ELECTRIFICATION DISCUSSED

At Meeting of Western Society of Engineers on March 16, Papers on Electric Operation of Steam Railroads Were Presented by C. A. Goodnow, W. S. Murray, George Gibbs and E. B. Katté

AT a meeting of the Western Society of Engineers held at its club rooms in Chicago, March 16, papers discussing the operating results of electrification of steam railroads were presented by W. F. Murray, consulting engineer New York, New Haven & Hartford Railroad; Edwin B. Katté, chief engineer Electric Traction, New York Central Railroad; C. A. Goodnow, assistant to president Chicago, Milwaukee & St. Paul Railway, and George Gibbs, consulting engineer for the Pennsylvania and Norfolk & Western Railways. Messrs. Murray and Goodnow were unable to attend the meeting in person, Mr. Goodnow's paper being read by E. H. Lee, vice-president Chicago & Western Indiana Railroad, and Mr. Murray's paper by E. T. Howson, engineering editor *Railway Age Gazette*. The papers by Messrs. Gibbs and Katté are abstracted on another page of this issue.

Since the electrification of the Chicago, Milwaukee & St. Paul Railway was merely under construction, Mr. Goodnow's paper was devoted largely to a description of the character of the work undertaken, all of which has appeared from time to time in these columns. He expected that the Milwaukee electrification would result in important economies not only because an entire engine division was to be electrified for the first time, but also because it would become possible to abandon the intermediate engine terminals and yards within the electric zone which had been required under steam operation. The saving in fuel was also an important factor.

In Mr. Murray's paper it was stated that more than 40,000,000 ton-miles trailing load were handled during the month of January, 1915, by the New Haven electric locomotives, this total tonnage being made up of fast, slow and local freight movements. Records of the wattmeters on the locomotives indicate that for fast freight the kilowatt-hours per 1000 ton-miles of trailing load are on the order of 30; for slow freight, 30; and for local freight, 85. These show that an electrical ton-mile requires half as much fuel as a steam ton-mile.

With regard to the handling of classification and switching yards by electric motive power, Mr. Murray said that in 1,000,000 electric switch-engine-miles there had been but one failure. The introduction of the electric engine had increased the speed of the switching yards very greatly, and this increase of speed had been secured with a ratio of electric engines to replaced steam enginees varying from 4:6 to 6:10.

With reference to the mercury-arc rectifier, Mr. Murray stated that the car which was in commercial operation on the New Haven Railroad had been giving most successful service and that it had solved the problem of the production and maintenance of the vacuum tube, both commercially and electrically. The possibilities accruing from such a result could be epitomized in the statement that while the economies of transmission by the single-phase system justified the utilization of a heavier and less efficient motive power, the rectifier to-day permitted railways not only to secure the economies gained in this transmission but to operate beneath the contact wires of such a system the more efficient and lighter d.c. apparatus. As a concrete and practical application of this result, the a.c. motive power now in use on the New Haven would be increased 25 per cent by the application of the rectifier.

With regard to administration, he said that past experience on the New Haven Railroad had shown the necessity for a complete understanding of the difference between the operation of a steam and an electric property. There was no necessity for any general change in an existing steam-operated organization, but the methods pursued in producing a ton-mile of any character upon a steam basis must be abandoned when the drawbar pull comes from electricity. The error of holding a steam master mechanic responsible for an electric engine-mile of any character is patent, and equally patent is the error of holding a steam railroad shopman responsible for the maintenance and repairs of electric engines.

Discussion

In the discussion which followed the reading of the papers it appeared to be the general belief that electrification could be brought about only by proving the economy of its adoption over steam operation on a given line. Density of traffic was the main factor that had accounted for the present development of the art, and if a traffic density sufficient to warrant electrification did not obtain, it would be folly to consider it. Regarding the electrification of the Norfolk & Western, C. S. Churchhill, chief engineer of that road, stated that the economies of electrification had been first considered in 1905. At that time electrical engineers were unable to show any other saving than that of reducing the number of men necessary to operate the trains. After a month's operation on the present electrified division it had been found that the number of men could not be reduced, but that the remarkable development in the efficiency of the electrical generating units and distribution system had made possible other savings which had been far greater and had made electrification of the Norfolk & Western particularly economical. In order to check the economy of electric over steam operation a log of steam-engine train costs for the electrified engine division had been kept, and consequently the Norfolk & Western had figures with which it might definitely calculate results of electrification.

