUBSTATION
W. S. No. 1

DAILY SUBSTATION LOG.

For 24 hours beginning 7 A. M. FRIDAY AUG 16 1907

LINE BREAKERS: Track 2, East, P.M. 6^{31}; Track 3, East, P.M. 6^{31}

MACHINE BREAKERS: No. 1, A.M. 10^{45}, 1^{55}, 6^{00}; P.M. 6^{31}. No. 2, A.M. 6^{00}; P.M. 6^{31}, 11^{45}

OIL SWITCHES: No. 1, A.M. 10^{45}; P.M. 6^{31}. No. 2, A.M. 5^{45}; P.M. 11^{50}

LINE NOTES, D.C.: DC off 6^{31} to 6^{40}. Overload, #1 [illegible] tripped

	Weather	Temp	A. C. Watt Meter No. 1		D. C. Watt Meter No. 1		D. C. Watt Meter No. 2		A. C. Watt Meter No. 2	
Noon	Fair	82°	7 A. M., to-day	610.45	7 A. M., to-day	961290	7 A. M., to-day	813170	7 A. M., to-day	98.65
6 P. M.	Cloudy	78°	Last Reading	604.95	Last Reading	952610	Last Reading	804420	Last Reading	88.30
Midnight	Cloudy	67°	Difference	5.50	Difference	8680	Difference	8750	Difference	10.35
6 A. M.	Fair	70°	Constant	1875.	Constant	100	Constant	100	Constant	1000.
			K. W. H.	10313	K. W. H.	868	K. W. H.	875	K. W. H.	10350.

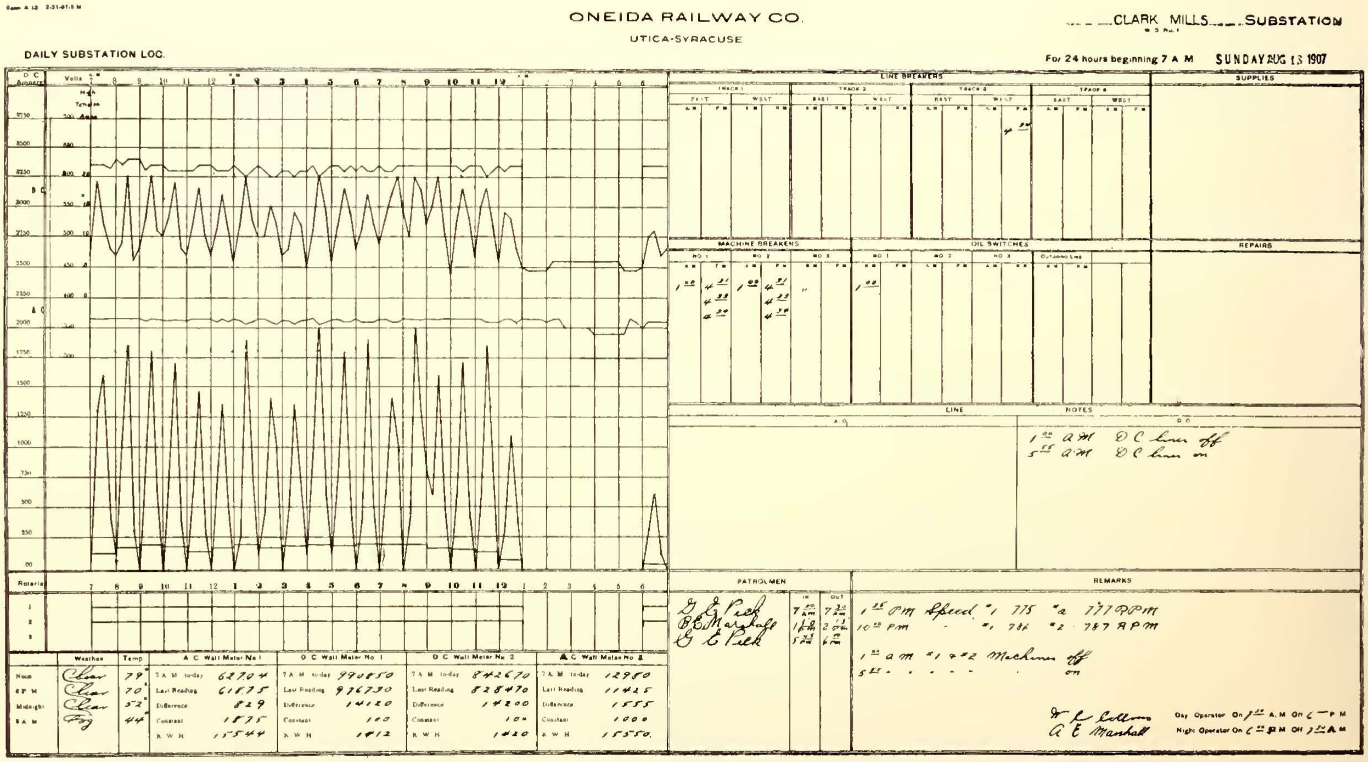
PATROLMEN	IN	OUT
G. E. Peck	6 a.m.	7 a.m.
B. E. Marshall	10	2
R. Stringer	3 p.m.	4 p.m.
G. E. Peck	5^{40} p.m.	6 p.m.

REMARKS

10^{45} a.m. #1 Machine off to put dial on a. c. volt meter
10^{55} a.m. #1 Machine on
12^{05} p.m. Speed #1-771 #2-778 R P M
9^{50} p.m. Speed #1-782 #2-782 R P M

A. E. Marshall Day Operator On 7^{00} A. M. Off 6^{00} P. M.
R. O. Kernan Night Operator On 6 P. M. Off 7 A. M.

LOG SHEET FOR CLARK'S MILLS SUBSTATION FOR FRIDAY, AUG. 16, 1907



Form A-12. 2-27-07-5 M.

ONEIDA RAILWAY CO.
UTICA-SYRACUSE

CLARK MILLS SUBSTATION
W. S. No. 1

DAILY SUBSTATION LOG.

For 24 hours beginning 7 A. M. SUNDAY AUG 18 1907

LINE BREAKERS: Track 3, West, P.M. 4^{30}

MACHINE BREAKERS: No. 1, A.M. 1^{00}; P.M. 4^{31}, 4^{33}, 4^{30}. No. 2, A.M. 1^{00}; P.M. 4^{31}, 4^{33}, 4^{30}. No. 3, A.M. ″

OIL SWITCHES: No. 1, A.M. 1^{00}

LINE NOTES, D.C.:
1^{00} a.m. D C line off
5^{55} a.m. D C line on

	Weather	Temp	A. C. Watt Meter No. 1		D. C. Watt Meter No. 1		D. C. Watt Meter No. 2		A. C. Watt Meter No. 2	
Noon	Clear	79°	7 A. M. to-day	627.04	7 A. M. to-day	990850	7 A. M. to-day	842670	7 A. M. to-day	12980
6 P. M.	Clear	70°	Last Reading	618.75	Last Reading	976730	Last Reading	828470	Last Reading	11425
Midnight	Clear	52°	Difference	829	Difference	14120	Difference	14200	Difference	1555
6 A. M.	Fog	44°	Constant	1875	Constant	100	Constant	100	Constant	1000
			K. W. H.	15544	K. W. H.	1412	K. W. H.	1420	K. W. H.	15550.

PATROLMEN	IN	OUT
G. E. Peck	7^{00} am	7^{30} am
B. E. Marshall	1^{10} pm	2^{15} pm
G. E. Peck	5^{45} pm	6^{00} pm

REMARKS

1^{15} pm Speed #1 775 #2 777 RPM
10^{00} pm " #1 786 #2 787 RPM

1^{00} am #1 & #2 Machines off
5^{55} " " " " " on

W. L. Collins Day Operator On 7^{00} A. M. Off 6 — P. M.
A. E. Marshall Night Operator On 6^{00} P. M. Off 7^{00} A. M.

LOG SHEET FOR CLARK'S MILLS SUBSTATION FOR SUNDAY, AUG. 18, 1907

OPERATING FEATURES OF THE LONG ISLAND CITY POWER STATION OF THE PENNSYLVANIA TUNNEL AND TERMINAL RAILROAD CO.

This station was described in detail in the Street Railway Journal of April 7, 1906, and in the present article particulars of the construction of the station are given only to the extent required for an understanding of the operating features.

The station is operated by the Pennsylvania Tunnel & Terminal Railroad Company, and eventually a large percentage of its output will be used in hauling trains through the tunnels now being completed by the company between New Jersey and Long Island. Since its completion about two years ago the output of the station has been purchased by the Long Island Railroad for operating the electrified portions of this system. Cost figures are not given for the reason that the station is being operated at only about one-fifth of its ultimate capacity, and any statistics given under these conditions would be without material significance.

The present building is designed for six 5500-kw generators, of which three are now installed. The power consumption of the Long Island Railroad, however, necessitates under normal conditions the use of only one turbine, but occasionally two are required. It will be readily understood that the labor and fuel cost per kilowatt is much greater than it will be when the station is operated at nearer its full capacity and when peaks and sudden fluctuations of load are smoothed out.

The station is in charge of C. S. Krick, superintendent of the Pennsylvania Tunnel & Terminal Railroad Company, and its operation is under the immediate supervision of F. G. Clark, superintendent of the station.

COAL

Coal for operating the station, generally known as mountain coal, is brought by rail from Pennsylvania to South Amboy, N. J., and is there loaded into barges of 850 gross tons capacity, which are towed across New York Bay and up East River to the power station.

The average analysis of the coal shows:

Moisture	1.16 per cent
Volatile matter	18.06 "
Fixed carbon	70.33 "
Ash	10.45 "
Total	100.00 per cent
Sulphur	1.69 "
Theoretical evaporation water per pound of coal	14.71 lbs.

The coal, it may be noted, is low in heat units and is high in ash and sulphur. Other grades higher in heat units have been tried, but these were objectionable because they contained an excessive amount of volatile matter and were consequently smoke producers.

A complete analysis is made once each month in the testing laboratories of the Pennsylvania Railroad Company at Altoona, Pa. In selecting a sample for analysis about one ton of coal is spread out on the boiler room floor and quartered. A sample is taken from each quarter and these samples are mixed together and quartered again. The process is continued until a representative 5-lb. sample is obtained. Calorimeter tests and carbon and ash tests are made twice each month in the station testing laboratories by means of a Parr calorimeter.

COAL HANDLING

The coal handling plant was fully described in the article previously referred to. A hoisting tower on the end of the dock and about 600 ft. distant from the station is connected to the station by a steel bridge built 107 ft. above the dock and at the height of the top of the coal bunkers. This bridge is provided with a cable railway which makes a complete circuit over the coal bunkers and around the tower. Three steam engines located in the hoisting tower about 25 ft. above the dock and supplied with steam from the power house boilers are employed to handle the two-ton Haywood "clam shell" bucket in which the coal is elevated from the barges. An engine to drive the coal crusher and another for operating the cable railway are installed in a closed compartment at the top of the tower.

Four men are required to operate the coal handling apparatus. Two are located in the barge being unloaded, a third stationed in the tower about 25 ft. above the dock operates the biter, trolley and hoisting engines which handle the bucket and a fourth man stationed at the top of the tower fills the cable cars.

From the "clam shell" bucket the coal is dropped in a small hopper. The fine coal passes through screens into a receiving hopper, while the larger lumps are run through a crusher. The man stationed at the top of the tower loads the cars from this receiving hopper. The cars are automatically dumped at any predetermined point over the bunkers and when empty continue around the loop track to the loading tower. The plant has a capacity of about 100 tons of coal per hour, but is operated at about a 75-ton per hour rate, as the reduced speed reduces the maintenance considerably. Usually about 3000 tons, or a three weeks' supply, of coal is stored in the bunkers. No special precautions are taken to prevent fires in the bunkers and practically no trouble has been experienced from this source. The coal is watched and whenever any is found to be heating it is used as quickly as possible. During the two years the station has been in operation the maintenance charges on the coal handling plant have been about the same as with other coal-handling systems. Repairs have been confined largely to the renewal of cables, which have a life of about 100,000 tons.

BOILER ROOM PRACTICE

The boiler installation consists of thirty-two Babcock & Wilcox water-tube boilers, sixteen boilers being installed on each of the two boiler room floors. All of the furnaces are fitted with Roney stokers driven by Westinghouse engines, there being one engine to eight stokers. The ashes from the furnaces on both boiler decks fall into chutes having outlets in the basement immediately over a track upon which small trucks carrying ash buckets are run.

Green economizers are installed in the rear of the boilers. The flue connections are such that all of the economizers may be thrown in multiple or they may be used in connection with only the boiler behind which they are installed. The gases are finally discharged into two steel stacks.

FIRING METHODS

With the present load more than fifteen boilers are never required, and it is the usual practice to operate the boilers on one floor for about six months and then to change to the other deck. The boilers on the idle deck are left entirely cool. In winter the lower deck is operated because of the danger of freezing to which the lower boilers would otherwise be subjected.

The boilers are usually fired with an .18 to .20 in. draft on the individual hand regulated dampers. There are in addition automatic stack dampers for controlling sudden fluctuations. Under a .20-in. draft the boilers are fired at about 75 per cent of their normal rating, which has been found to be most economical. A boiler fired at this rate is termed "active" and about 2000 lbs. of coal per hour are burned in the furnaces. When a peak load requires the boilers to be "forced" the dampers are adjusted to about a .5-in. draft, and at this setting approximately 3000 lbs. of coal are consumed per hour.

A "reserve" boiler is one kept in readiness for emergencies. The damper is adjusted to about .1-in. draft and about 1000 lbs. of coal are consumed per hour. A boiler held in reserve makes practically no steam, but it can be made active on a moment's notice. When the service of a boiler is not required for six hours or more it is "banked." The draft is shut off so that steam pressure is not kept up. About 3000 lbs. of coal are required to bank a boiler; no additional coal is needed for 36 hours, and with no leakage the period will be longer.

The fires are generally cleaned before the boilers are banked or reserved, and those of an active boiler are cleaned once in eight hours and those of a forced boiler once in four hours. The interval of cleaning depends, of course, on the character of the coal. One-half hour's time of one man is required to clean a fire and during this cleaning the boiler is out of service.

Soot is steamed off the tubes with the boilers in service twice a week, and at intervals of two to three months they are taken out of service and the tubes are cleaned thoroughly of soot. It is the general practice to blow the boilers down one gage once or twice a day. Attempt is made to clean the inside of the tubes when the scale or incrustation becomes 1/32 in. thick, and they are accordingly cleaned at about six months intervals. With untreated make-up water it would be necessary to clean them out about every two months.

The boilers are built for 200 lbs. pressure, but because of the small load they are operated at about 185 lbs. With high pressure at the present light load the quantity of steam would be less than required for proper operation of the valves of the turbine and accordingly the quantity is increased by decreasing the pressure. Steam leaving the boilers at normal load at 150 degs. superheat reaches the turbines at a superheat of about 125 degs. Saturated steam only is supplied to the auxiliary apparatus, but changes in the piping are contemplated which will permit all engines to be supplied with superheated steam.

FEED WATER

Fresh water is obtained from the Citizens Water Company, of Long Island City, and under present operating conditions about 30 per cent of the total used in the boilers is make-up water. The excessive amount is due primarily to the light load on the station. The auxiliary apparatus, a great portion of which exhausts into a closed heater, takes almost as much steam at half as at full load on the turbine. Arrangements are being made to use an open heater only, and this will decrease considerably the per cent of make-up water required.

The water is treated with about 4 lbs. of soda ash per 1000 gallons. The chemical is first dissolved by adding water and then boiling the mixture with steam. The solution is then allowed to mix with the make-up water in the proper proportion. The treated make-up water is heated to about 212 degs. in the Cochrane open heater and is then mixed with water from the turbine condenser hot wells at about 90 degs. The mixture enters the economizers from the closed heater at approximately 200 degs. and is fed into the boilers at an average of 265 degs. Saline tests are made on the hot well water at frequent intervals and water showing 20 grains of salt per gallon is regarded bad.

The boiler feed pumps are provided with a regulator which keeps the pressure in the feed mains fairly constant and at from 10 to 15 lbs. above the boiler pressure. The water tender regulates the feed valves of the different boilers by hand.

ECONOMIZERS

The economizers are usually operated in multiple, or in other words, flue gases are distributed through all of those on one boiler room deck irrespective of whether or not all the boilers are in service. Approximately 5 hp is required to drive the scrapers of each economizer, there being one economizer to two boilers. The maintenance on the economizers has been almost negligible. The water entering them is at a high temperature (about 200 degs.), and as there is no sweating of the pipes the scrapers remove practically all the soot deposited. The economizers are blown down each day and at intervals of a few months the soot is removed through doors provided for this purpose. They have a negligible throttling effect on the gases, the small difference in draft on the sides being due principally to the fall in temperature of the gases.

FLUE GASES

With normal load the flue gases leave the boilers at about 450 degs. When the boilers are forced the temperature rises to 600 or 700 degs. and with boilers reserved to about 350 degs. The drop of temperature in the economizer is 75 to 100 degs. A CO_2 recorder with connections to all of the boiler flues is installed in the boiler room. Gases from active boilers show about 15 per cent CO_2. Before cleaning the fires the percentage goes as low as 12, and with reserved boilers it is about 16.

TURBINE AUXILIARIES

Condenser water is obtained through an intake flume terminating at a point under the dock opposite the station. The flume is protected by two sets of screens of No. 10 gage copper wire, ½-in. mesh, which are held in vertical guides, there being three screens placed one above another in each set. The frames holding the screens are pulled up and cleaned twice each week, this work requiring about two hours' time of two men. The intake flume is provided with a rack for protection from ice and a connection has been provided from the overflow so that warm water may be run into the screen chambers in the event of ice blocking it, but no occasion has yet arisen for the use of this connection.

Water is supplied to each condenser by a 24-in. double suction centrifugal pump. Usually the pumps lift the water without any priming, but an injector is provided for use when necessary. In starting the pumps work against a 15-lb. head, but when once the condensers are filled with water the siphon effect reduces the working head to about 5 lbs. There is a very slight corroding effect noticeable on the pumps due to the salt water.

CONDENSERS

The turbine condensers are of the Alberger type, the cooling surface consisting of No. 18 S. W. G., 1-in. seamless drawn brass tubes. During the summer season the average temperature of the condenser water is about 60, in winter it is approximately 50. The vacuum maintained is in summer 28½ ins. and in winter 28¾ ins.

The condensers are tested for defective tubes whenever the saline tests of the hot well water indicate them by filling the condensers with water and noting the leakage. Wood plugs are kept on hand and when the leakage is excessive the condenser is opened up and the tubes plugged. After several tubes have been plugged in this manner and the cooling surface is appreciably lessened, the tubes are replaced. Salt water has not appreciably affected the condensers. Gases in the condensed water have corroded the interior of the cast iron centrifugal hot well pumps considerably, and these are to be replaced by bronze pumps.

CARE OF AUXILIARY APPARATUS

Auxiliary engines and pumps are tested at comparatively frequent intervals by taking indicator cards. If nothing transpires during a year's time to necessitate them being taken apart the working parts are then opened up and examined.

OILING SYSTEMS

Quite an extensive oiling system is provided for supplying bearing oil to the turbines. A storage tank 8 ft. in diameter and 14 ft. 8 ins. deep is located in the upper portion of the boiler room and from this the oil flows by gravity through the machine bearings and through coil coolers to filters. Two duplex piston pumps each with a capacity for 200 gals. per minute return the oil to the elevated tanks. All of the oil piping is of brass.

The system usually contains 7500 gals. of oil, and about 4000 gals. per hour pass through each operating turbine. The loss of oil due to the turbines is about one gallon per day per turbine operated. In passing through the bearings the oil is heated about 2 degs. and it is afterwards cooled by allowing it to come in contact with pipes containing the make-up water fresh from the city mains.

The oil is filtered through canton flannel bags approximately 1 ft. long and 4 ins. in diameter, of which about 400 are suspended from the filter tanks. The bags are washed each week in benzine or gasoline and are then wrung out with an ordinary clothes wringer. One man spends all of his time cleaning the filters and caring for the oil pumps. As the oil is entirely enclosed in the pipe system and is never open to the air except in the filters, no dirt gets into it, and practically all that the filters remove are the crushed and carbonized particles.

The oil employed is a much cheaper grade than that recommended by the turbine manufacturers. In selecting it specifications are sent out containing requirements for viscosity, flash test and other qualities and the bids sent in are accompanied by samples which are tested and analyzed in the Pennsylvania testing plant at Altoona. The oil must be a heavy one with hard globules and it must show a viscosity test of about 140 and a flash test of about 400.

CRANK CASE OIL

A separate system with two storage tanks is provided for the crank case oil used in the Westinghouse engines driving the stokers and the large centrifugal pumps. When the oil gets old it is separated out and is used to lubricate sheaves and other working parts which do not require a better grade of oil. Specifications for the crank case oil require that it be fairly heavy and that it emulsify rapidly.

TURBINE PRACTICE

The maintenance charges on the turbines have been very much less than would have been required on a reciprocating plant of the same capacity. The only repair parts carried in stock are one primary poppet valve complete, ready to put in the turbine, and a few pounds each of the different kinds of blading. The repairs to the governing mechanism have not been nearly as great as for a reciprocating engine and the repairs to the poppet valve mechanism have been less than are usually required by a Corliss valve mechanism. Very little trouble has been experienced with the blading.. The part requiring greatest attention is the governor mechanism, which is cleaned thoroughly once each week and is overhauled two or three times a day. The generators are cleaned after every shut down by blowing them out with compressed air and wiping them off with cheese cloth.

The method of excitation usually employed protects the generators against overloads. The exciter is driven by an induction motor supplied with current from the turbine generators and an overload on these lowers the voltage and decreases the power factor to such an extent that the motor slows down and reduces the excitation of the generator. This, of course, causes a further drop in the voltage. When the generator voltage on a short circuit drops below 5000 volts for an appreciable length of time the excitation is destroyed.

A Tirril regulator in the exciter field holds the voltage fairly constant, there being a variation of not more than 100 or 200 volts. In addition to the motor driven exciter, a steam driven generator or a storage battery may be employed. The load on the station is of a fluctuating character, the momentary loads running up to 16,000 kw. Fluctuations up to 12,000 kw are carried on one machine. On ordinary days the peaks are below this and the average load is usually considerably below 6000 kw, the most economical loading for one turbine.

To warm up a cold turbine properly and get it started would require two or three hours, but leakage of the throttle valve is usually sufficient to keep the machine warm so that in an emergency a turbine can be started and the load thrown on it in one or two minutes. With the turbine cold there would be no hesitancy in an emergency in getting a machine under load in twenty minutes. If valve leakage is not sufficient to keep the reserve turbine warm the pilot valve is opened sufficiently.

THE SWITCHBOARD

The switchboard is located in an enclosed compartment about 25 ft. above the turbine room floor. A small overhanging balcony permits a view of the floor, but while at the board the switchboard operator is in such a position that he cannot see the turbine room or communicate directly with the engineer. Operating signals are made by means of a special signaling apparatus. A signal device on the wall of the turbine room is connected to buttons on the switchboard operator's desk. Likewise signals on the switchboard are connected to buttons on a small board within easy reach of the throttle valve of each turbine. Pressing the different buttons illuminates the proper signals. Signals to start another turbine usually originate with the switchboard operator, but in case the engineer desires to shut down a turbine for any reason he may give the signal. Quite an elaborate code of signals has been gotten up. These care for practically every emergency that may arise. However, should it be desired to communicate directly with the engineer or any one on the turbine room floor a gong and a whistle are provided and a code of signals established whereby any one in the operating room may be called to a telephone booth on the turbine room floor.

OPERATING SIGNALS

On the south wall of the turbine room there is a general signal, a synchroscope and an air whistle electrically controlled. Opposite each turbine there is an opal globe, inside of which is a red, a white and a green lamp, and on a bracket outside of the globe a plain incandescent lamp. Near the main throttle of each turbine is a switchbox having four signals to the operating room and a gong push button for attracting the attention of the operator. The red, white and green lamps within the opal globe are used to denote the position of the weight upon the governor control of the turbine. The red lamp signifies speeding, the white lamp dead center and the green lamp slowing. These signals are pilot indications of the position of the governor control weight, which is controlled from the operating room.

The other apparatus is to be used as follows:

1. To Cut in Generator.

Operator.	Engineer.
(The number of generator) IN-Whistle.	(If O.K.) from the corresponding generator IN-Gong.

When turbine is ready for load the engineer sounds the gong again. The operator connects synchroscope and synchronizing lamp and when switched in parallel disconnects synchroscope and synchronizing lamp, signaling O.K.

2. To Cut out Generator.

Operator.	Engineer.
(The number of generator) OUT-Whistle.	(If O.K.) from the corresponding generator OUT-Gong.

Operator connects synchroscope and synchronizing lamp.

When the generator is cut out synchroscope commences to revolve and synchronizing lamp to pulsate.

Operator signals O.K.-Whistle and disconnects synchroscope and lamp.

Engineer signals O.K.-Gong.

All signals disconnected.

3. To Cut in Turbine.

Engineer.	Operator.
From Turbine, IN-Gong.	From corresponding generator, IN (if O.K.)
Operation then continues as in first case.	

4. To Cut out Turbine.

Engineer.	Operator.
From turbine, OUT-Gong.	From corresponding generator, OUT (If O.K.)
The operation then continues as in second case.	

5. To Change Over.

First and second or third and fourth to be followed in sequence, depending upon whether the change is made from the operating room or from the turbine room. In case of trouble of such a nature as to require one unit to be cut out before the other is cut in, the operator or the engineer will show both signals as (number of generator)—OUT (number of generator)—IN and give long blast of whistle or ring gong rapidly to call attention to the signals displayed.

6. To Cut in Exciter.

Operator.	Engineer.
(Number of exciter) IN-Whistle.	Brings exciter up to speed, when ready signals O.K.-Gong; from No. 1 Turbine.
Operator cuts in and signals O.K.	

All signals disconnected.

7. To Cut out Exciter.

Operator.	Engineer.
(Number of exciter) OUT-Whistle.	O.K.-Gong; from No. 1 Turbine.
When exciter is cut out operator signals O.K.	

All signals disconnected.

8. Stand-By Signals for Engineers.

Operator.	Engineer.
S.B.—(Number of generator) Whistle.	S.B.-Gong.
When over Operator signals O.K.-Whistle.	Engineer signals O.K.-Gong.

All signals disconnected.

9. Stand-By Signals for Operators.

Engineer.	Operator.
From turbine, S.B.-Gong. When over.	Number of generator, S.B.-Whistle.
Engineer signals O.K.-Gong.	Operator signals O.K.-Whistle.

All signals disconnected.

10. When whistle is given one long blast, or gong is sounded several times rapidly it is to convey the meaning that the operation, whether a single or a double one, is to be performed as quickly as possible.

To insure familiarity with the signals, the operating force goes through the complete set every few days in the same manner as when using the signals.

In starting a turbine the fields are built up gradually to full voltage after the machine has attained full speed. The generators are then synchronized and the main generator switch is thrown in. This switch is so wired that it cannot be closed until the synchronizing plug has been inserted into its socket in the operating board. In cutting out a machine the load is taken off the generator by reducing the field excitation and then the main switch is opened. Afterward the fields are cut out. With the fields out a turbine will continue to revolve about 45 minutes before coming to a standstill, but it will stop in about ten minutes with the fields excited.

The switchboard operator gets his orders to cut current off or to throw current on the high tension lines from the substation operator at Woodhaven Junction. He does not, however, change the switches until he is assured that the person giving the order has the authority to do so.

CARE OF SWITCHBOARD

The switchboard proper is wiped off two or three times a day and every three or four months it is given a coat of lacquer. The high tension switches are inspected two or three times a week, and in addition after every blow-out they are gone over carefully. Inspections include trying the switches to see that they work properly, and in going over the link motion and oiling all working parts. Once each week the contacts are inspected.

CALIBRATING INSTRUMENTS

The electrical department is provided with a testing board and precision ammeters, wattmeters and voltmeters. Some of the switchboard instruments are tested each month and the integrating wattmeters are calibrated about once in two months. In calibrating these wattmeters they are removed from the switchboard and the work is done at the testing board. They are adjusted to about ½ per cent accuracy at full load and about 1 per cent at half load.

STORAGE BATTERY

A storage battery consisting of 110 chloride cells with a discharge rate of 366 amps. for one hour is installed in the engine room basement. It was installed for operating the distant controlled switches, and for excitation and lighting in emergencies, and is controlled from the main switchboard. Usually it is floated across the lighting bus and it is generally employed to excite the first turbine started after the station has been completely shut down. In an emergency the battery would continue to excite one generator for about six hours, as about 100 amps. is required fully to excite each machine. The battery is inspected and cared for according to the standard directions of the manufacturers.

REPAIR METHODS

The power house is provided with a well equipped machine shop which occupies the gallery immediately over the switchboard gallery. It contains one of each of the following tools:

48 in. radial drill,
13 in. single spindle drill,

20 in. Bock geared shaper,
30 in. x 30 in. x 8 ft. planer,
16 in. x 8 ft. engine lathe,
11 in. x 14 in. speed lathe,
30 in. x 16 ft. engine lathe,
⅜ in. to 2 in. bolt cutter,
2-ton portable crane hoist,
2½ in. x 14 in. water tool grinder,
2½ in. x 18 in. dry tool grinder,
grindstone and hacksaw.

In addition there is located in the boiler room basement a blacksmith shop and a pipe cutting and threading machine capable of handling pipe up to 18 ins. in diameter. The machine shop was fitted up to care for the contemplated power station of the operating company in New Jersey as well. A foreman machinist has charge of the shop and of general repairs. Altogether thirteen men are employed in the repair department.

STORE-ROOM PRACTICE

A well equipped store room occupies a portion of the top gallery adjacent to the machine shop. Pipe fittings, packing and duplicate parts of all apparatus likely to get out of order are kept in stock. In addition all tools are kept in the store room and these are checked out only on a written order from the man in charge of the work for which they are required. A system of records in use in the store room has a card for every object and every kind of material in the department. Records of materials issued and materials received are kept on the cards, so that an inspection of the card shows the amount of material or supplies on hand. It is the intention to carry a two months' supply of materials.

DISTINGUISHING PIPING SYSTEMS

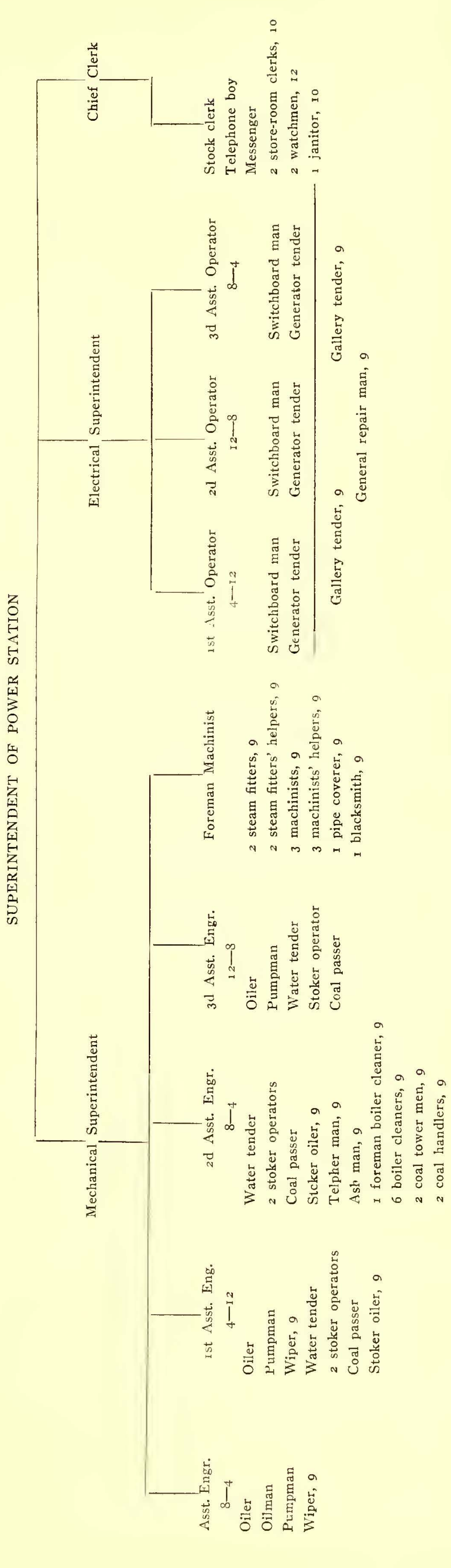
So many systems of piping are carried throughout the station that a means of readily identifying the different ones has been found of considerable convenience. A schedule of colors has been devised by the aid of which any pipe is readily identified as being a part of any system. All the pipe covers on the pipes are painted to correspond with the colors as given on a chart, posted at convenient points around the station.

PIPE COLORS

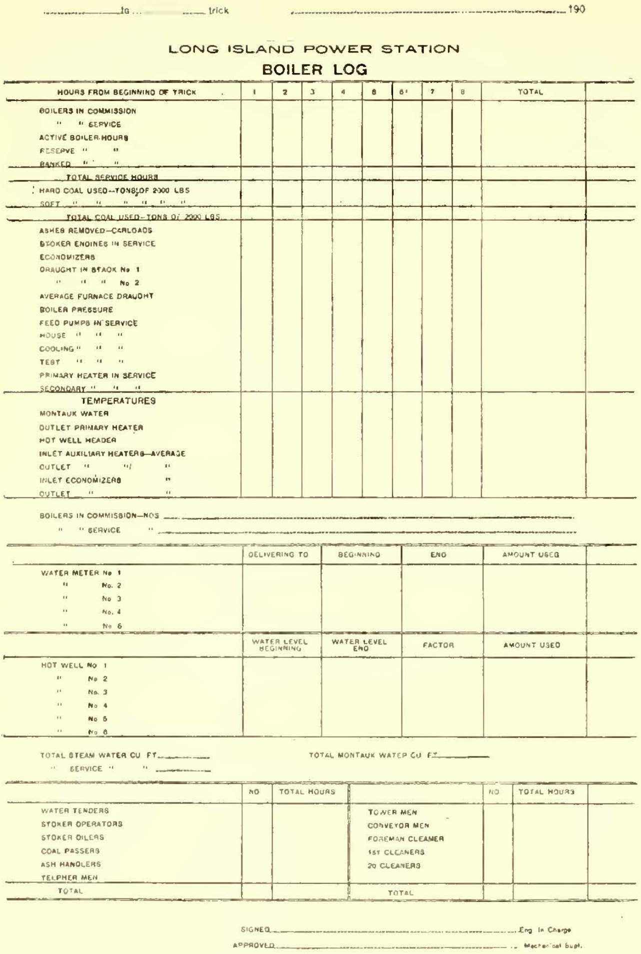
1. White—High pressure steam lines.
2. Red—Drips from superheated steam lines, including Holly system and Holly connections to boilers.
3. Red with black striping—Drips from saturated steam lines, including Holly system and connections to header.
4. Yellow—Exhaust from all auxiliary apparatus and low pressure drip pipes.
5. Black—Boiler feed pipes from feed pipes to boiler drums, closed heaters, open heaters, boiler drum heads, flues and economizer casings.
6. Blue—All water pipes other than feed pipes from pumps to boilers and fire pumps.
7. Structural—Fire protection system.
8. Maroon—Blow-off piping.
9. Green—Air piping.
10. Slate—Crank case oil piping between engines and separators.
11. Brass not painted—All oil piping other than crank case oil piping between engines and separators.

ORGANIZATION OF OPERATING FORCE

The organization of the operating force and the number of men usually employed are shown in the diagram. The number of hours a day the men in each position work is shown by the figures following the position.



ORGANIZATION OF THE OPERATING FORCE



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LONG ISLAND POWER STATION

BOILER LOG

HOURS FROM BEGINNING OF TRICK	1	2	3	4	5	6	7	8	TOTAL
BOILERS IN COMMISSION									
" " SERVICE									
ACTIVE BOILER-HOURS									
RESERVE " "									
BANKED " "									
TOTAL SERVICE HOURS									
HARD COAL USED—TONS OF 2000 LBS									
SOFT " " " " " "									
TOTAL COAL USED—TONS OF 2000 LBS									
ASHES REMOVED—CARLOADS									
STOKER ENGINES IN SERVICE									
ECONOMIZERS									
DRAUGHT IN STACK No 1									
" " " No 2									
AVERAGE FURNACE DRAUGHT									
BOILER PRESSURE									
FEED PUMPS IN SERVICE									
HOUSE " " "									
COOLING " " "									
TEST " " "									
PRIMARY HEATER IN SERVICE									
SECONDARY " " "									
TEMPERATURES									
MONTAUK WATER									
OUTLET PRIMARY HEATER									
HOT WELL HEADER									
INLET AUXILIARY HEATERS—AVERAGE									
OUTLET " " "									
INLET ECONOMIZERS "									
OUTLET " "									

BOILERS IN COMMISSION—NOS ……

" " SERVICE " ……

	DELIVERING TO	BEGINNING	END	AMOUNT USED
WATER METER No 1				
" No. 2				
" No 3				
" No. 4				
" No 5				

	WATER LEVEL BEGINNING	WATER LEVEL END	FACTOR	AMOUNT USED
HOT WELL No 1				
" No 2				
" No. 3				
" No 4				
" No 5				
" No 6				

TOTAL STEAM WATER CU FT……

" SERVICE " " ……

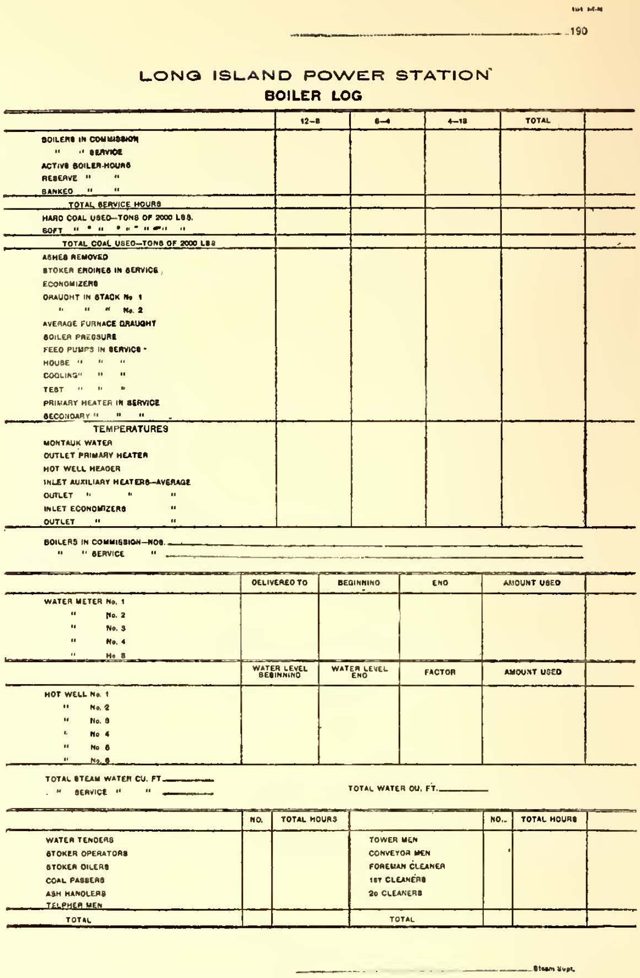
TOTAL MONTAUK WATER CU FT……

	NO	TOTAL HOURS		NO	TOTAL HOURS
WATER TENDERS			TOWER MEN		
STOKER OPERATORS			CONVEYOR MEN		
STOKER OILERS			FOREMAN CLEANER		
COAL PASSERS			1ST CLEANERS		
ASH HANDLERS			2D CLEANERS		
TELPHER MEN					
TOTAL			TOTAL		

SIGNED…… Eng In Charge

APPROVED…… Mechanical Supt.

BOILER LOG MADE OUT BY EACH SHIFT



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LONG ISLAND POWER STATION

BOILER LOG

	12—8	8—4	4—12	TOTAL
BOILERS IN COMMISSION				
" " SERVICE				
ACTIVE BOILER-HOURS				
RESERVE " "				
BANKED " "				
TOTAL SERVICE HOURS				
HARD COAL USED—TONS OF 2000 LBS.				
SOFT " " " " " " "				
TOTAL COAL USED—TONS OF 2000 LBS				
ASHES REMOVED				
STOKER ENGINES IN SERVICE				
ECONOMIZERS				
DRAUGHT IN STACK No 1				
" " " No. 2				
AVERAGE FURNACE DRAUGHT				
BOILER PRESSURE				
FEED PUMPS IN SERVICE				
HOUSE " " "				
COOLING " " "				
TEST " " "				
PRIMARY HEATER IN SERVICE				
SECONDARY " " "				
TEMPERATURES				
MONTAUK WATER				
OUTLET PRIMARY HEATER				
HOT WELL HEADER				
INLET AUXILIARY HEATERS—AVERAGE				
OUTLET " " "				
INLET ECONOMIZERS "				
OUTLET " "				

BOILERS IN COMMISSION—NOS. ……

" " SERVICE " ……

	DELIVERED TO	BEGINNING	END	AMOUNT USED
WATER METER No. 1				
" No. 2				
" No. 3				
" No. 4				
" No 5				

	WATER LEVEL BEGINNING	WATER LEVEL END	FACTOR	AMOUNT USED
HOT WELL No. 1				
" No. 2				
" No. 3				
" No 4				
" No 5				
" No. 6				

TOTAL STEAM WATER CU. FT……

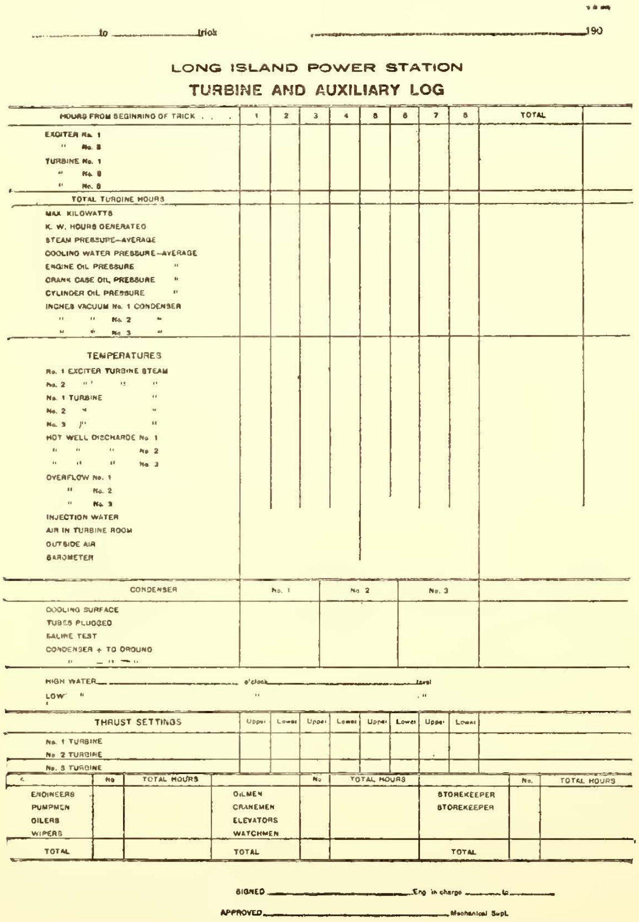
" SERVICE " " ……

TOTAL WATER CU. FT.……

	NO.	TOTAL HOURS		NO.	TOTAL HOURS
WATER TENDERS			TOWER MEN		
STOKER OPERATORS			CONVEYOR MEN		
STOKER OILERS			FOREMAN CLEANER		
COAL PASSERS			1ST CLEANERS		
ASH HANDLERS			2D CLEANERS		
TELPHER MEN					
TOTAL			TOTAL		

…… Steam Supt.

COMBINED BOILER LOG FOR THE THREE SHIFTS



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LONG ISLAND POWER STATION

TURBINE AND AUXILIARY LOG

HOURS FROM BEGINNING OF TRICK	1	2	3	4	5	6	7	8	TOTAL
EXCITER No. 1									
" No. 2									
TURBINE No. 1									
" No. 2									
" No. 3									
TOTAL TURBINE HOURS									
MAX KILOWATTS									
K. W. HOURS GENERATED									
STEAM PRESSURE—AVERAGE									
COOLING WATER PRESSURE—AVERAGE									
ENGINE OIL PRESSURE "									
CRANK CASE OIL PRESSURE "									
CYLINDER OIL PRESSURE "									
INCHES VACUUM No. 1 CONDENSER									
" " No. 2 "									
" " No. 3 "									
TEMPERATURES									
No. 1 EXCITER TURBINE STEAM									
No. 2 " " "									
No. 1 TURBINE "									
No. 2 " "									
No. 3 " "									
HOT WELL DISCHARGE No. 1									
" " " No. 2									
" " " No. 3									
OVERFLOW No. 1									
" No. 2									
" No. 3									
INJECTION WATER									
AIR IN TURBINE ROOM									
OUTSIDE AIR									
BAROMETER									

CONDENSER	No. 1	No. 2	No. 3
COOLING SURFACE			
TUBES PLUGGED			
SALINE TEST			
CONDENSER + TO GROUND			
" — " — "			

HIGH WATER…… o'clock…… level

LOW " " "

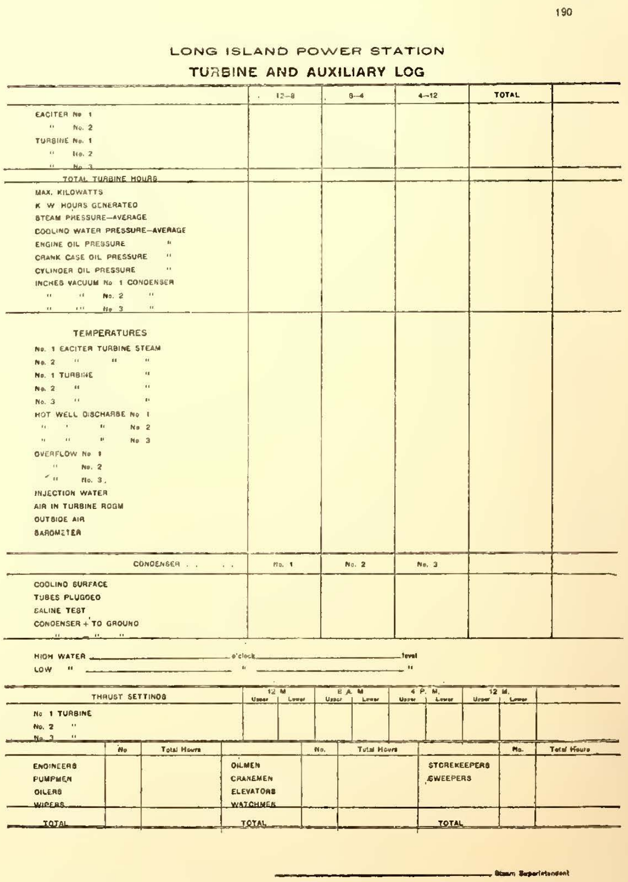
THRUST SETTINGS	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
No. 1 TURBINE								
No. 2 TURBINE								
No. 3 TURBINE								

	No	TOTAL HOURS		No	TOTAL HOURS		No.	TOTAL HOURS
ENGINEERS			OILMEN			STOREKEEPER		
PUMPMEN			CRANEMEN			STOREKEEPER		
OILERS			ELEVATORS					
WIPERS			WATCHMEN					
TOTAL			TOTAL			TOTAL		

SIGNED…… Eng in charge ……to……

APPROVED…… Mechanical Supt.

TURBINE AND AUXILIARY LOG MADE OUT BY EACH SHIFT



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LONG ISLAND POWER STATION

TURBINE AND AUXILIARY LOG

	12—8	8—4	4—12	TOTAL
EXCITER No 1				
" No. 2				
TURBINE No. 1				
" No. 2				
" No. 3				
TOTAL TURBINE HOURS				
MAX. KILOWATTS				
K W HOURS GENERATED				
STEAM PRESSURE—AVERAGE				
COOLING WATER PRESSURE—AVERAGE				
ENGINE OIL PRESSURE "				
CRANK CASE OIL PRESSURE "				
CYLINDER OIL PRESSURE "				
INCHES VACUUM No 1 CONDENSER				
" " No. 2 "				
" " No 3 "				
TEMPERATURES				
No. 1 EXCITER TURBINE STEAM				
No. 2 " " "				
No. 1 TURBINE "				
No. 2 " "				
No. 3 " "				
HOT WELL DISCHARGE No 1				
" " " No 2				
" " " No 3				
OVERFLOW No 1				
" No. 2				
" No. 3				
INJECTION WATER				
AIR IN TURBINE ROOM				
OUTSIDE AIR				
BAROMETER				

CONDENSER	No. 1	No. 2	No. 3
COOLING SURFACE			
TUBES PLUGGED			
SALINE TEST			
CONDENSER + TO GROUND			
" — " "			

HIGH WATER…… o'clock…… level

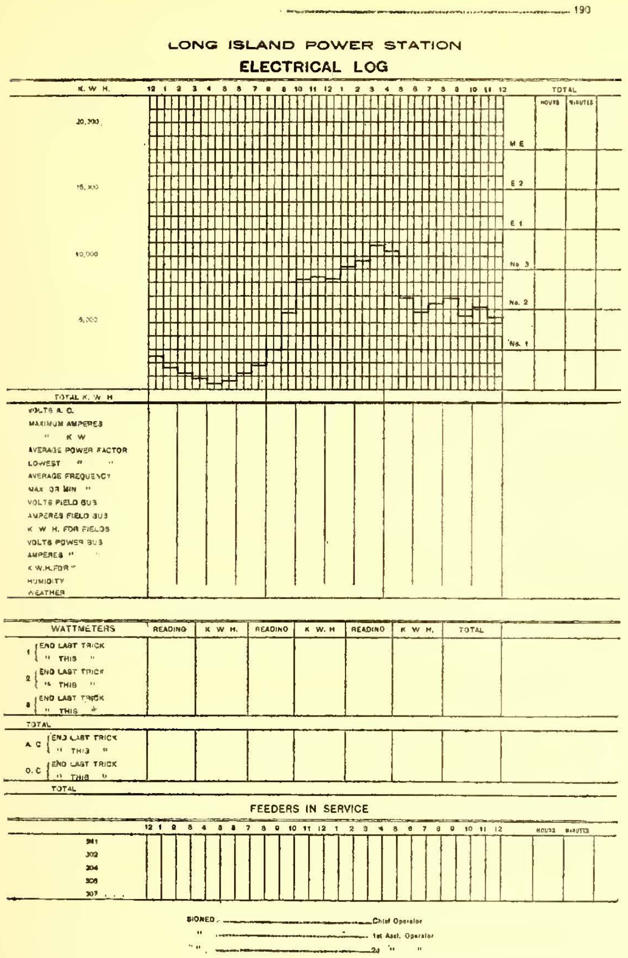
LOW " …… " …… "

THRUST SETTINGS	12 M Upper	 Lower	8 A. M Upper	 Lower	4 P. M. Upper	 Lower	12 M. Upper	 Lower
No 1 TURBINE								
No. 2 "								
No. 3 "								

	No	Total Hours		No.	Total Hours		No.	Total Hours
ENGINEERS			OILMEN			STOREKEEPERS		
PUMPMEN			CRANEMEN			SWEEPERS		
OILERS			ELEVATORS					
WIPERS			WATCHMEN					
TOTAL			TOTAL			TOTAL		

…… Steam Superintendent

COMBINED TURBINE AND AUXILIARY LOG FOR THE THREE SHIFTS



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LONG ISLAND POWER STATION

ELECTRICAL LOG

K. W. H.	12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12		TOTAL HOURS	TOTAL MINUTES
20,000		M E		
15,000		E 2		
		E 1		
10,000		No. 3		
		No. 2		
5,000		No. 1		
TOTAL K. W. H.				

VOLTS A. C.
MAXIMUM AMPERES
" K W
AVERAGE POWER FACTOR
LOWEST " "
AVERAGE FREQUENCY
MAX. OR MIN. "
VOLTS FIELD BUS
AMPERES FIELD BUS
K. W. H. FOR FIELDS
VOLTS POWER BUS
AMPERES " "
K. W. H. FOR "
HUMIDITY
WEATHER

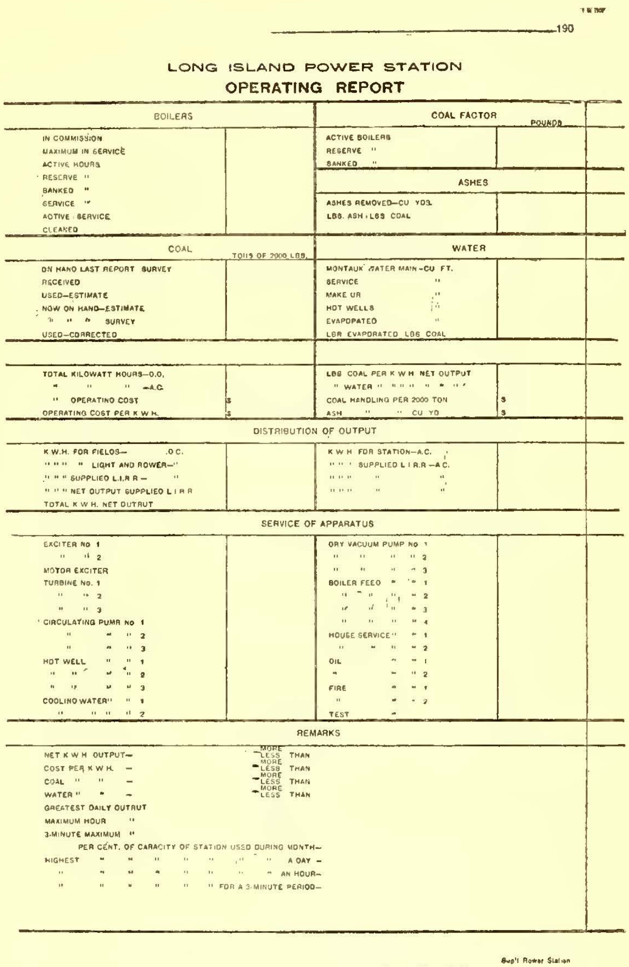
WATTMETERS	READING	K. W. H.	READING	K. W. H.	READING	K. W. H.	TOTAL
1 END LAST TRICK							
1 " THIS "							
2 END LAST TRICK							
2 " THIS "							
3 END LAST TRICK							
3 " THIS "							
TOTAL							
A. C. END LAST TRICK							
A. C. " THIS "							
D. C. END LAST TRICK							
D. C. " THIS "							
TOTAL							

FEEDERS IN SERVICE

	12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12	HOURS	MINUTES
301			
302			
304			
306			
307 . . .			

