The Success of Main Line Electrification*

A Discussion of Conditions Which Affect It, with Operating Data Dealing with Results on the New Haven

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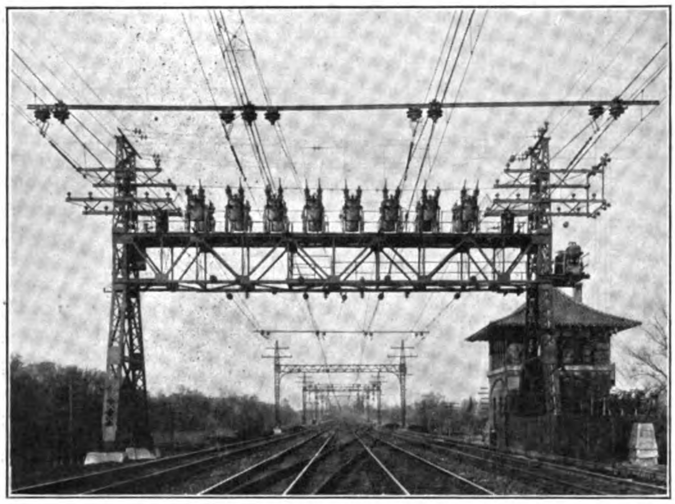
The part of the New Haven system that has been electrified constitutes its most important division, extending from New Haven to New York, and on its main line, yards, sidings, and spurs every class of railroad movement is being daily made by electricity. The route mileage electrified is 73 miles, of which 61 is of four tracks and 12 of six tracks, thus giving a total main line mileage, measured in single track, of 316. To this may be added 184 miles of yards, sidings, and spurs, thus making a grand total, measured upon a single-track basis, of 500 miles. It is of interest to note that of the yards electrified one includes 35 miles, the other 25 miles.



Four-Track Tangent Catenary Construction, Showing Anchor Bridge with Sectionalizing Switches Installed on It,

Electric power is supplied from a single station, centrally located, but this will, in a short time, be supplemented by other supplies to be applied at the east and west ends of the electrification zone. There are 100 passenger, freight and switching electric locomotives, and 69 multiple-unit cars. One main electrical shop has been completed, the capacity of which permits the maintenance and repairs of the above-mentioned electric motive power.

To date over $15,000,000 has been expended on this electrical transportation plant. While such a figure represents the cash outlay, there have accrued to its appropriation accounts, during the process of construction, large credits for steam equipment replaced, as, for example, the 150 steam locomotives which have been transferred to other parts of the New Haven system, and the steel bodies of the multiple-unit equipment, which would have been purchased even had not the electrification been undertaken.

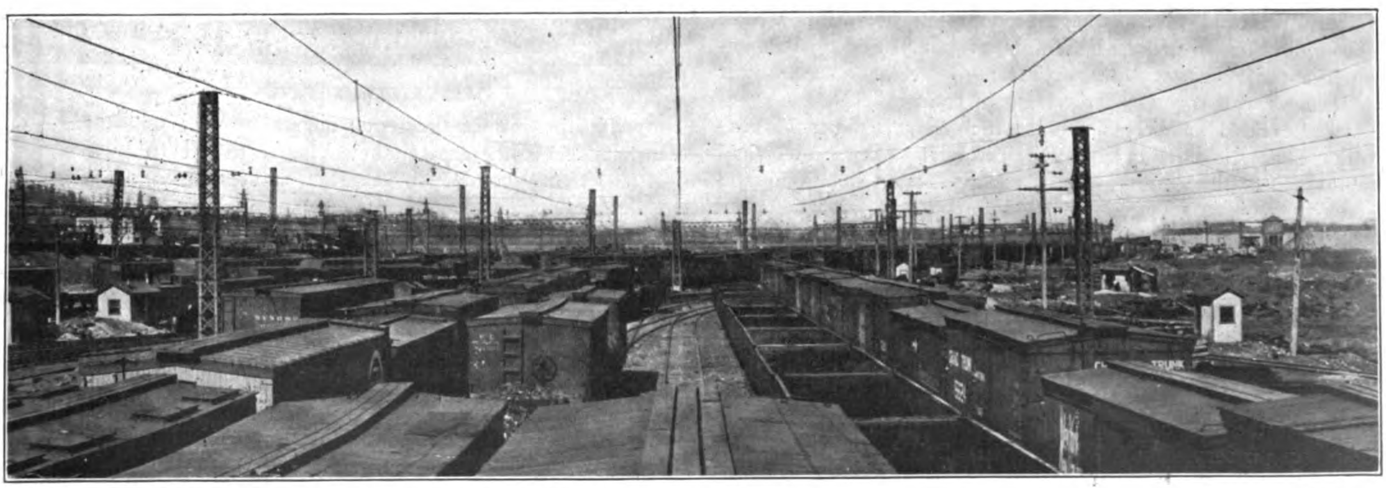
Passenger Service.—All passenger service west of Stamford, Conn., is electrically operated. For the winter timetable, excluding Sundays, the schedule calls for 68 trains per day into Grand Central Terminal, two through trains terminating in Harlem River station and the same number of trains out of the Grand Central Terminal and Harlem River, or a total of 140 trains per day. The Harlem River Branch service includes 19 trains each way per day, except Sundays, between New Rochelle and Harlem River. On the New Canaan branch 16 trains are operated each way between Stamford and New Canaan. This makes a total week-day schedule of 210 trains per day. Additional trains in and out of Grand Central Terminal are operated on Saturdays, and extra trains are also run on the Harlem River branch on Sundays.

