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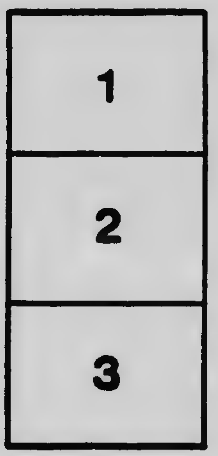
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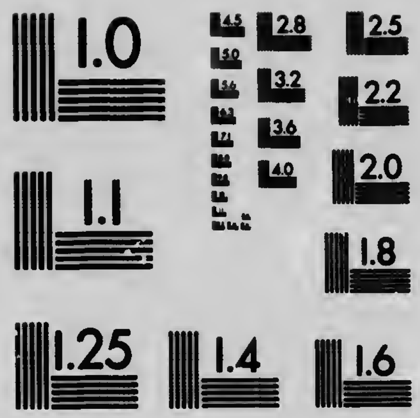

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1906

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The Power Plant of the Electrical Development Company

of Ontario, Limited

By F. O. Blackwell

Electrical Engineer

POWER HOUSE AT NIAGARA FALLS.

THE
ELECTRICAL DEVELOPMENT COMPANY
OF ONTARIO, LIMITED.

DIRECTORS:

LT.-COL. SIR H. M. PELLATT, PRESIDENT.

FREDERIC NICHOLLS,
1ST VICE-PRESIDENT AND MANAGING DIRECTOR.

WM. MACKENZIE, 2ND VICE-PRESIDENT.

HON. GEO. A. COX.

JAMES ROSS.

W. R. BROCK.

E. R. WOOD.

A. M. GRENFELL.

H. H. MACRAE,
SECRETARY AND GENERAL MANAGER.

D. H. McDOUGALL, TREASURER.

HEAD OFFICE:
TRADERS BANK BUILDING, TORONTO.

The Power Plant

of the

Electrical Development Company

of Ontario, Limited

SOME OF THE MAIN FEATURES OF THE PLANS OF THESE COMPANIES.

Horse-power being developed, 125,000 h.p.

Length of Main Tail Race Tunnel, 1,935 feet.

Length of Subsidiary Tunnels, 550 feet.

Height of Main Tail Race Tunnel, 26 feet.

Length of Wheelpit, 416 feet.

Depth of Wheelpit, 144 feet.

Length of Power House, 500 feet.

Eleven Generators, each of 12,500 horse-power.

Private right of way of minimum width of 80 feet, from Niagara to Toronto, for transmission of power.

Steel Towers, used for transmission line, instead of wooden poles.

Town site, having a frontage of one and three-quarter miles on Welland River, three miles from Niagara, has been purchased for the location of prospective industries.

A paper presented at the 16th Annual Convention of the Canadian Electrical Association, Niagara Falls, June 19th to 21st, 1906.

THE POWER PLANT OF THE ELECTRICAL DEVELOPMENT COMPANY OF ONTARIO, LIMITED.

BY F. O. BLACKWELL.

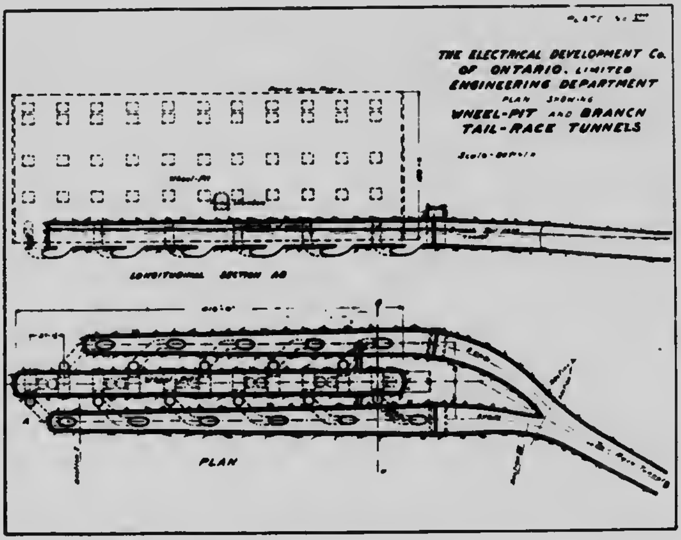
THE power plant of the Eelectrical Development Company was designed to utilize 11,200 c.f.s. of water under a head of 135.5 ft. The water is diverted from the Niagara River at Tempest Point, midway between the headworks of the Ontario Power Company and the Canadian Niagara Falls Power Company.

