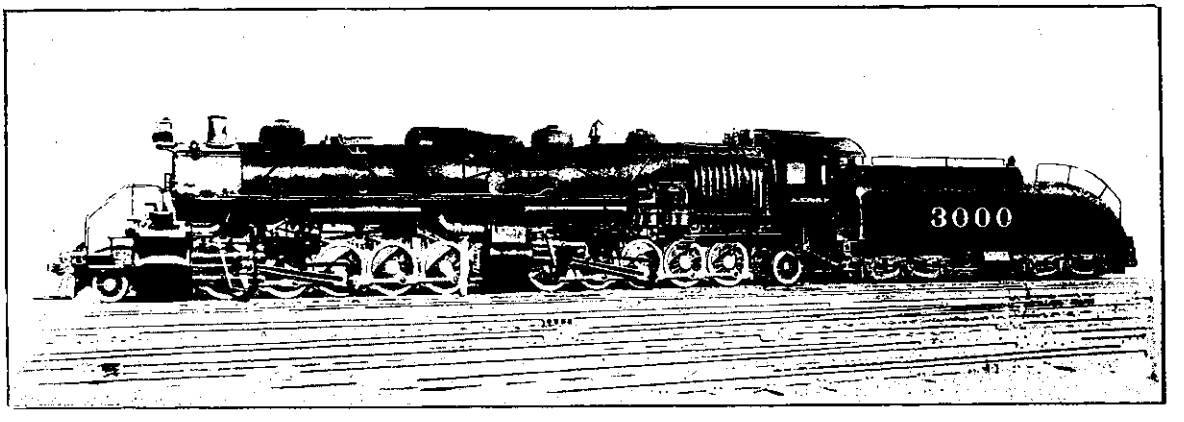
feet to the mile. These grades make steam haulage difficult for long, heavy trains, especially in winter. To-day electric locomotives not only haul heavier trains more smoothly over these grades, but travel at much greater speed than when steam was used. And weather makes little difference to them.

The electric power is delivered from the power houses to the sub-stations in 100,000 volt alternating current. At the sub-stations this is converted into a 3,000 volt direct current and in that form it goes to the locomotives. This reduction is accomplished as follows: The 100,000 volt alternating current is received through oil-switches, is conveyed to the high tension distributor, made up of three lines of copper tubings. From the current distributor the current is conducted through other oil switches to the transformers, entering at 100,000 volts and emerging at 2,300 volts—still alternating current. The next step is to convert to a direct current. The current passes through oil-switches and the motor generator sets and provides the power to operate



This is the largest Locomotive in the World, and belongs to the Atchison, Topeka & Santa Fe Railroad Co. The white line against the 3rd. Driving Wheel represents the height of an ordinary man. Length 121 feet 7 inches. Weight 587 tons. Drawbar pull 110,000. Driving Wheels 5 feet. Cost £8,800.

them. These motors are of the 60-cycle synchronous type which means that the current changes its direction sixty times each second. Each set generates a 1,500 or 2,000 volt direct current and the two generators employed, being permanently converted in series, delivers a combined direct current of 3,000 volts, which is the highest voltage direct current that has been adopted for railway work in the world. By way of comparison—the direct current used on electric tramways is only 550 volts. After passing through the control switches the 3,000 volt current is conducted to the feeder and trolley lines and, through the pantagraph—as the trolley frame is called—to the motors of the locomotive.

The overhead equipment presents some unusual features. To eliminate any likelihood of the trolley wire breaking and falling to the earth, a strong steel cable, called a "catenary" runs just above the trolley wire and parallel to it all the way. From this cable the trolley wire is suspended by hangers at short intervals. Single poles, each bearing a bracket support the catenary and it supports the trolley wire at curves and in station yards, "cross span" construction is used. The trolley wires of which there are two, are of 4/0 size, and are specially made for high voltage electrical power. They are the largest diameter copper wire employed for this purpose. The so-called twin conductor trolley wire has been installed after careful investigation and experiment. This form of construction permits the collection of heavy current through the twin contact of the pantagraph with the two trolley wires, and assures sparkless collection under all speeds.

Under normal conditions, 42 immense electric locomotives are required to haul freight and passenger trains over the electrified mountain districts of this railway. These locomotives cost about £22,400 each. They weigh 284 tons each and will haul 3,200 ton loads up a 1 per cent. grade at an average speed of 16 miles an hour. Similar locomotives, geared for greater speed will haul 800 ton passenger trains over the same stretch of road at a speed of 25 miles an hour and on a level run, at 60 miles an hour. To appreciate the tractive strength of these electric Goliaths, let it be said that the present day Mallet-steam locomotive has a tractive force of 76,200 pounds while these electric locomotives have a tractive power of 85,000 pounds. They measure 112ft. 8 in. in length and are driven by separate motors twin-geared to each of eight pairs of driving wheels. The cab extends over nearly the whole length of the locomotive.

There is a sermon for New Zealanders in this achievement of an American railway company. The cost of electrifying a similar stretch of line in New Zealand, moreover, would not be as expensive. Train loads are much lighter here. Where an American passenger train load runs to 800 tons, the express train in New Zealand rarely exceeds 300 tons, and freight train loads are likewise much less. This would mean that smaller locomotives, lighter lines, and lower power would be required. And the initial cost would be the heaviest. What the exact saving in running charges will be, have yet to be ascertained: the electrical operation of the Chicago, Milwaukee and St. Paul mountain section, began last year. But it is certain—was certain, in fact, before the work was undertaken, that the saving would be considerable.