

# Notes on the C., M. & St. P. Electrification\*

## Experience with Electrification of 645 Route-Miles of Track Shows the Reliability and Economy of Electrical Operation

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THE electrification of the C., M. & St. P. Railway now extends from Harlowton, Mont., to Avery, Idaho, and from Othello to Tacoma, Wash., a total distance of 645 route-miles, or of about one-third more track-miles. 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 this installation:

The electrification work on the Rocky Mountain and Missoula divisions was carried on during the years from 1914 to 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 more capable of application of the necessary corrective factors corresponding to present and other assumed pipe standards and approximate figures are given in Table I.

tween the electrified Rocky Mountain and Missoula divisions and the adjacent steam-operated divisions. The items are those which are affected by the type of motive power employed, cost of the Missoula division being taken as unity. The figures apply for the last six months of 1918, data for which were readily available.

TABLE II—COMPARATIVE OPERATING EXPENSE

	Columbia Division	Idaho Division	Missoula Division	Rocky Mountain 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	1.51
Train engineers 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
Enginehouse expense, train	3.15	2.50	1.00	0.80	3.71
Total yard service*	0.78	1.12	1.00	0.99	0.71
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 substations, 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.

TABLE I—COSTS AND OTHER DATA

	Average Cost per Route-Mile	Various Unit Costs	Per Cent Item Cost to Total, Excluding Locomotives
Trolley system complete	\$8,390		47.7
Transmission system complete	2,360		13.3
Per mile of transmission line		\$2,835.00	
Substation layout complete	6,050		34.4
Per station		189,400.00	
Per kilowatt		45.00	
Substation building and grounds:			
Per station		38,400.00	
Per kilowatt		9.50	
Operators' dwellings, etc.:			
Per station		6,100.00	
Per kilowatt		1.50	
Substation apparatus:			
Per station		144,900.00	
Per kilowatt		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 round houses, etc.	265		1.7
Engineering and administration, except that for drafting and inspection for substations, 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
Route-miles			438
Actual mileage transmission line			364
Total kilowatt capacity of substations			59,500
Number of locomotives—Twelve passenger, thirty freight and two switching locomotives.			
Number of substations, fourteen. 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 substations; costs not included.			

The figures in Table I are given mainly to furnish an approximate idea of the relative importance, from a cost standpoint, of the different items involved.

Table II indicates the relative magnitude of the more important items of freight operating expense, as be-

In considering the data in Table II, it should be noted that the Musselshell division is of low grade, maximum being 0.4 per cent, while the Rocky Mountain, 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 per cent. The Missoula division, crossing the Bitter Root Mountain, with long 1.7 per cent grades, might not appear to involve as difficult operating problems as the Columbia division, with its long 2.2 per cent grades on the east slope of the Saddle Mountain and its comparatively long 1.6 per cent grade on the west slope. However, the much more unfavorable weather and topographical conditions existing on the Missoula division more than offset the difference in grades.

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

The cost of engine repairs per 1,000 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 1,000 ton-miles is, on account of the greater capacity of the electric locomotive, much less. The engine-miles per 1,000 ton-miles for the Missoula division under electric operation in the 1918 period taken above were only about 55 per cent of that of the latter half of 1915 under steam operation.

Train conductor and brakemen expense per 1,000 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

\*Abstract of contribution to discussion of report of committee on electrification of steam railroads, F. M. Kerr, chairman, to N.E.L.A. at Pasadena Convention, May 21, 1920.

period was about 9 or 10 per cent less than that of the 1915 steam period, while on the Idaho and Columbia divisions, still operated by steam, the expense per 1,000 ton-miles more than doubled.

Enginemens' expense decreases 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 not based 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 question of the relative reliability of steam and electrical operation is one that is frequently raised. The data given 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 several railway divisions of the Milwaukee west of Mobridge. Similar information is not conveniently

## California Officials Meet

Convention in San Francisco Devoted Largely to Discussion with State Commissioners of Ways to Improve Conditions and Service

AT THE annual meeting of the California Electric Railway Association, held in San Francisco on May 25 with over 90 per cent of California's electric railways represented, comprehensive plans were made for active co-operation this year on common problems. Consideration was given primarily to means of securing much needed relief from paving and tax burdens and illegitimate bus competition. A three-hour conference was also held with four of the five State railroad commissioners and was pronounced one of the greatest strides ever made by California electric railways in that it enabled the companies to show the commission just what present conditions mean and enlisted the commission's aid and advice in planning relief. The seriousness of the situation which the railways are facing and conditions in urgent need of remedy were explained by W. R.

TABLE III—RECAPITULATION OF PASSENGER TRAIN PERFORMANCE, SHOWING DELAYS TO 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

Item	Mobridge to Marmouth Steam 190 Miles	Marmouth to Harlowton Steam 340 Miles	Harlowton to Avery Electricity 437 Miles	Avery to Cle Elum Steam* 525 Miles	Cle Elum to Seattle Steam* 90 Miles
1. Meeting and blocked behind passenger.....	18.33	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 substation.....	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	13.88
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.

available for freight train performance, but delays to freight service would naturally be reflected in the passenger train performance.

It will be noted from item 11 that the electrically operated territory shows less time of trains 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 in items 24 and 25.

In concluding, I believe it may be said that in no respect have the results of the electrification failed to equal the expectations of the railway organizations, and in most respects these expectations have been far exceeded. We have found by experience and estimates that items of operating expense depending upon whether steam or electricity is used as the motive power are so reduced and the benefits indirectly obtained are so great as to render justifiable, even with the increased investment charges, the serious consideration of indefinite extension of electrification even for lighter grades.

Alberger, vice-president San Francisco-Oakland Terminal Railways; Paul Shoup, president, and Frank Karr, chief counsel Pacific Electric Railway; W. E. Dunn, vice-president Los Angeles Railway; William Von Phul, president United Railroads of San Francisco, and others. E. O. Edgerton, president of the commission, spoke optimistically of the future prospects for the electric railways because of the essential service they render, and he advised showing the public that the electric railways cannot go on without relief. Emphasis, he said, should be placed not so much on protecting investment as on the importance of public service. Showing the real need of service, which only electric railways can render economically, should be the ground on which to urge the passage of bills at the coming session of the Legislature. The railways should adopt an affirmative, aggressive policy, not a program of defense.

It was agreed that a small committee of the association would meet with the Railroad Commission and work on details of plans for improving conditions affecting electric railway operation, particularly needed legislation. All officers of the association were re-elected.