THE "BENNINGTON" DISASTER.

The history of the United States navy does not furnish an instance of sudden disaster that appeals so directly to our sympathies as the recent tragedy on the United States gunboat "Bennington;" for although the explosion on the "Maine" in Havana harbor resulted in a greater loss of life, it was known that the ship was engaged on a mission that might end in actual war conditions, and there was, therefore, a proportionate sense of risk attached to it. In the present case, however, the trim little gunboat was about to start on a peaceful mission, and the thought of disaster, and disaster of such an appalling magnitude, was far from the thoughts of any one of the ship's company.

The "Bennington" is a two-masted schooner built by N. F. Palmer & Co., Chester, Pa., in 1890. She is of 1,664 tons displacement and on trial made 17½ knots, with 3,436 horse-power. She carries six 6-inch breech-loading guns, four 6-pounders, four 1-pounders, and two Colts. She is known as an unarmored steel gunboat, her protective deck being only ⅜ of an inch in thickness. She cost originally $490,000, and she carries a complement of eleven officers and 176 men.

At the time of the accident, the "Bennington" was lying in San Diego harbor, and in obedience to orders just received from the Navy Department at Washington, to sail that morning for Port Harford to meet the monitor "Wyoming" and convoy her to San Francisco, she had steam up and was in readiness for departure. Suddenly, without, as far as is known, any preliminary warning whatever, the starboard forward boiler exploded, the top of the lower furnace giving way, and the rush of steam drove the boiler against the boiler astern, which was also forced astern and exploded. As practically the whole complement of the ship was aboard and the majority of the crew were located amidships and forward, the casualty list was a shockingly large one, nearly half a hundred men being killed outright, and a large number of others so seriously wounded that the ultimate number of deaths will probably be not far short of seventy-five. The wrecking of the interior, breaking of valves, etc., caused the vessel to sink, although she was located in such shallow water that she can probably easily be salved.

In view of the fact that Secretary Bonaparte, of the navy, has appointed a special board to make a very thorough investigation, it will be idle and premature to enter into speculations as to where the blame for this shocking disaster is to be laid. It is stated that within the last ten months the Scotch boilers of the "Bennington" have been inspected at least three times, and repairs have been executed which were considered sufficient to keep them in service for a few months longer until new boilers could be given her. If the repairs were adequate there is nothing unusual in this course. At the same time there seems to be little doubt that this ship, like many others in our navy, was suffering from a scarcity of officers, particularly in the engineering department.

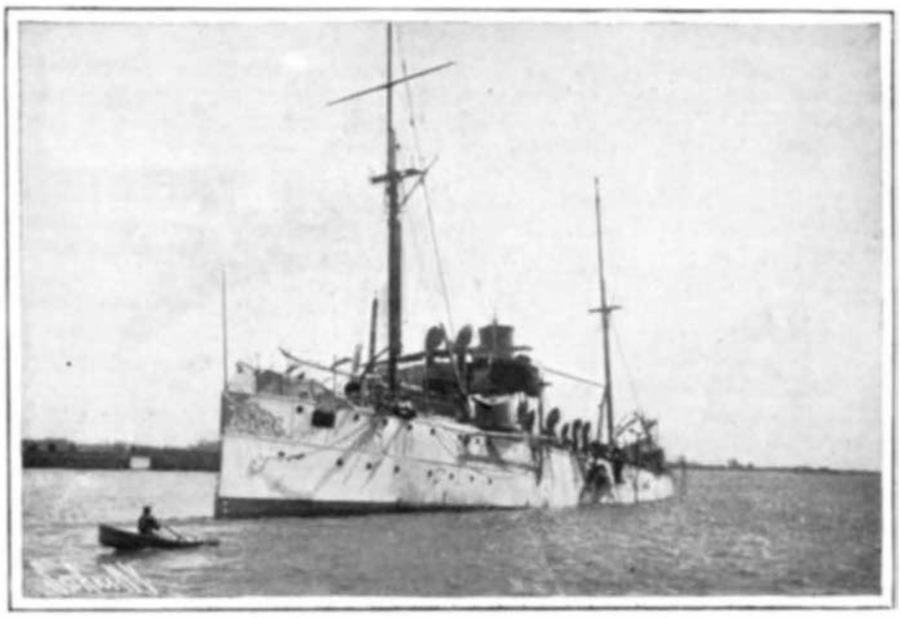
The following discussion of the type of furnace and boiler used on the "Bennington" and its possible bearing on the disaster is from the pen of Mr. Egbert P. Watson, one of the former editors of the Scientific American:

