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Electrical Operation of the West Jersey & Seashore Railroad

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ELECTRICAL OPERATION OF THE WEST JERSEY & SEASHORE RAILROAD

BY B. F. WOOD

The proceedings of our engineering societies abound in papers and discussions on the merits of steam and electric operation of railroads in which data are used, which to a large extent are lacking in figures taken from the actual cost of operation. A general impression prevails that operating officers of railroads will not consent to the publication of their operating costs. This to some extent may be true, but where such figures are correctly understood and properly used there should be no objection to their publication.

When the question of presenting certain data pertaining to the operation of the electrified portion of the West Jersey & Seashore Railroad before the American Institute of Electrical Engineers was discussed with the management of the Pennsylvania Railroad, the reply was made that not only would the information be furnished but that it would be a pleasure to have such information made public through the proceedings of the Institute. The following data were taken direct from the operating records with only such additions as would make them more readily understood. No effort has been made to curtail or to modify in any respect the data selected.

It is the object of this paper to present these data in as concrete form as possible without comparison with the operation of the parallel steam service, and no attempt will be made to analyze or compare the data with any that have heretofore been presented.

This paper will be of value if railroad engineers are encouraged to present before the Institute similar data, and if some standard

form for the compilation of such data is agreed upon. Comparisons could then be made more readily and their value enhanced.

It is hoped that a discussion will be developed which will

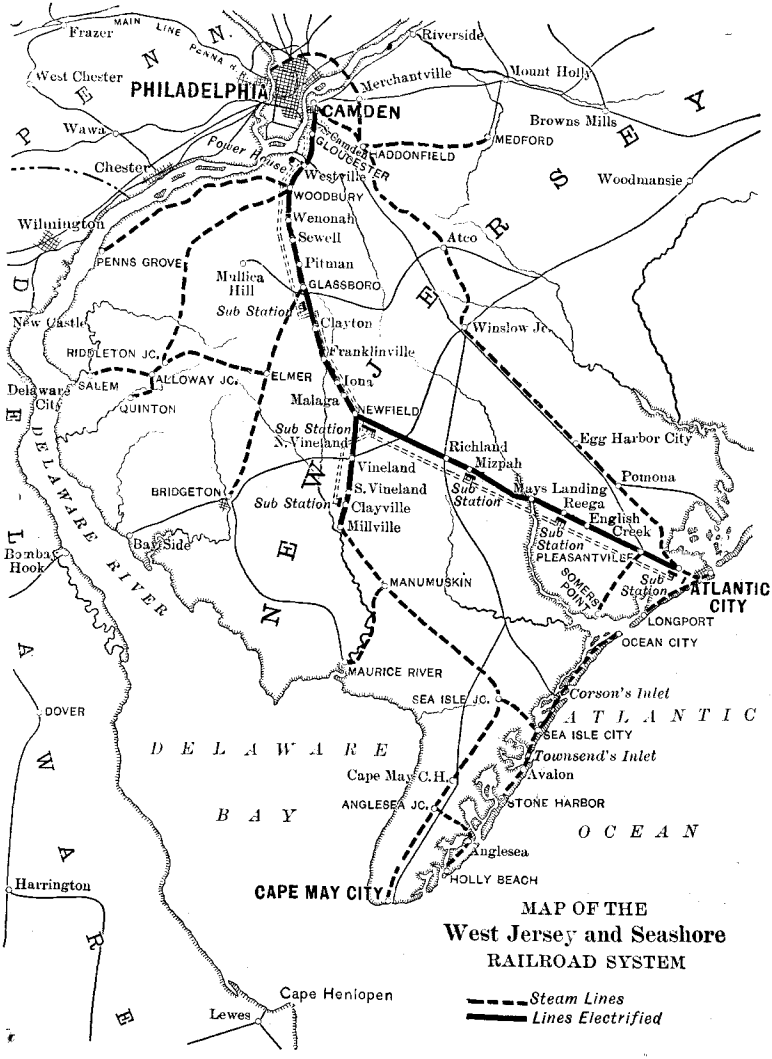


FIG. 1

enable operating officers and engineers to improve the efficiency, add to the reliability and reduce the costs of operation of electrically operated railroads.

No attempt will be made to describe in detail the construction used in the electrification of the West Jersey & Seashore Railroad as complete descriptions can be found by reference to the files of the Electric Railway Journal.[1]

The portion of the line which is electrically operated extends from Camden, via Newfield, to Atlantic City, a distance of 64.6 miles; and from Newfield to Millville, a distance of 10 miles. With the exception of the Millville Branch, which is a single track railroad, the line is double tracked with a third track extending for a distance of about six miles north from Woodbury.

This portion of the W. J. & S. R.R. was originally operated by steam and was a single track line south of Newfield. In the latter part of the year 1905 it was decided to electrify. The work was undertaken in December 1905 and had progressed to such a point that in the early part of July 1906 the first train was moved electrically. Regular operation by electric service was established in September of the same year.

The direct current over-running third-rail system operating at 675 volts was chosen for this installation.

A map of the West Jersey & Seashore Railroad is shown in Fig. 1, from which the electrified portion can be readily followed. The locations of the power station and the substations are shown, as well as the position of the transmission line with respect to the line of the railroad.

In order that the statements of cost of operation and detentions to train service may be more readily understood, the general characteristics of the electrified portion are given.

General Description

Track:

Main line, Camden to Newfield, double track, 100-lb. rails	30.2 miles
Main line, Newfield to Atlantic City, double track, 85-lb. rails	34.4 miles
Main line, South Camden to Woodbury, third track, 100-lb. rails	6.0 miles
Branch line, Newfield to Millville, single track, 100-lb. rails	10.0 miles
Total length of single track, including sidings	150.0 miles

Power Station:

Location: Westville, N. J., on Big Timber Creek, 5.6 miles from Camden Terminal. Rated capacity 8000 kw.

1. *Street Railway Journal*, November 10, 1906.
Street Railway Journal, October 12, 1907.