SIGNED ______________ Chief Operator
" ______________ 1st Asst. Operator
" " ______________ 2d " "

ELECTRICAL LOG, WITH TYPICAL LOAD CURVE



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LONG ISLAND POWER STATION

OPERATING REPORT

BOILERS		COAL FACTOR	POUNDS
IN COMMISSION		ACTIVE BOILERS	
MAXIMUM IN SERVICE		RESERVE "	
ACTIVE HOURS		BANKED "	
RESERVE "		**ASHES**	
BANKED "		ASHES REMOVED—CU. YDS.	
SERVICE "		LBS. ASH ÷ LBS. COAL	
ACTIVE ÷ SERVICE			
CLEANED			

COAL	TONS OF 2000 LBS.	WATER	
ON HAND LAST REPORT SURVEY		MONTAUK WATER MAIN—CU. FT.	
RECEIVED		SERVICE "	
USED—ESTIMATE		MAKE UP "	
NOW ON HAND—ESTIMATE		HOT WELLS "	
" " " SURVEY		EVAPORATED "	
USED—CORRECTED		LBS. EVAPORATED ÷ LBS. COAL	

TOTAL KILOWATT HOURS—D.C.		LBS. COAL PER K. W. H. NET OUTPUT	
" " " —A.C.		" WATER " " " " " " "	
" OPERATING COST	$	COAL HANDLING PER 2000 TON	$
OPERATING COST PER K. W. H.	$	ASH " " CU. YD.	$

DISTRIBUTION OF OUTPUT

K. W. H. FOR FIELDS— D. C.		K. W. H. FOR STATION—A.C.	
" " " " LIGHT AND POWER—"		" " " SUPPLIED L. I. R. R.—A. C.	
" " " SUPPLIED L. I. R. R.— "		" " " " "	
" " " NET OUTPUT SUPPLIED L. I. R. R.		" " " " "	
TOTAL K. W. H. NET OUTPUT			

SERVICE OF APPARATUS

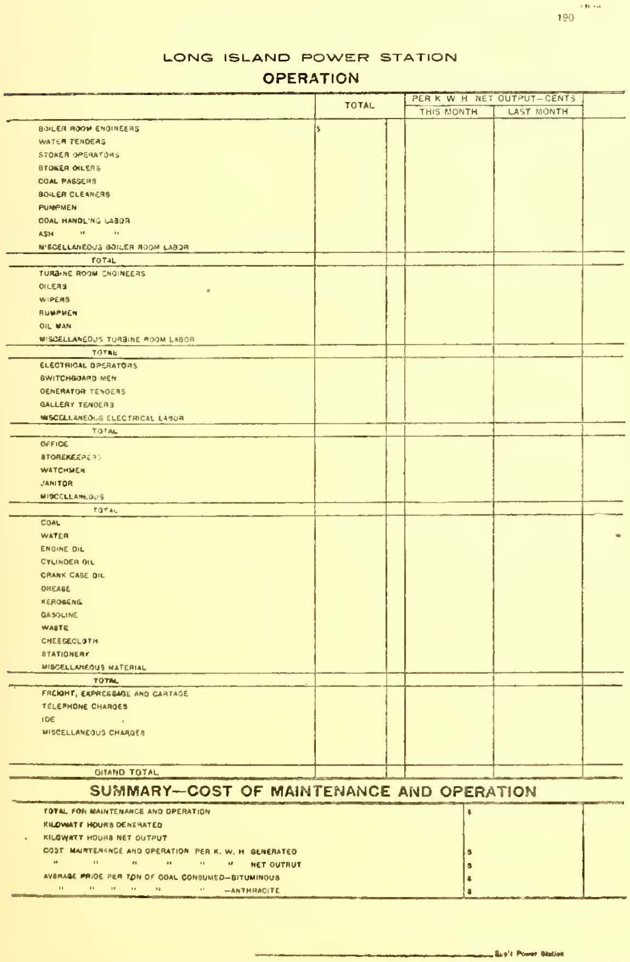
EXCITER NO. 1		DRY VACUUM PUMP NO. 1	
" " 2		" " " " 2	
MOTOR EXCITER		" " " " 3	
TURBINE NO. 1		BOILER FEED " " 1	
" " 2		" " " " 2	
" " 3		" " " " 3	
CIRCULATING PUMP NO. 1		" " " " 4	
" " " 2		HOUSE SERVICE " " 1	
" " " 3		" " " " 2	
HOT WELL " " 1		OIL " " 1	
" " " " 2		" " " 2	
" " " " 3		FIRE " " 1	
COOLING WATER " " 1		" " " 2	
" " " " 2		TEST "	

REMARKS

NET K. W. H. OUTPUT— MORE / LESS THAN
COST PER K. W. H. — MORE / LESS THAN
COAL " " — MORE / LESS THAN
WATER " " — MORE / LESS THAN
GREATEST DAILY OUTPUT
MAXIMUM HOUR "
3-MINUTE MAXIMUM "
PER CENT. OF CAPACITY OF STATION USED DURING MONTH—
HIGHEST " " " " " " " A DAY —
" " " " " " " " AN HOUR—
" " " " " " FOR A 3-MINUTE PERIOD—

Sup't Power Station

MONTHLY OPERATING REPORT



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LONG ISLAND POWER STATION

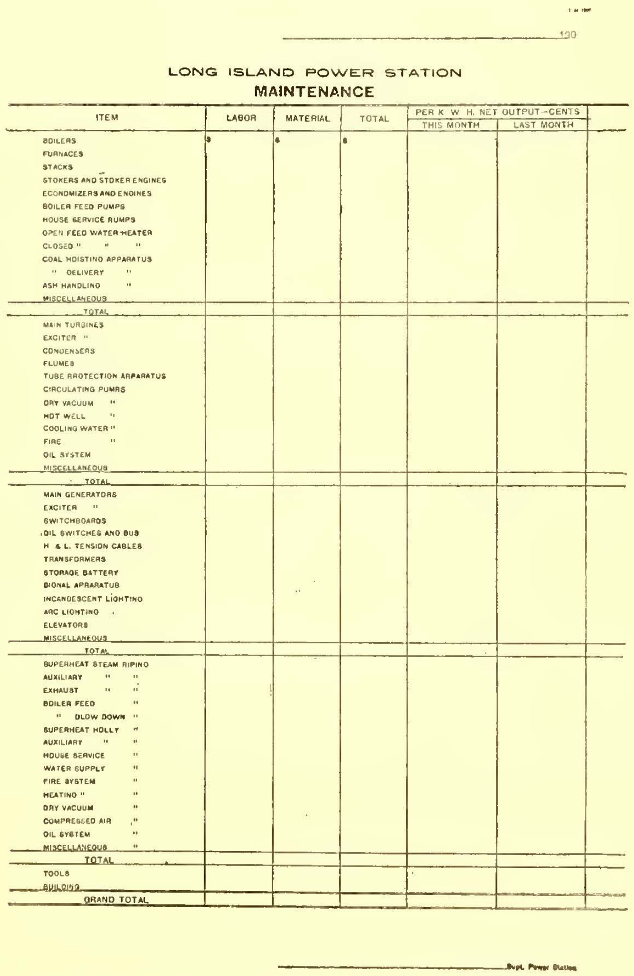
OPERATION

	TOTAL		PER K. W. H. NET OUTPUT—CENTS	
			THIS MONTH	LAST MONTH
BOILER ROOM ENGINEERS	$			
WATER TENDERS				
STOKER OPERATORS				
STOKER OILERS				
COAL PASSERS				
BOILER CLEANERS				
PUMPMEN				
COAL HANDLING LABOR				
ASH " "				
MISCELLANEOUS BOILER ROOM LABOR				
TOTAL				
TURBINE ROOM ENGINEERS				
OILERS				
WIPERS				
PUMPMEN				
OIL MAN				
MISCELLANEOUS TURBINE ROOM LABOR				
TOTAL				
ELECTRICAL OPERATORS				
SWITCHBOARD MEN				
GENERATOR TENDERS				
GALLERY TENDERS				
MISCELLANEOUS ELECTRICAL LABOR				
TOTAL				
OFFICE				
STOREKEEPERS				
WATCHMEN				
JANITOR				
MISCELLANEOUS				
TOTAL				
COAL				
WATER				
ENGINE OIL				
CYLINDER OIL				
CRANK CASE OIL				
GREASE				
KEROSENE				
GASOLINE				
WASTE				
CHEESECLOTH				
STATIONERY				
MISCELLANEOUS MATERIAL				
TOTAL				
FREIGHT, EXPRESSAGE AND CARTAGE				
TELEPHONE CHARGES				
ICE				
MISCELLANEOUS CHARGES				
GRAND TOTAL				

SUMMARY—COST OF MAINTENANCE AND OPERATION

TOTAL FOR MAINTENANCE AND OPERATION	$	
KILOWATT HOURS GENERATED		
KILOWATT HOURS NET OUTPUT		
COST MAINTENANCE AND OPERATION PER K. W. H. GENERATED	$	
" " " " " " NET OUTPUT	$	
AVERAGE PRICE PER TON OF COAL CONSUMED—BITUMINOUS	$	
" " " " " " —ANTHRACITE	$	

______________ Sup't Power Station



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LONG ISLAND POWER STATION

MAINTENANCE

ITEM	LABOR	MATERIAL	TOTAL	PER K. W. H. NET OUTPUT—CENTS	
				THIS MONTH	LAST MONTH
BOILERS	$	$	$		
FURNACES					
STACKS					
STOKERS AND STOKER ENGINES					
ECONOMIZERS AND ENGINES					
BOILER FEED PUMPS					
HOUSE SERVICE PUMPS					
OPEN FEED WATER HEATER					
CLOSED " " "					
COAL HOISTING APPARATUS					
" DELIVERY "					
ASH HANDLING "					
MISCELLANEOUS					
TOTAL					
MAIN TURBINES					
EXCITER "					
CONDENSERS					
FLUMES					
TUBE PROTECTION APPARATUS					
CIRCULATING PUMPS					
DRY VACUUM "					
HOT WELL "					
COOLING WATER "					
FIRE "					
OIL SYSTEM					
MISCELLANEOUS					
TOTAL					
MAIN GENERATORS					
EXCITER "					
SWITCHBOARDS					
OIL SWITCHES AND BUS					
H. & L. TENSION CABLES					
TRANSFORMERS					
STORAGE BATTERY					
SIGNAL APPARATUS					
INCANDESCENT LIGHTING					
ARC LIGHTING					
ELEVATORS					
MISCELLANEOUS					
TOTAL					
SUPERHEAT STEAM PIPING					
AUXILIARY " "					
EXHAUST " "					
BOILER FEED "					
" BLOW DOWN "					
SUPERHEAT HOLLY "					
AUXILIARY " "					
HOUSE SERVICE "					
WATER SUPPLY "					
FIRE SYSTEM "					
HEATING " "					
DRY VACUUM "					
COMPRESSED AIR "					
OIL SYSTEM "					
MISCELLANEOUS "					
TOTAL					
TOOLS					
BUILDING					
GRAND TOTAL					

______________ Supt. Power Station

MONTHLY OPERATING AND MAINTENANCE REPORTS, SHOWING COMPARISON WITH PREVIOUS MONTH

The chart shows that a total of seventy men, not including the superintendent, are employed for continuous operation of the station. On the day watch the second assistant engineer has charge of the boiler room and of boiler room repairs and other work of a similar nature. During the afternoon watch and the night watch the first assistant engineer and the third assistant engineer, respectively, have charge of both the turbine and boiler room forces. The switchboard operators are graded first, second and third assistant operators. All of the men in the electrical department are under the immediate supervision of the operator on the watch.

The duties of the generator tenders include in addition to taking care of the main generators general supervision and care of the auxiliary motors and the lighting system. The gallery tenders inspect and clean the high tension switches and occasionally help clean the generators.

POWER HOUSE RECORDS AND LOGS

To facilitate handling and filing all record sheets of power house operation are made of a uniform size, 10½ ins. x 17 ins. Separate boiler, turbine and auxiliary and electrical logs are kept. The readings are written directly on logs covering a period of only eight hours or of one watch. Afterwards the figures for the three separate watches of each day are copied on logs representing a day's duration and the three sets of figures are then totaled. The logs for the eight-hour periods do not leave the station, but copies of the daily logs are sent to the office of the railroad company.

At the end of the month an operating report is made up from the data on the logs mentioned. There is also made out at the end of the month an itemized account of the operating and of the maintenance costs.

The time the several pieces of apparatus are in operation is indicated on the boiler and on the turbine and auxiliary logs by drawing a heavy line under the hours operated and opposite the particular unit. The hours of operation of each unit are copied from the logs to cards and each month the daily hours are totaled on these and transferred to a monthly report. For the several logs temperature and water meter readings and others of a similar nature are taken every two hours. On the electrical log the load curve is plotted in red ink. The several exciters are indicated on this log by the symbols M. E. for motor exciter, E_2 and E_1 for the engine driven exciters. "No. 1," "No. 2" and "No. 3" indicate the three turbo-generators. Plus and minus signs are used before the power factor readings to distinguish leading and lagging currents. The humidity is recorded on this log because of its effect on static discharges.

The monthly operating report gives the total of the operating hours of the several units, total coal and water used and the distribution of the output. The amount of coal used is arrived at in two different ways. The coal factor or the amount of coal used per hour by forced, active, reserved and banked boilers is multiplied by the number of hours of service of each kind of boiler, and the figures so obtained are checked by surveying and estimating the contents of the bunkers at the end of each month and adding to this the amount of coal received during the month and subtracting the amount in the bunkers at the beginning of the month. In filling out the sheet either "more" or "less" is scratched out so that the line when filled out reads "more than last month" or "less than last month."

Only those expenses are entered on the monthly maintenance account that are occasioned by repairs and up-keep of the apparatus. The labor and material expenses are kept separate and are finally reduced to cents per kw-hour. These amounts are then compared with the preceding month.

The operating expenses are treated in a similar manner on a separate sheet. On this latter sheet is finally summarized the cost of the current per kw-hour generated and the cost of the net output.

In addition to the reports mentioned here is made out each month a "performance sheet" or a b. t. u. balance sheet. In brief this sheet takes into account all the b. t. u. entering the station in the coal and water and then account is made of the manner in which the b. t. u. received are lost or are used. It is of course necessary to approximate such items as the amount of water and consequently b. t. u. lost in boiler and economizer blow downs, but nevertheless comparatively accurate results are arrived at. The sheet shows the thermal efficiencies of the boilers, economizers, open and closed heaters, and finally gives the total thermal efficiency of these appliances.

SUBSTATION AND POWER TRANSMISSION PRACTICE OF THE LONG ISLAND RAILROAD

During April, June and July, 1906, the Street Railway Journal published a complete description of the physical features of the electrification of the Long Island Railroad. Electric trains have now been running for two years and some details of the operating features are available. In this article it is intended to describe such of them as may prove of interest, but for a clear understanding of these, a few points descriptive of the electrical features are necessary.

The distribution system consists of:

High tension circuit (overhead, underground, submarine).
Low tension feeders.
Protected third-rail.
Track return circuits.

The power house is located at Long Island City and the six substations and two portable substation houses, exclusive of two portable substations, are located as follows: (1) Atlantic Avenue near Grand Avenue, (2) Atlantic Avenue near Vesta Avenue (East New York), (3) Woodhaven Junction, (4) Rockaway Junction, (5) Hammel, (6) Valley Stream. The portable substation houses are located at Belmont Park and Springfield Junction.

Between the power house and Woodhaven Junction is a trunk line part underground and part overhead, consisting of five circuits. The underground portion, which is nearest the power house, is located in a conduit system containing eighteen ducts and the overhead section is supported upon steel poles. From Woodhaven Junction substation the transmission circuits go in three directions, west to substations Nos. 1 and 2, east to substations Nos. 4 and 6 and to the portable substation houses, and south to substation No. 5. The circuits west and the circuits east for about 2 miles are underground. The circuits to No. 5 substation are overhead and are carried part of the way on steel and the remainder of the distance on wood poles. From substation No. 4 overhead circuits lead to the Valley Stream substation, to Glen Cove and also to Belmont Park and Springfield Junction portable substation houses.

The current furnished from the power house to these substations is metered at both ends of the line. The power house meters are checked by those of the individual rotary panels in the substations and both sets of meters are calibrated as often as indications show necessary.

HIGH-TENSION CIRCUITS—OVERHEAD

All the high tension overhead lines are patroled once a day. Each of the several sections of the line is inspected by a man whose special duties are to report all defects in that section. As this inspection is made, the inspector, in some cases a lineman, in other cases a patrolman, makes it a practice to call up the substation operator at Woodhaven Junction from telephone boxes placed approximately 2000 ft. apart, and this permits the substation operator to keep in touch with the men at different points on the line. Whenever any trouble is noted report is at once made by telephone to the high tension emergency crews located either at Woodhaven Junction or at Long Island City. The high tension emergency force at Woodhaven Junction is on duty all the time. At Long Island City it is on duty only during the day, the night work being cared for from Woodhaven Junction. The crews at each point consist of a foreman, two linemen and a chauffeur, who also acts as a helper to the linemen. The crew are carried from their quarters to the point where trouble occurs on a gasoline emergency car. At times bicycle cars are also used.

Very little trouble has been experienced on the overhead lines. The breakage of insulators from all causes, during 1906, amounted to only sixty-nine. Part of this breakage was due to the small boy with the rock and part to electric and mechanical breakdown. As there are over 11,000 high-tension insulators on the system, this is considerably less than 1 per cent per year.

There has been little or no leakage over the insulators, notwithstanding the fact that a portion of the line is in close proximity to large bodies of salt water, and is subjected to the constant action of moist salt air.

There have been several short circuits on the high tension overhead lines caused by metallic materials being thrown across the wires, but in no instance have they been of sufficient severity to cause damage to other parts of the system or to interfere with train service. In most cases, it has happened that only one circuit has opened at a time, so that power was not entirely off the lines, even for a very short time.

To prevent injury to men working on the high-tension lines, the following precautions have been adopted:

When trouble occurs on a line, the substation operator cuts it out at each end and it is then grounded and tagged in such a way as to show that it is cut out for repairs. A feeder repair permit is then given to the foreman of the emergency crew, which is to work on the line. When repairs have been completed, the man receiving the permit reports, either over the telephone or in person, that the line is ready for current and no one else has authority to order restoration of current to that particular circuit. Tags and grounds are then removed and the circuit made ready for operation. Linemen on high-tension lines are provided with a grounding clamp which is attached to the running rail or to any other suitable ground before they go up the pole. The cables of the tagged circuit are then thoroughly grounded to this wire and clamp, after which any necessary repair work is done.

During the two and a half years that the pole lines have been erected, it has been found necessary to repaint a portion of the steel poles but once, and the paint was applied principally near the base of the pole over spots where rust had appeared.

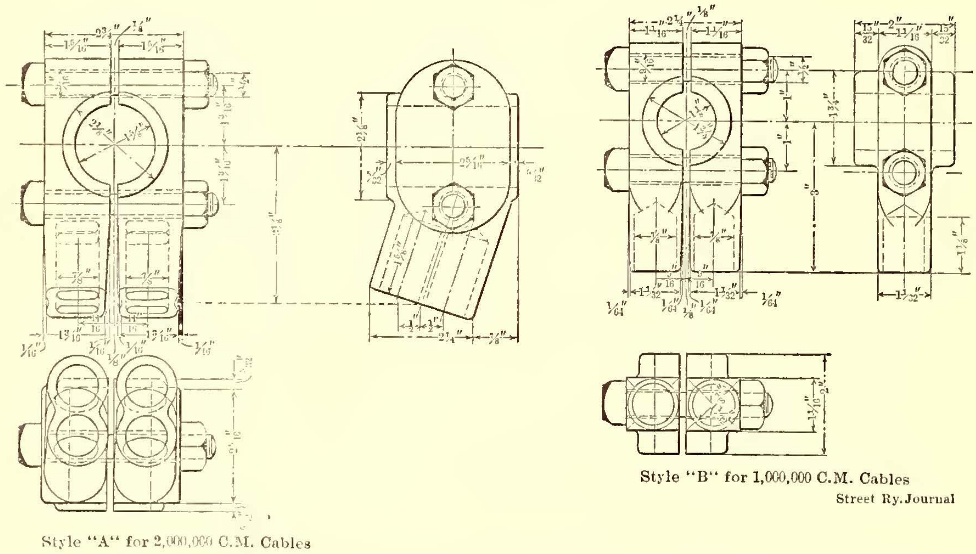
HIGH-TENSION CIRCUITS—UNDERGROUND

The underground high-tension circuits consist of three conductor paper-insulated lead-covered cables located in a conduit system, which is provided with manholes at frequent intervals. These manholes are inspected regularly by men who keep them free from water and dirt and who also see that the cables are in good condition. There are approximately 220 manholes in the conduit system and with the force employed the inspection of each manhole occurs about once in five or six weeks.

At Long Island City a portion of the conduit system is constructed below high-tide level, and to prevent accumulation of water, tile pipes running underneath the ducts carry seepage to sumps in which electric pumps with automatic control are located. The two pumps provided at each sump are arranged so as to operate when the water reaches different levels.

In this way should one pump fail to operate the second pump would cut in at a little later time and take care of the difficulty. Each pump is of ample capacity to care for the entire service, but the arrangement of floats is altered from time to time, so that each will get its fair share of duty.

Along the Atlantic division the conduit system for part of the distance is built into the walls of the tunnels, and at other points adjacent to the right-of-way fence and partly beneath some of the operating tracks. In these sections where it was possible the manholes are drained into the city sewer system. In tunnel sections the manholes drain directly into the tunnel system. On other portions where drainage has not been provided owing to the condition of the soil but little trouble has been experienced. What little water has accumulated has been removed by the crew that makes the regular manhole inspection.



Style "A" for 2,000,000 C.M. Cables

Style "B" for 1,000,000 C.M. Cables

Street Ry. Journal

SPECIAL TERMINALS FOR JUMPER CABLES—FLEXIBLE LEADS TO THE THIRD-RAIL ARE SOLDERED INTO THE SMALLER TERMINALS

A second conduit-inspection crew examines at regular intervals the electrolytic condition of cables in the conduit system. On the basis of the reports turned in by this crew necessary precautions are taken to prevent damage to the cables from this cause.

HIGH-TENSION CIRCUITS—SUBMARINE

At two points on Jamaica Bay there are located drawbridges, and these necessitate the use of submarine cables which are connected to the overhead lines through lightning-arrester houses. No trouble whatever has been experienced with the submarine cables.

LIGHTNING ARRESTER HOUSES

Lightning-arrester houses are located at two other points on the system where overhead and underground lines meet. The choke coils and arresters in these houses are inspected daily by the high-tension emergency crews. At each inspection one panel in each house is "cut out" and cleaned, so that the entire equipment is cared for at regular intervals. Sub-station Nos. 3, 4 and 6, and the portable sub-station houses at Belmont Park and Springfield Junction are entered by overhead high-tension lines. These sub-stations are equipped with lightning-arrester galleries which are cared for by the regular sub-station attendants and not by the emergency crew.

After lightning storms the arresters throughout the system are carefully inspected and tested for open circuit and ground. Although the overhead lines have been struck a number of times, no damage to cables or sub-station apparatus, outside of the arrester galleries, has been experienced, and the repairs required have been confined to some parts of the lightning-arrester equipment itself.

High-tension tests are not made on any of the circuits or apparatus at regular intervals, but are made only as required by change in the arrangement of cables to suit load conditions. When so required a test of 24,000 volts is applied between conductors and also between all conductors and ground for a three-minute period. This voltage is obtained by connecting the test apparatus at Woodhaven Junction through a separate line to one of the generators in the power station at Long Island City and varying the excitation of the generator to meet requirements. Should the insulation on the apparatus tested break down, a heavy surge of current would follow were it not for a water rheostat which consists of twelve cells containing a brine solution and arranged six in series. This limits the inrush of current to a predetermined amount. The high voltage is measured by a static voltmeter, which is checked for accuracy by means of a spark gap with needle points.

It is the usual practice to operate all high-tension circuits in multiple so as to get the most economical results from the copper in the conductors. During severe storms, however, the lines are separated and only such circuits are put in use as are required to carry the load. This leaves spare circuits between the power house and Woodhaven Junction sub-station and also between Woodhaven Junction and the remaining parts of the system. When operating under these conditions, it has happened that one of the active circuits has opened so that the apparatus was momentarily cut off. When this happens one of the spare circuits is immediately thrown into commission and the circuit which opened is tested out at convenience. Such a method of operation safeguards much of the spare apparatus as it is not in any way subject to the lightning disturbances. This applies especially to sub-station apparatus and to underground cables. It also tends to limit the damage to the lightning arresters, which can handle lightning discharges themselves more easily than when the lightning is followed by generator current.

LOW-TENSION FEEDERS

The only low-tension feeders on the system consist of short sections between the d. c. bus-bars in the sub-station and the third-rails, which pass near the sub-station buildings outside. No long feeders of this class have been found necessary.

THIRD-RAIL INSULATORS

There are approximately 90 miles of protected third-rail on the system, and this is inspected daily. The inspection is made by third-rail patrolmen who are on duty during the day only. They report broken insulators, damage to protection board and other defects, and indicate by chalk mark or some other convenient means the part which is considered defective so that the repair gang can locate the defects without loss of time. Urgent repairs are attended to immediately, while those of minor importance are taken up in regular order, as the repair gang works around the system on an established route.

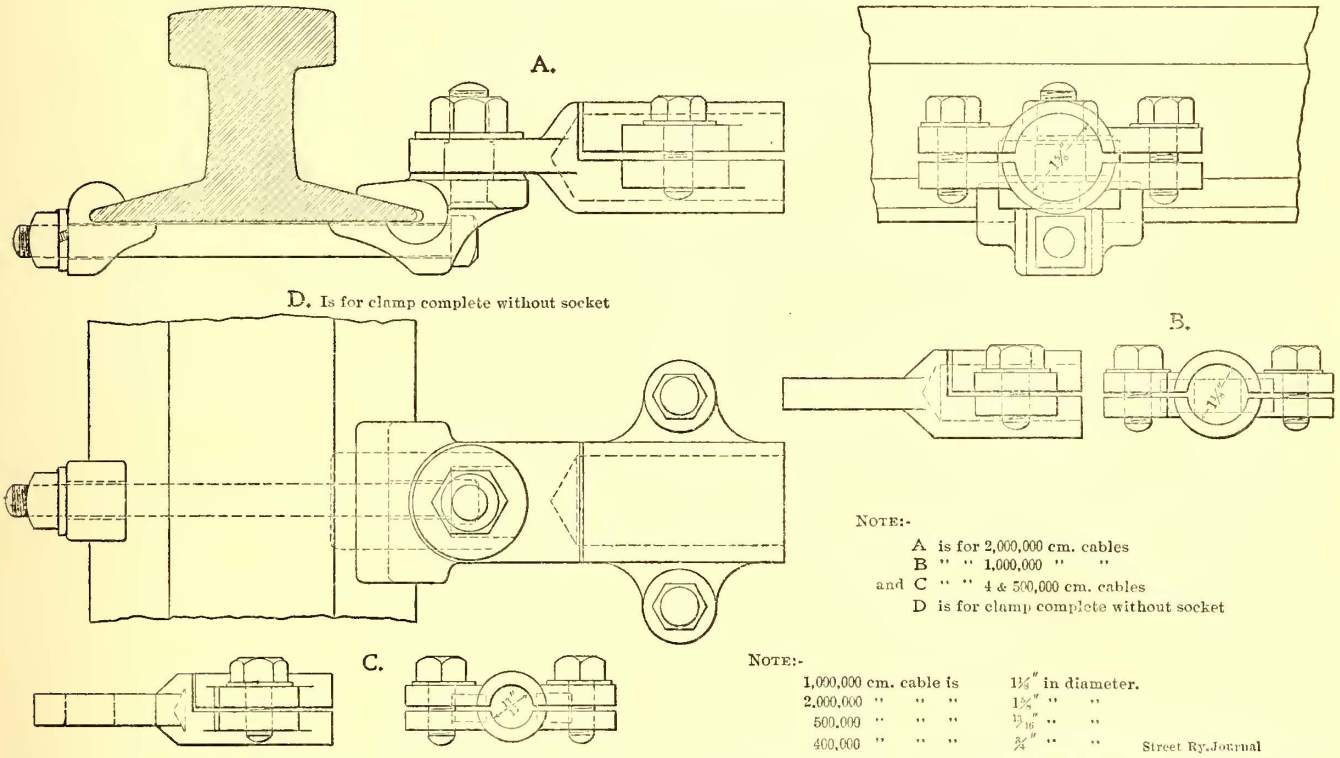
Two or three men are kept busy replacing third-rail insulators. These men, who usually travel together, carry with them a small jack for raising and holding the third-rail while the insulators are being changed. They usually start with a day's supply of insulators, which they place according to the distinguishing marks made by the patrolmen. There are approximately 50,000 insulators and the repairs average about 250 a month.

The chief causes of the failure of insulators are breakage or chipping of the glazed surface due to rail movement, burning of the insulators due to excessive moisture trickling down over the surface, displacement due to creeping of the third-rail, and breakage due to derailments. A considerable amount of leakage over the insulators, which would finally result in burning them, has been corrected by cleaning off the dirt with a piece of cloth. Breakage due to the rail creepage has been reduced by anchoring the rail as is described later on in this article.

JUMPERS

At road crossings and points in yards where there are insulated sections of third-rail, underground cables or "jumpers" are installed. These cables are provided with a varnished cambric insulation, covered with lead protected by jute and asphalt and are laid directly in the ground. The jumpers have been subjected to some mechanical injury on some sections, and on account of this, where there is likely to be a large amount of track work it has been found advisable to install the jumpers in ducts. The ducts terminate in concrete posts which are of sufficient strength to withstand a chance blow from pick or shovel without injuring the cable. Into these ducts are drawn jumpers having a varnished cambric insulation and braid covering, the lead, jute and asphalt not being considered necessary. The concrete posts are provided with terra-cotta caps which fit over the end of the jumpers where they are exposed to the weather.

It frequently happens that temporary jumpers between sections of third-rail are necessary. For this purpose a special cable clamp has been used. This is made of bronze, and is secured to the base of the rail by a bolt extending underneath. Split cable terminals of the different sizes used are attached to these clamps. The clamp does away with the necessity of drilling the rail whenever a jumper connection is required for a short time only. All jumper repair work is taken care of by four men, two of whom are splicers. Whatever excavation is necessary is done by the regular section gangs.



Note:-

A is for 2,000,000 cm. cables
B " " 1,000,000 " "
and C " " 4 & 500,000 cm. cables
D is for clamp complete without socket

Note:-

1,000,000 cm. cable is 1⅛″ in diameter.
2,000,000 " " " 1⅝″ " "
500,000 " " " 13/16″ " "
400,000 " " " ¾″ " "

CABLE CLAMPS AND SOCKETS FOR WIRE OF DIFFERENT SIZES USED IN TEMPORARY WORK TO SECURE JUMPERS TO THE THIRD-RAIL

THIRD-RAIL PROTECTION

For making repairs to the third-rail protection boards, two carpenters are employed. The field work is kept to a minimum by making the boards of a specified length in the shop and keeping a stock of these and of the posts on hand. The chief repairs to the protection board have consisted in replacing those damaged through accidents.

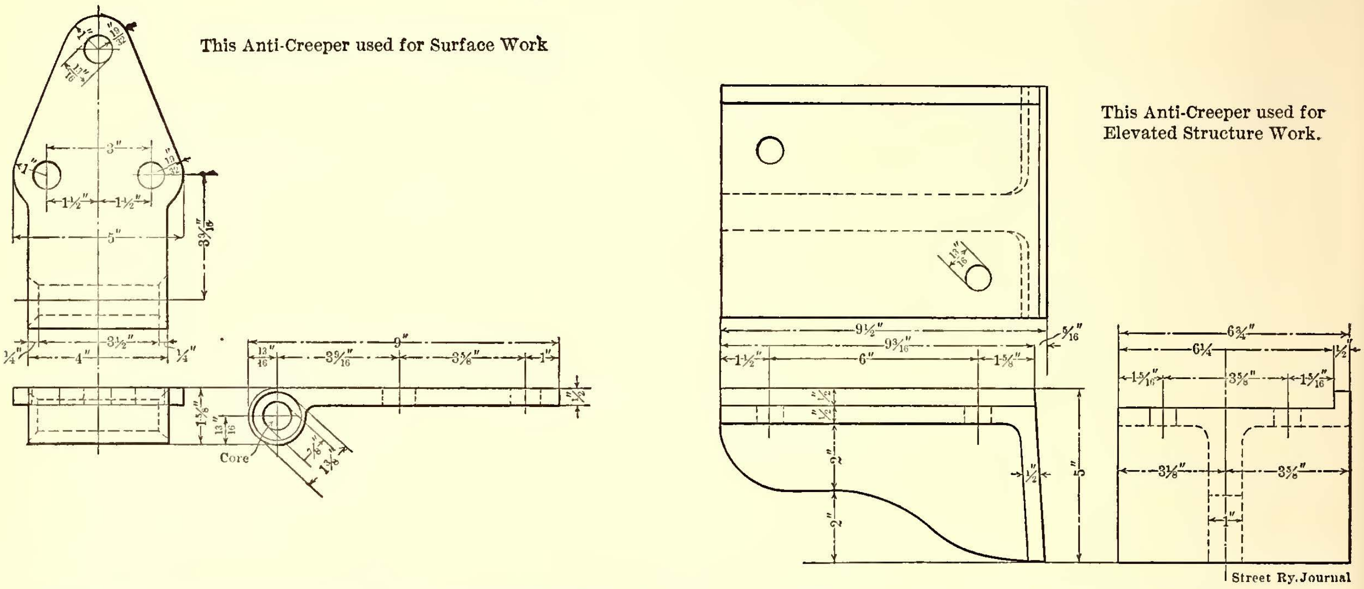
APPROACHES

A change has been found necessary in the wood side-approach boards which are placed at switches where the car shoes approach the third-rail at an angle or from a cross-over. These approach boards were originally set at an angle of about forty-five degrees with the horizontal, but this slope proved too steep for the shoes to mount at a high rate of speed and many shoe breakages occurred. All of the old boards have been replaced by others set at an angle of thirty degrees with the horizontal, and this change has obviated the trouble. The new side approaches are made of well seasoned maple and are so designed that they can be readily attached to or removed from the third-rail, as conditions require.

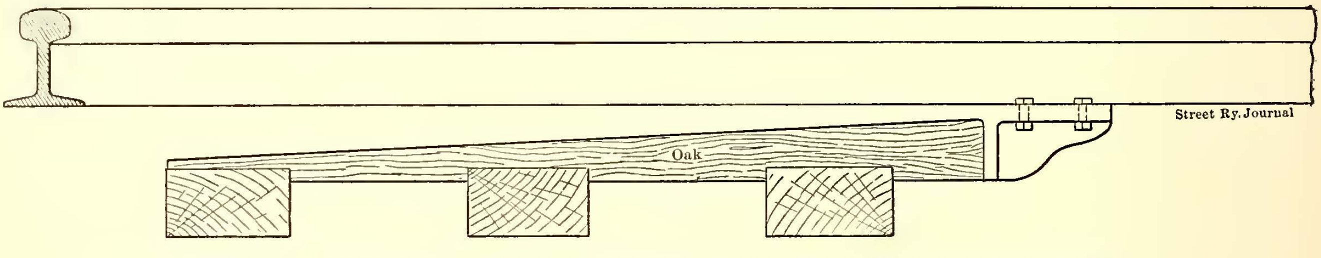
THIRD-RAIL

There has been no appreciable wear of the third-rail or the cast-iron end approaches due to action of the car shoes running over them, but the wooden approaches require occasional renewal, as the sleet scraping contact shoes cut into them. Considerable rusting has occurred on the sides and base of the third-rail and to prevent further oxidization the rail has been treated with a cheap grade of crude petroleum applied with a brush. Before this application of the oil, all of the loosened rust was scraped off with a wire brush, but the action of the oil has loosed scales of iron which were not removed by the brush. In these places it is probable that a second coat of oil will be necessary to give the desired protection.

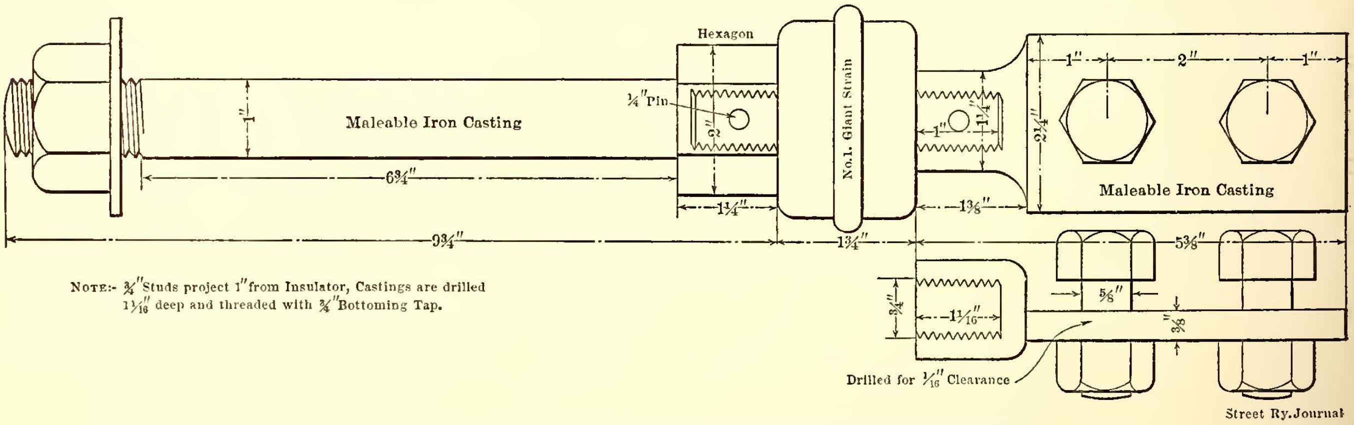
While third-rail creepage was anticipated it was not possible to determine the direction in which it would occur and consequently no attempt was made during construction to install anchors or other means to prevent this trouble. Two types of anchors have since been tried. One used on elevated structures consists of a wooden block, one end of which rests against a tie and the other end against a clamp attached to the third-rail. On ground sections a mica strain insulator is inserted between a clamp attached to the third-rail and a long iron strap lagged to several ties. The first of these anchors is intended to stand a pushing and the other a pulling strain. It is perhaps of interest to note that on one section 2 miles long where the rail is located on a dead level, no creepage has occurred. The anchors, as above described, were installed in other sections at intervals of approximately 1000 ft. Both types of anchors have stood service conditions in a fairly satisfactory manner, although in some instances the mica strains have proved inadequate to the pull exerted by the section of rail to which they were attached.



MALLEABLE CASTINGS SECURED TO UNDER SIDE OF RAIL, AND TO WHICH INSULATOR IS BOLTED IN ANCHORING THIRD-RAIL



METHOD OF ANCHORING THIRD-RAIL AGAINST CREEPAGE ON ELEVATED STRUCTURES



NOTE:- ¾" Studs project 1" from Insulator, Castings are drilled 1 1/16" deep and threaded with ¾" Bottoming Tap.

INSULATOR USED IN ANCHORING THIRD-RAIL IN SURFACE WORK

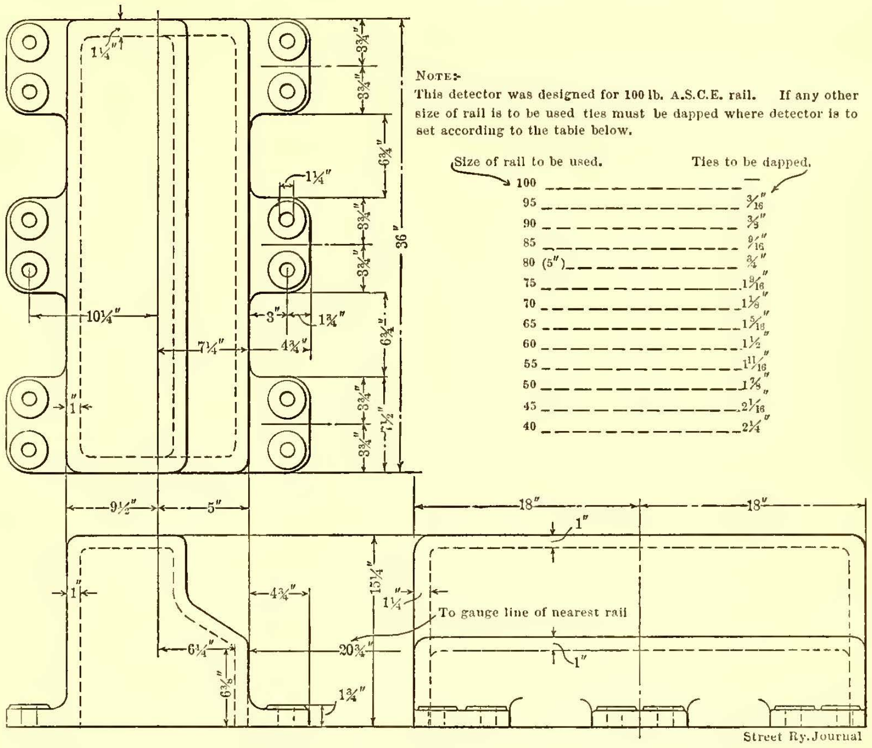
CLEARANCE INDICATORS

The gage line of the third-rail, or the edge of the head on the track side, is 26 ins. from the track gage line, and the elevation of the third-rail is 3½ ins. above the track rails. The protection board is 2½ ins. above the third-rail and is 2 ins. thick. This location has given a satisfactory clearance to all cars which have been brought on the system through transference of freight except in the case of a few hopper coal cars. While the latter would clear the rail itself they would interfere with the protection board. To prevent trouble from this source, at the two points on the system where foreign cars are received, namely, at Long Island City and Bay Ridge, indicators are placed so that all cars having on them projecting parts which would injure the third-rail or the protection board will automatically give notice to an inspector who will prevent their further movement. Each indicator is bolted down near the track and consists primarily of a sheet-iron vane covered with carpet daubed with white paint. The vane is attached to a shaft provided with a commutator, and contact points on this commutator complete an electric bell circuit when the vane is turned. When the position of the vane is altered by being struck by a car, the bell rings and a mark is made by the white paint on the projecting part of the car making the contact. The inspector's attention is attracted by the ringing of the bell and he can easily determine the causes of interference, and either have the part removed or arrange for a transfer of load.

To prevent the possibility of the part being overlooked and afterwards injuring the third-rail or its protection, heavy cast-iron clearance blocks are located beyond the detector signals. These blocks are of such a design and are so set in position that anything which passes them will clear the third-rail and they are made of sufficient strength to tear from any car any rigid projecting part striking them. They are 36 ins. long, 15¼ ins. high and 14½ ins. wide at the base and are filled with cement mortar and bolted to a concrete base.

SNOW AND ICE

Snow and ice have occasioned very little inconvenience to the electric system. Single and two-car trains may experience some difficulty, but the use of trains having greater length and weight with a larger number of contact shoes, has proved that the electric service is liable to very little interruption from ice and snow. At stations where the third-rail is installed near the platform and no opening exists to the rear, snow packs in between the rail and protection board, making a cushion over which several of the contact shoes may ride without breaking through. Under these conditions a short train may become stalled. With trains of greater length some one of the shoes forms contact with the third-rail and under these conditions service is maintained. The introduction of an electric system has resulted in a change of implements used by the section men, especially those for the removal of snow. Metallic shovels have proven dangerous, and consequently the men employed in cleaning interlocking parts and station tracks are now provided with wooden shovels and stable brooms for cleaning out points where snow would cause difficulty.

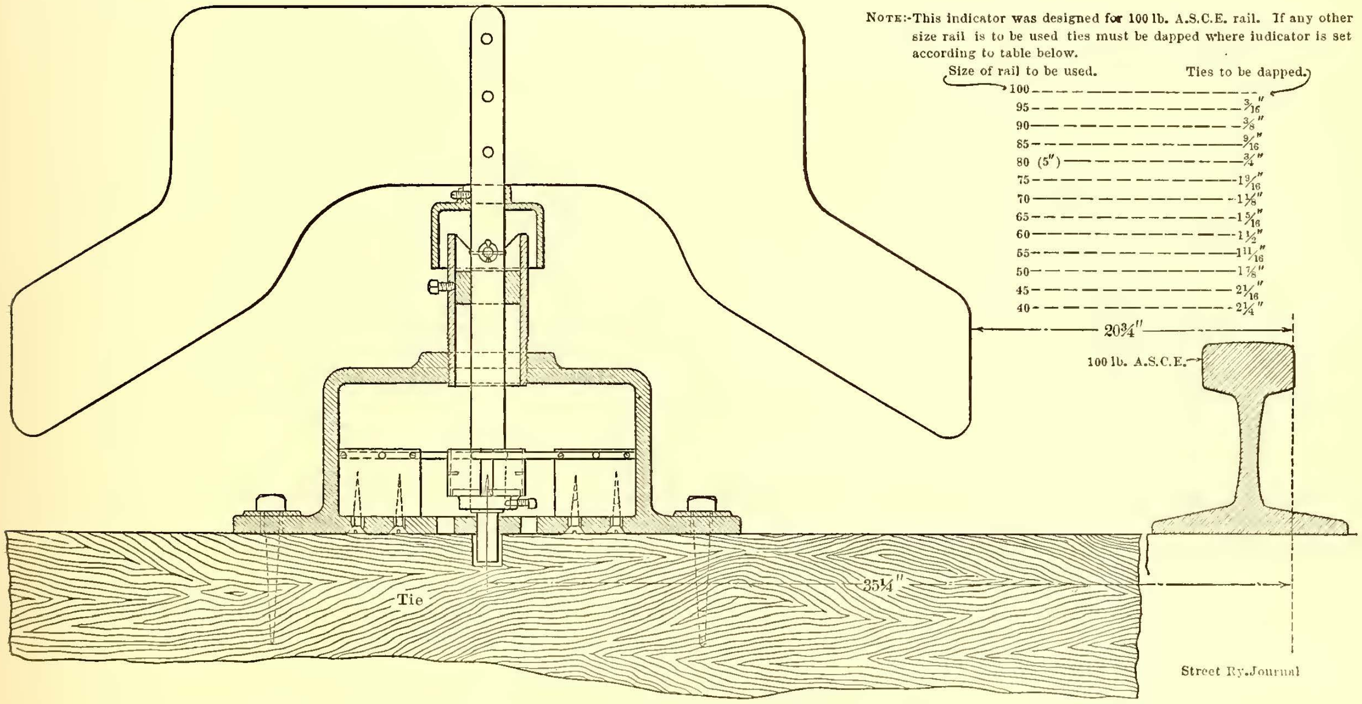


Note:-
This detector was designed for 100 lb. A.S.C.E. rail. If any other size of rail is to be used ties must be dapped where detector is to set according to the table below.

Size of rail to be used.	Ties to be dapped.
100	—
95	3/16"
90	3/8"
85	9/16"
80 (5")	3/4"
75	1 9/16"
70	1 1/8"
65	1 5/16"
60	1 1/2"
55	1 11/16"
50	1 7/8"
45	2 1/16"
40	2 1/4"

Street Ry. Journal

CAST-IRON BLOCK PLACED AT BEGINNING OF THIRD-RAIL TO PROTECT THE RAIL



Note:-This indicator was designed for 100 lb. A.S.C.E. rail. If any other size rail is to be used ties must be dapped where indicator is set according to table below.

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100	
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70	1 1/8"
65	1 5/16"
60	1 1/2"
55	1 11/16"
50	1 7/8"
45	2 1/16"
40	2 1/4"

Street Ry. Journal

INDICATOR DESIGNED TO NOTIFY INSPECTOR OF CARS THAT WILL NOT CLEAR THE THIRD-RAIL

TRACK-RETURN CIRCUITS

Both running rails are used for the return circuit without additional negative feeders. The rails are bonded to their full capacity by bonds of the soldered and compressed terminal types. These bonds are periodically tested by a gang of two and sometimes three men, who test two hundred and fifty or more joints per day. For this work a Whitney bond testing outfit is used. To obtain sufficient current for the test, regardless of what may at the time be flowing in the rails, a portable resistance consisting of iron wire coils, such as are used in the electric heaters in the cars, is employed. This is connected between the third-rail and running rails and allows a current of 30 amps. to 40 amps. to flow. A portable storage battery has also been used to give the required current through the rail.

The testing instrument is connected in the same manner as a Wheatstone bridge, and comparison is made between four feet of rail containing the joint and four feet of unbroken rail. The instrument reads directly in rail feet. If the section of rail containing the joint has a resistance exceeding eight feet it is considered defective, and a distinguishing mark to indicate the fact is placed on the protection board or tie nearby.

SUB-STATIONS

The six sub-stations, portable sub-station terminal houses and lightning arrester houses are in charge of a general foreman, whose headquarters are at Woodhaven Junction. The operating force and capacity of each sub-station are given in the following table:

Rotary Converters, K. W.	Fore-men.	Switch-board Men.	Rotary Ten-ders.	Wip-ers.
1. Grand Ave............3-1000 kw.	1	3	3	
2. East New York......3-1000 kw.		3	3	
3. Woodhaven Junction.3-1500 kw.	1	3	3	1
4. Rockaway Junction 2-1500 kw.		3	3	
1-1000 kw.	1			
6. Valley Stream........2-1000 kw.		2	1	
5. Hammel ....3-1000 kw.	1	3	3	1

These men operate in eight-hour shifts, beginning at 8 a. m., 4 p. .m. and 12 midnight, and two men are continuously on duty in all the sub-stations, except the one at Valley Stream. This is built with the switchboard on the operating floor so that it may be run by one man. Because of light traffic it is not usually operated as late as the others, and only a rotary tender is on the night shift. However, this man can in an emergency start up the machines.

In addition to sub-station operators the sub-station force includes repair men under a foreman, who take care of all repairs, an oil switchman and an instrument tester and his helper. The sub-station men, some of whom are technical graduates, usually start in as rotary tenders, and are afterwards promoted to switchboard operators.

Train movements are such that all sub-stations are usually shut down between the hours of 1 a. m. and 4 a. m. In order that no trains may be left stalled on the line the rotaries are not shut down until the operator at Woodhaven Junction receives word from the train dispatcher that all trains are in. In an emergency, should current be required while the sub-stations are shut down, power could be put on the line in about five minutes.

The rotary converters are liberally designed and can stand loads up to 150 per cent of their normal rating without injury, but the load on each machine is usually kept down to the normal rating by starting up additional machines when the total load warrants it. One machine in each sub-station normally carries the load from the time current is put on until 6.15 a. m. From this time until 7 p. m., two or three machines are required, after which machines are cut out as the load permits. Whenever there is any special movement of trains, the dispatcher notifies the operator at Woodhaven Junction, who orders enough machines cut in to care for the extra load.

The rotaries are usually started up by an induction motor mounted on the armature shaft. The connections are, however, so arranged that they may be started from the direct current side, should occasion arise.

In the Woodhaven Junction sub-station a wiper is employed to clean the electrical and other apparatus, but in the other sub-stations the rotary tenders do this work. Each sub-station is equipped with an air compressor and the rotaries and switches are blown out with compressed air every other day. The commutators are wiped off daily with cheese cloth and vaseline. The oil switches are regularly inspected and in addition they are carefully gone over whenever they are tripped out under short circuit. The instruments and meters are inspected regularly by the instrument man and kept accurately calibrated.

STORAGE BATTERY

The only storage battery in use on the power circuits is located at the Hammel sub-station, and consists of 314 cells having a one-hour rating of 3200 amp-hours. It is inspected and specific gravity and voltage readings taken on each cell weekly. In addition, specific gravity readings are taken every hour on a pilot cell. The battery is given an overcharge once a week and during the period of overcharging specific gravity readings are obtained every fifteen minutes and the overcharging is continued until five successive similar readings are obtained. The outside of the wooden boxes of the cells are treated with paraffine once a month, the paraffine oil being wiped over them with a rag. This is done to preserve the wood from the effect of the acid fumes. The batteries are kept filled with distilled water obtained from a still in the station and stored in a porcelain-lined tank. Samples of this water are sent to the battery manufacturing company for analysis before it is used. In normal operation the battery is floated on the line with the use of a booster. It thus takes the heavy swings on the station and at times when the high-tension current is suddenly cut off, it feeds the whole system. In some instances the swinging loads have reached 7000 amps.

PORTABLE SUB-STATIONS

The two portable sub-stations of 1000-kw capacity each are used regularly during the racing season; at Belmont Park while the races are at that track, and at Springfield Junction while the races are at the Jamaica track. At each of these places a terminal house has been specially built for them. At these times they are connected in multiple and operated as one sub-station by two men. At other times they are held in reserve in the permanent sub-stations, each of which except No. 1 is equipped with a connection for the portable.

EFFICIENCY

The high-tension lines were designed for a 10 per cent drop to the most distant sub-station at maximum load, but under normal operating conditions the loss is approximately three per cent. The combined efficiency of the rotary converter sub-stations from the high-tension side of the step-down transformers to the direct current bus-bars is from 82 to 84 per cent.

MAINTENANCE OF ELECTRIC ROLLING STOCK OF THE LONG ISLAND RAILROAD

The electric car equipment of the Long Island Railroad consists of 130 steel motor passenger cars, 5 express cars and a rotary snow plow. In addition there are 55 wooden trail cars which have been wired with lights and heaters. The express cars are provided with trucks, motors and controllers identical with those of the steel cars.

The steel cars are very similar to those on the New York subway and are of the Gibbs design. They are 51 ft. 2 ins. long over bumpers and 8 ft. 6¾ ins. wide over side sills. They are mounted on Baldwin M. C. B. trucks, the motor and trail trucks having wheel bases of 6 ft. 8 ins. and 5 ft. 6 ins. respectively. The wheels of the motor truck are 36 ins. and those of the trailer truck 30 ins. in diameter. The steel tires on all wheels are 3 ins. thick and are fastened to the centers by shrinkage and with double lipped retaining rings. Two Westinghouse No. 113 motors each of 200 hp are mounted on the motor truck and these are controlled by Westinghouse electro-pneumatic controllers.

Repairs to both electric and to steam equipments are combined to a great extent in the original steam equipment repair shops at Morris Park under the supervision of G. C. Bishop, superintendent of motive power. In view of the fact that the greater percentage of repairs on the electric equipment could be done in the already existing shop, it was deemed unnecessary to erect a separate shop for the electric equipment only. However, to care for the electric repairs a new building was erected adjacent to the old shop and a new electric equipment department was created. The new building consists of a one-story portion containing thirteen repair tracks each of which will accommodate two cars, and a contiguous two-story structure, the upper floor of which is used as a mill room by the steam equipment department. The one-story portion containing the repair tracks is 216 ft. long and 110 ft. wide. All of the tracks have pits and the two tracks adjacent to the two-story structure are provided with five-ton electric traveling cranes. The lower floor of the two-story structure is equipped for winding armatures and there are installed in it lathes and drill presses for doing minor repair work. The repair work of the electric equipment is all done by three departments of the shop. Wheels and air brake apparatus repairs are cared for by the locomotive department. The steam car department makes necessary repairs to truck and the car body, and the purely electrical apparatus is cared for by the electric car equipment department. While in the shop organization the electric car equipment department is on equal footing with the others, it is in reality somewhat isolated from and independent of them. The general foreman of this department is responsible for the condition of the electrical equipment and must see that the other sections are advised when repairs of any kind are necessary. He gets such repairs made by issuing shop orders on the other departments, and in issuing these care is taken to indicate to what they are to be charged, as in the accounting system all the maintenance charges on the electric equipment are kept separate from those for the steam cars.

DIVISION OF ELECTRIC EQUIPMENT REPAIRS BETWEEN DEPARTMENTS

In the maintenance of the electrical equipment of a car quite a large proportion of the repairs are of a semi-mechanical nature, and rather than provide facilities for making these repairs in the electric car department there has been a decided tendency to divert them to the other two departments in the original steam car shops. Accordingly air compressors are maintained with the exception of making field and armature repairs in the locomotive department. The same department takes care of the air valves and air cylinders of the controller. Although the armature winding is done by the electric car department the winders are principally mechanics promoted from the regular shop force.

To familiarize the old shop employees with the electrical apparatus, a regular instruction course is from time to time conducted by the electrical department. At one time all of the controller parts were mounted on wood frames and connected up so that their working could be observed. The shop apprentice course now includes a period of three months in the electrical department. In general it might be said that every effort is being made to free the regular shop men of the idea that there is any radical difference between the repairs to electric and steam cars.

As a result of the method of dividing the work very few mechanical repairs have been left to the electrical department and a few men in the regular repair shop keep up the work left to this department. Motor and controller breakdowns are of rather infrequent occurrence and the work of the repair force is largely that of overhauling the motors and repairing defects due to accidents. In addition to caring for the heavy cars this force of fifteen men also does considerable repair work for the Ocean Electric Railway, the Nassau County Railway and other trolley lines subsidiary to the Long Island Railroad, and it takes care of numerous motors installed on the railroad system.

OVERHAULING AND REPAIR PRACTICE

Cars are usually cared for and kept at the two inspection sheds at Dunton and Rockaway Park, and are brought into the repair shop only when in need of repairs.

Several cars have not yet been in the shops and the motors of these cars and also of some of those brought into the shop for car body repair only as well have not been opened since being mounted on the trucks more than two years ago. During this period the cars have averaged about 60,000 miles. The appearance of many of the original bearings, which are of brass with a thin babbitt lining, indicate that they are good for another year at least.

When a car is brought into the shop for any defect whatever the electrical equipment is gone over thoroughly, except that the motors are opened up only in case of motor troubles or of worn bearings. The motor axle bearings which wear first are changed when end wear on each bearing is ¼ in. or the wear of the bearing surface is ⅛ in. When a motor is overhauled it is lifted off the truck and the top shell is taken off. The field coils are taken out and treated with three coats of shellac. When replaced a sheet of red fiber 1-64 in. thick is inserted between the field and the motor shell.

In order to get the pinion housings off the armature shaft the pinion must be removed. In replacing them they are heated in a box to which steam is admitted for a period of about one-half hour before being mounted. This treatment not only expands the pinion but also cleans it thoroughly.

Several extra armatures are kept on hand, and usually to save time a spare one is substituted for the defective one.

Before being declared o. k. repaired armatures are subjected to a test of about 2000 volts, the high voltage being obtained from a transformer testing set mounted on a truck. Three spare motor trucks are kept in the shop and when there is a shortage of cars instead of holding a defective car in the shop for truck repairs one of these trucks is substituted for the defective one. Likewise three spare trail trucks are kept for emergencies.

In removing one pair of wheels the motor is lifted from the truck, and if both pairs are to be changed the motors are removed and after disconnecting the tie straps under the journal boxes the truck is lifted off the wheels by means of a crane. There has been no occasion to turn wheels because of wear of the tread or because of sharp flanges. All changes have been necessitated by flat spots. The wear on mate wheels is about equal, there being no tendency toward sharp flanges on one wheel and double flanges on the other.

In overhauling the controller the line switch is removed from the car, is taken apart, and is assembled after replacing any worn or defective parts. The reverser, unit switch box and other parts of the controller are inspected and the resistance grids and shoe beams are painted with an inexpensive grade of insulating paint. The paint is applied by spraying and the work requires about ten minutes per car. At each overhauling the 600-volt wiring and the 12-volt or control circuit wiring are tested by using the high voltage testing apparatus previously mentioned. A pressure of about 2000 volts is used in making the test which is applied for ground insulation only.

At each overhauling the compressor is dropped from the car and is removed to the air brake department of the steam shops. Here it is taken apart and cleaned and worn parts replaced. On being returned it is tested to 120 lbs. before being put under the car. Reducing valves, slide valves, feed valves and engineers' valves are taken apart and cleaned by the electrical department, but are repaired by the air brake department.

When a car is brought into the shop a tabulated sheet is placed on it and on this blank are recorded the repairs made, the materials used and the signature of the workman who does the work and who is afterward held responsible for it.

CAR BODY REPAIRS

None of the steel cars has been in an accident involving heavy repairs and it is therefore impossible to make a comparison of the costs of repairing bodies of wood and of steel construction. However, there have been several minor accidents resulting in bent vestibule fronts. For a time boiler makers and metal workers were called upon to make these repairs, but recently the work has been done by regular freight car repair men. In cases of bent dashes or beams the bent parts are heated with a large gasoline burner and are then hammered back to shape.

Repairs so far made indicate a less cost for steel cars than for those of wood construction. The labor item on the steel car is about 30 per cent higher, but the material cost is almost negligible, as in most instances the original materials are bent back into shape. The steel car, however, is out of service longer, as more time is required to make the repairs.

INSPECTION

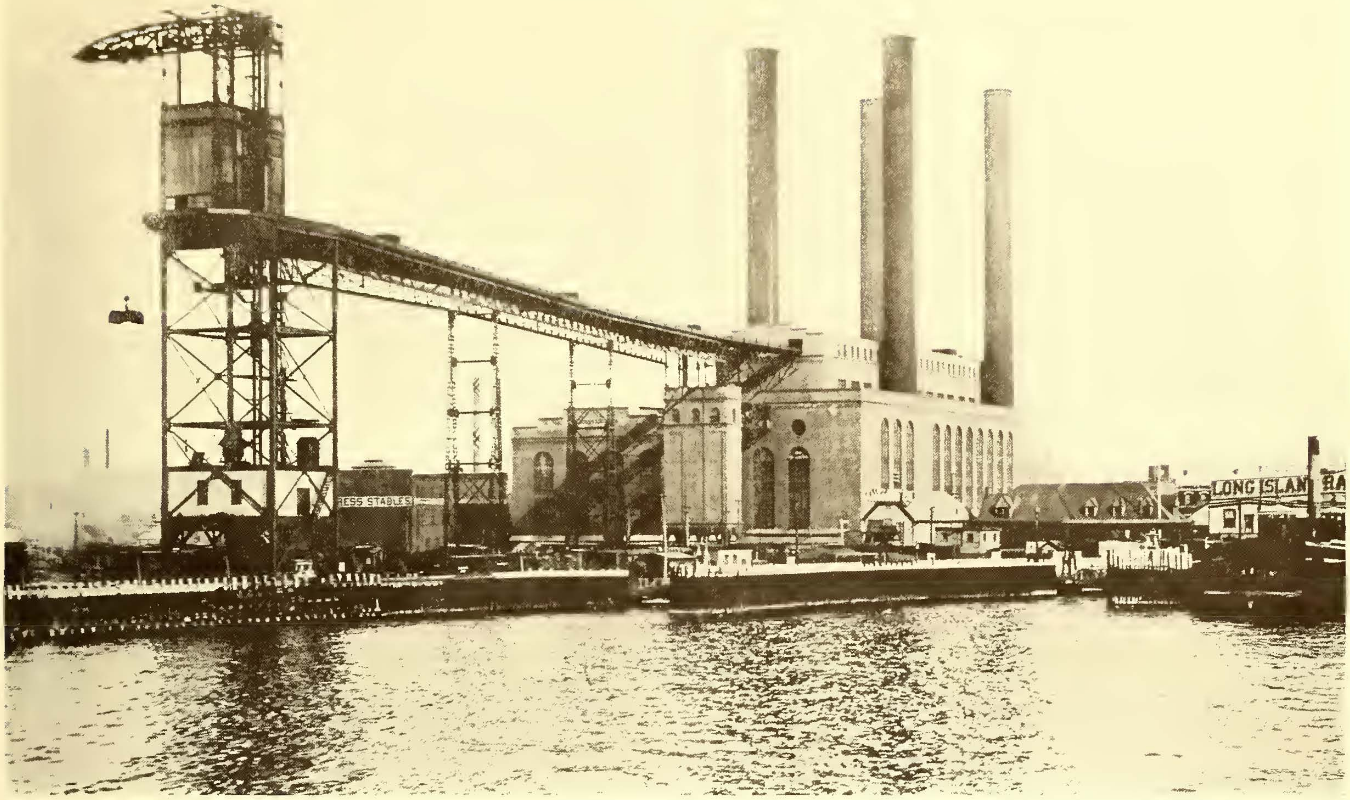
The small number of electrical repairs is no doubt due in a great measure to the careful inspection to which the cars are subjected at the Dunton and the Rockaway Park inspection sheds. The inspection shed at Dunton is 242 ft. 8 ins. long and 92 ft. wide and contains six pit tracks, each of which will accommodate five cars. The Rockaway Park inspection shed contains three pit tracks.