In order to understand the accident clearly a few words of explanation are necessary. The furnaces of marine boilers of the Scotch type are tubes usually four feet in diameter in large boilers and three-quarters of one inch thick. They are corrugated diametrically with about three-inch corrugations for the entire length, and riveted at both ends to the shell of the boiler proper. They are not braced or stayed in any portion, the form, a perfect circle, not requiring it. They have, however, an enormous load to withstand which they are amply equal to under normal conditions. These are that perfectly clean water be fed to them wholly free from any trace of oil or grease. Where these find their way into the boiler, collapse is imminent sooner or later. Twenty years ago, more or less, an epidemic of collapsing furnaces prevailed in the merchant marine all over the seas, and for a long time the cause of it was not discovered. It was at first attributed to scale on the furnace crowns, but examination of injured furnaces did not reveal any scale; they were as clean as when first put in; but an English engineer, Mr. Vivian Lewis, who was consulted on the subject, found that it was oil coming over in the feed water that did the mischief.

This conclusion was at first combatted by the engineers in charge until it was proven absolutely by Mr. Lewis's analysis and experiments; he asserted that the free oil which contaminated the feed floated around on the surface and caught the scum, of which there is more or less in all boilers; this soon rendered it heavier than water, so that it sank to the bottom or was carried in various directions by the circulation, becoming attached to metallic surfaces, which it happened to strike, with the tenacity of a plaster. This oily mud was a perfect non-conductor of heat and effectually prevented access of water to the plates, so that it was only a question of a short time before they became red-hot and gave way under pressure, forming pockets or bags in the shells of stationary boilers, and deforming marine boiler furnaces. Mr. Lewis proved his contention by making a paste of the deposit in the bottoms of boilers and lining sheet metal pans with it, through which he speedily burned holes even when they were full of water.

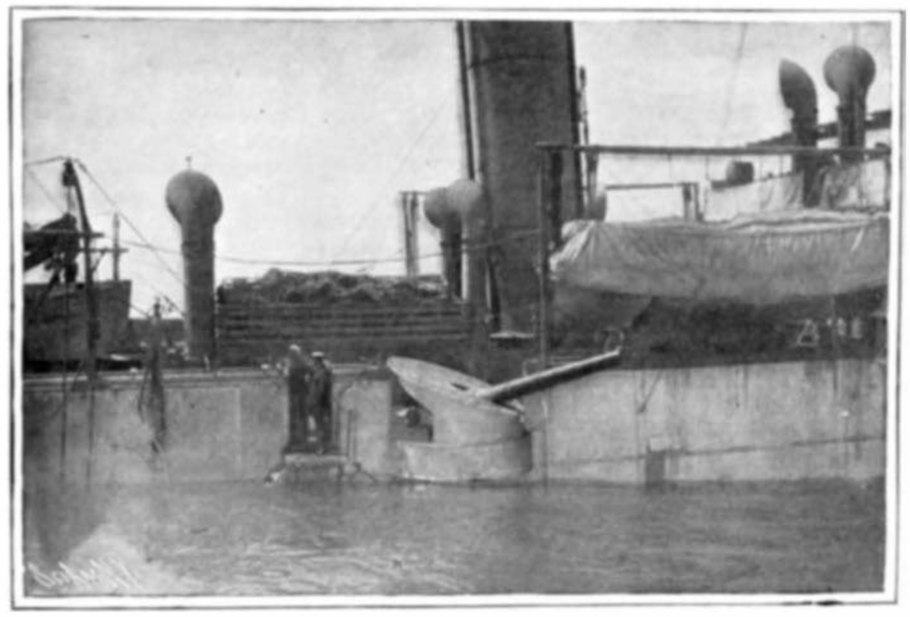
The cause of the trouble having been found it was easy to prescribe the cure, which was not to admit oily feed water to steam boilers. This seems very simple as it reads, but it was not so easy to carry out in daily service. Engineers had become so accustomed to using quantities of oil in the cylinders to prevent scoring them that it had become second nature; but imperative orders and one or two collapses, which might easily have resulted seriously, convinced the rank and file that radical changes were necessary. Filters were introduced and more carefully attended to; they were not unknown before, but were so seldom cleaned that they were practically useless, and not until they were looked after by every watch did the disasters here discussed measurably cease. It is very rare now to hear of marine boiler furnaces coming down; when they do it is very certain that remissness occurs in the management. The course generally, or sometimes followed is to jack them back into place. A hot fire is made under the injury and the sheets forced back into place, suitable cast-iron blocks fitted to the corrugations being employed to avoid distorting them. This does not always answer, because it is difficult to bring the furnace to a true circle, in which case it is apt to be deflected again even when no oil is present.