Equipment turbine room:
- Four 2000 kw. 6600 volt, three-phase, 25 cycle, Curtis turbo-generators.
- Twelve 700 kw. 6600/33000 volt, single-phase, 25 cycle, air blast transformers.
- Three 75 kw., 125 volt, Curtis turbo-exciters.
- Three 12 h.p. blowers, 20,000 cu. ft. per min. each.

Equipment auxiliary room:
- Four Williamson Bros. barometric condensers.
- Four I. P. Morris & Co., dry vacuum pumps.
- Four I. P. Morris & Co., centrifugal circulating pumps. (three driven by Reeves engines; one by Curtis turbine).
- Two Cochrane feed water heaters, each 539 cu. ft. capacity to overflow.

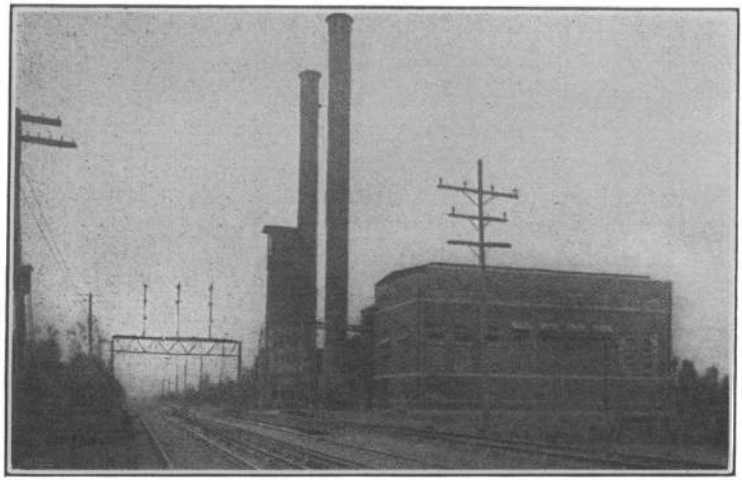


FIG. 2.—Power house at Westville, N. J.

- Three Worthington boiler feed pumps.
- Two Worthington make-up pumps.
- Two Worthington step bearing pumps.
- One R. D. Wood accumulator for step bearing, 800 lb. per sq. in., 100 gal. capacity.
- One R. D. Wood accumulator for step bearing, 100 lb. per sq. in.
- One Worthington oil pump.
- One Blake oil pump.

Equipment boiler room:
- Sixteen Sterling water tube boilers, 358 h.p. each, with superheaters
- Fourteen boilers equipped with Roney stokers.
- Two boilers equipped with Taylor stokers.
- Hunt gravity return system of coal handling used.

A general view of the exterior of the plant is shown in Fig. 2. In Fig. 3 a plan of the station is shown.

Transmission Line:

Length, 69.3 miles.

Line in duplicate, 33,000 volt, Y connected, neutral grounded.

Poles of chestnut, 45 ft. high, spaced 125 ft. apart—100 ft. at road crossings.

Head guys used every quarter mile, approximately.

Lightning protective ground wire strung on top of poles, 4 ft. above nearest wire, wire of 7 stranded steel galvanized cable, $\frac{5}{16}$ in. diameter. Grounded every fifth pole.

Two cross arms on each pole. Top arm 12 ft. long carries 4 insula-

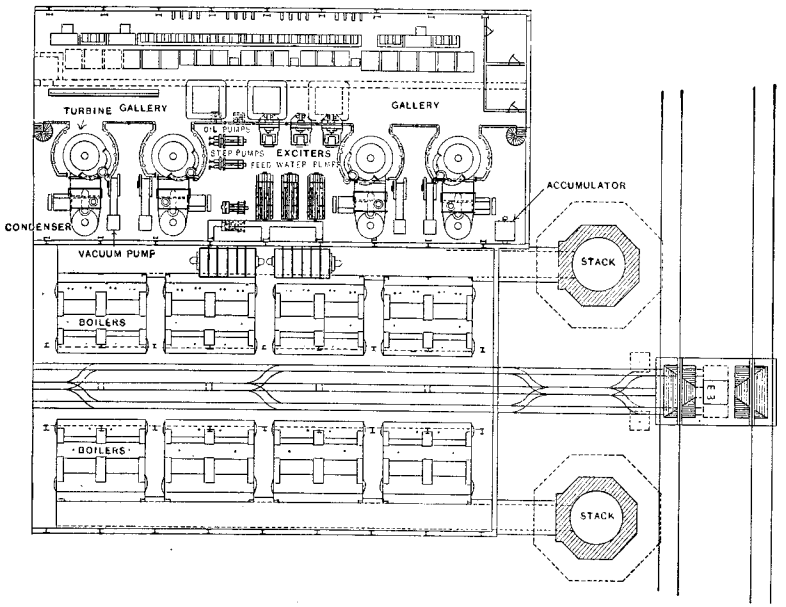


FIG. 3.—Plan of power house at Westville, N. J.

tors; lower arm 8 ft. 6 in. long carries 2 insulators. Insulators 42 in. apart, forming equilateral triangle.

Wire, No. 1 B. & S., hard drawn, solid copper.

Wires transposed by one complete spiral between each substation, making a total of seven transpositions.

Signal line and lighting circuit, 1100 volt, single-phase, runs below 33,000 volt line from Camden to Newfield and from Pleasantville to Atlantic City.

Substations:

The high-tension, three-phase current is reduced in pressure and converted to direct-current at 675 volts in eight substations located as follows:

South Camden, 2.3 miles from Camden terminal.
Westville (in power house) 3.6 miles south from South Camden.
Glassboro, 12.1 miles south from Westville.
Newfield, 12.2 miles south from Glassboro.
Mizpah 10.9 miles south from Newfield.
Reega, 10.1 miles south from Mizpah.
Atlantic City, 12.5 miles south from Reega.
Clayville, 8.0 miles from Newfield (on Millville branch).

