

of those towns, which are operated by continuous current at 550 volts. The system adopted, therefore, is to use continuous currents, at 990 volts in the open country, and at 550 volts in the towns.

#### *Simplon Tunnel.*

The traffic through this tunnel is worked by electric locomotives operated on the three-phase alternating-current system at pressure of 3,300 volts, the current being supplied from two water-power generating-stations, one near each end of the tunnel.

#### *Electric Traction on the New York Central.*

What is commonly called the Electric Zone on the New York Central comprises at present the line from the Grand Central Station to Wakefield, on the Harlem Division, a distance of thirteen miles, and from Mott Haven to Kingsbridge, on the main line, four miles, making a total of seventeen miles. The Electric Zone will eventually be extended on the main line to South Croton, and on the Harlem to North White Plains, and when this is done there will be fifty-two miles under electric traction. The track-mileage, including yard-tracks, now amounts to eighty-five miles, but when the extension of the electric system is completed there will be 292 miles in all. The rails weigh 100 lb. per yard.

The power-house is at Port Morris, and at that point electricity is generated as an alternating current at 11,000 volts pressure, and the current is carried to four substations, where the alternating three-phase current is transformed to direct current at 666 volts, which is supplied to the third rail in that form for use by the electric locomotives.

At each substation there is an auxiliary battery equipment by which it is intended to supply current in case of any serious derangement taking place at the central power-station.

In addition to the electric locomotives for through train service the company has 125 all-steel multiple-unit motor-cars for suburban service, each with a normal capacity of 400-horse power, and weighing each about 53 tons. There are fifty-five all-steel multiple-unit trailer cars for suburban work, each weighing about 41 tons. Six all-steel multiple-unit motor combined baggage and express cars, each of 400-horse power capacity, complete the equipment, which makes in all 221 vehicles for exclusively electric operation.

The signal system will require the use of alternating current for track circuits, while the propulsion system, by which the locomotives and motor-cars are driven, is direct-current.

#### *The Electrification of the Hammersmith and City (Joint Great Western and Metropolitan) Railway.*

The joint advisory committee appointed by the two companies to determine the system to be used on the circle recommended the adoption of the three-phase alternating-current traction. This decision was supported by the Metropolitan Railway; but the Metropolitan District Company, acting under American influence, advocated a direct-current system, three-phase transmission being used to substations, where the current would be changed to continuous. In 1901 the dispute came before Parliament, who referred the question to a special tribunal, to report to the Board of Trade which of the two systems was to be used. The arbitrator was the Hon. Alfred Lyttelton, K.C., M.P., late Secretary of State for the Colonies. A great mass of evidence, expert and otherwise, was heard, which indirectly must have been of great benefit to the electrical world in general. Subsequently Mr. Lyttelton presented his report, recommending the adoption of the continuous-current system, on the ground that it had been well tried, whereas the Ganz system was only in an experimental stage. The Board of Trade, acting on this report, decided that the continuous-current system should be used in the Inner Circle and lines in connection.

The engines are of a forced-lubrication high-speed type, developing 1,080 brake horse-power each normal load, and 1,400 brake horse-power at maximum load, and are coupled to eight three-phase generators, each developing 750 kw. normal load at 6,300 to 6,600 volts, and capable of a 15-per-cent. overload for one hour.

There are three substations, located at convenient points of distribution on the system. At these the alternating current is reduced in pressure from 6,600 volts three-phase, converted into 600 volts direct current, and fed by low-tension cables into the collector rails on the railway.

Twenty trains have been built for the new service by an outside firm. Each train consists of six coaches, two being motor-cars and four trailers, and is capable of seating 320 passengers.

The type adopted is similar to that adopted on the Inner Circle, and is designed for a schedule speed of sixteen miles an hour, including stops.

#### *Electrification of Sixty-seven Miles of Railway, Italy.*

High-tension three-phase railway with cascade motors (Ganz system).

Trains are made up of old rolling-stock plus the new motor-cars and new goods-locomotives.

Goods-locomotive weighs 46 tons, and is capable of starting a 270-ton load on an up grade of 1 in 90, or of drawing 450 tons at eighteen miles per hour uniform speed on same grade.

Total maximum horse-power of four motors in each locomotive is 600. The four motors in each motor-coach are in two cascade pairs, and at half-speed they together can exert 300-horse power. Other locomotives have been put on line to draw express trains of 250 tons at forty-four miles per hour, and goods-trains of 400 tons at twenty-two miles per hour.

The energy is brought from the central generating-station along the line as three-phase current at 20,000 volts and 15 per second frequency, is transformed at substations without rotary converters to 3,000-volt three-phase current, collected from trolley-wires, and led direct to motors.

Power is obtained from turbines driven by water from a river. Turbines develop 7,500 normal and 10,000 maximum horse-power.