

and the safety movement has its place in the mind of the power-station draftsman of the first order no less than it has its proper hold upon the attention of the man responsible for the productive service.

#### MORE NOTES ON REGENERATIVE BRAKING

In the issue of the *ELECTRIC RAILWAY JOURNAL* for May 15 attention was directed by the editors to certain features of regenerative braking. The live character of the subject is indicated by the fact that even while the paper was in press A. H. Armstrong was explaining the application of the principles of regenerative braking in the Chicago, Milwaukee & St. Paul electrification at the A. S. M. E. meeting in Chicago. In last week's issue a letter from Frank J. Sprague, one of the pioneers in electric traction referred to in the last editorial, was printed. There were also articles describing the electric locomotive equipment of the Norfolk & Western and that under construction for the Chicago, Milwaukee & St. Paul Railway. This general revival of interest is, of course, due to the electrification of important divisions of these railways on both of which very heavy trains are to be braked.

There seems to be some confusion as to the advantages and disadvantages of regenerative braking, the point of view being determined more or less by the experience and interest of the person holding it, as well as upon the conditions under which it is applied. In one case it is principally the energy saving which counts, in another it may be the reduction in power house cost, in another ease of control and in a fourth reduction in risk of wheel breakage and brakeshoe saving, while in other cases complication in control equipment and increase in motor capacity appear to be of overwhelming disadvantage. It may therefore be worth while to summarize the situation briefly, merely touching upon the points developed in the last editorial.

Energy saving is an attractive proposition as is indicated in Mr. Armstrong's statement on page 1073 of last week's issue to the effect that, on a 2 per cent down-grade, 55 per cent of the up-grade power consumption can be restored to the line. The average saving, even on a system having considerable 2 per cent grade, is very much smaller than this. It is worth while, however, especially if the energy is purchased from a power transmission company, but the principal result is likely to be in the reduction in service charge in the case of purchased power or its equivalent power house investment cost where power is generated by the railway. In the latter case, as previously stated, the kw-hour element of the cost may be negligible due to excess of supply of water power. The conditions cited apply principally in electrifications where considerable density of traffic is involved. There are undoubtedly other circumstances under which the whole matter of energy saving may be of negligible moment.

The advantages of regeneration from braking considerations come principally in the reduction in risk of injury to the wheel flange or to the whole tire. While, as was pointed out in the editorial referred to, it may not

always be possible to demonstrate a direct money saving in brakeshoes, wheels and track sufficient to warrant the complication of regenerative braking, yet, during long periods of heavy mechanical braking the concentration of heat on wheel treads and flanges may produce serious results, due to internal stresses developed, and it is even possible that tires may be loosened and flanges broken. In this connection a former superintendent of motive power of a large steam railroad recently said that under these conditions of continued mechanical braking he had seen the paper centers of Pullman carwheels charred for a depth of 2 in. under the tires, indicating a violent overheating. This condition has undoubtedly been very influential in forcing the development of electrical regeneration.

The objections to regeneration are really not serious when conditions otherwise warrant its use. The induction motor is a natural generator when polyphase excitation is furnished, with or without the phase converter. Its constant-speed characteristics are not insuperably objectionable in the only class of service in which regeneration is practicable. The series motor can be made into a good generator by the plan suggested by Mr. Sprague, or its equivalent, without unwarranted complication. The General Electric Company has actually undertaken to build regenerating d.c. locomotives on a large scale. And the motor-heating item is not so serious either under mountain-grade conditions for this reason. Hauling heavy freight trains up long grades at slow speed involves a considerable time element, in some possible future electrification several hours. The motors have time to attain nearly steady temperature, which motors with forced ventilation do very quickly. This is evident from the data, given last week by Mr. Armstrong, showing that the motors for the C., M. & St. P. locomotive have a continuous rating only 12½ per cent less than the one-hour rating. The operating conditions here are radically different from those where intermittent load is carried by non-ventilated motors. Under the latter conditions, as was pointed out in the editorial four weeks ago, electric braking, regenerative or otherwise, means larger motors. If all the motors are used in braking, the load on them is less than the climbing load by twice the friction load, and the heating is more than proportionately less. Hence a motor that is not overloaded on an up-grade sufficiently long to bring it to steady temperature will not, by a large margin, be overloaded in holding the same train on a down-grade of the same percentage. It follows, then, that less than the total number of motors can be used in braking without overloading by the proportion which twice the train resistance bears to the up-grade load. On the Norfolk & Western, one-half the motors only are used on the down grades.

Whichever main advantage of regeneration, better braking or energy saving, weighs more in the minds of the officials responsible for the choice of electrification systems, they all agree that regeneration should be used when heavy grades are involved.