Cars are brought in for inspection on a mileage basis. After making 800 miles they are submitted to a general inspection. They are inspected for every ten days of service, even if this mileage is not made. One man spends about one-half hour per car inspecting and cleaning the control apparatus. In making this inspection all the reverser, unit switch box and other covers are removed, the contacts are brightened, the tension on fingers is tested and finally the apparatus is blown out by compressed air. In inspecting the brushes the motor inspector removes them from the holders in order to inspect the face of the brush and this also assures that any tight fitting brush will be detected. The armature bearings are oiled and the motors are finally blown out with compressed air. The trucks and brakes are inspected, new brake shoes applied and the piston travel adjusted by other inspectors. The shoe fuses are all tested with a bank of lamps.

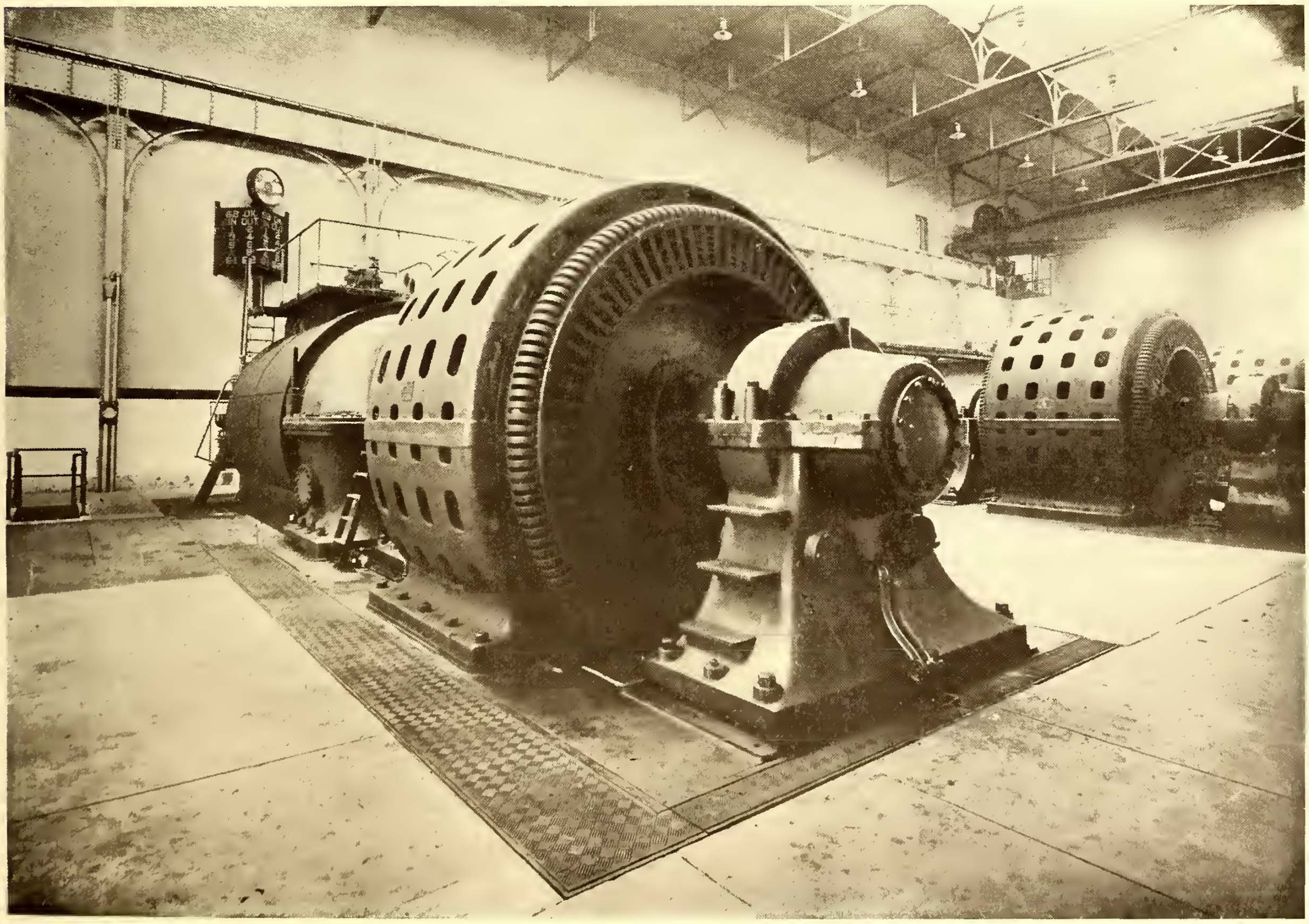
On a basis of 4800 miles the cars are brought in for "general oiling." The oil and waste is removed from the motor bearings, the waste is "teased" and the bearings are washed out. The armature clearance is determined by a gage having two thicknesses, 7-32 in. and 1/8 in. If the thin gage cannot be inserted under the armature the car is taken out of service. Failure to get the thick gage under indicates that this motor must be watched carefully in the future. The pedestals, side bearings, center castings, sector bars and all parts that chafe are oiled. The waste is pulled out of the journal bearings, is teased and the journal is lubricated with two gills of oil. The controller parts are all oiled and a coat of insulating paint is applied to the inside of all of the covers and to the insulators in the pipe conduits. Compressor oil is used in lubricating the 12-volt contacts and interlocks, as it has been found that vaseline sometimes destroys the contact. The thoroughness of the controller inspection may be judged from the fact that for a month during which ninety motor cars were being inspected daily at Dunton only five cases of controller trouble were reported, and these reports were for minor defects.

CARE OF BATTERIES

As the control system is completely dependent on the batteries for its operation these are given particular attention. Two sets are installed on each car. They are connected in multiple with a resistance which is in series with the compressor motor circuit so that when the motor is being operated they are charged. Double-throw switches are provided on the switchboard in the cab and by means of these the batteries may be thrown either on the pump circuit for charging or may be discharged through the control system. It is intended that one set of batteries be charged while the other operates the controller. As it is important that the batteries be not allowed to run down, it has been made the duty of one man at each inspection shed to throw the battery switches each morning. On even days the switches are thrown up and on odd days down. When two odd days come together, as at the end of months having thirty-one days, the switches are left up until the middle of the first odd day and then are thrown down until the end of the first day of the month. The man throwing the battery switches also tests the batteries by placing a lamp bank of 2-volt lamps across the switches. Batteries found weak are replaced by others and are recharged in a charging rack. The battery terminals outside the boxes are scraped clean once each month and a thick coating of vaseline is applied over them. When cars are not in use, or when the surplus equipment is stored during the winter, the compressor motors are run for about half an hour once each



EXTERIOR OF LONG ISLAND CITY POWER STATION, PENNSYLVANIA TUNNEL & TERMINAL CO.

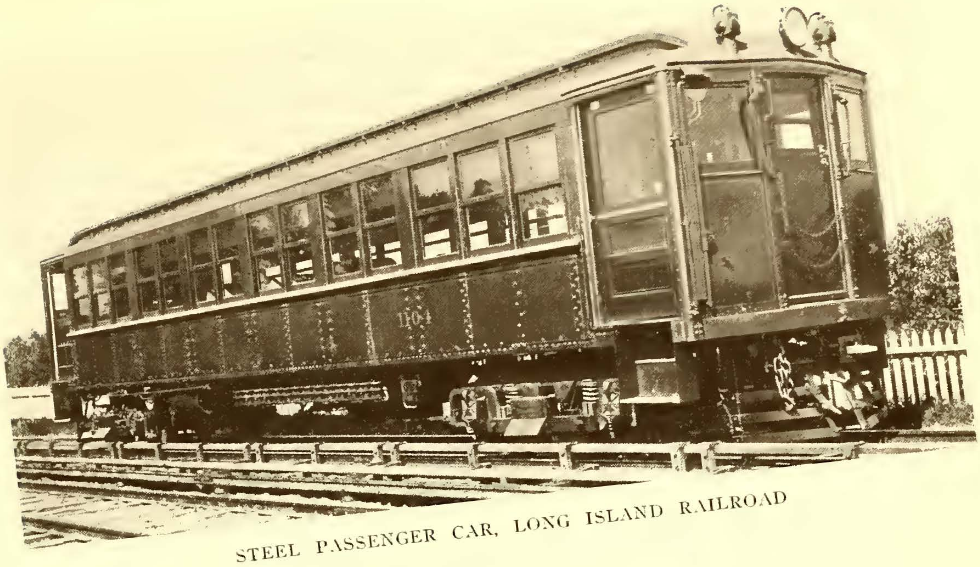


INTERIOR OF LONG ISLAND CITY POWER STATION, SHOWING 5000-KW TURBO-GENERATOR UNITS

INTERIOR OF EMPTY COAL BUNKER

CABLE FUEL-CONVEYOR ABOVE COAL BUNKER

VIEW OF BOILER ROOM, LONG ISLAND CITY POWER STATION, PENNSYLVANIA TUNNEL & TERMINAL CO.

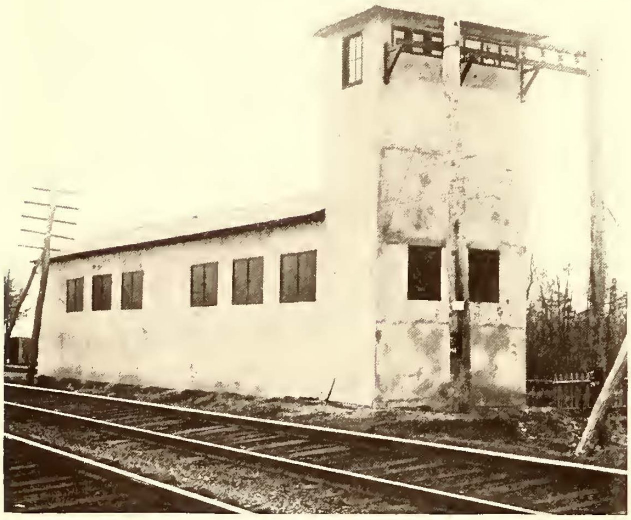


STEEL PASSENGER CAR, LONG ISLAND RAILROAD

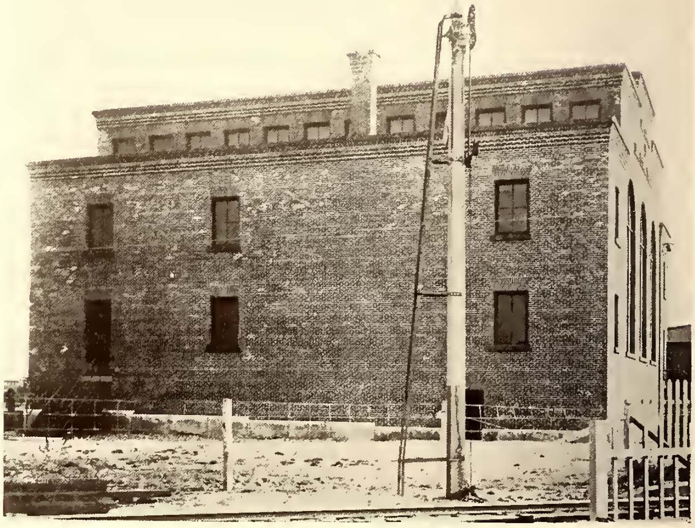
D. C. LOCOMOTIVE AT PRESENT IN USE ON LONG ISLAND RAILROAD

ROTARY SNOW-PLOW, LONG ISLAND RAILROAD

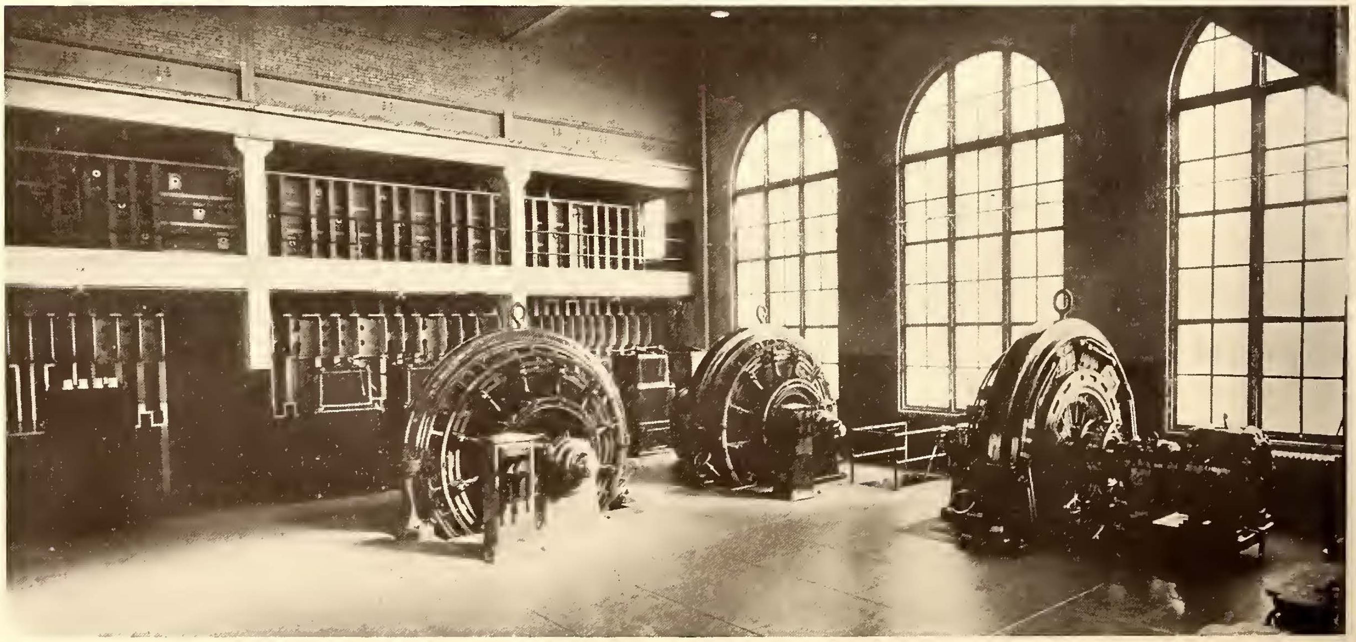
HIGH-TENSION TRANSMISSION LINE BETWEEN LONG ISLAND RAILROAD POWER STATION AND WOODHAVEN JUNCTION



EXTERIOR OF PORTABLE SUBSTATION HOUSE AT BELMONT PARK



EXTERIOR OF EAST NEW YORK SUBSTATION

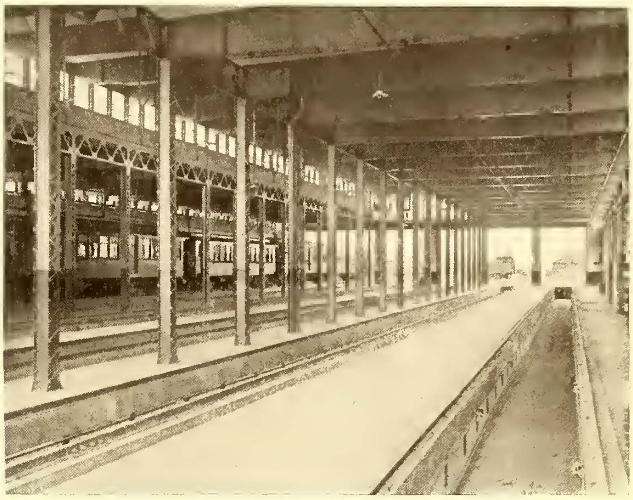


INTERIOR OF WOODHAVEN JUNCTION SUBSTATION, LONG ISLAND RAILROAD

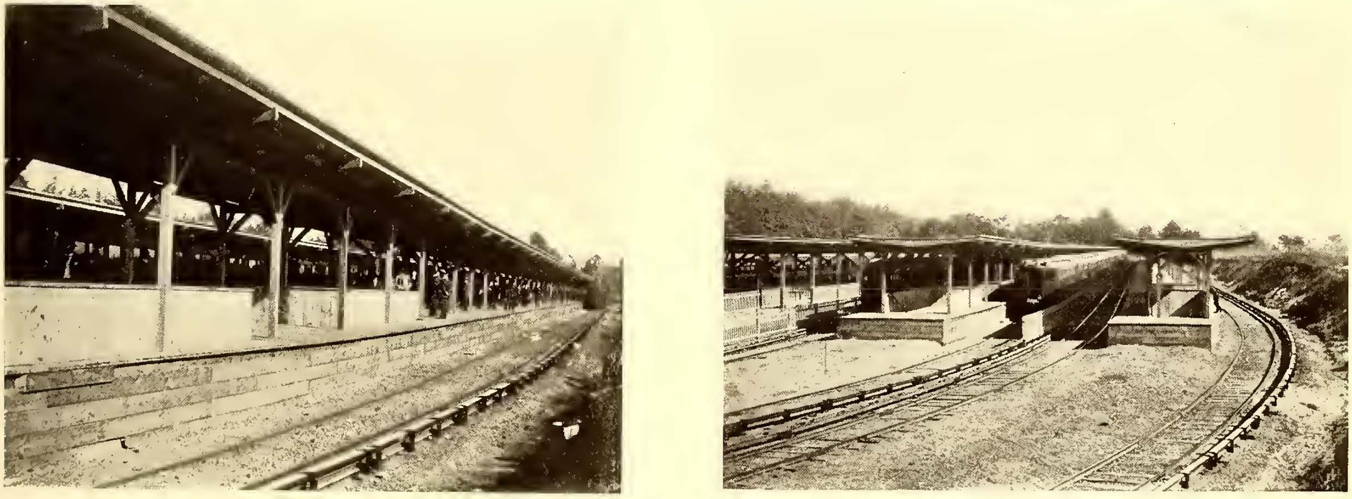
EXTERIOR OF INSPECTION SHED AT ROCKAWAY PARK

CONCRETE CAR-HOUSE AT DUNTON

INTERIOR OF INSPECTION SHED AT ROCKAWAY PARK



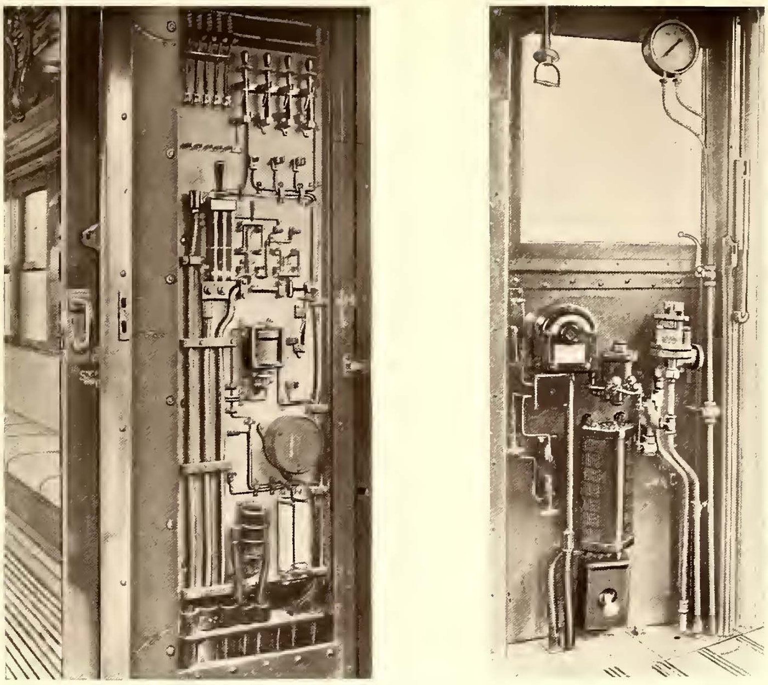
INTERIOR OF DUNTON CAR-HOUSE



ELECTRIC RAILWAY TERMINAL AT BELMONT PARK, LONG ISLAND RAILWAY

DIRECT-CURRENT LOCOMOTIVE HAULING CONSTRUCTION TRAIN ON LONG ISLAND RAILROAD

Plate XXXIV

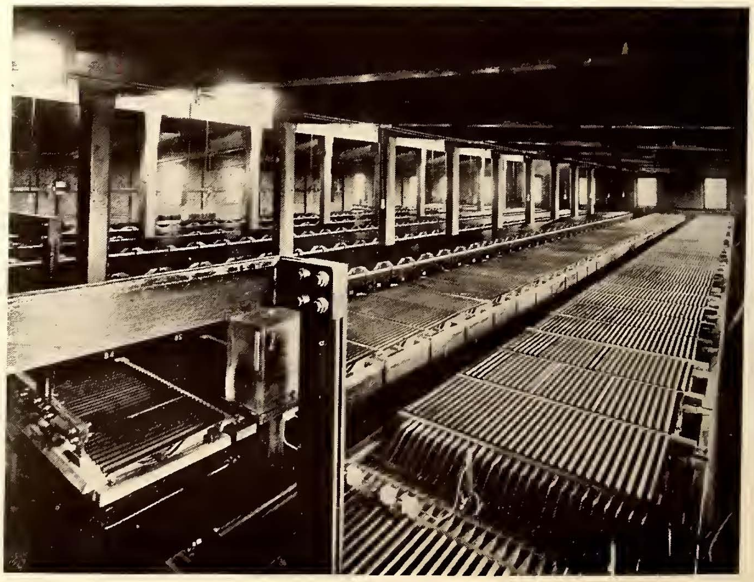


CAB SWITCHBOARD AND CONTROL APPARATUS

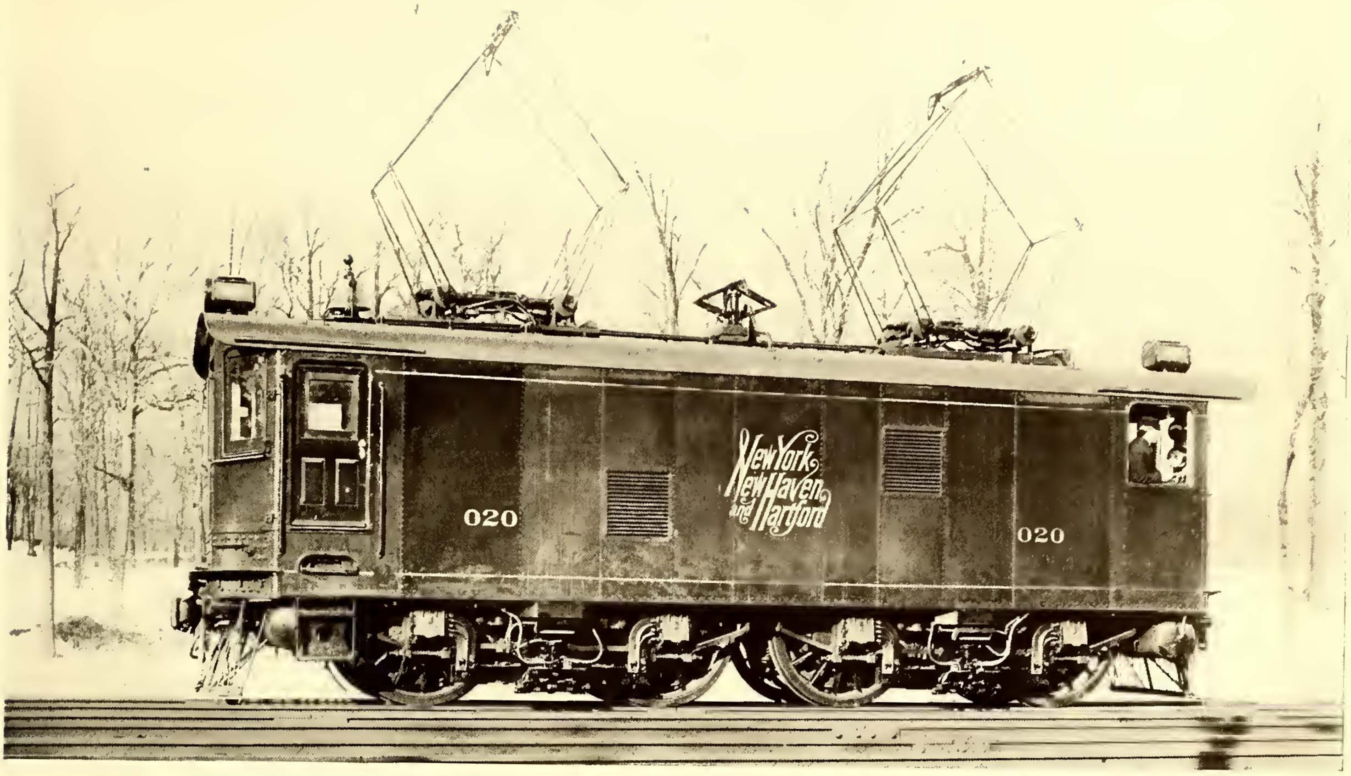
TROLLEY FOR MOVING CARS IN SHED

PITS AT DUNTON INSPECTION SHED, SHOWING METHOD OF LIGHTING

END VIEW OF STEEL CAR



BATTERY AT HAMMEL



LOCOMOTIVE WITH SINGLE-PHASE PANTOGRAPH TROLLEY RAISED, NEW HAVEN RAILROAD

LOCOMOTIVE WITH SINGLE-PHASE PANTOGRAPH TROLLEY LOWERED, NEW HAVEN RAILROAD

RAISING TOP GIRDER FOR FOUR-TRACK OVERHEAD TROLLEY BRIDGE, NEW HAVEN RAILROAD

BRIDGES IN YARDS, VIEW TAKEN BEFORE ERECTION OF CATENARY, NEW HAVEN RAILROAD week in order to keep the battery charged. The air brakes and control system are also operated (without power) several times during these intervals to prevent rusting and sticking. Practically no battery troubles have been experienced; about the only trouble, in fact, is the occasional breaking of the jumper at end of cells, due to corrosion.

BRUSHES AND COMMUTATORS

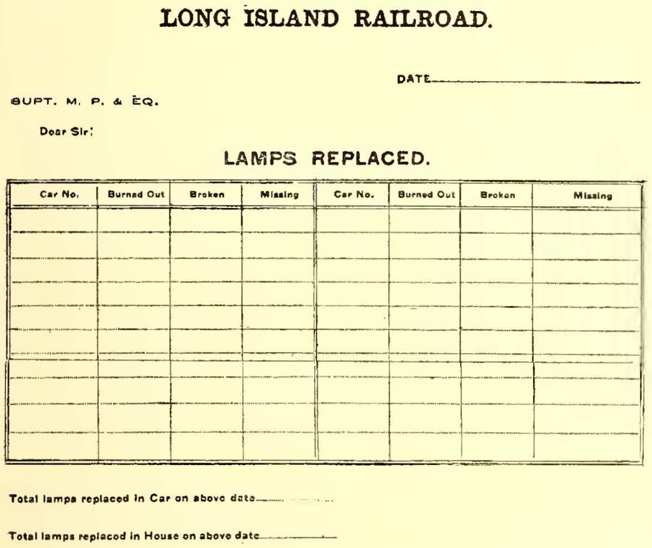
Both soft and hard brushes have been tried and best results have been obtained by staggering the brushes in the holders so that a soft and a hard brush bear on the same commutator surface. The brush holder springs are set to a tension of six pounds for hard and four pounds for soft brushes. In putting in new brushes a scale is used to get the proper tension. No shunts are used in connection with the brushes. The bare brush is simply slipped into the holder with the brush holder spring pressing directly upon it. Whenever it is found that a brush is cutting the segments the commutator is rubbed off with an oily rag. Very little trouble has been experienced with flat commutators. The mica has been grooved out of a few commutators, but as no trouble has been experienced with high mica the practice has been discontinued. These slotted commutators have in fact given trouble by short circuiting between bars.

BRAKE SHOES

Brake shoes have shown a life in express service on the trail truck of approximately 6500 miles and of about 4700 miles in local service with a loss of about 18 lbs. of metal. The life of the motor truck shoes is shorter, due to the heavier braking.

CONTACT SHOES

The contact shoes with which the cars were originally fitted were flat with upturned edges. This type of shoe had a tendency to ride over ice and sleet on the third-rail and because of this a special winter type was designed having sharp edges on either side. The shoe also has two openings through the sliding surface which permit of additional cutting edges. Normally the shoe is applied to the rail with a pressure of from 10 to 15 lbs. In winter a special tension device is applied to the shoe beam which enables a tension of 100 lbs. or more to be used. The motormen are instructed to increase the tension on the shoes by means of the device in the event of sleet. Shoe troubles have been confined to the breakage of shoes, due largely to obstructions left in the path of the shoe by track repair men.



LONG ISLAND RAILROAD.

DATE

SUPT. M. P. & EQ.

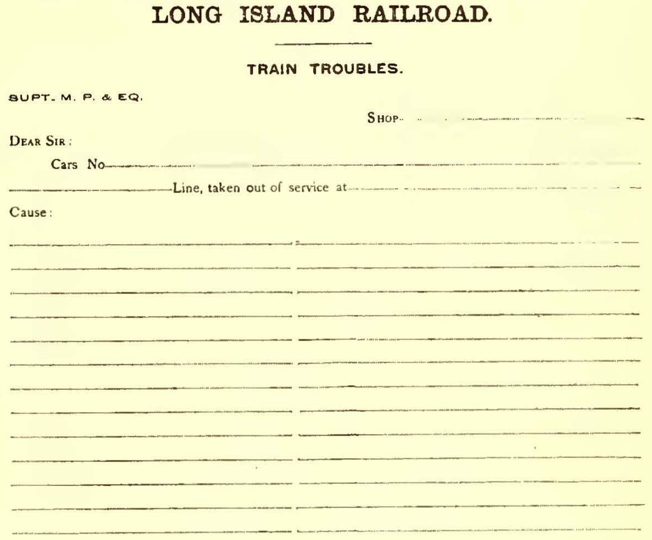
Dear Sir:

LAMPS REPLACED.

Car No.	Burned Out	Broken	Missing	Car No.	Burned Out	Broken	Missing

Total lamps replaced in Car on above date

Total lamps replacod in House on above date



LONG ISLAND RAILROAD.

TRAIN TROUBLES.

SUPT. M. P. & EQ.

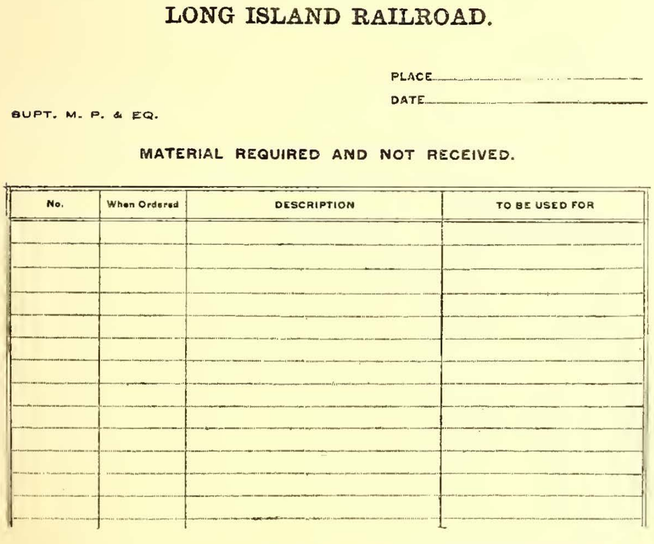
Shop

Dear Sir:

Cars No

Line, taken out of service at

Cause:



LONG ISLAND RAILROAD.

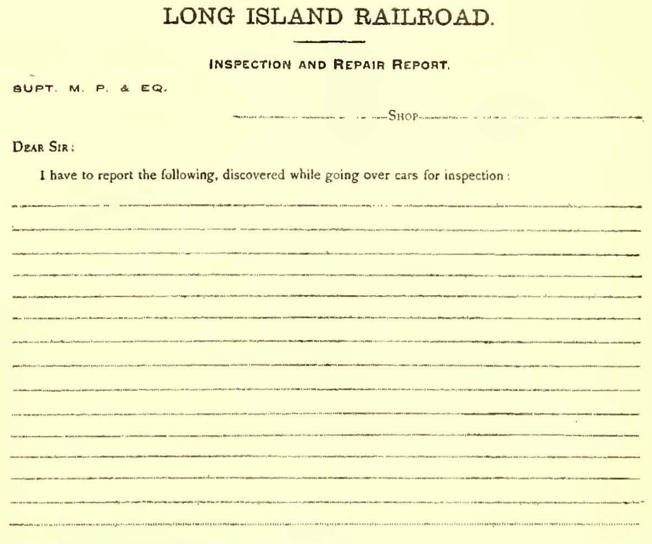
PLACE

DATE

SUPT. M. P. & EQ.

MATERIAL REQUIRED AND NOT RECEIVED.

No.	When Ordered	DESCRIPTION	TO BE USED FOR



LONG ISLAND RAILROAD.

Inspection and Repair Report.

SUPT. M. P. & EQ.

Shop

Dear Sir:

I have to report the following, discovered while going over cars for inspection:

SOME OF THE BLANKS USED IN THE CAR MAINTENANCE DEPARTMENT

OPERATION OF ELECTRIC LOCOMOTIVES BY THE NEW HAVEN RAILROAD

The construction details of the electric locomotives used by the New York, New Haven & Hartford Railroad were described in the issues of the Street Railway Journal of April 14, 1906, and Aug. 17 and 24, 1907. The actual handling of the machines in service illustrates the flexibility with which such high powered rolling stock units, designed for both direct and alternating current working, can be utilized under the exacting conditions of the terminal service between New York and Stamford. Under the present conditions it is inevitable that the electric locomotives of the New Haven road shall constitute the most complex portion of the physical equipment which is displacing the steam hauled trains. A study of the manner in which operation is carried on within the cabs of the machines, however, shows that if the number of parts in a combined single-phase d. c. locomotive is large, it is still possible to arrange the handling of those parts in a clear and straightforward way.

PRECAUTIONS

Each motorman is provided with one reverse lever with a controller plug attached. This lever is returned to the terminal office at the end of each run, and locomotive operators are not allowed under any circumstances to leave it on the machine.

In case any irregularity, such as a short circuit, arcing, blowing of a fuse or smoke, develops in any part of a locomotive while either standing or running, the controller is immediately thrown to the off position, and if on a. c. power the controller button marked "A. C. Trolley" is pressed down. If the machine is on d. c. power, paddles are placed between the shoes and the third-rail before investigating the cause.

PREPARING LOCOMOTIVE FOR A. C. OPERATION

When the locomotives are in the terminal or lying idle in the a. c. zone at the end of a run the condition of the apparatus is supposed to be:

1. Both trolleys (18 and 57)* locked down.
2. Both a. c. circuit breakers (19 and 143) open.
3. Both air compressor switches (71 and 128) and blower switches (70 and 127) open.
4. Controller lever in "off" position.
5. Reverse lever and controller plug removed.
6. Battery switches (167 and 168) and motor-generator switches (169 and 170) open.
7. Third-rail shoes up.
8. D. C. main switch (61) closed.
9. D. T. heater switches (114 and 181) in down position. Train line heater switch open.

When preparing to run on a. c. power the motorman first sees that both a. c. circuit breakers (19 and 143) are open and that both trolley safety chain catches are unhooked. He then raises the a. c. trolley, either by a push button or by the use of the hand pump. Both a. c. circuit breakers are then closed, and it is noted that the transformers are energized. The next step is the starting of the air compressors, securing 140 lbs. pressure, and noting that the compressors automatically cut off at this pressure. The battery switches are thrown up on even days of the month and down on odd days, and the charging motor generator is started by closing the motor generator snap switch and after it the knife switch. The controller plug is then inserted, the bell tested and sanders and light circuits tried. The control is tested out as is later described, and the d. c. trolley and third-rail shoes are lowered and raised three or four times to make sure that they operate properly. The fan motors are then started, the fans being kept in constant operation while the locomotive is running.

When running on a. c. power only one trolley is used normally, the other being kept in good working condition for emergency use. The trolley not in use is kept locked down and the lock cut out by closing the air cock on the trolley side of the magnet valve leading to the unlocking cylinder of this trolley. Trolleys are changed each day and under no circumstances is one trolley used continuously. At the end of each day's run the trolley used during that day is cut out and the other one cut in ready for the next day's run. The trolley is greased once each day before starting on the first run in the morning by filling its central groove with heavy grease. The a. c. trolley locks are inspected each morning before starting out, and both batteries are tested out at least once each day or before starting on each run, by the use of a 20-volt lamp.

PREPARING LOCOMOTIVE FOR D. C. OPERATION

Emergency procedure in case of a short circuit or other irregularity is the same when standing in the d. c. zone or in leaving a terminal as in the a. c. zone. It is assumed that while in the d. c. zone, standing, all apparatus will be in the condition described when standing in the a. c. zone, except that the shoes will be in contact with the third-rail, direct current will be in the locomotives and the motor generator switches will be open.

When it is necessary to retain a locomotive in the d. c. zone and ready for service for a period of over one hour the battery switches are opened, and if the temperature of the motors is less than 50 degs. C., as read on the temperature meters, the blowers are shut off. After reaching the end of the run the blowers are allowed to run until the temperature of the motors is reduced to 50 degrees.

In preparing to run on d. c. power the motorman first starts the air compressors and sees that 140 lbs. reservoir pressure is secured, with automatic cut-off of pumps at this pressure. The battery switches are then operated as in preparing for starting on a. c. power, and the motor generator switches are open. The controller plug is inserted, the control tested out, with trial of bell, sanders, lights and d. c. trolley.

In leaving a terminal, passing over switches, transfer or turntables and coupling up to a train, and in running at other places where slow speeds are required, the controller handle is allowed to be retained in one of the switching positions, but these positions are not allowed to be considered for anything but unavoidable conditions. There are six economical running positions of the controller handle when operating on a. c. power, and four in d. c. service. All other positions are uneconomical and are avoided as much as possible, not only to save power, but to keep from burning out grid resistances. When the motorman first throws current into the motors he is required to be sure that the ammeters in both ends of the locomotive are registering, as a check on both pairs of motors being cut in.

OPERATING TRAINS WITH A. C. POWER

When starting a train with a. c. power the controller handle is drawn promptly to a. c. position No. 1, and from this point

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*These numbers refer to those on Supplement to STREET RAILWAY JOURNAL, Aug. 17.

to positions 2, 3, 4, 5 or 6, with whatever speed is necessary for obtaining the desired acceleration. While the locomotive is accelerating, the ammeter is watched carefully and a current of 1600 amps. is maintained as nearly as possible, the rule being never to exceed 1800 amps. If the controller lever is by mistake pulled beyond No. 6 a. c., the power is cut off from the locomotive and the lever is at once to be pushed back to No. 6. Should the locomotive slow down before this is done, the plug is removed from the side of the master controller and the controller handle then pushed to the off position, the plug reinserted and the controller handle then pulled to the desired running position. A locomotive is never allowed to stand with current in the motors.

OPERATING TRAINS WITH DIRECT CURRENT

In starting a train with direct current the controller handle is promptly brought to a notch which will give a current of about 1600 amps. on the meter, and then promptly brought up to the series d. c. notch, taking care never to exceed 1800 amps. In case 2500 amps. are exceeded the d. c. circuit breakers open, and in order to reset these the controller handle has to be thrown to the off position. If a speed is desired lower than that obtained with the controller handle in the d. c. series notch, the handle is retained in this notch for a short period and then shut off, with coasting, to get a low average speed.

CHANGING FROM A. C. TO D. C. POWER

When running on a. c. power and approaching the change-over point to d. c. two posts are noted on the right of way. These posts are illuminated at night. On reaching the first one, marked "Shoes Down," the motorman presses the controller button similarly marked and notes that all the shoes are down on both sides of the locomotive. On reaching the second post, marked "Power Off," the controller lever is thrown to the off position. The storage battery knife switch and the motor generator snap switch are opened. The third-rail shoes after being down are automatically locked in that position and the train is allowed to coast over the lap between the a. c. power and d. c. power supplies. As soon as the third-rail shoes come in contact with the third-rail the a. c. trolley is automatically lowered, the a. c. apparatus in the locomotive is automatically cut out, and the d. c. equipment is cut in. As soon as the motorman notes that direct current has entered the locomotive, and the above changes have taken place, he pulls the controller lever to the proper speed point. If the third-rail shoes are not lowered in time to catch the third-rail the locomotive will receive no current, and the train must be pulled back by a switch engine. If the third-rail is not charged when the shoes come in contact with it, the a. c. trolley will not be lowered automatically, but must be lowered by pushing the appropriate controller button.

CHANGING FROM D. C. POWER TO A. C. POWER

When running on d. c. power, and immediately after reaching the overhead a. c. construction, a sign post (illuminated at night) is noted on the right of way, marked "Controller Off." On reaching this post the engineer throws off power as directed, taking care to throw the controller to the off point before the end of the third-rail is reached, to avoid drawing an arc which would damage the shoes. The controller button marked "Shoe and Trolley Unlock" is pressed and held down until the shoes leave the third-rail, and the motor-generator switches are closed in the order named.

When the shoes leave the third-rail they automatically fold up to the side of the locomotive, and the a. c. trolley is automatically forced up in contact with the trolley wire. As soon as a. c. power enters the locomotive all d. c. apparatus is automatically cut out and the a. c. apparatus cut in. As soon as it is noted that this operation has taken place and that the transformers are energized, the controller lever can be handled for the proper speed point.

MULTIPLE OPERATION

When two or more locomotives are to be operated together, all locomotives are operated from one locomotive and one controller, preferably the one at the forward end of the leading locomotive. The first operation is to make the three jumper connections between the locomotives; the second is to test the control and make sure that its operation is perfect in all locomotives, and the third is to remove reverse levers and controller plugs from all controllers except the one from which the train is to be handled. While operating locomotives in multiple on a. c. power, one trolley on each locomotive is used.

OPERATION WITH D. C. OVERHEAD RAIL

About the d. c. zone, at crossovers and switches, d. c. overhead conductors have been installed at many points where there is a gap in the third-rail. Some of these points can be coasted without the use of the overhead trolley, but in other cases, where the gap in the third-rail is long, or when handling heavy trains, power is obtained from this overhead conductor as follows: First, the controller handle is allowed to remain in a running position if the speed is not reduced; second, the master controller push-button marked "D. C. Trolley Up" is held down and the controller handle is operated as in d. c. service on the third-rail. The d. c. overhead trolley remains up only as long as the controller button is held down, and it is necessary to retain pressure on this button until the shoes come in contact with the third-rail. The d. c. overhead trolley is always kept down when the locomotive is not under the overhead rail.

RAISING A. C. TROLLEYS

Under normal conditions air pressure for unlocking the a. c. trolleys comes from the main reservoirs, which carry 130 lbs. pressure. After a locomotive has been standing for some time, such as over night, the pressure may leak off from these reservoirs, and the unlocking can then be done by pressure from the emergency control reservoir, which under normal conditions carries 130 lbs. pressure. To do this the handle of the three-way cock is thrown to the right, and after the trolley has been unlocked the handle is restored to its central position.

If there is no pressure on the emergency control reservoir. trolley No. 2 is unlocked by the use of the hand pump. The trolley can be unlocked by three or four strokes, after which it will be raised automatically. If both these methods fail, the latch in the trolley lock may be pulled by the hook on the end of the wooden pole carried in the locomotive. This is not done from the top of the locomotive, as it can be done safely by standing in the side door, or on a ladder. The pole is kept dry and rubber gloves are used in handling it in wet weather.

TESTING CONTROL ON A. C. POWER

In testing the control by daylight without electric lights the motorman first sees that at least 70 lbs. air pressure is on the control reservoir, and then opens the a. c. circuit breakers. He inserts the reverse lever in the controller, moves it to its forward position and notches up the controller to each successive a. c. position, making sure that the proper switches as shown in Fig. 6, Aug. 24 issue, come in at each successive a. c. position. The controller handle is then returned to the off position, the reverse lever thrown to the backward position and the test repeated. Finally the a. c. circuit breakers are closed.

In testing the control on a. c. power at night when electric lights are required either controller may be used and only half the equipment can be tested at one time. The first move is to see that the balancing transformer is completely disconnected by throwing its connecting switches to the down position and opening the air compressor switches. No. 1 right hand auto-transformer is then disconnected from the trolley by opening the right hand a. c. circuit breaker. The handle of No. 2 motor control cutout is then thrown to the "out" position, and the controller and reverse lever tests made as in daylight testing. This tests switch groups 4, 5 and 6 on the right hand side of the locomotive. The next step is to throw the handle of No. 1 motor control cutout to the "out" position, then to reset the right hand a. c. circuit breaker, open the left hand a. c. circuit breaker, throw the handle of the left hand motor control cutout to the "in" position and test with reverse lever and controller handle. This tests switch groups 1, 2 and 3 on the left hand side of the locomotive, and completes the test. The left hand circuit breaker is then reset, and the handle of the left hand motor control cutout thrown to the "in" position.

TESTING CONTROL IN D. C. ZONE

This test may be made from either master controller. The first move is to open the d. c. main switch. The reverse lever is then inserted in the controller and thrown forward. The master controller handle is then brought to the d. c. switching position and then notched up to full multiple, the action of the appropriate switches being noted. The controller is then thrown off, reversed, and the test repeated, after which the d. c. main switch is closed. This does not cut current out of the lighting and heating circuits, or the circuits for the compressor or blower motors.

INTEGRATING WATTMETERS

Each locomotive is fitted with one a. c. integrating wattmeter and one d. c. integrating wattmeter which show the total amount of power used. On taking charge of a locomotive both of these meters are read and a record kept of the reading. On releasing charge of a locomotive both instruments are read a second time, and a signed record of both readings is turned in to the foreman at the terminal.

ELECTRIC HEATERS

Current at about 600 volts, both a. c. and d. c. for heating trains, will be fed through the heater change-over switch to the heater bus line of the locomotive. The bus line has a jumper socket beneath the floor at each end of the locomotive for attaching a jumper with which to make connection to the cars. The change-over switch is connected to the heater bus line by the single pole single throw heater bus line knife switch. This switch must be closed in order to secure either a. c. or d. c. power in the heater bus line, and when the electric heaters are not in use it is opened. A. C. power is fed to the change-over switch through a small balancing transformer which may be connected to either one or both of the main transformers through the single pole double throw knife switches. One switch connects the balancing transformer to the No. 1 main transformer, and the other switch connects it to the No. 2 main transformer. When the electric heaters are required, under normal conditions, both switches are in the upward position, and when they are not required the switches are down.

In the event of one of the transformers being out of service and heaters required, one of them should be up and the other down, under which condition all heating current will be drawn from one transformer. These switches have no work to perform while operating on d. c. power, as the heater change-over switch has a connection direct to the third-rail shoes. When running from a. c. to d. c., or vice-versa, the heater change-over switch adjusts the circuits automatically.

TRANSFORMERS

In case of trouble with a transformer it is cut out by opening the circuit breaker which feeds current to that particular transformer, and also by making sure that the switch connecting that transformer to the balancing transformer is in the down position and by opening the compressor motor switch.

A. C. CIRCUIT BREAKERS

While running on a. c. power, if over 1800 amps. are thrown on the motors, the circuit breakers one or both are liable to go out, and can be reset by hand, but the controller handle is always kept in the "off" position then. If a circuit breaker goes out repeatedly with less than 1800 amps. on the motors, the adjusting screw on the overload trip is screwed down to a point which will allow of this amount of current without the operation of the trip. If a circuit breaker goes out repeatedly without apparent cause, the control cutout on the side of the locomotive on which the circuit breaker is located is thrown upon the "out" position, which cuts out one pair of motors.

A. C. TROLLEYS

In case any mechanical difficulty occurs with the a. c. trolley in use, the trolley is lowered, and if the locking mechanism permits it is locked down, the air cock on the trolley side of the magnet valve leading to the unlocking cylinder of the trolley also being closed. The trolley is tied down with a rope if the locking mechanism is out of order, and the safety chains are not allowed to be used for this purpose, as they are grounded and would cause a short circuit. In case of trouble with the cable which connects the two trolleys, this cable is disconnected from both trolleys by adjusting set screws and drawing out the cable terminals. Under this condition it is necessary to use both trolleys for operating the locomotive in order to secure the use of both pairs of motors.

If trouble occurs between one of the trolleys and the circuit breaker the cable between them is disconnected, cutting out one pair of motors. Employees are not allowed to go on top of a locomotive under any circumstances when any trolley is in contact with any wire. Immediately after anyone goes on top of a locomotive when the trolleys are down the safety chains are snapped to both trolleys, which locks them down and makes it impossible for them to be raised from the inside of the locomotive. Before the top of the locomotive is left both safety chains are unsnapped in order to permit raising the trolleys. If one trolley should be raised while the other is chained a short circuit would occur between the high tension trolley wire and the ground.

UNIT SWITCH GROUPS

A failure of the unit switch groups is due usually to low air pressure, low battery voltage or to improper contacts in the control circuits. If low air pressure is suspected the gage is required to register at least 70 lbs. in the control line, with normal pressure of 130 lbs., on the main reservoir gage. Trouble in the three-way cock, if due to some slight obstruction, is usually removable by throwing the handle from one extreme position to the other several times. Any slight obstruction in the reducing valve can as a rule be remedied by tapping it with a hammer. In the event of low battery voltage, in case the switches do not respond to controller movement with the apparatus in normal condition, the battery switches are thrown to the reverse position, which cuts in the other storage battery.

If a movement of the controller handle to running position results in the coming in of a portion of the switches and a failure on the part of others, the trouble is usually due to improper contacts of some of the fingers of the motor control cut-outs, change-over switches or master controller. In this event, if it is possible to handle the train with one pair of motors, the side of the locomotive in which the failure occurs is cut out and operation takes place on the other side. If this cannot be done the locomotive circuits are arranged as described for testing control, and the master controller is notched up until the point of failure is reached. The cases of the control cut outs, change-over switches and master controllers are opened, and a piece of wood is run along the control fingers and interlocks. A failure to make contact is noted quickly in this way and an adjustment of the troublesome fingers follow. If the failure cannot be located in this way and it is impossible to run the train on two motors the only recourse is a call for assistance.

THIRD-RAIL SHOES

A broken third-rail shoe or shoe support is broken entirely off when in the judgment of the motorman it will cause the least delay. In either case before the shoes are touched the d. c. switch is opened, compressor and blower switches opened; also the single pole single throw switch to the heater change-over switch, and wooden paddles are inserted between the third-rail and all contact shoes on the locomotive. A tool with a wooden handle is used to break off the remainder of a broken shoe. A crowbar or a coupler pin are not allowed to be used around the electric locomotives, and locomotives are not allowed to enter the d. c. zone without at least one good shoe on each side of each truck.

CHANGE-OVER SWITCHES

Air pressure for operating the change-over switches is supplied from the control reservoir at eighty pounds. If one of these switches does not throw properly under at least seventy pounds, the relay box is opened and it is noted whether the relays are in their proper positions; that is, if on a. c. power, both relays up and the d. c. relay down, and if on d. c. power, both a. c. relays down and the d. c. relay up. If they are not in their proper positions the change-over switch is thrown by hand and the trouble reported at the terminal. A lever for throwing this switch by hand is provided in the cab.

MASTER CONTROLLER

A failure of the master controller caused by an improper contact or the displacement of one of the contact fingers is readily noted and any slight difficulty of this nature is remedied on the road. In case of any serious disarrangement of the parts the controller is cut out, the reverse lever and plug removed, and the locomotive operated with the controller at the other end.

REVERSING

In case the brakes fail, as an extreme measure the motors are used for braking by throwing the controller lever to "off," reversing and notching up slowly until a stop is made. A train can be stopped by the above method if power is off the line. If running in the a. c. zone the lever is moved to any position, but if in the d. c. zone the controller is brought to a notch beyond the d. c. shunt No. 2.

OPERATING ON A. C. POWER WITH ONE TRANSFORMER OR ONE PAIR OF MOTORS CUT OUT

In case a motor or transformer becomes disabled and it is necessary to cut out a pair of motors the control cutout is thrown out, the circuit breaker leading to the pair is opened and the balancing transformer on the side of the locomotive to be killed is cut out by the reversing switch. When operating under this condition a maximum of 2000 amps. is allowed.

OPERATING ON D. C. POWER WITH ONE PAIR OF MOTORS CUT OUT

If it becomes necessary to cut out motors Nos. 3 and 4 when on d. c. power, the corresponding motor control cut out is operated, and the same thing is done with Nos. 1 and 2 when necessary. The d. c. main switch is then opened, and the trap door raised in the floor over the motors. The leads are disconnected and the cable ends taped to prevent grounding. When operating in this condition the locomotive is handled in exactly the same manner as when operating with four motors, and a current of 2000 amps. is the maximum allowed.

OPERATING WITH ALTERNATING CURRENT THIRD-RAIL

The draw of the Cos Cob bridge is not equipped with the overhead trolley, and it is the company's intention that under normal conditions trains will be allowed to coast over this draw without the use of any current, and with the a. c. trolley down. When a motorman approaches this draw he watches the overhead wire closely, and just before reaching the draw throws the controller handle to the "off" position. He then lowers the trolley and after the draw has been passed raises it again. This draw is equipped with an a. c. third-rail to be used in the event of a train becoming stalled on it. To operate under this condition the first step is to see that the d. t. heater switches are both in the "up" position. The main d. c. switch is then thrown up and the third-rail shoes lowered. The tower operator is signalled to cut current into the third-rail and the controller is handled as in other a. c. operation. The train is run on as low a speed point as is possible on the master controllers, as rapid acceleration under this abnormal condition is liable to injure the equipment. Just before reaching the end of the third-rail the controller handle is thrown to the "off" point, the d. c. main switch is then thrown down and the trolley raised, which operation folds up the shoes.

BLOWERS

Each locomotive has two motor-driven blowers for forcing a blast of air through the main motors, transformers and resistance grids to prevent their becoming overheated. The blower motors run on both a. c. and d. c. power. Each blower has a conduit which carries the air from it through one pair of motors and the transformers and grids connected thereto; but the conduits are connected in such a manner as to, in the event of one blower being disabled, carry air from one blower through both pairs of motors, both transformers, and both sets of grids. Each conduit is fitted with two dampers close to the blower, and in the event of a blower being disabled both of these dampers are kept closed in order to prevent the air from the blower in service from exhausting through the standing blower instead of through the apparatus.

The air inlet to each blower is fitted with snow shutters which can be closed during snow storms. Under this condition air is supplied to the blowers from the interior of the cab, and in order to furnish this air, if the storm is not severe, one of the cab doors is opened, otherwise one or two of the trap doors in the floor.

REPLACING FUSES

In replacing third-rail shoe fuses the main compressor and heater switches are opened and wooden paddles inserted between the shoes and the third-rail. In replacing light, blower and heater circuit fuses the appropriate switches and breakers are first opened and paddles used whenever the third-rail itself is involved through direct connection.

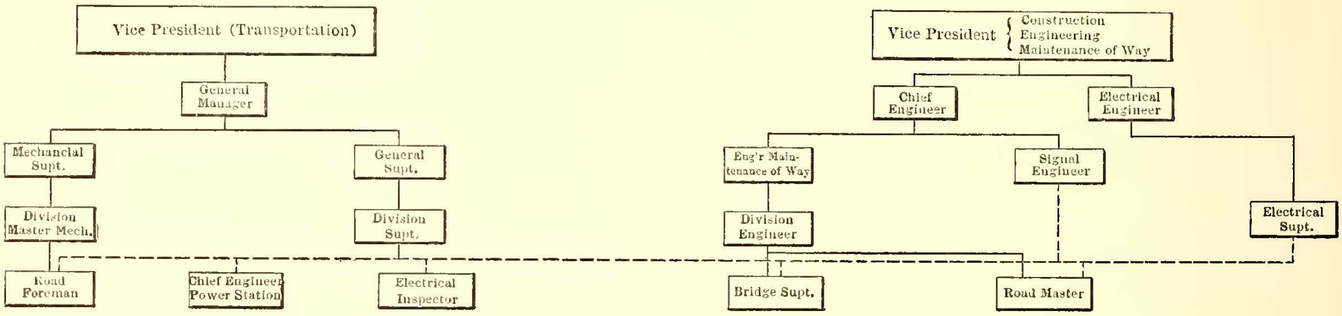
MISCELLANEOUS OPERATING CONVENIENCES

The push buttons for operating the sanders, both forward and back, are also connected with foot treadles. Each locomotive is provided with an electric speed indicator which receives current from a small magneto and registers the speed in miles per hour on dials located on the instrument board in each end of the locomotive. The cab lights are controlled separately from the head and instrument lights. The readings of the temperature meters are obtained from exploring coils, one of which is located in motor No. 1 and the other in motor No. 4. Each locomotive is provided with a steam boiler for heating trains in cold weather. It is fired with oil, the fuel being forced in by an air pressure of about 25 lbs. The oil tank can be filled either from the top of the locomotive or from the floor.

ELECTRIC RAILWAY PRACTICE OF THE NEW HAVEN RAILROAD

The electric train service of the New Haven system in and near New York has been in operation so short a time that practice has not yet become thoroughly settled in any department of the work. Experience alone will determine the routine of handling the business electrically and the form of records best adapted to the requirements. The problems of a rapidly developing system, however, are no less interesting than those of a long established organization, and the fact that any given expedient or method may be modified later in no wise detracts from the value of that method in representing the best knowledge of how to meet a present situation.

Simplicity of organization has been sought to a remarkable extent in the New Haven electric zone, as well as freedom from complication in the equipment as a whole. As a high official of the company tersely remarked, "The road is remarkable for what it has not." As far as possible every effort has been made to disturb the existing steam organization as little as possible; to handle the business with a new motive power but with as little additional or altered operating personnel as is consistent with good service. At this writing the New Haven electric train service in and out of the Grand Central Station aggregates but thirty trains per day. The load is therefore too small to enable representative studies to be made of either the power house operation, the train movements in terms of equipment capacity, or of maintenance problems. Sweeping conclusions cannot as yet be accurately drawn as to the value of detailed practice, but already the central fact stands forth, as in the case of the New York Central service, that the electric locomotive is crowding its steam driven predecessor off the rails. In the months to come there is to be little question about the complete triumph of electricity as a motive power in heavy terminal service.



Street Railway Journal

Dotted line indicates jurisdiction is limited to electrical subjects

CHART SHOWING OPERATING ORGANIZATION OF THE NEW HAVEN RAILROAD

ORGANIZATION OF ELECTRICAL DEPARTMENT

The inter-relation of steam and electric practice can be seen readily in the chart on this page, which represents the organization of the electrical service in the New York terminal zone of the New Haven system. As far as possible the regular steam organization handles the work. Operation is in general charge of a Vice-President, whose special interest is transportation; and construction, engineering and maintenance of way matters are likewise under the authority of another Vice-President. The general manager, mechanical superintendent, division superintendent and division master mechanic are responsible as indicated on the transportation side of the diagram, and the chief engineer, electrical engineer, signal engineer, engineer of maintenance of way, division engineer and roadmaster are responsible as indicated on the construction and maintenance side. Up to this point electrical operation is not in evidence. The central operating authority in the electrical zone is the electrical superintendent who reports to the general superintendent in transportation matters, and is expected to work with the division superintendents and master mechanics. In maintenance of way and construction matters he reports through the engineer of maintenance of way and electrical engineer, and is expected to work closely with the division engineers. Road foremen, bridge supervisors and roadmasters act under his instructions in electrical matters. His authority over the chief engineer of the power station and the electrical inspector is practically exclusive. The responsibilities in electrical matters are indicated in the dotted lines in the chart.

