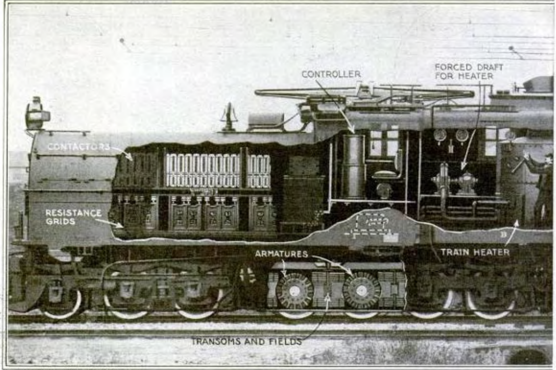


Like a trolley-car this huge electric locomotive, which hauls trains over the Cascade and the Rocky mountains on the Chicago, Milwaukee & St. Paul Railway, can be controlled from either end. Hence turntables are not required at division points

The electric locomotive needs no tender filled with fuel. It can run one thousand miles without overhauling; for there are no ashes to dump, no flues to clean, no boilers to inspect. Its horsepower is about 3500, so that it does the work of four steam locomotives

Over the Rockies

THE steam-locomotive boilers of the country generate, all told, 50,000,000 horsepower. One quarter of all the coal mined in the United States is thus consumed. This total horsepower is just about equal to the water-power that is going to waste. Hence, if water-power were used to operate railways, 150,000,000 tons of coal would be saved annually, and an army of mine and railroad workers would be released for other employment.

Despite these well known facts, the electrification of our railroads has been a slow process, due chiefly to the fact that the problem of substituting electricity for steam involves not merely the employment of another kind of locomotive, but the adoption of a fundamentally different method of train propulsion.

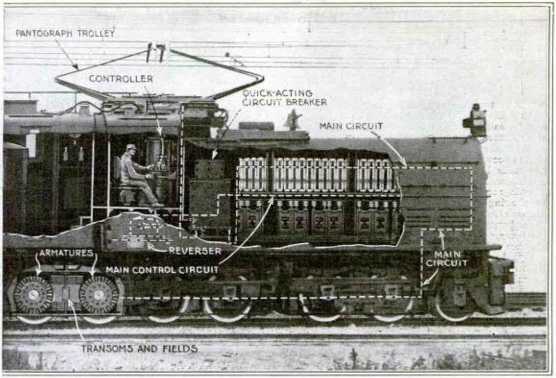
Railroad electrification has received an enormous impetus now that the Chicago, Milwaukee & St. Paul system has banished steam entirely from its Pacific coast division. The total electrified main-line trackage is 700 miles, so that the United States becomes the possessor of the longest electric railway in the world. The road extends from Harlowton, Montana, to the Pacific coast, crossing on its way two mighty mountain ranges, the Rockies and the Cascades.

Fifteen water-power stations make available a combined electric horsepower of 410,000, so that, in a sense, you are carried by a waterfall as you travel over the mountains.

Electric operation has reduced by twenty-two and one half per cent the number of trains and by twenty-four and one half per cent the average time per train. It has improved operating conditions, so that nearly thirty per cent more tonnage can be handled electrically in eighty per cent of the time formerly needed to handle the lesser tonnage by steam-engines. The capacity of the road has been thus increased about fifty per cent.

Of the locomotives that have made these marvels possible fifty-one were designed and built for the Chicago, Milwaukee & St. Paul railway by the General Electric Company. There are sixty-one of them all told, including passenger, freight, and switching engines. They have released for service no

In front of the engineer, at each end, is an "apparatus cab," filled with resistance coils, through which passes the 3000-volt current, controlled from the engineer's levers through solenoid switches. The front section, or "apparatus cab," is closed when the engine is running. If a man were thrown against the coils while the engine is rounding a curve, he might be killed. The central passage accommodates a man, who can make repairs when the locomotive is idle



It hauls a 960-ton, twelve-car passenger-train on a two per cent grade at twenty-five miles an hour; the steam locomotive would make only twelve miles. On the level, the electrically hauled train makes an average speed of sixty miles an hour

The over-all length of the locomotive is 76 feet, its total weight 260 tons. Between the leading 3-axle trucks at each end are two 8-wheel driving-trucks. The train hauled by the locomotive is heated not electrically but by steam from an oil-fired boiler

on a Waterfall

fewer than 162 steam-engines and have effected an annual saving of 300,000 tons of coal and of 40,000,000 gallons of fuel oil.

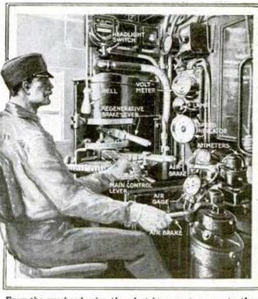
The electric locomotive takes its current from an overhead wire like a trolley-car, not with the usual pole and wheel, but with an ingenious double trolley, called a "pantograph" after the drafting instrument of the same name. The pantograph always insures perfect contact. The locomotive never "gets off the trolley."

Current at 3000 volts—the highest direct-current voltage employed in railway work anywhere—is taken from an overhead wire. But the huge electric locomotive must not be regarded as a magnified trolley-car. It embodies so many new ideas, both in railroading and electrical engineering, that it marks a new epoch in transportation and in locomotive building.

The low-tension currents used on a street-car (600 volts) can be handled directly by the "controller" of the motorman. But in the case of this 3000-volt current the controller in the engineer's compartment operates certain "banks" of electromagnetic switches (solenoid switches), and these in turn feed the current to the motors.

The electric locomotive returns power on the down grades. The speed slackens. The motors (not the brakes—for they are not needed) assert their control. The grade becomes steeper. As the engineer scans the dial before him, he sees the trembling pointer slowly reverse its motion—creep, point by point, in the opposite direction. The motors, now converted into generators, are giving back current to the power line! The air-brakes are used only to stop the train at stations and in emergencies.

"Regenerative braking," as it is called, is not electric braking. It is electric speed control. The motors on the down grade produce an electric current when the armatures are revolved, and the recovered current is restored either to the railway's power line or to the power company's transmission line. In the latter case, the restored current automatically sets back the power company's meters and credits the railway with the amount of the regenerated current. Electricity keeps its own books!



From the overhead wire the electric current passes to the engineer's control levers. A glimpse of the interior seems bewildering, with its ammeters, gages, and speed-indicators. Compared with the devices required to convey the 3000-volt direct current to the motors, the "controller" of an ordinary trolley-car is as a safety-pin to a watch for complexity. Yet, to the engineer who presides over the "solenoid switches," through which the current is relayed to the motors, all this is like reading a thermometer