

normal position of the commutating switch, it being turned to parallel only when the more or less infrequent call comes for high speed. This switch not being intended for operation when the car is in operation, is not provided with any provision for extinguishing the arc; if opened with current on the motors it would probably be destroyed.

There are several interesting peculiarities in connection with the series-parallel method of control, the reasons for which are not always apparent. One is that of wheel slipping, which is especially troublesome with single truck cars. If one of a pair of wheels start to slip, the motor in series, it will be seen that it is almost impossible to get reasonable traction from the car as long as the motors remain connected in this manner, because that motor which is running comparatively fast, due to its consequent high counter E.M.F., takes but little current. This in turn means that the other machine, being actuated by the same current, has but a small torque due to the little current flowing, and the grip of the slipping wheels being practically nil, the total tractive power of the car is but small. On the other hand, if the motors were in parallel, the one not slipping, due to its slow speed and consequent low counter E.M.F., would take a large current and therefore have that

much more tractive power. Wheel slippage is much more common on single than on double truck cars, because in the former it is comparatively easy to unbalance the distribution of weight, in the latter the relative length of the car past the trucks, or the overhang, as it is called, is much less, and consequently the position of the passengers has less influence. On the other hand, a single truck car, with the modern long rear platform, is frequently loaded down so as to take quite a large amount of weight off the front wheels; again, at starting, which is the time slipping is felt, the truck tends to go forward and the body to stay behind, the result is a tilting action also tending to decrease the weight on the front wheels. For this reason, and also because dirt or snow is encountered first by the front wheels and the rail more or less cleaned by them before the rear pair pass, single truck cars, when on straight track, usually slip most in the front wheels. On the other hand, when on curves the front flanges grip on the sides of the rail head, and also on the lip if a grooved section be used, the trailing pair riding comparatively free, so that the condition is reversed, the rear wheels being more likely to slip.

Another peculiar point is that, under a certain condition of trouble with the wiring or

controller, a car which normally gathers speed with each successive step of the controller, runs faster on some of the series or lower speed steps than on the first one or two of the parallel positions, this condition being that of a ground on the wiring of no. 1 motor between the point of its leaving the machine and entering the controller, and which, until the motors are not in series, virtually short circuits machine no. 2; consequently the latter is not in circuit until the controller is turned to the parallel position.

The foregoing applies to individual controllers, one or two per car, manually operated, the multiple unit or master control system involves various special features; it is not possible in the scope of this paper to do more than enumerate the broad principle, which is as follows:

Each car equipped for master control has mounted upon it its own motors, two or four in number, a main controller to handle them, a set of bus wires, extending from end to end of the car and connectable to those of the next car, for moving this controller, and one or two master controllers for energizing these bus wires. From the foregoing it follows that when the bus wires of two or more coupled cars are connected they can be energized throughout the whole length of the train, from

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