Equipment:

	Converters	Total cap.	Transformers	Alternating current line panels	Direct current feeder panels
South Camden	Two 750-kw. One 1000-kw.	2500-kw.	Six 275-kw. Three 370-kw.	2	2
Westville	Two 750-kw. One 1000-kw.	2500-kw.	Six 275-kw. Three 370-kw.	2	6
Glassboro...	Two 750-kw. One 1000-kw.	2500-kw.	Six 275-kw. Three 370-kw.	4	4
Newfield....	Two 750-kw. One 1000-kw.	2500-kw.	Six 275-kw. Three 370-kw.	6	5
Mizpah.....	Two 500-kw.	1000-kw.	Six 185-kw.	4	4
Reega.....	Two 750-kw.	1500-kw.	Six 275-kw.	4	4
Atlantic City	Two 750-kw. One 1000-kw.	2500-kw.	Six 275-kw. Three 370-kw.	2	4
Clayville....	Two 500-kw. One 1000-kw.	2000-kw.	Six 185-kw. Three 370-kw.	2	2

Converters, 6-phase, diametrically connected, started from alternating current end in three steps.
Transformers air cooled, placed over air duct, supplied by two blowers.
Automatic oil line switches.
Multigap lightning arresters in all stations.
The plan and section of a typical substation are shown respectively in Fig. 4 and 5. Fig. 6 shows the exterior of the substation at Newfield.

Third Rail:

Length, single rail, main line and branch.....137.12 miles
Sidings..... 4.61 miles

Total.....141.73 miles

Rails:
Standard P. R.R. cross section and composition, 100-lb. per yd.
Conductivity equal to that of copper rod of 1,200,000 cm. cross section. Located 2 ft. 2 in. from gauge line of track and 3½ in. higher than running rails.
Contact made on top of rail.

Bonded with concealed ribbon bonds, solid copper terminals, pressed into one inch holes drilled in the rail. Two bonds per joint, 500,000 cm. each.

Road crossing jumpers consist of one cable per rail, of 1,000,000 cm., in bituminized fibre conduit laid in concrete.

Jumpers brought out of concrete posts with removable hoods and bonded to rail by two stub-end bonds.

Third rails are provided with protection boards at all stations and for 20 ft. on each side of all road crossings. At stations side protection boards are also used. Top board, two in. plank, supported on castings held by maple posts placed six ft. apart.

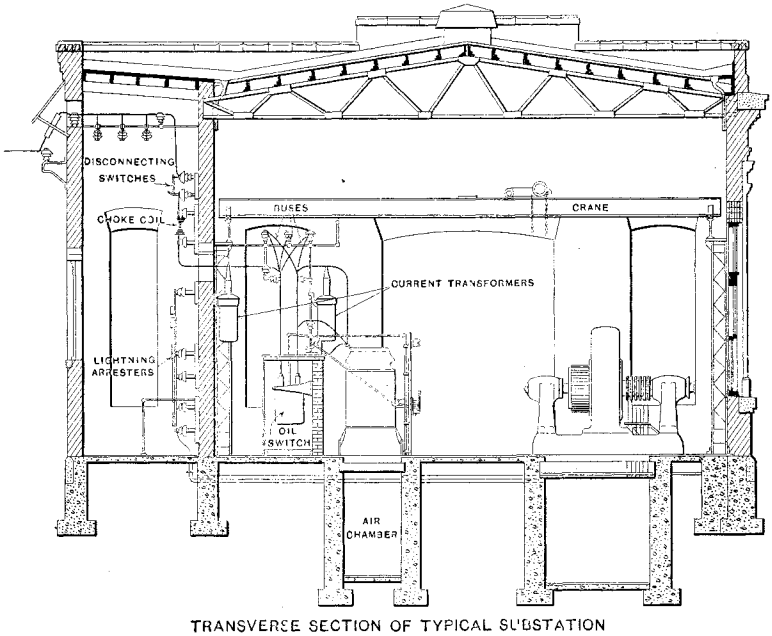


FIG. 4.—Transverse section of typical substation.

The third rails are sectionalized at each substation, each north-bound and each south-bound rail having a separate feeder.

The two rails are cross-bonded at three points between sub-stations.

No feeders are used in connection with third rail.

In Fig. 7 is shown a view of the third rail approach block, the top and side protection for the third rail.

In Fig. 8 is shown the third rail arrangement at cross-over and shows unprotected as well as protected rail.

In Fig. 9 is shown a general view of the yard at Camden, in which all of the third rail is protected.

Trolley:

Length of single wire,

Main line	8.60 miles
Sidings	0.04 miles
Overlapping	0.91 miles
Total	9.55 miles

Wire is No. 4/0 grooved section, supported by $\frac{3}{8}$-in. galvanized steel stranded span wires at a height of 22 ft. above track rails.

There are two 750,000 cm. feeders, South Camden substation to Haddon Avenue, Camden, and one 500,000 cm. cable South Camden substation to South Gloucester.

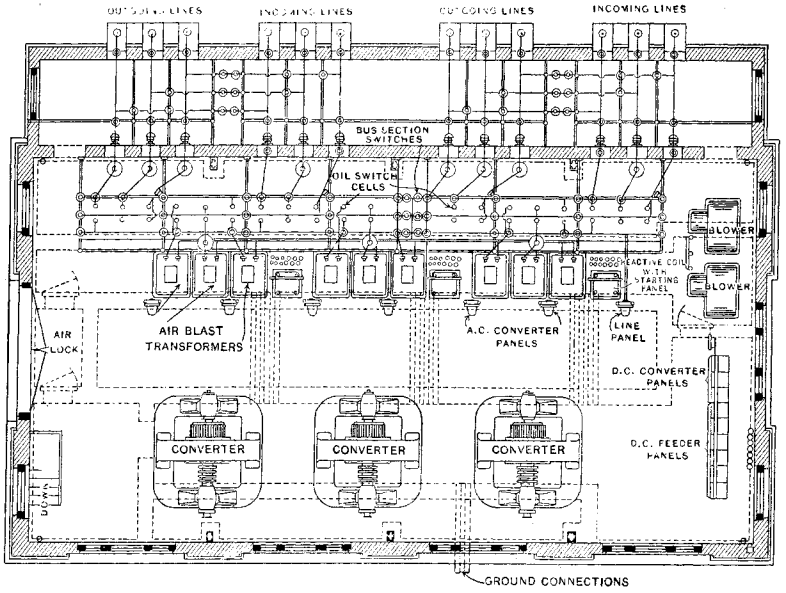


FIG. 5.—Plan of typical substation.

