station, with the turbines directly over the boilers, results in almost an entire absence of entrained moisture in the steam as delivered to the turbine throttles. The low cost of coal in the region in which this plant is situated was also a factor in deciding to omit superheaters as the gain in efficiency of the turbines when using superheated steam measured in cost of coal was hardly enough to warrant the additional cost and complication of installing superheaters.

Other features of the equipment of the stations under review are shown in the accompanying outline plans and tables.

ELECTRICAL NIGHT AT THE NEW YORK RAILROAD CLUB

The greater part of the proceedings of the New York Railroad Club on Friday evening, March 19, was given up to a discussion on the "Approaching Transfer of the Electrification Problem." The first speaker, William McClellan, said that the problem of electrification was now transferred from possibility to practicability: in other words, that the electrical engineer would have to give way to the railroad engineer familiar with the broader financial aspects of heavy railroading. The electrical engineer need not necessarily drop all connection with the work, but if he is an electrical engineer and nothing more, his sole function will be the perfection of details and methods. Railroads are now confronted with no less than five different electric systems, any one of which would probably do the work reliably with more or less economy and would be financially practicable. These systems are the 600-volt, d.c. third-rail; the 1200 volt or higher d.c. third-rail or trolley; the high-voltage a.c. single-phase; the high-voltage a.c. three-phase, and various gasoline-electric or straight gasoline cars. All of these have their own advantages under certain conditions, but they will not command real backing until there is a practical unanimity among technical men as to what simple or composite system is generally applicable. The simplest method appears to be the use of a high-voltage system for trunk lines, with either low a.c. or d.c. voltage in cities. The low-voltage a.c. was preferable to d.c. because the potentials could be varied so easily. The speaker thought that now was the time to consider the standardization of certain features of heavy electric lines, like the location and type of third-rail and shoe; location of overhead contact conductor; side and top clearances; location of end couplings; low voltage for d.c. and a.c. on third-rail and overhead contact lines; high voltage for overhead contact lines; frequency of alternating current. Such standardization might well be confided to a committee appointed by the American Institute of Electrical Engineers, acting jointly with the several steam railroad organizations. He regarded it as a maxim that no feature of electrification design should hamper railroad operation proper.

W. S. Murray, electrical engineer of the New York, New Haven & Hartford Railroad, said that electrification depended on two things, law and economy. Experience has shown that electrification must take place in cities with great terminals and on mountain divisions of railroads where the ruling grade indicates that trains can be handled more cheaply by electricity. He quoted some interesting figures on the electrification of Prussian State railways, printed in the United States consular reports, according to which the present capitalization of the Prussian State railways is $2,250,000,000; length of single track, 12,785 miles; annual operating expenses, $241,796,000; annual receipts, $404,483,000. It was assumed that power could be delivered at 0.833 cent per kw-hour, if the alien stations supplying the same were allowed 4 per cent interest on their investment and that the power was being transmitted for distances up to 125 miles. The cost of the electric system, inclusive of distribution and transformer houses, was over $234,500,000. It was estimated that the present number of steam locomotives could be replaced by electric locomotives numbering 36 per cent less. The cost per pound of electric locomotives was estimated at 18.34 cents and that of steam locomotives at 11.86 cents. The report concluded that the economies of electric traction warranted electrification. Standardization was a very dangerous proposition just at present, but certain things had been accomplished in the several systems which would bear discussion in detail. Evidently the power conditions of steam railroad operation must be different from those on street railways, for direct current had been used on the latter for 20 years without any important applications to the former. On the other hand, the alternating current had behind it the advantages of long distance and capacity long before it was applied to railway work. For the past four years he has had the opportunity of observing the operation of a.c., d.c. and steam on the same train, and he was convinced that if any railroad has a situation similar to that of his own, it should adopt alternating current. He believed, however, that low-voltage generators should be used; that is, the high voltage should come from the transformers rather than from the generators direct. The transformers may be said to introduce a softening effect between the contact line and the generators. The cost and efficiency per kilowatt installed would not be seriously affected by this arrangement, because the efficiency of the low-voltage machines is higher and the transformer losses are so low that the combination will give an output equal to the high-voltage machine alone. The difference in initial cost is slight. Mr. Murray also referred to the use by the New Haven railroad of its steel working conductor, which he compared to the use of a floor on the members of a bridge. The steel wire is easily replaced and costs but 4 or 5 cents per pound, as against 20 to 25 cents per pound for copper or phosphor bronze. The wear of the steel wire has been only 0.0005 in. in six months at the worst places on the line. As regards frequency, he did not wish to say that he was absolutely in favor of 25 cycles, but stated that its advantages should not be overlooked, especially as there are many plants where 25 cycles is the standard frequency.

Mr. Murray mentioned that the New Haven railroad's electric zone had originally been sectionalized about every 1½ miles, but said the sections were now much longer. It is useless to have the section breaks at points where they cannot be utilized by crossovers. The latter, therefore, are very important in fixing the length of sections, which, consequently, are not amenable to standardization. The electric zone of the New Haven railroad comprises three terminal runs, respectively 17.25 miles to New Rochelle, 25 miles to Portchester, and 33 miles to Stamford. The engine mileage is about 210 miles a day per annum for each electric locomotive, while statistics on 115 steam engines doing inter-division work showed an average of 158 miles. It was apparent, therefore, that in replacing the steam locomotives by electric stock one should bear in mind these differences in ability to make mileage. Mr. Murray then compared the speed-torque curves of steam and electric locomotives.

