the weight at this point, which reacted against soft material underlying it and the canal bottom, so that the soft material was pressed down at one point, pushed up at another, thus forming a ridge in the bottom of the canal. At any rate, this seems a reasonable explanation of this and similar occurrences. The same slide repeatedly produced the phenomenon of pushing up the bottom of the canal.

There are two great slides near Culebra, one on the western bank and the other on the eastern bank. These two move toward each other and produce a double effect. They affect a length of canal channel amounting to more than half a mile. Both are north of the two ridges known as Gold Hill and Contractor's Hill, which face each other across the canal. The two slides comprise an enormous total of slipping material. The estimate runs as high as nine million cubic yards. The limits of the movement are located at considerable distances back from the line of the canal. On the eastern side the break goes back to a line 1,500 feet distant from the canal axis. On the western side the break is nearly as far back. The movements extend far up the slopes—in the one case to a level 265 feet above the canal surface and in the other to a level 500 feet above. The material is being taken away at the bottom.

Cucaracha Slide may be counted on to be active at almost any time slides should be working. If the canal had been constructed as a sea-level waterway, these slides would probably have been still more active than they now are, because of the greater opportunities with an added 85 feet of depth to Culebra Cut.

It seems doubtful whether the movements of earth and rock at Panama are in general due to the steepness of the slopes to either side of the canal. Such an influence may, indeed, play its part. The controlling cause appears rather to be tilted, underlying rock. The mass on the rock moves down, however it may be piled up. It seems rather curious, though, that the canal should have been located just where two such tilted rock surfaces intersect each other—that is, just above the bottom of a hidden rock valley.—Reprinted from Popular Science.

ELECTRIFICATION OF MOUNTAIN DIVISION OF THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

The Chicago, Milwaukee & St. Paul Railroad Company is making trial spins of the first of its huge new electric locomotives that are to haul freight and passenger trains over the mountain divisions from Harlowton, Mont., to Avery, Idaho. This event heralds the placing in operation in January of the most ambitious electrification project in the history of American railroading. A trolley system is to be inaugurated and steam traction entirely abandoned over a 440-mile stretch of mountain country.

Including the various yards and spur tracks that have been electrified, the "Milwaukee road" will have 640 miles of track operating under the electrical system when the work now nearing completion is ready for use.

The improved system of handling mountain traffic has required three years for its installation and its cost will be about $15,000,000. Figures show that there will be an immense saving annually and, in fact, it is primarily in the interests of economical operation that the work has been undertaken.

Operating officials of all transcontinental railroads have their eyes directed toward the long stretch of trolley-wired road that crosses the great continental divide, including the Belt Mountain Range, the Rockies and the Bitter Root mountains. With the suc-

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cess of the St. Paul's initial effort, there is said to be reason to expect the launching of similar enterprises by other transcontinental lines.

The first of the locomotives, of which 50 will be required for the mountain divisions, has just been placed on exhibition in Chicago, Milwaukee, Minneapolis and St. Paul. It does not resemble the steam locomotive, but is more like two mail cars coupled together so far as first impressions are concerned, and weighs 260 tons. It is constructed to haul 2,500-ton loads over 1 per cent grades at an average speed of 16 miles an hour, exercising 3,440 horsepower. The same locomotive geared for varying speeds will haul 800-ton passenger trains at a speed of 60 miles an hour.

These are the first electrical locomotives ever constructed with direct current motors, and they are designed to carry a potential of 3,000 volts. The engines are 112 feet, 8 inches long and are designed to save track wear and tear by minimizing the vertical and horizontal blows of drivers through the use of a separate motor, twin-geared to each of eight pairs of driving wheels. The drivers are spaced at 10-feet intervals. They are 52 inches in diameter and are equalized in pairs on each side, so that each of the four driving-wheel trucks is independent. The cab extends nearly the full length of the locomotive.