Of the 70 through trains per day between Grand Central Terminal, or Harlem River, and New Haven, 46 are electrically operated the entire distance, steam locomotives being used between New Haven and Stamford on the remaining 24 trains. Of the 210 trains per day, 114 are hauled by electric locomotives, multiple-unit equipment being used on the remaining 96 trains. There are 48 a.c.-d.c. locomotives used in passenger service. The multiple-unit equipment at the present time comprises four a.c. motor cars, 21 a.c.-d.c. motor cars, and 46 trailers.

The average number of electric train miles per day is about 6,600, of which 1,400 are made by multiple-unit equipment, the remaining being trains hauled by electric locomotives.

The passenger locomotives make an average of 8,200 miles per day, some of the individual locomotive mileage being as high as 450 to 500 miles. Forty-one of the 48 passenger locomotives

*From a paper presented at a joint meeting of the Franklin Institute and the Philadelphia section, American Institute of Electrical Engineers, January 20, 1915.



View in Westchester Yard, Harlem River Branch; the Cross Catenary Span in the Immediate Foreground Serves Ten Tracks

used in a.c.-d.c. service were originally designed to haul trains of 200 tons trailing weight in local service, 250 tons in local express service, and 300 tons for through express service between New York and New Haven. The remaining seven a.c.-d.c. passenger locomotives were originally designed to haul local trains of 350 tons trailing weight or express trains of 800 tons trailing weight at a maximum speed of 45 miles an hour. In actual service these locomotives attain a maximum speed of 55 miles an hour.

The multiple-unit motor cars make an average of 2,100 miles per day. The proportion of trailers to motor cars for a.c.-d.c. equipment averages two trailer cars to one motor car.

Freight Service.—There are 36 alternating current locomotives used in freight service. These are geared locomotives of 1,400 horsepower each and were designed originally to haul a trailing load of 1,500 tons in through service at 35 miles an hour, although they are used at times for heavy passenger service in the a.c. zone during the summer months, when the heating of trains is not required. Some of these a.c. locomotives are used in transfer service between Oak Point and Westchester freight yards on the Harlem River branch, others in way freight and switching service, but the majority are used on through freight trains between Harlem River and Bridgeport or New Haven. Outside of the fast freights, which are usually under 1,500 tons trailing weight, most of the freights are hauled by two locomotives, the trailing tonnage averaging from 2,500 to 3,000 tons, although, as an experiment, tests have been made in using three locomotives with trains of over 200 cars and 4,500 tons trailing weight. About 20 freight trains are hauled daily at the present time by electric locomotives between Harlem River and Bridgeport or New Haven.

Switching.—Electric switchers are used in the three main switching yards on the Harlem River branch, located at Westchester, Oak Point and Harlem River; also at Stamford, Port Chester, New Rochelle, Mt. Vernon and at Van Nest, the latter yard being principally used for storage.

At Oak Point and Harlem River the switchers are used principally for unloading and loading floats and making up trains. One switcher was placed in service in March, 1911, at Stamford, and the remaining 15 have been in operation since September, 1912. They have been highly successful in operation, and their reliability is evidenced by the fact that to date there has only been one case of grounded main motor, although the 16 locomotives have made approximately 50,000 miles each. Some of these locomotives have been at times in continuous service 24 hours a day for 30 days, the only attention received being the renewal of blower or compressor motor brushes, or contact shoe of pantograph trolley at such times as change was made of the operating crew. Four of these electric switchers have been found to do about the same work as six of the steam switchers, which they have displaced.

Our experience to date has taught us that electrification points to three principal places where economy of operation can be secured, and in the order of their importance they may be mentioned as follows: Saving in fuel; saving in motive-power maintenance and repairs; and saving in train miles.

Assets created by electrification, which may at times be controlling factors, as, for example, the reclamation of city terminal property, after the removal of gas and smoke by the elimination of steam locomotives, are of most important consideration. In cases, however, that do not involve large city terminal electrification, the general credits and debits resulting from electrification work may be said to about offset each other, and thus the value of the returns can be based upon the three items first mentioned. If we know the number of freight and passenger train miles in a division proposed for electrification, and the cost of each one of the train miles, today we can say with very little chance of error what the cost of each one of those train miles in freight and passenger service will be when that division is operated by electricity. If we were to duplicate the steam train movement by an electric train movement, a certain economy would be shown, but by reason of the ability to concentrate in single train movements greater tractive efforts and higher speeds, greater individual tonnages can be translated, and thus the third item of economy appears in the reduction of train miles.