Comment has been made by the daily press upon the alleged neglect to inspect the boilers of the "Bennington" by the Bureau of Steamboat Inspection, but naval vessels are exempt from examination by it, all govern-



Displacement, 1,664 tons. **Speed,** 17.5 knots. **Complement,** 187 officers and men.

Gunboat "Bennington" After the Explosion.

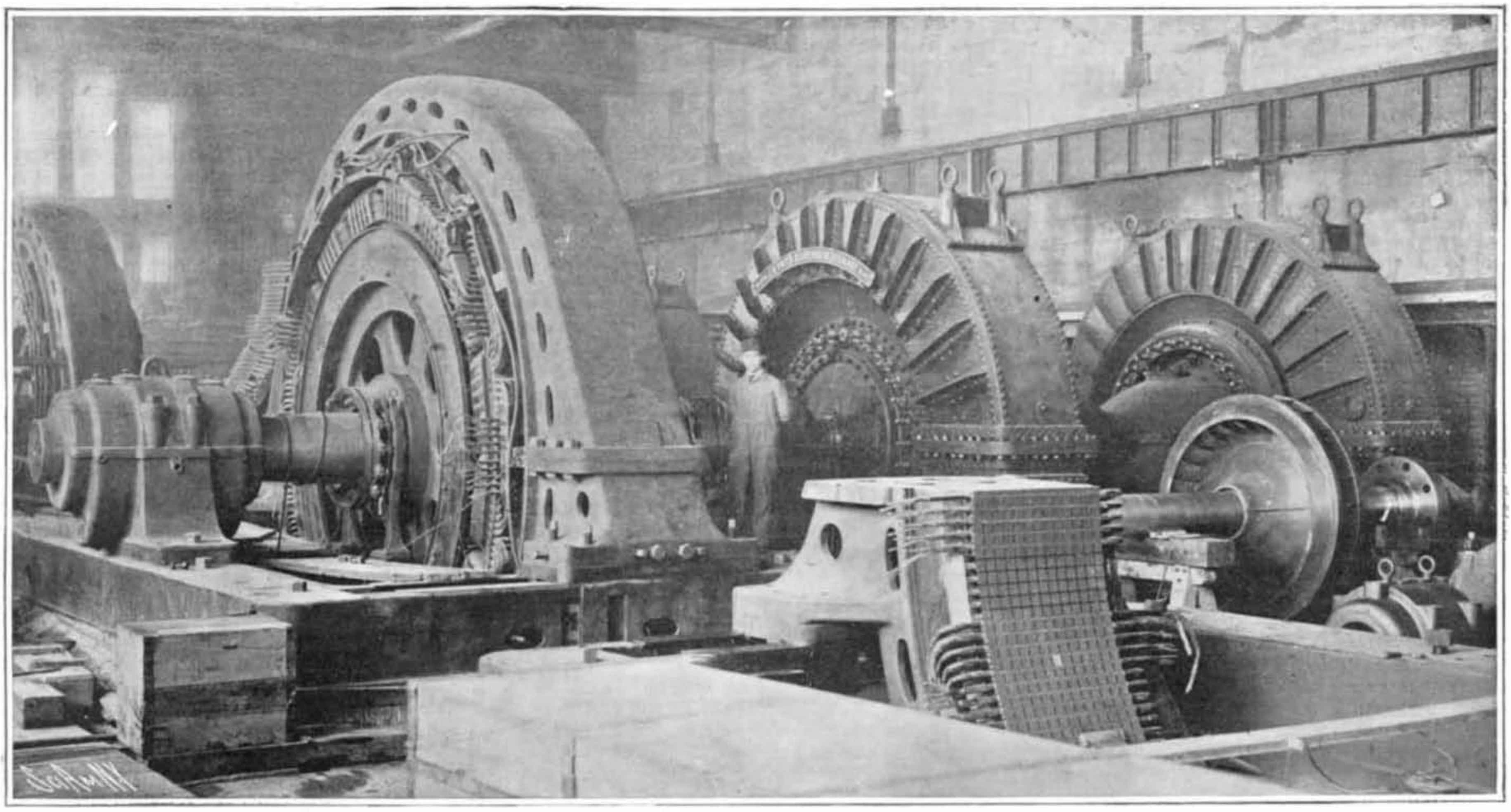


Starboard Side Amidships; the Vessel Sunk to the Bottom, After Explosion. Note 6-inch Midship Gun.

View on Starboard Deck Which Was Awash After the "Bennington" Rested on the Bottom.

Burial of the Victims in the Military Cemetery at Fort Rosencrans.

THE "BENNINGTON" DISASTER.