The division of work of those reporting to the electrical superintendent on electrical matters is as follows:

Road Foreman of Electric Locomotives, who has jurisdiction over the maintenance and operation of electric locomotives, and instructions to motormen and their helpers. He receives his instructions in electrical matters pertaining to the operation and maintenance of electric locomotives from the electrical superintendent. In mechanical and ordinary routine matters he reports to the master mechanic in the usual manner. Requisitions and accounts are controlled in the master mechanic's office.

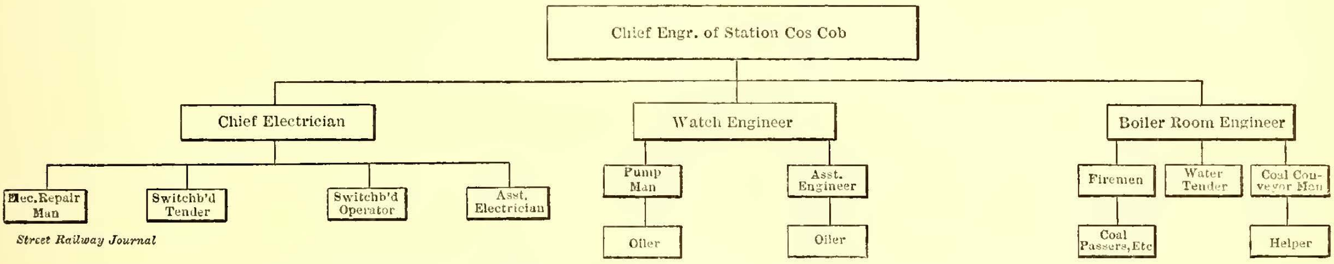
Chief Engineer of Power Station (Cos Cob), who has charge of the operation and maintenance of the electrical equipment. In all matters pertaining to the operation and maintenance of the power station, he receives his instructions from the mechanical and electrical superintendents. All requisitions on the mechanical department must be approved by the electrical superintendent.

Electrical Inspector, who reports direct to the electrical superintendent. He has access to the power station and the privilege of inspecting electric locomotives during operation.

Supervisor of Bridges, who has charge of the maintenance of all bridges and culverts, and of the catenary bridges and electric transmission lines. He reports to the division engineer in all ordinary and routine matters, and to the electrical superintendent in all matters relating to the character, method and execution of all maintenance, repairs and restoration of catenary bridges, transmission lines and other appurtenances not otherwise excepted. All routine reports, material and payroll distributions, methods of accounting, etc., are handled through the division engineer's office, being noted for his information, so far as desired by the electrical superintendent. The electrical repair and car force in connection with the same are under the jurisdiction of the supervisor of bridges.

Track and bonding repairs are under the charge of the Roadmaster, reporting through the division engineer to the engineer of maintenance of way. The electrical superintendent supervises and directs the proper installation and maintenance of track bonds through the engineer of maintenance of way.

In matters pertaining to the maintenance and repairs of track bonding, catenary bridges, overhead lines, signals and signal apparatus, the electrical superintendent reports through the engineer of maintenance of way. In matters pertaining to the operation of the power station and the electric locomotives, other than electric, the electrical superintendent takes his instructions from the mechanical superintendent and from the division superintendent. The electrical superintendent furnishes, through the electrical engineer, such data and reports as may be required.



PRELIMINARY ORGANIZATION OF STAFF AT COS COB POWER STATION

In all matters pertaining to the operation of trains, not specified above, the division superintendent has absolute control.

POWER PLANT OPERATION

The operation of the New Haven power plant at Cos Cob has not as yet settled into the routine practice which should result from the completion of the electric train service between New York and Stamford. The load upon the station manifests itself mainly in the morning and afternoon hours when local traffic between Portchester and New York is at its height. The different shifts have not as yet acquired a full measure of routine duty, and construction work is still in progress at the plant. Records of plant performance have not reached the point where they would be instructive to the general reader, but some tentative chart blanks and forms are included in the following notes for the reason that they show the way in which the company is working toward a settled routine.

The present equipment of the Cos Cob plant represents a generating capacity of 15,000 kw. Three 5000-kw Westinghouse turbo-alternators are ready for service and a fourth unit of 6000 kw rating will shortly be installed. Twelve 550-hp Babcock & Wilcox boilers with superheaters provide the steam for the plant. Mechanical draft is used instead of natural draft, and the station supplies current at 11,000 volts, 25 cycles, to the single-phase trolley lines in the 21 miles of electrified four-track line between Stamford and Woodlawn.

Bituminous coal is brought to the plant by rail at the present writing, but it will shortly be handled by barges on the Mianus River, which flows past the plant. This is a tide water stream, and an extensive coal handling equipment has been installed to facilitate the transfer of coal from the barges to the pockets in the power plant. Coal will pass from the barges into a hopper, thence to a crusher and second hopper, whence cable cars will carry it to an automatic weighing outfit. From this point it will be delivered to the bunkers and handled at the boiler furnaces by Roney stokers. The capacity of the coal machinery is 400 tons in 9 hours.

At present the plant is burning about 30 tons of coal per day. The coal is crushed to nut size or finer before being used. The bunkers are of the underground type and have a total capacity of 350 tons. They are kept full practically all the time. No trouble has as yet been experienced from fires in the bunkers, and as the coal is turned over completely about every 12 days, it is not considered necessary to take temperatures. If necessary the bunkers can be flooded. Besides the capacity available in the bunkers a temporary storage of 350 tons in the yard is available.

BOILER AND AUXILIARY HANDLING

Three shifts of 8 hours each per day are now on duty at Cos Cob. The station is in service continuously, but as outlined above the output is largely confined to the hours of peak load. These are from 5 a. m. to 9:30 a. m. and from 3 p. m. to 7 p. m. One boiler in full service is sufficient to handle the load during the light hours, the rest being either banked or dead. As yet only six boilers are required at the hours of peak load. Typical records and charts of boiler performance are not as yet in shape, as some of the boilers are still under construction. The grates are cleaned about every two hours by shaking. The make-up water supply at present comes from the mains of the city of Greenwich, Conn., and a tank of 600,000 gals. capacity is located in the yard to provide enough extra make-up water to tide over any emergency. The draft of the boilers is controlled by a Ford regulator installed in connection with the throttles of the fan engines. The usual silver nitrate test is used in connection with the water returned to the boilers from the surface condensers. The supply of feed water is controlled by a Ford regulator in the pump lines. In nine months' operation of one boiler no scale has been discovered. The boilers are blown off daily, the work being done at about midnight to about half the water gage. The exteriors of the tubes are blown off daily with a steam jet blower. It takes two men half an hour to do this. All the auxiliaries are supplied with superheated steam, and the boiler pressure carried is 200 lbs., with 75 to 100 degs. F. superheat. The boilers are ordinarily operated in multiple, but if desired the station can be operated on the unit plan. The feed water reaches the boilers at from 240 to 300 degs. F. Three Green economizers are installed, one unit for each four boilers. The scrapers are driven about two hours daily, a 4 in. x 5 in. engine being installed on each economizer. So far but one economizer has had to be used regularly, but all can be run in multiple if desired. Flue gas temperatures and analyses have not yet been studied.

The average temperature of the circulating water discharge is from 75 to 80 degs. F., and the vacuum carried is 29 in. The condensers are cleaned weekly, but to prevent deterioration in daily service they are flushed with fresh water for two minutes each time they are shut down. The circulating pumps are designed to deliver water against a static head of about 20 ft., and have not lost their suction in regular service. All the auxiliaries are engine driven with the exception of two exciters and the coal handling system. If the condenser intake gives trouble next winter on account of ice a steam jet will be used to keep the conduit clear.

An important accessory to the condensing equipment is a motor generator set installed to prevent the electrolysis of condenser tubes by saline circulating water. In many plants this trouble has attained serious proportions. At Cos Cob a 400-volt 8-hp General Electric induction motor is direct connected to a 110-volt direct current dynamo, and from the latter current is led to a regulator panel board at each condenser in the basement. Each condenser is provided with seven taps into which current is led at a potential of 4 or 5 volts in opposite direction to that of any probable electrolytic current to counteract the effect of the latter. The plant has, of course, not been in operation long enough for a final determination of the value of this apparatus, but it is expected that it will do away with the annoyance and expense of having to open up condensers frequently, plug defective tubes, and then replace them when enough have accumulated to interfere with the most successful performance of the outfit.

TURBINE OPERATION

At present two turbines are required in service between 5.30 and 9 a. m. and between 4 and 7 p. m. Galena turbine oil is used on the bearings, Galena valve oil on auxiliaries, and the same brand of crank case oil in the exciter and auxiliary engine crank cases. Control switches, emergency lights and signal lamps are supplied with current from a 55-cell storage battery at 110 volts.

In starting a turbine from the cold state the centrifugal circulating pump is first primed, and then started, to pass circulating water through the condenser. The turbine is warmed up by the admission of steam to the throttle valve and started up by being slowly turned over for ten minutes. It is then brought up to half speed; the atmospheric valve is closed, and the turbine exhausts into the condenser. It is brought up to full speed, full field is put on, and the machine synchronized at 11,000 volts. This takes about 15 minutes.

In starting a turbine which is warm, the turning over process is dispensed with, and in from 3 to 5 minutes the machine is ready for service.

In shutting down the "stand-by" signal is first given. The machine is cut off the line by the high-tension oil switch, the field excitation reduced and the field opened. The automatic stop valve which closes the throttle valve is then tripped, and after this the atmospheric valve is opened, breaking the vacuum. With an open field the turbine will run about 30 minutes.

The signal system in the Cos Cob plant represents the latest ideas in this branch of power-station operation. The usual red and green pilot lamps are in service to show the condition of high-tension switches. To facilitate communication with the floor from the switchboard gallery and vice-versa an illuminated transparency is installed in a central position on the gollery facing the floor. This contains space for each machine number, and the designations "stand-by," "in," "out" and "o.k." An emergency blank, and exciter numbers are also included. This is operated by switches on the main control board, and eliminates the possibility of mistake due to misinterpreting the sound of an audible signal. A whistle signal in the turbine room simply calls attention to the transparency and the work goes on from that point. Between the turbine-room floor and the pump-room in the basement below the signalling is done by two mechanical gongs and by speaking tubes, the former simply calling attention to the latter. The plant also has a private branch telephone exchange with instruments located in the chief engineer's office, switchboard gallery, boiler-room, turbine-room, coal tower, machine shop and the nearest anchor bridge. The switchboard operator is charged with the responsibility of following the load and putting machines in and out of service.

ORGANIZATION

A diagram of the preliminary organization at the Cos Cob power house is shown on page 609. Each shift is in immediate charge of a watch engineer. On the turbine-room floor are an assistant engineer and oiler on each shift, and in the pump room, a pump-man and oiler. The plant has one boiler-room engineer, and in his absence each shift is in charge of a water tender, under whom are one fireman for every 4 boilers, coal passers, a coal conveyor man and helper. The complete organization here has not yet been settled. The station has one chief electrician. Reporting to him are on each shift a switchboard operator, a tender or helper, assistant electrician (night service), and one repairman for the 24 hours.

PIPE COLORS

To facilitate the handling of piping the following colors have been adopted, and in the boiler, pump and turbine-rooms tabulations in actual colors are posted:

High pressure steam lines	White.
Holly drip system	Red.
Exhaust from auxiliary apparatus	Yellow.
Boiler feed	Black.
All other pipes except fire lines	Blue.
Fire protection system	Gray.
Blow-off piping	Maroon.
Air piping	Green.
Crank case oil piping	Light green.
Cylinder oil piping	Pink.
Turbine oil piping	Brass (not painted).

MACHINE SHOP

A small machine shop is installed at the Cos Cob station, and it contains the following tools, driven in group by a 15-hp motor:

2 lathes, 36-in. and 18-in.
1 planer, 24-in.
1 shaper, 16-in.
1 radial drill, 48-in.
1 speed drill.
1 pipe-cutting machine, 6-in.
1 emery grinder and stone.

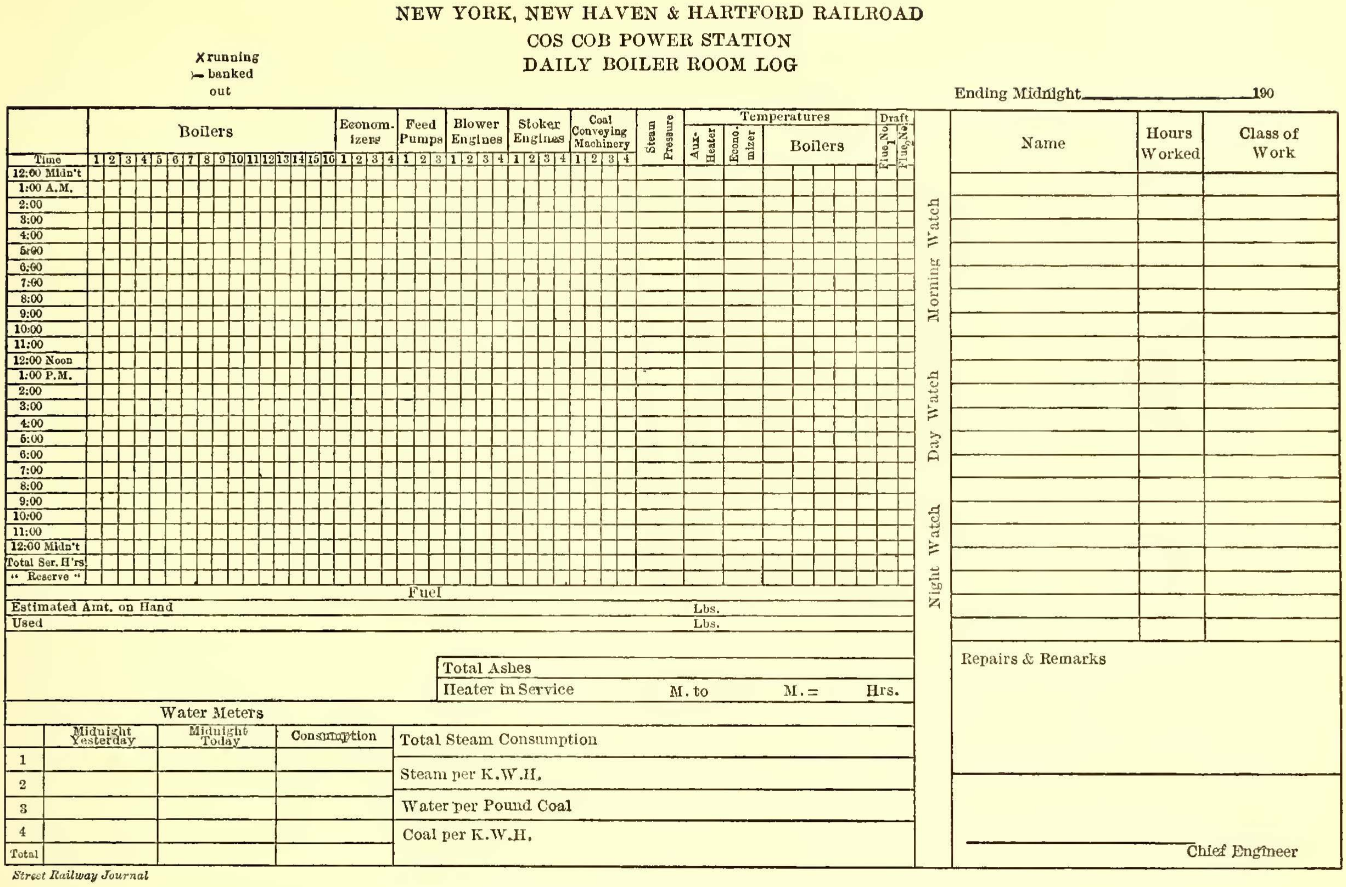
The turbine room is lighted by eleven 24-in. Cooper-Hewitt mercury vapor lamps and two large flaming arcs, which in combination produce a brilliant yet soft and pleasing illumination.

BLANKS AND FORMS

Several blank forms for station records have been drawn up in a tentative way, and are shown in the accompanying reproductions:

The daily engine-room log, original 17½ ins. x 11 ins., gives the important pressures and temperatures of each unit at each even hour of the twenty-four, as well as the attendance, hours of service, oil and waste consumption, inpection and repair accounts.

The daily boiler-room log, original 17½ ins. x 11 ins., gives the hours of service of each boiler, economizer, pumps,



NEW YORK, NEW HAVEN & HARTFORD RAILROAD
COS COB POWER STATION
DAILY BOILER ROOM LOG

X running
⟝ banked
out

Ending Midnight______________190

	Boilers																Econom-izers				Feed Pumps			Blower Engines				Stoker Engines				Coal Conveying Machinery				Steam Pressure	Temperatures						Draft	
Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	1	2	3	1	2	3	4	1	2	3	4	1	2	3	4		Aux-Heater	Econo-mizer	Boilers				Flue No 1	Flue No 2
12:00 Midn't																																												
1:00 A.M.																																												
2:00																																												
3:00																																												
4:00																																												
5:00																																												
6:00																																												
7:00																																												
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12:00 Noon																																												
1:00 P.M.																																												
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8:00																																												
9:00																																												
10:00																																												
11:00																																												
12:00 Midn't																																												
Total Ser. H'rs																																												
" Reserve "																																												

Fuel

Estimated Amt. on Hand Lbs.
Used Lbs.

Total Ashes
Heater in Service M. to M. = Hrs.

Water Meters

	Midnight Yesterday	Midnight Today	Consumption
1			
2			
3			
4			
Total			

Total Steam Consumption
Steam per K.W.H.
Water per Pound Coal
Coal per K.W.H.

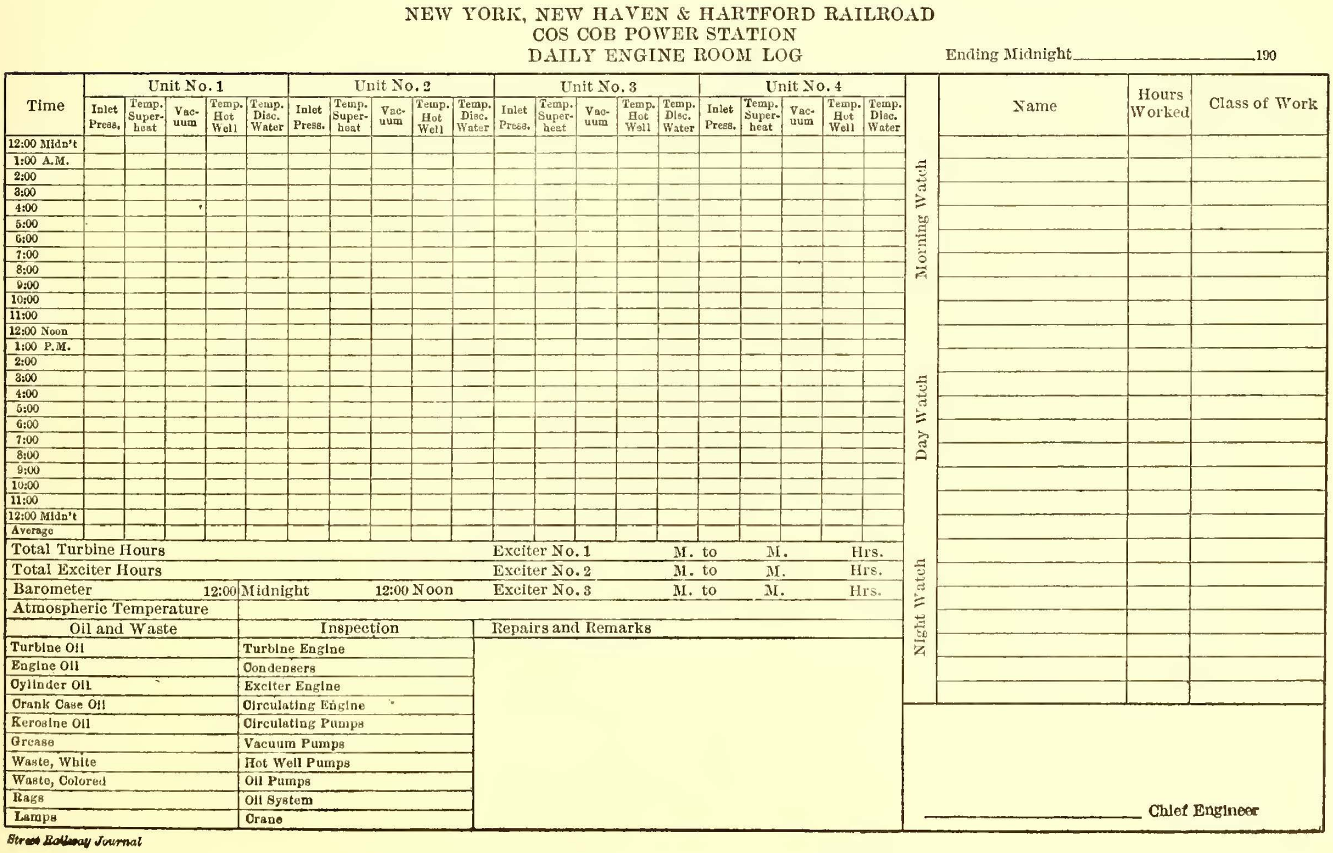
	Name	Hours Worked	Class of Work
Morning Watch			
Day Watch			
Night Watch			

Repairs & Remarks

____________ Chief Engineer

Street Railway Journal

DAILY BOILER ROOM LOG, COS COB POWER STATION



NEW YORK, NEW HAVEN & HARTFORD RAILROAD
COS COB POWER STATION
DAILY ENGINE ROOM LOG

Ending Midnight______________190

Time	Unit No. 1					Unit No. 2					Unit No. 3					Unit No. 4				
	Inlet Press.	Temp. Super-heat	Vac-uum	Temp. Hot Well	Temp. Disc. Water	Inlet Press.	Temp. Super-heat	Vac-uum	Temp. Hot Well	Temp. Disc. Water	Inlet Press.	Temp. Super-heat	Vac-uum	Temp. Hot Well	Temp. Disc. Water	Inlet Press.	Temp. Super-heat	Vac-uum	Temp. Hot Well	Temp. Disc. Water
12:00 Midn't																				
1:00 A.M.																				
2:00																				
3:00																				
4:00																				
5:00																				
6:00																				
7:00																				
8:00																				
9:00																				
10:00																				
11:00																				
12:00 Noon																				
1:00 P.M.																				
2:00																				
3:00																				
4:00																				
5:00																				
6:00																				
7:00																				
8:00																				
9:00																				
10:00																				
11:00																				
12:00 Midn't																				
Average																				

Total Turbine Hours Exciter No. 1 M. to M. Hrs.
Total Exciter Hours Exciter No. 2 M. to M. Hrs.
Barometer 12:00 Midnight 12:00 Noon Exciter No. 3 M. to M. Hrs.
Atmospheric Temperature

Oil and Waste	Inspection	Repairs and Remarks
Turbine Oil	Turbine Engine	
Engine Oil	Condensers	
Cylinder Oil	Exciter Engine	
Crank Case Oil	Circulating Engine	
Kerosine Oil	Circulating Pumps	
Grease	Vacuum Pumps	
Waste, White	Hot Well Pumps	
Waste, Colored	Oil Pumps	
Rags	Oil System	
Lamps	Crane	

	Name	Hours Worked	Class of Work
Morning Watch			
Day Watch			
Night Watch			

____________ Chief Engineer

Street Railway Journal

DAILY ENGINE ROOM LOG, COS COB POWER STATION blowers, stoker engines, and coal handling machinery, steam pressures, atendance, temperatures, voltmeter records and unit performance are planned for.

In the daily electrical log, original 11 ins. x 18 ins., spaces are provided for an hour to hour load curve, readings on different phases and meters, attendance, remarks and weather conditions.

The weekly comparison and efficiency report, original 8 ins. x 10½ ins., shows the labor, fuel, repairs, construction and material accounts in lots and per kw-hour for two compared weeks, with space for increase, decrease and percentage.

Another form provides for the distribution of charges for labor and material in a week in terms of the different equipment, for both operation and maintenance. The original is 8 ins. x 10½ ins.

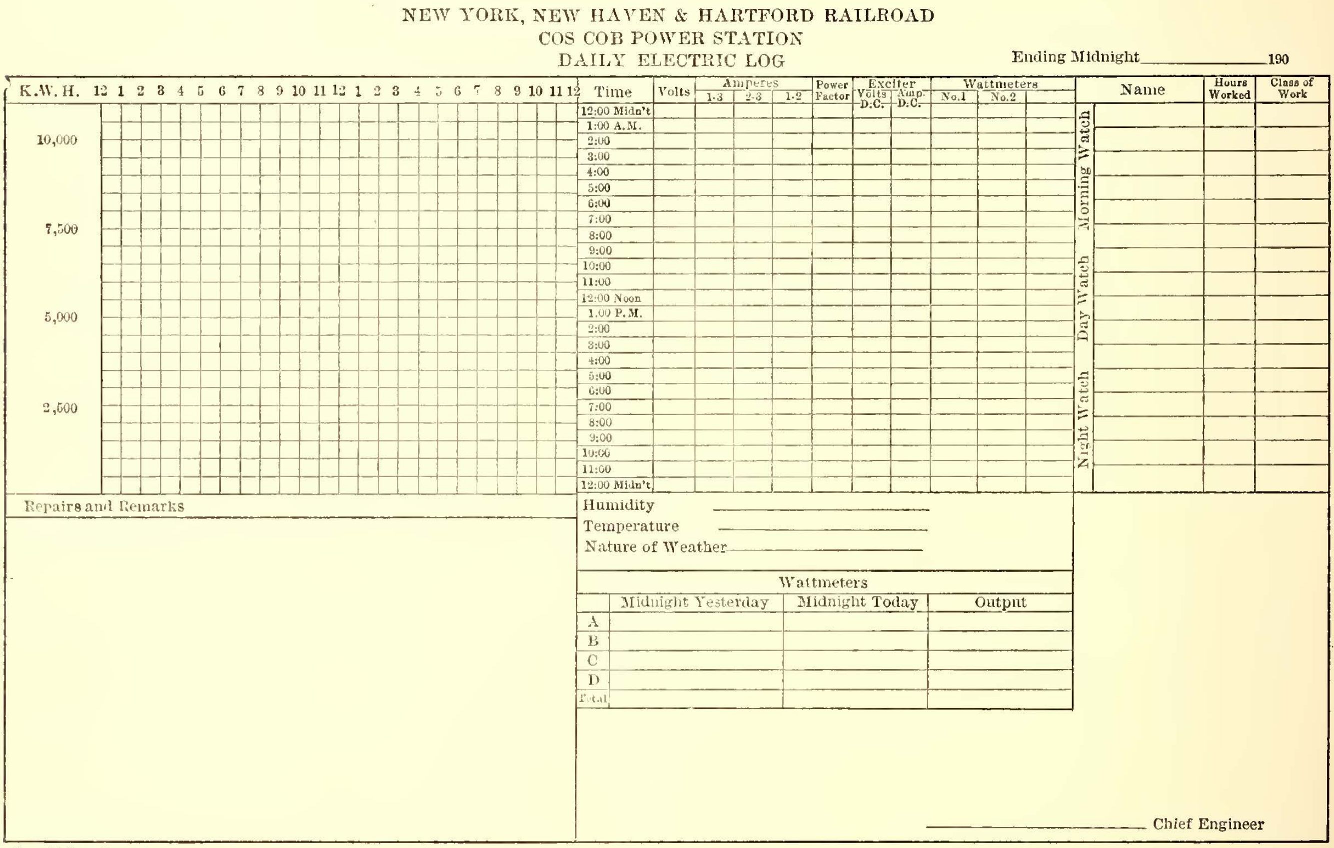
DISTRIBUTION SYSTEM

The distribution scheme of the New Haven electrical zone has been described in previous issues of the Street Railway Journal, as have the other essential physical features of the work. The arrangement of 11,000-volt circuits from the operating standpoint, however, has not been discussed to any extent. It partakes of the simplicity which characterizes the New Haven problem's solution in general, but allows for a flexibility in operation scarcely realized by those who have not made a personal study of the layout. Safety and continuity of service are the keynote of the treatment.

The diagram on page 613 shows the 11,000-volt trolley and auxiliary connections in detail between Stamford and Woodlawn. Between Woodlawn and the Grand Central Station the service is on the 660-volt third-rail operated tracks of the New York Central & Hudson River Railroad.

At each anchor bridge the four main line catenary trolley wires, No. 0000 B and S cross section, are carried through oil switches to a bus-bar looping around the bridge. Overhead trolley wires are given the same numbers as the main tracks beneath them; that is Line No. 1 is the line suspended over track No. 1, etc. Parallel to the trolley wires are four other wires carried along the sides of the roadbed for supplementary work. One pair of these lines are power wires, and the other pair, auxiliary lines. One power and one auxiliary line are carried along each side of the right of way. The auxiliary wire on each side is broken by a section insulator at every alternate anchor bridge, and the power wire on each side is tapped to a transformer primary at every alternate anchor bridge. At every anchor bridge the bridge-bus is supplied with 11,000-volt power through two auxiliary lines, the auxiliary connection being double, one branch passing through an oil switch to the auxiliary on one side of a section insulator, and similarly with the other branch, a connection is made through a switch to the auxiliary. There are two transformers at each anchor bridge with permanently alive primaries. These transformers supply power for bridge lighting, motor-driven signals in some cases, and for the remote control from the adjacent signal towers of the oil switches on the bridges. Two were provided to enable a reserve to be available.

Every cross-over is divided by one or more section insulators so that it will not interfere with the cutting out of either adjoining sections of track. No section of the line can be cut dead from a single tower or anchor bridge, but two adjacent towermen must co-operate in order to kill any section of trolley between two successive anchor bridges. Any section of trolley can be fed from either end of the section, and any section can be cut out over any corresponding track without interfering in the slightest degree with the supply of power to the other sections. Any given double tower section of auxiliary line can be killed by opening the necessary oil switches in the towers affected. If the power supply fails at one end it can



NEW YORK, NEW HAVEN & HARTFORD RAILROAD
COS COB POWER STATION
DAILY ELECTRIC LOG

Ending Midnight____________190

K.W.H. 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

10,000

7,500

5,000

2,500

Time	Volts	Amperes			Power Factor	Exciter		Wattmeters		
		1-3	2-3	1-2		Volts D.C.	Amp. D.C.	No.1	No.2	
12:00 Midn't										
1:00 A.M.										
2:00										
3:00										
4:00										
5:00										
6:00										
7:00										
8:00										
9:00										
10:00										
11:00										
12:00 Noon										
1.00 P.M.										
2:00										
3:00										
4:00										
5:00										
6:00										
7:00										
8:00										
9:00										
10:00										
11:00										
12:00 Midn't										

	Name	Hours Worked	Class of Work
Morning Watch			
Day Watch			
Night Watch			

Repairs and Remarks

Humidity ____________
Temperature ____________
Nature of Weather____________

Wattmeters

	Midnight Yesterday	Midnight Today	Output
A			
B			
C			
D			
Total			

____________ Chief Engineer

Street Railway Journal

DAILY ELECTRICAL LOG, COS COB POWER STATION

THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD COMPANY
COS COB POWER STATION

Weekly Comparison & Efficiency Report, week ending ____________________190

	Week Ending Date	Week Ending Date	Increase	Decrease	Per Cent
Operation					
Repairs					
Construction					
Total Cost of Labor					
Number of Men					
Cost of Fuel					
Cost of Fuel per Ton					
Tons Used					
Kinds of Coal					
K.W. per Hr. Output					
Lbs. Water per K.W.H.					
Lbs. of Water per Lbs. Coal					
Lbs. of Coal per K.W.H.					
Cost of Fuel per K.W.H.					
Cost of Labor per K.W.H.					
Total Cost Fuel Water Labor and Material used					
Total Cost per K.W.H.					
K.W. hours per man per week					

Remarks:

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Chief Engineer

Street Ry. Journal

WEEKLY COMPARISON AND EFFICIENCY REPORT

THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD COMPANY

COS COB POWER STATION, week ending ____________________190

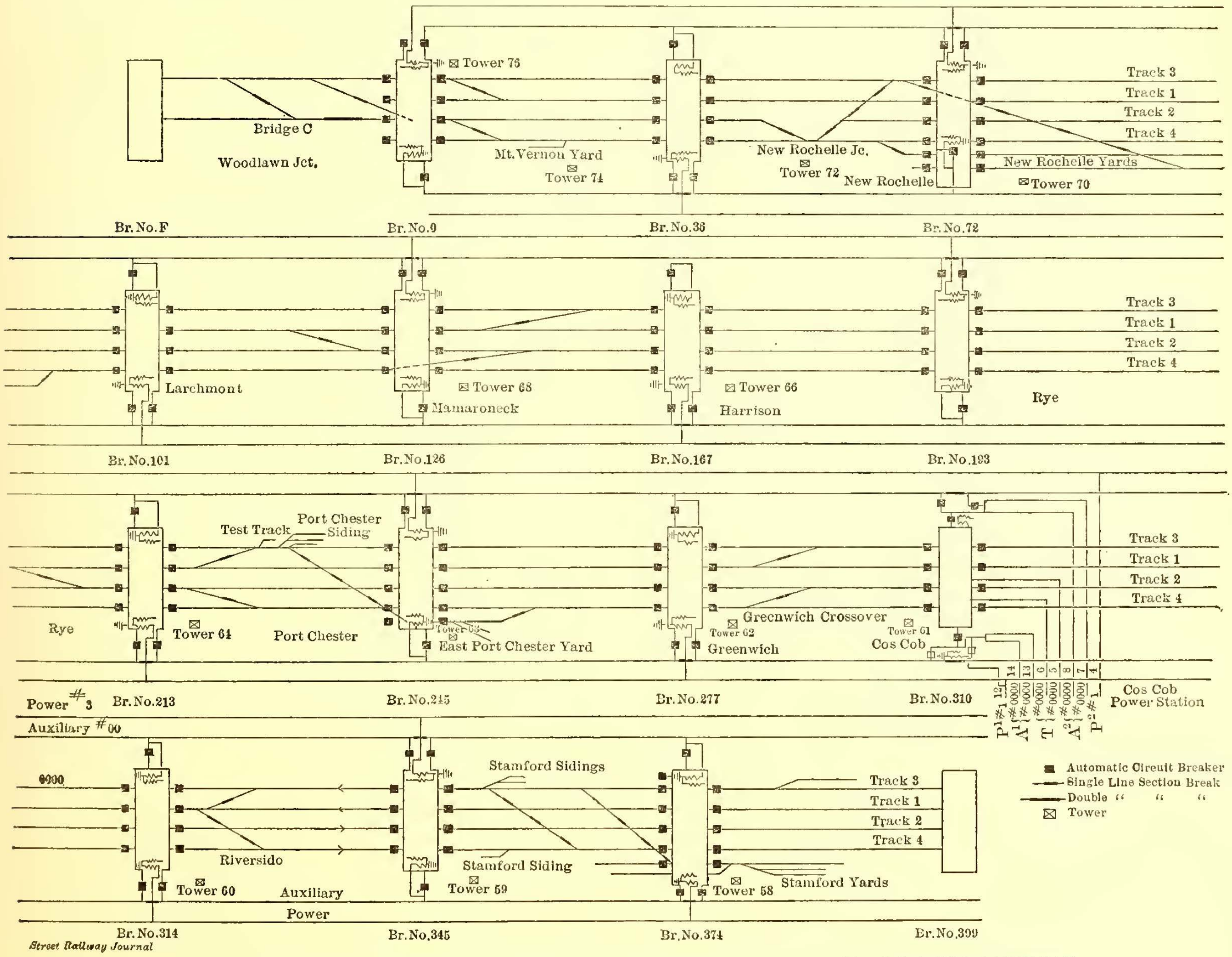
Distribution of Labor & Material:	Operation	Maintenance Labor	Material
Engineer, Oilers, Pumpmen			
Turbines & Exciter Engine			
Condenser & Pumps			
Fireman and Water Tenders			
Boilers			
Stokers			
Economizers			
Steam & Water Piping			
Coal & Ash Handling Machinery			
Switch Board Operation			
Generators & Exciters			
High Tension S.B. & Cables			
Low " " " "			
Static Transformers			
Storage Batteries			
Storage Batteries			
Motors			
Lamps & Small Wires			
Fuel Water Lubricants Waste Other Supplies & Expenses			
Total Expenses			

Remarks:

Street Ry. Journal

____
Chief Engineer

WEEKLY DISTRIBUTION OF LABOR AND MATERIAL



Street Railway Journal

DIAGRAM SHOWING TROLLEY AND FEEDER DISTRIBUTION SYSTEM, NEW HAVEN RAILROAD be had from the other, and if one side goes out of service, the other side is available for the supply of current. The combinations possible are easily apparent as the diagram is studied.

No definite dates have been set for the inspection of the catenary. Anchor bridges are inspected once in ten days. It has not been found necessary to inspect overhead trolleys at any definite period. Oil switches are inspected when the anchor bridge inspection is made. Gases from the steam locomotives have not caused any trouble. For overhead inspection and maintenance between Port Chester and Woodlawn six linemen and one oil switch inspector and helper are required. These are under the bridge supervisor, and are also subject to call for emergency work. An emergency train fully stocked with material is located at New Rochelle, and is held in readiness at all times for service.

EMERGENCIES

In case of a wreck in the electric zone, the conductor is required to proceed at once to the nearest tower, and advise the towerman as to the location, extent of wreck, tracks obstructed, wires affected, etc., and then to fill out the regular accident report, which is wired at once to the superintendent of the division. The towerman first opens the switches supplying power to his end of the affected section over tracks obstructed, and instructs the towerman in the tower next beyond the wreck to open the switches at the other end of the affected section, thus cutting off all power from the lines immediately over the wreck. The conductor remains at the tower until notified in writing by the towerman that power has been turned off the lines affected, and he then returns to the wreck and notifies all concerned that the power has been removed.

The superintendent notifies the electrical superintendent, the bridge supervisor, the electrical inspector, the road foreman of electric locomotives and the electrical emergency crew. The first duty of the emergency crew upon arriving at a wreck, is to ground the overhead wires from which power has been removed. In clearing wrecks great care has to be taken that the derrick boom does not come in contact with the overhead wires. After a wreck has been cleared and the overhead construction is in order, the last duty of the emergency crew is to remove these grounds and notify the towerman that the line is ready for operation. The rules for handling wrecks remain unchanged except as modified in the foregoing paragraphs to meet the requirements of the electric service. Every train will carry a telephone, and a complete telephone system will shortly be in service with a plug box at every third column in the catenary bridge construction. The emergency repair crew is located at New Rochelle, and live material is kept at both New Rochelle and Stamford.

The repair car used by the emergency crew is equipped with a small gasoline engine and generator set of sufficient capacity to operate the car at a low rate of speed independently of the overhead system. This insures the movement of the car to the scene of trouble, even though the normal operating current is entirely shut off. The advantages of such an arrangement are apparent.

MAINTENANCE

The maintenance work so far performed in the New Haven electric zone consists almost entirely of the light adjustments resulting from inspection of the equipment in partial service. As has been intimated before, the service at present given by electricity is too small a percentage of the service of the completed electric zone to produce normal conditions of wear. The inspection work has in itself not been standardized, and practically no repairs have as yet been necessary in connection with the electric locomotives. Some provision for inspection and repairs has of course been made, and this is touched upon in the following paragraph, though with the qualification that it does not necessarily represent permanent conditions and methods.

Electric locomotives are inspected upon their arrival in the Grand Central Station, New York, at the end of each round trip. Nothing like the full mileage possibilities of the locomotives is yet obtained in the limited service given. At the end of each 300 miles' run the locomotives are given an exhaustive inspection, the work taking place at New Rochelle or Port Chester. The inspection at the Grand Central takes a man and his helper about an hour. Thirty-five electric locomotives are now nearly in readiness for service in the New Haven electrical zone, one of these being at the Jamestown Exposition. New locomotives were shipped from Pittsburg by fast freight, and only minor adjustments and assembly were required before the machines were ready for service.

Practically no spare parts except fuses are carried upon the locomotives. Motormen make no repairs on the road. No trouble from excessive wear of third-rail shoes or pantograph trolleys has been experienced, and the overhead trolley shows no signs of wear as yet.

TEMPORARY SHOP

At Stamford a small temporary shop has been set apart for the maintenance of the electric locomotives. This is a wooden building with two inspection tracks and a pit with a short section of third track in the middle of the building. The shop is equipped with a 24,000-lb. radial cantilever hoist, and the following machine tools driven by a 47-hp 500-volt General Electric motor:

1 speed lathe,
2 engine lathes,
1 shaper,
2 vertical drills,
1 planer,
1 emery wheel grinder.

Spare armatures, facilities for bench work and racks for control storage battery cells are providtd. The general store room for line material is located close by.

TRAIN SERVICE

Eight cars per locomotive is the maximum number allowed before a second locomotive is brought into service on that specific train. Commercial service began July 24, 1907. Through trains are not as yet handled by electricity.

THE POWER STATION PRACTICE OF THE WEST JERSEY & SEASHORE RAILROAD

The West Jersey & Seashore Railroad was the first steam railroad whose adoption of electricity as a motive power was suggested by reasons other than, principally, to avoid the use of smoke-producing locomotives. The New York Central and the New York, New Haven & Hartford Railroads for that reason had been required by statute to install some other motive power than steam, and the Long Island Railroad, while not yet running its trains under the East River into New York, expects to do so during the next two years, so that its electrification was due largely to its future plans in this respect. With the West Jersey & Sea Shore, however, there was no requirement as to the reduction of smoke. Its electrification was due primarily to the desire upon the part of the owners of the property, the Pennsylvania Railroad Company, to give uniformly frequent and agreeable means of transportation for its local travel and also for its through travel between Philadelphia and Atlantic City, its great seashore resort, and at the same time to forestall possible competition.

The electrified section of this road was described in the Street Railway Journal Oct. 10, 1906, and a detailed account of its equipment will not be given here. The present series of articles is devoted to operation, but they require for their better understanding a brief description of the system.

The electrified lines consist of 64 miles of double track between Camden and Atlantic City and 10 miles of a line branching off from the main line at Newfield and extending to Millville. With the exception of the Millville branch and a short portion of the main line in the city of Camden the road is equipped with a third-rail. Power is generated in a turbine station at Westville about six miles out of Camden, and is fed to seven substations exclusive of the one in the power station. The road was electrified during the winter and spring of 1906 by the General Electric Company as contractors for the electrical equipment. As chief engineer of electric traction of the railroad company George Gibbs had general supervision of the work. The electrified lines are operated as a division of the West Jersey & Seashore Railroad, of which D. H. Lovell is superintendent. This road is in turn a subsidiary line of the Pennsylvania Railroad system. The operating electrical features of the road are in charge of an assistant electrical engineer, which position is held by C. B. Keiser.

POWER HOUSE OPERATING FEATURES

When the power house was built twelve Sterling boilers and three Curtis 2000-kw turbines were installed. Four boilers and one turbine have since been added to the station. The plant is not built strictly on the unit system, but each turbine has its own auxiliary apparatus, and in the event of accident the boilers may be cut off from each other to furnish steam to separate turbines.

Coal for operating the station is obtained from Cresson, Pa., and is delivered in hopper bottom cars. The coal shows the following analysis:

Fixed carbon	66.97	per cent
Volatile matter	19.67	"
Ash	12.26	"
Moisture	1.10	"
Total	100.00	per cent
Sulphur	3.37	"
B. T. U.	13497.	

It is known as E vein coal. Better grades have been tried, and there was a smaller consumption per kw-hour with these, but the difference in the price makes it more economical to use the lower grade. Coal is handled by a standard C. W. Hunt coal handling plant. A tower outside the building contains a hoisting engine crusher and hopper, and a steel bridge extends from the tower into the station and over the bunkers. After the cars are unloaded the coal is dropped into a concrete hopper between the track rails, from which it is passed through a gate and into a skip bucket. The bucket after being hoisted up the side of the tower is dumped into a crusher hopper at the top. After passing through the crusher the coal is caught in a hopper underneath the crusher and from this it is let into a gravity return car operating on the bridge, which car is automatically dumped over the bunkers at any predetermined point and returned to the tower.

Usually five men are required to operate the coal handling plant. Two are stationed in the car being unloaded, another loads the skip bucket and signals to the engineer at the top of the tower and another is required at the top of the tower to load the gravity car. About 50 tons per hour is the maximum capacity of the hoist.

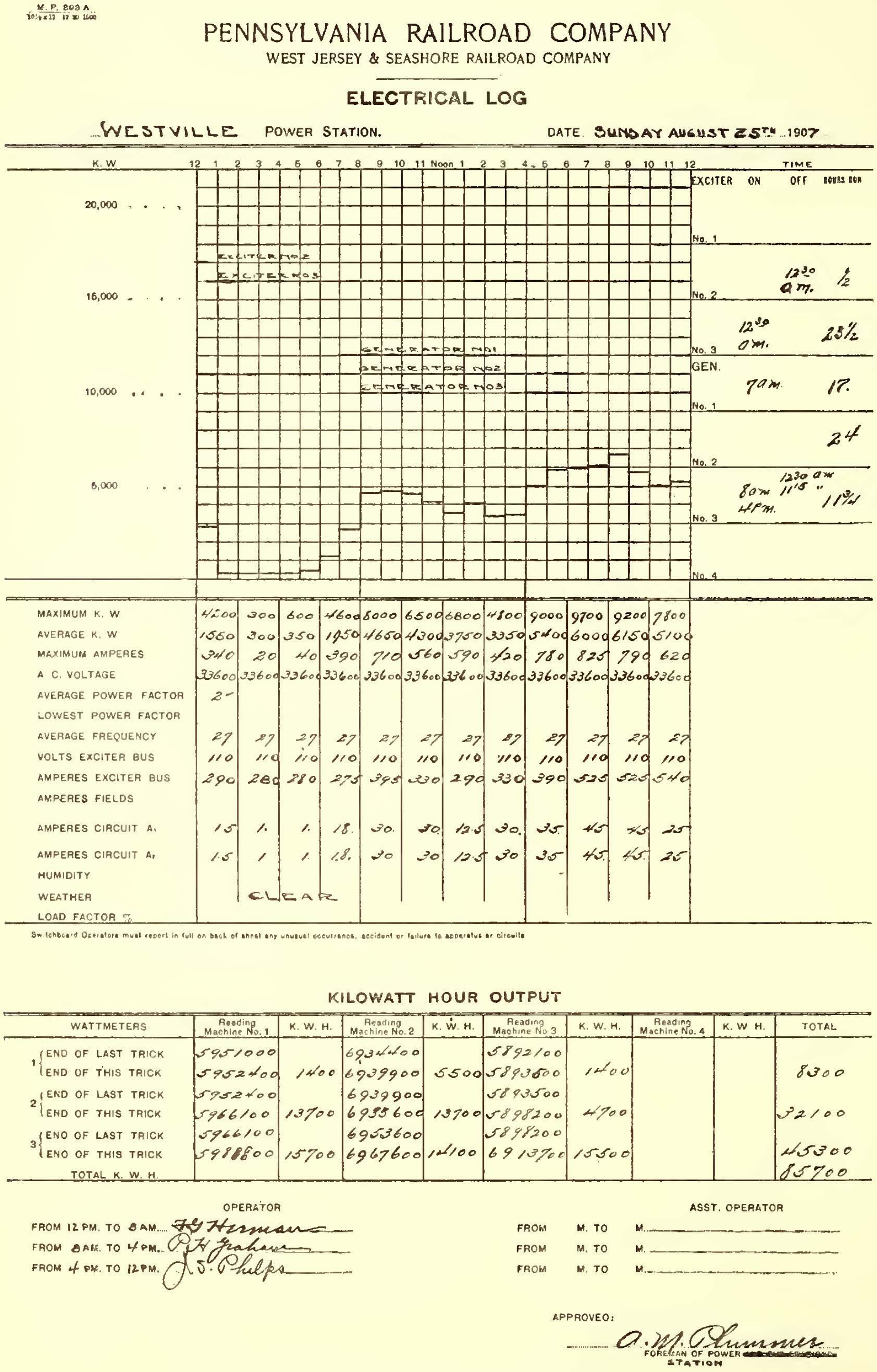
Ashes are loaded into cars on the boiler room floor and are then discharged into the skip bucket used to elevate the coal. From this bucket they are dumped into a bin in the coal handling tower under the crusher and when they accumulate the ashes are dropped into standard steam road cars.

The coal bunkers have a capacity for 400 tons, or about four days' supply of coal under conditions of operation during the summer season. The bunkers are usually kept well filled and in addition seven or eight loaded cars are kept on the siding. The frequency with which the coal in the bunkers is changed removes any danger of overheating in the bunkers and no trouble from fires has occurred. But in the event of a fire the coal could quickly be let down to the boiler room floors.

Coal tests and tests of other materials and supplies for the station are made in Altoona by the regular testing department of the Pennsylvania Railroad.

The four boilers recently installed are equipped with Roney stokers. The others are hand fired, but arrangements have been made to install stokers under all of the boilers. The number of boilers in service in the summer season varies from twelve during the day and evening to four in the early morning hours, when the others are "reserved." Under ordinary conditions boilers are never banked as it is believed that banking them for short periods necessitates a greater coal consumption than putting them in reserve. The fires get frequent cleanings during the day, but the grates are all cleaned out thoroughly after 11 o'clock at night. Draft regulation is obtained by means of hand regulated dampers in each boiler flue and a Spencer automatic damper in each stack uptake. Boilers in service have their individual dampers opened wide, and when reserved the damper is left open only enough to permit the gases to escape. At 50 per cent overload the draft in the boiler flues is about 0.8 ins. The auxiliary operator takes care of the boiler-feed pumps, which are provided with automatic regulators and a water tender regulates the feed to each boiler.

The soot is blown off the tubes about four times a week and the exterior parts are given a thorough cleaning once a month when the boilers are washed out and the interiors inspected. At this time a hydrostatic test is made at the working pressure. A turbine tube cleaner is used to remove scale from the tubes that cannot be removed by washing.



M. P. 893 A.

PENNSYLVANIA RAILROAD COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

ELECTRICAL LOG

WESTVILLE POWER STATION. DATE SUNDAY AUGUST 25TH 1907

TIME	ON	OFF	HOURS RUN
EXCITER No. 1			
No. 2		12 30 a m.	½
No. 3	12 30 a m.		23½
GEN. No. 1	7 a m.		17.
No. 2			24
No. 3	8 a m 4 P M.	12 30 a m 11 15 "	11¾
No. 4			

MAXIMUM K. W	4200	300	600	4600	8000	6500	6800	4800	9000	9700	9200	7800
AVERAGE K. W	1550	300	350	1950	4650	4300	3750	3350	5400	6000	6150	5100
MAXIMUM AMPERES	340	20	40	390	710	560	590	420	780	825	790	620
A. C. VOLTAGE	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600
AVERAGE POWER FACTOR	2-											
LOWEST POWER FACTOR												
AVERAGE FREQUENCY	27	27	27	27	27	27	27	27	27	27	27	27
VOLTS EXCITER BUS	110	110	110	110	110	110	110	110	110	110	110	110
AMPERES EXCITER BUS	290	280	280	275	395	330	290	330	390	525	525	540
AMPERES FIELDS												
AMPERES CIRCUIT A1	15	1.	1.	18.	30.	30	12.5	30.	35	45	45	25
AMPERES CIRCUIT A2	1.5	1	1.	1.8.	30	30	12.5	30	35	45.	45.	25
HUMIDITY												
WEATHER		CLEAR										
LOAD FACTOR %												

Switchboard Operators must report in full on back of sheet any unusual occurrence, accident or failure to apparatus or circuits

KILOWATT HOUR OUTPUT

WATTMETERS		Reading Machine No. 1	K. W. H.	Reading Machine No. 2	K. W. H.	Reading Machine No 3	K. W. H.	Reading Machine No. 4	K. W. H.	TOTAL
1	END OF LAST TRICK	5951000		6934400		5892100				
	END OF THIS TRICK	5952400	1400	6939900	5500	5893600	1400			8300
2	END OF LAST TRICK	5952400		6939900		5893500				
	END OF THIS TRICK	5966100	13700	6935600	13700	5898200	4700			32100
3	END OF LAST TRICK	5966100		6953600		5898200				
	END OF THIS TRICK	5988800	15700	6967600	14100	6913700	15500			45300
TOTAL K. W. H.										85700

OPERATOR
FROM 12 PM. TO 8 AM. F G Herman
FROM 8 AM. TO 4 PM. P H Graham
FROM 4 PM. TO 12 PM. J S. Phelps

ASST. OPERATOR
FROM M. TO M.
FROM M. TO M.
FROM M. TO M.

APPROVED:
A. M. Plummer
FOREMAN OF POWER STATION

ELECTRICAL LOG, WESTVILLE POWER STATION

The turbine condensers are of the barometric type and the boiler feed water is all taken from the condenser overflow flume. Analysis shows it to be entirely free from salt and comparatively free from scale-forming ingredients, so that no chemical treatment is required. The plant is not provided with economizers, and the water after passing through Cochrane heaters goes directly into the boilers. The feeding temperature is usually 212 degs. Gases pass from the flues at a temperature of approximately 500 degs. with full load on the boilers. No provision is made for obtaining a continuous record of the flue gas analysis, but analysis on a test gave the following results:

CO_2	9.10 per cent
O	9.54 "
CO	.36 "

AUXILIARY APPARATUS

The intake for the condenser water extends about 20 ft. into Big Timber Creek, a branch of the Delaware River, and terminates in a concrete well supplied with screens. Some slight trouble was caused by anchor ice last winter, but changes will be made before the coming season to prevent their recurrence. The screens are usually cleaned two or three times a week. During the fall and early winter, however, choking up with leaves sometimes necessitates their being scraped off as many times a day. The centrifugal pumps supplying the condensers can be started without priming except during periods of low water. It is customary, however, to start the dry vacuum pumps first, and let the vacuum in the condenser cause the water to rise into the centrifugal pumps. Other than at times when ice has interfered with the flow of water through the intake no trouble has been experienced with pumps losing their vacuum. Due to the purity of the condenser water there is no corrosion of the interior parts of the pumps. The vacuum carried in the condensers under ordinary conditions is about 28 ins.

OILING SYSTEMS

There are two separate oiling systems in use in the station. One is under 80 lbs. pressure and is used for the top bearings of the turbines and for other purposes. The other is under 600 lbs. pressure, at which it is maintained by an accumulator, and is for the step bearings of the turbines. For a time water was used on the step bearing, but in accordance with the policy of the turbine manufacturers, oil was recently substituted. Cooling coils are placed in a filter through which the oil passes before being pumped back into the pressure system. A good grade of engine oil is used on the bearings.

TURBINE PRACTICE

Practically no trouble has been experienced with the operation of the turbines and the maintenance cost has been exceedingly small. No provision is made for heavy repairs to the machines and the only extra parts carried in stock are a few governor and bearing parts. The throttle valves when closed permit very little leakage of steam. In fact, leakage is so small that in a few hours the turbines get cold enough to permit the men to work on them. It is, therefore, necessary to warm them up before starting. The load on the station is comparatively regular from day to day and the requirements can usually be anticipated so as to have machines warmed up and in readiness. Whenever there is to be any unusual movement of trains the power house is previously notified. The trainmaster notifies the assistant electrical engineer at Camden and the order is then sent to the power-station foreman who orders the necessary machines started.

To warm a turbine, the throttles are opened slightly about one-half hour before the machines are required. They are never started without first warming. In starting, the turbine is brought up to speed with the throttle opened one-fourth or half way. The excitation is then brought up so that when the machine is cut in it will be practically without load. After it has been cut in, the throttle is opened wide and the excitation is brought up until the machine takes its share of the load. About five minutes is required to get a turbine under load after it has been warmed. When the engineer is at the throttle he is in plain view of the switchboard operator, so that a simple signal system suffices to make the two men understand each other.

POWER-STATION FOREMAN

8 a. m. to 4 p. m.	7 a. m. to 6 p. m.	4 p. m. to 12 p. m.	12 p. m. to 8 a. m.		
Watch engineer	Boiler-room engineer, 10 hrs.	Watch engineer	Watch engineer		Storekeeper
Switchboard operator	Boiler cleaners, 10 “	Switchboard operator	Switchboard operator		Clerk
Auxiliary operator	Towerman, 10 “	Auxiliary operator	Auxiliary operator		
Turbine oiler	Conveyor man, 10 “	Turbine oiler	Turbine oiler		
Wiper	Helpers, 10 “	Wiper	Wiper	Machinist, 10 hrs.	
Water tender		Water tender	Water tender	Repairman (pipe fitter), 10 “	
Firemen		Firemen	Firemen	Blacksmith, 10 “	
Coal passers		Coal passers	Coal passers	Blacksmith helper, 10 “	
Cleaner, 10 hrs.				Bricklayer, 10 “	

ORGANIZATION CHART, WESTVILLE POWER STATION

When the station was first put in operation it was customary to start up other machines as the load came on, to avoid loading the turbines much above their rated capacity. Lately the practice has been to defer cutting in other machines until those in operation are considerably overloaded. In fact, machines are allowed to take peaks of half a minute duration of 75 per cent overload. On a test with 28 ins. vacuum, 175 lbs. steam pressure and 125 degs. superheat, the turbines required 18.3 lbs. of steam per kw-hour at full load. At 50 per cent overload the consumption was 18.12 lbs.

SWITCHBOARD AND ELECTRICAL APPARATUS

The switchboard is located on a gallery between the turbines and the transformers. The mechanism of the oil switches is gone over every two weeks, but the parts are inspected only after storms or blow-outs. Although periodic testing and adjustment of switchboard instruments has not yet been put into practice, the important instruments are tested whenever readings indicate that they are out of adjustment. The electrical machinery, including the air blast transformers, is blown out at frequent intervals by compressed air.

An adjacent building contains a machine shop in which the greater portion of the power house repairs are made. The equipment of machine tools consisting of lathes, shaper, drill presses and emery wheels, is driven by a motor. Another building contains a well-equipped blacksmith shop. The repair force consists of five men, a machinist, a pipe fitter, a blacksmith, blacksmith helper and bricklayer.

STORE-ROOM PRACTICE

Repair materials for the power house, sub-stations, third-rail and overhead lines are kept at Westville in a store room which is in charge of and handled by one man. A card system is employed to keep account of the material on hand. Each bin is provided with a tin card holder and whenever material is put in or withdrawn from the bin proper entry is made on the card. On the first of each month entry is made from the card on a stock record book, of the amount of the different kinds of material on hand. The stock record book shows about 2500 different classifications of material in the store room.

POWER-HOUSE ORGANIZATION

The watch engineer has entire charge of the station in the absence of the power-house foreman. The only electrical operator in the station is the one switchboard man, and he is directly under the watch engineer. The regular operating force work on eight-hour shifts; the repairmen, coal passers, boiler cleaners, the turbine-room cleaner and the men operating the coal-handling plant, however, work ten hours. As the coal-handling plant is operated only about five hours per day the men operating it are employed the remainder of their time in cleaning the intake screens, assisting in boiler cleaning and in doing work of a miscellaneous character about the power house. The number of firemen varies considerably at different seasons of the year, being heaviest during July and August. There is usually one man to two boilers, and a total of fifteen men is usually required in the heaviest season, there being six on the day watch, six on the night watch and three on the early morning watch. The clerk and the store keeper divide their time between the power station and the sub-station and third-rail departments. The repair force is also called upon from time to time to do considerable work for the sub-stations and the third-rail repair men.