Experience with the movement of billions of ton miles in freight, passenger and switching service by electricity has justified the early predictions that one pound of coal burned under the boilers of a central electric power station and converted into electrical energy and transmitted to an electric engine will develop twice the drawbar pull at the same speed as a similar pound of coal burned in the firebox of a steam locomotive; and, second, that the maintenance and repairs on electric locomotives of the straight alternating-current type are on the order of one-half of those required for steam locomotives of equal weight on drivers. It is thus seen that the problem of electrification merely revolves around the question of the density of traffic in which the economies aforesaid can be practiced, and, therefore, the denser

TABLE I

THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD COMPANY. STATISTICS OF ELECTRICAL OPERATION—NEW YORK AND SHORE LINE DIVISIONS. FOR THE MONTH OF NOVEMBER, 1914, COMPARED WITH THE MONTH OF OCTOBER, 1914.

Cos Cob Power House.

	November		October	
	Total	Per KWH	Total	Per KWH
Coal consumed (tons)	12,439.44	2.78 lbs.	12,280.84	2.75 lbs.
Water consumed (gallons)	38,778,000	4.33 gal.	35,835,000*	4.01 gal.*
Cost of coal	$34,084.07	.381c	$33,526.69	.375c
Cost of water	1,582.15	.017	5,015.55*	.057*
Cost of other supplies	317.20	.004	655.85	.007
Maintenance of power plant and machinery	3,655.27	.041	3,434.87	.038
Wages and salaries	6,056.62	.068	6,704.00	.075
Total Cost, Maintenance and operation	45,695.31	.511	49,336.96*	.552*
Fixed charges (interest, taxes and insurance)	16,106.89	.180	16,106.89	.180
Total cost	61,802.20	691	65,443.85*	.732*
Power Consumption (KWH)				
Passenger Service (Elec. Locos.)	2,894,465		3,072,145	
Passenger Service (M. U. Cars)	630,039		499,367	
Freight Service	1,508,306		1,494,082	
Switching Service	984,255		848,613	
Non-Revenue Service	10,340		6,191	
Total used by Electric Locomotives and Motor Cars	6,027,405		5,920,398	
Signals	107,465		117,445	
Other company purposes	389,652		399,401	
Line loss	543,235		617,804	
Total used for company purposes	7,067,757		7,055,048	
New York, Westchester & Boston	676,144		636,058	
Other companies	1,205,699		1,255,139	
Total power used	8,949,600		8,946,245	
Maximum daily output	Tuesday, November 24th 343,300 KWH		Friday, October 30th 316,630 KWH	
Maximum swing	30,000 KW Friday, Nov. 6—7.00 P.M.		29,800 KW Sunday, Oct. 4—8.27 A.M.	
Maximum daily output	Tuesday, November 3rd 249,800 KWH		Sunday, October 18th 256,155 KWH	
Average Daily Output	301,902 KWH		288,589 KWH	
Power Purchased from N. Y. C.				
Power purchased (K.W.H.)	1,244,021		1,306,017	
Cost of power	$16,097.67		$16,348.47	
Cost per K.W.H. (Cents)	1.294		1.252	
Total Power:				
Total power consumed (K.W.H.)	10,193,621		10,252,262	
Total cost of power (including fixed charges)	$77,899.87		$81,792.32*	
Cost per K.W.H. (cents) (charges)	.764		.798*	

*Revised.

the traffic the greater the requisite motive power for its movement, and hence the greater the saving to be effected.

It is perfectly possible to keep the maintenance and repairs of the electric locomotive down to one-half of those of steam under the most favorable conditions of steam maintenance, and in many cases below this figure. On the other hand, due to the peculiar nature of the electric engine, which has not as yet been enough appreciated, it will be only by the most rigorous and careful inspection and conformity to rules of operation that this relation can be maintained. Indeed, if electric engines be treated as has been the custom of treating steam locomotives, then their repairs, instead of costing far less, will cost far more than those of the steam engine.

An inheritance by the New Haven of the old steam locomotive engineers for the operation of their electric engines is a case where the tail of the dog wags the body. While it is a good argument that these men understand the roadbed and signals better than anyone else, this argument fails when engineers without electrical experience or training can bid in the electric runs, depending upon their seniority and record of service. The condition might be alleviated by one set of men, once in remaining in; but there is a constant change, and it is a long time before the steam locomotive engineer divorces himself from the fact that he is not operating a steam locomotive. During his period of learning how to operate the electric engine he does not suffer, the people do not suffer, but the road suffers, and the locomotive suffers most. Here, therefore, we see the necessity of electrically trained men.

While all of the main line tracks of the New York division are electrified, there still remains in passenger and freight service, as the statistics of electrical operation, and give operating information with reference to:

1. The amount, distribution and cost of electric power generated at Cos Cob station. (Table I.)
2. Statistics and operating costs of electric passenger service.
3. Statistics and operating costs of electric freight service.
4. Statistics covering line and equipment failures.