The general plan of development adopted called for the construction of a wing wall to gather the water from the rapids, the excavation of a forebay of sufficient capacity with the river at its lowest future stage, a wheel pit, and a tailrace tunnel discharging under the centre of the Horseshoe Falls, where the flow of water over the Falls is greatest.

The forebay in the rapids and the tunnel outlet under the Falls were both bold and original conceptions, which were thought at the time to be practically impossible of execution.

In order to uncover the forebay it was necessary to construct a coffer dam 2,200 ft. long in the rapids, where, for a portion of the way, the cribs had to sunk in water 26 ft. deep and running at a velocity of 22 ft. a second. This work was started in April, 1903, and proved to be an extremely difficult undertaking, but was successfully completed in about twelve months.

The tailrace tunnel was started in May, 1903, by the sinking of a construction shaft on the bank of the river 150 ft. deep and 15 x 7 ft. inside the timbering. From this shaft a drift 14 ft. wide and 7 ft. high was run 670 ft. to the portal of the tailrace tunnel, work upon which was only actually started in December of the same year.



The final opening under the Falls proved very difficult on account of the large amount of water encountered near the face and the mass of detritus that had to be cleared away by men exposed to the full force of the wind and spray from the Falls.

The wing dam is 785 ft. long, and its maximum height is 27 ft. The elevation of the crest is 527 ft., and there will be from 3 to 8 ft. of water flowing over it, depending upon the condition of the river. Near the power house the dam is cut away for a length of 30 ft. to an elevation of 524 ft., so that there will be 3 ft.

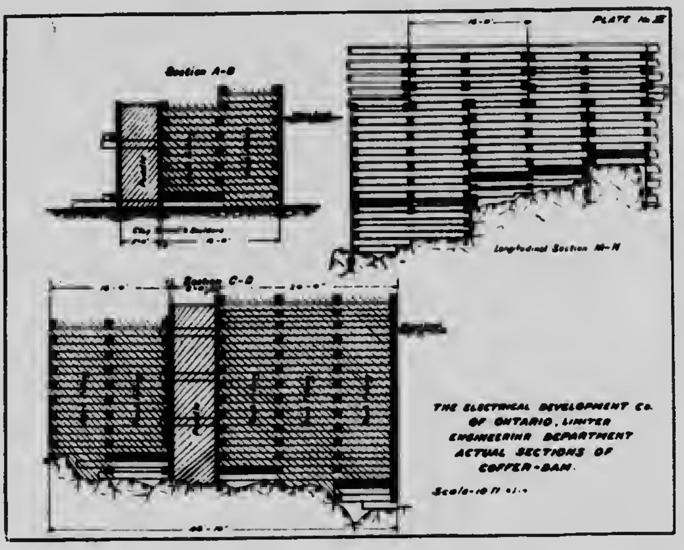
additional depth of water to carry away ice from the sumerged arches in front of the power house. This question of guarding against ice is one of the most important problems which had to be met. In addition to the first line of submerged arches just referred to, a second wall has been constructed outside of the racks. The spaces between the outer and inner walls, and between the latter and the racks, are arranged each with a spillway at one end, so that such ice as passes through will float out at the north end of the building.

COFFERDAM CONSTRUCTION IN CASCADE ABOVE FALLS. WATER AT THIS POINT ABOUT 26 FEET DEEP, AND VELOCITY OF 22 FEET PER SECOND.

The wheel pit is 416 ft. long and 22 ft. in width inside of the brick lining, which is 2 ft. thick, and is spanned by masonry arches at three levels to carry the machinery. The ends of the pit are also closed by arched wall linings. The arches were not allowed to be put in until the pit had closed in as much as it would and come to rest. There has been no movement whatever at the union of the arches and the walls that the most accurate observations could detect, which is interesting on account of the theory once advanced that there was a periodic change in the distance apart of the sides of the pit.

