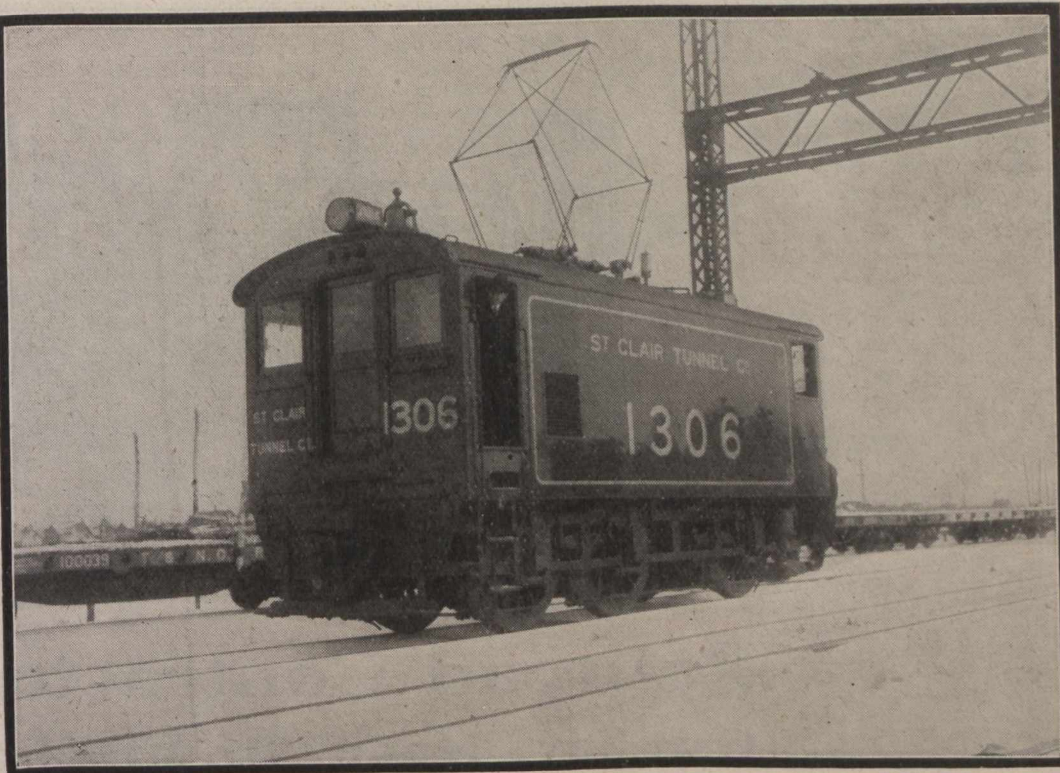

ELECTRIC LOCOMOTIVE USED IN THE G.T.R. ST. CLAIR TUNNEL.

125 tons. All the weight is on the drivers. The locomotive has a nominal rating of 1,500 h.p. It can haul a 1,000 ton train up a 2% grade at 10 miles an hour. It can give a draw bar pull of 80,000 lbs. before slipping its wheels.

The 15 cycle experimental single phase locomotive (double header) made for the Pennsylvania Railway weighs 140 tons. One hundred tons of this weight are on the drivers. The locomotive has a continuous capacity of 9,200 lbs. draw bar pull at 61 miles an hour (1,500 h.p.), and one hour capacity 14,700 lbs. draw bar pull at 51 miles an hour (2,000 h.p.), a maximum draw bar pull of 48,000 lbs. and maximum capacity of 3,000 h.p. The three phase locomotive of the Italian State Railways weighs 95 tons. All of the weight is on the drivers. The nominal rating of the locomotive is 2,250 h.p. The maximum draw bar pull is 47,500 lbs. Mr. Armstrong says that the great claim for recognition of the electric locomotive lies in its great horse power output, its ability to carry full tractive effort, or slip its wheels at speeds two or three times greater than can be done with any steam locomotive yet built. Four motor equipments can be built to deliver a draw bar pull of 56,800 lbs. at 23 miles an hour (3,500 h.p.). Two of these trucks combined into one engine could give a draw bar pull of 113,600 lbs. at speed of 23 miles an hour (7,000 h.p.). The various independent locomotive units can be articulated to give practically unlimited power. The several articulated units can be handled by multiple control as a single unit.

The electric locomotive is a simpler machine than the steam locomotive. The motors are simpler than the steam engines they replace. The motor auxiliary apparatus consists of current collecting and current controlling devices. These accessories are insignificant in comparison with the generating plant of the steam locomotive. The manipulation of these electrical accessories is concentrated in a master controller.