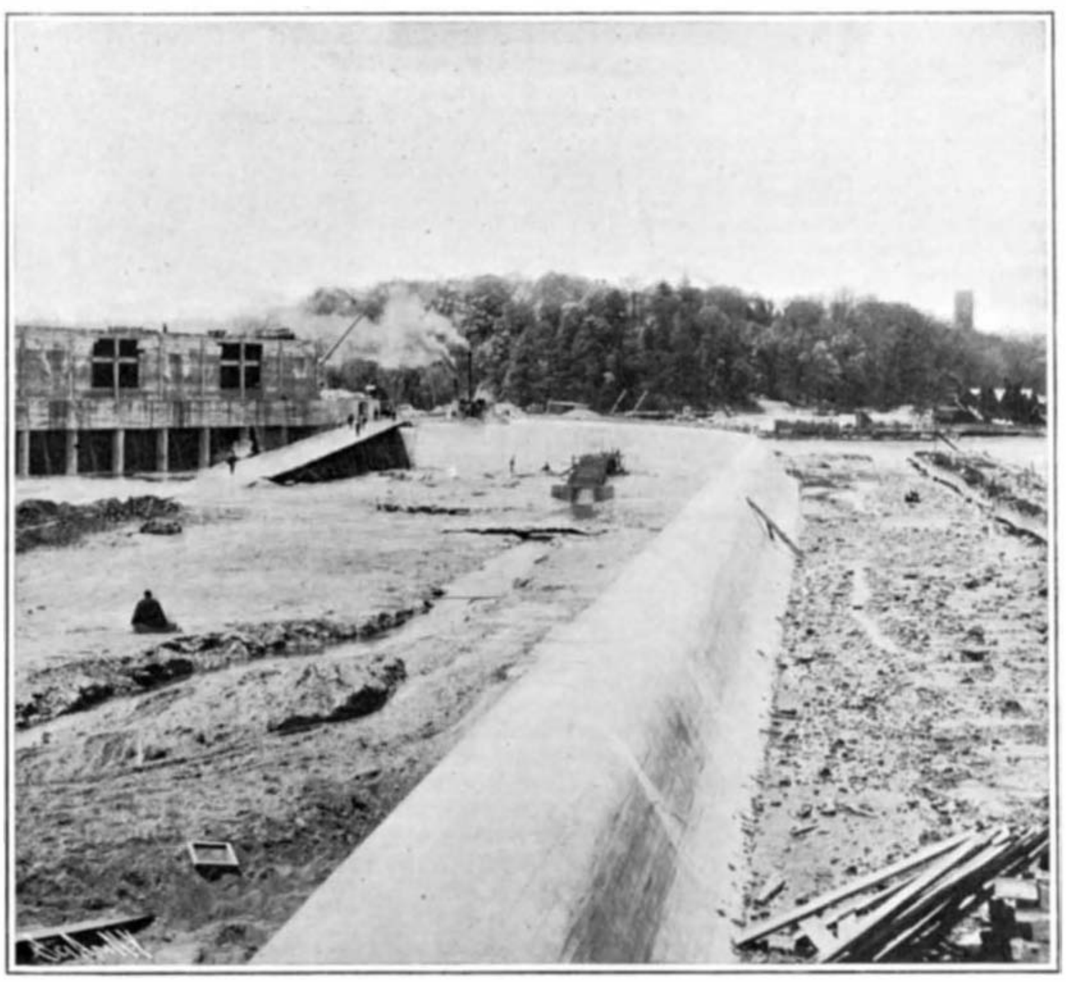


The station will be 1,000 feet long, and will contain 18 of these units, developing a total of 180,000 horse-power.

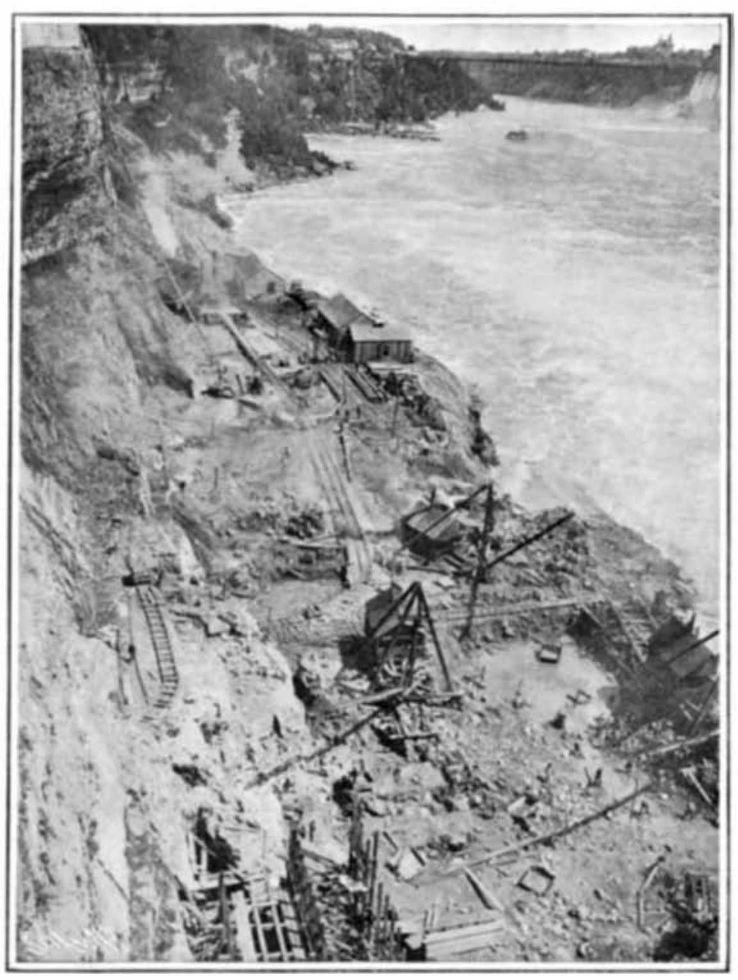
One of the 10,000-Horse-Power Units in the Generating Station.

Sand-Blasting One of the 18-foot Steel Conduits.

Interior of Wooden Form for Concrete Wing-Dam.



Concrete Wing-Dam for Gathering the River Water into the Forebay.



Excavating the Site for the Generating Station at the Foot of the Cliffs.