For the power to be developed the length of the wheel pit is much less than in previous developments of this character. This is due to the penstocks alternately being on the right and left hand sides of the water wheels, permitting one hoistway to serve two wheels.

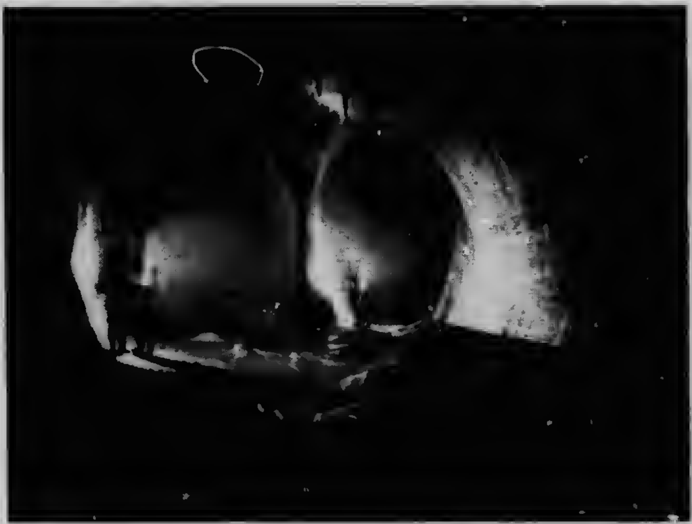
The water after passing through the racks enters a cast iron bell-mouth, which in turn joins on to a riveted steel penstock 10 ft. 6 in. in diameter.



There are 11 penstocks, and at the head of each there is an electrically operated gate to control the water. The penstocks are connected at the bottom to water wheels of 13,000 h.p.. capacity, running at a speed of 250 revolutions per minute. The wheels and penstocks rest on a heavy concrete foundation, which covers the bottom of the wheel pit.

The hydraulic apparatus is being furnished by the I. P. Morris Company, of Philadelphia.

Each wheel unit consists of two Francis internal discharge turbines 5 ft. 4 in. in diameter. The discharge of water is to be governed by cylinder gates, and the weight of the moving parts will be partially taken by a water piston in the wheel. There is a single cast iron draft tube 9 ft. in diameter for each wheel, and the units alternately discharge water underneath the east and west tailrace tunnels. The object of the under discharge is to seal the draft tubes and prevent loss of vacuum, no matter what the elevation of the water in the tunnels may be, and without the necessity for a tailrace



JUNCTION OF BRANCH TUNNELS AND MAIN TAILRACE TUNNEL, 144 FEET BELOW BED OF RIVER. TURBINES DISCHARGE UPWARDS INTO SIDE TUNNELS—SIX ON RIVER SIDE AND FIVE ON SHORE SIDE—MAKING TWO COMPLETE PLANTS IN ONE.

weir. By using two tunnels it is possible to shut off the water entirely from one-half of the wheels without interfering with the other half. By closing down the wheels, discharging water into either tunnel, that tunnel will drain itself, and there is no necessity for closing off the mouth of the tunnel. A gate is provided at the mouth of both tunnels, however, in case of extreme back water, which has been known to be 50 ft. above normal in the lower river.

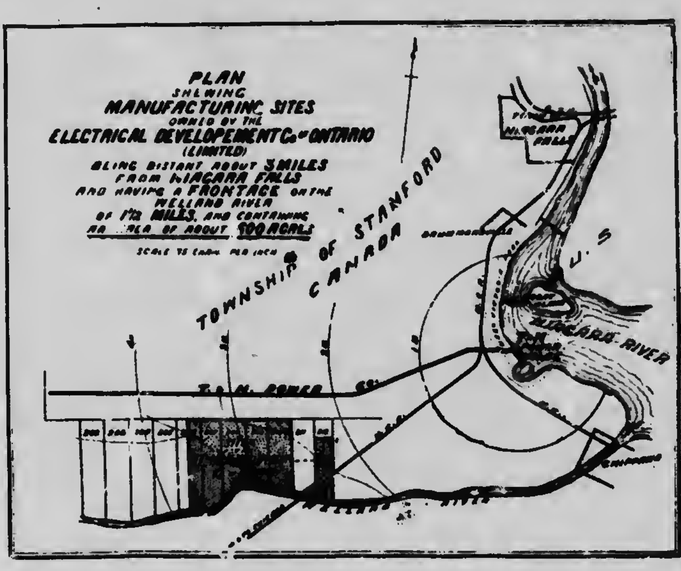
As the wheel pit is not connected to the tail race, the hydraulic apparatus can never be flooded out.

