the process of regenerative braking, and this returned-energy helps to haul other trains. While this is a very important item, and reduces the power bills, it is only regarded by the management as of secondary importance in comparison with the more safe and easy operation of trains on the grades, and the elimination of former delays for changing brake shoes and repairs to brake rigging when operating with steam locomotives. The electrics maintain their schedules much better than steam engines. In three months the electrics only waited for the right of way 254 minutes, while the steam engines in a similar period waited 1910 minutes—or 7½ times as long. Extra cars on trains only delayed electrics 1/9 of the time steam trains were delayed for a similar reason. Cold weather delayed steam trains 445 minutes in the three months under discussion, but the electrics were not delayed a minute; the latter are *more efficient* in cold weather. Many of the delayed steam trains were double-headers—but never more than one electric is hitched to a passenger train. An entire suspension of freight service, due to steam engines losing their steaming capacity and freezing up, was not an uncommon experience. Electrical energy for the operation of these trains costs considerably less than coal. This latter statement is one of the most interesting in connection with the operation of the C. M. & St. P. Ry. and it is especially interesting because it was made more than two years ago.

Electric Motor Only a Link

"The foregoing actual operating experiences on large railway electrification projects show what the electric locomotive is doing every day. As the vice-president of the last mentioned railway said 'electrification has made us forget that there is a continental divide.'

"We must remember that while a steam engine will only do the work for which it was designed, the electric motor is only a link between the central station and the load, and it will pull any train of any weight whatever that is provided with strong enough couplings. All that is necessary is to make the electric locomotive large enough and strong enough so that it will not burn out.

"The limitations of the steam locomotive are due to the fact that it is a mobile steam power plant of limited capacity; it is compelled to carry its own supply of coal and water; and, it is unable to take advantage of many of the economical refinements of the large modern stationary steam plant. On the other hand the electric locomotive has no such limitations; it merely acts as a connecting-link between efficient stationary steam or water power plants of unlimited capacities—because they may be extended indefinitely—and the train to which it is connected. The Electrical World summed up the situation some time ago when it said:—'Why continue to haul millions of tons of coal, for and by uneconomical steam locomotives, all over the country, and thus add more loads to the already over-burdened railways, when the power which they need so badly can be much more economically and efficiently transmitted to electric locomotives over a wire the size of one's little finger?'

Old Estimates Need Revision

"The continual increasing cost of coal and fuel oil will force railway managers to look more and more carefully into railway electrification. Estimates of a few years ago now need revision. Money may be hard to get but if, at times, fuel cannot be obtained at all some substitute must be obtained—if normal life is to be continued in northern latitudes.

"A representative of the National City Bank of New York, writing of the period after the war, referred to the stagnation which might ensue, in all the great industries then engaged in war work, as soon as peace is declared; the multitude of the people thus thrown out of work in addition to the men of the returning armies may create unbearable conditions unless suitable employment will have been arranged for them in advance; he referred to the economic advantages of railway electrification and was of opinion that this work might solve the whole question if soon taken up with vigor. The Minister of Public Works, Hon. F. B. Carvell, M.P., addressing the Ottawa Branch of the Engineering Institute of Canada a number of months ago, spoke of the necessity for conserving the energy of our water powers—instead of letting them run to waste—so that this great store of energy might be employed in assisting to build up our own country and to rebuild other countries when peace comes. How nicely these two ideas, water power development and railway electrification, would work together if properly carried out!

Generalization Always Dangerous

"With the view of securing something worthy of presentation to this important meeting I wrote to an eminent engineer, a man of international fame and recognized as an authority on railway electrification, requesting him to tell me his own views upon this subject. A specialist's opinion, in my opinion, is always very valuable. Here is a short extract from his interesting reply. He said:—'Generalization is always dangerous, especially in connection with electrification of railways, where so many factors such as the physical location, character of loads, the power situation, etc., come in to affect the decision if applied locally.' From this sober statement it may be seen that my correspondent is an engineer—not a politician. He proceeded as follows: '. . . with present equipment-prices the cost is absolutely prohibitive.' This opinion, let me point out, as in connection with the proposal to 'electrify everything.' Do not let it dampen our enthusiasm. Listen to this also and kindly keep it in mind; it is another extract from the address of C. W. Rice above referred to. He said:—'I think we can demonstrate that there is no other way known to us by which the railroad problem facing the country can be as quickly and as cheaply solved as by electrification.'

"While the recent fuel shortage and kindred questions have made us look to railway electrification for relief I feel such projects on a large scale can only follow or go hand in hand with water power plant development and co-operative operation of power plants. The location of a number of plants at different points—large water power plants and auxiliary steam plants—so situated and inter-connected that a failure at one plant, or the connections to it, will not jeopardize the others or completely cut off and isolate an important railway district is, in my opinion, an essential and a prime necessity in connection with any large railway electrification project.

"The 99 year power contract of the C. M. & St. P. Ry. above referred to is worthy of more than a moment's attention and consideration in this discussion. That railway has a contract with a power company which has a series of plants stretching across the whole country parallel to the railway. The railway owns its sub-stations and secondary lines but it is not concerned with the high tension lines or power plants of the power company. A reasonable and fair deal—a contract, in fact, which each party knows the other will respect—is the basis and the real reason for that great railway electrification. Neither party questions the other's integrity or financial soundness. One delivers the power it has undertaken to supply and the other uses it. The arrangement is ideal in its simplicity and entirely satisfactory to everybody concerned. It will, in my opinion, be necessary to have such attractive power conditions as those outlined above, backed by abundant supplies of power, in order to foster and encourage 'railway electrification' in this country.

"Railway electrification is a truly economic (financial and engineering) problem—a problem worthy of the best attention of the most highly trained and experienced specialists."

Discussion by W. G. Gordon

Regardless of grades, the electric locomotive can pull a train at the highest speed allowed by the alignment of the track, declared W. G. Gordon of the Canadian General Electric Co., who showed a large number of slides giving views of electric locomotives and statistics showing a saving in maintenance costs amounting to as much as 37.8%, and an increase of revenue ton miles hauled of 10.7%, or an actual saving of 44%. On one railroad 19.72 watt-hours per ton mile were required with the regenerative braking and 24 watt-hours without regenerative braking.