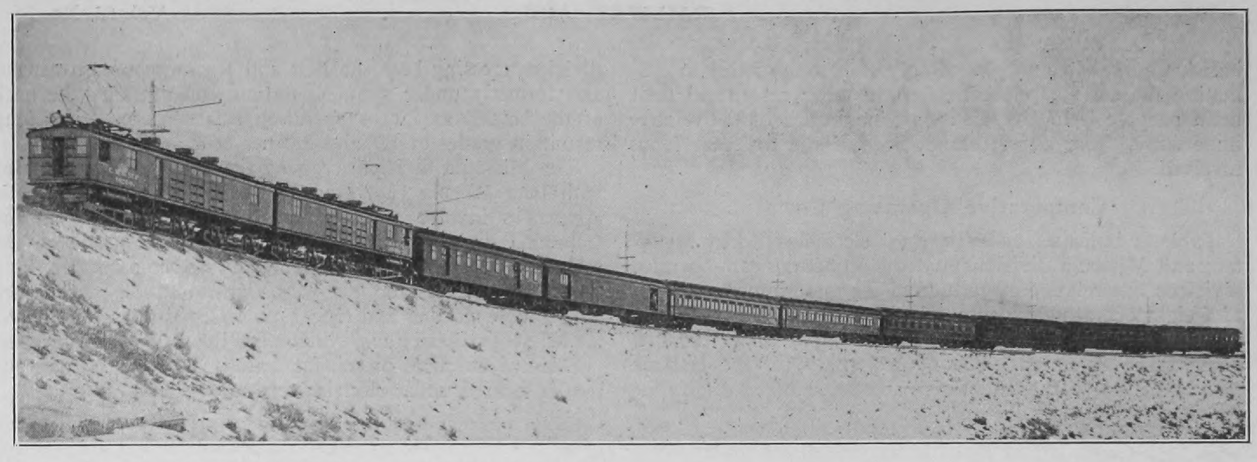

Electric Passenger Train on the Rocky Mountain Division of the St. Paul

Notes on the C. M. & St. Paul Electrification*

Delays Reduced While Locomotive Maintenance and Train and Engine Crew Expense Is Decreased

By R. Beeuwkes
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THE ELECTRIFIED TERRITORY of the Chicago, Milwaukee & St. Paul now extends from Harlowton, Mont., to Avery, Ida., and from Othello to Tacoma, Wash., a total distance of 645 route miles, or of about one-third more track miles.

The first portion to be put into electrical operation was that between Three Forks and Deer Lodge, the west sub-division of the Rocky Mountain division. This was in December, 1915. The second portion, Three Forks to Harlowton, the east sub-division of the Rocky Mountain division, began to be electrically operated in April, 1916, and the section from Deer Lodge to Avery, the Missoula division, in November and December, 1916.

Electric helper service was installed on the Saddle mountains, west of Othello, in August, 1919, and on the Cascade mountains in November of the same year. Electric road freight service is being installed as rapidly as the conversion, by change of gear ratio, of the original passenger locomotives of the Rocky Mountain and Missoula divisions into freight locomotives will permit. Regular electric passenger service west of Othello was started in March of this year. This section now comprises the west sub-division of the Columbia division, extending from Othello to Cle Elum, and the coast division extending from Cle Elum to Tacoma and Seattle, two engine divisions, but the entire district will shortly be merged into and operated as one electrified division.

The following general notes regarding some of the items of a list suggested as representing matters of particular interest in connection with electrification work are based on experience with the above installations.

First Costs

The electrification work on the Rocky Mountain and Missoula division was carried on during the years 1914, 1915 and 1916, when labor and material conditions were comparatively stable and arrangements for the supply of both could be made in such a way as to avoid the delays to which the work west of Othello, carried on largely during the war, was more or less subject. Costs for the former work are, therefore, believed to be the more capable of application of the necessary corrective factors corresponding to present and other assumed price standards and approximate figures are given in Table I.

TABLE I

Route miles	438
Actual mileage transmission line	364
Total kw. capacity of sub-stations	59,500

Number of locomotives—12 passenger, 30 freight and two switching locomotives.

Number of sub-stations, 14. Two operators' buildings at each station.

Automatic signals—Existing battery fed track circuit and semaphore signals were replaced with alternating current light signals fed from a 4,400-volt primary circuit connected to sub-stations; costs not included.

