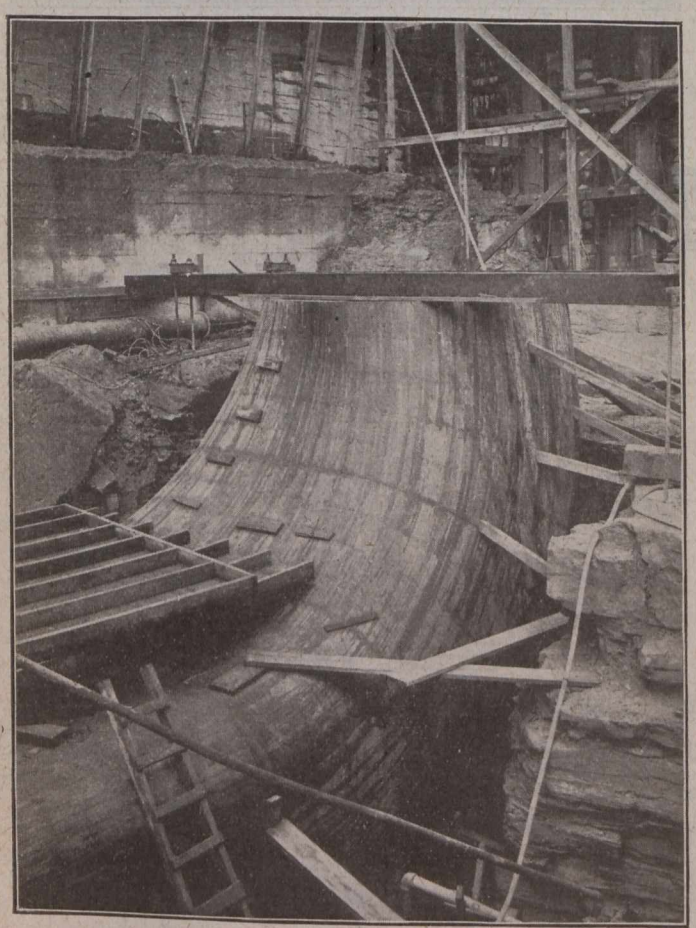
The portions of the straight sections of the distributor to which the bell-mouthed entrances are attached, were first assembled and bolted together in the shop. Upon this portion of the distributor was erected a timber frame made up of ribs cut to the proper curves of the mouth-pieces. Beaver board cut to the approximate size of the plates was then carefully fitted to the frame and matched-marked so as to obtain a pattern for the steel plate. The ½-inch steel plates were cut to their required shape from the beaver board pattern, after which they were rolled and forged to the required curvature. These plates were then fitted and bolted together on the timber frame to form the finished mouth-piece. As the structure was too large to ship riveted up, it was matched-marked and shipped knocked down to the site of the work at Niagara Falls.

Penstocks Nos. 15 and 16 deliver the water to the two new turbines in the power house. These penstocks are 216.2 feet in length. They drop vertically 48.3 feet, then turn through a 45-degree elbow for 99-feet tangent to another 45-degree elbow, and from the lower elbow run out to the turbines in a horizontal plane. Each penstock ends in a supply pipe with two taper connections bolted to the spiral casings of the turbines. At the end of the supply pipe is located a 36-inch pressure regulator, which is directly connected to the turbine governor. Each penstock has a 16-inch drain discharging into the draft tube.