I would ask those who review these statistics with an analytical eye to bear in mind that they are taken from an electrical plant which, from its inception, has been handicapped both from a construction and operating point of view. The underlying principle applying to the New Haven electrification required that its motive power equipment be designed to operate on both alternating and direct-current power, and that, further, on account of inadequate shop facilities in the past it has been necessary, since

TABLE II

STATISTICS OF ELECTRICAL OPERATION NEW YORK AND SHORE LINE DIVISIONS.
MONTH OF NOVEMBER, 1914, COMPARED WITH MONTH OF OCTOBER, 1914.

Passenger Service.

	Express trains.				Local trains				Multiple unit trains			
	Eastbound		Westbound		Eastbound		Westbound		Eastbound		Westbound	
	November	October	November	October	November	October	November	October	November	October	November	October
Train miles	49,436	50,385	53,768	54,032	29,128	32,941	23,839	28,622	21,569	19,338	22,552	19,363
Locomotive miles	82,298	85,220	88,898	89,162	41,148	45,008	31,558	39,722	29,937	28,504	32,220	28,857
Car Miles	386,883	404,166	410,574	425,363	157,770	182,564	137,502	172,338	76,544	74,004	79,292	72,793
Ton miles	23,880,554	24,483,292	24,654,186	25,697,939	7,314,489	8,444,023	6,432,307	7,812,994	5,093,352	4,755,814	5,296,525	4,634,919
K. W. H. used	1,120,801	1,133,588	1,231,060	1,220,947	643,284	719,423	524,871	651,374	346,385	305,267	341,496	279,137
Locomotive miles per train mile	1.66	1.69	1.65	1.65	1.41	1.37	1.32	1.39	1.39	1.47	1.43	1.49
Car miles per train mile	7.83	8.02	7.64	7.87	5.42	5.54	5.77	6.02	3.55	3.83	3.52	3.76
K. W. H. per train mile	22.67	22.50	22.90	22.60	22.09	21.84	22.02	22.76	16.06	15.79	15.14	14.42
K. W. H. per locomotive mile	13.62	13.30	13.85	13.70	15.63	15.98	16.63	16.40	11.57	10.71	10.60	9.67
K. W. H. per car mile	2.90	2.80	3.00	2.87	4.08	3.94	3.82	3.78	4.53	4.12	4.31	3.83
K. W. H. per 1,000-ton mile	46.93	46.30	49.93	47.51	87.95	85.20	81.60	83.37	68.01	64.19	64.48	60.22

Operating Costs.

	Locomotive repairs		Power		Locomotive Supplies		Engine house Expenses		Enginemen		Trainmen		Total	
	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.
Trains hauled by locomotives:														
Cost per train mile (cents)	17.15	13.80	19.33	19.89*	2.23	1.53	.57	.54	8.81	8.37	9.51	9.55	57.60	53.68*
Cost per locomotive mile (cents)	10.61	8.56	11.96	12.29*	1.39	.95	.38	.34	5.41	5.20	5.88	5.91	35.63	33.25*
Cost per car mile (cents)	2.45	1.93	2.76	2.79*	.32	.21	.08	.08	1.26	1.17	1.36	1.34	8.23	7.52*
Multiple unit trains:														
Cost per train mile (cents)	15.27	11.83	11.39	11.42*	.24	.16	.91	.78	5.17	5.20	8.84	7.53	41.82	36.92*
Cost per motor car mile (cents)	10.51	7.98	7.84	7.70*	.17	.11	.62	.53	3.56	3.51	6.08	5.08	28.78	24.91*
Cost per car mile (cents)	4.32	3.12	3.22	3.01*	.07	.04	.25	.21	1.46	1.37	2.52	1.98	11.85	9.73*

*Revised.

as previously shown, a considerable amount of steam operation, made necessary by the New Haven having had to avoid capital expenditure for power house and motive power equipment. It can be readily understood that a large reduction in operating expense can be effected when the division is placed on a 100 per cent electrical basis.

OPERATING RESULTS

Essentially necessary is a wholesome confidence on the part of railroads undertaking electrification that the result predicted will be attained, and what we are doing on the New Haven today electrically from an operating standpoint could not be better epitomized than by the presentation of one of the last monthly operating reports. They are shown herewith, and are known securing new shop facilities, to make very heavy repairs throughout the entire electric motive power of the road. I have, therefore, to offer this word of caution in analyzing the statistics that are presented, for it is to be noted that the cost of locomotive repairs is high. For example, referring specifically to the table of operating costs of electric passenger engines, Table II, it is to be noted that in the month of October the repairs are recorded as 8.56 cents per locomotive mile, while for November these repairs have increased to 10.61 cents per locomotive mile. At first this would seem to indicate that the new shop facilities were increasing rather than diminishing maintenance costs. This, however, may be explained by the fact that all of the passenger engines have been undergoing general repairs, and invoices for material were passed in greater amounts for November than for October. Many of the electric locomotives have not received a general overhauling since 1907, and during this time their log sheets of operation show some of the locomotives have made over 350,000 miles.

