

defect. The brake is then applied at the summit of a grade, and kept on until the descent has been accomplished, any stops required in the interval being effected by means of the wheel-brake, the car being restarted if necessary by the use of power, the track-brake not being interfered with.

The great simplicity of the mechanical or hand-worked track-brake, and its complete independence of all other brakes, renders the combination of this brake with an effective wheel-brake one of the most reliable arrangements for the control of tram-cars on steep gradients.

Rheostatic brake.

(4.) That rheostatic braking, throwing, as it does, the work of retarding the car on to the motor-equipment, and controlling only the motor-driven wheels, is an undesirable arrangement for level or undulating districts, but with carefully designed motor-equipment of ample capacity constitutes a valuable auxiliary for use in descending long grades, such as are to be met with on mountain rail and tram ways.

Magnetic brake.

(5.) That the Newell electro-magnetic combined track and wheel brake is exceedingly effective as a brake, and in careful hands, and within certain speed-limits, is reliable. The necessity for avoiding the too rapid reduction of the resistance in circuit renders it, in the hands of a not absolutely cool motorman, liable to flashing-over, skidding, and failure, especially in the case of sudden emergency, when the motorman would probably put the controller-handle hard round, instead of dwelling on the intervening brake-notches.

The magnetic-brake windings form, when in use, a portion of the external circuit of a pair of powerful series generators, running in parallel; consequently it is imperative that in the design of these generators (the car-motors) the nature of this circuit should be considered.

The more satisfactory results obtained in Dunedin as compared with Wellington are probably largely due to the whole of the car-equipment at the former place having been supplied by the manufacturers of the brake, and the motors having been designed with a view to its use.

Limitation of effective speed a danger.

The limitation of speed at which this brake is effective constitutes a very real source of danger when steep gradients are worked, especially when "coasting" on some other form of brake is permitted. Should the brake in use fail, the lapse of only a few seconds will permit the car to attain a speed above that at which the magnetic brake will operate.

A car travelling at ten miles per hour down a grade of 1 in 8.77 will, on the removal of control, attain a speed of twenty miles per hour in $4\frac{1}{2}$ seconds, or down 1 in 12 in $6\frac{1}{2}$ seconds. It is thus possible for a car on which the magnetic brake is fitted, but not in use, to get completely out of hand before the danger is realised.

Skid-proof attachment.

The Westinghouse Company, who are the manufacturers of the magnetic brake, have introduced improvements intended to overcome the drawbacks mentioned. They have devised what they term a "skid-proof attachment," in which, on the current in the braking-circuit reaching a predetermined value, solenoid-controlled switches shunt the motor field-windings, and so further increase in excitation, voltage, and current is prevented. It is claimed by the manufacturers, and experiments in traffic appear to substantiate their claim, that this simple and easily applied device renders the brake absolutely skid-proof up to thirty-five miles per hour, no matter how suddenly it may be applied, all flashing-over and injury to the motor-equipment being prevented.

Mechanical attachment.

A second improvement consists in the addition of hand gear to the magnetic-brake rigging; this enables that brake to be applied altogether independently of the electrical equipment.

The application for "coasting" can be made by hand, all heating of the motors due to this work being avoided, and the magnetic action is still available for service or emergency stops.