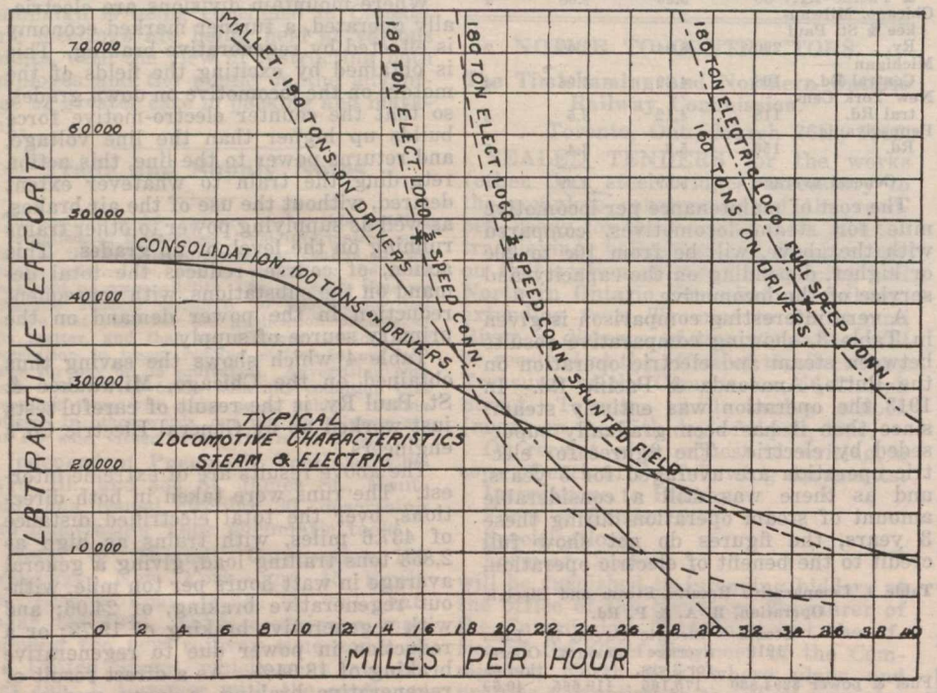
year in brake shoe wear alone is close to $200,000. On the Denver & Rio Grande Rd. 4% grade, between Soldier Summit and Tucker, the instructions are with steam operation not to exceed 8 to 10 miles an hour, and to stop every 5 to 7 miles, for from 15 to 30 minutes, to cool brake shoes and wheels. Under these conditions the energy dissipated between each brake shoe and wheel may be as high as 20 h.p., so it is readily seen that even on much easier grades of long extent the brake shoe wear, with steam operation, is a serious factor of expense.

The steam locomotive is a power plant, which, owing to physical limitations, can attain only a certain capacity and efficiency. On the other hand, the electric locomotive, itself very efficient, can draw any amount of power desired from a system fed by hydro electric plants, or highly efficient steam electric plants. The continuous draw bar pull of the electric locomotive is limited only by the strength of the draft rigging on the cars. By series, and various series-parallel combinations of the motors, a wide range of running speeds can be obtained, without rheostatic losses. This range can be further varied by shunting the motor fields. Due to the power input available, draw bar pulls can be maintained at speeds impossible with steam locomotives. This means that over any line, trains of heavier tonnage can be hauled at a much better schedule speed than with steam locomotives. In the case where a single track steam line has reached its capacity, and would have to be double tracked to handle increased ton mileage, electric operation will obviate the necessity of double tracking, and permit of a large expanse in ton mileage handled. The accompanying curve sheet giving typical locomotive characteristics, steam and electric, shows a comparison of pounds tractive effort, at various speeds, of 2 steam locomotives, a Mallet with 190 tons on drivers, and a consolidation with 100 tons on drivers, with an electric locomotive having 160 tons on drivers. It will be noted that the tractive effort of the Mallet drops off rapidly above 8 miles an hour, while the tractive effort of the consolidation drops off steadily, though not so rapidly, above 10 miles per hour. Curves are given for 3 of the 6 running speeds of the electric locomotive. At 16 miles an hour the continuous tractive effort which the electric locomotive can exert is greater than that of either of the steam locomotives, while at about 35 miles an hour the continuous tractive effort of the electric locomotive is more than three times the tractive effort of the consolidation.

