Seven main units, each of 2,200 h.p., under the normal head of 94 feet, constitute the power installation. Each unit consists of a single reaction turbine, made by Riva, Monneret & Co., of Milan, and a 1,500 kw. three-phase alternator by Brown, Boveri & Co., of Baden, directly connected, on horizontal shaft, at 180 r.p.m. The turbine runners are "American" type, having inward or radial admission, with register gates and axial discharge. The governors, shown in Fig. 2, are operated automatically by water pressure from direct acting pumps, and give close

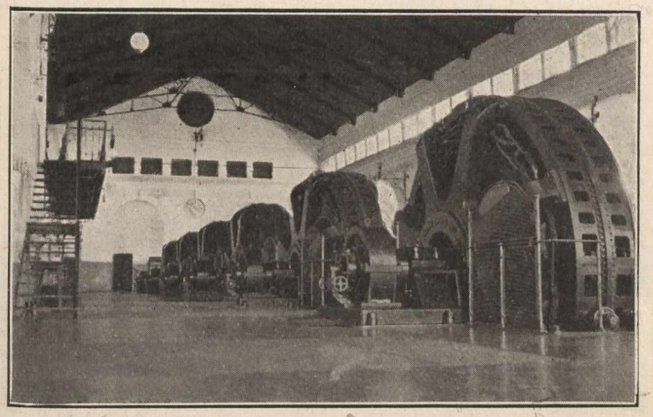

Fig. 3.—Paderno: Interior of Generating Station.

regulation. The generators are wound for 14,000 volts at 42 cycles, and work through the switchboard to the transmission directly, without transformers. In the days when this electrical equipment was installed the high generating tension was a new departure, but there never has been trouble from such cause; and, indeed, the paralleling of this with the steam station at Milan and with other hydraulic plants is frequently accomplished without incident. Fig. 3 is an interior view of the station, showing generators and switchboard gallery.

The transmission lines of the Paderno plant have become noteworthy in electrical engineering, as they were the first in Europe using metallic poles with high tension. All the fears then expressed have proven groundless, and this line, traversing a region where storms are violent, has been remarkably free from troubles. In the light of transmission practice of the present day, however, with tensions three and four times that of Paderno, much that has been learned from this pioneer European work is now eclipsed by American practice. The line towers, with a roadway crossing "cradle," are shown in Fig. 4. The insulators used, though frequently illustrated, still remain a standard, and may be of added interest herein. (See Fig. 5.) The main line to Milan, 25 miles long, is in duplicate, carrying six circuits on two lines of towers nine feet apart, and spaced about 35 feet high above ground, and are set in concrete. Railroad crossings are elaborate, consisting of veritable structural steel bridges, very substantial, but very unsightly.

As before noted, this company owns and operates the city and suburban electric railways and lighting systems, and a visitor to Milan cannot but be struck by the admirable modern methods everywhere in operation, especially in the street railway. In 1904 the company had some 100 miles of track, with 425 cars; also 2,500 arc and 190,000 incandescent lamps. In motors for general use in and around Milan they sold about 21,000 h.p. to 3,600 motors. The prices obtained are approximately as follows: In Milan, depending on use, amount and distance from a minimum of 2 cents to a maximum of 8 cents per kilowatt hour for the use of 1,000 hours or less per year; for large powers, for, say, 6,000 hours per year, the price is as low as 1 cent per kw. hour. The price of steam coal in Milan is about $7 per ton.

The Vizzola Plant, Ticino River.

In a similar manner to the Adda River, the Ticino drains Lake Maggiore, another of the beautiful Italian lakes, and in its course to the River Po is rich in valuable water-power, which is being gradually developed. The Vizzola plant is only about ten miles from the lake, and is situated on the north side of the valley, in such a manner as to have an intake common with that of a navigation and irrigation canal, on the banks of which the station is situated.

This plant differs from Paderno in that it supplies many independent towns and works widely separated from each other. These works consist mainly of silk, cotton, and fabric mills, which had previously been operated by steam, or low-head direct hydraulic installations. The generating station is situated 30 miles north-west of Milan by railroad and road, but the main transmission lines, which form a network in the surrounding cities, notably Gallarate, Legnano, Busto Arsizio, and Saronno, vary in length from 10 to 30 miles. The total output is about 20,000 h.p.

The common head canal is about 3¾ miles long, winding along the edge of the valley until arriving at a deep cut near the station, where it separates into three outlets, one to the power station, a middle course to a series of three locks down to the Ticino River at tail-race level, and a third following the valley for navigation.

That portion of water required for the power station, amounting to about 2,200 cubic feet per second normal, is conveyed by means of an aqueduct to an elevated forebay above the station, whence by inclined penstocks it is led in the usual manner to the turbines. The elevated concrete aqueduct and forebay, or receiving basin, constitutes the principal feature of this installation. As shown in Fig. 7,

Fig. 4.—Paderno: Transmission Line, showing a Roadway Crossing.

the aqueduct is a massive structure, a monolith of concrete, about 700 feet long, passing over a former depression, and carried on arches of 16 feet span, 36 inches thick at crown. The waterway is 22 feet wide and 12 feet deep, of trapezoidal section, having sides on a batter of 1:4, and the surface of water is about 35 feet above the graded ground level. The whole structure is supported on a pile foundation; this fact, together with the feature of unequal expansion in the aqueduct and adjoining forebay, a total length of 1,000 feet, involved special design to secure tightness and stability, and the subject was consequently most care-