N. W. Storer, of the Westinghouse Electric & Manufacturing Company, spoke of the studies and efforts now under way toward the electrification of terminals in large cities. The recent decision of the Pennsylvania Railroad to use direct current in New York was influenced by the fact that it already had a heavy d.c. investment on Long Island and that much of the new work would be through tunnels, but he believed that should the Pennsylvania Railroad consider electrification of long distances between cities it would tend to favor the single-phase. The Great Northern Railroad was the only one in the United States which had adopted three-phase operation. There was no question that three-phase motors can be used, but not for general railway service. They are not adapted for multiple-unit trains, and with the frequency of 15 cycles the speed of a two-pole, three-phase motor is only 900 r.p.m., whereas standard railway motors are running at 1500 to 1800 r.p.m. Such a three-phase motor would be a poor one to have, and if four poles were used the speed would be reduced to 450 r.p.m., making a very large motor. On one of the Italian railways he had seen a locomotive with two three-phase motors, one having eight poles and rated at 1500 hp, the other having 12 poles and rated at 1200 hp on an hourly basis. But since the motors could not be operated together at their highest speeds, it would be wrong to state the total output as 2700 hp. The constant speed characteristic of the three-phase motors also makes them uneconomical for railway service, aside from the double overhead trolley. In conclusion, he added that electrification must not be considered simply from the point of cars and locomotives. Single-phase locomotives did not cost so much more that their price should frighten any one, and if the equipment was 10 to 12 per cent heavier, it produced a saving of 25 to 40 per cent in the cost and efficiency of the transmission system.

E. B. Katte gave the following figures on the reliability of the New York Central electrical service during 1908: There was not one minute delay because of the power station, substations or transmission lines; delays from feeders, 7 train minutes; from third-rail, 150 train minutes; from locomotives, 400 train minutes. The total locomotive mileage was nearly 1,000,000. The multiple-unit cars traversed 3,500,000 miles with train delays of 830 minutes, about equally divided between electrical and mechanical causes. The total number of train minute delays from all causes was 1400, and the average train miles per minute delays was over 3000. The average number of electric train movements per day was 450 and the amount of current generated for the service 120,000 kw-hours.

C. L. Muralt said that a great deal of standardization really has been going on in the past. Power plants, for instance, had practically adopted 25 cycles, although it might be noted that the Swiss study commission on electrification had recommended a frequency of 12 to 15 cycles. The transmission and distribution systems had also practically standardized. The one large problem which remained was the standardization of rolling stock motive power. There was no good reason why electric rolling stock should be limited to one type any more than steam locomotives are at the present day. It was not correct to assume that the three-phase motor could only operate on low frequency, as there were over half a dozen three-phase lines on the Continent now using 40 cycles or more. The 1200-hp and 1500-hp motors mentioned by Mr. Storer give in tandem a total slightly less than 2700 hp. Three-phase locomotives weigh even less than d.c. locomotives. He then criticised the weight and performance of the New Haven locomotives, and drew some speed-torque curves to indicate the superiority of the three-phase locomotive.

H. G. Stott, superintendent of motive power, Interborough Rapid Transit Company, indorsed the remarks that Mr. McClellan had made on standardization, and thought that it was time to concentrate attention on the location of the contact rail and overhead wires.

N. W. Storer, replying to Mr. Muralt, said that while three-phase motors could be used with high frequencies, they operated better on low frequencies. He had made some calculations on three-phase locomotives to fulfill the conditions of the New Haven electric zone service, and found that it would require a 1500-hp locomotive to handle the loads and give the maximum speed of 50 m.p.h., which is now given by a 1000-hp single-phase locomotive. Furthermore, the single-phase locomotive, in spite of its greater weight, would require less power, because it has no rheostatic losses during acceleration. The single-phase locomotive also has the advantage of being able to increase its speed when necessary.

W. S. Murray stated that the New Haven locomotives were intentionally designed for operation in multiple, because 80 per cent of the New Haven train-weights range between 200 and 250 tons, which is the unit capacity of one locomotive. It was thought better to have two locomotives ready for the few heavy trains than single larger locomotives, which would be operating inefficiently with most trains.

Dr. Cary T. Hutchinson said that he had decided in favor of three-phase operation on the Great Northern Railroad because he believed the three-phase motor best adapted for the heavy trains and grade on the division being electrified. The motors were extremely simple and hardy, and the power tests made were away above the guarantees. He considered it the most powerful electric motor in existence, whether a.c. or d.c. The hourly rating of each motor is 540 hp, and for the four motors 4000 hp; the continuous ratings are respectively 420 hp and 1700 hp. The operating officials of the Great Northern Railroad did not object to having a constant speed of 15 m.p.h., whether going up or down a 2 per cent grade. He had also received a report favoring three-phase from an engineer who was working on plans for the electrification of a western division of a trans-continental railroad. He felt quite certain that the Pennsylvania Railroad would seriously consider the adoption of three-phase motors on the low-grade freight line between Harrisburg and Trenton.

N. W. Storer, referring to Dr. Hutchinson's remarks, said that he was now designing a single-phase locomotive having a continuous capacity of 2750 hp and capable of running on 2 per cent grades at 20 m.p.h. Mr. Muralt said that he also had under consideration a 6000-hp, three-phase locomotive, but after all there need be no dispute as to the limits of horse-power capacity in any form of electric locomotive.

After brief remarks by other members the meeting was adjourned.

At the Cedarburg shop of the Milwaukee Northern Railway a pair of bare copper wires installed between two roof-supporting columns along a repair track are connected with the telephone circuit leading to the dispatcher's office, and afford a ready means for testing in the shop the portable telephone sets and hook attachments carried on the car.