The electric locomotive is more economical than the steam locomotive. Assuming that the steam locomotive consumes 4 lbs. of coal per h.p. hour, and that the modern central station can deliver a h.p. hour to the dynamo for 2 lbs. of coal, and assuming further that the addition of an electrical system to the central station only adds 5% to the total losses, it follows that the electric locomotive can deliver a h.p. hour to the draw bar with approximately half the coal consumption of the steam locomotive doing the same work. Moreover the electric locomotive consumes no power when idle, nor when coasting. Not only is the electric locomotive more economical of power than the steam locomotive but its maintenance is less. Taking the locomotive mileage for 1907 as 1,300,000,000 miles, and cost of repairs and renewals as $104,000,000.00, the locomotive maintenance was 8c. per locomotive mile. The figure for 1904 was 8.1c. According to such authorities as Messrs. Stillwell and Armstrong, the maintenance of the electric locomotive need not exceed 5c. per locomotive mile. This is an instance of an important contract that contains the guarantee that the maintenance of the electric equipment of the locomotive shall not exceed 4c. per locomotive mile.

Admitting that the electric locomotive is more powerful, simpler, and more economical than the steam locomotive, it is true that it is helpless in case of failure of power supply. A complete failure of the power system could tie up the electric zone. However, the possibility of such a contingency is remote. The reliability of the power station and the reliability of the transmission system is based on 20 years' experience. Each power station has reserve units, and the various power stations are inter-connected. The transmission lines are in duplicate. Repairs can be rapidly effected. Traffic can be shunted around local trouble as in steam service. The reserve units in the power stations, the interconnection of stations, and the duplication of the transmission systems practically eliminate the hazard of a complete stoppage of traffic due to failure of power. A destruction of the track due to such causes as wrecks and floods would carry away the third rail, and the third rail would interfere with repairs. However, the overhead trolley would practically render the power supply system independent of the permanent way.

In the discussion of the subject of electrification it is frequently assumed that a steam locomotive costs $10 per h.p., and the electrical equipment $100 per h.p. ($15 for the electric locomotive and $85 for the power station and the transmission system.) But coal chutes, water tanks, cinder pits, boiler shops, and a part of the machine shops should be charged up to the steam locomotive. They are as much a part of the steam locomotive equipment as the power house and transmission system are a part of the electric locomotive equipment. These steam accessories would have to be scrapped in a completely electrified division. It is not any more necessary for the railway company to own the power plant than it is for it to own a coal mine. There will be power companies as there are coal companies. It will be possible to buy power delivered to the trolley just as it is possible to buy coal delivered to the sidings. As to the cost of a h.p. hour at the draw bar of an electric locomotive compared with the cost of a h.p. hour at the draw bar of a steam locomotive, for equal work done the cost of current is greater than the cost of locomotive coal. However, according to Mr. Armstrong, the operating expense for 1,000 ton miles up and down a 2% grade is $1.39 for the steam locomotive and $1.02 for the electric locomotive. The cost in the case of the steam locomotive is made up of coal, crew, maintenance. In the case of the electric locomotive it is made up of current, crew, maintenance.

Assuming the cost of operation of the electric locomotive to be less than the cost of operation of steam locomotive, a given h.p. of electric locomotive will do more work in a year than an equal h.p. of steam locomotive. The electric locomotive is in service more hours per day than the steam locomotive. It is in service more days per year than the steam locomotive. There is no turning, coaling, watering, cleaning of fires, boiler washing. In the aggregate the steam locomotive makes 80 miles a day. The freight locomotive will average 6 hours a day on the road. Selected figures show better results. According to the American Master Mechanics' Report, 1905, on 2,620 locomotives distributed among 22 roads, the engines averaged 20% of their time in the roundhouse, 33% of their time awaiting orders to go on the road and 47% of their time actually on the road. The more common assumption is that the time in the roundhouse exceeds 30%. This is instanced in the following quotation from the Railway Age: "If we consider the average run of a steam locomotive consumes 10 hours, and that a 5-hour lay over is customary at the roundhouse, we see that one-third of the time is not available for earning dividends, and the motive power of the railroad is practically reduced by 33%—exclusive of engines that are in the shop." The increased availability of the electric locomotive, coupled with its high speed and heavy tractive effort characteristics, mean that the electric locomotive can handle more ton miles per year than an equal horse power of steam locomotive can handle. Messrs. Stillwell and Putnam believe that the ratio of electric locomotives to steam locomotives for a given service will not exceed 2 to 3, and will probably approximate 1 to 2.

Taking the normal steam service on a 2% grade to be 500 ton trains at 10 miles an hour, it is a simple matter to replace the steam locomotives with electric locomotives that can haul a 1,000 ton train up a 2%