Track Bonding:

Concealed ribbon bonds used with solid copper terminals compressed into one inch holes drilled in the rail.

Two bonds per joint, 400,000 cm. each.

Special splice bars used to admit bonds.

Bonds tested every six months by means of millivoltmeters and Whitney Bond Tester.

Cars and Equipment:

Car equipment consists of:

79 coaches, seating capacity 58.
2 combined passenger and baggage, seating capacity 36.
6 baggage and mail.
6 baggage.

Total 93 cars.

Coaches weigh 94,500 lb. or 1,630 lb. per passenger.
Electrical equipment of each car consists of two 200 h.p. motors with multiple unit system of automatic control.
Gear ratio. 46:29.
Additional equipment has been authorized consisting of 15 steel

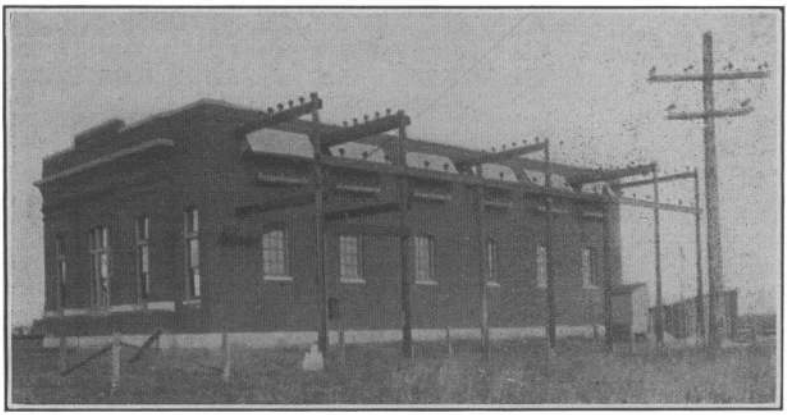


FIG. 6.—Exterior of Newfield substation

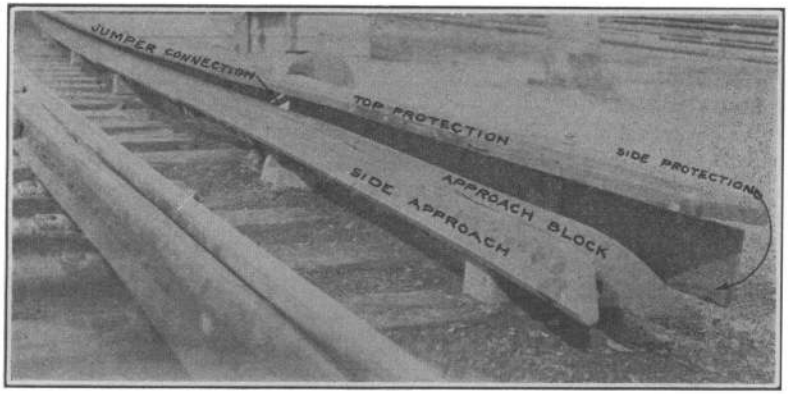


FIG. 7.—Third rail approach block, top protection and side protection

coaches, having a seating capacity of 72. The cars will weigh 103,500 lb. or 1445 lb. per passenger.

Inspection Sheds:

All inspections and repairs made in Camden shed. Other sheds used for emergency inspection and light repairs.

Camden shed, three tracks, accommodates 9 cars.
Atlantic City shed, two tracks, accommodates 6 cars.
Millville shed, one track, accommodates 3 cars.
Third rail is not continued into sheds, overhead trolly being used.

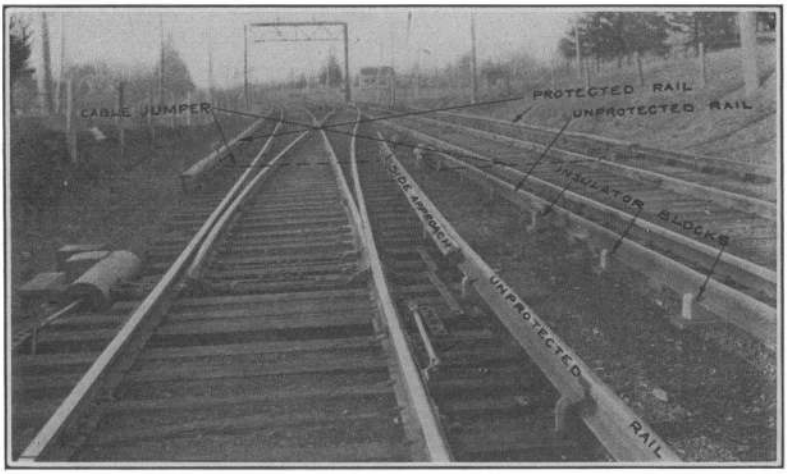


FIG. 8.—Third rail at cross-over

FIG. 9.—View of electrified yard at Camden terminal

COST OF CONSTRUCTION

A table is included showing the cost of construction in connection with the electrification and includes costs made necessary by electrification. It will be noted that the electrification

costs represent less than half of the total cost involved in the change of motive power.

Costs are also presented showing the unit costs of power station transmission line, substations etc.