THE 180,000-HORSE-POWER PLANT OF THE ONTARIO DEVELOPMENT COMPANY AT NIAGARA FALLS.—[See page 126.]

ment vessels being inspected by the Navy Department only.

Corrugated furnaces were first introduced to the attention of engineers in 1853-4 by Richard Montgomery, a boiler-maker of the period, at the Morgan Iron Works, in New York city; his examples were, however, defective in that they were corrugated in the flat sheet, afterward bent to a circle and riveted; this left a joint and a flat spot, which was looked upon as dangerous under high pressures. Montgomery's conception of the furnace was all right, but, unfortunately, there was not at that time any way of welding seams, and it was not until the Continental Iron Works, at Green Point, devised a method of doing such work that corrugated furnaces came into general use many years afterward.

ELECTRIC POWER DEVELOPMENTS AT NIAGARA FALLS.—I.

Outside of the technical world it is but little understood how vast are the electrical power plants which are now under construction on the Canadian shore at Niagara Falls. When the Niagara Power Company announced, some dozen years ago or more, its intention of building on the American side of the river a power plant that would develop 50,000 horse-power, the world was incredulous; and not until the first turbine and generator were successfully at work was it willing to believe that the thing could be done. Yet today, not only has the original plant been doubled, but there are in course of construction, and partly completed, turbines and generators installed in three separate plants, that will have a combined capacity over eight times as great as that of the parent plant, while charter rights have been given for the development of power which will amount in the aggregate to over 900,000 horse-power. Named in the order of their size, these three installations are that of the Ontario Power Company, which will develop 180,000 horse-power; the Electrical Development Company, of 125,000 horse-power, and the Canadian Niagara Power Company, which will develop 110,000 horse-power, the latter duplicating the capacity of its original power plant.

The bird's-eye view of Niagara Falls and vicinity on our front page has been drawn with a view to show the location of the new power plants with reference to the Falls. The point of view is from a position over the Canadian shore, and slightly below the steel arch bridge which, a few years ago, took the place of the old highway suspension bridge. We are looking up the river, directly across the Horseshoe Falls, toward the broadly curving Canadian shore, and the rapids which extend for about 3,500 feet back from the crest of the falls. The rapids commence at a point opposite the upper end of Goat Island, and there is a fall of 50 feet in the next 3,500 feet to the edge of the Falls. It is at the head of Goat Island that the Niagara River begins its broad sweep through an angle of over 90 degrees, before discharging its waters over the Falls, and this broad curvature on the Canadian shore, coupled with the rapid rush of the waters, has been taken advantage of by the engineers in selecting the sites for power development. Two of the companies have boldly built out massive wing-dams into the torrent, starting them first at right angles to the shore line, and then curving them upstream at an acute angle with the shore. These wing-dams serve to draw the water in toward the intakes, through which it is led to the supply pipes or the penstocks, as the case may be, for ultimate use in the turbines. The other company has placed its power house at a point where the river was so full and deep that a wing-dam was not necessary, and the water flows directly through the sluice gates into the penstocks. The present article is devoted more particularly to a description of the works of the Ontario Power Company, and the other two installations will be treated at length in later issues.