W. F. M. Goss also took part in the discussion and stated that although he was unable to give out any information regarding the Chicago terminal electrification, he wanted to leave the thought with the members and guests of the society that the proposed electrified zone would include more track than the total miles of electrified steam roads now in existence in the rest of the world. He ventured the statement that if the Chicago terminals were electrified more electric locomotives than there were now in existence would be required.

Bion J. Arnold spoke of the remarkable development in the efficiency of the steam locomotive during recent years. The problem of electrification now resolves itself into one of relative efficiency of operating units or trains rather than the relative efficiency of the two types of locomotives, since they were about at par at the present time. Regarding Mr. Katté's paper and particularly referring to the operating costs, Mr. Arnold predicted that if the electrified zone of the New York Central was extended, the costs would be greatly reduced and the whole electrification would prove to be economical. He stated that the extension of the New Haven electrification had made possible greater economies. He also predicted that good results would be obtained from the electrification of the Chicago, Milwaukee & St. Paul Railway. Regarding the Chicago terminals, Mr. Arnold stated that, although he doubted the practicability of electrifying the existing terminals as an economical proposition, he did believe that if they were rearranged, systematized and grouped so that the unified property could be utilized to its fullest capacity, there would be a complete change in the aspect as regards electrification.

Others taking part in the discussion included J. C. Mock, signal engineer Michigan Central Railroad, and E. W. Herr, vice-president Westinghouse Electric & Manufacturing Company.

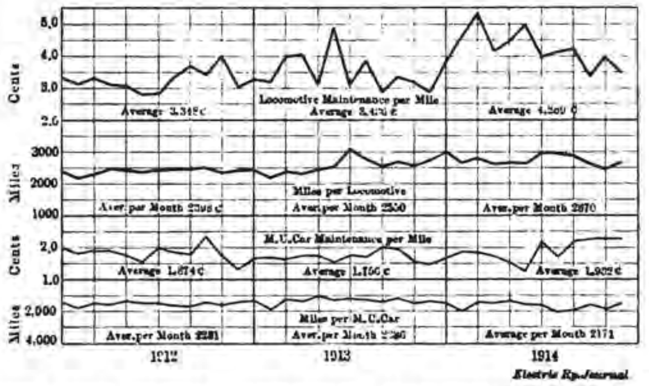
MAINTENANCE COSTS ON THE NEW YORK CENTRAL

BY E. B. KATTÉ, CHIEF ENGINEER ELECTRIC TRACTION NEW YORK CENTRAL RAILROAD

The electric locomotive service of the New York Central Railroad in New York includes switching in yards and terminals, hauling shop trains for a distance of about 6 miles, and a main line express and local service on one 34-mile division and on another 24-mile division. The average cost for locomotive maintenance, including inspection, repairs, renewals, cleaning and painting varies from month to month, but the average cost, covering a period of eight years, is not far from 3½ cents per mile. The maintenance during the past year has been about 4 1/3 cents per mile, the increase being caused by the renewal of driving-wheel tires on the first thirty-five locomotives that were purchased.

The suburban service in the vicinity of New York City is handled by multiple-unit trains consisting of from two to eleven cars. Maintenance, including mechanical and electrical repairs, inspection, renewals, painting, etc., excluding only sweeping and window cleaning, has averaged somewhat less than 2 cents per car-mile. The cars are all-steel, 60 ft. long. They seat sixty-four passengers and weigh 57 tons. There is one motor truck under each car that is equipped with two 200-hp motors, giving a maximum speed of 54 m.p.h.

The New York Central Railroad Company has a special type of under-running third-rail, which is believed to afford greater protection from accidental contact than any other type. Its chief characteristics are, first, a wooden sheath inclosing the live third-rail, except on the bottom or contact surface, and, second, an insulated support so hung as to afford flexibility to prevent strains due to the up and down movement of the supporting ties under traffic. The cost of maintaining this protected third-rail is higher than for the usual type of third-rail, and the large amount of construction work in progress adjacent to the third-rail has increased the maintenance cost above normal. The average cost has been about $26 per mile per month on the main line and $40 for yards and terminals, including track bonding and cable connections, both positive and negative. As a general statement, it may be said that the cost of maintaining the three-phase, high-tension, overhead and under-



NEW YORK CENTRAL EQUIPMENT—MAINTENANCE COSTS OF ELECTRIC LOCOMOTIVES AND MOTOR CARS

ground lines is about $8 per circuit-mile per month, and the d.c. cables cost about $13 per cable-mile.