THE DISTRIBUTION AND SUB-STATION SYSTEM OF THE WEST JERSEY & SEASHORE RAILROAD

The high-tension transmission system of the West Jersey & Seashore Railroad reaches eight sub stations. One of these, however, supplies current to the Atlantic City and Shore Line with which this article is not concerned. The high-tension lines, which are in duplicate throughout, are carried on 45-ft. poles, spaced 125 ft. apart, with the six wires disposed in inverted triangles on two cross arms 12-ft. and 8-ft. 6-in. long respectively. The insulators are 42 ins. apart, and the transformers are Y-connected with the neutral point grounded. The lines are protected by a ground wire of 5/16-in. galvanized steel cable stapled to the top of the pole. Both lines are installed in sections extending between sub-stations, which sections terminate at the sub-station bus-switches, with cutting through and disconnecting switches arranged so that either line may be made continuous throughout its length and may be used to feed any or all of the sub-stations. This arrangement makes it possible to dispense with a section of either line between sub-stations without interfering with the operation of the road. In the event of a short circuit the affected section may be cut out and all the current for the sub-stations beyond the point of trouble may be carried the distance between the two sub-stations on one line. At the sub-station just beyond the short circuit the current may be divided at the bus-bars between the two lines continuing from this sub-station.

For convenience in operation the different sections of the lines are distinguished by letters and numbers. Between the Camden and Glasboro stations, for example, the sections are designated A_1 and A_2. Succeeding sections are termed B_1 and B_2, C_1 and C_2.

The sub-stations are all built with a view of their being operated by one man. All of the apparatus and the switchboard is installed on one floor. The lighting arresters and other high-tension apparatus are in a separate room.

The following stations each contain two 750 and one 1000-kw rotaries: South Camden, Westville, Glassboro, Newfield and Atlantic City.

Reega contains two 750-kw rotaries, Mizpah two 500-kw rotaries, while Clayville contains two 500 and one 1000-kw machines. The machines are connected for starting from the a. c. side through low voltage taps brought out from the transformer. The transformers are of the air-cooled type.

SUB-STATION OPERATING FORCE

The sub-station operating force (Westville excepted) consists of two men at each station, one extra operator and one repairman. The sub-station men work alternately; one-half of the month day-time and the other half night-time. They are relieved by the extra operator who goes about from station to station, thus enabling the shift to be made without necessity of the men working overtime. On the first of the month the extra operator takes the day shift at the South Camden sub-station; the former day man follows him at night and the former night man goes on the following day. As a result each man gets 24 hours off from the time he leaves duty to the time he reports. The extra operator works in succession at each of the other sub-stations, reporting again at South Camden on the 8th of the month, relieving the day operator. Each day operator at the other stations is relieved in a similar manner. A change of shift is again made at the South Camden sub-station on the 16th, and the day operator is relieved on the 24th. The extra operator has the 15th, 30th and 31st of the month off. The extra man is not required to do cleaning about the sub-stations, but acts rather as an inspector, making daily report to the electrical supervisor of the condition of the station apparatus, and any suggestions which he may see fit to make regarding the operation of the station. This position is held by a college graduate or technical man, and is a training course to fit himself for responsible positions should the electrification of the lines be continued by the company. After the extra operator has received thorough training in the operation of sub-stations, he is given work at the power station, after which he is transferred to the Engineering Department.

TESTING-OUT APPARATUS

As all of the oil switches and other apparatus are in use almost every day, they are not operated at any stated periods simply to see that they are in order. Instruments are tested only when there are indications that they are out of adjustment. As the voltmeters in all the sub-stations are kept at 650 volts, instruments out of adjustment to an appreciable amount would be evidenced by one station feeding back into another.

CARE OF APPARATUS

Sub-station operators are required to care for all the apparatus, and are held responsible for the general condition of their station. The rotaries are blown out at frequent intervals and the transformers are blown out every two weeks. The bearings of the rotary converters are drained and washed once a month. Each sub-station is provided with a 40-gal. Liberty filter, through which the oil is cleansed. The commutators are cleaned with cheese cloth and gasoline at frequent intervals. Ordinary dynamo oil is applied to the commutator several times a day with a piece of oil-soaked cloth on the end of a stick. The alternating current brushes are removed from the holders at frequent intervals and are washed in gasoline.

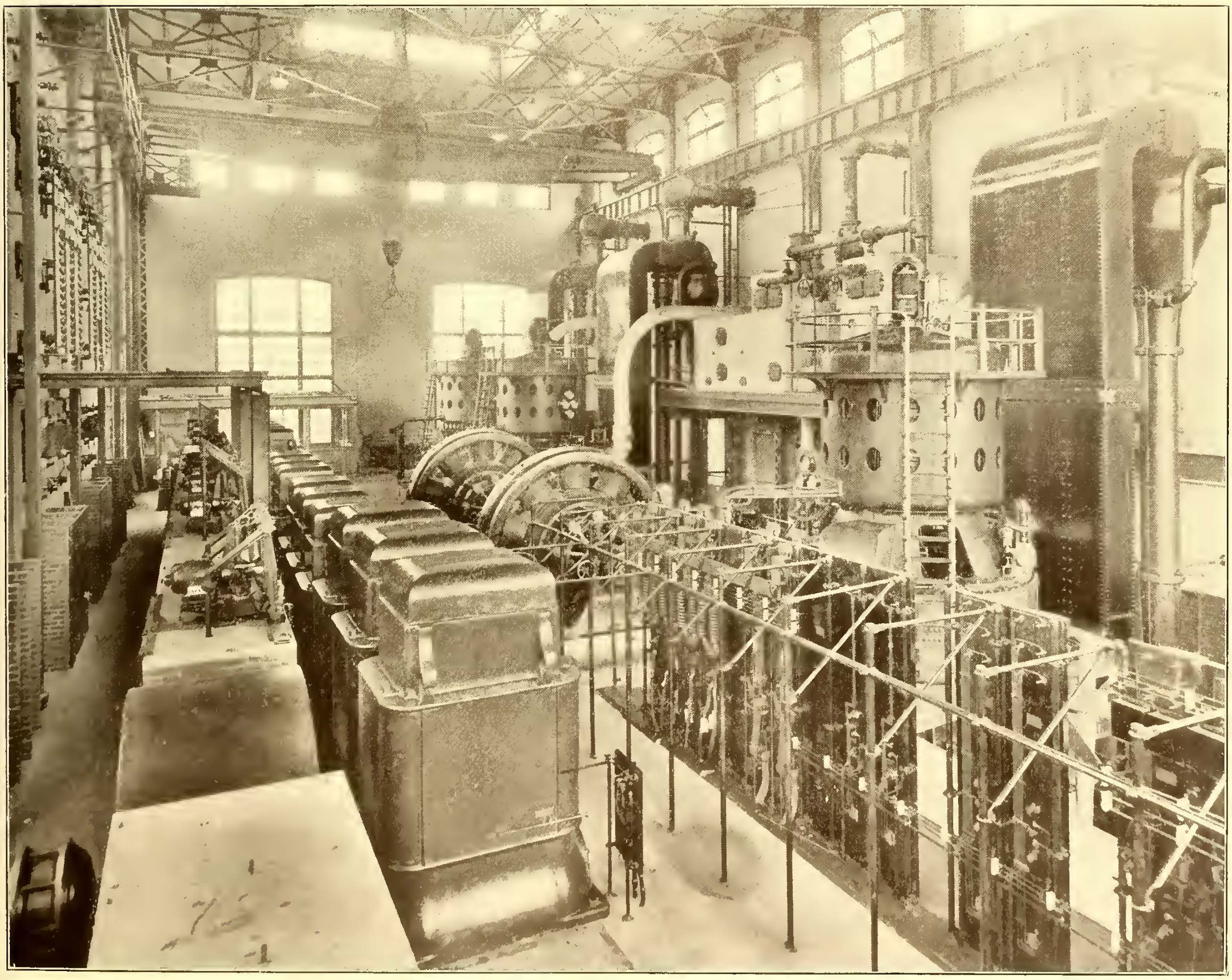
The rotary converters are always started as induction motors from the a. c. side. When the machine comes up with polarity reversed the commutating switch in the field circuit is used to reverse the fields. The rotary converters are built to stand overloads of 100 per cent, and it is the practice to allow the peaks to rise to this amount on one machine before another is cut in.

Readings of the sub-station wattmeters are taken every hour. These readings and other matters relating to operation are entered on sub-station log sheets, one of which serves over a twenty-four-hour period. In addition to entering the opening of automatic circuit breakers on the log sheet the sub-station operator notifies the power station operator by telephone as soon as a breaker has been put in. Whenever for any reason current is cut off the high-tension lines at the power house the sub-station operators are given one minute to clear their boards. In the meantime the power house operator is clearing his own sub-station board. When the high-tension lines are cut in again the men are instructed to get their machines in as quickly as possible. With the high-tension lines dead current has been gotten on the third-rail from all of the sub-stations in three minutes.

STORAGE BATTERIES AND PORTABLE SUB-STATIONS

There are no storage batteries in connection with the system, and as there is very little shifting of load over the system no portable sub-stations are provided.

MAIN TERMINAL STATION FOR ELECTRIC CARS OF THE WEST JERSEY & SEASHORE RAILROAD, TENNESSEE AVENUE, ATLANTIC CITY

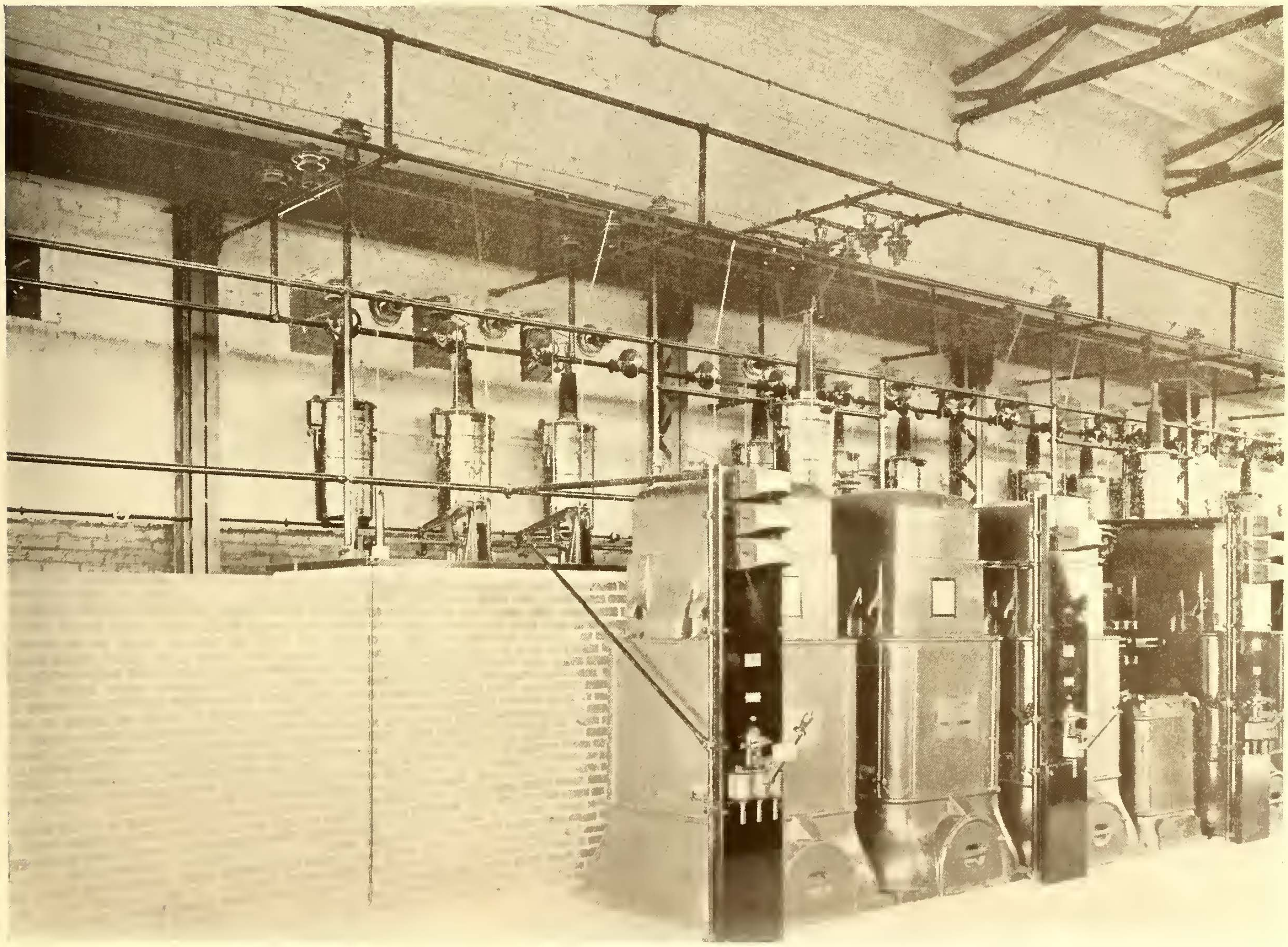


INTERIOR OF TURBINE ROOM, WESTVILLE POWER STATION, WEST JERSEY & SEASHORE RAILROAD

ATLANTIC CITY MEADOWS, LOOKING TOWARD ATLANTIC CITY SUBSTATION, WEST JERSEY & SEASHORE RAILROAD

END OF THIRD-RAIL ON TRESTLE AT CAMDEN AND BEGINNING OF TROLLEY, WEST JERSEY & SEASHORE RAILROAD

APPROACH TO SOMERS POINT LINE TRESTLE WORK, ATLANTIC CITY MEADOWS, WEST JERSEY & SEASHORE RAILROAD



HIGH TENSION WIRING, NEWFIELD SUBSTATION, WEST JERSEY & SEASHORE RAILROAD

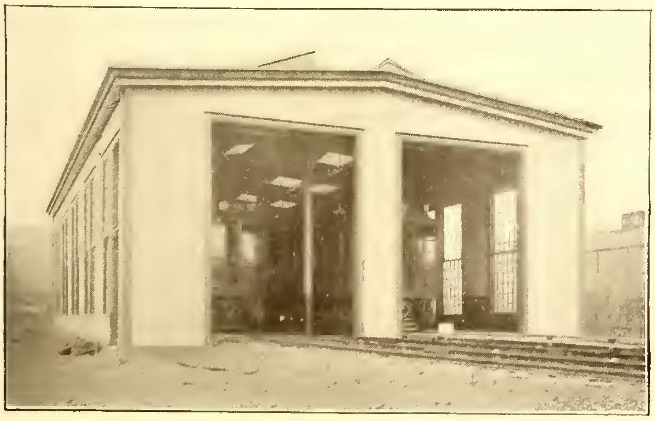
Plate XL

INTERIOR OF ATLANTIC CITY SUB-STATION, WEST JERSEY & SEASHORE RAILROAD

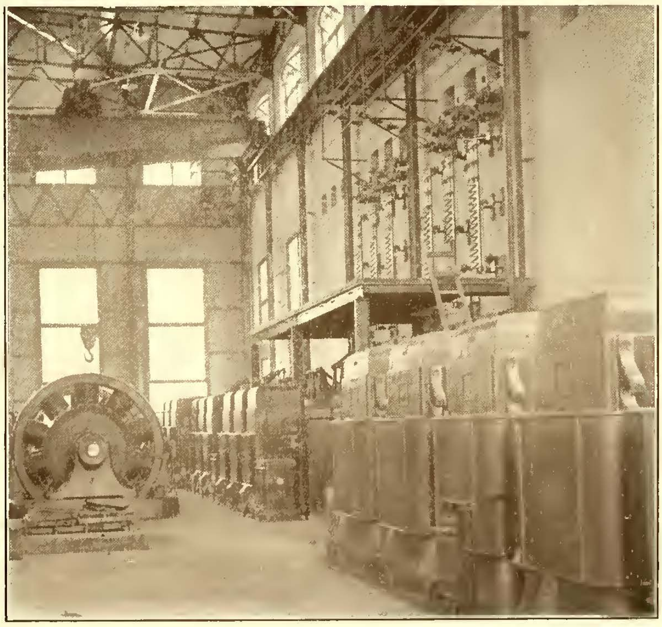
SECTION OF TRACK NEAR MIZPAH, N. J., SHOWING THIRD-RAIL AND TRANSMISSION LINE OF THE WEST JERSEY & SEASHORE RAILROAD

EXTERIOR
OF
NEWFIELD
SUBSTATION,
WEST JERSEY & SEASHORE
RAILROAD

EXTERIOR
OF
GLASBORO
SUBSTATION,
WEST JERSEY & SEASHORE
RAILROAD



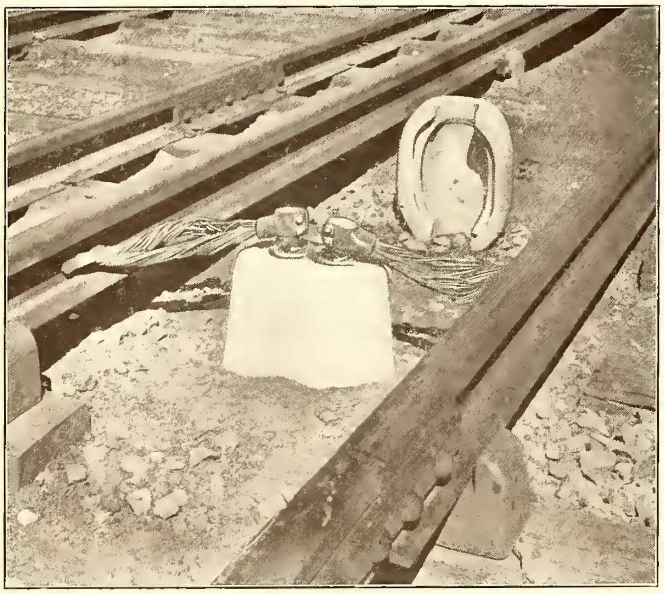
INSPECTION SHED AT ATLANTIC CITY



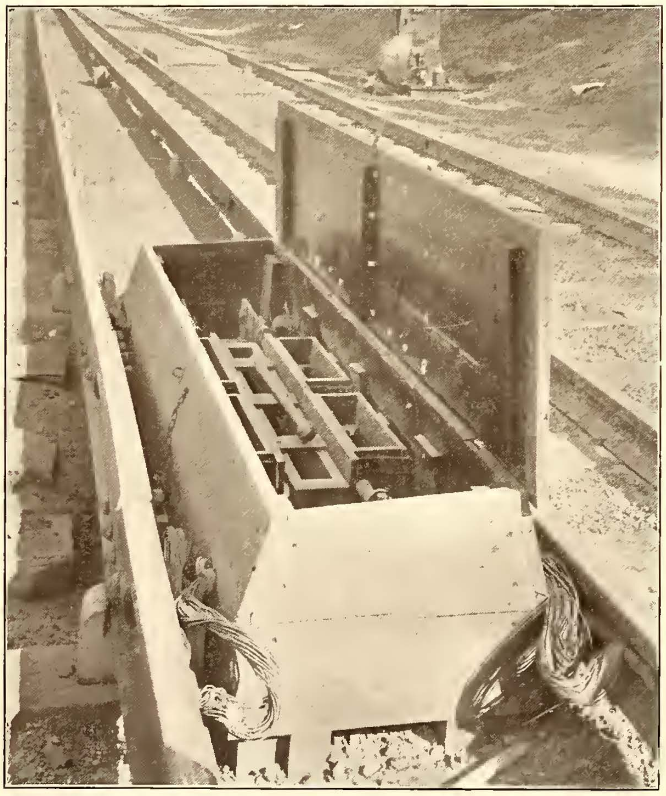
TRANSFORMERS AND LIGHTING ARRESTERS, WESTVILLE

SINGLE THIRD-RAIL JUMPER

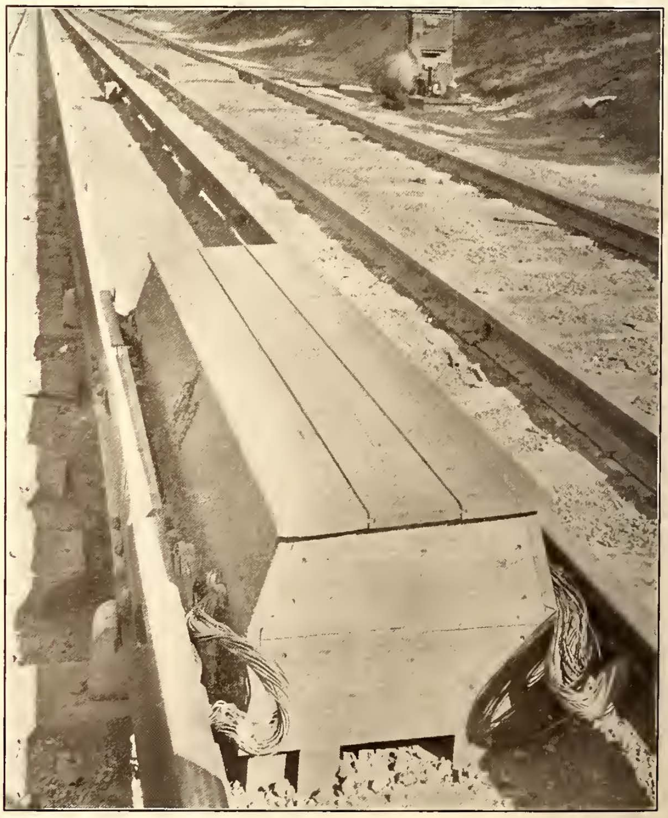
MOTOR CAR TRAIN



DOUBLE THIRD-RAIL JUMPER, WITH COVER REMOVED



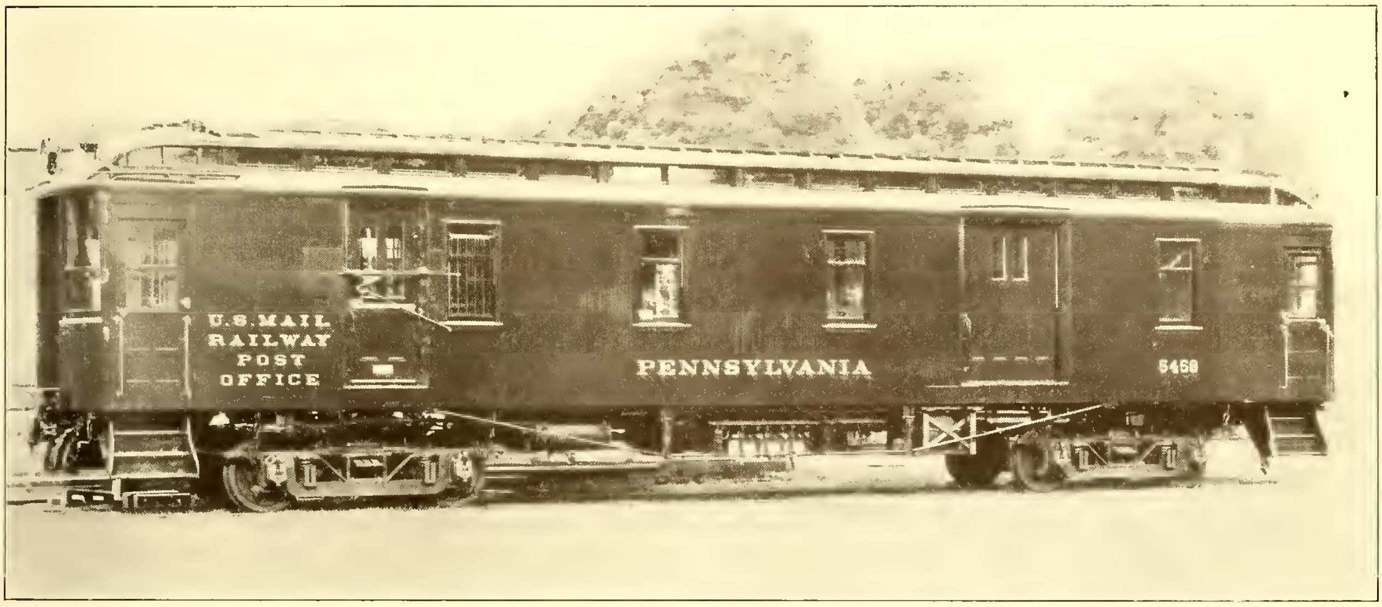
THIRD-RAIL SECTION FUSE BOX, OPEN, WEST JERSEY & SEASHORE RAILROAD



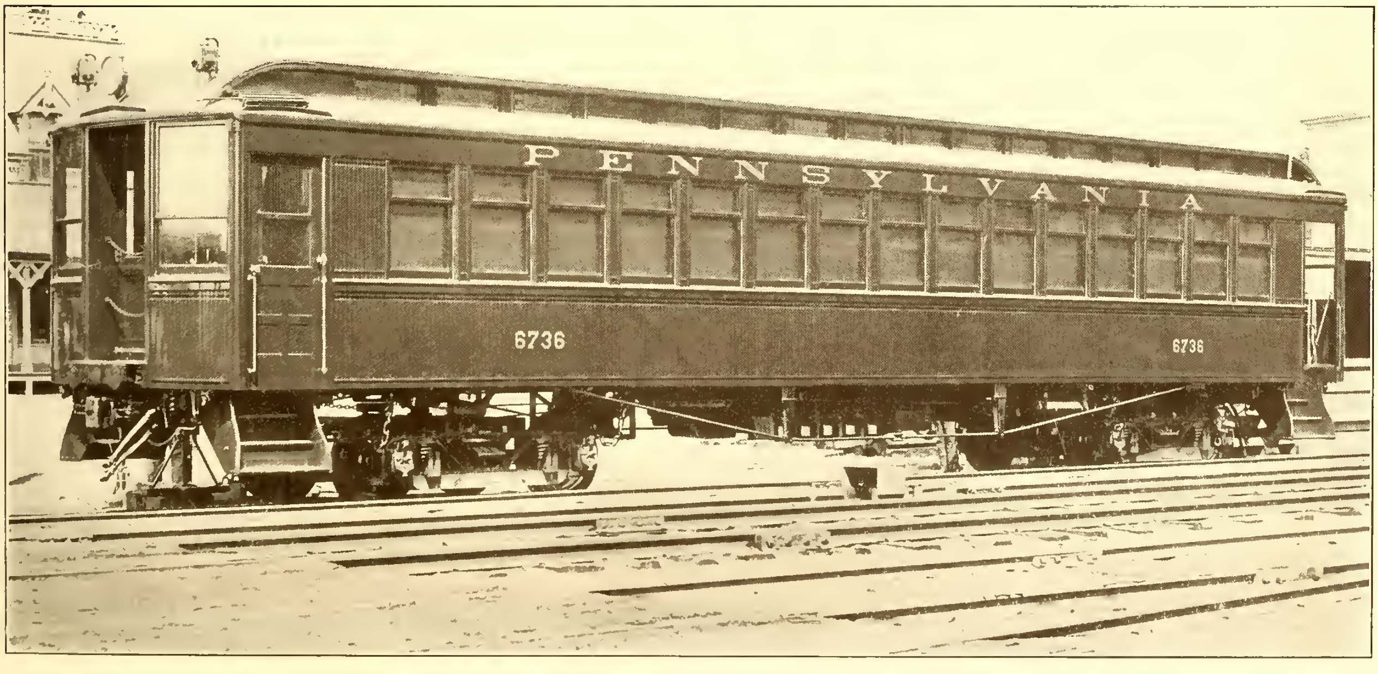
THIRD-RAIL SECTION FUSE BOX, CLOSED, WEST JERSEY & SEASHORE RAILROAD

LIGHTNING ARRESTER ROOM, NEWFIELD SUBSTATION

INTERIOR OF MOTOR CAR

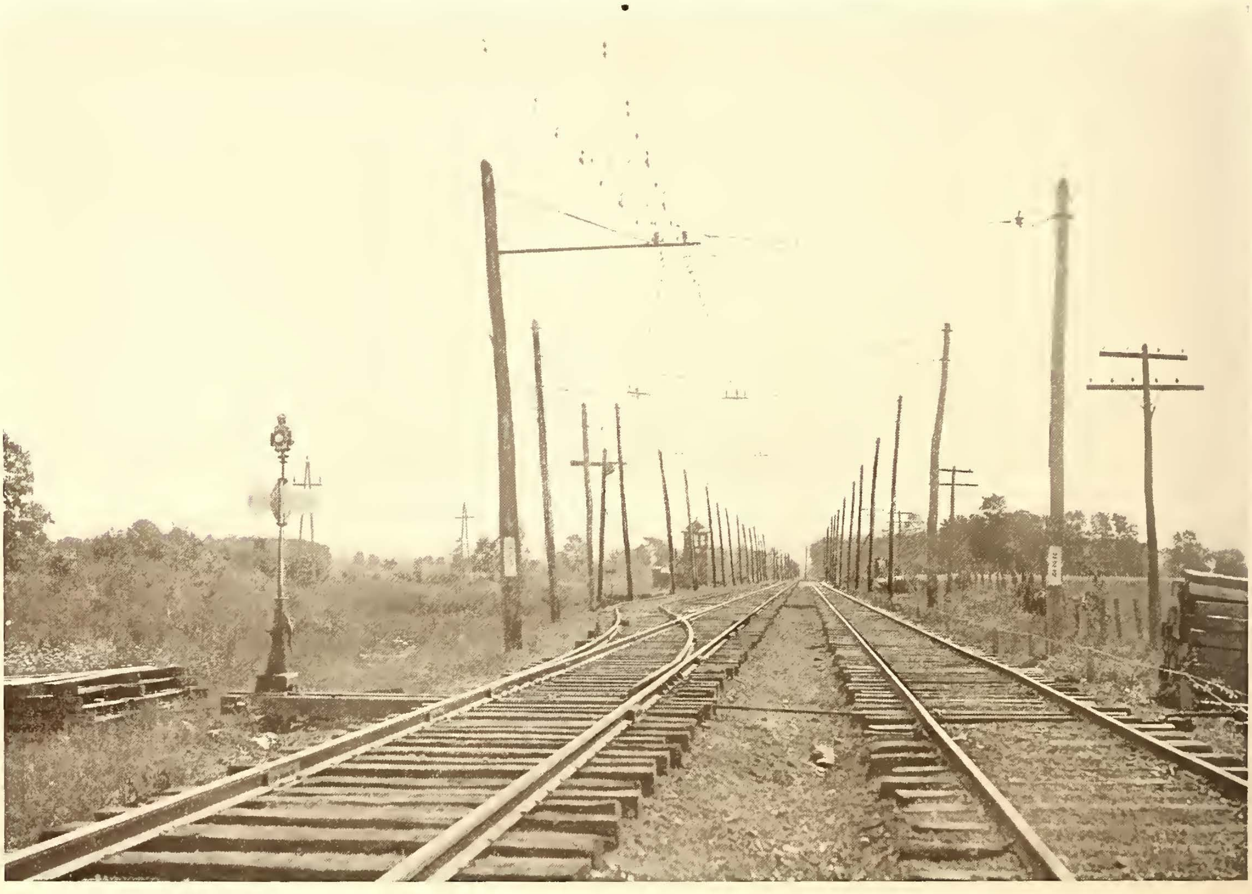


STANDARD BAGGAGE AND MAIL CAR, WEST JERSEY & SEASHORE RAILROAD



STANDARD PASSENGER MOTOR CAR, WEST JERSEY & SEASHORE RAILROAD

TERMINAL YARD AT ROCHESTER OF THE ELECTRIFIED DIVISION OF THE ERIE RAILROAD



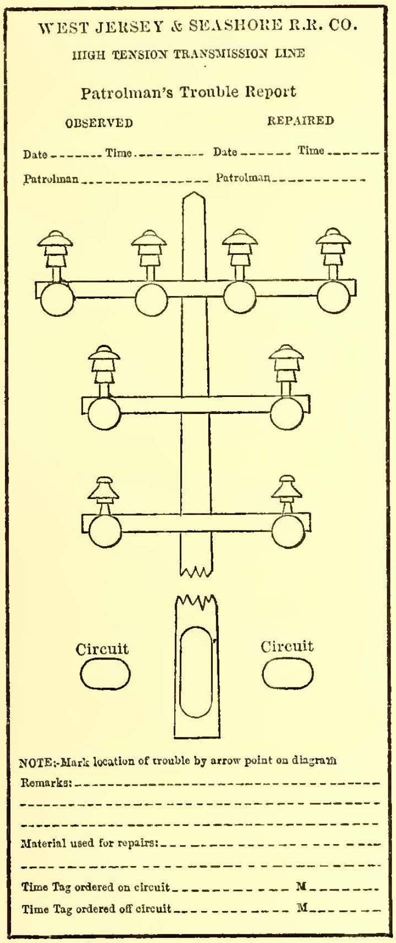
SIDING AT MORTIMER, ERIE RAILROAD, SHOWING OVERHEAD CONSTRUCTION, SWITCH TOWER, SIGNAL AND SWITCH LOCK

SYSTEM OF CURRENT SUPPLY

With the exception of about 4 miles, the main line is equipped with third-rail. The third-rail insulators are placed 8 ft. apart, and the rail is bonded with concealed ribbon compressed terminal bonds, two of 500,000-circ. mil capacity being used per joint. Third-rail protection is used only in yards and at stations and on a short strip near Camden. The branch to Millville, 10 miles long, and a stretch about 4 miles long near Camden are equipped with an overhead trolley. The transmission line, sub-station and third-rail maintenance and operation are in charge of the electrical supervisor who reports to the assistant electrical engineer. The department has its headquarters and store rooms at the power station.

INSPECTION OF THIRD-RAIL, TROLLEY AND TRANSMISSION LINES

To look after the third-rail, overhead trolley and high-tension transmission lines there are one foreman and eleven men, seven of which patrol the 74 miles of electrified track between Camden, Millville and Atlantic City. The other three consist of two first-class linemen and one third-rail repairman, who assist in making heavy repairs and changes and in installing new work. The patrolmen are divided into two classes; namely, first and second. The first-class men are in reality linemen, who make repairs on the 1100-volt signal line and 33,000-volt high-tension line, which are necessarily in service twenty-four hours a day, while the second-class men are used to assist



WEST JERSEY & SEASHORE R.R. CO.
HIGH TENSION TRANSMISSION LINE

Patrolman's Trouble Report

OBSERVED REPAIRED

Date ------- Time --------- Date ------ Time ------

Patrolman ---------------- Patrolman -----------

NOTE:-Mark location of trouble by arrow point on diagram

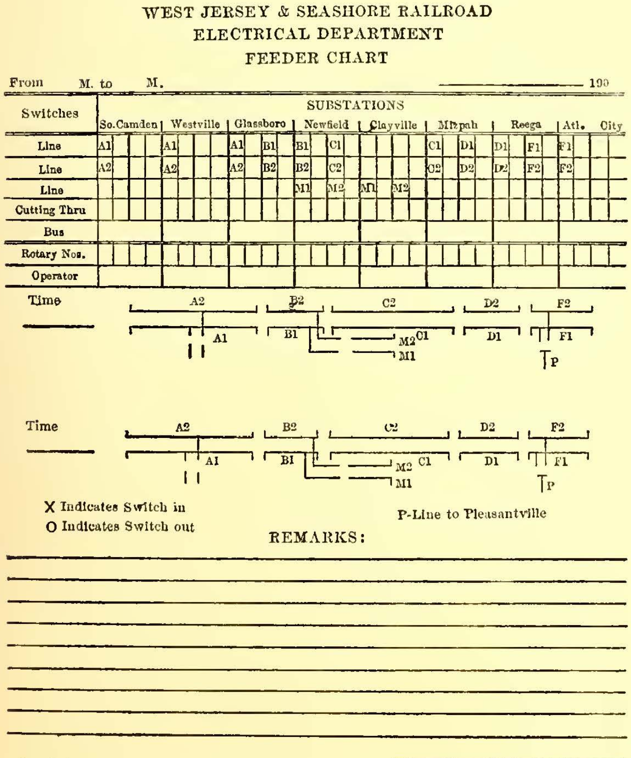
Remarks: ---------------------------------

Material used for repairs: ----------------------

Time Tag ordered on circuit ------------ M --------

Time Tag ordered off circuit ------------ M --------

Street Railway Journal



WEST JERSEY & SEASHORE RAILROAD
ELECTRICAL DEPARTMENT
FEEDER CHART

From M. to M. ------------ 190

Switches	SUBSTATIONS So.Camden	Westville	Glassboro	Newfield	Clayville	Mizpah	Reega	Atl. City
Line	A1	A1	A1 B1	B1 C1		C1 D1	D1 F1	F1
Line	A2	A2	A2 B2	B2 C2		C2 D2	D2 F2	F2
Line				M1 M2	M1 M2			
Cutting Thru								
Bus								
Rotary Nos.								
Operator								

Time ------

Time ------

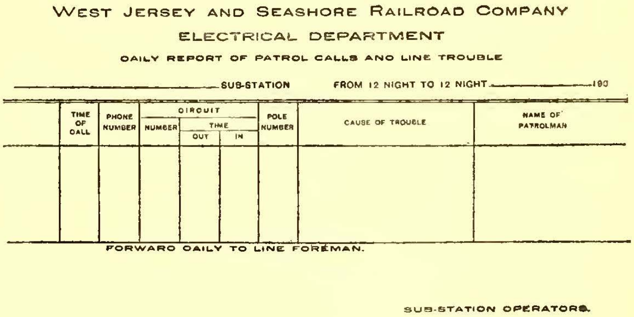
X Indicates Switch in
O Indicates Switch out

P-Line to Pleasantville

REMARKS:

------------ Switchboard Operator

Street Railway Journal



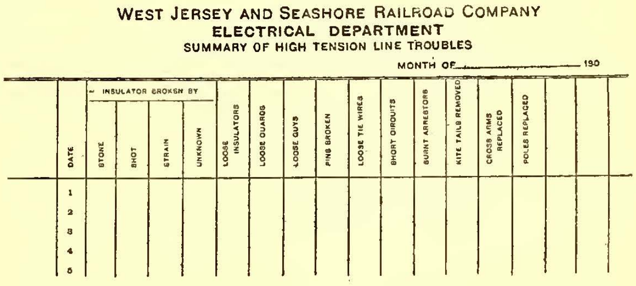
WEST JERSEY AND SEASHORE RAILROAD COMPANY
ELECTRICAL DEPARTMENT
DAILY REPORT OF PATROL CALLS AND LINE TROUBLE

------------ SUB-STATION FROM 12 NIGHT TO 12 NIGHT ------------ 190

	TIME OF CALL	PHONE NUMBER	CIRCUIT NUMBER	CIRCUIT TIME OUT	CIRCUIT TIME IN	POLE NUMBER	CAUSE OF TROUBLE	NAME OF PATROLMAN

FORWARD DAILY TO LINE FOREMAN.

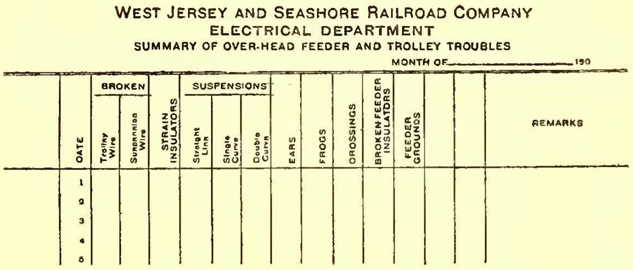
SUB-STATION OPERATORS.



WEST JERSEY AND SEASHORE RAILROAD COMPANY
ELECTRICAL DEPARTMENT
SUMMARY OF HIGH TENSION LINE TROUBLES

MONTH OF ------------ 190

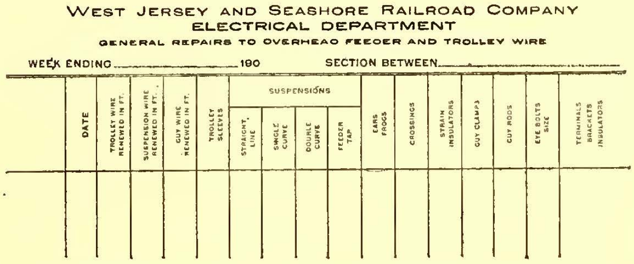
	DATE	INSULATOR BROKEN BY STONE	SHOT	STRAIN	UNKNOWN	LOOSE INSULATORS	LOOSE GUARDS	LOOSE GUYS	PINS BROKEN	LOOSE TIE WIRES	SHORT CIRCUITS	BURNT ARRESTORS	KITE TAILS REMOVED	CROSS ARMS REPLACED	POLES REPLACED			
	1																	
	2																	
	3																	
	4																	
	5																	



WEST JERSEY AND SEASHORE RAILROAD COMPANY
ELECTRICAL DEPARTMENT
SUMMARY OF OVER-HEAD FEEDER AND TROLLEY TROUBLES

MONTH OF ------------ 190

	DATE	BROKEN Trolley Wire	BROKEN Suspension Wire	STRAIN INSULATORS	SUSPENSIONS Straight Line	SUSPENSIONS Single Curve	SUSPENSIONS Double Curve	EARS	FROGS	CROSSINGS	BROKEN FEEDER INSULATORS	FEEDER GROUNDS			REMARKS
	1														
	2														
	3														
	4														
	5														



WEST JERSEY AND SEASHORE RAILROAD COMPANY
ELECTRICAL DEPARTMENT
GENERAL REPAIRS TO OVERHEAD FEEDER AND TROLLEY WIRE

WEEK ENDING ------------ 190 SECTION BETWEEN ------------

	DATE	TROLLEY WIRE RENEWED IN FT.	SUSPENSION WIRE RENEWED IN FT.	GUY WIRE RENEWED IN FT.	TROLLEY SLEEVES	SUSPENSIONS STRAIGHT LINE	SUSPENSIONS SINGLE CURVE	SUSPENSIONS DOUBLE CURVE	SUSPENSIONS FEEDER TAP	EARS FROGS	CROSSINGS	STRAIN INSULATORS	GUY CLAMPS	GUY RODS	EYE BOLTS SIZE	TERMINALS BRACKETS INSULATORS

FORMS OF REPORTS USED BY THE LINE DEPARTMENT, WEST JERSEY AND SEASHORE RAILROAD in making third-rail and line repairs, and also to do all track bonding. The sections which these men patrol are arranged as follows:

One first-class patrolman who looks after third-rail, high-tension trolley and signal lines between Camden and South Westville, a distance of 6.4 miles. This man also looks after the electrified portion of the Camden yard, and is located at Westville.

One second-class patrolman between South Westville and Glassboro, a distance of 12.9 miles. This man is located at Pitman.

One second-class patrolman between South Glassboro and Forest Grove. Distance, 14.3 miles. This man is located at Newfield.

One second-class patrolman between Forest Grove and Mays Landing. Distance, 13.9 miles. This man is located at Newfield.

One second-class patrolman between Mays Landing and Pleasantville. Distance, 11.6 miles. This man is located at Mays Landing.

One second-class patrolman between Pleasantville and Atlantic City. Distance, 4.7 miles. This man is located at Pleasantville. In addition to patrolling the lines he looks after the switch tower built at Pleasantville to connect the Somers Point sub-station of the Atlantic City & Shore Railroad to the transmission lines.

One first-class patrolman between Newfield and Millville. Distance, 10 miles, who looks after the overhead trolley and high-tension transmission line.

One second-class patrolman stationed at Atlantic City, who, in addition to looking after the third-rail at the electric terminal, has charge of all yard and station lighting at both the steam and electric terminals; also the motors used at the round house and machine shop.

All the men are provided with telephone connections and are subject to call twenty-four hours every other day; or in other words, one-half of the force is on duty twenty-four hours each day. Patrol boxes are located along the line one mile apart. As the men go over their section they call up the nearest sub-station operator from each box, reporting broken insulators, tight jumpers due to third-rail creepage, loose or broken protection boards at stations, loose or worn side approaches, broken conduits, conduit caps, broken cross bonds, burnt-out cables, feeder bells, trolley ears, span wires, side guys, broken feeder taps, blown fuses in section boxes, etc. The men are provided with screw drivers, socket wrenches, pliers, small monkey wrenches and climbers; and they make all repairs possible while covering their section. On such repairs as cannot be made alone the men of two adjacent sections double up and assist each other. The repairs made consist in cutting off or extending the third-rail when creepage necesstates, rebonding both third and running rails, replacing insulators for both the third-rail and high-tension lines, and replacing and tightening guy wires.

In addition the patrolmen are sworn in by the governor of the state, thus enabling them to make arrests in any county. The mere fact that they are officers of the law has saved the company considerable annoyance from persons throwing wires and scrap iron on the third-rail and high-tension lines and shooting at insulators. The company has, therefore, without extra expense, eleven police scattered the length of the line.

The men are being made familiar with the operation of the sub-stations, so that they may be called upon to operate them in cases of emergency. They also assist the electrical repair force in making repairs at sub-stations, and thereby avoiding the necessity of sending a number of extra men over the road. They are sometimes called upon to assist the men at Westville in doing regular construction work, such as replacing poles, stringing trolley wire and laying third-rail. As they are all electrical men and work in the electrical department they can be called on to do any work on the third-rail, overhead trolley, sub-station and power house.

The high-tension lines are comparatively free from troubles of any sort. The section traversed is open country and is not subjected to many of the troubles of lines near large cities. The ground wire run on top of the poles has proven effective in shielding the line from lightning troubles. The high-tension lightning arresters which are all installed either in the sub-stations or in the power station, are inspected and cleaned every two weeks and are kept free from dust. After showers they are gone over and inspected for trouble. Test papers are kept between the cylinders, and these are examined for puncture from time to time and always after storms. The papers bear the date when put in and when removed. Those punctured are always sent to the sub-station foreman together with a report of any unusual happening or occurrence. Since installation there has been no necessity for replacing any of the arrester parts.

INSULATOR BREAKAGE AND REPLACEMENT

Patrolmen are supplied with a special blank on which the breakage and replacement of high-tension insulators are reported. The blank has upon it a diagram of a pole top with the insulator drawn in such a manner that the nature and position of a crack or defect may be indicated definitely by pencil marks. The patrolman also indicates the circuit or line on which the broken insulator is located, as this is not always shown by the position of the insulator, because wires are transposed to make a complete revolution between sub-stations. The insulator blanks which are sent in after repairs are made bear the date the broken insulators were observed and replaced, the patrolman's name and any additional remarks.

Insulator breakage has been comparatively light since the line was installed. For July, 1907, two insulators were reported broken and there was none the two preceding months. There are about 32,000 insulators on the system, and the breakage for a period of three months was therefore about .0006 per cent.

PROTECTION TO REPAIRMEN WHEN WORKING ON THE HIGH-TENSION LINES

When men are sent out to make repairs on the high-tension line, an order is sent to the foreman of the power station to have the line cut "dead." A written order is then given to the switchboard operator, who proceeds to cut out the line as follows: The sub-station operators at either end of the line or section to be cut out are instructed to cut the line "dead," which is done by first opening the oil switch controlling the line, then the disconnecting switches. A warning tag is placed on the switch panel and the switchboard operator at Westville notified that the line is cut "dead." The sub-station operators then proceed to make out a standard tag, filling in the time and date at which the circuit is cut out, placing the tag on the oil switch, and removing the warning tag. If the section is connected with the power house, the switchboard operator also opens and tags the proper switches. After the line is cut out the foreman of the repair gang is notified.

The lineman is provided with a grounding device on one end of which is a clamp for attachment to the running rail. The other end terminates in three branches provided with small clamps for attachment to the three wires of the high-tension circuit. The small clamps, moreover, are fastened on bamboo rods. After the device has been grounded to the rail the lineman ascends the pole and attaches the smaller clamps to each of the three wires, to which they are secured firmly by thumb screws. When the repair work is completed, the grounding devices are removed from the line and the foreman of the power station is notified that the work is completed. If there are two breaks in a line, or repairs are to be made on the same section at two points, the repairmen act independently of each other in getting the line cut out. Even though it is known that the line is "dead," the second repairman proceeds just as though it is "alive." In such an event the switchboard operator receives two orders, and must receive an order from each of the repair gangs that the work is done before putting current on the line. The three wires of each circuit are located on each side of the pole, and it is customary for repairmen to work on one circuit while that on the other side of the pole is alive. However, they never work under this condition on wet or rainy days. On such days, if repairs must be made, both lines are cut out.

No provision is made for subjecting the lines or other high-tension apparatus to high-voltage tests. Broken insulators are always located by inspection. The peculiar humming sound given off by a cracked insulator usually enables it to be located a week or more before it breaks down completely.

Telephone and telegraph lines are located on poles on the opposite side of the track and about 75 feet distant from the high-tension lines. Except in very damp or foggy weather there is no inconvenience from induced currents. The two high-tension lines are always operated in multiple, as this is the most economical method of operation. Each line is connected to the bus-bar at every sub-station and the two lines are therefore tied together at each sub-station. This method is not only the most economical one but, as already stated, a break down or cutting out of one line between two sub-stations simply results in the shunting of all the current over the other line for a short distance.

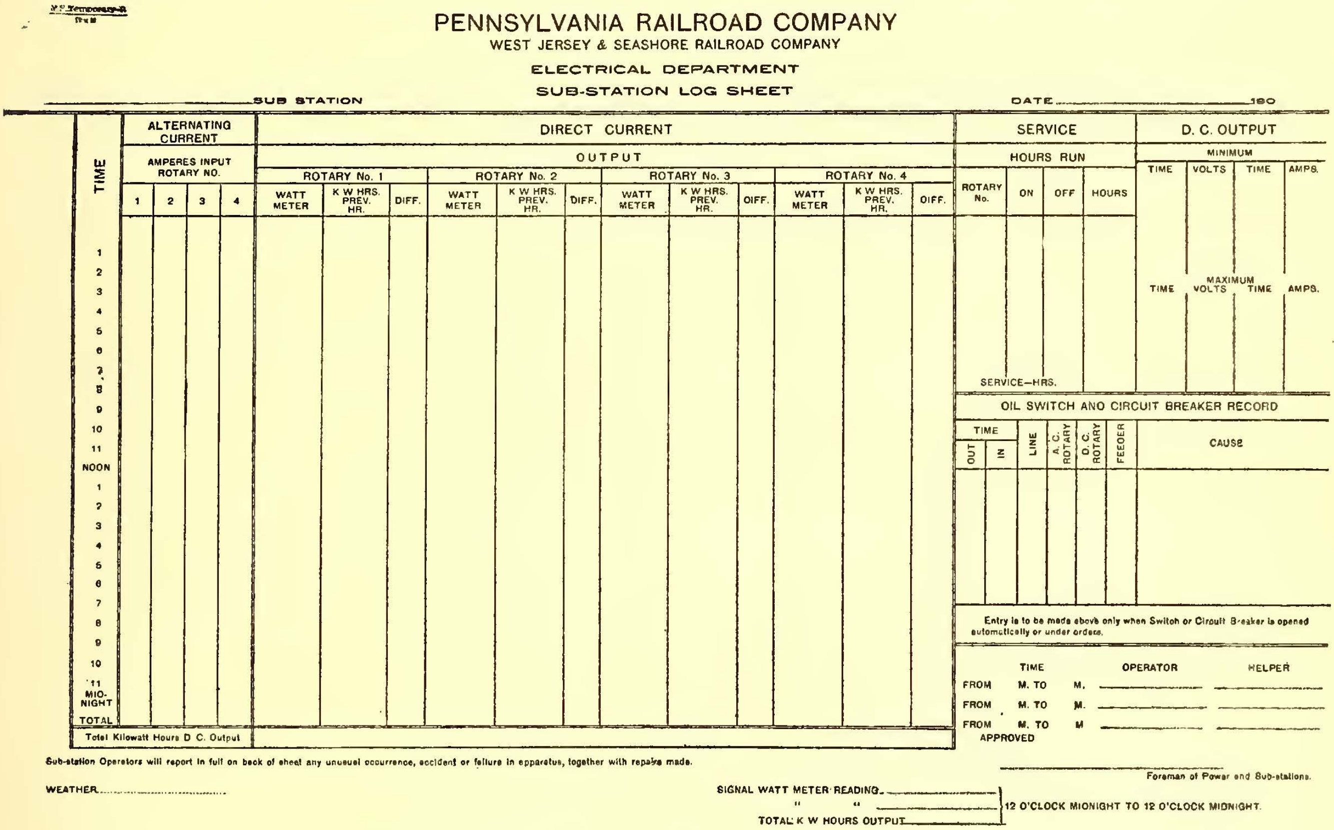
REPORTS ON SWITCHES

An accurate record is kept of the position of all switches at all times on the high-tension lines. The switchboard operator in the power house is provided with a blank having upon it spaces for indicating the position of each switch, and a diagram of the high-tension lines for indicating the position of cutting through switches. When the switchboard operator comes on the watch at the power house he calls each sub-station operator over the telephone and has him report the position of all the switches in his sub-station.

The switchboard operator then marks his sheet, indicating the closed position of the various switches by connecting the lines left disconnected on the chart with a pencil mark. This chart is then compared with the preceeding one, and if it does not agree, the proper sub-station is called up and the error located. Any changes made in the connecetions afterwards are reported and indicated on the sheet, together with any special remarks, such as time current was off the line.

THIRD-RAIL REPAIRS

The patrolmen usually wait until several third-rail insulators are broken on their section before beginning to replace them, and they then call upon the patrolmen of the adjacent section for help. The two men carry a lever with which the rail is raised high enough to allow the insulator to be slipped under it. During July there were 91 broken insulators. There is a total of about 82,000 insulators on the 125 miles of third-rail, and the breakage for July was consequently a little over one-tenth of 1 per cent. The trouble report for July, which is a typical one, also showed three broken posts and eleven defective protection boards and one defective jumper. Only one or two cases have been reported of grounding of underground jumpers under highway crossings and at other points. The jumpers are of rubber covered weather-proof wire run in bituminized fibre conduit laid in concrete. Rail creepage



PENNSYLVANIA RAILROAD COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
ELECTRICAL DEPARTMENT
SUB-STATION LOG SHEET

_______________ SUB STATION

DATE _______________ 190

TIME	ALTERNATING CURRENT				DIRECT CURRENT											
	AMPERES INPUT ROTARY NO.				OUTPUT											
					ROTARY No. 1			ROTARY No. 2			ROTARY No. 3			ROTARY No. 4		
	1	2	3	4	WATT METER	K W HRS. PREV. HR.	DIFF.	WATT METER	K W HRS. PREV. HR.	DIFF.	WATT METER	K W HRS. PREV. HR.	DIFF.	WATT METER	K W HRS. PREV. HR.	DIFF.
1																
2																
3																
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NOON																
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4																
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6																
7																
8																
9																
10																
11																
MID-NIGHT																
TOTAL																
Total Kilowatt Hours D C. Output																

SERVICE			
HOURS RUN			
ROTARY No.	ON	OFF	HOURS
SERVICE—HRS.			

D. C. OUTPUT			
MINIMUM			
TIME	VOLTS	TIME	AMPS.
MAXIMUM			
TIME	VOLTS	TIME	AMPS.

OIL SWITCH AND CIRCUIT BREAKER RECORD

TIME		LINE	A. C. ROTARY	D. C. ROTARY	FEEDER	CAUSE
OUT	IN					

Entry is to be made above only when Switch or Circuit Breaker is opened automatically or under orders.

TIME			OPERATOR	HELPER
FROM	M. TO	M.		
FROM	M. TO	M.		
FROM	M. TO	M		

APPROVED
____
Foreman of Power and Sub-stations.

Sub-station Operators will report in full on back of sheet any unusual occurrence, accident or failure in apparatus, together with repairs made.

WEATHER.....................

SIGNAL WATT METER READING _______________
" " _______________
TOTAL K W HOURS OUTPUT _______________
12 O'CLOCK MIDNIGHT TO 12 O'CLOCK MIDNIGHT.

SUB-STATION LOG, WEST JERSEY AND SEASHORE RAILROAD and the straining of jumpers, however, has caused some trouble. For emergency use cables are kept at several of the sub-stations and the patrolmen are instructed to watch jumpers closely, and in the event of one being found hot to install the extra cable in a temporary manner by burying it a few inches below the roadway.

BOND TESTING

Comparatively little trouble has been experienced with poor bonding. A Whitney bond tester is used, but on account of the intermittent flow of current through the rails little headway has been made in making a thorough test of the bonding. The company is contemplating the use of a car fitted with a motor generator set and the necessary instruments for making these tests.

WEAR AND CREEPAGE OF THIRD-RAIL

Creepage of the third-rail occasioned considerable inconvenience soon after its installation. The tendency of the rail is to creep in the direction of travel and, as has been mentioned, caused trouble by pulling on and straining the jumpers between sections. In a few extreme cases of creepage three or four feet of one end of the rail was cut off and was spliced to the short end. Expansion of the rail gave trouble particularly on curves by breaking insulators. Trouble from creepage and expansion was practically eliminated by loosening the angle bars and oiling the joints. The bars were made loose and are kept so by the patrolmen, who go over the joints occasionally and strike them with a sledge. As a further precaution anchors are being installed at intervals of from 1000 to 1500 ft. Nothing is being done to prevent the rail from rusting. It has become coated with rust, but it is believed that it will not be eaten to any depth.

FIGHTING SLEET

Sub-station men are instructed to keep close watch at times when sleet is likely to form, and to give immediate notice of any signs of sleet to the line foreman, who is in constant touch with all points on the line. Calcium chloride cars are held for emergencies at Camden and at Atlantic City, and these are hauled over the road by steam locomotives or motor cars. The cars are simply old box cars provided with barrels having an outlet extending over the third-rail. In summer the cars are usually dismantled and used for other purposes. Shoes with cutting edges of practically the same design as used on the Long Island Railroad are employed in winter, and are supplied with an extra tension device. Without the device the tension on the shoes is about 18 lbs. and the pressure may be increased up to 90 or 100 lbs. with it. It can be put into service without tools in a very few minutes. The winter shoes are removed in summer because of the danger of wearing the side approaches and replaced by lighter shoes. These approaches are the only part of the third-rail insulators showing wear, there being no perceptible wear of the rail or the end approaches or of the section insulators, which are installed midway between sub-stations and at sub-stations.

Switches and fuses are located in boxes at the section insulators between sub-stations. Instructions issued to operators and others concerned state that the station and signal tower operators are to open the switches when instructed to do so by the superintendent or in case of wreck at the request of the motorman or conductor or the section foreman. The third-rail foreman is to see that they are properly closed. Those who open the switches are to take the name and occupation of the person requesting them to do so, and they are to advise the superintendent promptly after doing so. Each box is supplied with a hook on a long wood handle and this is hooked into the blade when opening the switch.

THIRD-RAIL PROTECTION

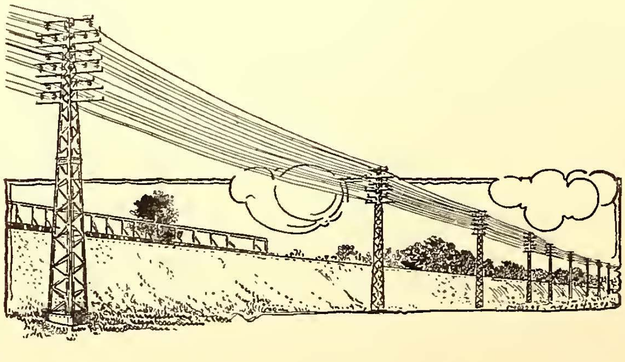
The third-rail is provided with protection boards in yards, at stations and at other points where people might come in contact with it. Cast iron warning signs are erected on posts at all highway crossings, and notices in the cars state that the third-rail must not be stepped on or touched and that passengers must not get off cars except at stations and upon station platforms.