COST OF CONSTRUCTION

Power Stations:		
Building, stacks, coal and ash handling machinery	$354,000	
Equipment	640,900	
Total		$994,900
Transmission line		241,500
Substations:		
Buildings	72,000	
Equipment	419,560	
Total		491,560
Third rail		557,636
Overhead trolley		80,500
Track bonding		102,659
Cars		1,135,900
Car repair and inspection sheds		46,674
Right-of-way, additional		592,100
Reconstructing tracks		763,800
Constructing new tracks		2,071,000
Terminal facilities and changes at stations		252,400
Signals and interlocking plants		561,900
Changing telegraph and adding telephone facilities		105,100
Fencing right-of-way, cattle guards, etc		88,400
Miscellaneous items		44,200
Total		8,130,229

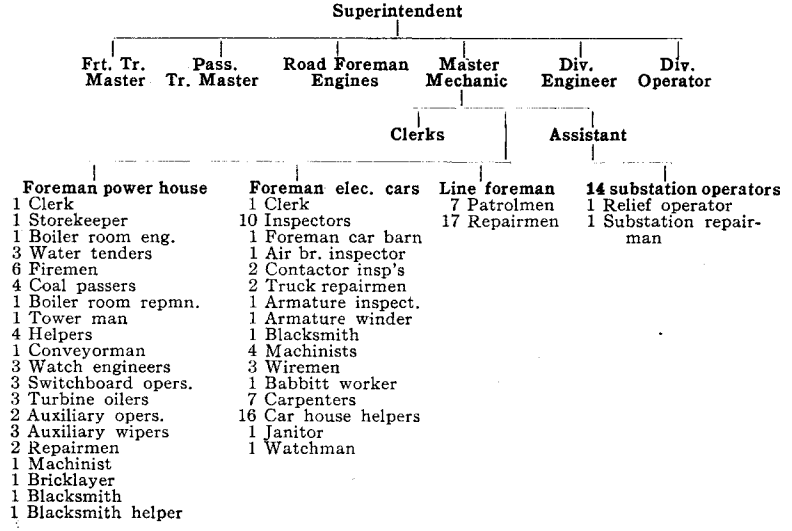
UNIT COST OF ELECTRIFICATION

Power station, cost per kw	$124.36
Transmission line, cost per mile	3,485.00
Substations, building and equipment cost per kw	28.90
Third rail, cost per mile	4,235.00
Overhead trolley, cost per mile	4,120.00
Track bonding, cost per mile	684.50
Cars, including electrical equipment each	12,214.00

ORGANIZATION

With the introduction of the electric service the organization of the road was not changed but was expanded to provide for the new duties. A chart of the Motive Power Organization is

shown below, which shows the number of employees engaged in the various departments:



Cost of Operation and Maintenance

The cost of operation and maintenance is shown under several headings as follows:

1. Cost of operation in cents per car mile.
2. Cost of operation and maintenance of Westville power station.
3. Cost of maintenance of high-tension transmission line.
4. Cost of operation and maintenance of substations.
5. Cost of maintenance of third rail.
6. Cost of maintenance of trolley.
7. Cost of maintenance of bonding.

Table I shows the cost of operation for the years 1909 and 1910, in cents per car mile, and subdivides the cost of operation into the general headings, repairs, electric equipment of cars; repairs, passenger cars; other maintenance of equipment costs; electric power at car shoes; yard service, shifting cost; motormen; trainmen; train supplies and expenses; total of above; other expenses; total expenses. The table also shows the total car miles per month and the average cars per train. The headings of this statement are probably sufficiently explanatory, other than "other expenses," which includes cost of maintenance of way and structures, despatching trains, telephone and tele-

graph, crossing gatemen, together with traffic expenses and general expenses.

Table II shows the cost of operation and maintenance of the Westville power station for the year 1910. This statement is subdivided under the general headings of operation and

TABLE I

WEST JERSEY & SEASHORE RAILROAD

Electric train service

Passenger train statistics

Cost of operation in cents per car mile

	Repairs, Electric Equipment of Cars.	Repairs Passenger Cars.	Other Maintenance of Equipment Costs.	Electric Power at Car Shoes.	Yard Service Shifting Costs	Motormen	Trainmen.	Train Supplies and Expenses.	Total.	Other Expenses	Total Expenses.	Car Miles, Total.	Average Cars per Train.
Year 1909													
January	1.06	2.05	0.48	4.78	0.51	0.93	1.53	1.20	12.53	10.25	22.78	279,210	3.113
February	1.07	2.42	0.38	4.63	0.51	0.91	1.49	1.22	12.63	10.99	23.62	258,130	3.163
March	1.18	1.97	0.35	4.99	0.52	0.99	1.65	1.18	12.83	10.17	23.00	279,193	3.092
April	1.26	2.03	0.25	4.43	0.46	0.89	1.40	0.61	11.32	9.14	20.46	317,963	3.483
May	0.84	1.73	0.26	3.98	0.44	0.88	1.45	0.45	10.03	9.18	19.21	318,006	3.482
June	0.40	0.68	0.31	3.58	0.25	0.86	1.41	0.42	7.91	9.35	17.26	339,294	3.530
July	0.33	0.44	0.12	2.82	0.20	0.80	1.25	0.40	6.36	6.95	13.31	478,203	3.669
August	0.28	0.40	0.14	2.75	0.20	0.75	1.18	0.36	6.06	6.29	12.35	517,223	3.921
September	0.43	0.67	0.14	2.75	0.25	0.83	1.32	0.42	6.81	6.87	13.68	428,571	3.584
October	0.64	0.71	0.24	3.84	0.31	0.92	1.53	0.62	8.81	10.21	19.02	307,825	3.046
November	0.52	0.39	0.29	3.85	0.29	0.95	1.70	0.82	8.81	9.30	18.15	291,816	3.327
December	0.87	1.08	0.29	12.31	0.30	1.00	1.72	1.30	18.87	15.05	33.92	292,175	3.318
Avg.	0.68	1.10	0.25	4.30	0.33	0.88	1.44	0.69	9.67	9.08	18.75	4,107,609	3.457
Year 1910													
January	0.86	1.03	0.67	4.59	0.46	0.96	1.64	2.24	12.45	7.22	19.67	292,523	3.169
February	0.79	1.78	0.33	5.38	0.50	0.97	1.48	1.07	12.30	12.44	24.74	262,488	3.137
March	1.04	1.13	0.28	3.87	0.48	0.88	1.51	0.89	10.08	12.91	22.99	333,252	3.445
April	0.62	0.76	0.31	4.57	0.49	0.97	1.62	0.70	10.04	11.55	21.59	302,463	3.344
May	0.57	0.78	0.24	2.78	0.48	0.89	1.41	0.44	7.59	9.92	17.51	351,994	3.651
June	0.79	0.67	0.24	2.80	0.45	0.97	1.62	0.58	8.12	10.13	18.25	375,023	3.406
July	0.44	0.46	0.18	2.47	0.34	0.89	1.39	0.36	6.53	6.66	13.19	565,787	3.641
August	0.29	0.57	0.15	2.48	0.33	0.85	1.38	0.37	6.42	5.62	12.04	594,852	3.811
September	0.37	0.54	0.21	2.71	0.39	0.85	1.42	0.42	6.91	7.34	14.25	487,543	3.771
October	0.73	1.19	0.28	3.05	0.47	0.91	1.69	0.52	8.84	12.34	21.18	339,789	3.564
November	1.40	2.45	0.47	3.71	0.51	0.96	1.71	0.54	11.75	10.58	22.33	311,882	3.379
December	0.63	1.94	0.21	3.93	0.51	0.93	1.71	0.74	10.60	12.13	22.73	334,936	3.494
Avg.	0.66	1.01	0.27	3.33	0.43	0.91	1.52	0.67	8.80	9.39	18.19	4,552,532	3.518