There are 14 electrical substations on the route between Harlowton and Avery, each of which, with its equipment, cost $160,000. Two attractive bungalows have been erected adjoining each of the substations, for the housing of substation employes. The substations contain high-tension electrical transformers which receive their power from connecting power company lines at a pressure of 100,000 volts alternating current and turn it out to the feed lines of the system in a 3,000-volt direct current. The cost of the installation complete will foot up about $34,000 a mile, including the price of 50 locomotives at $100,000 each. There are 29,000 poles supporting the overhead wire structures and 6,500 tons of copper have been used in the wire installation.

The electrification of the mountain divisions undoubtedly constitutes one of the greatest advances of modern railway operation and it is expected to lead to important future developments in steam railway electrification, as there is no doubt among the engineers, that the large saving anticipated will be fully realized in operation. For instance, the hauling of coal for use in the mountains will be eliminated. The electrical locomotive requires neither coal nor water. It carries no tender and has no boilers. It does away with the heavy item of fuel trains and makes way for paying freight trains. It will run over two or even three ordinary railway divisions without injury and at a uniform rate of speed. It will operate with the highest efficiency in the coldest weather. These locomotives will run 1,000 miles or more without inspection. The steam locomotives at present in use require looking over every 125 miles and, moreover, while waiting trains they consume 80 per cent of the coal used when hauling a heavy train. The new engines are always ready to start, they use no power when they are at a standstill and when braking heavy trains down a mountain side they return about 30 per cent of the power used in uphill work to the wires, this becoming available for helping the next train up grade.

Two types of electrical locomotives already have been contracted for and a third type for switching is under consideration. The two types now being turned out for freight and passenger traffic differ only in that the passenger

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engine is equipped for varying speeds and has heating and lighting apparatus.

The Chicago, Milwaukee & St. Paul Railway will receive its power from the Montana Power Company for the entire 440 miles of main line electrification. This power company covers a large part of Montana and Idaho with a network of wires which collects and transmits power from great waterpower developments. The Hebegon reservoirs, where 418,000 acre feet of waterpower is stored, supplies in turn the several installations on the Madison and Missouri rivers, so that the same storage capacity is used many times. The horsepower developed by these rivers is transmitted over wires supported by steel towers to the substations, which transform it in the manner already shown and feed it to the locomotives.

When the road goes under electrical operation the train dispatcher will become also the power dispatcher, because, knowing the location of all trains, he will be able to minimize "peak" loads. With the power under his hand, so to speak, he will be able, by holding a freight train for a brief time at the foot of a grade, to prevent an excessive peak in energy consumption. At first glance this plan appears to complicate the duties of the train dispatcher, but his work, it is held, will be easier than now, all things considered.

Under electrical propulsion a train is subject to none of the delays inseparable from operation with steam. It can be made to move at the precise speed calculated, so that meeting and passing points may be figured to the minute. Moreover, the electric locomotive will be ready for instant service at terminals as soon as a new crew is put aboard.

The 200 miles of sidings that have been electrified consist largely of tracks in freight yards at Harlowton, Avery, Three Forks, Deer Lodge and Alberton. An important feature of the system will be the doing away with intermediate yards, for it is the intention to run the electric locomotives over two of the present engine stretches, or about 220 miles, changing crews midway. The stations containing the transformers are about 32 miles apart. Beginning at Two Dot on the east, they are located at Summit, Josephine, Eustis, Piedmont, Janney, Morrell, Gold Creek, Ravenna, Primrose, Tarkio, Drexel, East Portal and Avery. They are either two or three unit stations, in accordance with the conditions governing in each instance, such as grades. The high-tension transformers in these stations weigh 28 tons each and are the largest ever constructed. The buildings are erected of brick, on concrete foundations, with concrete roofs supported on steel girders, which afford a foundation for overhead high-voltage installations. Each building is equipped with a crane of sufficient capacity to move the heaviest part of the substation apparatus.

Perhaps one of the most remarkable features of the installation is the electric-braking control to hold back trains on long descending grades and to return power to the line. When the train drops down a grade the locomotive's motors are immediately converted into electric generators, which begin producing current and returning it to the line.

The air brakes will be required only in emergency, so that in addition to the economy in power consumption there is a marked advantage over ordinary friction braking, because of the reduced wear and tear on track, wheels and brakeshoes.—Steam Shovel and Dredge.

England's Trade Union congress has 3,000,000 affiliated members.

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