The tunnels on each side of the wheel pit are 25 ft. deep, and vary in width from 66 to 30 ft., with a velocity of from 15 to 21 ft. a second. At a point about 150 ft north of the wheel pit the tunnels come together. At the junction the tunnel is 35 ft. wide and 25 ft. 6 in. high and tapers to a width of 23 ft. 5 in. and a height of 26 ft. 13 in., which section is carried to the edge of

PORTAL OF TAILRACE TUNNEL, WHICH DISCHARGES DIRECTLY BEHIND THE CENTRE OF THE HORSE SHOE FALLS, ABOUT 150 FEET BELOW THE BRINK, AND ABOUT 8 FEET ABOVE HIGH WATER OF THE LOWER RIVER.

the Falls, a distance of 1,935 ft. The slope of the main tunnel is .005, making the total loss about 10 ft., and the velocity is 26 ft. a second. The tunnels have a lining 2 ft. thick throughout of concrete faced with brick, except for 300 ft. at the north end, where the lining consists of concrete rings in 6 ft. sections, which are expected to break off as the Falls gradually wear away. This is necessary, as the crest in the centre has been receding at an average rate of 2½ ft. a year.

The power of the water wheels is delivered to the electric generators through vertical shafts 150 ft. long, consisting of riveted steel tubes 30 inches in diameter between bearings and solid shafts 14½ inches in diameter at bearings. This shaft is held at three points in the wheel pit by steady bearings resting on concrete arches. At the upper end there is an oil thrust bearing 37½ in. in diameter fed by oil under a pressure of 350 lbs., which is sufficient to carry the weight of the entire revolving parts should the water thrust fail from any cause.



There will be ultimately eleven 8,000-k.w. generator units, four of which are now being installed by the Canadian General Electric Company. These are of the revolving field type and run at a speed of 250 r.p.m. They deliver three-phase alternating current at a periodicity of 25 cycles and a potential of 12,000 volts. There are at first to be two 500-k.w. water wheel driven exciters in a room underground, and two motor-generator sets of the same capacity on the generator floor. Eventually three sets of each type will be installed, any two of which will excite all the alternators.

The controlling switchboard for the entire plant, including transformers and transmission lines, is located in the centre of the power house, where the operator can see the generators. It consists of an enclosed compartment with a bench-board in front and doors at the ends. The instruments which are ordinarily employed in the operation of the station face towards the generator room. On the back are the recording instruments

SKETCH PLAN SHEWING ROUTE OF TORONTO & NIAGARA POWER CO'S LINE BETWEEN NIAGARA FALLS & TORONTO

and switches, which are only occasionally used or referred to. Dummy bus bars and signal lamps on the bench-board clearly indicate to the operator the connections in the station, and the instruments are so located that each is over the switch which controls them. The generator instruments, for instance, are over the generator control switch. The board is so compact that an operator standing in front of it can see all the instruments from one position, and can conveniently reach all the controlling switches. The power house bus bars, generator oil switches, instrument and switch transformers are located immediately below the power house floor in brick compartments. The wiring arrangement is such that a generator can either be connected to the bus bar or to separate outgoing cable. In ordinary operation the current from each generator will leave the building by the shortest possible route, and there

STEP-UP TRANSFORMER HOUSE, NIAGARA FALLS, WHERE VOLTAGE IS RAISED FROM 12,000 TO 60,000 VOLTS FOR TRANSMISSION TO TORONTO, 80 MILES.

will be practically no cables running the length of the power house.

The power house will be a handsome building in the style of the Italian Renaissance, about 500 ft. long., and 70 ft. wide. The height will be 40 ft., except at the centre and end bays. The centre bay will stand out from the face of the building, and, besides being the main entrance, will give room for the offices of the Power Company. On the inside it will also afford space for the switchboard and auxiliary apparatus. The power and transformer houses are 1,817 ft. apart, and will eventually be connected by four underground conduits. One conduit will be in reserve, and the plant will not be crippled unless two conduits should simultaneously fail.

