public service commissions the carriers have been attacked by the opposition. Yet the necessity of a depreciation reserve is fundamental to good finance, finance that protects the public not only in keeping up service, but in providing for its improvements from time to time. The Supreme Court of the United States has expressed itself plainly (Knoxville case, 1909) on this point, holding that it is not only the right of the company to make such depreciation provision out of current income, but that it is its duty. The Public Service Commission of the Second District of New York in the Niagara Light, Heat & Power case declared that to provide for depreciation by borrowing was wholly unsound and added to its discussion of this subject the observation that "an end to such rottenness of method finally comes in a dilapidated and useless plant."

We speak of these things here only because of the common and unfair criticism leveled at the carriers, who because they point out the necessity of providing for depreciation out of current income have been accused of attempting to "rob" the public. To the voice of the New York State commissions and of the Supreme Court of the United States is now added the voice of the President of the United States to answer this unsound and unfair criticism.

Long-Distance Transmission in Heavy Electric Traction

PRACTICE on the Chicago, Milwaukee & St. Paul with regard to power transmission directs attention to the rather remarkable manner in which the limitations of load factor—that bane of electric operation with thin traffic—are being nullified by extension of intervals between power stations. On the St. Paul's most recent project, that of the electrification between Othello and Tacoma, power is to be furnished from a network of high-tension lines at the western end, while a 100,000-volt line from Long Lake on the Spokane River extends across country for about 100 miles before reaching the eastern end near Othello. From this point the railway's transmission line along the right-of-way supplies substations for practically 150 miles further until the power network west of the Cascade Mountains is reached.

Much the same thing is in evidence at the western end of the company's original 440-mile electrification. The eastern part of this section of the railway approximates the form of a great circular arc which begins just west of the main range of the Rockies and swings first southeast and then northeast across the Big Belt range out onto the plains of western Montana. Approximately at the center from which this arc is struck with a 90-mile radius are the Great Falls developments. These form the main source of power for the eastern end of the electrification, although they, together with a network of lines from smaller stations, also supply industrial loads in the cities of Butte and Anaconda, respectively 130 miles and 160 miles away. At the western end of this electric zone in Idaho the factor of industrial loads is materially less, and dependence for continuity of supply is placed upon a single hydroelectric station at Thompson's Falls near the extreme western end of the division. In consequence, a short circuit on the railway's right-of-way transmission line near its western end would mean that distribution must be effected all the way from Great Falls to the Idaho line. This maximum transmission distance, similarly to the case of the electrification now in progress, is roughly 250 miles.

No doubt the satisfactory record of the existing installation, notwithstanding the length of line involved, has been due in part to the excellent working conditions existing throughout the Rocky Mountain region, whose extreme dryness is reported even to permit the occasional use of impregnated wood for high-tension insulating purposes. Yet the possibility of 250-mile intervals between power stations has thus at least been made very definite.

What this means to heavy electric traction may be exemplified by assuming, for the sake of illustration, a level road with a 250-mile spacing for the points of power supply. Neglecting passenger service, it may be said that each freight train will require about eighteen hours to pass through the zone served by a power station, and if only two trains per day are operated in each direction the demand on the station, assuming reasonably even train spacing, cannot be less than the load imposed by two trains nor more than that imposed by four. Neglecting starts and waits, this would give in theory a load factor of 75 per cent. If four trains were operated each way daily, the minimum number of trains at one time in a power station zone would be six and the maximum eight, giving in theory a load factor of 87 per cent.

If, now, the length of zone should have been only half that assumed above, or 125 miles, the minimum number of trains served by a power station would be zero, in case two trains each way were operated daily and the spacing each way was therefore twelve hours. The maximum load would be that of two trains, and it is conceivable that this load might last only nine hours, or the time required for one train to pass through the zone, in case the trains met midway. The theoretical load factor would then be only 37 per cent, as opposed to 75 per cent with the longer zone, while if four trains each way per day were operated the figure would be 75 per cent, as opposed to 87 per cent with a power station spacing of 250 miles.

Of course, these figures for load factors are impossible of attainment in practice, because in the first place the heavy drafts of energy for starting trains have been neglected, and in the second place no time has been allowed for trains to stop en route. In addition, daily load factors only have been considered, although seasonal variations in traffic as great as 50 per cent are not uncommon. However, when relative values of the figures are considered there is clearly shown the vital necessity for keeping intervals between power stations at a maximum, especially when traffic is thin.