STEAM RAILWAY ELECTRIFICATION.

THE factors entering into the selection of a system when contemplating the electrification of a steam railway were ably discussed in a paper read by Mr. J. A. Shaw, of the Canadian Pacific Railway Company, at the 24th annual convention of the Canadian Electrical Association, held last week in Montreal. The importance of choosing a system suitable for general conditions, to permit interchangeability of rolling stock between different sections, and to allow extensions to be made as economical and reliable operation, or other conditions warrant, were properly emphasized. We reproduce the following from Mr. Shaw's paper:—

Three systems now exist which include all which need be considered in view of the present state of electrical development. One, the three-phase alternating, is not suitable for general electrification, on account of requiring two trolley wires, with the resulting complications and the peculiar characteristics of the motors employed. The remaining systems are single-phase alternating current, and the 2,400-volt direct current.

The single-phase system has been used in the electrification of the New York, New Haven and Hartford Railway from New York to Stamford, and is now being considerably extended. It has also been used on a number of light railways, notably the Spokane and Inland. Abroad it is in use on the London, Brighton and South Coast Railway, the Swedish State Railway and others, and has been adopted by the German, Swiss and Austrian State Railways as their approved system, although it cannot as yet be considered as completely through the experimental stage.

The 2,400-volt d.c. system is a development from the 600-volt system, which is practically the standard in all street railway and interurban work, and which has been so successful on that field. The electrification of the New York Terminals of the New York Central and the Pennsylvania lines, the Atlantic City Line of the Pennsylvania, the New York Subway, and all elevated railways have also employed this system. Abroad it has been used on the Lancashire and Yorkshire Ry., and in general under conditions similar to those in this country. During the past three years a number of light railways have been installed using 1,200-volt d.c., in most cases, however, using 600-volt motors, and from the experience obtained, the 2-400-volt system has been developed, using 1,200-volt motors, and this system has now been in use on the Butte, Anaconda and Pacific Ry., preparatory to a further use of it on two divisions of the Chicago, Milwaukee and Puget Sound Ry., for the past 10 months. A lower voltage installation at 1,500 volts has been in service over three years on the Piedmont Ry. in South Carolina.

Supply of Power.—It is possible that in the majority of cases for years to come that power will be generated for locomotive purposes alone, without considering its use for other purposes. However, electrification will be made possible more through cheap power being available from existing power plants, where if a separate plant had to be erected it would be too expensive. Possibly in the future power plants will be constructed at points where commercial power is not available, but even in that case at other points on adjoining divisions commercial power might be obtained, and to permit of uniform equipment the power generated would either have to be uniform with that purchased or the latter converted to the character required. Throughout the West and in the Montreal district, 60-cycle, 3-phase transmission is practically universal, and, while 25-cycle, 3-phase current is employed on the Hydro-Electric and Toronto-Niagara transmissions from which 25-cycle single-phase could be obtained by stationary transformers, balancing apparatus would be required. In view of the tendency to use 15-cycle in place of 25-cycle current in single-phase electrification and the remoteness of general electrification in Ontario, it is reasonably safe to assume that converting apparatus will be required for either single-phase or direct-current installation. The application of 15-cycle generators in 60-cycle power stations or of frequency changing apparatus to furnish single-phase current, while possible, does not actually change this assumption, as the increased price asked for by the power companies equals the cost of conversion by the railroad in addition to requiring the erection of separate transmission lines.

The general arrangement of the two systems is outlined in Table I.

TABLE I.

Single Phase.	Direct Current.
A 1. Power line of supply company.	D 1. Power line of supply company.
A 2. Conversion station at one or two points per division furnishing single-phase current from motor-generator apparatus and step-up transformer for raising potential. If power lines are available at several points on division, number of conversion stations may be increased, and length of transmission lines correspondingly reduced.	D 2. Transmission line to sub-stations. Where supply company power lines are available at several points on division, sub-stations may be conveniently located at such points, and length of transmission line correspondingly reduced.
A 3. Transmission line from conversion stations to transformer stations.	D 3. Sub-stations in which three-phase power is converted to direct current by motor generator apparatus.
A 4. Transformer station in which high voltage single-phase current is transformed to 11,000 volts for trolley line.	D4. Feeder line by which direct current is supplied to trolley line.
A 5. Trolley line and bonding.	D 5. Trolley line and bonding.
A 6. Electric locomotives or motor cars.	D 6. Electric locomotives or motor cars.

Cost of Installation.—An inspection of above table shows that as a general proposition certain of the items are practically common to both systems. Transmission lines A-3 and D-2 will be required for the entire length of the division if power were received at one point: whereas if power were received at several points, while several single-phase conversion stations could be installed, that would not prove practically economical, and with direct current there would be a saving in the transmission line required. The transmission line for single-phase current costs 20 per cent. more per mile than that for 3-phase, so that it is entirely fair to the single-phase to consider the cost of transmission lines equal.

The trolley line and bonding are practically the same. For single-phase, higher insulation is required on account of the higher voltage and the surging which occurs. With the improvements that have been made in the manufacture of insulators, the difference would not exceed 10 per cent. of the cost of the trolley line.

The conversion stations and transformer stations A-2 and A-4 for single-phase will correspond to the sub-stations D-3 for direct current. For heavy traction work on the Chicago, Milwaukee and St. Paul Ry., where it is proposed to handle 1,600 tons on 1 per cent. grades, the sub-stations will be located from 18 to 24 miles apart, the feeder being 1,000,000 cm. Considering a direct