Just here, however, with this bird's-eye view before us, we will briefly recapitulate the work that has been done at the present time in power development at Niagara. On the New York shore, about a mile above the American Falls, are the two power houses of the Niagara Falls Power Company—one on each side of its intake canal. The original plant is of 50,000 horse-power, and the second power house is of 55,000 horse-power. Each power house is located over its own wheel pit, and the water is conducted through penstocks to turbines in the bottom of the pits, and is led away through a tail-race tunnel over a mile in length, the discharge of which will be noticed in our bird's-eye view, just below the abutment of the steel arch bridge on the New York side. Fifteen hundred feet below the Niagara Power Company's intake canal is a canal which leads through the city of Niagara to a forebay on the edge of the cliff below the steel arch bridge. Here the water is led by penstocks down to the power house of the Niagara Falls Power and Manufacturing Company, which has an ultimate capacity of about 40,000 horse-power. Beginning at the head of the rapids on the Canadian side, we have first the intake of the Ontario Power Company, from which the water is led in underground pipes to the cliff above the generating station, where it is led down to the latter in penstocks and the power is developed on the edge of the river in a generating station that is a thousand feet in length. About 2,000 feet further down the rapids on the Canadian shore is the power station of the Electrical Development Company, where the water is deflected by a wing-dam through a series of screens and gates into penstocks which lead to turbines at the bottom of a huge wheel pit. The tail-race water is discharged by means of a tunnel which has been cut from the bottom of the wheel pit right through below the river to the edge of the falls, discharging at the river level below and back of the falls. About half a mile further down the rapids we see the power station of the Canadian Niagara Power Company, where the water is similarly led through penstocks to the bottom of a wheel pit, and discharged through a tail-race tunnel, whose outlet is just above the surface of the river below the falls and about half way between the falls and the generating station of the Ontario Power Company.

It will thus be seen that on both sides of the river the power plants have been built on two broadly different systems, one consisting in sinking a huge wheel pit to a level sufficiently higher than that of the river below the falls to allow of an easy delivery for the tail-race waters, and placing the turbines at the bottom of this pit, and the generators at the top of it at the level of the power house; the other method consists in carrying the waters from the upper level of the river by means of a canal or pipes and penstocks to a power station located on the shore of the lower river and at a sufficient height above the latter to give the proper clearance for the draft tubes.

ONTARIO POWER COMPANY DEVELOPMENT.

In the year 1887 the government of the Dominion of Canada made a grant to the Ontario Power Company for the development of hydraulic power at Niagara Falls, these concessions being made contemporaneously with the first concessions granted in the United States. Briefly stated, the works consist of a large system of intakes located abreast of the commencement of the upper rapids, and near what are known as the Dufferin Islands. These consist of an intake proper, an outer forebay, a system of screens, an inner forebay, and control gates. The intake, which is 618 feet long, extends diagonally from the shore out into the river, and consists of a series of concrete piers which carry a concrete curtain wall. This wall extends vertically downward 7 feet below the surface of the river, to within 6 feet of the river bed, and it projects 5 feet above the river level. The water passes through the intake in the 6 feet of space between the river bed and the under side of the curtain wall. As the river rushes along the curtain wall, its current is increased and the masses of ice that come down in the winter time are swept along the face of this wall, only a part of the water passing through and beneath it into the outer forebay, which contains an area of 8 acres. This forebay is bounded on the shore side by an artificial island; on the river side toward the falls, it is bounded by a massive wing-dam, of which we present an illustration. This dam extends out into the river at the lower end of the forebay with a broad curve and swings around upstream to meet the lower end of the intake curtain wall. Except during extremely low stages of water, the wing-dam will be constantly submerged, the water spilling over it into the river, as over a weir, and carrying with it such floating ice and debris as may pass through the outermost intake. The section of the wall 100 feet in length which is adjacent to the screen house, has its crest lower than the rest of the dam, thus forming a spillway of increased capacity at that point. Its effect is to create a strong surface current across the front of the screens, and sweep out into the river all ice that may have passed the ice curtain and escaped the general spill over the wing-dam.

From the inshore end of the wing-dam a series of massive screens have been built across the entrance to the inner forebay, which has an area of two acres. They are set on inclined guides in concrete masonry, and are removable by means of a crane. The gear for handling the screens, etc., is inclosed in an artistic stone building, on the roof of which is a broad promenade from which a magnificent view of the rapids may be obtained. After passing through the inner forebay, the water is conducted through three massive gates into three gigantic steel conduits, or water pipes. The gates are of the Stoney pattern. They are square in form, are counterbalanced, and run between roller-guides. As will have been judged from the foregoing description, the capacity of the head works is very large. Indeed, when the entire capacity of the plant is being generated, the flow of water will be 12,000 cubic feet per second. The depth of water increases gradually from 13 feet at the intake to 30 feet at the gate house. It should be explained that the designs of all the buildings throughout the works have been approved by the park commissioner, and they have been drawn to harmonize with the landscape gardening effects in the park.