Item	Average cost per route mile	Various average unit costs	Per cent item cost to total, excl'd locomotives
Trolley system complete	$8,390	.....	47.7
Transmission system complete	2,360	.....	13.3
Per mile of transmission line	.....	$2,835.00	....
Sub-station layout complete	6,050	.....	34.4
Per station	.....	189,400.00	....
Per kw.	.....	45.00	....
Sub-station building and grounds:			
Per station	.....	38,400.00	....
Per kw.	.....	9.50	....
Operators' dwellings, etc.:			
Per station	.....	6,100.00	....
Per kw.	.....	1.50	....
Sub-station apparatus:			
Per station	.....	144,900.00	....
Per kw.	.....	34.00	....
Miscellaneous, including right-of-way, changes in telegraph and telephone lines to clear transmission and trolley, store-houses, minor apparatus at shops and roundhouses, etc.	265	.....	1.7
Engineering and administration, except that for drafting and inspection for sub-stations, charged direct	514	.....	2.9
Locomotives, including transportation, messenger and miscellaneous charges:			
Per road locomotive	.....	122,500.00	....
Per switching locomotive	.....	37,700.00	....
Total per route mile, excluding locomotives	17,579	.....	100.00

The figures shown in Table I, without a detailed knowledge of the labor and material figures on which they are

*A paper presented before the 43rd annual convention of the National Electric Light Association held at Pasadena, Cal., May 18-22.

based, would, of course, be of only very rough value in estimating the costs of electrification in other cases, and their main purpose is to give an approximate idea of the relative importance, from a cost standpoint, of the different items involved.

Comparative Operating Costs

Table II indicates, as between the electrified Rocky Mountain and Missoula divisions and the adjacent steam-operated divisions, the relative magnitude of the more important items of freight operating expense, which are affected by the type of motive power employed, costs for the Missoula division being taken as unity. The figures apply for the last six months of the year 1918, this period being taken due to the fact that the data had already been worked up for other purposes and was therefore most readily available.

TABLE II

Item	Columbia Division	Idaho Division	Missoula Division	Rocky Mtn. Division	Musselshell Division
Steam or electric locomotive repairs	$1.97	$2.34	$1.00	$0.86	$2.26
Train conductors and brakemen	2.78	3.05	1.00	1.46	1.61
Train enginemen and motormen	1.84	2.17	1.00	1.30	1.21
Train locomotive fuel or power	2.05	2.34	1.00	1.04	1.38
Engine-house expense, train	3.15	2.50	1.00	.80	3.71
Total yard service*	.78	1.12	1.00	.99	.71
Total of items of expense affected by type of motive power†	1.67	1.90	1.00	1.11	1.33

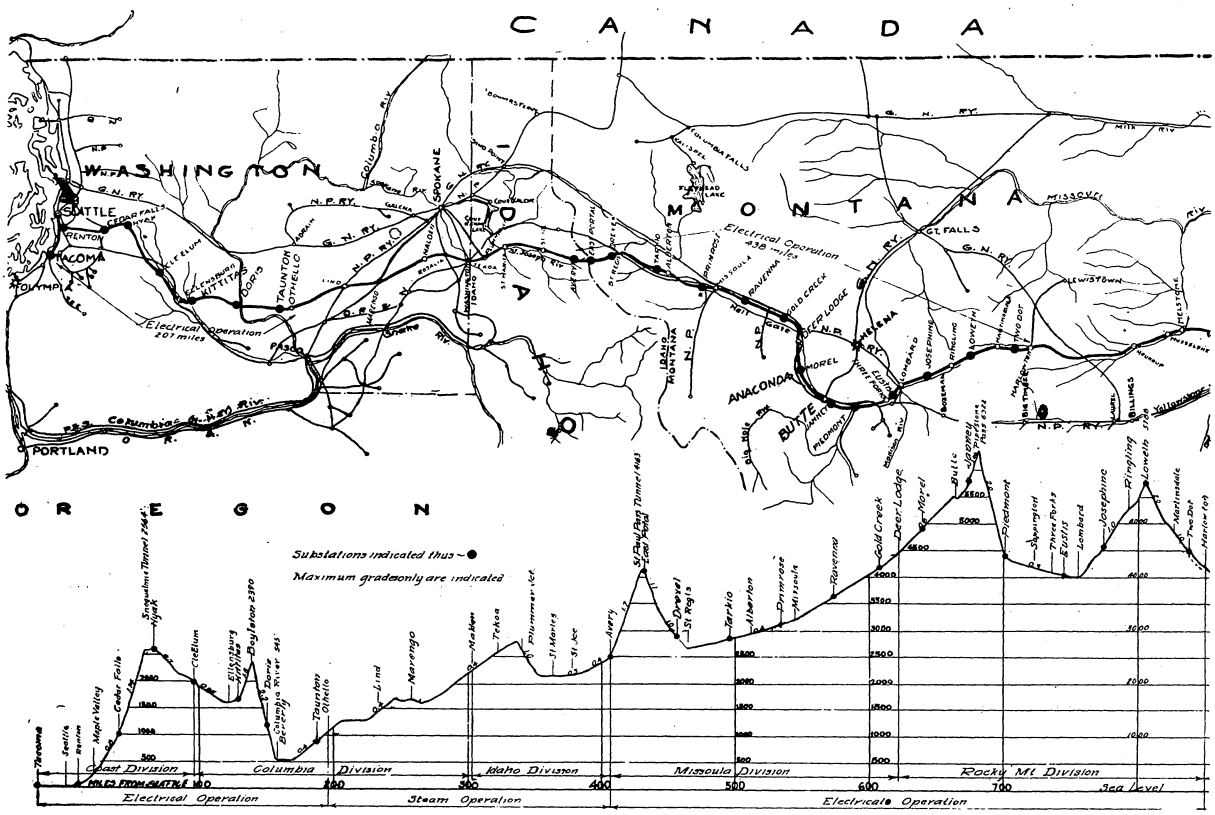
*In 1918 a considerable portion of the switching was still done by steam, sufficient electric switching locomotives not having yet been received.