NIGHT OPERATION

Electric cars are not usually operated between the hours of 1 and 5 a. m., but as the motor-driven compressors used in connection with the signal system take current from the third-rail the sub-station in the power house is usually operated continuously and current kept on the third-rail twenty-four hours.

TROLLEY AND OVERHEAD CONSTRUCTION

The patrolmen on the sections equipped with trolley keep record of all repairs and defects the same as the third-rail patrolmen and send in reports to the foreman, who makes out reports summing up all troubles, which he sends to the office of the assistant electrical engineer. These reports are then summarized for the month on special blanks. A baggage car fitted up as a repair or tower car is used in making repairs. The car is pulled over the road by a steam locomotive or motor car. Lightning arresters are placed on every eighth pole or at 1000-ft. intervals, and these protect the trolley line satisfactorily. Arresters are inspected after every storm. Only one car has been struck by lightning. This happened when lightning struck a signal bridge just as the car was passing under it and resulted only in the blowing of the control circuit fuses.



MAINTENANCE OF ELECTRIC ROLLING STOCK, WEST JERSEY & SEASHORE RAILROAD

The original electric car equipment of the West Jersey & Seashore Railroad consisted of sixty-two passenger cars and six combination baggage and mail cars. Recently seventeen additional passenger cars, two combination passenger and baggage and two straight baggage cars were added. The cars are 55 ft. 5½ ins. long and 9 ft. 8¾ ins. wide over side sills and are of the Pennsylvania standard wood construction. They are mounted on Baldwin M. C. B. trucks. Two G. E. 69 C. motors of 200-hp capacity each are hung on one truck, which has a 7-ft. wheel base. The wheels of this truck are 36 ins. in diameter and have 3-in. steel tires shrunk and bolted on. The control equipment is the Sprague-General Electric automatic multiple unit type. All the wiring is in iron pipe conduit. The trail trucks are fitted with Schoen 33-in. solid rolled steel wheels.

CAR REPAIRS AND INSPECTION

Heavy repairs and general overhaulings are made in the Pavonia shops of the Pennsylvania Railroad Company, located near Camden. These shops were formerly used as a general locomotive and coach shop, but repairs to locomotives have been discontinued and the shops are now used for steam and electric car repairs only. There are three inspection sheds on the road. One at Camden near the terminal train sheds has three tracks, each of which will hold three cars. The shed at Atlantic City has two tracks and that at Millville one track. The tracks in all the sheds are provided with pits. At the two smaller sheds only emergency repairs and inspections are made. All regular inspection is done in the Camden shed, which is well equipped for such inspections and also for making light repairs. One track is equipped with an overhead traveling crane and a small shop is provided in one corner. There are no storage barns for electric cars on the system and when not in service the cars are stored outside at the points at which they are likely to be required.

Inspection of the electrical apparatus is made on a mileage basis. When the road was put into operation the limit was 600 miles, but it has since been increased to 1200 miles. The mileage is computed by the night inspector from the conductors' slips by multiplying the number of trips the car has made during the day by the miles between terminal points. When the cars have made in the neighborhood of 1000 to 1200 miles, a list of such cars is given to the station master at the electric terminal, who instructs the yard drill crews to have the cars set aside for inspection. The average time between inspection varies from three to seven days, according to the season of the year. The inspections are so arranged that all cars will be in service Saturday afternoons and Sundays.

On Monday mornings about half of the total equipment is due for inspection, and all men in the shop are put at inspection, and from 20 to 30 cars are gone over. The number inspected per day then diminishes towards the latter part of the week and by Saturday noon all reported have been gone over. At these inspections the hand-hole covers of the motors are removed and the motors are blown out and the commutator brushes and the clearances are inspected. A French brush manufactured by Le Carbone Company is being used. The commutator end armature bearing is oiled with 1½ gills and the pinion end bearing with 2 gills of oil. The compressor motor armature bearings are also oiled. The control apparatus is opened up and the switch and interlock contacts are cleaned with sandpaper.

Triple valves and engineers' valves are inspected and cleaned every three months.

OILING

The journals are oiled and taken care of by a man stationed on the terminal platform. An unusual amount of oil is required on the motor axle bearings because of the sand roadbed. Attempt is made to flood the sand out by using a pint of oil on a 5000-mile basis. Because of this sand roadbed, the side bearings are not lubricated, but the center bearing is lubricated every three months. Gears are greased with 4½ lbs. of grease every two months. The crank shaft bearings and the gears of the compressors are oiled every 30 days.

TROLLEY WHEELS

Although the cars are operated in trains, it is necessary to have one trolley wheel on each car in contact with the wire, for otherwise there is danger of blowing the trolley fuses. The trolley wheel is 5½ ins. in diameter and is of special type, having a hub 3 ins. long and ½ in. in diameter. The long hub necessitates a special type of harp to prevent the wire catching between the harp and the wheel. The wheels have a life of about 1500 miles and are oiled and inspected by a man at the Camden terminal after each round trip.

BRAKE SHOES

Cast-iron brake shoes have been tried, but their life was too short and the U Lappin flanged steel back shoe made by the American Brake Shoe & Foundry Company is now used. The original weight is 39 lbs. and they are worn down to 16 or 17 lbs., giving 22 and 23 lbs. of wear. Due to the fact that the cars are not turned at terminals the shoes wear very evenly.

CONTACT SHOES

There is very little breakage of contact shoes and practically all of them are replaced because of wear. A few have been broken by striking obstructions left by track men and laborers. The number replaced per month varies from 20 to 75. In June, 34 were renewed and replaced. During that month 65 cars were operated with a total mileage of 292,767 miles.

ELECTRICAL EQUIPMENT TROUBLE

Troubles with equipment have been extremely light. In a year's time there has been only one grounded armature. There has been no field trouble at all and the motors have never been known to flash over between brushes. Trouble with pump motors have been limited to those caused by bad brushes and there have been very few cases of control trouble.

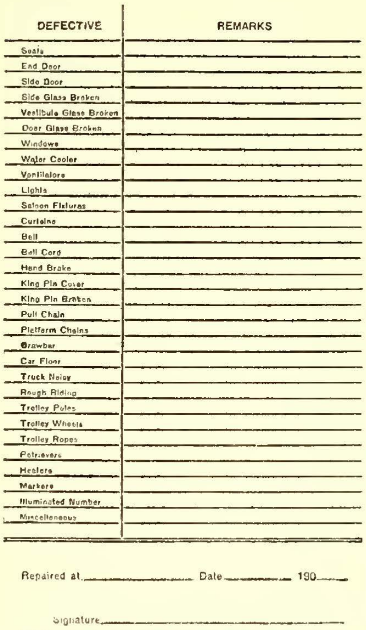
INSPECTION FORCE

The inspection and light repairs are in charge of the foreman of electric cars. The force in the inspection shed at Camden consists of a barn foreman, electrical and air brake inspector and oilers. There are also four men engaged on truck repairs and replacing wheels, and there are two carpenters employed in making general repairs.

The outside inspection force consists of day and night general inspectors and a trolley pole inspector at the Camden terminal and day and night inspectors at Millville and Atlantic City. For the use of the Atlantic City and Millville inspectors extra jumpers, trolley wheels, oil and waste are kept at these points.

GENERAL OVERHAULING

The cars are given a general overhauling in the Pavonia shops on a 50,000-mile basis. The motors are opened, the fields removed and the shell is cleaned. The fields are cleaned, the armature blown out and fields and armatures are given a coat of insulating paint. The armature is then given a ground test of 1000 volts. Armature bearings are usually renewed to prevent possible danger of them wearing through the babbit lining and cutting the shaft. The lining is only 1/16 in. thick, and with new bearings there is only 3/16 in. clearance of the armature. The controller compressor, air brake equipment and all parts get a general cleaning at overhaulings. It is the intention to bring the cars in for varnishing and painting every year.

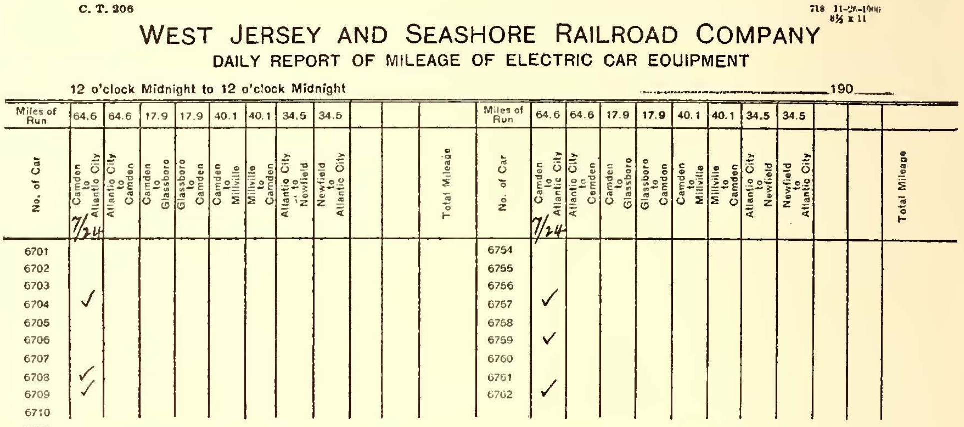


DEFECTIVE	REMARKS
Seats	
End Door	
Side Door	
Side Glass Broken	
Vestibule Glass Broken	
Door Glass Broken	
Windows	
Water Cooler	
Ventilators	
Lights	
Saloon Fixtures	
Curtains	
Bell	
Bell Cord	
Hand Brake	
King Pin Cover	
King Pin Broken	
Pull Chain	
Platform Chains	
Drawbar	
Car Floor	
Truck Noisy	
Rough Riding	
Trolley Poles	
Trolley Wheels	
Trolley Ropes	
Retrievers	
Heaters	
Markers	
Illuminated Number	
Miscellaneous	

Repaired at__________ Date________ 190____

Signature____________________

BACK OF CONDUCTOR'S DEFECT REPORT



C. T. 206

718 11-26-1906
8½ x 11

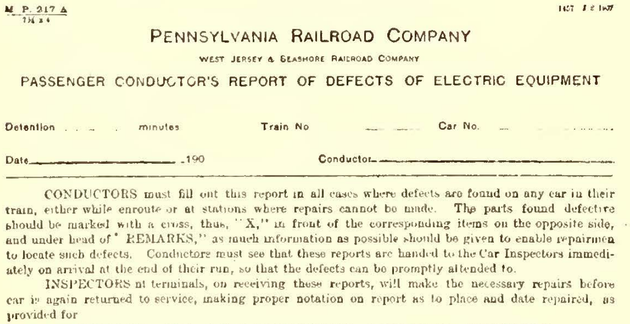
WEST JERSEY AND SEASHORE RAILROAD COMPANY

DAILY REPORT OF MILEAGE OF ELECTRIC CAR EQUIPMENT

12 o'clock Midnight to 12 o'clock Midnight ________________190____

Miles of Run	64.6	64.6	17.9	17.9	40.1	40.1	34.5	34.5				Miles of Run	64.6	64.6	17.9	17.9	40.1	40.1	34.5	34.5			
No. of Car	Camden to Atlantic City 7/24	Atlantic City to Camden	Camden to Glassboro	Glassboro to Camden	Camden to Millville	Millville to Camden	Atlantic City to Newfield	Newfield to Atlantic City			Total Mileage	No. of Car	Camden to Atlantic City 7/24	Atlantic City to Camden	Camden to Glassboro	Glassboro to Camden	Camden to Millville	Millville to Camden	Atlantic City to Newfield	Newfield to Atlantic City			Total Mileage
6701												6754											
6702												6755											
6703												6756											
6704	✓											6757	✓										
6705												6758											
6706												6759	✓										
6707												6760											
6708	✓											6761											
6709	✓											6762	✓										
6710																							
6711																							

BLANK FOR RECORDING MILEAGE OF CARS



M. P. 217 A
7½ x 4

[illegible]

PENNSYLVANIA RAILROAD COMPANY

WEST JERSEY & SEASHORE RAILROAD COMPANY

PASSENGER CONDUCTOR'S REPORT OF DEFECTS OF ELECTRIC EQUIPMENT

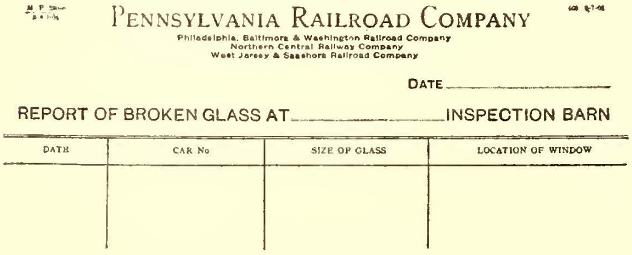
Detention . . . . minutes Train No _____ Car No. _____

Date____________190 Conductor____________

CONDUCTORS must fill out this report in all cases where defects are found on any car in their train, either while enroute or at stations where repairs cannot be made. The parts found defective should be marked with a cross, thus, "X," in front of the corresponding items on the opposite side, and under head of " REMARKS," as much information as possible should be given to enable repairmen to locate such defects. Conductors must see that these reports are handed to the Car Inspectors immediately on arrival at the end of their run, so that the defects can be promptly attended to.

INSPECTORS at terminals, on receiving these reports, will make the necessary repairs before car is again returned to service, making proper notation on report as to place and date repaired, as provided for

FRONT OF CONDUCTOR'S DEFECT REPORT



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PENNSYLVANIA RAILROAD COMPANY

Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Railroad Company

DATE__________

REPORT OF BROKEN GLASS AT____________INSPECTION BARN

DATE	CAR No	SIZE OF GLASS	LOCATION OF WINDOW

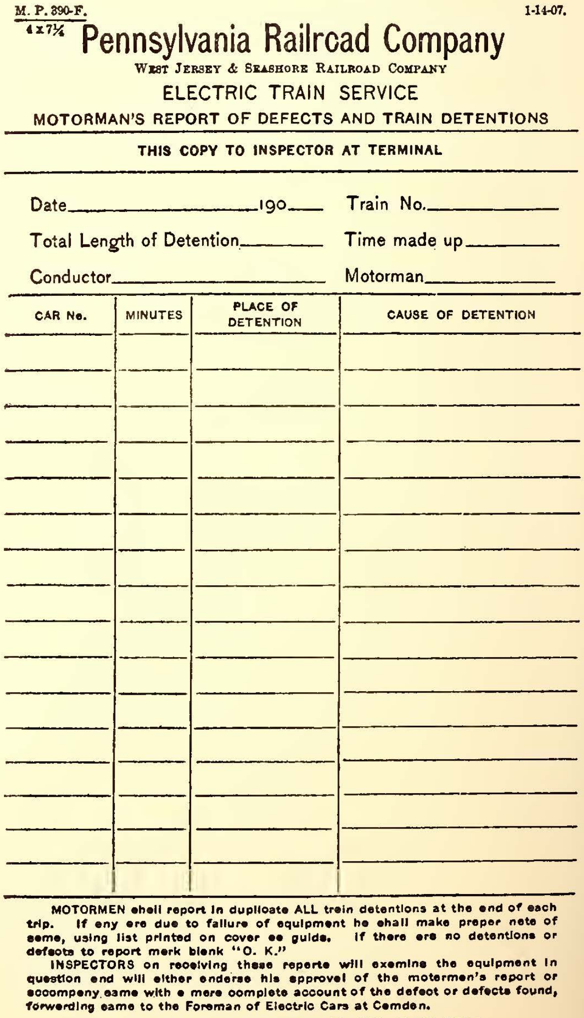
BROKEN GLASS REPORT

EMPLOYMENT AND INSTRUCTION OF TRAINMEN

Steam locomotive men only are being employed as motormen, and of the applications for motormen those longest in the service are given preference. The men are already familiar with the road so that they need instruction regarding the electrical equipment only. A special instructor is employed to teach them regarding the apparatus and the general principles on which it works. Particular attention is given to overcoming troubles which would result in delay on the road. For use in instructing the men a book has been compiled and special instruction apparatus has been built.

INSTRUCTION APPARATUS

All of the controller parts have been hung on frames in such a manner that their working can be readily observed. The circuit breaker and reverser and lamps to represent the motor are on one frame, the apparatus located on the car switchboard and the master controller are on another and the contactors are hung on two others. All of the wiring is open and the wires are spread out so they can be easily traced. Lamps placed over the painted outline of motors serve as fields and armatures and other lamps in series represent the rheostats.



M. P. 390-F.
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1-14-07.

Pennsylvania Railroad Company

WEST JERSEY & SEASHORE RAILROAD COMPANY

ELECTRIC TRAIN SERVICE

MOTORMAN'S REPORT OF DEFECTS AND TRAIN DETENTIONS

THIS COPY TO INSPECTOR AT TERMINAL

Date__________190____ Train No.________

Total Length of Detention________ Time made up________

Conductor__________ Motorman________

CAR No.	MINUTES	PLACE OF DETENTION	CAUSE OF DETENTION

MOTORMEN shall report in duplicate ALL train detentions at the end of each trip. If any are due to failure of equipment he shall make proper note of same, using list printed on cover as guide. If there are no detentions or defects to report mark blank "O. K."

INSPECTORS on receiving these reports will examine the equipment in question and will either endorse his approval of the motormen's report or accompany same with a more complete account of the defect or defects found, forwarding same to the Foreman of Electric Cars at Camden.

MOTORMAN'S DETENTION REPORT

After the men have received instruction they are subjected to examinations regarding what they would do to get a train in operation under different conditions.

THE INSTRUCTION BOOK

A general notice in the instruction book states that all trainmen will be required to become familiar with the name, location and purpose of all apparatus in order that they may carry out instructions given them by motormen or conductors, and that motormen will be required to know in addition the general principle upon which the operation of the various apparatus depends, the manner in which it should be operated and the method of procedure in case of train failure. The book describes in a rather detailed manner the air brake apparatus, including the compressor and the compressor governor. Instructions are given regarding handling the brake in service and also regarding what is to be done in cases of failure of the brake to work. The motor control and the master control circuits are treated in a similar manner. In connection with the descriptive matter numerous cuts are presented, several of which show cross section views of the apparatus. A complete diagram of the control and motor circuits is given so that there is nothing to prevent the student going as deeply as he desires into the workings of the apparatus. The cuts on brake equipment and control apparatus are bunched, and those to which frequent reference must be made in following the reading matter are on insets, so that they can be studied while the book is open at any page.

The instructions regarding caring for failures of the motors and control apparatus are very much to the point and are as follows:

A train failure—that is, a failure of a train of one or more cars to move or to attain full speed when the directions for train operation have been followed—may be due to one or more of the following causes:

First—Failure of power.
Second—Defect in master control circuit.
  (a) Master control fuse blown or imperfect.
  (b) Grounded train cable.
  (c) Poor contact in master controller.
  (d) Loose train cable jumper.
Third—Defect in motor control circuit.
  (a) Circuit breakers open.
  (b) Bus fuses blown.
  (c) Loose or disconnected bus jumper.
  (d) Main fuse blown.
  (e) Shoe or trolley fuses blown.
Fourtb—Failure of air brakes to release.

A failure of power can be detected by closing the lighting switches; if lights burn, power is on.

To determine if master control circuit is open, turn master controller handle to the first notch and open the master controller switch. The noise of slight arcing indicates that tbe master control circuit is closed and that the trouble is elsewhere. No arcing shows that the master control circuit is open and indicates that fuse is blown or imperfect. A black or charred spot in the center of the label, called a "Tell-tale," indicates that the fuse is blown and should be replaced. A fuse which shows no indication of being blown should be tested to detect faulty construction by removing a fuse from a lighting circuit and inserting the fuse to be tested. The lights burning indicate that the fuse is good, and it can then be replaced.

To determine if train cable is grounded, operate tbe master controller. If tbe master controller fuse blows, it indicates that one or more wires of the train cable are in contact with the ground, and the cable is said to be "grounded."

To locate a ground in the train cable, disconnect train cable on operating car from rest of train by removing train cable jumper from its socket on second car. If the fuse now blows, when the controller handle is operated, it indicates that the ground is either in the operating car or its train-cable jumper.

To determine whether ground is in train cable or jumper, remove the jumper. If the fuse blows when the controller is operated, the ground is in the car. If it does not blow, the ground is in the jumper, and a new one should be inserted. If the fuse does not blow when the jumper is disconnected from the second car, the jumper should be replaced and the one between the second and third car disconnected from its socket on the third car, and so on until the fault is located.

If the fault is found to be caused by a defective jumper, and if the train is not provided with an extra jumper, the jumper between the last two cars of the train should be taken to replace the defective one.

If the fault is found to be on the car and not in tbe jumpers, tbe seven-point control cut-out switch on that car should be turned to the "off" position, and the test repeated. If the fuse still blows when the handle is operated the fault is in the train cable. If the fuse does not blow, the ground is between the cut-out switch and the contactors, reverser and circuit breaker. If this is the case the cut-out switch on the defective car should remain in the "off" position, thus cutting out the fault as well as rendering that car inoperative, but in no way interfering with the train cable, and permitting the operation of other cars in the train, through the train cable in the usual manner.

If opening the cut-out switch does not remove the fault—that is, if the fault is in the train cable and the defective car is near the rear end—the train should be operated from the front car as usual, the defective car and those following being cut out by removing both train cable jumpers on that car; if at or near the head of the train, the train should be run from the following car, all cars ahead being cut out.

To detect poor contact in master controller, open the master controller switch, remove the cover from the controller and turn the handle slowly, noting if each finger makes good contact with the drum. If any contact is poor and cannot readily be readjusted by the motorman, he should run the train from the next car.

To detect loose train cable jumper the trainmen should note if the contactors on each car are working while the train is accelerating. If there is a loose train cable jumper, all cars ahead of the jumper will operate; others will not. The motorman should be immediately informed if any car is not operating.

If one or more circuit breakers of a train blow when starting or running, return the controller handle to the "off" position and move the handle of the circuit breaker switch to the "on" position. If the circuit breakers again blow when the controller handle is operated, the brakes should be examined to see if they have released.

If the circuit breaker on any car repeatedly blows, the motorman should make an examination to see that it is properly adjusted. If the trouble is not with the circuit breaker, the car should be cut out by opening the seven-point cut-out switch on the switchboard and the main switch beneath the car.

An open circuit in bus-line may be detected when the train is at a crossover and current cannot be obtained on operating car, although other cars of the train have current. This indicates that the bus-line fuse or fuses are blown, or that a bus-line jumper is loose or disconnected between the operating and adjacent cars.

The motorman should inspect the bus-line jumpers, and if the trouble cannot be quickly remedied, he should go back to the first car having current and move the train through the crossover. The motorman should then return to the first car and proceed in the usual manner.

When the main fuse is blown the motors will not operate, although the contactors may be in working order and the circuit breaker closed. This should occur very seldom, as it can only be caused by short circuit or grounding in the motors or motor circuits, which are usually protected by the quicker acting circuit breaker. This fuse should not be replaced on the road except to avoid serious delay to the service, as in the case of single cars. Before renewing main fuse, open the main switch.

A shoe fuse may blow from short circuit, grounding of the car wiring on some part of the car or truck, or may be caused by a contact shoe on the car or train grounding, due either to being broken or from fouling or picking up something along the line. If it is necessary to replace a shoe fuse on the road so as to prevent delay to service, the motorman should open the third-rail switch on the switchboard and insert the wooden paddles, provided for that purpose, between all shoes on that car that are in contact with the third-rail.

A trolley fuse may blow from short circuit or grounding of tbe car wiring on the car or truck, or because it has been overloaded by running in a train with other trolleys down and taking current for the whole train through the one fuse. If this latter has been the cause, the fuse should be replaced on the road if it is required to prevent delay to service. Before replacing the fuse, pull down both trolleys and open the trolley switch.

REPORT OF CARS INSPECTED

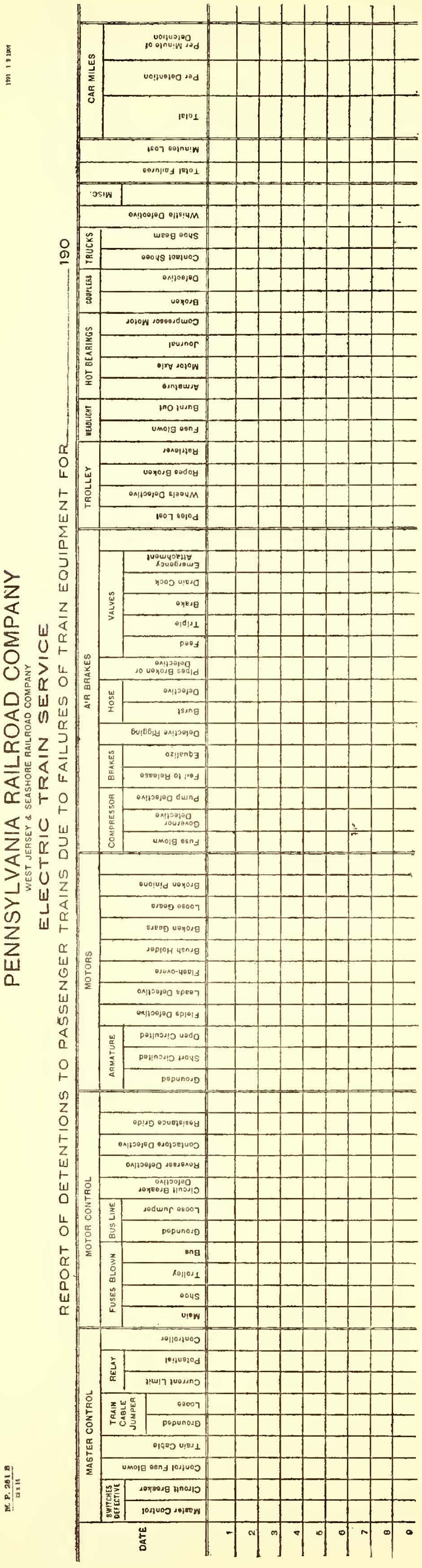
The foreman of electric cars sends in to the office of the assistant electrical engineer a daily report which shows by their numbers the cars inspected, their mileage since last inspection, and the number of days out of the shop.

There is also given the total mileage of all the cars since their last inspection, the average mileage maximum and minimum mileage and the average number of days out of the shop. The report for Aug. 6, which is a typical one for the summer season, showed:

Total mileage	26,511
Number of cars inspected	21
Average mileage	1,262 3/7
Average number of days out of the shop	5 20/21
Minimum mileage	740
Maximum mileage	1,845

RECORDS OF DETENTIONS

An effective method is pursued to find out the exact cause of all train detentions and the amount of detentions. Motormen are supplied with blanks for reporting the extent and



PENNSYLVANIA RAILROAD COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
ELECTRIC TRAIN SERVICE
REPORT OF DETENTIONS TO PASSENGER TRAINS DUE TO FAILURES OF TRAIN EQUIPMENT FOR______190

M. P. 261 B

DATE	MASTER CONTROL									MOTOR CONTROL										MOTORS										AIR BRAKES														TROLLEY				HEADLIGHT		HOT BEARINGS				COUPLERS		TRUCKS						CAR MILES		
	SWITCHES DEFECTIVE				TRAIN CABLE JUMPER		RELAY			FUSES BLOWN				BUS LINE						ARMATURE										COMPRESSOR			BRAKES			HOSE			VALVES																									
	Master Control	Circuit Breaker	Control Fuse Blown	Train Cable	Grounded	Loose	Current Limit	Potential	Controller	Main	Shoe	Trolley	Bus	Grounded	Loose Jumper	Circuit Breaker Defective	Reverser Defective	Contactors Defective	Resistance Grids	Grounded	Short Circuited	Open Circuited	Fields Defective	Leads Defective	Flash-overs	Brush Holder	Broken Gears	Loose Gears	Broken Pinions	Fuse Blown	Governor Defective	Pump Defective	Fail to Release	Equalize	Defective Rigging	Burst	Defective	Pipes Broken or Defective	Feed	Triple	Brake	Drain Cock	Emergency Attachment	Poles Lost	Wheels Defective	Ropes Broken	Retriever	Fuse Blown	Burnt Out	Armature	Motor Axle	Journal	Compressor Motor	Broken	Defective	Contact Shoes	Shoe Beam	Whistle Defective	Misc.	Total Failures	Minutes Lost	Total	Per Detention	Per Minute of Detention
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BLANK FOR RECORDING DELAYS DUE TO DEFECTS OF VARIOUS KINDS

cause of detentions. The blanks are put up in books consisting of 50 duplicate yellow and white sheets. A heavy cardboard cover has printed on it a list of possible causes of detentions which serve as suggestions and guides in making out reports. The blanks have spaces for filling in the car numbers, the place and cause and the number of minutes of any detention. They are made out in duplicate at the end of each trip. The original on white paper is handed to the inspector at the terminal and the copy on yellow paper is deposited in a box and is later sent to the road foreman of engines. The cause of detentions is given as specifically as possible, together with such information as will enable the inspector to readily locate the trouble.

The yellow copies received by the road foreman of engines are carefully examined by the air-brake and electrical inspector, who notes whether the motormen took the right procedure in remedying the trouble. In case they were unnecessarily long and evidently did not understand exactly what to do, he gives them instructions. All such detentions are called to the notice of the other motormen in order that they may be posted as to what to do in similar circumstances.

As a check on the reports the inspector examines the equipment reported and either o.k's the motorman's report or makes out a more complete one. In either case the motorman's report, and if there be one, the more complete report is sent to the foreman of electric cars at Camden. Even though there are no detentions the motorman makes out a defect slip, marking it o.k.

The conductors are also required to make out a regular report of all detentions, which is telegraphed to the train dispatcher at the end of each run. In addition he has a special form for reporting broken windows, seats and any defects about the car which do not come properly under the jurisdiction of the motormen. These reports are handed to the terminal inspector, who sees that the necessary repairs are made before the car goes out again. The train dispatcher makes out a report from the conductor's blanks which are sent each morning to the heads of departments. A list of all train detentions, due to motive-power failures, is made up from these sheets by the assistant electrical engineer and forwarded to the foreman of electric cars, foreman of power station and line foreman, who make a daily report of all failures with which they are concerned. From these reports a daily report is made up by the assistant electrical engineer and sent to the heads of the Motive Power Department at Jersey City and Altoona. At the end of the month a summary report of all motive-power failures is made up similar to that used in steam practice, which in turn is sent to the heads of Motive Power Department. This summary includes 59 different defects, giving the number of detentions each day for any particular cause together with total minutes lost. Totals are given for each day and for each cause and the delays are reduced to car-miles per detention and car-miles per minute detention.

In June this report showed 9 detentions with a total duration of 90 minutes, due to electrical equipment. This gave 32,529 car-miles per detention and 3252.9 car-miles per minute of detention. On July 4, which might be said to have been the first crucial test of the electrically equipped road, there was not a detention due to defects of electrical equipment. The car equipment is generally responsible for most of the detentions; occasionally, however, the third-rail and the power-house are at fault.

TRAIN OPERATION

The daily and Sunday time tables are followed closely and comparatively few extra trains are run, as the length of trains is made to vary with the traffic. At times when the number of passengers is uncertain a train of six cars is kept at the terminal. The rear cars are closed and as the front ones fill up the rear ones are opened one by one to accommodate the new arrivals. The length of trains consequently varies from one to six cars. During July the average length was 3 cars.

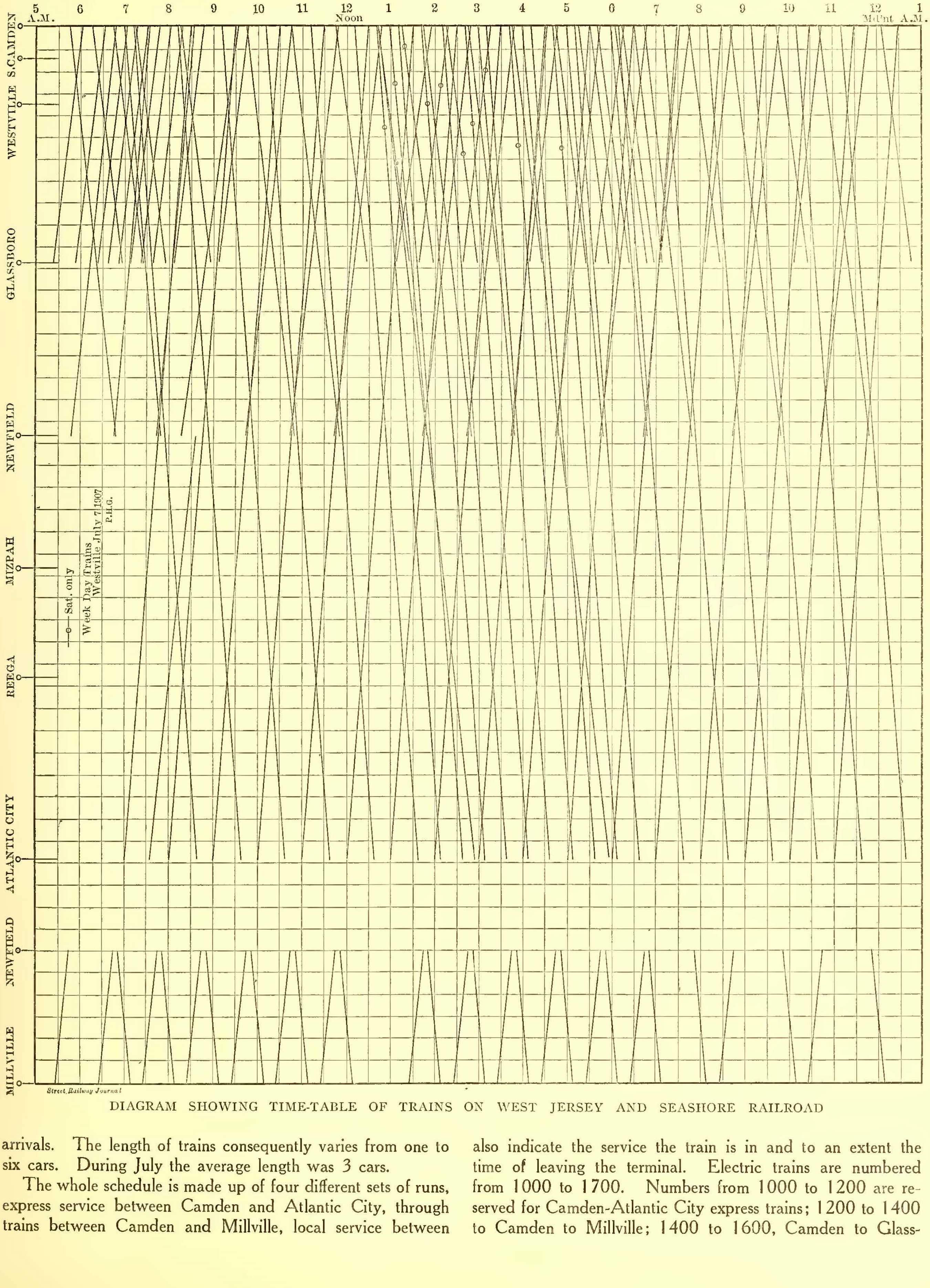


DIAGRAM SHOWING TIME-TABLE OF TRAINS ON WEST JERSEY AND SEASHORE RAILROAD

The whole schedule is made up of four different sets of runs, express service between Camden and Atlantic City, through trains between Camden and Millville, local service between Camden and Glassboro and local service between Atlantic City and Newfield.

For regular trains a system of numbers has been adopted such that the numbers distinguish electric from steam trains, and also indicate the service the train is in and to an extent the time of leaving the terminal. Electric trains are numbered from 1000 to 1700. Numbers from 1000 to 1200 are reserved for Camden-Atlantic City express trains; 1200 to 1400 to Camden to Millville; 1400 to 1600, Camden to Glassboro; and 1600 to 1700 to Atlantic City and Newfield trains. Eight numbers are reserved for each hour. This allows for eight trains out of one terminal per hour without changing the numbers of trains already scheduled. For example, the first train out of Camden in the morning is No. 1017 at 7 o'clock. The number of the 8 o'clock train is 1025 and the 9 o'clock one 1033. A train leaving near the half-hour has a number four greater than that of the train leaving the hour preceding. Extra trains take the number of the head car in accordance with the custom of numbering extra steam road trains from the locomotive number.

good indication of the amount of suburban traffic that has been established. This is all the year around travel made up largely of people going to and from their work in Philadelphia. Careful attention is being given to its development, as it holds up well throughout the year. The Camden-Atlantic City traffic is, of course, heaviest during the summer season. Last winter it fell to a point where trains were required every two hours only and usually the trains run were short ones.

TERMINALS

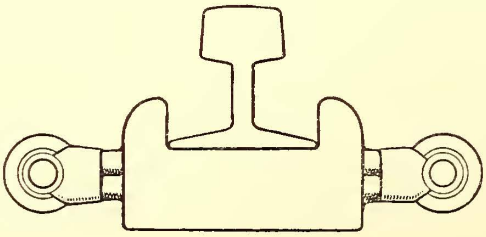
The only additional station facilities occasioned by the electrification was a five-track train shed at Camden adjacent to the steam train shed and a terminal at Atlantic City. Here a new passenger station, baggage-room and five-track train shed was built at some distance from the steam terminal.

	Distance.	Run Numbers.	Intermediate Stops.	Time Out for Stops, Minutes.	Average Speed.	Time in Minutes, Average Run.	No. Trips Sunday.	No. Trips Saturday.	No. Trips Week Day.	Train Mileage Sunday.	Train Mileage Saturday.	Train Mileage Week Day.
Camden to Atlantic City	....	1000	2	..	43	90	23	21	17	....	....	2196
	64.6	and	to	..	....	..	..	..	Mon. 16	2907	2490	Mon.
Atlantic City to Camden	....	1100	5	..	43	90	22	17	17	....	....	2132
Camden to Glassboro	....	1400	..	..	26.2	41	2	21	19	....	....	....
	17.9	and	14	..	....	..	..	..	..	74	700	645
Glassboro to Camden	....	1500	..	..	26.5	40	2	17	18	....	....	....
Camden to Millville	....	1200	..	..	28.6	84	11	15	15	....	....	....
	40.1	to	22	..	....	..	..	..	..	881	1203	1203
Millville to Camden	....	1300	..	..	29.3	82	10	15	15	....	....	....
Atlantic City to Newfield	....	....	..	17	34.5	60	3	3	3	....	....	....
	34.5	1600	16		....	..	..	..	..	203	207	207
Newfield to Atlantic City	....	....	..	21	32.3	64	3	3	3	....	....	....
					Total mileage					4065	4600	4251 Monday 4187

ANALYSIS OF TIME-TABLE OF TRAINS DURING SUMMER SEASON, WEST JERSEY AND SEASHORE RAILROAD

The table shown above gives an analysis of the time table for the summer season, and from this it may be noted that the Saturday and Sunday schedule varies from the week-day one. The difference consists primarily in increasing the number of through trains between Camden and Atlantic City on Sunday and decreasing the number of local trains between Camden, Glassboro and Millville. The increased number of trains on the through run to Atlantic City, however, is not a true indication of the increased number of passengers carried, as longer trains are run on Sunday than on week days. The extra trains on Sunday are run on the half-hour, as the regular week-day trains are run almost every hour from 7 a. m. to 11 p. m. The number of trains between Camden and Millville and particularly between Camden and Glassboro on week days is a

The five-track terminal at Camden has not yet been tested to its full capacity, although in a given time the electric trains have hauled as many passengers out of it as have been handled by the steam trains in the thirteen-track terminal adjoining. The fact that no switching is necessary and that an electric train is ready to go out again as soon as it has been unloaded and loaded decreases considerably the terminal station room required. The lessening of the time at terminals results also in better use of the equipment. On July 4 about the same number of people were hauled on the electric line as on the paralleling steam road with twice the number of cars.



OPERATING FEATURES OF THE ELECTRICALLY EQUIPPED SECTION OF THE ERIE RAILROAD

The recently electrified section of the Erie Railroad consists of 34 miles of single track of the Rochester division, extending due south from Rochester through Avon to Mt. Morris. The physical features of this single-phase road are fully described in another section of this issue. In brief, however, it may be said that the road is supplied with current from the high-tension lines of the Niagara, Lockport & Ontario Power Company.

The one transformer sub-station is located at Avon, 19 miles from the Rochester terminal and 15 miles from Mt. Morris. It supplies the entire line with power and contains three 750-kw 60,000 to 11,000-volt transformers, the lower voltage being that supplied to the trolley. The car barns are located at Avon, adjacent to the sub-station. The six motor cars are all equipped with the Westinghouse system of multiple unit control.

OPERATING FEATURES

The electrical section is operated as a portion of the Rochester Division, and has the same operating officers, with the exception that the electrical features are in charge of a Supervisor of Electric Service. Under this supervisor are eight men employed in the maintenance of the electrical apparatus. As the company supplying the power delivers the current to the sub-stations the railway company is not concerned with the operation and maintenance of the high-tension lines.

The sub-station is very economical with regard to the amount of labor required to operate it. Two car-house men, who work in 12-hour shifts, one at night and the other during the day, have charge of the sub-station and each does not usually devote more than an hour's time a day in caring for the sub-station. This time is spent in frequent inspections of the station, occasional cleaning of the apparatus, and changing the chart on the recording wattmeter once a day. This recording wattmeter is used in addition to an watt-hour meter to measure the energy supplied to the road. Up to the present no systematic plan of testing instruments has been inaugurated. However, the oil used in the transformer is tested and run through a dehydrater at intervals.

Although the cars are operated over a period of only 15 hours a day, under ordinary conditions, current is left on the trolley twenty-four hours a day and the sub-station switches are not disturbed except when for some reason it is desired to cut the current off the trolley. Since the beginning of operation there have been no breakdowns of sub-station apparatus or necessity of renewing parts, and it may be said that the sub-station practically runs itself.

THE TROLLEY

The trolley line is inspected once a day by an inspector who rides over the line on a regular train. In addition once a week a more thorough inspection is made by a man who either walks over the line or makes the trip on a bicycle car. This trip is made particularly to examine the condition of the poles. The inspectors are part of the regular trolley maintenance crew of three men. These men have their headquarters at Avon, and although they work regularly only 12 hours a day, they are within reach by telephone at all hours. Practically the only trouble that has been experienced with the trolley line has been the grounding of two or three strain insulators. Not one of the porcelain insulators on the line has broken down in service.

The line crews are provided with box cars fitted with platforms on the roofs. Repairs that are not urgent are made at night. At such times the power is shut off and the repair car is hauled over the road by a steam locomotive. When the lines are to be repaired at night the linemen simply notify the substation man to disconnect the current. It is a fixed rule that after current is once cut off it is not to be put on again until 6 o'clock in the morning, but that it will be put on at this time unless special word not to do so is received from the linemen. To guard against possible accident the trolley is always grounded by the men working on it.

Section switches are located at five points on the line or about 5 miles apart. These switches are opened and closed by the station agents nearest them only on orders from the electrical supervisor. Up to the present time bonds have not been tested but they are examined by the regular track walkers and when found in bad order repairs are made by the regular line crew.

Steam trains operate under the trolley, but several careful examinations have failed to disclose any corroding effect on the trolley and messenger wires due to the gases from the locomotives.

CAR MAINTENANCE

The car shops at Avon themselves contain no tools or machinery, but they are located adjacent to the Avon round-house, which possesses some facilities for making repairs. However, the shops are fitted with an arrangement for changing trucks. Between two of the tracks there is a shallow pit containing a transfer table large enough to hold one truck and provided with a section of track. When trucks are to be changed the car is placed so that the truck is on the transfer table. The car is then jacked up and the transfer table with the defective truck is pushed out sideways and the truck runs off on the adjacent track.

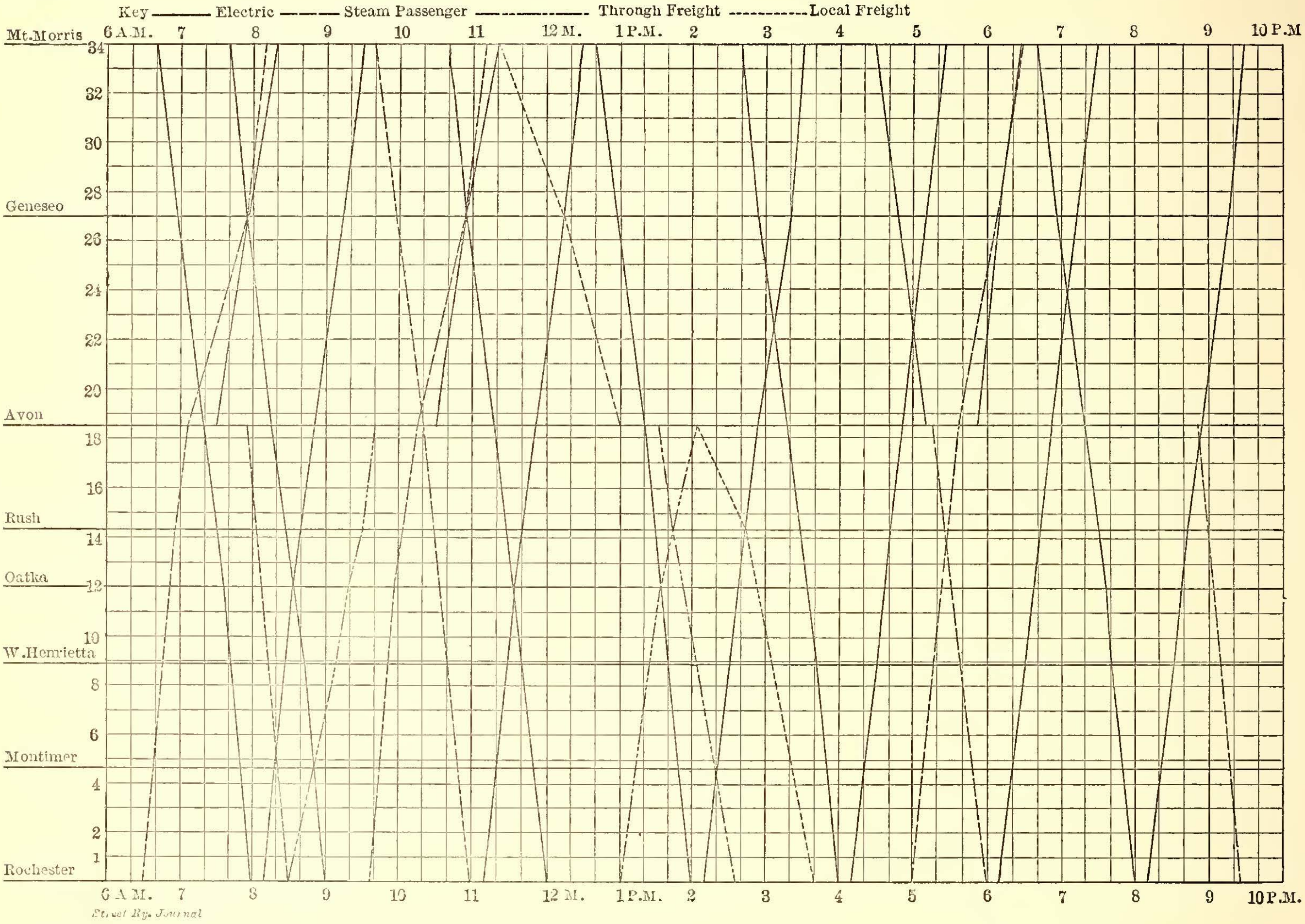
Up to the present time there has been no occasion for extensive repairs to cars, in fact, the only work done on them, which could not be classed as inspection work, has been the replacement of contact tips and trolley shoes.

Cars are brought in for inspection on an 800-mile basis. At this time the motors and all of the control apparatus and the air motor are blown out with compressed air, the motor brushes are taken out of the holders and examined, and the electrical apparatus in general gets a thorough examination, cleaning and oiling. All of the motor bearings are supplied with oil wells in which the height of the oil can be determined. The height is gaged at each inspection and oil is kept at the proper level by additions whenever required. Journal bearings get half a pint of oil each at inspections in addition to a small amount of oil put in them each day at the terminals.

About 10,000 miles wear is gotten out of the pantograph trolley shoes. These trolleys are kept on the wire with a tension of 8 lbs., the tension being tested with a spring balance at every inspection. The shoes are lubricated with graphite and vaseline once a day. Up to the present time copper shoes have been used, but steel shoes are now being substituted. About two hours' time of one man is required to change trolley shoes.

Cars are cleaned by the mechanical department at the Rochester terminal. All the car-barn work is done by two day men and one night man, and two of these men spend a portion of their time in the sub-station, as has already been mentioned.

Some of the minor defects to cars are taken care of by two inspectors, one located at each terminal, who go over the cars at the end of each trip. They are aided in this work by detention reports filled out by the motormen and conductors. These reports are made out in duplicate, one copy going to the terminal inspector and another copy to the supervisor of electric service. Spaces are provided on them for the car number and the length, place and cause of the detention. The inspector on examining the equipment either endorses his approval of the report or sends it with a more complete account of the defect to the supervisor. In all cases the defect is repaired at the terminal if this is possible.



GRAPHICAL TIME-TABLE OF THE TRAINS ON THE ROCHESTER BRANCH OF THE ERIE RAILROAD

TRAINING OF MOTORMEN

Old engineers only are employed as motormen. After an engineer has made application for a position on an electric train he is given personal instruction regarding the electrical equipment by the supervisor and an instruction book gotten up especially for the equipment aids him in getting a knowledge of the apparatus. After he has become, in the judgment of the supervisor, sufficiently familiar with the apparatus, he is required to make several trips with a regular motorman and is then given a run.

SCHEDULES

Four classes of trains operate over the electrified section—electric trains which are first class, steam passenger trains or second class, through freight or third class, and way freight trains or fourth class. The only steam passenger trains run are those which continue beyond the electrical section. As first-class trains the electric cars have right of way over all steam trains. In all other cases the general rules for train operation of the Erie Railroad apply. No trouble whatever has been experienced because of the mixed service. As the operation of four classes of trains over a single-track line is necessarily a complicated proposition, and as the Erie conditions are typical of a vast majority of roads in the United States, a graphical timetable of the line is presented on this page. Particulars will also be given of the block signal system under which the trains operate and are passed at the different switches.

BLOCK SIGNAL SYSTEM

The electric division is protected by a positive manual block signal system operated in accordance with the standard code of the American Railway Association. There is a total of eleven signal stations and the blocks consequently average about 3 miles long. Some of the signal stations are located at regular way stations, and in most cases of this kind the regular agent operates the signals. The signal towers at other points are in charge of men working in twelve-hour shifts. The telephone is used instead of the telegraph or the bell signal system, for communicating between signal stations, so that there is no necessity for the tower men to be telegraph operators, and usually they are not.

All switches are electrically locked and are controlled from the nearest tower. This makes it impossible for a train to move off a siding on to the main track without the knowledge of the operator.

The operation of trains is in charge of a chief despatcher located at Rochester. He, of course, supplies the motorman or engineer with train orders on leaving, and under ordinary conditions this train is blocked through without further orders. The block operators know the schedule of the train and as the time for it approaches each operator telephones the next operator ahead, asking whether or not the block is clear. The first operator sets his signals in accordance with the reply, and if the block is clear the second one sees that the stop signal is set for opposing trains. The signals, however, automatically return to the stop position. Trains off schedule are blocked through in the same manner. The telephone is not employed in giving train orders, and where it is necessary for any reason to give orders of this kind, they are received by the motorman or engineer and conductor at regular way stations from the telegraph operators at these points.

The term "positive" block signal system carries with it the idea that only one train will be admitted to a block at a time, and does not permit of the free use of "permissive" orders whereby a train may be permitted to follow another one into a block before the first one has cleared the block. Permissive orders are given only by the chief despatcher, and are given only in case of wreck or some very unusual occurrence. When they are given, a detailed account of the circumstances by which they are occasioned accompanies them.

All block signal operators are required to keep block sheets of the usual form which gives the times of the passage of the trains together with the train numbers.

TRAIN SERVICE

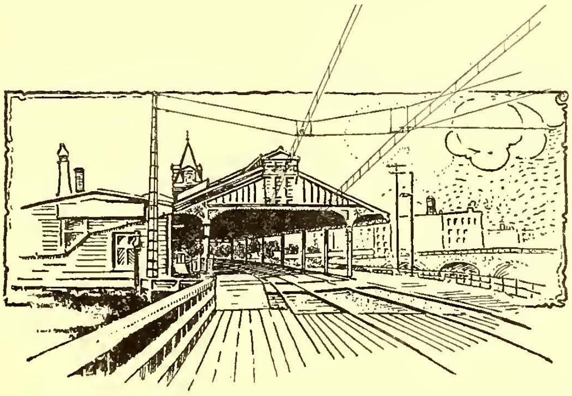
The daily electric train mileage is approximately 500 miles on week days and 400 miles on Sundays. On week days one train makes six and another four round trips between Mt. Morris and Rochester. A third train makes one round trip between terminals and in addition two round trips between Avon and Mt. Morris. On Sunday the two trains operated each make three round trips between terminals.

The schedule is somewhat irregular, but on week days it approximates a two-hour service for twelve hours a day. The run between terminals, 34 miles, is made in one hour and twenty minutes. There are six regular stops and in addition twenty-two other signal stops. The steam trains which make only the regular stops are scheduled at approximately the same speed as the electric trains.

The electric trains vary from one to four cars in length, but in ordinary service one and two-car trains are run. Two-car trains are usually made up of a motor car and a standard steam coach as a trailer. Longer trains contain two motor cars. In general it may be said that the length of trains varies with the traffic, for at terminals trailers are kept behind motor cars and are either left behind or coupled up as the service requires.

The train crew of single cars consists of a motorman and conductor, but two-car trains carry a brakeman in addition, and a brakeman is always carried when there is baggage to be handled.

The notable feature in the operation of the electrical division is the few men required to operate and maintain the electrical apparatus. The alternating current sub-station, of course, eliminates a great deal of labor, as does also the absence of trouble on the line or with the car apparatus.



OPERATING FEATURES OF THE FIFTY-NINTH STREET STATION OF THE INTERBOROUGH RAPID TRANSIT COMPANY

The Interborough Rapid Transit Company operates two generating stations, one at Fifty-Ninth Street and North River, for the subway system, and another at Seventy-Fourth Street and East River, for the Elevated lines. As superintendent of motive power of the Interborough system H. G. Stott has charge of both stations, and the engineers immediately under him divide their time between the two. The same general practice is consequently followed in the operation of both plants except where different practice is necessitated by differences in design. The operating features of the Fifty-Ninth Street station are therefore representative of the Interborough Company's central station practice.

The construction of this station was described by John Van Vleck in a contributed article in the Street Railway Journal of Oct. 8, 1904, so will not be taken up here. It is sufficient to say the station is built on the unit system. Each section consists of twelve boilers, two reciprocating engine driven units, two condenser equipments, boiler feed pumps and smoke flue systems. This sectionalizing system is carried out for the five sections installed, with the exception that one of the reciprocating engine units is substituted by three 1250-kw turbines.

COAL

Pennsylvania semi-bituminous coal is used exclusively and is bought and delivered under printed specifications which require that it be delivered by water in self-trimming lighters containing at least 700 tons. According to the specifications, "Coal must be a good steam, caking, run of mine, bituminous coal, free from all dirt and excessive dust, a dry sample of which will approximate the company's standard in heat value and analysis as follows:"

Carbon	71	per cent
Volatile matter	20	" "
Ash	9	" "
Sulphur	1.50	" "
B. T. U.	14250	" "

Samples for analysis are obtained from each lighter by taking a quantity from each weighing hopper. The bulk so obtained is crushed and quartered successively to about ten pounds and placed in a box. Other bulks obtained while the lighter is being unloaded are treated in a similar manner, and finally the entire bulk obtained is crushed and quartered to a two-pound sample. This is afterwards pulverized and submitted to chemical analyses by the company's chemist. The analyses are made in accordance with the standard adopted by the American Chemical Society, and the results of the analysis made each day are sent to the station on special blanks at the end of each week. Samples for moisture determination are taken from the sample bulk before it is finally crushed and quartered.

The price to be paid by the company varies from the contract price in accordance with the moisture b. t. u., ash, sulphur and volatile matter values as shown by analysis. Roughly, one cent per ton is deducted from or added to the price for each variation of 50 b. t. u. below or above the standard value. Deductions are also made for excessive amounts of moisture, volatile matter, ash and sulphur.

One of the two coal handling plants consists of a movable electric hoisting tower on the dock, containing a crusher and weighing apparatus. A clam shell type bucket of 44 cu. ft. capacity, operated by a 200-hp motor, elevates the coal from the lighters to the crusher. The other coal handling plant is entirely steam driven. After being weighed the coal falls on belt conveyors and is carried to the bunkers. Seven men are required to operate the plant at a rate of 185 tons per hour.

The bunkers usually contain about 7500 tons. The station is operated on 2.38 lbs. of coal per net kw-hour output. The bunkers are cleaned out thoroughly once in four months, and very little trouble has been experienced from fires in them. When fires do occur the coal is drawn and burned out as fast as possible. An arrangement for transferring coal makes it possible in the event of fire or other emergency to take that from any one bunker and distribute it to all of the boilers.

BOILER ROOM PRACTICE

The boiler installation, which consists of sixty 600-hp Babcock & Wilcox water-tube boilers, is on one deck. All are provided with Roney automatic stokers. Ashes are discharged into hoppers underneath the furnaces, and thence into ash cars on the basement floor. Sturtevant fuel economizers are located on the floor above the boiler room and over the rear end of the boilers.

The boiler force consists of one water tender, two stoker operators and two assistant stoker operators to every set of eight boilers. During the day the second assistant engineer is in charge of the boiler room, and there is in addition a watch engineer for each watch. The boiler room force, as well as all the men of the steam department, work in eight-hour shifts, the changes being made at 8 a. m., 4 p. m. and 12 midnight.

The high peak loads and the periods of very low loads necessitate the number of boilers in service and the rate of firing these to be varied greatly during different portions of the day. To provide for the irregular demands for power the number of boilers required to be kept in reserve and to be kept banked is rather large. Usually the monthly report shows the number of banked boiler hours to be approximately half the number of service hours, and in addition the number of reserve hours is near one-third that of the service hours. An idea of the coal consumption occasioned by the irregular firing may be obtained from the fact that a banked boiler requires 150 lbs. of coal per hour. The reserved boilers, of course, require considerably more.

The irregularity of the load moreover allows the boilers to be fired at their most economical rating, which is the full load rating, for only about six hours in twenty-four. During the peak load they are fired 35 to 50 per cent above rating, and during the early morning hours they are just kept alive. Over a twenty-four-hour period the average rate of firing for the active boilers is about 80 per cent.

Firing conditions will be considerably improved by the installation of a duplicate set of stokers under the rear of the boilers. The installation is now being made, and when completed the boilers may be fired during the peak load at double their rated capacity. This will, of course, decrease the number of banked and reserved boilers required.

Draft on the fires is controlled by dampers placed in each boiler uptake. The automatic feature of these dampers has been discarded, and they are now regulated by hand. Attempt is made to keep the draft at .25 in. for a boiler working under average conditions, as it has been found by a long series of experiments that with the coal used this gives the most economical results. The dampers are not changed, but the furnace doors are closed when a boiler is banked or reserved. The draft of .25 in. is cut down about .05 in. by the drop in the economizers.