Showing, however, what can be done with electrical equipment under the care of a better maintenance, I present in Table III monthly costs and mileages for one of these locomotives made since these engines have passed through the shops. Notwithstanding the engines are of the alternating current-direct current type, it is of interest to note that their records so far show an average

TABLE III

PERFORMANCE OF N. Y., N. H. AND H. R. R. ELECTRIC PASSENGER LOCOMOTIVE 032.

	1913					
	July	Aug.	Sept.	Oct.	Nov.	Dec.
Labor	32.90	83.01	61.59	23.67	20.18	89.17
Material	20.68	38.61	67.96	21.64	34.56	104.86
Total labor and material	53.58	121.62	129.55	45.31	54.74	194.03
Mileage	4802	5517	4695	4716	4687	4592
Cost per mile	.011	.022	.028	.010	.012	.042
Average cost per mile	.011	.017	.020	.018	.017	.021
Total miles to date	4,802	10,319	15,014	19,730	24,418	29,005
	1914					
	Jan.	Feb.	Mar.	April	May	June
Labor	200.97	85.94	36.52	65.42	91.01	70.70
Material	95.79	27.12	29.15	32.57	70.01	90.28
Total labor and material	296.76	113.06	65.67	97.99	161.02	160.98
Mileage	4,392	6,017	5,310	5,270	5,889	5,839
Cost per mile	.068	.019	.012	.019	.027	.028
Average cost per mile	.027	.026	.024	.024	.024	.024
Total miles to date	33,397	39,414	44,724	49,995	55,884	61,723
	1914					
	July	Aug.	Sept.	Oct.	Nov.	Dec.
Labor	212.36	74.45	147.53	219.47	55.25	.....
Material	131.49	156.72	173.96	780.92	146.09*	.....
Total labor and material	343.85	231.17	321.49	1000.39	90.84*	.....
Mileage	6,165	7,401	5,459	5,678	6,714	.....
Cost per mile	.056	.031	.058	.176	0	.....
Average cost per mile	.027	.027	.030	.039	.036	.....
Total miles to date	67,888	75,289	80,748	86,426	93,140	.....

NOTE.—Cost in dollars. * Cr.

cost of under five cents per locomotive mile. It is of particular interest to note that locomotive No. 032, which received its overhaul first, has now operated 93,140 miles at an average cost of 3.6 cents per locomotive mile.

The maintenance figures for the 10 engines first through the shops give a sharp contrast to those in the general table of passenger engine operating costs (Table II) and emphasize the lack of maintenance to which the electric locomotives were subjected in the early days of their operation. Had conditions permitted

TABLE IV

STATISTICS COVERING ELECTRIC PASSENGER MOVEMENT AND "POWER RATE" CONSTANTS FOR DIFFERENT SERVICES—EASTBOUND.

	New Haven express trains	Stamford express	Stamford local	Port Chester trains	New Rochelle trains	Total
Number of trains	52	901	667	185	2	1807
Number of locomotives	84	1407	859	214	2	2566
Number of cars	497	7,054	3,875	1,000	10	12,436
Tonnage	35,625	566,033	279,904	67,884	619	950,065
Train miles	3,120	18,921	14,003	2,405	8	38,457
Locomotive miles	5,048	30,954	18,894	2,889	8	57,793
Car miles	29,394	148,134	80,263	13,000	40	270,741
Ton miles	2,108,700	11,886,253	5,832,923	882,492	2,456	20,712,824
K. W. H. used	66,076	405,835	343,846	58,933	222	874,912
W. H. Pr. T. M.	31.4	34.2	59.0	66.7	90.2	42.2

Stamford local trains include one train, New Rochelle to Stamford.

our electric passenger engines to be of the straight alternating-current design, in my opinion their average maintenance would not have exceeded four cents per locomotive mile.

During the past six years of electric operation there have been collected some very valuable data with regard to the amount of power required to operate trains of variable tonnage in passenger, freight and switching service. Based on this data, the power required to operate trains under normal or peak conditions of schedule can be calculated with results practically coinciding with the estimates.

By means of wattmeters installed on all locomotives and motor cars it has been possible to record the differences of power required by trains operating under local and express conditions. The long period over which these statistics were kept and power rate constants thus developed has permitted us to abandon an elaborate tabulation and consolidate the information in a more general statement. Of value to those who are interested to follow more closely these results, Tables IV, V and VI will be of assistance. These tables are compiled from the June, 1914, statistics of electric passenger and freight train operation b tween Woodlawn and points east to New Haven. At that time the overhead system had only recently been completed to New

TABLE V

STATISTICS COVERING ELECTRIC PASSENGER MOVEMENT AND "POWER RATE" CONSTANTS FOR DIFFERENT SERVICES—WESTBOUND.