The price paid for coal in New York averages from $2.50 to $3 per short ton, and power stations in this vicinity are operated on three eight-hour shifts, in place of the more common twelve-hour shifts. Under these conditions, 11,000-volt, three-phase, twenty-five cycle current measured at the busbars of the Port Morris Power Station averages between 0.45 cent and 0.50 cent per kilowatt-hour for operating, labor and materials. When fixed charges are added, the cost averages about 0.75 cent. The transmission and transformation losses, together with all fixed charges, will bring the average total cost of current, delivered to the third-rail shoes, to about 1.75 cents per kilowatt-hour.

As a measure of the reliability of electric equipment, it may be said that during the year 1914 the average

Electric Zone Train Detention Record for 1914. New York Central Railroad

Month	Train Minute Detention — Electric Power Trouble: Power Station	Substation	Trans Line: 11000 Volts	Trans Line: 600 Volts	Third Rail	22½-Volt Signal Line	Total	Electric Locomotives: Fuses	Contactors	Reversers	Misc. Elec.	Brakes	Misc. Mech.	Total	Multiple Unit Cars: Fuses	Contactors	Relays	Control Jumpers	Misc. Elec.	Brakes	Hot Boxes	Misc. Mech.	Total	Total for All Causes	Mileage — Locos.: Total	M. U. Cars: Electric Zone	M. U. Cars: Total	Av. Miles per Min. Det. — Locos.: Total	M. U. Cars: Elec. Delays	M. U. Cars: Mech. Delays	M. U. Cars: Total for All Causes
January		11			5		16	36	18		86	5	124	269		13			27	21	5	43	109	394	188,314	459,989	475,607	700	11,500	6,893	1,685
February			157			35½	192½	21	4	22	60	8	193	308	2		7	5	76	26½		35½	152	652½	166,740	409,701	423,680	541	4,552	6,834	905
March			47			3½	50½		9	24	9	4	65	111	2				7½	41	22	40	112½	274	175,555	459,250	474,219	1581	48,342	4,604	2,371
April									50		54	3		107			3		17		18½	9	47½	154½	164,136	462,703	478,300	1534	23,135	17,393	4,158
May		3	133		25	14	175	4		60	4	19		87		5	4			48		3	60	322	166,034	471,724	489,234	1908	52,414	9,593	2,035
June			260		6½	12	278½			10	65		14	89					2	32	95	3	132	499½	165,851	449,854	465,339	1863	224,927	3,580	1,264
July		12				194½	206½	5	32		9	7	19	72				3	18		16	13	50	328½	185,656	441,956	461,564	2579	21,045	15,916	1,970
August					3	70	73				41		37	78	3					6		13	22	173	185,659	403,266	420,018	2380	134,422	22,106	3,501
September									14	12	14			40				3				13	16	56	180,548	412,802	429,728	4514	137,601	33,056	10,898
October						13	13	5	6		113½	4		128½					12			7	19	160½	165,670	451,312	467,138	1289	37,609	66,734	3,943
November									39		83	9	13	144	38				25		22	9½	94½	238½	155,860	421,944	437,350	1082	6,698	13,884	2,487
December					9	121	130				32		10	42						62½			62½	234½	166,230	458,451	474,426	3958		7,591	2,732
Total		26	597		48½	463½	1135	71	172	128	570½	59	475	1475½	45	18	14	11	184½	237	178½	189	877	3487½	2,066,253	5,302,952	5,406,603	1400	19,457	9,093	2,169

Note:—Locomotives—Number of Detentions, 94; Miles per Detention, 21,981.
M. U. Cars—Number of Detentions, 108; Miles per Detention, 50,894.

mileage per locomotive per detention was 22,000, while the multiple-unit cars averaged 51,000 miles per detention. The train detentions due to electric power troubles totaled 840 minutes for the year. To this aerial lines contributed most largely, with 535 train-minutes; the third-rail caused 244 minutes' delay, and sub-stations twenty-five minutes. The power stations have never caused a minute's delay during their eight years of operation.

Mr. Katté also presented the accompanying chart and table on costs, shown on page 580, and presented views of the equipment.

ELECTRIFICATION ON THE NORFOLK & WESTERN RAILWAY

BY GEORGE GIBBS, CONSULTING ENGINEER

The Norfolk & Western Railway, an important trunk line with a large business in coal, has electrified a section of line that is known as the Elkhorn grade in the Pocahontas coal region. The tonnage on the road is very heavy, and this produces a favorable condition for electric traction. The electrified section includes about 30 miles of heavy grade along the western slope of the Allegheny Mountains and covers practically the entire gathering division for that particular coal-field.