With regard to collection of current, experience has shown that with the slider type of pantograph 1,000 amperes can be taken sparklessly from a single trolley wire. Using 2 trolley wires suspended side by side, as on the Chicago, Milwaukee & St. Paul Ry., 2,000 amperes can be collected. This at 3,000 volts is 6,000 k.w., or over 8,000 h.p. As there is no sparking, the wear on the trolley wire is exceedingly slight, as may be judged from the fact that here in Canada we are getting a life of from 10,000 to 12,000 miles from a single wearing strip on the pantograph.



Typical Locomotive Characteristics, Steam and Electric.

As regards substations, a further decided economy is now credited to electric operation, through the perfection of automatic control. One serious operating condition was the flashing over of the generators from some short circuit outside the station. This might be severe enough to necessitate cleaning up the brush rigging and commutators. Continuity of operation required an attendant at each substation, while the generating sets were in operation. This trouble has been entirely overcome by the use of a high speed circuit breaker, which will open a short circuit, of many times the normal full load value of the generators, in less than eight thousandths of a second. With the further use of flash barriers on the commutators, flashing over of direct current generators is absolutely eliminated. With automatic control, the sets are stopped and started through the voltage drop reaching a definite value at any point on the system. In addition to doing away with substation attendants, this also improves the all-day efficiency of the generator sets, as they are shut down during periods where they are not automatically started up to maintain the line voltage at a fixed value. With the refinements now available for substation operation, it can be confidently asserted that the substation equipment is now 99% efficient.

The question of load factor on the power supply lines of the Chicago, Milwaukee & St. Paul Ry. electrification is of considerable importance, since the price of energy per k.w. hour is based upon an assumed load factor of 60%. In case the ratio of the average to the maximum load is less than this amount, the price is somewhat higher. Because of the desirability of maintaining a relatively high load factor, there has been designed and installed, a power limiting and indicating system, which automatically limits the maximum load to certain predetermined peaks, and also indicates to the dispatcher the exact amount of power which the whole system is receiving at any instant. This apparatus is installed in the dispatcher's office at Deer Lodge, and in each of the substations, which are connected to the main office by pilot wires. Two totalizing k.w. meters are located over the dispatcher's desk, indicating respectively the amount of power being drawn by the 200 miles east and the 220 miles west. By means of the pilot wire control, acting upon the motor-generator sets in the substations, the trolley voltage is reduced temporarily on the overloaded substations, so that the total k.w. consumption on the totalizing meters never exceeds the predetermined maximum. By careful dispatching, it is thus possible to keep the maximum load within reasonable limits, without materially slowing up the movement of trains.

As to the reliability of the modern electric locomotive for continuous service, the returns for 1918 just made public by the New York Central Rd. show that the locomotives were inspected after each 3,000 miles of running and that they averaged 33,000 miles per detention.

In changing to electric operation there is practically no upsetting of the regular steam organization, as the locomotive crews, under instruction, readily become highly efficient in the operation of electric locomotives.

Proposed Bridge over St. Lawrence River at Montreal.

Some of the municipalities on the south shore of the River St. Lawrence, opposite Montreal, have taken up recently the question of securing the building of a bridge across the St. Lawrence between Montreal and the south shore, crossing St. Helens Island. A plan, issued by the Montreal Harbor Commissioners in 1914, showed such a bridge, as part of the proposed works in connection with the harbor improvements, provision to be made for steam and electric railway, vehicular and foot traffic. We are advised that no plans have been prepared for the bridge, nor has any charter been applied for. So far the Harbor Commissioners have not given any consideration to the construction of the bridge, but it is felt by south shore municipalities that it should be built in the near future to give them better access to Montreal, it being claimed that the G.T.R. Victoria bridge is congested. A deputation from the south shore municipalities waited on the Canadian National Rys. directors in Toronto recently, to enlist their co-operation.

The Winnipeg Board of Trade has established a Traffic Department, in charge of P. G. Denison, to give service to members of the board.