Flue gases leave the boiler at about 480 degs. and the economizer at approximately 320 degs. A CO_2 recorder installed has connections to all of the boiler uptakes, and the analysis of the gases shows from 10 to 14 per cent of CO_2 under normal conditions. Indications as high as 17 per cent have been made for all-day periods.

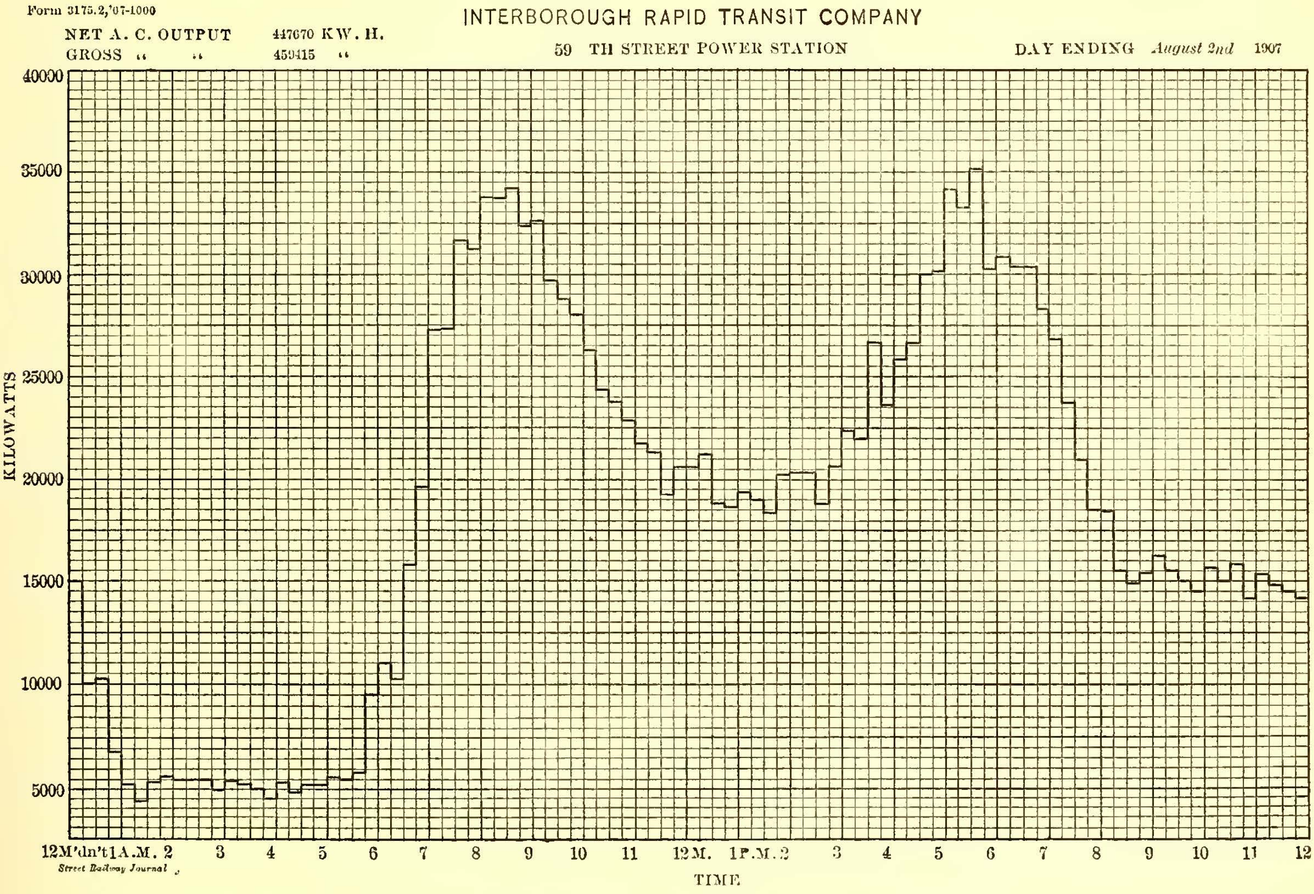
As a check upon the firemen and as a precaution against smoking chimneys a man stationed on the dock watches the smoke stacks, and when smoke is observed notifies the firemen of that section of the boiler house by means of an electric signalling system, and they at once remedy the cause. The watchman sends in his report on a special blank, which gives the time the stacks were observed to be smoking and also the names of the stoker operators on each watch.

The exterior of the boiler tubes are blown off with steam every watch, or, in other words, at eight-hour intervals. The interior of each boiler gets a general cleaning once a year, and this requires the time of two men for four days. The deposit on the tubes, which is largely calcium sulphate, varies from practically none in the bottom portion up to a coating of 1/8 in. thick on the top rows of tubes. An air-driven turbine tube cleaner is employed in the work. In addition every two months the bottom rows of tubes and the mud drums are cleaned, and at intervals of three weeks the boilers are emptied and enough feed water is injected into them to wash out any loose sediment. At such cleaning the fires are allowed to go out 12 hours before emptying, so that the boilers are practically cool when flushed. The boilers are never blown down, as frequent washing removes the necessity of doing so.

When the station was erected forty-eight boilers were equipped for hand firing, arrangements being made, however, to install automatic stokers should it be deemed advisable. The fact that hand firing with anthracite coal did not permit the boilers to respond to the sudden fluctuations of load was largely responsible for the abandonment of hand firing altogether.

FEED WATER, ECONOMIZERS AND CONDENSERS

All of the condensers are of the barometric type, and all of the boiler feed water is obtained from the city mains. Untreated water is used, but it is probable that chemical treatment will be adopted. This treatment will, of course, eliminate to a great extent the mechanical cleaning of the boilers.

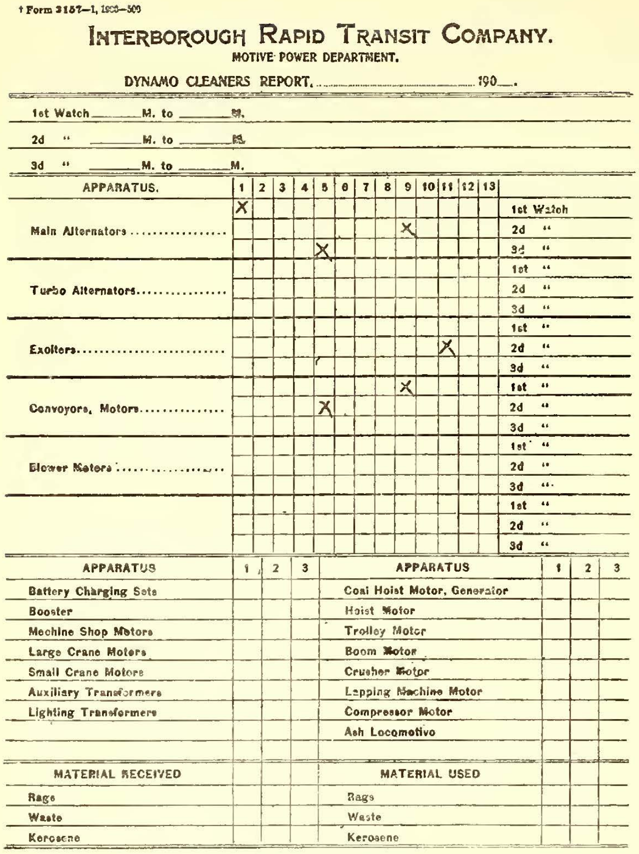


TYPICAL WEEK-DAY LOAD OF 59TH STREET POWER STATION

Water from the city mains is piped into open type feed water heaters and thence into storage tanks, and from the tanks it is fed through the economizers to the boilers. The feed water heaters add 50 degs. to the temperature of the water, which is received from the mains at about 60 degs., and the economizers add about 100 degs., so that the water is fed into the boilers at about 210 degs. The efficiency of the economizers, it may be seen, is rather high, and reduces the coal consumption approximately 10 per cent.

Automatic regulators on the boiler feed pumps keep the feed line pressure at about 20 lbs. above the boiler pressure, and the feed to each boiler is regulated by the water tender.

The economizers are arranged to be operated either in multiple or series. The customary practice, however, is to operate them in series or to make all water for a unit of three boilers pass through all of them in succession, as by so doing



† Form 3157—1, 1903—500

INTERBOROUGH RAPID TRANSIT COMPANY.
MOTIVE POWER DEPARTMENT.

DYNAMO CLEANERS REPORT, ... 190__.

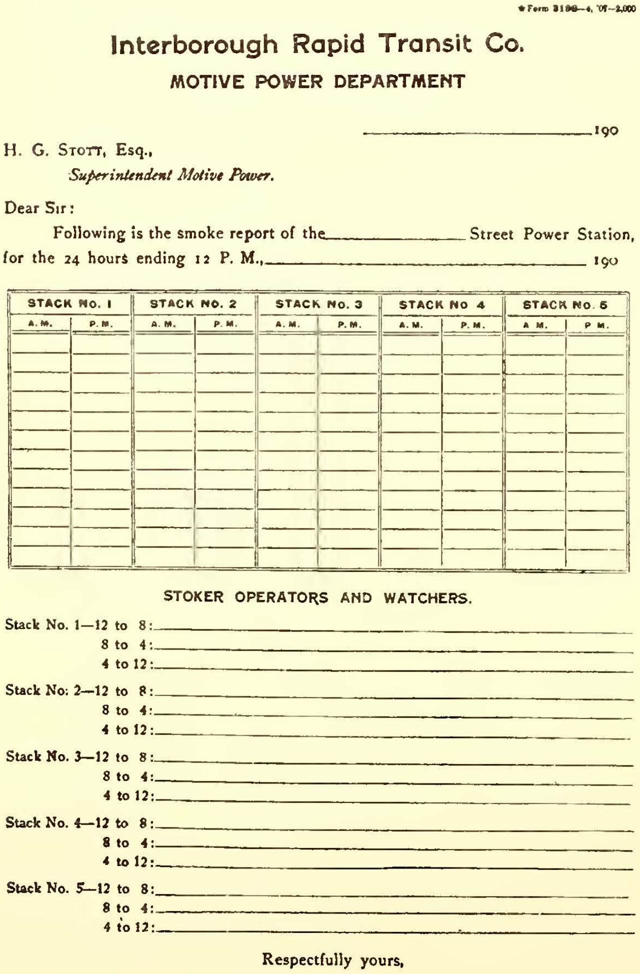
1st Watch ________M. to ________M.
2d " ________M. to ________M.
3d " ________M. to ________M.

APPARATUS.	1	2	3	4	5	6	7	8	9	10	11	12	13	
Main Alternators	X													1st Watch
									X					2d "
					X									3d "
Turbo Alternators................														1st "
														2d "
														3d "
Exciters..........................														1st "
											X			2d "
														3d "
Conveyors, Motors...............									X					1st "
					X									2d "
														3d "
Blower Motors														1st "
														2d "
														3d "
														1st "
														2d "
														3d "

APPARATUS	1	2	3	APPARATUS	1	2	3
Battery Charging Sets				Coal Hoist Motor, Generator			
Booster				Hoist Motor			
Machine Shop Motors				Trolley Motor			
Large Crane Motors				Boom Motor			
Small Crane Motors				Crusher Motor			
Auxiliary Transformers				Lapping Machine Motor			
Lighting Transformers				Compressor Motor			
				Ash Locomotive			
MATERIAL RECEIVED				MATERIAL USED			
Rags				Rags			
Waste				Waste			
Kerosene				Kerosene			

MISCELLANEOUS.

DYNAMO CLEANER'S REPORT



* Form 3190—4, '07—2,000

Interborough Rapid Transit Co.
MOTIVE POWER DEPARTMENT

______________________190

H. G. STOTT, Esq.,
Superintendent Motive Power.

Dear Sir:

Following is the smoke report of the______________Street Power Station, for the 24 hours ending 12 P. M.,______________________190

STACK NO. 1		STACK NO. 2		STACK NO. 3		STACK NO 4		STACK NO. 5	
A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.	A. M.	P. M.

STOKER OPERATORS AND WATCHERS.

Stack No. 1—12 to 8:______________________
8 to 4:______________________
4 to 12:______________________

Stack No. 2—12 to 8:______________________
8 to 4:______________________
4 to 12:______________________

Stack No. 3—12 to 8:______________________
8 to 4:______________________
4 to 12:______________________

Stack No. 4—12 to 8:______________________
8 to 4:______________________
4 to 12:______________________

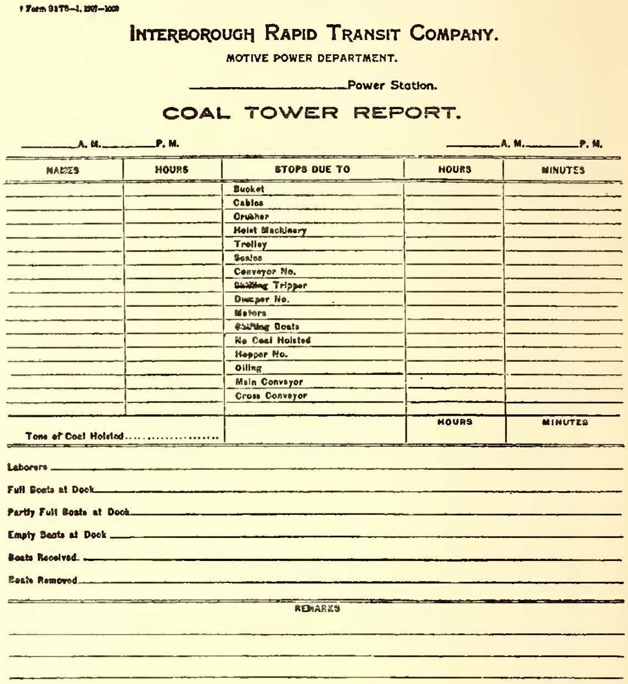
Stack No. 5—12 to 8:______________________
8 to 4:______________________
4 to 12:______________________

Respectfully yours,

STOKER'S REPORT

the velocity of the water in the tubes is so high that the scouring effect on the tubes tends to keep them clean. If, under heavy loads, too much pressure is lost by this series operation they may be thrown into multiple by opening and closing proper valves without interrupting the feed to the boilers. The interior of the tubes are cleaned once a year and accumulated dust is drawn off through the lower soot doors once a month.

Condenser water is obtained from North River through concrete flumes. These terminate below the low-tide level,



† Form 3178—1, 1907—1000

INTERBOROUGH RAPID TRANSIT COMPANY.
MOTIVE POWER DEPARTMENT.

______________________Power Station.

COAL TOWER REPORT.

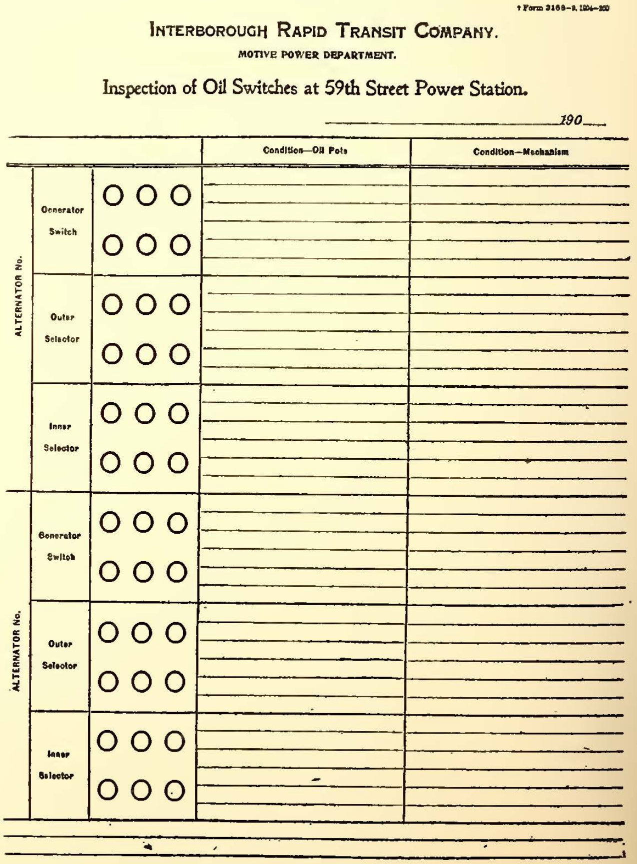
________A. M.________P. M. ________A. M.________P. M.

NAMES	HOURS	STOPS DUE TO	HOURS	MINUTES
		Bucket		
		Cables		
		Crusher		
		Hoist Machinery		
		Trolley		
		Scales		
		Conveyor No.		
		Shifting Tripper		
		Dumper No.		
		Motors		
		Shifting Boats		
		No Coal Hoisted		
		Hopper No.		
		Oiling		
		Main Conveyor		
		Cross Conveyor		
Tons of Coal Hoisted......................			HOURS	MINUTES

Laborers ______________________________
Full Boats at Dock______________________________
Partly Full Boats at Dock______________________________
Empty Boats at Dock ______________________________
Boats Received______________________________
Boats Removed______________________________

REMARKS

COAL REPORT



† Form 3169—9, 1904—200

INTERBOROUGH RAPID TRANSIT COMPANY.
MOTIVE POWER DEPARTMENT.

Inspection of Oil Switches at 59th Street Power Station.

______________________190__

			Condition—Oil Pots	Condition—Mechanism
ALTERNATOR No.	Generator Switch	○ ○ ○ ○ ○ ○		
	Outer Selector	○ ○ ○ ○ ○ ○		
	Inner Selector	○ ○ ○ ○ ○ ○		
ALTERNATOR No.	Generator Switch	○ ○ ○ ○ ○ ○		
	Outer Selector	○ ○ ○ ○ ○ ○		
	Inner Selector	○ ○ ○ ○ ○ ○		

OIL SWITCH REPORT

so that no trouble is occasioned by blocking of the intake with ice. The screens at the river end of the flume are raised and cleaned once a day by three men, who spend about one hour in the work.

The average vacuum carried is 27¾ ins. The temperature of the condenser water, which is supplied in the proportion of about 45 to 1, is about 45 degs. in winter and in summer 60 degs. In summer the temperature of the discharge is approximately 110 and in winter 100 degs. The condensers require no cleaning whatever. The pumps are started against a head of about 45 ft., but the vacuum in the condensers reduces the effective head to about 15 ft.

OILS

The practice of requiring oil furnished to conform to a specified formula of ingredients has been abandoned, partly because good and bad oils sometimes showed ingredients so nearly in the same proportion that chemical analysis did not indicate the difference. Results are now specified, and a certain wear and appearance of the bearing are required.

The engine bearings are flooded with oil under about 30 lbs. pressure from a central oiling system containing about 10,000 gals. The amount circulated per hour varies with the number of engines in service, there being 200 gals. circulated per hour for each large unit operated. About 50 gals. of oil are lost out of the system per day, some of this being drawn off in filtering the oil and the remainder being lost in leakage.

The oil, after being filtered through canton flannel bags, is passed slowly through a tank provided with barriers, which necessitate it flowing first to the top of the tank and then to the bottom. The finer impurities are precipitated to the bottom of the tank. This precipitate and the water carried into the filters with the oil are cleaned out each day. The bag trays are made in duplicate so that the oil may be diverted from one to the other, while the bags of one tray are being cleaned. The bags are washed each day in the power house laundry.

TURBINE PRACTICE

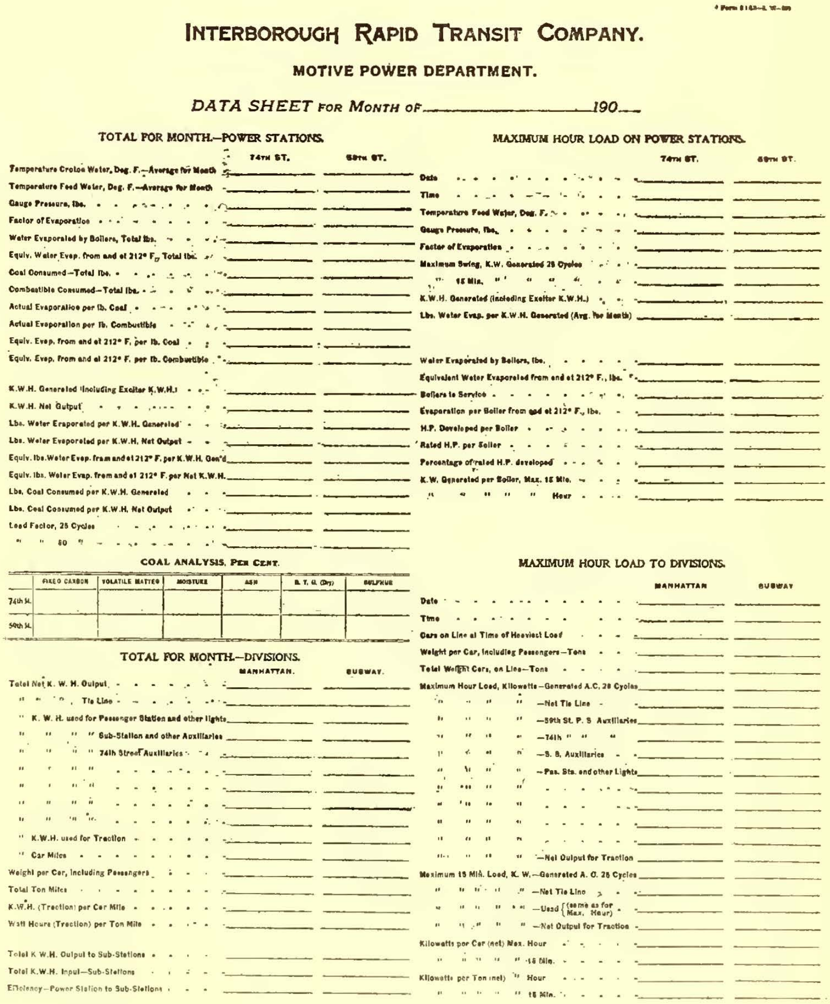
The station is provided with three 1250-kw Westinghouse turbo-generator units used for lighting the subway. Maintenance cost of these turbines and of those in the Seventy-Fourth Street station of the company, in comparison with the reciprocating engines, show ten to one in favor of the turbines. In arriving at these results actual maintenance figures were taken, and those for the turbines were multiplied by the proportional capacity of the reciprocating engines to turbines. The operating force required per kw capacity for the turbines is about one-fifth that required for the reciprocating engines. It is the practice to open up the turbines and examine the blades at intervals of six months. The only duplicate parts of the turbines kept in stock are some governor parts.

The average load factor on the turbines in the Fifty-Ninth Street station is only about 75 per cent of full load, and the maximum overload carried is about 50 per cent. To determine their most economical loading, overloads up to 70 per cent have been carried on the turbines, and at this load the best showing was made. Further loading was prohibited by the heating of the generator.

About one-half hour is required to warm up a cold turbine, but as valve leakage usually keeps them warm they can be started up and gotten under load in an emergency in about five minutes. The reciprocating engines have the advantage with respect to time required in starting, as it is the common practice to get them under load from a standstill in two minutes, and it has been done in 45 seconds.

SWITCHBOARD

The control and instrument boards are located on the second gallery above the engine room floor, and speaking tubes, telephones, red lights and whistles are employed as means of communication between the men in the gallery and the engineers and floor men. When a unit is to be started the engineer is usually called to the telephone by a whistle and given the necessary instructions. After the engine has been started the switchboard operator informs the engineer that the generator has been cut in by closing the circuit through a red light on the engine. Each engine, moreover, is provided with an indicating wattmeter which enables the engineer to note the load. One engine is kept ready for any emergency and is indicated by a metal sign hung on it. A special whistle signal signifies that this engine is to be gotten up to speed as quickly as possible, and when this signal is given the engineer gets the engine ready for load without any further instructions. After the engine has been started the emergency sign is transferred to another unit.



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INTERBOROUGH RAPID TRANSIT COMPANY.

MOTIVE POWER DEPARTMENT.

DATA SHEET FOR MONTH OF ________________ 190__

TOTAL FOR MONTH.—POWER STATIONS.

	74TH ST.	59TH ST.
Temperature Croton Water, Deg. F.—Average for Month		
Temperature Feed Water, Deg. F.—Average for Month		
Gauge Pressure, lbs.		
Factor of Evaporation		
Water Evaporated by Boilers, Total lbs.		
Equiv. Water Evap. from and at 212° F., Total lbs.		
Coal Consumed—Total lbs.		
Combustible Consumed—Total lbs.		
Actual Evaporation per lb. Coal		
Actual Evaporation per lb. Combustible		
Equiv. Evap. from and at 212° F. per lb. Coal		
Equiv. Evap. from and at 212° F. per lb. Combustible		
K.W.H. Generated (Including Exciter K.W.H.)		
K.W.H. Net Output		
Lbs. Water Evaporated per K.W.H. Generated		
Lbs. Water Evaporated per K.W.H. Net Output		
Equiv. lbs. Water Evap. from and at 212° F. per K.W.H. Gen'd		
Equiv. lbs. Water Evap. from and at 212° F. per Net K.W.H.		
Lbs. Coal Consumed per K.W.H. Generated		
Lbs. Coal Consumed per K.W.H. Net Output		
Load Factor, 25 Cycles		
" " 60 "		

COAL ANALYSIS, PER CENT.

	FIXED CARBON	VOLATILE MATTER	MOISTURE	ASH	B. T. U. (Dry)	SULPHUR
74th St.						
59th St.						

TOTAL FOR MONTH.—DIVISIONS.

	MANHATTAN.	SUBWAY.
Total Net K. W. H. Output		
" " " Tie Line		
" K. W. H. used for Passenger Station and other lights		
" " " " Sub-Station and other Auxiliaries		
" " " " 74th Street Auxiliaries		
" " " "		
" " " "		
" " " "		
" " " "		
" K.W.H. used for Traction		
" Car Miles		
Weight per Car, Including Passengers		
Total Ton Miles		
K.W.H. (Traction) per Car Mile		
Watt Hours (Traction) per Ton Mile		
Total K.W.H. Output to Sub-Stations		
Total K.W.H. Input—Sub-Stations		
Efficiency—Power Station to Sub-Stations		

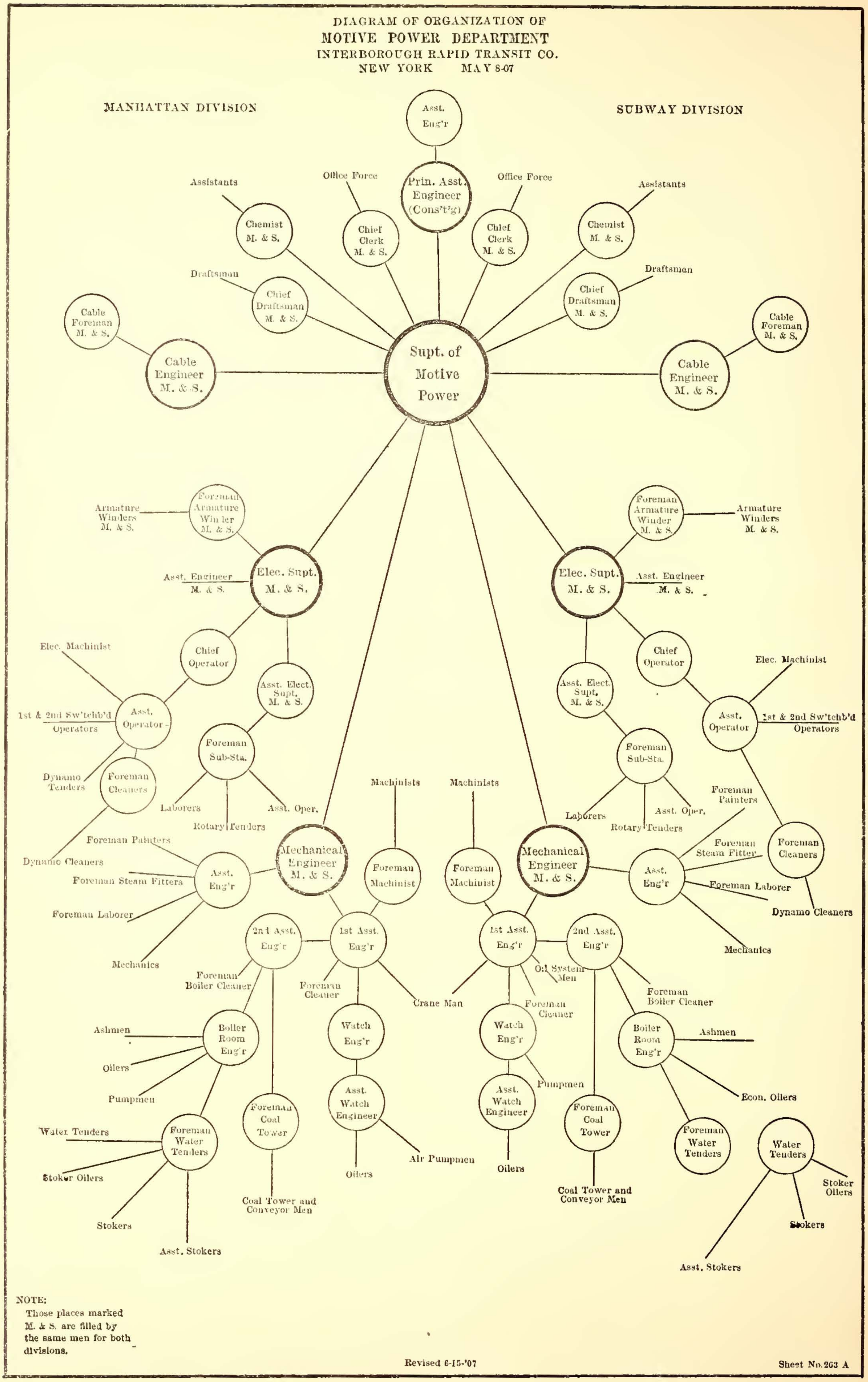
MAXIMUM HOUR LOAD ON POWER STATIONS.

	74TH ST.	59TH ST.
Date		
Time		
Temperature Feed Water, Deg. F.		
Gauge Pressure, lbs.		
Factor of Evaporation		
Maximum Swing, K.W. Generated 25 Cycles		
" 15 Min. " " " "		
K.W.H. Generated (Including Exciter K.W.H.)		
Lbs. Water Evap. per K.W.H. Generated (Avg. for Month)		
Water Evaporated by Boilers, lbs.		
Equivalent Water Evaporated from and at 212° F., lbs.		
Boilers in Service		
Evaporation per Boiler from and at 212° F., lbs.		
H.P. Developed per Boiler		
Rated H.P. per Boiler		
Percentage of rated H.P. developed		
K.W. Generated per Boiler, Max. 15 Min.		
" " " " " Hour		

MAXIMUM HOUR LOAD TO DIVISIONS.

	MANHATTAN	SUBWAY
Date		
Time		
Cars on Line at Time of Heaviest Load		
Weight per Car, Including Passengers—Tons		
Total Weight Cars, on Line—Tons		
Maximum Hour Load, Kilowatts—Generated A.C. 25 Cycles		
" " " " —Net Tie Line		
" " " " —59th St. P. S. Auxiliaries		
" " " " —74th " " "		
" " " " —S. S. Auxiliaries		
" " " " —Pas. Sts. and other Lights		
" " " "		
" " " "		
" " " "		
" " " "		
" " " " —Net Output for Traction		
Maximum 15 Min. Load, K. W.—Generated A. C. 25 Cycles		
" " " " " —Net Tie Line		
" " " " " —Used {(same as for Max. Hour)		
" " " " " —Net Output for Traction		
Kilowatts per Car (net) Max. Hour		
" " " " " 15 Min.		
Kilowatts per Ton (net) " Hour		
" " " " " 15 Min.		

MONTHLY DATA SHEET



Street Railway Journal

DIAGRAM OF ORGANIZATION OF MOTIVE POWER DEPARTMENT, INTERBOROUGH RAPID TRANSIT COMPANY, NEW YORK

Special precautions are taken by the men inside the station and those outside to insure against injury to workmen on the high-tension apparatus. Before working on a high-tension switch or cable it is tested by means of a ground wire provided with a long, high-tension fuse on the end of a stick. The fuse protects the apparatus and the workman in the event of the line being alive. Afterwards the line is well grounded, both at the station and sub-station, and these grounds are not removed until the sub-station operator and the switchboard man in the power station are properly notified by the linemen.

The switchboard is in a comparatively clean place, and it is only necessary to brush the dust off the parts once in about two weeks. At six-month intervals it is cleaned thoroughly. One man in the power station gives all his time to the inspection and maintenance of switches, which are inspected every day, and every two weeks they are gone over carefully. The oil pots are opened and inspected after every short circuit or blow out, but otherwise these are left without attention for a year. Reports of oil switch inspections are made on special blanks, upon which the oil pots of the switches are indicated by circles. When pots are inspected the corresponding circles on the reports are marked. These inspection sheets are kept on file by the chief operator.

Switchboard instruments are calibrated and taken care of by the company's regular testing department. Wattmeters and other important instruments are calibrated and corrected once a month, while the less important ones, including feeder ammeters, are tested at three-month intervals. All of the instruments are tested on the switchboard in their regular position. The switchboard in the power station is so arranged that a spare panel may be substituted whenever the instruments of one section are to be tested.

STORAGE BATTERIES

One battery is installed for exciting the generators in emergency, and another smaller one is provided for operating the oil switches and other control apparatus. One man gives all of his time to the care of these batteries. They are overcharged once each week, and during the remainder of the week they are brought down about 15 points in gravity. Pilot cell readings are taken every hour, and each week voltage and specific gravity readings are taken of each cell. A duplicate of these readings is sent to the storage battery manufacturers. Water for the batteries is distilled in the power station. The generators are usually excited from motor generator exciters across which the large storage battery is floated. In an emergency the battery will continue to excite the generators for about two hours.

REPAIR METHODS

A machine shop is located on one of the galleries, and all of the repairs are made by the station repair force. A winding room is provided for making armature and field repairs. Spare armature and field coils are kept for the larger generators and for the auxiliary motors, of which there are about 150 in and around the station. A very heavy stock of repair parts are kept in the store room. For engines the parts carried include spare pistons, rods, valves and in fact a sufficient number of parts to equip an extra unit.

HANDLING SUPPLIES

On the 10th of each month the motive power department makes a requisition on the general store room of the company for operating supplies required for the following month. The materials are then delivered to the store room on the first of the following month. For those required within a week's time special emergency requisitions are made. All supplies are received at the power station by the storekeeper, and store-house orders are made on him as they are required.

ORGANIZATION OF OPERATING FORCE

The mechanical and cable engineers, the electrical superintendent and all those operating men who report direct to Mr. Stott fill similar positions for both the Manhattan and the subway divisions. In general it might be said that the mechanical engineer has under him all those men concerned with the operation of the station from the coal to the generators.

In addition to having charge of the generators and all of the electrical apparatus in the stations the electrical superintendent is responsible for the maintenance and operation of the high-tension feeders and the sub-stations. The first assistant engineer, who is under the mechanical engineer, has immediate charge of the operating room, and the second assistant engineer under him has charge of the boiler room and coal handling.

The chief operator under the electrical superintendent is held immediately responsible for the operation and maintenance of the electrical apparatus in the station. The switchboard force under the electrical superintendent consists of a chief operator, three assistant operators and a first and a second switchboard man. The assistant operator is on duty during the day watch only.

POWER STATION LOGS AND RECORDS

The greater portion of the operating data kept by the several departments is used to make up a monthly data sheet, upon which are entered all items of vital importance, including pounds of water evaporated and pounds of coal consumed per kw-hour, evaporation of water per pound of coal, total kw-hours generated and maximum loads and load factor for the month. This monthly sheet is made out in such a manner that the results of the Seventy-Fourth Street and Fifty-Ninth Street stations may be readily compared. Many of the data for it are gotten from the summary of power station daily logs, which is made up from the boiler-room daily log, the engine-room log and the electrical log. In most instances the data on these three logs are compiled from subsidiary record sheets.

The watch engineers in the boiler room keep record of and report on special blanks the number of active, working and banked boilers each hour. For every 24-hour period, ending midnight, the station engineer submits a report giving a summary of the reports of the three preceding watches on boilers, and also gives the amount of water taken from the mains, the amount of coal received, consumed and quantity in the bunkers, quantity received at the dock during the day and the quantity at the dock. Figures regarding coal are obtained principally from a report made out by the foreman of the coal tower which in addition gives the duration of stops of the coal handling apparatus and the causes. The daily boiler-room log is made out by the boiler-house clerk from the several data sheets referred to. On this log is also given the temperature of the boiler feed water each hour.

Data regarding the operation of the engines are entered by the watch engineers directly on a yellow daily log sheet, from which a white copy is made for office use. This log shows the periods of operation of the different engines, the steam and vacuum pressure and the condition of the oil tanks.

The engine room and boiler room daily logs are not made out as much in detail as they would be, were it not for the fact that in each room there is kept a log book in which all important events are entered. On the daily electrical log is entered the readings taken at 15-minute intervals of each of the main generator wattmeters, and from these the daily load curve is plotted. Hourly readings of the output of the generators and of the amounts generated and used by the exciters and auxiliaries are also entered on it. Finally a summary is made showing the total output, total consumption for station operation and net output.

ELECTRICAL EQUIPMENT OF MAIN LINE RAILWAYS IN EUROPE

By Philip Dawson, M. Inst. C. E.

The electrical equipment of main line railways is a subject which appeals with great force not only to the railway authorities throughout the world, but always, perhaps with even greater force, to engineers and manufacturers.

The interest which such papers as that of Messrs. Stillwell and Putnam, as well as Mr. Sprague's criticism thereof, have excited, and the heated discussions they have caused, clearly prove the actuality of this important and vast field. Moreover, the amount of work already completed, under construction or contemplated, must convince even the most skeptical that the era of the electrical equipment of railroads on a scale thought impossible a few years ago is not very far remote.

Railways or railroads, as differentiated from tramways or street railways, originated in the old country, just as the latter originated in the United States. Hence the views held on this side of the water must necessarily carry considerable weight, and may therefore prove of interest to your readers on both sides of the ocean.

Reference has already been made by the writer in previous articles in this journal to the general headings under which railway electrification in different countries may be considered. It may be of interest to again review some of these headings and discuss them in the light of work which is now actually proceeding or has been determined upon.

The three we will mention, although obviously only two need be seriously examined in the present case, are:

(1) Railways which, through local conditions, are compelled to equip electrically within a given area all classes of traffic and service.

(2) Railways which find it advantageous to adopt electric power, in consequence of special local conditions, such as cost of fuel, gradients, and the existence of water power, for some or all of their services.

(3) Railways which resort to electrical equipment of suburban portions of their systems in consequence of tramway competition or insufficiency of existing lines and termini to handle current requirements.

The first of the above three cases requires few, if any, remarks, as obviously railways which are compelled to abandon steam have no other alternative but to adopt electric traction. Suffice it here to cite some examples of such cases, as for instance, the New York Central and New York, New Haven & Hartford railroads, so far as the electrification of their New York ends is concerned; the underground and tube railways all over the world; Alpine tunnels, like the Simplon, etc.

In all these cases no arguments in favor of electric traction were required. They were furnished nearly twenty years ago when the system which was to be adopted for hauling trains on the City & South London Railway was finally settled upon. Nothing has happened since to vitiate the decision the directors of that pioneer company came to so many years ago, to use electric traction, then only in its infancy.

The far more interesting cases which have to be discussed are those in which arguments have to be put before the railway authorities, of such a nature as to be absolutely convincing to shrewd men of business, that the great capital expenditure required by the introduction of electric traction is justified by the benefits which are certain to accrue in consequence of its introduction, and that no equally efficacious and cheaper means exist at present, or are indicated in the near future, for obtaining similar ends. It is only if such arguments are forthcoming and can be demonstrated to be sound and capable of proof, that railways can be expected to adopt that method of haulage to which electrical engineers look to confer such boons, both on the traveling public and on the owners of the railways, be they a body of shareholders or a Government.

It must be borne in mind that in the present instance it is intended to consider only the problem of the conversion of existing steam roads to electrical haulage, and not the proposition of the construction of entirely new railway systems. It will be evident that if a good case can be made for the replacement of steam by electricity on existing lines, that "a fortiori" it would be of greater advantage in the case of new lines, where no scrapping of expensive plant or alteration of existing methods would prove necessary.

The theoretical advantages, as they might be called, of railway electrification as well as those which have been deduced from calculations, have of late been much before the public. Suffice it as an example here to refer to Messrs. Stillwell and Putnam's paper so recently published in the columns of this journal. It may, therefore, be of interest to examine this fascinating problem, which is so full of promise for the future of the electrical industry, in the light of what has been either actually carried out, what is now under consideration, or what responsible railway authorities are seriously contemplating, and to investigate the causes which have brought this about, as well as the arguments which have been successful in causing steam railways, which are the most conservative bodies in all countries, to adopt entirely new methods.

The first case which will be considered is that in which it is intended to convert a long distance main line from steam to electric haulage, and perhaps the most interesting at present in contemplation is the electrification of what is known in Germany as the Eifel Bahn. The route of this line is shown on Plate XLIX, on a map prepared specially for this article.

Other cases which are also of considerable interest, but in which the reasons for conversion are more obvious, owing to expensive fuel and plentiful and cheap water power, or to other local conditions, such as difficulty of ventilation of long tunnels, will next be considered.

THE EIFEL BAHN

The Eifel Bahn extends from Cologne to Treves and is 112 miles long and double track. It passes through what is known as the Eifel, a bleak mountainous high volcanic plateau, seamed with rocky gorges, and situated between the rivers Rhine, Moselle and Roer. This plateau extends over a length of about forty-five miles, and is some twenty-five miles wide. The nature of the land traversed has resulted in the line having, for a railway, many severe gradients. The line starts at an elevation of 120 ft. above the sea at Cologne, and passes the watershed at a height of 1815 ft. fifty-two miles from Cologne. It then descends to Treves, which is 435 ft. above sea level. As will be seen from the map, a short distance beyond Treves there is the very important coal and iron field of the Saar, while on the other side and close to Cologne there are other large and important coal and iron districts. The mineral and other freight traffic between these two important industrial centers of Germany is of great volume. Two railway systems connect these rich districts; the one along the valley of the Rhine via Coblenz, the other the Eifel line now under consideration. The former line is already overcrowded with traffic, both passenger and freight; the latter has so hilly a profile that the most powerful existing steam locomotives can only haul small trains under uneconomical conditions. Careful calculations have convinced the Prussian State Railway engineers that the use of electric locomotives combined with the adoption of the single-phase system will not only produce considerable economy in operation, but will also enable trains a thousand tons or more in weight to be hauled, a thing which with present methods is quite out of the question.

It is with this end in view that Dr. Eichberg (whose name is so intimately connected with the Allgemeine Electricitaets Gesellschaft's successful single-phase work in Europe) has recently completed several 25-cycle, 350-hp, single-phase motors (see Plate LII), and a locomotive to be fitted with such motors and gear driven is now nearing completion at the works of the Allgemeine Electricitaets Gesellschaft in Berlin.

The overhead construction for a railway of this description can be of the cheapest character, and probably a line pressure of 10,000 volts will be adopted, the current being transmitted to static transformer substations at from 30,000 to 40,000 volts. Power will probably be furnished by two generating stations, one of which will probably be erected in the neighborhood of Cologne on the lignite coal fields which are to be found there, and which can be exploited in a most economical manner, as the lignite is in a very thick bed and can be got at directly by excavating from the surface without the necessity of sinking any shaft. The motors, which have only six poles, are fan-cooled, which method, given a large locomotive cab and the necessity of a locomotive driver, offers no difficulty. By this means astonishingly favorable results have been obtained, as shown by the following figures:

Brake H. P.	R. P. M.	Horiz. Effort in Kgs.	Efficiency in per Cent.	Power Factor in per Cent.
205	600	1400	81.5	90
368	425	3550	89.5	94.5
395	400	4000	90	94.5

This motor, thanks to its design and forced ventilation, is capable of giving continuously 250 hp, a very valuable feature considering the sort of work it will be called upon to perform. The gear ratio is 1:4.15, and the maximum horizontal pull at starting can reach 4500 kgs. The locomotive is being fitted with wheels 1400 mm in diameter, and the actual results which will be obtained with it will no doubt be watched with the greatest interest by all railway engineers throughout the world.

So much for this very interesting decision of the progressive Prussian Government railway authorities to electrify a main line railway—a decision caused by the necessity of hauling heavier loads than could be done by steam and at more economical rates, notwithstanding the cheapness of fuel and the practical absence of any available large water power. The conditions obtaining in this case are particular, and no general deduction can be made as regards the probability of electricity replacing steam under ordinary working conditions. At the same time it is a great step forward and there is little doubt that the results obtained will be of the greatest practical value to railway men throughout the world.

We now come to the consideration of other causes—and one can even say more easily comprehended causes—for replacing steam by electricity, such as expensive fuel and plentiful water power—conditions which exist in Austria, Switzerland, Italy and Sweden. In many cases it is not only the abundance of utilizable water powers, but also the great difficulties of proper ventilation of long tunnels, which have caused the governments of these countries to study the subject of electrification seriously.

SWITZERLAND

The Swiss have appointed a special committee of experts who have reported on the whole subject of railway electrification throughout the country, and the Oerlikon Company has equipped the Seebach Wettingen line near Zurich with its well known single-phase system, with a view to the Government acquiring experience from actual results. The Government itself is acquiring water powers all along the route of the St. Gothard, which will probably be one of the first main line railways in Switzerland to be converted to electric traction. Here again the difficulty of ventilating the St. Gothard tunnel has materially influenced the Swiss railway authorities in their decision. Switzerland may be looked upon as one of the pioneers of main line electrification with high pressure alternating current, for it was the Swiss who were responsible for the historic Burgdorf-Thun line equipped many years ago by Messrs. Brown and Boveri.

ITALY

Italy must not be overlooked as one of the pioneers of main line railway long distance electrification, for the Valtellina line, worked on Ganz's concatenated three-phase system, is world-famed, and the Milan Gallarte Porto Ceresio line is too well known and has been too often described to require any comment here. At the same time the results obtained on these lines, as well as the very serious question of tunnel ventilation, the great cost of fuel and the presence of water power, have influenced the Italian Government in its decision to increase greatly the extent of electrically operated main line railways, and the Government has consequently authorized the expenditure of $10,000,000 for immediate electrification of several important lines.

The Valtellina line, the electric operation of which now terminates at Lecco on the lake of Como, is to be extended south as far as Milan; furthermore, lines connecting the Valtellina system with the town of Bergamo are to be electrified, naturally on the already operating Valtellina three-phase system. The roads, so far as their passage through the Apennines is concerned, between Milan-Genoa and Turin-Genoa, are to be electrified, and electric traction is to be introduced on the Mont Cenis tunnel. The electric operation on the three-phase system installed by Messrs. Brown and Boveri on the Simplon has been so successful that it is proposed at once to extend it to Domodossola, and eventually to Milan. The existing Gallarate third-rail line is to be extended to Arona and Laveno on the Lago Maggiore.

The passage of the main line from Milan to Florence through the Apennines, when again the tunnel question crops up, is also to be electrified between Pistora and Poretta. Two other lines, which are electrified for other reasons, due to heavy traffic, which will be discussed later in this article, are in the neighborhood of Naples.

It will thus be seen that Italy is already pledged to electric railway traction on a very considerable scale, but unfortunately on many different systems, all of which are being extended, the authorities apparently not having come to any definite conclusion as to what system is most advantageous to fill their requirements.

SWEDEN

Last but not least we must consider Sweden, and here one cannot but admire the business-like and scientific methods with which here, no less than in Germany, the problem has been approached by the chief engineer of the Swedish State Railways, Robert Dahlander, and his able assistants. The first point to settle was the general advisability of electrification, and a careful study has convinced the Swedish Government that owing to very costly fuel and the presence of large and numerous waterfalls, electricity offers great advantages. Calculations show that there would not be a very great financial benefit due to electrification, but the fact that the Government would be relieved of the necessity of importing foreign coal was a great feature in the decision generally to electrify all the Swedish railways. A careful and thorough study convinced Mr. Dahlander that the only system which would meet his requirements, and which indeed would be of utility to Sweden, was the single-phase system. That important point decided, he proceeded to equip a few short sections of line round Stockholm, and to acquire motor equipments of various makes, purchased for this purpose one locomotive equipped with Westinghouse single-phase motors, one locomotive equipped with Siemens-Schuckert single-phase motors and two motor coaches, each equipped with two W. E. 115 single-phase motors from the Allgemeine Electricitaets Gesellschaft.

He has carefully studied the results and has convinced himself that for his purpose an economical and simple overhead and transmission system is essential; and his experiments have shown him that with the single-phase system such a line can be very readily and economically installed, and that, provided proper precautions are adopted, no interference with telegraph or telephone circuits need be apprehended. Indeed there is no other engineer who has collected so much valuable and important information in this direction as Mr. Dahlander, and it is to be hoped that the very interesting information and data which he possesses may shortly be made public by him for the benefit of the engineering profession. Suffice it to say that his experiments, carried out for over a year, have satisfied him and his Government that the electrification of many, and eventually of all, of Sweden's railways is desirable; and the necessary steps have already been taken to acquire the requisite water powers, so that the electrification of all the Swedish railways is now a thing of the near future.

In the foregoing the case of general electrification has been considered and a few of the causes have been cited which may eventually bring about the electrification of entire railway systems.

GREAT BRITAIN

We will now consider the conditions which obtain in Great Britain and ascertain how these differ from those already investigated and see how far, at present, electric traction promises to replace steam. We shall also consider the principal causes which may be expected to bring about such a transformation. In this connection it must be carefully borne in mind that whatever systems are discussed, it is only in connection with the electrification of existing lines of our main line railways, since new constructions might very likely present factors which might render advisable a different system from that which would prove most suitable in the case of the electrification of an existing system; moreover, the discussion only applies to British lines which are, or will be, governed by Board of Trade rules and regulations, and which must be operated by existing railway officials, and therefore as far as possible meet with their approval.

Considering general conditions that obtain in Great Britain, it will at once be seen that no such circumstances exist as have induced the Prussian Government to electrify the Eifel Bahn. All our lines are practically level and straight—in fact, perhaps too much so—and consequently enormously expensive. There are no water powers to speak of, in any case none are available, and the cost of fuel is relatively low. Neither do we suffer, except so far as the Mersey tunnel and Metropolitan, District and tube lines are concerned, from the difficulty of ventilation experienced in Austria, Italy and Switzerland. Neither are there any lines now in existence in this country which, as in the case of the New York Central or New York, New Haven & Hartford Railroad, have had electrification forced upon them by law. But there are other causes quite as important which are no less certainly compelling our railway companies to adopt electric traction for at least a portion of their systems, although by no means on such an extensive scale as Messrs. Stillwell and Putnam would have us believe will be the case in the United States.

Let it at once be stated that the only portion of railways on which present experience would indicate that electric haulage would be beneficial are the suburban lines in and around our great cities, and the interurban connections between large cities which are near each other and between which there exists a very heavy and frequent train service, such as between Manchester and Liverpool, Leeds and Bradford and other similar cases.

The two principal reasons which will compel our railways to action are (1) the very serious financial losses due to electric tramway competition, which in the case of one railway alone—the London, Brighton & South Coast—amount to over £30,000 per annum, and (2) the constant growing demands for a frequent and rapid suburban train service, resulting both from the increase of population and the education which the public has received in rapid transportation, from electric tramcars, motor omnibuses and tubes. These considerations definitely prove the desirability—yea, necessity—of increasing the net profits, or at least of finding some means of counterbalancing the losses the railways are suffering due to competition from other modes of rapid transit, and of increasing their carrying capacity and speed of their trains without incurring undue and excessive additional capital expenditure.

It is apparent therefore that it is to increase present facilities rather than to reduce actual total working expenses that railways will enter into the path of electrification, and experience has shown that when that path is once entered there will be no retreat. Conditions in London as well as in most of Britain's great cities, are practically unfavorable to the railway companies, as the tramways are nearly exclusively operated by the municipalities at fares so low as in many cases to threaten serious losses to the rate payers, among the largest of which the railways themselves are numbered. Fortunately for the railways, municipalities are gradually awakening to the fact that fares may be made too low, and the railway shareholder can therefore hope that a better time may be in store for him, provided the railways introduce electricity on their suburban systems.

Owing to the short distance between stations—on most London suburban lines this distance is well under one mile—the average speed of local trains is between 12 and 14 m. p. h., and in consequence of the overcrowding of existing lines and termini as much as half an hour or more may have to elapse between two local trains. On the other hand, the London County Council tramways frequently give a five to ten minutes service and operate at an average speed of 10 m. p. h., or only very little slower than the railways. Hence it is not surprising that passengers prefer a crowded tramcar rather than to miss a train and to have to wait over half an hour for the next, and then to travel at a speed perhaps not 20 per cent greater than that of a tramway.

All London main lines end in termini, a fact which conduces to delays, as some six minutes must elapse after the arrival of one train before the platform at which it arrived again becomes available for another. Electricity changes all this, as it will enable a platform to become available for the next train in two instead of six minutes, a saving of four minutes for each suburban train. Furthermore, it will enable an average traveling speed of from 20 to 25 m. p. h. to be obtained, as compared with the present 12 to 14 miles speed. In other words, the use of electricity, taking into consideration the small proportion of long distance trains to local ones, will practically result in doubling not only the average speed of local trains, but also in doubling the carrying capacity of existing lines and terminal facilities. What this latter point means can be gathered from the fact that the enlarging of one of London's big termini has cost approximately $6,000,000 and that there is a large number of such termini where enlargements even at a much greater cost is practically impossible.

COMPARISON OF OPERATING EXPENSES AND OTHER RESULTS OF ELECTRIFICATION

Having shown the reasons which are inducing railways to decide on the electrification of their suburban lines, the question of operating expenses becomes important and may conveniently be considered at this juncture.

It is practically impossible to compare directly the cost of electricity and steam per train mile and obtain anything like satisfactory results, for the reason that the introduction of electrical haulage on a suburban line will at once alter the size and type of train adopted, and in all probability lead to shorter train units being used and run at more frequent intervals than was the case with steam.

Furthermore, whereas for suburban service there is very little difference, as far as steam locomotive costs are concerned, in hauling a train having a capacity of, say, 250 passengers, as compared with the cost of hauling a train seating, say, 700 passengers, with electricity on the multiple unit system, a unit train, say, of three cars, once adopted, would according to requirements, be made up in multiples of three and the cost per train mile for locomotive power would be practically strictly proportional to the number of units of which a train is composed. Still, it may be interesting to compare some published results on the train mile basis for steam and electricity on the same road.

The Mersey Railway is the only one of what may be called main line systems which has been completely electrified in this connection and working for a sufficient number of years so that figures are available to warrant fairly accurate conclusions being drawn from the results obtained. It is also a good example to quote, since electricity superseded steam on a given day when the whole system was converted from steam to electric haulage. There is little use in considering the increase of traffic resulting from electrification in this case, because the line when operated by steam gave a fairly rapid and frequent service. It is a short distance traffic line, and there existed no particular reason why electricity should largely increase the traffic.

But the financial results as regards cost of operating and the cost of locomotive power per train mile operated by steam and electricity, as well as the cost of maintenance of permanent way, fully bear out the expectation of those engineers who have made electric haulage on railways a serious study. The figures show that with the increased speed which electrification renders possible, with slightly smaller and therefore more convenient train units, the train mileage can be enormously increased without increasing the total operating costs, and that notwithstanding the very much larger train mileage, the repairs of permanent way do not, as might be expected, increase, but are rather lower in their total annual cost than when steam is the propelling power.

The following table affords a highly interesting comparison of steam and electric operation on the Mersey Railway for the years 1901 and 1905, respectively:

Items.	1901 with Steam.	1905 with Electricity.
Locomotive cost per train mile in pence..	13.653	6.29
Train lighting and cleaning per train mile in pence	1.665	0.580
Repairs and renewals of carriages and wagons per train mile in pence........	1.719	1.075
Train miles run.........................	311,360	829,898
Total expenditure.........................	£64,662	£69,036
Maintenance of permanent way..........	£6,055	£3,793

The total gross receipts for the half year ending June 30, 1901, were £38,327, while those for the half year ending June 30, 1906, were £47,129, or an increase of 23 per cent.

Another comparison of Mersey figures is between the year 1901, operated by steam, and the year 1906, operated by electricity, which entirely confirms the figures given in the previous table; thus, in 1901 the total expenditure, including everything, was £64,662, the train mileage being 311,360 train miles; in 1906 the total expenditure, including everything, was £70,930 and the train mileage 829,188 train miles. It will thus be seen that an increase in train mileage of 167 per cent increased the total expenditure by only 10 per cent.

In comparing the cost per train mile of steam and electricity it must be borne in mind that steam trains were, on the average, composed of seven cars, having a capacity of 350 passengers. Now, when operated by electricity, according to the time of day, the number of cars per train varies from two to five, and the average seating capacity of an electric can be taken as 55 passengers, as compared to the average seating capacity of steam cars of just under 50 passengers.

These figures clearly demonstrate the great benefit which railways will get by electrification of their suburban systems. It shows that they will, owing to the high rate of acceleration, be able greatly to increase the average speed, and therefore the number of trains, and thus to utilize better the existing facilities, both as regards tracks and termini. Consequently they will largely augment their earning capacity without increasing their present total working expenses. And as Mr. Aspinall (the general manager of the Lancashire & Yorkshire Railway) has always maintained, the object of electrification is not so much to decrease the expenditure of a railway company as to increase its earning power. Nothing but a greatly accelerated and more frequent service can enable them to hold their own, and it is only electric traction that will provide this acceleration. That frequent and rapid service does, in most cases, provide an efficient remedy is clearly shown by the satisfactory results obtained both in the case of the Lancashire & Yorkshire Railway and of the North Eastern Railway. The latter is a particularly good example, because the electric lines between Newcastle and Tynemouth suffer from the most acute tramway competition. Notwithstanding this fact, the profits are considerably greater now on this railway than they were in the days before there existed any electric tramway competition. This is clearly shown in the following table:

NORTHEASTERN RAILWAY ELECTRIFICATION RESULTS.

Items.	Half Year Ending 1903. Steam Operation.	Half Year Ending 1905. Elec. Operation.	Percentage of Increase.
Gross earnings	£129,000	£151,000	17.1
Running costs	£42,761	£47,779	11.7
Ratio of costs to receipts..	33.2%	31.8%	....
Loco. costs per train mile..	14.5d.	6.75d.	....
Passengers carried	2,844,000	3,548,000	24.8

In reading the above table it must be borne in mind that the figures given as running costs for steam operation, are, if anything, too low. An exact figure is unobtainable owing to the difficulty of differentiating between the costs for local service and the total locomotive costs for the whole service. But even on the supposition that the comparison is a fair one, it affords a most satisfactory proof of the advantages to be obtained from electrification, particularly in view of the fact that electric tramway competition has very largely increased of late, which shows that the electrification of the railway has, therefore, not only enabled it to hold its own but also to increase its traffic.

Having thus considered the actual results as regards working expenses which are obtainable and authenticated, it may be interesting to study some figures specially compiled for London conditions and in which an attempt has been made to compare on a similar basis the cost of operating a service under similar conditions.

EXPENSES UNDER LONDON CONDITIONS.

	STEAM	ELECTRIC
Items.	Cost per train mile, 7-car train, with seating capacity of 520 passengers.	Cost per train mile, 3-car train, with capacity 210 passengers in London.
Fuel or current	6.96d.	5.00d.
Water, oil, waste and stores	0.90d.	0.09d.
Maintenance and repairs	3.41d.	0.85d.
Wages	3.25d.	1.58d.
Lighting	0.85d.	included in current.
Total	15.37d.	7.52d.