The coal trains over these heavy grades are hauled by Mallet engines which operate only on the gathering division, three engines being required to haul the train at a speed of 7 m.p.h. or 8 m.p.h. In a tunnel on the division this speed is reduced to about 6 m.p.h., the tunnel being of limited cross-section so that difficulties with smoke have been intensified. The line is a very crooked one throughout the division. While the scheduled weight of the trains is 3250 tons now, with Mallet service, this is cut down in winter time to 2900 tons in order to get the trains over the division.

When electrification was first considered it was apparent that the use of a third-rail was impossible. That narrowed the problem to a consideration of high voltage systems, and an analysis of the cost and expense of operation resulted in the adoption of the single-phase system. On account of the enormous amounts of power which had to be applied to each train it was desirable to keep the amount of current as low as possible by adopting the highest possible voltage.

The single-phase power is converted on the locomotive into three-phase power and is used with three-phase motors. By this arrangement there is obtained the advantage of a rugged electrical machine together with a single overhead conductor, the latter being important in complicated yards and on crooked lines. The three-phase motor is not adapted to other classes of railway service, as it is essentially a one- or two-speed motor. It is not suitable for main line service requiring speed, but it is eminently satisfactory for tonnage work on heavy grades on account of its rugged characteristics.

With this system the speed of the train will be maintained irrespective of the load and the grade at any speed at which the motors are set. If the speed is exceeded by coasting down grade, with the train pushing the locomotive, the motors automatically return the current to the line at normal voltage and this power may be used in propelling trains up grade.

For this service there are provided twelve locomotives. Each is equipped with eight three-phase motors, arranged with eight-pole and four-pole combinations to produce 14 m.p.h. and 28 m.p.h. respectively. The total length of the locomotive is 105 ft. over all and the diameter of the driving wheels 62 in. The weight is 270 tons, with 220 tons on the drivers. The drawbar-pull varies from 114,000 lb. during acceleration at the 14-mile speed, to 86,000 lb. when operating at this speed uniformly on a one per cent grade, but on a recent test a locomotive developed a tractive effort in excess of 170,000 lb., indicating, however, a coefficient of adhesion which cannot be assumed in practice. The maximum guaranteed accelerating tractive effort for a locomotive is 133,000 lb.

At the present time about half of this section of the road, including the entire heavy grade division, has been operating for about a month, and the experience thus far encountered indicates that the anticipations are to be realized in obtaining a remarkably successful installation. The trains accelerate promptly and without jerking on the heavy grades. On a 2.5 per cent down grade the trains are held at a speed not to exceed 14 m.p.h. As soon as the speed exceeds the 14-mile limit the current drops to zero, then mounts up in the opposite direction and there is returned automatically to the line an amount of power probably in excess of 2000 kw.

The acceleration of these heavy trains, as regards the amount of power required, is impressive. Preliminary tests indicate a development of 11,000 hp on one train during the acceleration period and 8000 hp when running at uniform speed. These figures are probably in excess of any amount of power delivered on a single train anywhere in the world.

Mr. Gibbs' paper concluded with a brief account of the electrification of the Pennsylvania main line between Broad Street Station, Philadelphia, and Paoli, a distance of 20 miles. This installation was described in the ELECTRIC RAILWAY JOURNAL for April 18, 1914.

Electrolytic Corrosion Discussed at British I. C. E. Meeting

At a recent meeting of the Institution of Civil Engineers H. E. Gerbury outlined the general principles of pipe corrosion, with and without railway stray currents, quoting conditions in Sheffield by way of illustration. He stated that, as current density and current duration are the most important factors, potential readings are somewhat misleading. Where a comparatively high difference of potential exists there is, as a rule, less injurious current passing. This is largely due to the counter-emf of polarization. In Sheffield, when the tramway system and generation station have been shut down, differences of potential up to 0.66 volt have been observed on pipes. Incrustation in the bore of pipes is often caused by local electrolytic action. This growth might be started as a speck of rust, thus forming with the iron a galvanic couple, the oxide being electronegative to iron. The electrolyte might be created by the secretions of animalculæ or other acids. This nucleus would then establish a closed circuit, and the growth would continue by the increased bulk of oxide acting as a shell to retain the electrolyte.

Ferro-manganese and the European War

Ferro-manganese, which has come to play an important part in street and electric railway special work, frogs and crossings, is sold under severe conditions by England during the present war. English producers require that American buyers must obligate themselves not to ship steel to Germany, Austria or Turkey, or even to countries contiguous thereto except through London. It is said that some buyers have declined to agree to these stipulations, while others, because of the large amount of business on hand, have been forced to do so in order to keep their plants in operation.