Starting from the main gate house, the water will be conducted in three 18-foot steel conduits for a distance of about 6,200 feet to the top of the bluffs below the Canadian Falls. Of these three, the first has been completed. It is built of half-inch steel plates, and to secure additional stiffness 7-inch bulb-deck beams are riveted to the upper half of the pipe at every four feet, and the whole is incased in a thick layer of concrete. To insure that the conduits shall not interfere with the appearance of the park, they are being laid in trenches and will be entirely covered from view.

The first of these conduits is completed. From the under side of it six 9-foot penstocks are carried down in pairs through vertical shafts and out through horizontal tunnels in the solid rock of the cliff to the generating station. Each penstock supplies water for a 10,000-horse-power unit. The vertical depth from the center of the conduit to the center of the turbine is 133 feet. Two small penstocks of 30 inches diameter lead from the main conduit through an inclined tunnel to the power house, and supply water for the two exciter turbines.

It will be seen from the above description that this installation is entirely different from that of the Niagara Power Company on the New York side, in that it does not employ a wheel pit. The generating station is located on a bench at about the normal level of the river, which has been cleared of rock at a point about 700 feet down stream from the Canadian Falls. This building is 76 feet wide, 65 feet high, and when it is completed will be 1,000 feet in length. The main generators and their turbines are placed on the floor of the station 20 feet above mean water level. Each turbine unit consists of a pair of Francis turbines, mounted, side by side, on the same horizontal shaft that carries the generator, and operating at 187.5 revolutions per minute, at a rated horse-power of 11,400. After passing through the wheels, the water flows through concrete draft tubes, which terminate in tail-races built in the foundations of the station. These, in turn, discharge over a weir wall into the river. The crest of this weir wall is at elevation 349. Under full load conditions the water rises on it to elevation 353, giving a gross head between forebay where the water level is at elevation 553 and tail-water level of 200 feet. Of this head 175 feet is effective on the turbines. The first installation, which is now nearing completion, consists of six of the twenty main generators provided for by the general plan. Each generator is rated at 7,500 kilowatts, and delivers three-phase current of twenty-five cycles at 12,000 volts. The generators are of the rotating field type, the external diameter of the armature being about 21 feet. On a raised gallery which extends down the power house on the side opposite the river, are located the exciter turbines, the direct-connected exciting dynamos, and the turbine governors.

An entirely new feature in this power house is that the actual operation of the generating station is conducted from a separate distributing and control station, located at a distance from the generating station. This building is 550 feet inshore from the generating station, and stands on the bluff at an elevation of 250 feet above it. The control circuits pass from the generating station in insulated cables, carried through inclined tunnels in the cliff, which extend to a point on the hillside a little above the main conduits. Thence they are carried up the bluff, under ground to the distributing station. Here, in a separate switch room, the 12,000-volt automatic oil switches are mounted in brick cells. They are of the vertical plunger type and are magnetically actuated.

The transformers are arranged centrally throughout the length of the distributing station building, except at the center of the building, where space is given to the control room. Each transformer is rated at 2,500 kilowatts, or 3,350 horse-power, and they weigh 40 tons apiece. They are designed for a potential of 60,000 volts.

It is anticipated that as construction proceeds the foregoing plans will be modified to provide for 200,000 horse-power ultimate capacity, with 22 units of 10,000 horse-power each in the installation.

We are indebted for our information to P. N. Nunn and L. L. Nunn, the engineers of the company, who are responsible for the design and execution of this great work.

E. H. R. Green, of Dallas, Texas, one of the leading citizens of the State and president of one of the railroads of that section, and who enjoys the additional distinction of being the son of the famous Hetty Green, of New York, has gone in for automobiling as a pastime, with the result that he has designed an electric system for the timing of automobiles on the racetrack. It is said to be extremely simple in its construction and application, and can be laid down upon any course without any elaborate preparation. As the vehicle passes certain points along the course, a record is made of the time at the judges' stand at the starting point. The system involves the use of the wireless method.