	New Haven express trains	Stamford express	Stamford local	Port Chester trains	New Rochelle trains	Total
Number of trains	49	958	604	185	0	1,796
Number of locomotives	78	1,502	791	185	......	2,556
Number of cars	434	6994	3941	972	......	12,341
Tonnage	31,963	574,569	261,202	62,559	......	930,293
Train miles	2,940	20,118	12,684	2405.	......	38,147
Locomotive miles	4,620.5	33,044	17,402	2,497.5	......	57,564
Car miles	24,855.5	146,870	81,676	12,591	......	265,992.5
Ton miles	1,899,957	12,065,689	5,441,943	811,539	......	20,219,128
K. W. H. used	60,900	486,203	346,935	62,734	......	956,772
W. H. Pr. T. M.	32.0	40.3	63.7	77.3	......	47.4

Haven, and there was but a small percentage of electric service, both as regards passenger and freight between Woodlawn and New Haven. While the tonnage in both passenger and freight service has been greatly increased since that time, these tables, however, may be taken as giving reliable data in connection with the electric train movements recorded. The watt hours per ton mile (abbreviated in tables as W.H.P.T.M.) are secured through meters recording input power to the electric motors. To determine the actual amount of power taken from the contact wire, these figures should be divided by 97 per cent, thus allowing an average loss of 3 per cent for the step-down transformers installed on the electric engines and motive power. As examples of the increments of electric service, since the extension of the electrification to New Haven, while it is to be noted that the total electric passenger ton-miles for June, 1914, were approximately 41,000,000, and that of the freight 9,400,000, the former has now increased to 62,000,000, and the latter to 44,000,000.

Of special interest to the writer with regard to the tables covering electric passenger operation is the variation in watt hours per ton-mile for the various express and local services.

TABLE VI

STATISTICS COVERING ELECTRIC FREIGHT MOVEMENT AND "POWER RATE" CONSTANTS FOR EASTBOUND AND WESTBOUND SERVICE.

	Eastbound	Westbound	Total
Number of trains	109	116	225
Number of locomotives	109	117	226
Number of Cars	2,939	2,829	5,768
Tonnage	106,905	86,706	193,611
Train miles	5,273	5,564	10,837
Locomotive miles	5,486	5,784	11,270
Car miles	142,542	135,792	278,334
Ton miles	5,184,893	4,161,888	9,346,781
K. W. H. used	170,259	137,048	307,307
W. H. Pr. T. M.	32.8	33.0	32.9

For example, it is to be noted that the power rate for New Haven express trains eastbound is 31.4 watt hours per ton-mile, this rate being increased slightly for trains operating to Stamford; the rate rises quite rapidly for trains operating in local service to Stamford, and continues to rise for local trains operating to Port Chester and New Rochelle respectively. It is, of course, well known that the rate of power supply per ton for express operation is very much lower than that required for local operation, as in the case of the latter the train suffers, under the conditions of braking, the loss of the kinetic energy stored in it under the conditions of acceleration. The increasing watt hours per ton-mile as shown in the tables are practically proportional to the diminishing distance between train stops. It may also be said that the distance between stops increases progressively east of New York City, and if, for example, suburban territory under consideration for electrification has to be served by train schedule with distances between stations approximately the same as those obtaining on the New Haven Road, the "power rate" constants as shown in these tables will be found to be sufficiently accurate in the study of power necessary to train movement.

In the tabulated statistics covering electric freight operation the point of principal interest is the difference between the rate per ton-mile as indicated in the June tabulation as against those tion of heavy freight trains. It was first thought that when these large train units were placed on the line the power house would be subjected to very heavy drafts of power under conditions of accelerating them. The reverse, however, was found to be the case, and where, previous to the operation of these trains, the power station output curve showed peaks of a fluctuating character, these heavy trains have served to smooth out the curve of power station output. A reasonable explanation of this would seem to rest in the fact that when a number of the heavy trains are under translation, and it becomes necessary to accelerate one from rest, the supply of current necessary to this acceleration, while not reducing the line voltage materially, does so, however, to a point which corresponds to a speed of the trains in translation lower than the speed at which they are actually operating, and thus these heavy trains, by their own mass energy, as in the

TABLE VII

Statistics of Electrical Operation— New York and Shore Line Divisions.
Month of November, 1914, Compared with Month of October, 1914.

Freight Service.

