level tracks, the remaining ones drawing no current, the load will be increased a little more than three fold, not counting the extra energy required to start, and unless the regulation be prompt they will start slowly.

The ratio between maximum load and mean load is a factor which enters largely into the determination of the prime mover to be employed, both as to size and kind. Taking the same example, the maximum load would be somewhere about 100 h. p. at car axle, while the mean might be 35 h. p., depending, of course, on local circumstances, a ratio of 3 to 1; as the total number of cars operated increases, the variations due to a few cars being thrown on or off become relatively smaller, the load tends to even itself and become steadier, and the ratio between maximum and minimum may approach unity. It thus appears that the duty required of a prime mover on a small road is more severe than that of a plant of considerable size, a fact which may at first sight seem somewhat surprising. The prime mover employed ought, therefore, to be one capable of very sensitive and quick regulation, and which, while able to develop the power required for maximum load, should work at its best efficiency at about the average load, and further, this efficiency figure should not vary much for small changes of load.

Of all the different sources of power only two, viz., steam power and water power, are made use of to any extent in electric railway work, and of the prime movers of these two classes the steam engine best fulfils the required conditions. In point of operation its two great advantages are:

1. Its regulation, which, though far from perfect, is vastly superior to that of any water wheel.

2. Its range of power; a steam engine can much exceed its rated output for a short period, while a turbine can never develop more than a certain fixed quantity. For this reason a water power plant will usually show greater friction losses.

The style of engine best employed, whether high speed or slow speed, will be determined by the sizes of the power units and the ratio of maximum load to mean. It is a matter on which there exists much difference of opinion. High speed engines regulate quicker and they do not require intermediate pulleys to bring up speed; for these reasons they are mostly used where the power of the station is subdivided into a number of smaller units, or where the total output is comparatively small. If each engine be directly belted or directly coupled to one or two dynamos, the losses due to counter-shafting are entirely eliminated, and if we install several sets of units more than are actually necessary the liability of a breakdown is reduced to a minimum. Slow speed engines, on the other hand, better utilize the expansive power of steam and operate more economically, especially where they are used compound condensing and where the units are large. The usual method is to connect all the engines to one countershaft, from which in turn all the dynamos are driven, thus enabling any set of dynamos to be driven from any engine, a consideration of some advantage, but we must now also allow for the extra losses due to shafting and we cannot provide so well for a breakdown.

Of the steam generating plant we need not make special mention.

The objections to the use of turbines as prime movers are, as already stated, their slow regulation, and the fact that since they cannot exceed their rated output they must often be worked at a low efficiency. The power they exert does not vary strictly in accordance with that required on the line, since their regulation is not only slow, but is also hindered by a factor which may be called the time lag, and which is due to the slow action of the governors; when the external load is suddenly changed the momentum of the station machinery is largely drawn on, and by the time the governor action is felt, its speed may be so much accelerated or reduced that an extra shifting of the gates is needed to restore normal speed. In the tests of the Neversink Mountain Railway made during the summers of 1891 and 1892, under the direction of Messrs. H. S. Hering and W. S. Aldrich, the general working of turbines as prime movers for railway service was well shown. The existence of the time lag was clearly demonstrated. In one instance the electric horse-power dropped abruptly to zero, then rose again to a maximum in fifteen seconds, while the turbine horse-power showed a corresponding minimum 35 seconds later and a maximum 45 seconds later; during forty-four minutes consecutive running a maximum difference of 140 horse-power was shown between turbine shaft and dynamo terminals, and a minimum of only 12 horse-power. The speed variations were found to be great and sharp, showing at the turbine shaft a maximum of 104 and a minimum of 78 revolutions per minute during thirteen minutes The voltage keeping pace with the changes of speed, rose to a maximum of 550 and fell to a minimum of 260 during the same time; the load during this period was about 45 per cent. of the capacity of the station, and the gate varied from 41 per cent. to 8.5 per cent. of full gate. These fluctuations are of course extreme examples. Two vertical turbines were used at that time, coupled to the same shaft, but individually governed; the governors did not always act simultaneously, and it happened occasionally that one turbine was driving the other.

In the case of accumulator roads the required conditions of the generating plant are materially changed. The load is now a constant quantity approximately equal to the mean power required to operate the cars, and the rated output of the generating station need therefore only be large enough to accommodate this load. In a paper lately presented before the American Institute of Electrical Engineers, by Charles E. Emery, Ph.D., the author compares the working expense of engines for constant and variable loads. Assuming that for the latter case the power plant is required to be fifty per cent. larger and that a somewhat greater allowance must be made for depreciation on the machinery account, other conditions being the same, he estimates that for a case where the total cost per horse power per year amounts to $52.66 for the variable load, it will only be $47.27 for the constant load, both reckoned for 365 days of 20 hours each. A water power is admirably adapted for storage battery roads. The turbines can be operated at their best efficiency, and, if the source of power be inconveniently situated, we can easily transmit current to the car barns or any other convenient charging station.

As to the question of cost of steam power or water power we beg to refer to the very exhaustive paper by Dr. Emery already mentioned.

TRANSMITTING PLANT.

In all electric railways of the first type the transmitting plant is of the same form, viz., that of a trolley line with its mains and feeders all radiating from the