maintenance and under the further sub-headings of material and labor. The statement shows the total monthly cost as well as the cost in cents per kw-hr. for each item.

The total net output from the station is also shown as well as the pounds of coal per kw-hr. and the cost of coal per ton of 2,000 lb.

Table III is given showing the cost of maintenance of the transmission system, which includes high-tension transmission, overhead trolley, third rail and running track bonding.

In connection with the maintenance cost of overhead trolley, it should be borne in mind that the trolley construction is of

TABLE III
WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE
Cost of maintenance of transmission systems
Year 1910

	High tension		Overhead trolley		Third rail		Running track bonding	
	Total	Per mile	Total	Per mile	Total	Per mile	Total	Per mile
January...	$142.96	$2.04	$690.84	$35.32	$492.96	$3.74	$26.67	$1.51
February..	409.74	5.85	266.38	13.62	580.80	4.41	562.82	3.75
March.....	198.62	2.84	381.28	19.49	495.55	3.76	39.26	0.26
April.....	403.44	5.76	446.57	46.71	745.16	5.26	†30.24	0.20
May.....	256.14	3.66	291.51	30.49	1,126.40	7.95	190.05	1.27
June.....	123.21	1.76	864.62	90.44	957.42	6.75	312.08	2.08
July.....	167.90	2.40	393.62	41.17	818.29	5.77	494.79	3.30
August....	357.20	5.10	317.49	33.21	1,631.72	11.51	32.99	0.22
September.	508.51	7.26	389.73	40.77	838.87	5.92	202.05	1.35
October....	604.93	8.64	245.75	25.70	647.27	4.57	98.66	0.66
November.	171.58	2.45	363.35	38.01	1,062.98	7.50	189.83	1.26
December.	100.34	1.43	244.02	25.52	1,466.71	10.35	125.03	0.83
Total and avg. per mi. per mo....	$3,444.57	$4.10	$4,895.16	$36.70	$10,864.13	$6.46	$2,445.72	$1.36

†Credit for scrap 58.75

TABLE IV
WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE
Cost of operation and maintenance of substations
Year 1910

	Total for eight substations				
	Operation	Maintenance	Total	Cost per kw-hr.	Substation output kw-hr. 675 volts direct-current
January.....	$1,573.82	$373.10	$1,946.92	$0.001136	1,655,800
February.....	1,601.78	147.39	1,749.17	0.001157	1,460,200
March.....	1,618.16	174.27	1,792.43	0.001035	1,678,400
April.....	1,728.98	275.64	2,004.62	0.001251	1,554,900
May.....	1,760.46	370.91	2,131.37	0.001267	1,635,900
June.....	1,794.44	432.55	2,226.99	0.001310	1,655,600
July.....	2,006.97	317.62	2,324.59	0.001047	2,175,700
August.....	1,751.03	194.13	1,945.16	0.000811	2,349,000
September....	1,776.14	903.45	2,679.59	0.001285	2,035,200
October.....	1,744.23	145.99	1,890.22	0.001069	1,712,100
November....	1,750.62	142.23	1,892.85	0.000986	1,860,100
December.....	1,745.68	130.02	1,875.70	0.000829	2,199,400
Year.....	$20,852.31	$3,607.30	$24,459.61	$0.001082	21,972,300

rigid span type and also that current is collected by a trolley wheel on each car of a train, the number of cars per train varying from two to seven, the average being about three.

Originally the ten mile line from Newfield to Millville was equipped with overhead trolley of the same construction as the present line. This trolley was replaced by third rail the latter part of March, 1910, hence the maintenance cost per mile in Table 3 is based on 19.55 miles to March, inclusive, and on 9.55 miles from that time on.

The operation and maintenance of substations for the year 1910 is shown in Table IV. This shows the cost of operation and maintenance of the eight substations during the year 1910, by month, as well as the cost per kw. hr. output per substation and the output in direct current at 675 volts.

Detentions to Train Service

A detailed statement of the detentions to electric train service occurring during the year 1909 is given in table No. VIII. The column headed "Number of detentions," means number of trains detained and is subdivided into totals and per cent of total. The column headed, "minutes detention", shows the train minutes of detention for each cause and is subdivided into the headings of totals and per cent of totals. The column headed "car miles per minute of detention", shows the total car miles per train minute of detention for each cause.

A further subdivision of the detentions due to train equipment shown under the general heading "motive power", is given in Tables IX and X the first being for the year 1909 and the second for the year 1910. This statement shows the detentions that occurred during each year by months and it may be well to say that the figure shown above the line represents the number of detentions, while the figure below the line represents the train minutes delay for that particular detention.

Renewal of Parts of Car Equipment

The number of renewals of the various parts of car equipment for the year 1909 is given by months in Table V and the same information for the year 1910 is given in Table VI.