Ratio of locomotive costs of electricity to steam 48.5 per cent (including current and capital charges on conduction and distributing system).

From the above table it will be seen that on the train mile basis the locomotive costs for electric traction, maintenance and capital charges in electrical distribution included, are less than half the cost per train mile if operated by steam. Against this, however, would have to be placed the fact that the capacity of the steam train is more than double that of the electric train under consideration. But there is the additional important consideration that the costs given for electric service are for an average acceleration more than double that obtained with steam, and consequently that the average speed of traveling with the electric train is nearly double the maximum that the local steam trains, with present stops, can attain.

It must be borne in mind that it would be impossible with steam haulage to increase effectually the speed of these local trains. To make a fair comparison, one must take as the average speed for electric trains the same speed as that of the present steam trains. On that basis the same number and power of motors that are required to drive the three-car train as given in the previous table, would be amply sufficient to operate a seven-car train, and if the trailer and rolling stock were the same as that at present in use with steam haulage, the carrying capacity of the train should easily equal that of the present steam trains. The table previously given would then very closely represent the comparative cost of operating by steam and electricity under the same conditions.

From this it will be seen that, when compared on the same basis, the cost of hauling suburban trains by means of electricity is less than half that of operating by steam, with the additional advantage already cited thrown in, of the saving of time effected at termini, owing to the use of motor cars and multiple unit control.

But there remains another and most important factor to take into consideration, and that is the better use of the seating capacity per hour if run by smaller and more frequent trains instead of fewer and more capacious trains.

COMPARISON OF SYSTEMS

Having thus briefly considered the present state of electric traction in Europe and the various causes which are operating in the minds of those who have brought about the present condition of affairs, it may be interesting briefly to consider the various systems now in existence, and the reasons which have caused the single phase system to occupy so important a place in the minds of European as well as of many American railway engineers.

The three systems which are now under consideration and have been practically adopted for railway work are:

(1) The continuous current motor { Low tension 600 volts.
High tension 1000 to 2000 volts.
(2) Three-phase motors.
(3) Single-phase motors.

As far as the first of these is concerned the standard low-tension motor has been so fully developed and has proved so satisfactory that nothing further need be said in its favor.

As regards the second, or three-phase system, it has been introduced with satisfactory results on the Valtellina line and on the Simplon, but so far all those who have had to decide when electrification of suburban systems was in question have not found it advisable to adopt it and little therefore need be said of it here, so that the only two systems which require serious consideration or which need be compared are the continuous current high-pressure motor constructed up to 1000 volts and claimed as possible and useful up to 2000 volts pressure, and the single phase low-pressure motor.

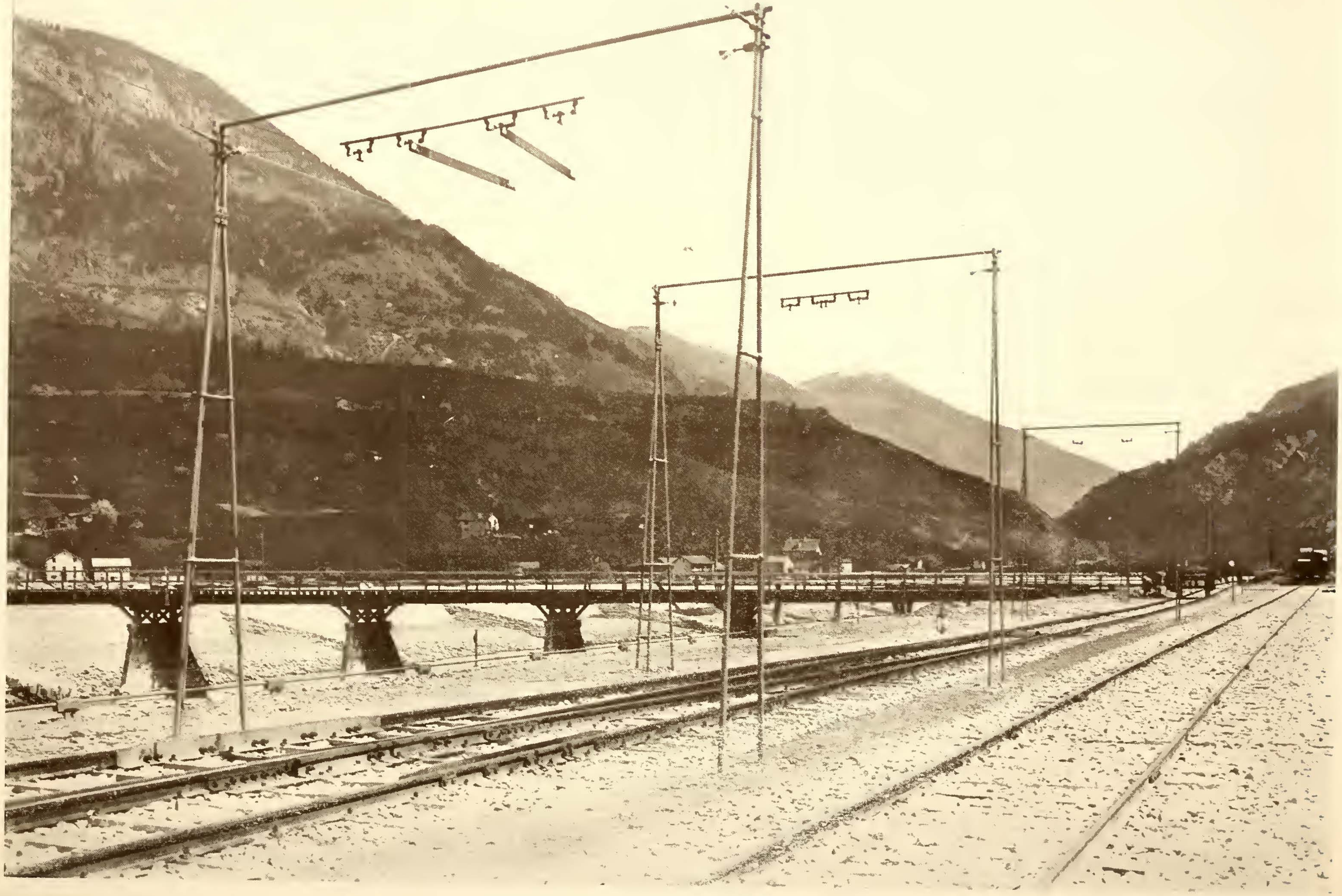
The fight over these has raged so hotly in America that it is unnecessary to reopen it here; suffice it to recapitulate briefly the reasons which have weighed with those railways which have adopted electric traction on the single phase system, and to consider the weight of those objections which are so frequently brought up against single phase motors.

In this connection it is instructive to remember that one of the chief engineers of the Prussian State Railway, Herr Geheimer Baurat Wittfeld, after the most careful investigation, and having only in view the best interests of his railway, decided on the adoption of a single phase system for the suburban line of Hamburg Ohlsdorf Blankenese. An order was consequently placed for fifty-four two-car trains with the Allgemeine Electricitaets Gesellschaft of Berlin, each train being equipped with three W. E. 115 motors, and an order for six similar trains, each equipped with two Siemens-Shuckert single phase motors, was placed with the Siemens-Shuckert Werke. Furthermore, it is this system which the Prussian Government has adopted for the Eifel Bahn. Robert Dahlander, the chief engineer of the Swedish State Railway, also, after most careful research and investigation, has decided upon the single phase system for the Swedish Government railway electrification. As regards Switzerland, it is this system with which experiments are being carried out on the Seebach Wettingen line with a view to its adoption on the St. Gothard. In Italy the position is different, but in that case the greatest portions of the work there under consideration are extensions of lines equipped before the single phase motor came into the field or had been made a practical success. The Midland Railway in England has also adopted single phase for the experimental line it is now equipping, and the London, Brighton & South Coast Railway, after the most careful investigation on the writer's part, is installing it on the first portion of its suburban system, now being equipped with Winter Eichberg single phase motors.

The only serious objection brought by its detractors against the single phase motor is the additional weight and consequent additional cost of a single phase equipment as compared with the equivalent continuous current equipment, and the

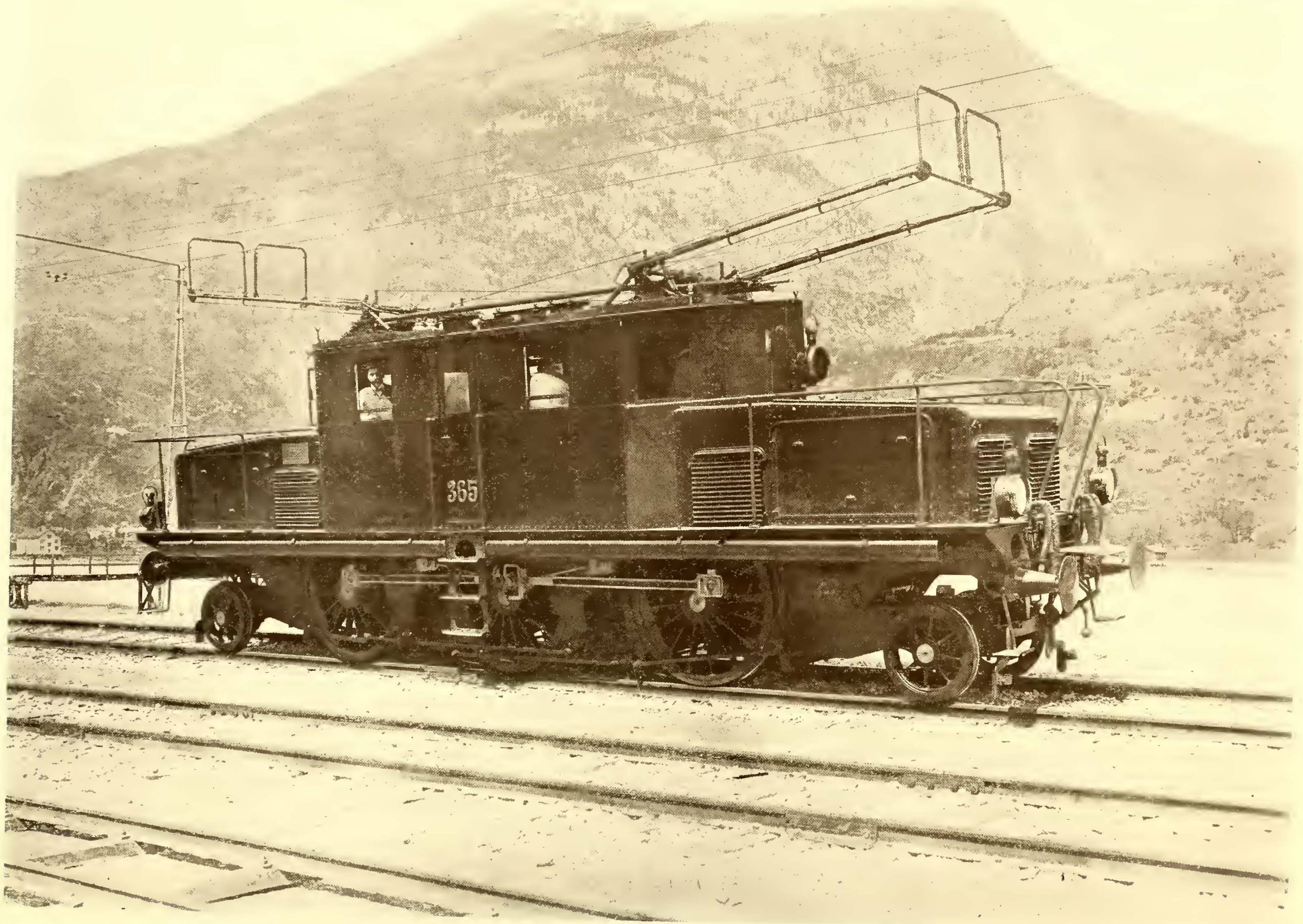
Plate XLV

HAMBURG-ALTONA BLANKENESE OVERHEAD CONSTRUCTION



SIMPLON TUNNEL RAILWAY—OVERHEAD CONSTRUCTION AT BRIGUE END OF LINE

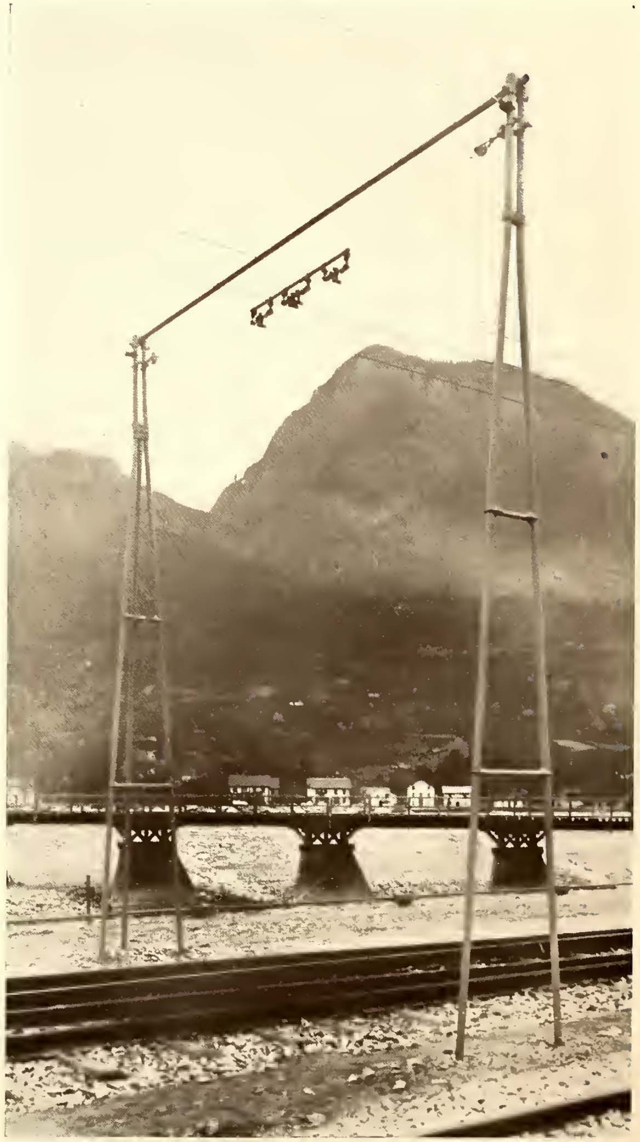
Plate XLVII



BROWN-BOVERI ELECTRIC LOCOMOTIVE USED IN SIMPLON TUNNEL

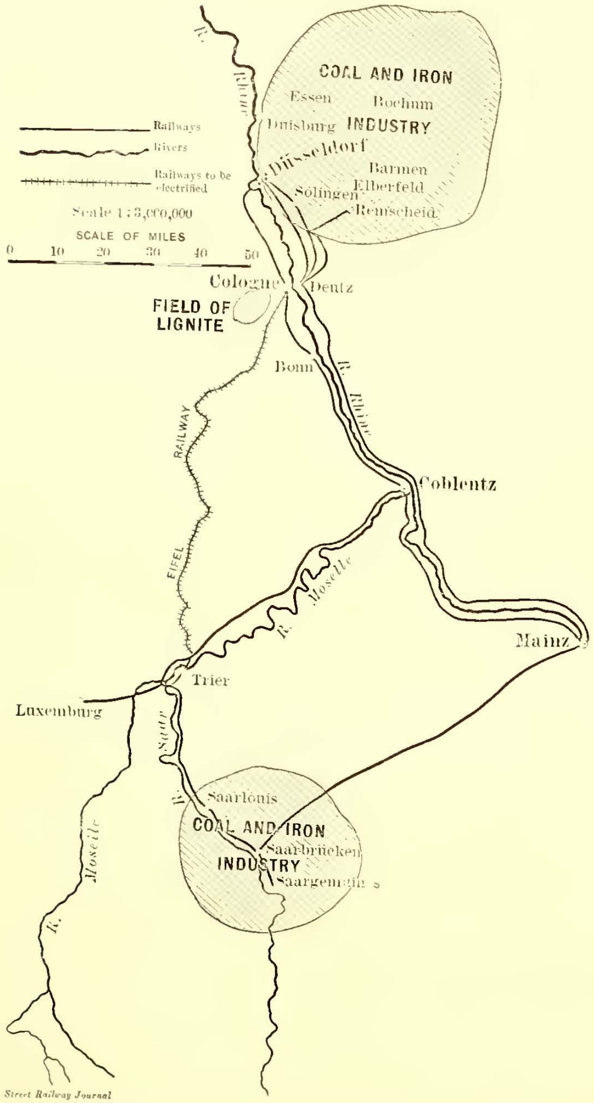
VIEW OF OVERHEAD CONSTRUCTION ON SWEDISH STATE RAILWAYS

WESTINGHOUSE ELECTRIC LOCOMOTIVE WITH OERLIKON OVERHEAD COLLECTOR HAULING TRAIN ON GOVERNMENT RAILWAYS AT STOCKHOLM



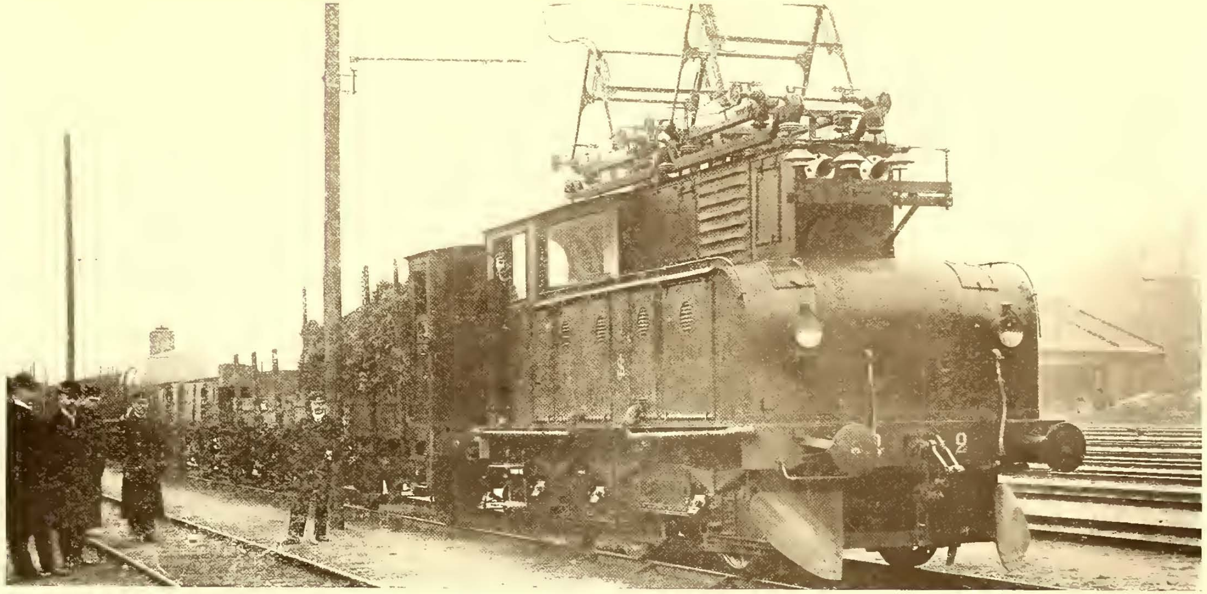
SIMPLON TUNNEL—THREE-PHASE OVERHEAD CONSTRUCTION AT BRIGUE END OF THE LINE

Plate XLIX



Street Railway Journal

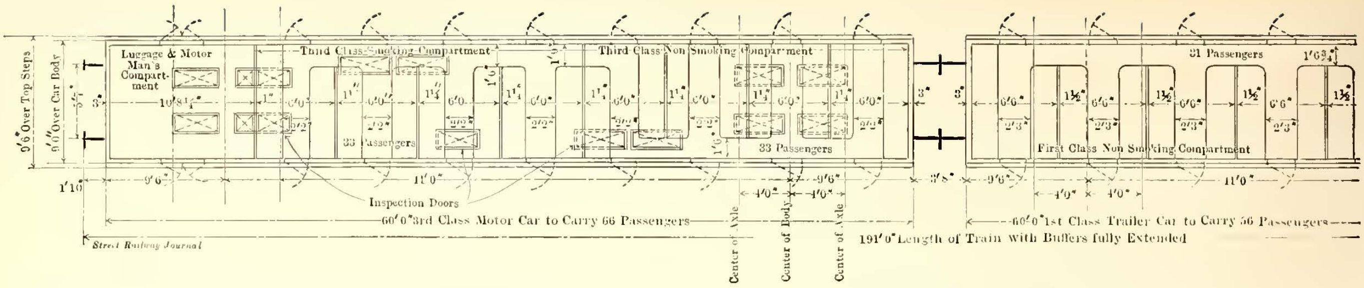
MAP SHOWING ROUTE OF EIFELBAHN, GERMANY



SIEMENS-SCHUCKERT LOCOMOTIVE HAULING FREIGHT TRAIN IN STOCKHOLM

MOTOR CAR AND TRAIN EQUIPPED WITH A. E. G. MOTORS IN PRINCIPAL STATION IN STOCKHOLM

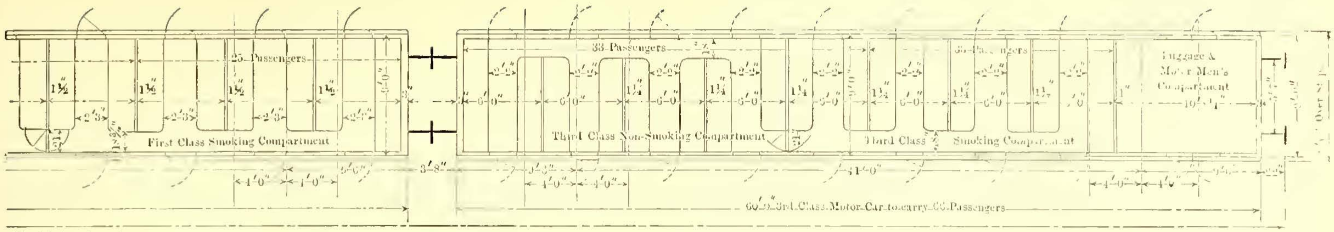
Plate L



Street Railway Journal

FORWARD END OF 3-CAR TRAIN ON LONDON, BRIGHTON & SOUTH COAST RAILWAY, SHOWING ARRANGEMENT OF SEATS

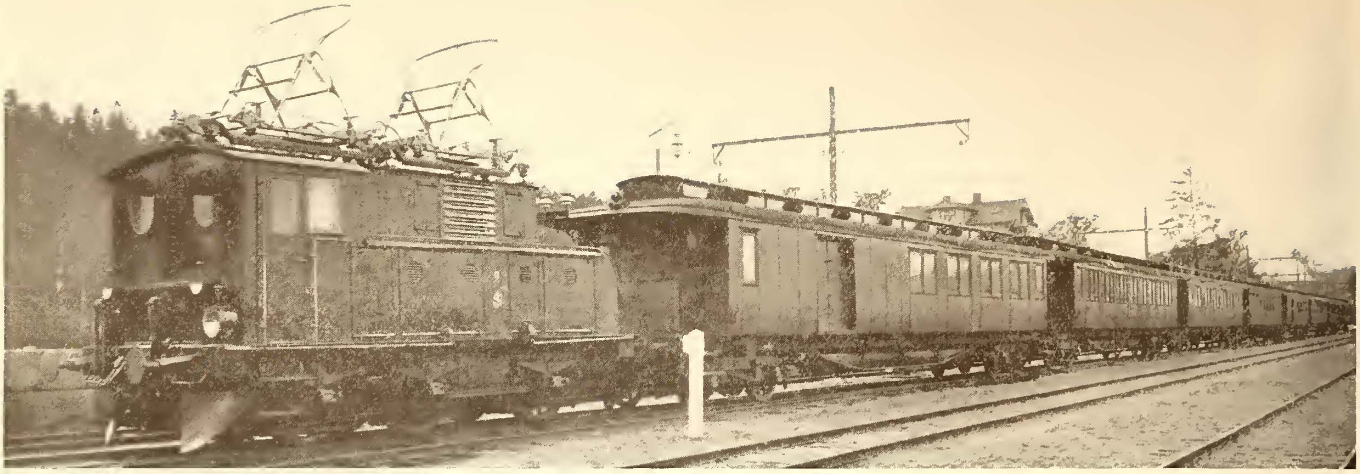
OVERHEAD LINE ON THE HAMBURG-ALTONA RAILWAY, SINGLE-PHASE, 6000 VOLTS, 25 CYCLES



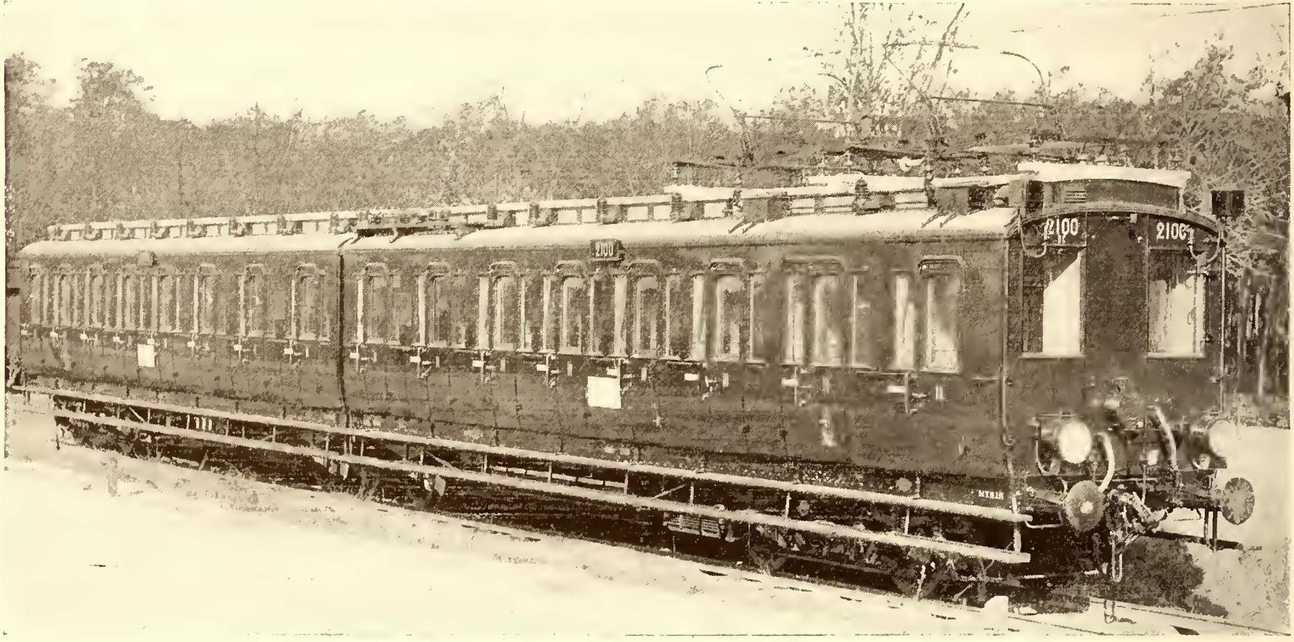
Street Railway Journal

REAR END OF A 3-CAR TRAIN ON LONDON, BRIGHTON & SOUTH COAST RAILWAY, SHOWING ARRANGEMENT OF SEATS

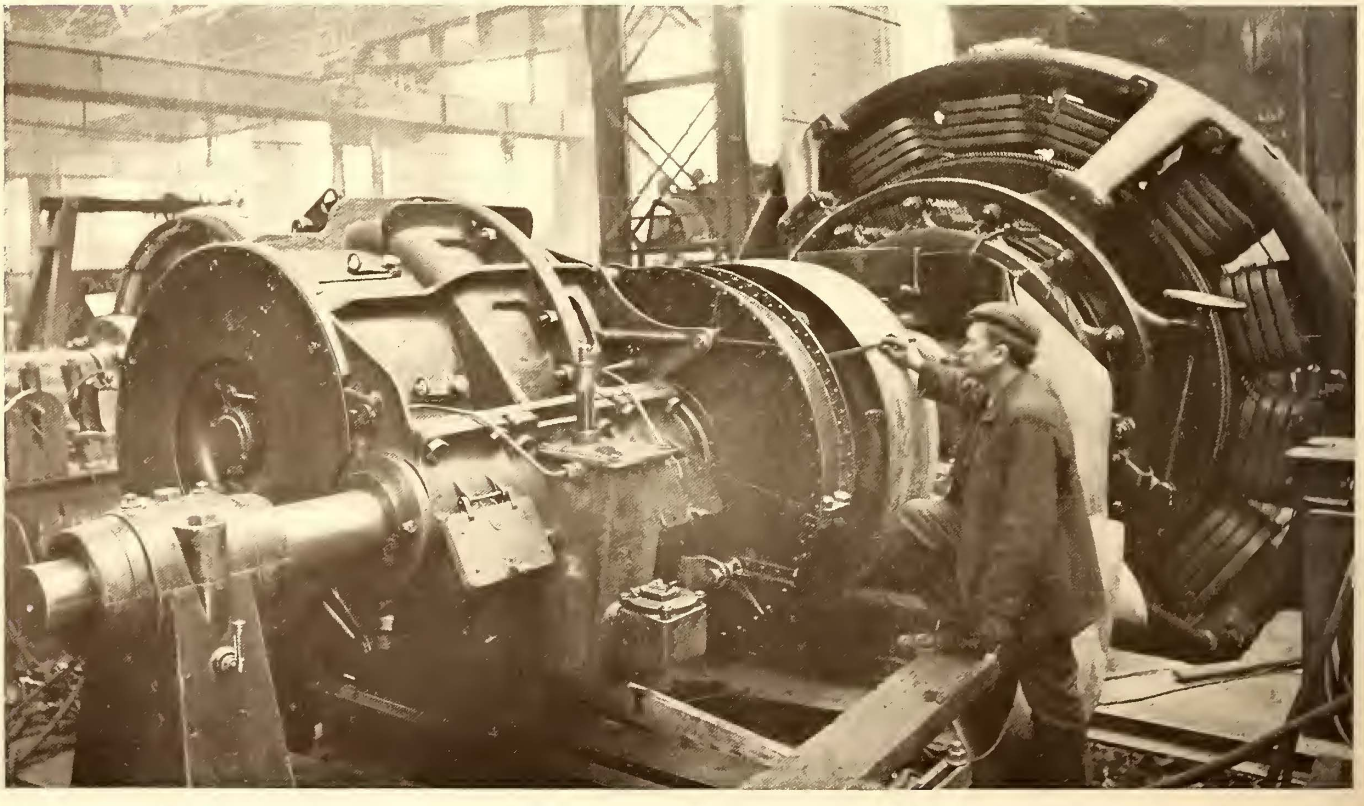
FLOOR OF HAMBURG-ALTONA SINGLE-PHASE MOTOR CAR, SHOWING HOW THE WIRING IS DONE ON THE CAR FLOORING, WHICH IS TURNED UPSIDE DOWN FOR THAT PURPOSE, BEFORE THE BODY IS BUILT INTO IT



SIEMENS & HALSKE SINGLE-PHASE LOCOMOTIVE AND TRAIN ON SWEDISH GOVERNMENT RAILWAYS



A. E. G. CAR ON THE HAMBURG-ALTONA-BLANKENESE SINGLE-PHASE RAILWAY



350 H.P. SINGLE-POLE, 25 CYCLE A. E. G. MOTOR TO BE USED ON THE EIFEL BAHN LOCOMOTIVES, SHOWN ON TEST BED DRIVING A DIRECT-CURRENT GENERATOR

lower efficiency of the motors—i. e., greater energy consumption —which its opponents claim for it.

As regards the first point, it is perfectly true that a single phase motor equipment is more costly and more heavy at present than direct current equipment, and that the former requires a transformer on the car which is not required with direct current motors.

But even granted that the enormous difference in weight which Mr. Sprague claims between d. c. and a. c. motors exists and that the cost were equally disproportionate, the difference in weight and cost would take but an unimportant place among those many and complicated considerations which weigh with practical as well as theoretical railway engineers, managers, and directors when deciding upon the system most suitable to fill their requirements. For taking the weight of a train unit at 120 to 150 tons, the difference of 5 tons or even 10 tons in weight would be unimportant when compared with traffic and management requirements. A good example of this in railway work is to be found in the weight of the cars, particularly those forming part of the most modern American trains, such as the Pennsylvania Limited, etc. What manager would think of rejecting a more useful or comfortable dining, sleeping, or drawing-room car, because it weighed 7½ per cent or even 10 per cent more than a car which in other ways is less desirable? And in this connection let it be reiterated that it is not reduction of working expenses which constitute the chief or even a very important factor in the minds of railway authorities when considering the question of electrifying a suburban line.

In the case of a suburban system, careful calculation has demonstrated that there is not much to choose as regards first cost (although what difference exists is in favor of the single phase) between a complete d. c. and a. c. installation from and including the power station, feeder distribution, conducting system, and rolling stock, provided the installation is properly carried out so as to comply with the Board of Trade regulations which obtain in Great Britain.

As regards lower efficiency, this is to a very large extent counterbalanced by the absence of regulating resistances which the d. c. system necessitates, as the voltage regulation is done by means of a transformer, instead of having the difference in motor terminal and line voltage largely absorbed by resistances, as is necessary with continuous current motors. But besides this it must be borne in mind that for any large railway system the current must of necessity, if present means are adopted, be generated as alternating current, and therefore not only the losses in transformation from a. c. to d. c., but also the extra cost entailed of operating and maintaining such substations must be added onto the d. c. motor before a fair comparison can be instituted. If this is done it will be found that the a. c. motor comes out on the whole very well indeed; in fact, many authorities maintain far better than the d. c. motor.

But it is not the object of this article to enter into polemics on what might be called "the battle of systems," but only to show that there are far greater possibilities in the a. c. system than some would have us believe. All the disadvantages and objections which d. c. enthusiasts, who appear blinded to all except their own arguments, bring up against the a. c. motor are fully known to those engineers who having no interests in any particular system have investigated simply those in existence and have adopted the a. c. as the most suitable to their own special requirements. They are fully cognizant of any weakness which the a. c. system may possess, as well as of the many very admirable features of the d. c. motor, which has continually been perfected during the past twenty years.

One of the principal advantages of the a. c. motor is the absence of a third rail and the possibility of using very high pressure in the conductors without any dangerous pressure having to be manipulated in the car, or being at all accessible either to the officials or the public. This undoubted advantage is evidently appreciated even by those who would detract from the merits of the a. c. system, as their alternative is nearly always the adoption of a d. c. motor, worked at pressures untried as yet in the practical railway field, and which would not permit the use of a third rail, which so many d. c. enthusiasts have held to be a benefit instead of a necessary nuisance at the best. In this connection it should not be forgotten that the first main line electrification in the United States, on the Baltimore & Ohio, was originally installed with overhead conductors, but owing principally to current-collecting difficulties, the method had to be abandoned in that case in favor of the third rail arrangement.

Summing up, it becomes clear that for continuous current motors to bear comparison with alternating current motors, motors of at least half the required pressure advantageous for operation and distribution must be commercially produced, leaving out of consideration many disadvantages which might accompany their adoption. Such high pressure motors would also necessitate the use of rotary conversion, or their equivalent continuous current at 6000 to 10,000 or even 15,000 volts.

All the previous remarks are not intended in the least to belittle the endeavor of those who are attempting to develop and place on a sound manufacturing basis the high-pressure continuous current motor, and two firms at least are known to the writer whose 2000-volt continuous current motor and controlling apparatus are essentially workmanlike and satisfactory. There may be a great many cases in which such a motor might with the greatest benefit to all concerned find application. All that has been attempted is to show that the single phase motor as at present constructed possesses great and real advantages which make it admirably suited to the requirements of railways working under all conditions, and just as suited to handling heavy suburban traffic as long distance traffic, to which latter field only many, particularly American, engineers would have it relegated. Fortunately for all, operations will shortly be conducted on a sufficiently large scale to enable satisfactory conclusions to be drawn from three examples of single phase main line railways whose suburban traffic is electrically handled, namely, the Hamburg Ohlsdorf-Blankenese, which is now working experimentally, and which is expected to be operating regularly by the end of this year; the "Victoria-London Bridge" section of the London, Brighton & South Coast Railway, now under construction, and which should be completed early next year; and last, but not least, the New York, New Haven & Hartford Railway. By the end of next year, therefore, some real substantial facts should be available, facts which will be most appreciated by all railway men all over the world, and which will be of great assistance to railway authorities in guiding their future actions, which, in the opinion of the writer, are intimately bound up with the electrical industry.

The recent decision to electrify the Berlin Stadt and Ring Railway with the single-phase system clearly upholds this view. The complete plan embraces some 366 miles of track. The voltage employed on the trolley will be 10,000, and motor-car trains, probably of the two-car form of the A. E. G., like those on the Hamburg Altona line, will be used. A headway of two minutes is planned and a maximum speed up to 38 m. p. h. will be reached. The first section is to be electrically equipped by 1913 and the entire system by 1920.

SOME OF THE APPARATUS IN USE ON THE CONVERTED STEAM RAILROADS

The plan of this issue, devoted as it is principally to the subject of operation, has precluded any extended reference to the types of apparatus used upon the electrically equipped sections of the steam railroads described. It is not the intention in this chapter to mention all of the equipment installed, but to give credit, so far as it has been possible to collect the data from the different manufacturers, for the electrical equipment supplied to the trunk line railways whose practice is described in this section.

THE GENERAL ELECTRIC COMPANY furnished for the electrical equipment of the West Jersey & Seashore Railroad all of the active elements, including three 2000-kw Curtis turbine generators, exciters, transformers and switchboards for supplying 33,000-volt, 3-phase current through 70 miles of double transmission lines to seven rotary converter sub-stations. These sub-stations aggregate 11,000 kw in capacity and distribute 650 volts direct current to 110 miles of third rail and 27 miles of overhead trolley. There are ninety motor cars, each equipped with two 69-C General Electric railway motors and Sprague General Electric type M multiple-unit train control system. The West Shore Railroad electric equipment supplied by the General Electric Company comprises four sub-station equipments, each containing two 330-kw transformers, two 300-kw, 600-volt, 40-cycle rotary converters and accessories; also seventeen GE-73 four-motor car equipments with Sprague General Electric multiple-unit control. The New York Central equipment supplied by the General Electric Company included thirty-five locomotives, eight Curtis turbines, four two-unit, two-bearing motor generator sets, four 200-kw o. c. transformers, 125 type M control, two-motor GE-69 equipments, 250 GE-69 C motors, eighteen 550-kw., the fifty-four 375-kw transformers for sub-stations, switchboards for eight sub-stations, power cables, circuit-breaker houses, etc.

THE AMERICAN LOCOMOTIVE COMPANY built the thirty electric locomotives for the New York Central electric division, in conjunction with the General Electric Company. The locomotives were erected at the Schenectady plant of the locomotive builder, and the specifications called for work of the same quality as furnished by the builders for the New York Central steam locomotives. As will be seen from the engravings of these locomotives, they were designed and built as far as possible in accordance with regular locomotive practice.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, the Westinghouse Machine Company, the Westinghouse Air Brake Company, Westinghouse, Church, Kerr & Company and the other Westinghouse interests were largely represented in the equipment of the railway lines described. A complete list is hardly necessary, in view of the recent dates of the publication of articles on the different roads. It might be said, however, that all the New Haven locomotives and line appliances are of Westinghouse make, that Westinghouse-Parsons turbines are used in the power stations of the New Haven and Long Island Railroads and that Westinghouse motors are used on the Long Island and Erie Railroads. A large part of the rotary converters in the New York Central sub-stations are of the Westinghouse make. Roney stokers are employed very extensively in the different power stations. Westinghouse, Church, Kerr & Company were the designing engineers and contractors for the Long Island and Erie installations and for the New Haven power station.

BALDWIN LOCOMOTIVE WORKS, of Philadelphia, built both motor and trail trucks for the Long Island Railroad and the West Jersey & Seashore Railway, and trucks for the locomotives for the New York, New Haven & Hartford Railroad. The trucks for the Long Island company are built for standard-gage track, and designed to carry a weight of 29,000 lbs. on the center pin. The motor trucks are each equipped with two Westinghouse No. 86 motors arranged for nose suspension. The wheelbase is 6 ft. 8 ins. The wheels are 36 ins. in diameter, with cast-iron centers and steel tires. The journals are M. C. B. standard, 5 ins. x 9 ins. Cast steel is used for the bolsters and centerplates, while the end frames, center transoms and spring planks are of channel iron. The bolster springs are double elliptic, 28 ins. long, and the equalizing springs are double coil. The loaded height from rail to center plate is 31½ ins. The trailer trucks are similar in many respects to the motor trucks, although they are lighter in construction. The wheel base is 5 ft. 6 ins., and the wheels are 30 ins. in diameter.

The latest trucks built for the West Jersey & Seashore Railroad by the Baldwin Works are designed to carry a load of 30,500 lbs. on the center plate. The motor trucks are each equipped with two G. E. No. 69-C motors, arranged for nose suspension. The wheel base is 7 ft. 3 ins. The wheels are 36 ins. in diameter, and the journals are 5 ins. x 9 ins., M. C. B. standard. These trucks are equipped with wrought-iron frames, cast-steel bolsters and center pins, channel iron transoms, triple elliptic bolster springs and double coil equalizing beam springs. The height from rail to center plate is 31½ ins. loaded. The trailer trucks have a wheelbase of 7 ft., with wheels 33 ins. in diameter. The journals are 4¼ ins. x 8 ins. The working loads and heights are the same as those for the motor trucks.

THE RAIL JOINT COMPANY, of New York, furnished insulating rail joints to the New York Central & Hudson River Railroad, of a "Special" Weber type. To the New York, New Haven & Hartford Railroad, the Long Island Railroad and the Rochester Branch of the Erie Railroad, it furnished standard Weber insulating joints.

THE ELECTRIC SERVICE SUPPLIES COMPANY, of Philadelphia, secured a good share of the rail bond work on the Long Island Railroad, both for the track rail and contact rail, including the bonds for the a. c. signal system. The company's total sales of rail bonds to the Long Island exceed 150,000 bonds. The entire rail bond contract of the New York, New Haven & Hartford Railroad was secured by the Electric Service Supplies Company, including the bonds required for the signal system. The total of bonds was a little more than 40,000. The Electric Service Supplies Company secured the contract for all the rail bonds of the Rochester Branch of the Erie Railroad, through Westinghouse, Church, Kerr & Company. The company also secured the contract for the special pole brackets for the catenary construction, and much of the other details of the overhead catenary work, through Westinghouse, Church, Kerr & Company. For the West Jersey & Seashore Railroad the Electric Service Supplies Company furnished rail bonds for the a. c. signal system, through the Union Switch & Signal Company.

W. N. MATTHEWS & BRO., of St. Louis, furnished Stombaugh guy anchors in large quantities to the New York Central, Long Island Railroad and Erie Railroad for the Rochester Branch. The New York Central has used Kearney cable clamps in connection with its work. The Erie Railroad has adopted the Hold Fast lamp guard, made of No. 14 B. W. G. wire, and call it the Erie Standard. Matthews & Brother have furnished the company several thousand in the past few months.

THE STANDARD STEEL WORKS, of Philadelphia, Pa., supplied the wheels and axles for the Long Island Railroad, the West Jersey & Seashore, the New York, New Haven & Hartford, and the Erie Railroad.

THE POWER SPECIALTY COMPANY, of New York, supplied the Foster superheater, erected in connection with Babcock & Wilcox boilers, purchased by the New York, New Haven & Hartford Railroad. The superheaters supplied are of standard Foster construction, the steam being taken from each drum separately and carried down through connecting pipes made of seamless drawn-steel tubing, fitted with expanded joints. These tubes lead into transverse headers, from which the steam is distributed through a series of return elements, also made of seamless drawn tubing, covered with rings of cast iron for protection against the heat. The bent portion of the tube is protected by a cast-iron jacket, cast in halves and held firmly against the tube by heavy band rings, shrunk on. The outlet header, which is directly below the inlet header, is connected with the steam pipe by means of seamless tubing with expanded joints. The entire superheater is supported from overhead, and does not rest on the brickwork or interfere in any way with the action of the boiler. No joints or hand-hole plates are so located that they will come in contact with the very hot gases. An important feature of this construction is that each tube contains an inner tube or core centrally supported, leaving an annual space between the main tube and the core, through which the steam is forced to pass, rendering the heating surface highly efficient. No flooding is necessary in this type of superheater. Hence, there is no danger of scale forming on the inside, or of water being delivered to the engines when the apparatus is being put into service.

THE RAILWAY SPECIALTY & SUPPLY COMPANY, of Chicago, Ill,, has a large number of its Arc-Damp lightning arresters in use by the signal department of the New Haven Road in the electric zone. With the 11,000 volts, at 25 cycles, there exists an appreciable induction in signal, telephone and telegraph wires, and the company has installed metallic circuits for its signal system and has equipped these circuits with the arc-damp arresters to take care of lightning and heavy static charges. The Arc-Damp arrester is in multiple between the line and ground, and not in series with the line. There are no fuses to blow under light charges, and there is no chance of escape of the working current to ground through the fusing of any choke coil to the ground plate, or through the lodging there of drops of water or other material.

THE NATIONAL CARBON COMPANY, of Cleveland, Ohio, supplied the New York Central Railroad with Columbia carbon brushes for its generators, and to the Long Island Railroad the National Company supplied its National No. 15, Laclede and National regular brushes; to the West Jersey & Sea Shore, Partridge brushes, and to the New York, New Haven & Hartford, Columbia and Partridge brushes.

THE COLUMBIA MACHINE WORKS & MALLEABLE IRON COMPANY, of Brooklyn, N. Y., made inclines, third-rail brackets, contact shoes, frames, overhead brackets, hook bolts and nuts, and various devices for the third-rail and overhead equipment of the New York Central & Hudson River Railroad Company, Long Island Railroad, Oneida Construction Company, New York, New Haven & Hartford Railroad Company, and the West Jersey & Seashore Railroad.

THE AMERICAN CAR & FOUNDRY COMPANY (Jackson & Sharp plant), of Wilmington, Del., built two orders of car bodies for the West Jersey & Seashore division of the Pennsylvania Railroad Company. The original order was for twenty-two cars, which were shipped in May, 1906. Another order of eleven cars has just been completed. These were similar to those supplied on the first order, differing only in minor details. Both lots of cars were 46 ft. 6 ins. over body framing in length, with steel underframe. The other dimensions were similar to those for steam car construction, with the necessary changes in the vestibules to adapt the cars for electrical service.

THE OHIO BRASS COMPANY, of Mansfield, Ohio, furnished to the New York Central Railroad all the third-rail insulator blocks. These are of semi-porcelain and similar to the blocks which were supplied to the West Shore Railroad between Utica and Syracuse, which were described in the Street Railway Journal of June 8, 1907. The Ohio Brass Company also furnished a portion of the third-rail bonds used on the New York Central electrified division, which were a special form of bond very much similar to the company's Type GA—Form 2. This is a soldered terminal bond for application to the ball of the rail, and is of the ribbon type with the body bent to a "U" shape, and the terminals formed by compressing the ends of the ribbons in special dies to a solid terminal, as in the case of all of the "All Wire" bonds manufactured by this company. These bonds are of 500,000 c. m. cross-section, and two are installed at each joint. The terminals were slightly recessed on the side next to the rail, which makes a somewhat better soldered union in bonds of extra large size, such as these were. To the West Jersey & Seashore the company furnished "All Wire," Type F—Form 7, compressed terminal bonds.

THE CLIMAX STOCK GUARD COMPANY, of Chicago, Ill., equipped the Long Island Railroad and the West Jersey & Seashore Railroad with its Climax clay cattle guards, which are adaptable to third-rail construction, as they can be fitted in around the jumper plugs, located in cross-overs and turnouts without special preparation.

THE AUTOMATIC VENTILATOR COMPANY, of New York, equipped all the cars used in the electric service of the New York Central & Hudson River Railroad with the automatic ventilators. The device is applied in the clerestory of the car in the space occupied by the ordinary deck-sash, and furnishes a copious supply of fresh air, as well as removing the vitiated air, odors, and smoke from the cars. It is neat and attractive in appearance, and is capable of easy application to all conditions, as is shown by the manner of ventilating the saloons in these cars, the same being connected by metal pipes with the clerestory, through which the fresh air is driven, and the vitiated air withdrawn. A noticable feature of the device is that it secures an ample supply of fresh air to all parts of the car without draughts.

THE SHERWIN-WILLIAMS standard car body color, made by the Sherwin-Williams Company, of Cleveland, is in use on the New York, New Haven & Hartford Railroad and the Erie Railroad. On the New York Central and Erie, practically all the locomotive and car equipment is finished with various products of the Sherwin-Williams Company.

THE LOCKE INSULATOR MANUFACTURING COMPANY, of Victor, N. Y., furnished its No. 600 porcelain strain insulators for 11,000 volts to the New York Central Railroad. To the New York, New Haven & Hartford Railroad, the company furnished the large 14-in. bridge insulators, and to the Erie Railroad it furnished its No. 601 strain insulator for use on the Rochester Branch. The Locke Company also has the contract for the complete equipment of high voltage insulators and the metal pins for the West Jersey & Seashore Railroad, furnishing its No. 312 insulators to the extent of about 21,000. After more than a year of service the operating department of the West Jersey Company reports that not a single insulator has failed.

THE GREENBRIER POLE COMPANY, of Charleston, Kanawha, W. Va., supplied the Long Island Railroad Company nearly all of the poles used in its overhead work.

THE HAYES TRACK APPLIANCE COMPANY, of Geneva, N. Y., reports that its derailing devices are in extensive use on the New York Central, Long Island Railroad, West Jersey & Seashore, New York, New Haven & Hartford, and the Rochester Branch of the Erie Railroad. This company understands that its derails have been used exclusively, wherever derails are required, in the territory electrified on the New York Central, Long Island Railroad, and Rochester Branch of the Erie Railroad.

THE FELT & TARRANT MANUFACTURING COMPANY, of Chicago, has its Comptometer adding and calculating machine in use in large numbers by the New York Central Railroad Company, the Long Island Railroad, and the New York, New Haven & Hartford.

DOSSERT & COMPANY, of New York, report that the New York Central & Hudson River Railroad Company has made extensive and varied use of the Dossert solderless connector in the electric zone. Up to date the company has used more than 1000 straight two-way connectors of all sizes up to 1,000,000 c. m., and of cable taps the company has used an even larger number, the sizes being from 350,000 c. m. up to 1,350,000 c. m. These cable taps were used principally in tapping off from the third-rail, in series of three, to connect by way of the structure to the overhead cables. Dossert & Company have also made for the New York Central Company an emergency jumper clamp connector, which in case of a break in the third-rail current is attached to the third-rail on either side of the break, thus preventing a tie-up of the service until the regular flow of current is re-established.

THE WILDER SNOW-PLOW & MANUFACTURING COMPANY, of Worcester, Mass., designed a special radial plow to meet conditions on the electrified zone of the New York Central Railroad. C. E. Lindsay, engineer maintenance of way of the railroad, informed the Wilder Company that their company's regular snow plow equipment could not be used here owing to the third rail, expressing his belief that the radial plow could only be used. Mr. Lindsay was especially anxious to have the wings done away with, and the sides of the plow built out to cover the third-rail. With the exception of changes noted, the plow is the same as the Wilder Company's standard Style A, size 2. The plow is further designed to take the railroad company's regular motor car wheels, axles, boxes, motors, etc. On the sharpest curves, 300 ft. radius, the deviation of the extreme point is less than 1½ ins. from the normal line on tangent, so that it may practically be disregarded.

THE W. T. VAN DORN COMPANY, of Chicago, installed on the Long Island Railroad electrical equipment, the "Van Dorn" drawbars as used in the New York Subway. The company also installed on the branch lines of the New York, New Haven & Hartford different styles of its couplings for electric service. Van Dorn couplers are also in use on the New York Central and on the Rochester Branch of the Erie Railroad.

THE CONSOLIDATED CAR HEATING COMPANY, of New York, reports that the New York Central steel cars are all equipped with the company's No. 217L type of cross-seat heater. Thirty of these heaters are used per car under cross-seats and six of the No. 203S truss plank heaters. Two of the truss plank heaters are placed in each cab, and one in each saloon. The heating equipments are arranged for four degrees of heat. All the steel cars for the Long Island Railroad are equipped with the company's panel heaters No. 205, which is attached to perforated steel riser. There are also two motormen's cab heaters, No. 192MS, one used in each cab. The heating equipments are arranged for three degrees of heat. The motormen's cabs of the new cars for the West Jersey & Seashore Railroad are equipped with the company's electric heaters, No. 192MS, two of these heaters being used on each platform. Seven of the New York, New Haven & Hartford Railroad coaches are equipped with Consolidated heaters. The New Haven Company has equipped very few cars, and these heaters are for trial. The company equipped five cars with Consolidated No. 217L type of heater, same as used in the New York Central, but use thirty-four heaters per car of this type and two No. 192W heaters fitted with wall hangers, one for each saloon; and two cars with their No. 192H type of heater, with two No. 192W heaters for saloons. The heating equipments arranged for four degrees of heat. All the cars of the Rochester Branch of the Erie Railroad are equipped with the company's truss plank heaters, No. 203S.

THE SAMSON CORDAGE WORKS, of Boston, Mass., has its Samson spot waterproofed trolley cord and Samson drab and mahogany signal cord in use on the New York Central & Hudson River Railroad, the Long Island Railroad, the West Jersey & Seashore Railroad and the Erie Railroad.

AMERICAN BRAKE SHOE & FOUNDRY COMPANY, of Mahwah, N. J., furnished to the New York Central electric lines steel-back crucible insert type shoes for the electric locomotives, and for motor and trailer brake shoes a flanged steel-back Christie type brake shoe, with expanded metal and hard inserts, and to the Long Island Railroad the company furnish Christie type steel-back flanged brake shoes, with expanded metal and hard iron inserts. To the West Jersey & Seashore Railroad the company is supplying a flanged steel-back Christie type brake shoe, "U" type, with extra face chill. This is a shoe similar to that used on the Interborough subway and elevated lines of New York City. To the New York, New Haven & Hartford Railroad the company furnished a flanged steel-back Diamond "S" shoe (expanded metal insert). For the Erie Railroad the company furnished a flanged steel-back Christie type shoe with expanded metal insert. It will be noted that all these roads use a flanged steel-back wrought lug brake shoe, and in all cases the body metal is of hard iron, which forms, in connection with inserts, a very durable and effective shoe. The steel-back flanged shoes of the M. C. B. Christie type noted herein are similar in pattern to shoes advocated for general use on electric railway equipment for 3-in. treads and over, all taking the M. C. B. Christie brake head. The flanged steel-back Christie type brake shoe is in universal use on heavy interurban equipment using the width of wheel treads of steam railroad practice, and is giving great satisfaction.

THE HARRISON SAFETY BOILER WORKS, of Philadelphia, is well represented in the different power stations through its Cochrane feed-water heater and purifier which is used in the Long Island City power station and also in that of the West Jersey & Seashore Railroad.

THE BABCOCK & WILCOX COMPANY, of New York, furnished boilers of the Babcock & Wilcox type for the Long Island City power station, and also for the two power stations of the New York Central & Hudson River Railroad Company. The Stirling department of the Babcock & Wilcox Company was the contractor for the boilers and boiler settings for the Westville power station of the West Jersey & Seashore Railroad.

THE ALBERGER CONDENSER COMPANY, of New York, supplied the condensers and the vacuum and hot well pumps for the Long Island City power station; the feed-water heaters for the power stations of the New York Central & Hudson River Railroad Company, and the condensers and pumps for the Cos Cob station of the New York, New Haven & Hartford Railroad.

THE UNITED INDURATED FIBER COMPANY, of Lockport, N. Y., supplied the indurated fiber protection for covering a large part of the third-rail construction of the West Shore Railroad and of the New York Central Railroad.

JOHN A. ROEBLING'S SONS & COMPANY, of New York, supplied a large part of the third-rail bonds for the West Shore Railroad.

THE UNION SWITCH & SIGNAL COMPANY supplied the block signal system of the West Jersey & Seashore Railroad and of the Long Island Railroad.

HENRY R. WORTHINGTON., INC., of New York, supplied the boiler-feed pumps, make-up pumps, step-bearing pumps and step-bearing water-return pumps used in the power station of the West Jersey & Seashore Railroad. The same company also supplied the condensers for the New York Central power stations.

HALE & KILBURN MANUFACTURING COMPANY, of Philadelphia, furnished the seats for the cars of the West Jersey & Seashore Railroad.

THE GENERAL RAILWAY SIGNAL COMPANY, of Buffalo, N. Y., furnished the block and interlocking systems used in the New York Central electric zone. This installation is unique in being the first which is supplied with power from a single source, as all of the track circuits, signal mechanism, line relays, signal lights, interlocking battery, charging motor-generator sets, etc., are supplied with alternating current from one transmission line.

THE ADAMS & WESTLAKE COMPANY, of Chicago, supplied the hardware for the New York Central & Hudson River and West Jersey & Seashore cars.

THE AMERICAN STEEL & WIRE COMPANY supplied the New York Central Railroad with by far the larger part of the bonds used on its third rail and running rail. It also furnished the company a large amount of 7-strand bare copper wire for 11,000 volts, paper insulated cables, accessories, telephone wire, etc. In the Long Island Railroad installation a number of Crown bonds are used on both running and third rails. The West Shore Railroad employs a great many twin terminal bonds of the company's make for both the running rail and third rail. The company also supplied for this installation bare stranded copper cable. In the New Haven equipment the company supplied some concealed bonds for the running rails and a large amount of bare and insulated cable. The American Steel & Wire Company supplied the messenger wire in the Erie installation.

THE CURTAIN SUPPLY COMPANY, of Chicago, states that its Forsyth fixture No. 86 is in service in cars on the Rochester Branch of the Erie Railroad and the West Jersey & Seashore. This is its standard Forsyth fixture which has been in service a number of years, having the adjustable and self-righting features. Upon the New York Central and New York, New Haven & Hartford cars a later type fixture is being used, namely, the Ring, No. 88.

THE J. G. BRILL COMPANY, of Philadelphia, has furnished cars for both the West Jersey & Seashore Railway and the New York, New Haven & Hartford Railway, as follows: West Jersey & Seashore, sixteen regular passenger coaches, built by the J. G. Brill Company, and twenty-two of the same type by the Wason Manufacturing Company. A more recent shipment from the Wason Manufacturing Company consisted of seven passenger cars, two combination passenger and baggage and two baggage and mail cars. New York, New Haven & Hartford, five motor combination passenger and baggage cars and twelve trailer cars for passengers only. These cars measure 31 ft. 6¼ in. over the bodies; 40 ft. over the end panels. The company also supplied the rolling stock for the electrified division of the West Shore Railroad.

THE ELECTRIC STORAGE BATTERY COMPANY, of Philadelphia, Pa., furnished elaborate storage battery systems for the Long Island Railroad and the New York Central & Hudson River Railroad.

THE STANDARD UNDERGROUND CABLE COMPANY, of Pittsburg, Pa., supplied the Long Island Railroad with varnished cloth, lead-covered cable which, with special end-bells or terminals, have been installed for an operating pressure of 11,000 volts. The New York, New Haven & Hartford Railroad Company was furnished with rubber-insulated and weather-proof braided cable for 11,000 volts operating service.