ELECTRIFICATION OF STEAM RAILWAYS.

In *The Canadian Engineer* for July 9th, 1914, appeared a discussion of the steam railway electrification problem, by Mr. J. A. Shaw, of the Canadian Pacific Railway Company. The following, extracted from a paper read by Prof. D. D. Ewing before the Indiana Engineering Society, will be found of particular interest, as the statements advanced by both authorities leave little to be desired in the matter of general information respecting the systems that have received practical recognition. Prof. Ewing states that power companies are interested in electrification because they have electrical energy for sale. The railway companies can build and operate their own power plants, but in many cases they find it cheaper to buy energy than to generate it, the low ratio of average demand to maximum demand making a railway load alone rather unprofitable for a power station.

As far as the power station and transmission lines are concerned, nearly all systems of electric traction are similar, consisting generally of three-phase power generation and high voltage and three-phase transmission. It is in the motive power equipment and the distribution systems that the differences come. Four systems are finding practical application to-day.

Direct-Current System.—In this system direct-current series motors are used on the locomotives or motor cars and voltages ranging from 600 to 2,400 volts are used on the trolley or third rail. The trolley or third rail and its feeders receive direct-current energy from substations located at intervals along the right-of-way. In the substations, transformers and rotary converters change the high-voltage three-phase currents of the transmission system to direct current at the proper trolley voltage. This is the well-known system used on street railways, modified to meet the demands of steam line traffic, and up to the present time has found wider application in this country than all of the other systems put together. Of interest in connection with this system is the recent announcement that the Chicago, Milwaukee and Puget Sound Railway has decided to use it in its electrification over the Rocky Mountains.

Single-Phase System.—Either series or modified repulsion type, single-phase motors are used on the locomotives or motor cars. The trolley receives its single-phase current supply from transformers, located at intervals along the line, which transform the high voltage of the transmission system to a value suitable for the trolley. Trolley voltages range from 3,300 to 25,000 volts, 11,000 volts being common in this country. A balanced three-phase load is approximately secured by dividing the trolley line into sections and feeding the different sections from different phases. Transformers on the locomotives or motor cars step the trolley voltage down to a value suitable for the motors. The motors are rather complicated and have high maintenance charges. On account of the high trolley voltages used, the first cost and line losses of the distribution system are low. The most prominent example of this system, in this country, is that of the New York, New Haven and Hartford Railway.

Three-Phase System.—In this system three-phase induction motors are used on the locomotives, and two trolley wires are required, the track forming the third leg of the three-phase circuit. Trolley voltages up to 11,000 volts have been used. Transformers on the locomotives step the trolley voltage down to a value suitable for the motors.

The two trolley wires required complicate the overhead work, but the motors are simple and rugged. The system is readily adapted itself to regenerative control of trains on down grades. The motor is inherently a constant speed motor, and will carry its load up grade approximately as fast as it will carry it down grade or on the level. With some modifications in the design of the motor, its speed can be varied in steps without seriously affecting its efficiency.

The Great Northern Cascade Tunnel electrification is the only example of this system in this country, although locomotives having an aggregate rating of about 200,000 h.p. are in use in Europe.

Split-Phase System.—The locomotives are equipped with polyphase motors and single-phase current is supplied from the trolley. A phase converter on the locomotive converts the single-phase energy to the polyphase energy required by the motors. The distribution system is the same as with the single-phase system, and the motive power equipment is the same as with the three-phase system, with the exception of the phase converter. In a measure the good points of both systems are combined. The system is a new one, and is possibly the most spectacular development in electric traction made during the year just passed.

Advantages and Disadvantages of Electric Traction.—The following are a few of the more important advantages and disadvantages of electric traction for railway trains. Briefly, the advantages are:—

The safety of operation is increased because signals are not obscured by smoke and steam, and the locomotive-driver can give his entire attention to driving, and his seat can be located so that he can see both sides of the track at all times.

Regenerative control is possible with all systems of electric traction. With regenerative control the air-brakes are used only in stopping or in case of emergency. Car wheels and brake shoes are not heated by long-continued applications of the brakes on down grades, and the number of wrecks due to cracked wheels is lessened. The energy that would otherwise be used up in heating the brake shoes and wheels is pumped back into the line and helps pull some other train up hill. While regenerative control is possible with all systems, it has not been used on all systems in the past on account of the resulting complication in the control apparatus and motor windings of series type motors.

The dispatcher can stop a train at any time by ordering the power supply shut off from the section in which the train is running, and the control mechanism may be readily arranged so that the brakes are applied automatically if the power is shut off from the trolley.

In mountain grade work, higher speeds may be maintained over the grades than is possible with steam locomotives. Going upgrade, the speed of the steam locomotive is limited because its power output is limited by the boiler capacity. The electric locomotive is not limited in this way, and for short intervals it can carry large overloads.

Powerful motors can be mounted on comparatively light locomotives. While the weight of a locomotive fixes the drawbar pull at starting, its horsepower capacity fixes the pull when running at a given speed. This means that electrically operated trains can be accelerated at much higher rates than steam trains and can be operated at higher speeds over grades.

Electric locomotives require inspection once in from 1,200 to 2,500 miles of operation. To keep steam locomotives in similar condition they must be inspected and cleaned at the end of every run. On those roads which are operating electric locomotives, the daily mileage of