The car mileage for 1909 being 4,106,765 and for 1910, 4,552,056, it is seen that the number of car miles per third rail shoe replaced in 1909 was 8068 and in 1910 was 4079, giving an average of about 6005 car miles per replacement. As each car is

TABLE V

WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE
RENEWAL OF PARTS OF CAR EQUIPMENT
1909

Part of equipment	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Third rail shoes replaced	42	38	51	42	12	10	39	59	28	71	62	55	509
Brake shoes replaced	388	237	353	423	304	435	536	592	689	476	402	462	5297
Trolley poles bent	3	1	14	8	9	12	12	15	10	10	3	11	108
Trolley poles broken	0	0	1	0	0	0	0	1	0	0	1	0	3
Trolley poles missing or replaced	0	1	0	0	0	0	0	0	0	0	4	0	5
Trolley wheels lost or replaced	24	23	25	19	27	2	36	17	38	13	11	24	259
Trolley retriever dogs broken	0	0	0	0	0	0	0	0	0	0	0	0	0
Trolley harps broken or replaced	11	7	5	2	5	3	6	6	5	1	0	0	51
800 ampere shoe fuses blown	264	198	226	193	180	113	101	125	69	138	197	279	2081
800 ampere trolley fuses blown	52	33	34	40	15	26	45	101	37	53	46	36	518
800 ampere bus fuses blown	15	10	17	9	11	6	17	14	11	21	12	59	202
25 ampere controller fuses blown	5	7	6	6	2	0	0	1	2	6	5	11	51
20 ampere No. 2 heater fuses blown	15	18	9	24	4	7	0	0	2	23	16	26	144
10 ampere No. 1 heater and comp. fuses blown	21	27	25	18	7	2	1	9	24	28	27	35	224
5 ampere cab heater fuses blown	0	1	0	0	0	0	0	0	1	0	0	4	6
4 ampere control cable fuses blown	3	4	11	1	0	1	1	2	7	1	1	2	34
2 ampere headlight fuses blown	4	0	1	3	2	0	2	3	5	1	0	13	34
1 ampere car light fuses blown	2	1	0	4	9	6	5	8	19	7	3	11	75
50 c.p. headlights burned out	20	18	10	18	11	22	40	40	36	24	16	16	271
50 c.p. headlights missing	1	1	1	3	1	4	1	0	3	1	0	1	17
16 c.p. lamps burned out	188	148	180	182	140	103	129	153	163	141	156	169	1862
16 c.p. lamps missing	41	45	42	14	42	26	15	21	33	18	28	51	376
16 c.p. lamps broken	9	18	4	18	5	22	6	7	6	9	7	14	125
Gauge lamps replaced	24	18	14	10	12	5	4	12	4	5	11	10	129

TABLE VI

WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE
RENEWAL OF PARTS OF CAR EQUIPMENT
1910

Parts of equipment	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Third rail shoes replaced	198	125	157	43	27	58	26	41	67	54	73	60	933
Brake shoes replaced	425	454	511	469	511	570	675	780	531	416	444	514	6300
Trolley poles bent	4	6	12	12	5	9	8	12	16	2	1	2	89
Trolley poles broken	3	3	1	3	1	0	3	0	3	1	0	0	18
Trolley poles missing or replaced	2	4	0	1	0	1	1	4	3	1	0	4	21
Trolley wheels lost or replaced	19	2	13	9	10	19	18	5	13	3	1	12	124
Trolley retriever dogs broken	0	0	0	0	0	0	0	0	0	0	0	0	0
Trolley harps broken or replaced	2	4	1	4	0	4	2	1	3	2	0	2	24
800 ampere shoe fuses blown	186	199	284	173	178	248	229	304	287	210	197	303	2798
800 ampere trolley fuses blown	56	55	51	23	22	48	107	75	70	32	17	19	575
800 ampere bus fuses blown	48	11	25	29	17	29	19	22	22	6	3	17	248
25 ampere controller fuses blown	14	8	4	6	1	2	4	0	0	1	20	5	65
20 ampere No. 2 heater fuses blown	17	13	19	7	0	2	0	0	0	2	33	13	106
10 ampere No. 1 heater and comp. fuses blown	28	31	21	19	7	9	2	1	3	5	27	25	178
5 ampere cab heater fuses blown	0	14	0	0	0	0	0	0	0	0	0	1	15
4 ampere contrl. cable fuses blown	0	0	2	0	0	1	6	5	6	2	4	3	29
2 ampere headlight fuses blown	9	24	4	6	3	2	1	1	7	5	3	17	82
1 ampere car light fuses blown	4	16	21	3	3	6	2	2	6	3	3	7	76
50 c.p. headlights burned out	25	14	3	18	16	14	21	13	18	14	12	9	177
50 c.p. headlights missing	17	21	1	3	2	3	3	2	6	0	0	6	64
16 c.p. lamps burned out	193	211	159	125	93	76	96	109	135	163	157	182	1699
16 c.p. lamps missing	72	59	64	50	49	45	25	26	27	39	54	67	577
16 c.p. lamps broken	19	20	7	6	0	2	5	4	9	5	3	3	83
Gauge lamps replaced	27	17	6	13	9	8	10	8	7	1	4	0	110

equipped with four shoes this gives an average life of 24,020 miles per shoe.

Likewise the number of car miles per brake shoe was 775 in 1909 and 722 in 1910 or an average of about 747 car miles per replacement. The average life of each brake shoe is therefore about 5976 miles.

The number of replacements of the remaining items is governed rather by special occurrences than by mileage, with the exception of the lamps, the average life of which is not readily obtainable owing to incomplete data concerning number of hours burned.

A statement is also included showing the breakage of gears and pinions by month for the years 1909 and 1910. This will be found by reference to Table VII.

TABLE VII

WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE

Gear and pinion breakages

	1909	1910
January	4	1
February	3	1
March	5	3
April	2	1
May	1	5
June	0	1
July	0	0
August	1	0
September	1	0
October	2	0
November	0	0
December	2	1
Total	21	13

Table XI shows, by months, for the years 1907, 1908, 1909 and 1910 certain general power data, which are included as being of some interest. This statement, shows the kw-hr. output from power station, the cost in mills per kw-hr. output, pounds of coal per kw-hr., and the efficiency of transmission and conversion from the alternating current bus in the power station to direct current bus in substations.