	Fast freight.				Slow Freight				Local Freight			
	Eastbound		Westbound		Eastbound		Westbound		Eastbound		Westbound	
	November	October	November	October	November	October	November	October	November	October	November	October
Train miles	3,283	3,484	4,954	7,576	8,485	9,177	6,152	4,880	2,880	3,240	2,933	3,240
Locomotive miles	3,283	3,486	8,042	11,128	16,529	18,038	11,269	9,824	2,956	3,321	3,012	3,321
Loaded car miles	130,147	140,202	159,377	219,435	484,644	529,559	203,556	209,889	29,965	33,893	32,990	37,339
Empty car miles	335	203	60,545	106,040	57,346	59,801	184,978	177,831	16,304	16,339	12,072	20,456
Caboose miles	3,283	3,484	4,954	7,576	8,485	9,177	6,152	4,880	2,880	3,240	2,933	3,240
Ton miles	4,399,743	4,589,492	5,941,893	8,677,627	21,121,401	22,885,161	10,496,232	10,448,521	1,301,163	1,414,569	1,432,065	1,702,877
K. W. H. used	108,749	112,033	186,401	265,088	566,983	571,972	340,830	294,602	118,423	110,757	106,650	114,828
Locomotive miles per train mile	1.00	1.00	1.62	1.47	1.95	1.97	1.83	2.01	1.03	1.03	1.03	1.03
Loaded car miles per train mile	39.64	40.24	32.17	28.96	57.12	57.71	33.09	43.01	10.40	10.46	11.25	11.52
Empty car miles per train mile	1.10	1.06	13.22	15.00	7.76	7.52	31.07	37.44	6.66	6.04	5.12	7.31
Ton miles per train mile	1,340.16	1,317.31	1,199.41	1,145.41	2,489.26	2,493.75	1,706.15	2,141.09	451.79	436.60	488.26	525.58
Ton miles per locomotive mile	1,340.16	1,316.55	738.86	779.80	1,277.84	1,268.72	931.43	1,063.57	440.18	426.55	475.45	512.76
Percentage of tonnage to rating	96%	95%	....	....	94%	93%	....	....	....	....	....	....
Ton miles per hour	26,779	27,335	19,109	18,092	26,008	27,912	18,637	23,297	2,614	2,679	3,423	3,622
Average Speed (m. p. h.)	19.98	20.75	15.93	15.79	10.45	11.19	10.92	10.88	5.79	6.14	7.01	6.89
K. W. H. per train mile	33.12	32.16	37.63	34.99	66.82	62.32	55.40	60.37	41.12	34.18	36.36	35.44
K. W. H. per locomotive mile	33.12	32.11	23.18	23.82	34.30	31.71	30.24	29.99	40.06	33.35	35.41	34.58
K. W. H. per car mile	.81	.78	.83	.80	1.03	.96	.86	.75	2.41	2.07	2.22	1.88
K. W. H. per 1,000-ton miles	24.72	24.41	31.37	30.54	26.84	24.99	32.47	28.20	91.01	78.29	74.47	67.43

Ton miles are based on weight of trailing load.
Percentage of tonnage to rating is found by dividing the total tonnage of trains as they leave Harlem River by the rating of locomotive hauling those trains.
Ton miles per hour is found by dividing ton-miles by the total running time of trains between terminals.
Average speed is found by dividing train-miles by total running time of trains between terminals.

Operating Costs.

	Locomotive repairs		Power		Locomotive Supplies		Engine house Expenses		Enginemen		Trainmen		Total	
	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.
Cost per train mile (cents)	15.51	15.98	28.51	27.90*	.54	.63	.48	.58	10.66	10.44	17.83	17.46	73.53	72.99*
Cost per locomotive mile (cents)	9.69	10.19	17.82	17.79*	.34	.40	.30	.37	6.67	6.66	11.14	11.13	45.96	46.54*
Cost per 1,000-ton miles (cents)	9.95	10.16	18.30	17.73*	.35	.40	.31	.37	6.84	.663	11.45	11.09	47.20	46.38*

* Revised.

shown under the general tabulation of freight service (Table VII), where it is to be noted that the kilowatt hours for fast and slow freight are, on the average, considerably below 30 watt hours per ton mile, this rate being based upon the tonnage of the trailing load. Allowing for the weight of the electric engine, the watt hours per ton-mile will be reduced to 26, and, as some 200,000,000 ton-miles have been actually recorded by meter registration in freight service, it may be said that 30 watt hours per ton mile on level track is a reliable figure, with slight margin to cover electric freight operation in a combination of fast and slow service; *i.e.*, without stops for trains averaging between 1,500 and 3,000 tons trailing load.

It is of interest at this juncture to point to an interesting experience we have had in connection with the electrical operacase of a flywheel, automatically release a large amount of power, which becomes available for the accelerating train.

The matter of savings to be effected in engine repairs are subject to local conditions, for, while it may be said that steam locomotive repairs, upon an average, may be placed at 10 cents per locomotive mile, on the other hand there may be situations where the railroad has, for example, to use water of severe scaling characteristics and thus run up the cost of repairs excessively.

In the matter of train miles the savings to be effected are dependent upon local conditions, but it can be stated as a general conclusion, based on a very considerable experience, that electric engines of the order of 100 tons on drivers should be maintained at a rate not exceeding five cents per locomotive mile, and that the coal bill for transportation is cut to at least one-half.

Having determined for any situation what savings can be effected by the substitution of electricity for steam, then, as previously stated, the commercial justification of a change to the new motive power is entirely based upon whether these savings will cover the interest, insurance, depreciation and taxes on the electrical investment necessary.