†Includes superintendence, maintenance of sub-stations, transmission and trolley systems, water and fuel stations, shops and engine-houses; also locomotive and train supplies, in addition to the items for which individual comparison is given in the tabulation.

In considering the above it should be noted, as shown on the attached profile, that the Musselshell division is of low grade, maximum of 0.4 per cent, while the Rocky Mountain division, crossing both the Belt and Rocky mountain ranges, and formerly under steam operation, constituting "the neck of the bottle" as far as operation was concerned, has long mountain grades of 1.7 and 2.0 per cent.

The Missoula division, crossing the Bitter Root mountains with long 1.7 per cent grades, would not from the profile appear to involve as difficult operating problems as the Columbia division with its long 2.2 per cent grade on the east slope of the Saddle mountains and its comparatively long 1.6 per cent grade on the west slope, but the much more unfavorable weather and topographical conditions existing on the Missoula division more than offset the difference in grades.

Some of the more prominent reasons for the advantageous results secured under electrical operation are as follows:



Map and Profile Showing the Two Electrified Sections of the St. Paul and the Steam Operated Section Between Them

Cost of engine repairs per thousand-ton miles is much decreased, due to the fact that not only is the cost of repairs per engine mile of the electric locomotive much less than that of the average steam locomotive replaced, but the number of engine miles per thousand-ton miles is, on account of the greater capacity of the electric locomotive, much less. The engine miles per thousand-ton miles for the Missoula division under electric operation in the 1918 period taken above was only about 55 per cent of that of the latter half of 1915 under steam operation.

Train conductor and brakemen expense per thousand-ton miles is reduced under electrical operation, due to increased ton miles per train mile and increased train speed. This item for the Missoula division for the 1918 period was about nine or ten per cent less than that of the 1915 steam period, while the Idaho and Columbia divisions, still operated by steam, the expense per thousand-ton miles more than doubled.

Enginemen's expense decreased under electrical operation, due to the same causes which decrease trainmen's expense.

For the Missoula division this item increased only a few per cent for the 1918 period as compared with the 1915 period, while for the Idaho and Columbia divisions it practically doubled.

Regarding the items of train locomotive fuel, it should be stated that the factors given are based not on the actual cost of fuel for the particular divisions involved but on the average fuel price for the system. Cost of fuel haul is not taken into account.

The above is at best only an incomplete statement of some of the more direct benefits derived from electrical operation. Constant improvement is to be expected as further advantages are recognized and developed through operating experience.

Reliability of Service

The question of the relative reliability of steam and electrical operation is one that is frequently raised, and it is believed the "Recapitulation of Passenger Train Performance" shown in Table III will be of interest in this connection.

This recapitulation gives the delays to passenger trains, on basis of miles of line operated, for the various railway divisions of the St. Paul west of Mobridge. Similar information is not conveniently available for freight train performance, but delays to freight service would naturally be reflected in the passenger train performance.