An improvement will be noted in the reduction of cost of power, as well as a reduction in coal consumption per kilowatt hour. The most marked improvement, however, will be noted in efficiency of transmission and conversion, which is accounted for by the fact that the operation of the substations is followed up with care so as to minimize the idle operation of rotaries.

TABLE VIII
WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE
Detentions
Year 1909

Causes	Train detentions, number, time and per cent for various causes				
	Number of detentions		Minutes detention		
	Total	Per cent of total	Total	Per cent of total	Car miles per minute detention
Transportation.					
Boat connection	51	0.553	180	0.403	22,815.36
Baggage, express and mail	1898	20.575	8373	18.749	490.47
Heavy travel	1232	13.355	4612	10.328	890.45
Collecting tickets	72	0.781	334	0.748	12,295.70
Train connections	977	10.591	5517	12.354	744.38
Traffic ahead	1723	18.677	7842	17.561	523.68
Held at signal	1390	15.068	4767	10.675	861.50
Stops on order	73	0.791	165	0.369	24,889.49
Fast schedule	34	0.368	57	0.128	72,048.50
Picking up and cutting off cars	411	4.455	1312	2.938	3,130.15
Fog	41	0.444	127	0.284	32,336.73
Signal failure	208	2.255	860	1.926	4,775.31
Accidents	26	0.282	261	0.584	15,734.73
Obstructions	33	0.358	194	0.434	21,168.89
Miscellaneous	283	3.068	1427	3.196	2,877.90
Total transportation	4852	91.621	36028	80.677	113.98
Motive power.					
Power house trouble	15	0.163	69	0.155	59,518.30
High tension line trouble	14	0.152	81	0.181	50,700.80
Lightning	12	0.130	47	0.105	87,377.90
Overloads in substations	11	0.119	61	0.137	67,324.00
Third rail shorts	3	0.032	14	0.031	293,340.40
Third rail out of place	1	0.011	8	0.019	513,345.13
Third rail anchor on fire	1	0.011	5	0.011	821,353.00
Third rail protection out of place	1	0.011	1	0.002	4,106,765.00
Trolley wire trouble	253	2.742	1920	4.299	2,138.94
Train equipment	237	2.569	1568	3.511	2,619.11
Total motive power	548	5.940	3774	8.451	1,088.17
Weather Conditions.					
Snow, head winds, wet rail	178	1.929	4043	9.054	1,015.77
Sleet on third rail	47	0.510	812	1.818	5,057.59
Total weather condition	225	2.439	4855	10.872	845.88
Grand total	9225	100.00	44657	100.00	91.96

Total car mileage	4,106,765
Car miles per detention	445.18
Car miles per minute of detention	91.96

TABLE XI
WEST JERSEY & SEASHORE RAILROAD ELECTRIC TRAIN SERVICE
General power data

	1907				1908			
	Alternating Current kw hr Power Station Output	Cost in Mills per Kw-hr. Output	Lb. of Coal Kw-hr. Output	Efficiency Power Sta. Bus to Substation Bus	Alternating Current Kw-hr. Power Station Output	Cost in Mills per Kw-hr. Output	Lb. of Coal Kw-hr. Output	Efficiency Power Sta. Bus to Substation Bus
January.....	1,911,600	8.83	3.91	72.6	2,009,600	6.10	3.49	73.3
February.....	1,691,500	7.95	3.63	74.5	1,913,100	6.35	3.55	73.6
March.....	1,583,000	7.76	3.96	71.5	1,873,300	6.17	3.46	72 3
April.....	1,464,300	7.43	3.95	74.0	1,836,200	5.86	3.45	71.8
May.....	1,400,400	6.81	3.53	72.1	1,744,900	6.06	3.40	69.6
June.....	1,395,700	7.65	3.98	70.6	1,707,500	5.91	3.52	74.8
July.....	1,938,100	6.05	3.65	71.6	2,104,300	5.43	3.37	75.6
August.....	2,082,000	6.00	3.43	71.6	2,268,000	5.43	3.18	75.8
September...	1,855,300	6.07	3.46	71.7	1,849,200	5.76	3.18	74.7
October.....	1,849,800	5.99	3.53	82.8	1,786,700	5.78	3.25	72.8
November....	1,893,600	5.86	3.51	71.3	1,802,000	5.78	3.35	74.7
December....	2,053,600	6.00	3.51	72.5	1,993,000	5.80	3.25	76.2
Av. for year..	1,759,900	6.80	3.67	72.2	1,907,300	5.92	3.37	73.8
	1909				1910			
January.....	1,959,700	5.67	3.23	76.1	2,131,000	5.15	3.31	81.8
February....	1,756,500	5.71	3.25	76.1	1,865,300	5.73	3.46	82.4
March.....	1,903,600	6.04	3.33	76.1	2,168,600	5.42	3.27	81.3
April.....	1,869,300	5.90	3.27	75.0	2,031,400	5.62	3.22	80.1
May.....	1,788,800	5.65	3.26	75.5	2,115,900	5.25	3.27	79.5
June.....	1,749,200	5.77	3.22	77.7	2,167,500	5.68	3.14	80.3
July.....	2,426,000	5.21	3.25	78.0	2,784,300	5.88	3.16	82.5
August.....	2,324,400	5.27	3.34	81.5	3,088,300	5.11	3.06	80.7
September....	2,056,100	5.28	3.34	80.3	2,590,400	5.17	3.31	82.9
October.....	1,836,600	5.40	3.27	80.1	2,229,000	5.48	3.17	80.8
November....	1,869,500	5.49	3.41	80.7	2,381,500	5.19	3.29	81.9
December....	2,154,800	5.42	3.41	81.0	2,759,300	5.31	3.35	83.4
Av. for year..	1,962,600	5.55	3.30	78.4	2,359,400	5.42	3.25	81.6