The motive power feature of electrification, like its other parts, has virtually reached the pound stage. Electric locomotives of approximately 100 tons will, under present conditions of cost of labor and material, vary between 18 cents and 20 cents per pound. This figure is practically irrespective of speed-torque characteristics, a high-speed passenger locomotive and a low-speed switcher not varying greatly in cost upon a pound basis. Multiple-unit cars, now usually built of steel, do not vary greatly from the above figures, but, if anything, may be quoted as being slightly higher in cost per pound. As a concrete example, I would say that a first-class, high-speed, 100-ton, straight alternating-current electric passenger locomotive, capable of handling a 250-ton trailing load in normal large city suburban service, should cost $40,000. A steam locomotive which would do the same work would probably not cost more than $15,000, but the savings effected due to the greater operating economy of the electric engine would represent a figure of twice or three times the amount invested in the electric engine. Thus we might say that for every electric engine we purchase we would be justified at least in making a capital investment of $40,000 to cover the cost of electric power houses and transmission equipment necessary to supply that electric engine with current. By this reasoning we again approach the answer as to the conditions affecting the success of main line electrification in the fact that it is the density of traffic and in the use of a large number of electric engines by which we can save enough money to pay for the capital expenditure necessary to the supply of power to them for the operation of many trains.

In conclusion, I would plead for an especially conservative point of view on the part of the public with regard to electrification. While the savings to be effected under certain conditions of electrification may be considerable, on the other hand the construction investment necessary to these savings may be very great. So many roads in this country have either passed or lowered their dividends that it is hardly necessary to emphasize the fact that only a healthy condition of finance throughout the country will warrant the consideration of electrification, and again I would say that partial electrification, such as that applying to yards only and not main line, while it might prove of advantage to a public, might at the same time prove to be a serious and unfair burden for the railroad to carry.

TABLE VIII

STATISTICS OF ELECTRICAL OPERATION—NEW YORK AND SHORE LINE DIVISIONS.
FOR THE MONTH OF NOVEMBER, 1914, COMPARED WITH THE MONTH OF OCTOBER, 1914.

Line and Equipment Failures.

Line failures

	Catenary insulator failures				Dead end failures				Other line failures				Equipment failures			
	Nov.		Oct.		Nov.		Oct.		Nov.		Oct.		Nov.		Oct.	
	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay
Between Woodlawn and Stamford	1	22	1	14	..	..	..	..	1	..	1	8	..	...	1	143
Between Stamford and New Haven	2	..	..	..	..	..	..	..	3	41	4	47	6	141	5	23
On New Canaan Branch	..	..	..	..	..	..	..	..	..	..	..	..	..	...	..	...
On Harlem River Branch	..	..	..	..	..	..	..	..	1	13	1	7	..	..	..	...
In Yards	..	..	..	..	3	..	1	..	2	7	4	..	4	28	1	...
Total	3	22	1	14	3	..	1	..	7	61	10	62	10	169	7	166

	Signal failures				Outside interference				Failures of employes				Total failures			
	Nov.		Oct.		Nov.		Oct.		Nov.		Oct.		Nov.		Oct	
	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay	No.	Total Delay
Between Woodlawn and Stamford	..	..	1	..	2	..	3	..	..	..	..	..	4	22	7	165
Between Stamford and New Haven	1	15	..	..	2	..	..	..	..	..	..	..	14	197	9	70
On New Canaan Branch	..	..	..	..	..	..	..	..	..	..	..	..	..	...	...	...
On Harlem River Branch	..	..	..	..	..	..	..	..	..	..	..	..	1	13	1	7
In Yards	..	..	..	..	..	..	..	..	1	..	..	..	10	35		...
Total	1	15	1	..	4	..	3	.	1	..	..	..	29	267	23	242

Equipment Failures.

Class of service	Heated parts		Broken parts		Grounds		Miscellaneous		Total failures		Miles per failure		Minutes detention per failure	
	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.	Nov.	Oct.
Passenger	1	4	2	1*	20	25*	12	6	35	36*	7,071	7,328*	11	13*
Freight	1	2	1	2	3	2	0	1	5	.7	13,183	9,506	56	60
Switch	0	0	0	0	0	0	0	0	0	0	40,964	39,624	0	0
Multiple	3	0	2	1 *	2	0	11	11	18	12*	3,554	4,331**	18	7*
Total	5	6	5	4*	25	27*	23	18	58	55*	7,213	7,672*	17	18*

PRUSSIAN STATE RAILWAYS.—In a semi-official communication just issued in Berlin, the communal authorities are warned, in making up their revenue estimates, not to count on receiving any communal income tax from the Prussian state railways on account of lines passing through their districts. The communication says that, while there has recently been some increase in the railway earnings, the falling off in the receipts during the first month of the war was so great as to leave little prospect of a credit balance for the year, and the communes must therefore not count on getting anything from them for the fiscal year 1915.