statistics of high-tension cable failures, and it has also presented them for the year 1919. Operating results in 1919 appear to have been considerably better than in preceding years, showing only 8.2 failures per 100 miles of cable as compared with 13.1 during 1918. It is impossible to draw any general conclusions with only two years' data at hand, but the improvement is due in part to the replacing of old-type joints by some companies, to more favorable weather conditions in certain localities for the dissipation of heat, and in some cases to the reinforcing of feeders to clear up overload conditions.

R. T. Lozier, National Conduit & Cable Company, New York City, urged more exchange of experience on underground cable operation since it will help manufacturers meet requirements better.

Steam Railroad Electrification

The report of the committee on electrification of steam railroads, F. M. Kerr, vice-president Montana Power Company, chairman, consisted of separate reports by the following members: A. H. Armstrong, chairman electrification committee of the General Electric Company; R. Beeuwkes, electrical engineer Chicago, Milwaukee & St. Paul Railway; H. H. Cochrane, chief engineer Montana Power Company; Peter Junkersfeld, engineering manager Stone & Webster; F. H. Shepard, director of heavy traction for Westinghouse Electric & Manufacturing Company, and J. E. Woodbridge, resident engineer with Ford, Bacon & Davis, San Francisco.

Mr. Kerr explained that the committee found it advisable to discuss electrification from the viewpoint of the purchaser and the seller of electrical energy for railway purposes. He said that the Chicago, Milwaukee & St. Paul Railway and the Montana Power Company have demonstrated in Montana the entire practicability and the great superiority of electric power for the operation of a heavy trunk-line railway by more than four years of 100 per cent operation. The total yearly cost of operation averages about $11,000 per mile for the entire system of 10,000 miles. The cost of electrical energy purchased for the Rocky Mountain division is $1,600 per mile, or less than 15 per cent of the average total cost for the system.

Electrified Railroad as a Power Consumer

Mr. Cochrane discussed power supply for electrification on the basis of experience obtained in supplying power to the Butte, Anaconda & Pacific and the Chicago, Milwaukee & St. Paul Railways.

He suggested that in future electrification projects the power company own all high-voltage lines, switches and transformers and deliver power to the railway at a suitable voltage for its motor-generator sets or whatever converting apparatus is used. With this arrangement the power company would own all the equipment necessary to supply consumers other than the railroad along electrified sections.

Mr. Cochrane pointed out that the ideal rate for a railroad is a straight kilowatt-hour rate. Peak loads do not come at the same time as a general thing, and the fact that they exist is ascertained by referring to the records rather than by any physical effect which they have on the power system. The power factor is about unity, and the load is so scattered that fluctuations in railroad loads have practically no effect on voltage regulation. The load factor on the entire division was about 50 per cent. Combining the total railway load with that of the rest of the Montana Power Company's system makes a total load with a daily load factor frequently in excess of 90 per cent, typical figures at present being 144,000 kw. average and 160,000 kw. maximum.

Energy Supply to Railroads

Mr. Junkersfeld discussed the requisites of an equitable power contract for railways. He said that the contract for power should provide automatically for wide fluctuations in cost of labor, fuel and other principal elements. This may take the form of a simple rate, perhaps a "block" rate, based upon both demand and consumption, with a provision for revision at suitable intervals at the option of either party to correct it for unforeseen conditions—changes in the art, in the purchasing power of money, in interest rates, in taxes and in other factors which may affect the cost of electric service.

Electrification Economical for Railroads

F. W. Bellinger outlined the electric operation of the Butte, Anaconda & Pacific Railway since 1912 and gave data on the cost of locomotive maintenance, which varied from 5.3 cents per locomotive-mile in 1914 to 6.8 cents in 1919. He compared this with 16.1 cents per locomotive-mile for steam operation in 1909.

For the Chicago, Milwaukee & St. Paul electrification Mr. Beeuwkes gave details of first cost and comparative operating data for electrified and steam operated divisions which showed that the repairs were much less than for the steam locomotives replaced. He pointed out that electrification had in most respects far exceeded the expectations of the railway organization from an operating standpoint.

Mr. Shepard, in reviewing the service and needs of railroads, pointed out that the traffic of the country doubles about each twelve years, so that facilities must be provided in advance of needs without regard to the necessity for immediate financial return. The physical means by which the most can be obtained from the railroad plant is electrification.

Mr. Armstrong stated that a total consumption of about 53,500,000 tons is a rough approximation of the coal required to produce the electric power to haul the tonnage of 1918 by electric locomotives. This indicates the possible saving of 122,500,000 tons of coal as the annual return on universal electrification of the country's railways. Electrification, he said, involves no experiment with novel and untried apparatus. On the contrary, universal electrification could well follow closely along the lines of installations now in successful operation.

In discussing this report, the success of actual electrifications was confirmed by various companies. W. C. L. Eglin testified to the success of the electrified divisions in the Philadelphia district, as did also F. W. Smith of New York. The viewpoint of railroad men was presented by A. H. Babcock of the Southern Pacific Railroad, who pointed out the importance of disillusioning company officials who believe that money can be better spent in double-tracking systems or along other lines with which they are familiar.