and the passenger trains crawl up at from 10 to 20 miles per hour. These grades always form the "neck of the bottle," and limit the amount of traffic that can be handled by an entire road. Even if it cost a great deal more to operate such grades by electricity, it would pay large dividends on the investment by increasing the capacity of the entire road.

Some one may wish to inquire how this electrification will increase the capacity of the entire road. It is effected by increasing the speed both on the up-grade and the down-grade, and by the greater reliability of service. On electrified divisions, the heaviest freight trains of 2,000 to 3,000 tons trailing load can readily be hauled up a grade of 2 per cent. by electric locomotives at speeds of 15 to 20 miles per hour, while the speed with steam locomotives would be usually from 5 to 8 miles per hour. This is possible because the electric locomotive has the power house back of it, but does not have to haul it up the hill. At speeds of 15 to 20 miles per hour it will have all the weight on drivers, and usually only as much as is necessary for adhesion. This being the case it can haul the trains at 20 miles per hour just as efficiently as at 10 miles per hour.

The steam engine, on the other hand, must haul its entire power plant up with it, and consequently, the higher the speed at which it operates up a grade, the less load it can pull, so that the economical speed is very soon reached. This appears to be 10 miles per hour, or less, for a 2 per cent. grade with heavy freight trains.

As the electric locomotive can take a train up a heavy grade much faster on account of its greater power, so it can take a train down the grade at a much higher speed because the motors can hold the train from accelerating by regenerating power and putting it back into the line to help some other train up the grade, or by using it up in a resistance on the locomotive. This saves the brake shoes for use in stopping the train only and thereby eliminates a great deal of the danger of taking trains down grades. Incidentally, the saving in power may be as much as 25 per cent., and the saving in brake shoes and general wear and tear of the equipment will also amount to a considerable item.

We, therefore, have the greatest confidence in inviting the attention of railroad officials to the electrification of their mountain grades, for if the traffic is at all congested there, electrification is bound not only to improve the service, but to give a very substantial return on the investment. The electrification work that has already been done is enough to show that electric locomotives can handle any kind of service from the heaviest slow speed freight service to the fastest of heavy passenger work.

The next question is, when will the great lengths of line between the terminals, and connecting terminals and grades, be electrified? That is something that will depend entirely upon the territory through which the road passes and the population of the terminals. I regard it as entirely possible, if not highly probable, that within the next ten years one can travel from Boston to Washington by fast trains over the New York, New Haven & Hartford and the Pennsylvania Railroads, behind electric locomotives. The New Haven is now operating all trains between New York and Stamford by electricity and is rapidly extending its electrfication to New Haven. It is also working at the Boston end of the line between Boston and Providence, besides having its Harlem River division and its immense freight classification yards operated exclusively by electricity.

The Pennsylvania has the vast network of lines on Long Island, besides the New York terminal, operated by electricity. It is now working on the Philadelphia terminal which must be electrified in order to increase its capacity. The bad tunnel at Baltimore must be electrified and the terminal at Washington must soon follow. With these city terminals all electrified, it is a foregone conclusion that the whole distance from New York to Washington will be equipped, as it would be impractical to have any breaks in the service; aside from this consideration, however, I believe that the population is so large as to make it a paying investment anyway.

Similar results will follow in other sections of the country, but more slowly and only as it is found by the railroads to pay a good return on the investment. That is the only thing that will make general electrification possible. No matter how desirable it would be to the public the railroads cannot electrify until it can be made to pay, either at present rates for freight and passenger service or by the undesirable alternative of higher rates for the improved service.

Just a word to people who are for compelling the railroads to electrify their terminals in large cities. Don't do it. The railroads in this country are fully alive to the advantages of the electrification for such situations; or if not now, they soon will be, for they are all studying the subject with the greatest care. I believe the matter can be safely left in their hands for a few years, at least, until the necessary plans can be made and all the innumerable details connected with the adoption of the new motive power are fully worked out. Without this careful consideration, the plans will be only half baked, and vast sums of money will be wasted and the full advantages of electrification will not be secured. When the railways of any city decide to electrify the terminals, they should work out a harmonious plan that will include all of them, so that power may be furnished from a common power house, and all equipment be interchangeable.

Electrification is bound to come on a large part of the railroads sooner or later in any case, but the steam railways should not be forced into it until they have had ample time to mature their plans.

There are many, many advantages from it, some of which are only beginning to be understood and some of which have never had the correct value. When all have been shown by experience to have certain definite values, and the best way to secure the advantages has been thoroughly worked out, the railroads will need no compulsion.

Following the foregoing paper, Mr. Storer presented a number of lantern slides showing various types of electric locomotives and discussed their salient features. Prominent among the list were the locomotives of the New York, New Haven & Hartford, the Pennsylvania, the St. Clair tunnel, the Boston & Maine and several European types. In general, the types were shown to exhibit the various forms of connections between the motors and the driving wheels, and to show the disposition of the weight, and the arrangement of wheels as affecting the riding qualities of the locomotive. The different forms of transmission between motors and driving wheels were distributed as follows:

1st. Gearing motors directly to the axles as on the ordinary street car. Among the locomotives of this type shown was one experimental locomotive for the Pennsylvania Railroad, the St. Clair tunnel and the Spokane & Inland, all being suitable for service at speeds below 30 miles per hour.

Operating with this type of locomotive with heavy motors mounted directly on the axle, is confined to low speeds because of the effect upon the track on account of the dead weight on the axle and the low centre of gravity.

2nd. The locomotive having the motors mounted on a hollow shaft surrounding the axle; these hollow shafts or quills being connected to the wheels through the springs.