The steel plate used in the construction of the penstocks varies in thickness from ⅜ inch at the upper end to 13/16 inch at the lower end. The penstocks were designed for a

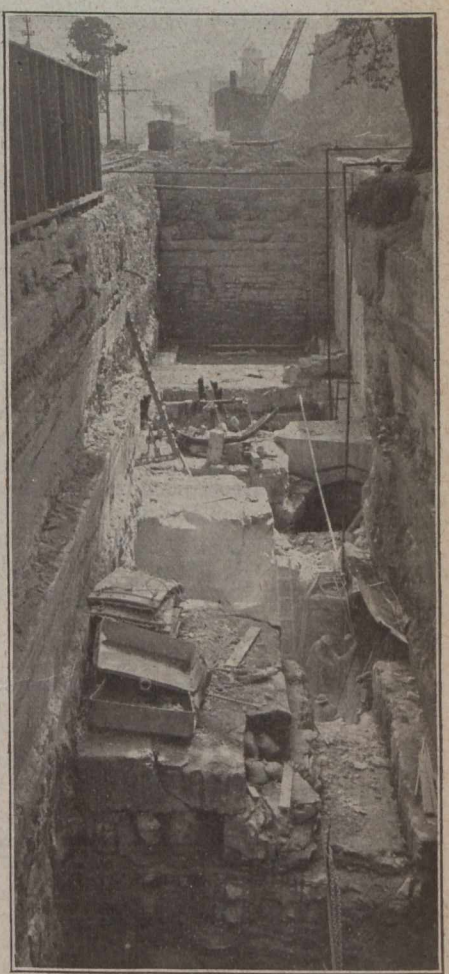


No. 15 Draft Tube Forms in Position, Ready for Concreting

pressure equal to 150 feet head of water at the upper end, increasing to 320 feet at the lower end at entrance to the turbines. Allowance for the pressure rise due to a turbine gate closure time of three seconds, with relief valve closed, has been included in the pressure limit given above. The types of joints used on the longitudinal seams for ⅜-inch and 7/16-inch plate were triple riveted lap, and for 9/16-inch plate and thicker, triple riveted butt, and on the girth seams, single riveted lap.

Unit stresses of 15,000 lbs. per sq. inch in tension, 10,000 lbs. per sq. inch in single shear and 20,000 lbs. per sq. inch in compression were used in designing the penstock. On top of this an allowance was made in the thickness of the plate to take care of corrosive and erosive action.

From the distributor trench to the power house the excavation for the two penstocks was entirely in tunnel and consisted in each case of a vertical, an inclined, and a horizontal section. The excavation for the vertical shaft, with the exception of a few feet at the lower end, was through Niagara limestone, while the inclined and horizontal sections are through shale and limestone.



Excavation for Distributor and Valve Chamber

The space between the outside of the penstock and the rock is filled up with a lean concrete which holds the penstock in position and protects the outside from corrosion. All the plates for the penstock were shipped to the site knocked down, with one shop coat of paint.

The water wheels, built by the S. Morgan Smith Co., are double runner, central discharge turbines with spiral casings, running at 187.5 revolutions per minute and delivering 20,000 horse power under 180 feet head.

The draft tubes are moulded in the concrete foundation of the power house, changing from a circular shape in a horizontal plane to rectangular shape in a vertical plane, and reducing the high velocity of the water at point of outlet from the runner to a velocity of four feet per second at point of outlet to the tail bay. The gates are operated by vertical servo-motors, which are in turn controlled by 60,000-foot pound actuators. These actuators are mounted on the gallery above the turbines and are equipped with distance speed controllers, hydraulic hand controllers, gate limiting device, over-speed, shut-down device, manual speed adjuster, gate-opening indicator and tachometer. The centrifugal elements are of the leaf spring type mounted directly on centrally located vertical speed shafts supported on double race ball bearings and projecting downwards centrally through the actuators to a position below the gallery floor, where they connect to a gear and belt drive off an extension of the main turbine shaft. Helical gear rotary pumps, delivering 62.5 gal. per minute against 200 lbs. pressure at 187.5 revolutions per minute, furnish the pressure oil. These pumps are equipped with unloading valves of such design that when the pressure is up to normal the unloading valves open, and the pumps discharge directly into the sump tanks at atmospheric pressure. The sump tanks are each of 350 gallons capacity and are provided with the necessary screens for cleaning the discharged oil before it is returned to the system.