TABLE III

Recapitulation of "Passenger Train Performance," Showing Delays to Passenger Trains on the Basis of Miles of Line Operated; Lines West of Mobridge; Months October, November and December, 1919, and January, February and March, 1920

Division	Delayed time in minutes per mile of line operated				
	Mobridge to Marmouth	Marmouth to Harlowton	Harlowton to Avery	Avery to Cle Elum	Cle Elum* to Seattle
Motive power	Steam	Steam	Electricity	Steam*	Steam
Miles	190	340	437	325	90
Item					
1. Meeting and blocked behind passenger	18.83	11.33	15.15	10.33	12.60
2. Meeting and blocked behind freight	14.03	5.88	6.49	1.98	2.89
3. Extra cars	1.33	0.58	0.02	2.35	1.37
4. Excess time switching	1.35	2.69	2.16	1.54	4.51
5. Electric block signals	0	0.13	9.52	4.07	10.62
6. Slow orders	4.54	1.37	1.29	0.33	5.38
7. Bad weather and poor coal	109.2	13.59	3.53	3.48	4.91
8. Engine condition	20.92	25.20	11.43	9.39	10.54
9. Accidents and derailments due to engine	2.63	2.25	0.15	3.85	2.05
10. Trolley and sub-station	0	0	3.93	0.03	0
11. Total of items 1 to 10 inclusive, which are affected by the type of motive power used	172.65	62.95	52.73	35.34	54.93
12. Average of items 1 to 10 inclusive, for the four steam divisions..74.75					
13. Awaiting connections	0	1.16	0.02	1.82	1.94
14. Handling extra heavy bag mail and express	6.79	3.26	2.09	1.20	0.97
15. Extra stops for passengers and railway crossings	0.92	0.97	1.99	0.22	1.13
16. Car conditions	8.63	18.05	9.75	6.87	6.10
17. Accidents and derailments not due to engine	27.69	12.51	17.75	14.63	30.49
18. Slides, earth, rock and snow	2.53	0	3.64	3.86	13.80
19. All other causes	11.30	1.78	11.03	4.91	9.95
20. Total of items 13 to 19 inclusive, which are not affected by the type of motive power	57.80	37.85	46.30	33.86	103.69
21. Average of items 13 to 19 inclusive, for the four steam divisions..46.77					
22. Total of all items	230.45	100.80	99.03	69.20	158.62
23. Average of items 13 to 19 inclusive for the four steam divisions..121.52					
24. Minutes lost on schedule running time per mile of line operated	205.5	69.7	8.94	0.00	162.2
25. Minutes made up per mile of line operated	46.6	35.6	100.00	81.00	11.54

*Electrical operation commenced in March.

It will be noted from item II that the electrically operated territory shows less time delayed than any of the steam operated divisions, except that between Avery and Cle Elum, a district particularly favored as regards its freedom from climatic, topographical and other conditions which tend to cause delays. Attention is also called to the favorable showing, for electricity, of items 24 and 25.

Conclusion

In no respect have the results of the electrification failed to equal the expectations of the railway organization, and in most respects these expectations have been far exceeded. The extent of the electrification is such as to leave no doubt as to the practicability of indefinite expansion with an insurance of increased reliability and safety and a marked and determinable increase in capacity. Items of operating expense dependent on whether steam or electricity is used as a motive power we have found by experience and estimates to be so reduced and the benefits indirectly obtained to be so great as to render justifiable, even with the increased investment charges, the serious consideration of indefinite extension of electrification, even for lighter grades.

The Ninth International Railway Congress

L. WEISSENBRUCH, secretary of the International Railway Association, 11 Rue de Louvain, Brussels, Belgium, has issued a list of questions to be discussed at the ninth congress of the Association, which it is proposed to hold in Rome, Italy, from April 18 to May 1, 1922.

Following are the principal heads in the program of subjects, with names of the men who are to prepare papers, where these are given. Where the letter "X" is shown the "reporter" is to be a person, yet to be appointed, from the country named.

Section I: Way and Works

Construction of roadbed and track: Denmark, Sweden and Norway; K. Ahlberg, Swedish State Railroads. Great Britain, E. F. C. Trench, L. & N. W. America, X. Other countries, Mr. Henry, Eastern of France, and Mr. Candelier, Northern of France.

Maintenance and supervision of track: Great Britain, C. J. Brown, Great Northern. America, X. Other countries, X (an Italian).

Special steels: America, W. C. Cushing, Pennsylvania. France, Mr. Mesnager. Other countries, Mr. Sand, Swiss State Railroads.

Reinforced concrete: Denmark, Sweden and Norway, C. Ernst, and P. M. Bulow, Danish State Railroads. Holland, C. Leemans, Holland State Railroad. Great Britain, W. W. Grierson, Great Western. America, G. A. Haggander, C. B. & Q. Other countries, Mr. Golard, Belgian State Railroads.

Section II: Locomotives and Cars

Superheaters, feed-water heaters, etc.: Countries using the English language, G. J. Churchward, Great Western (Eng-