At present two conduits only are constructed, each with sixteen 4¼ inch ducts placed two wide and eight deep. The manholes are common to the two conduits, but are divided into two parts by a central partition, so that one duct system would not be damaged by a burn-out on the other.

TRANSMISSION LINE, CONSTRUCTION MAIN LINE, NEAR BRONTE.

The cables required for the portion of the power plant first installed are six 500,000 c.m. triplex for 12,000 volt power, two oo B. & S. for the switch motor bus bars, two with 45 No. 8 B. & S. wires for oil switch control, two each of 13 No. 12 and 14 No. 7 wires for instrument connections. The cables are in duplicate, and either half of the ducts might be disabled without shutting down the power system.

The transformer house is on top of the bluff outside of the Park limits, and is designed to accommodate fifteen 2,670-k.w., transformers furnished by the Canadian General Electric Company, twelve of which are now being installed. These transformers are of the oil-immersed, water-cooled type, and are wound for 10,000, 11,000 and 12,000 volts primary and 60,000, 50,000 and 40,000 volts secondary. They will be connected in delta on both primary and secondary sides.

Each transformer is placed in a separate closed fireproof room, so as to minimize the fire risk and prevent the possibility of trouble in one transformer being communicated to others. The transformers are mounted

SWITCHBOARD, TORONTO TERMINAL STATION.

on rails and arranged to slide out of the compartments into a gangway, where they can be readily handled by an overhead travelling crane.

The piping for oil and water is placed in the basement under the back of the building and on the wall of the transformer compartments.

The cables from the power house are carried in ducts to a gallery above the transformers, where the 12,000 volt switches, instrument transformers and bus bars are located.

The high potential bus bars, wiring instrument transformers and oil switches for the 60,000 volt circuits are located in the room back of the transformers, and connected through the gallery floor to the high potential oil switches on the floor above.

The outgoing transmission lines leave the building through porcelain bushings at the back, and are protected by lightning arresters on the wall below.

The wiring throughout is completely enclosed in brick compartments, the only openings being through asbestos doors placed at points convenient for inspection.

TORONTO TRANSFORMER HOUSE, SHOWING OIL SWITCHES.

The transmission line to Toronto, constructed by the Toronto and Niagara Power Company, is built on a private right of way 80 ft. wide, which can latter be used for a doubletrack railway. With this idea in view, the line was located so that the maximum grade at no point need exceed one per cent., and the minimum radius of track curvature can be made as low as a quarter of a mile.

Two complete steel tower transmission lines will eventually be constructed, one only being erected at present. Each tower carries two circuits of 190,000 c.m. copper conductor. The standard distance between poles in 400 ft., although much longer spans are used in crossing rivers and ravines. For curves and long spans special extra heavy towers are employed, with double and triple insulators. The height of the standard tower is sufficient to support the lower cable at a height of 40 ft. from the ground. Fifty and sixty-foot towers are made by bolting extensions to the bottom of the standard towers, and are used wherever there are depressions along the right of way. In two places towers 150 ft. and 175 ft. high are required in order to cross navigable channels at the Welland Canal and at Burlington Beach.

The copper cable consists of six strands with a hemp centre, and has a tensile strength of 60,000 lbs., and an elastic limit of 40,000 lbs. per square inch. It was made by the Dominion Wire and Cable Company, of Montreal.

A large portion of the power is delivered to synchronous apparatus, the Toronto Street Railway employing rotary converters, and Lighting Company synchronous motor-generator sets. The loss of power, when transmitting 10,000 h.p. to Toronto over each circuit, will be less than 10 per cent., and either line can transmit 20,000 h.p. with less than 20 per cent. loss should the other become disabled.

The insulators are 14 in. in diameter and 14 in. high, and are tested for a potential of 120,000 volts complete, or 60,000 volts on each [illegible] three parts of which it is composed.

The transmission towers are heavily galvanized after all machine work upon the parts has been completed. They were made by the Canada Foundry Company, of Toronto, and the Riter-Conley Manufacturing Company, of Pittsburg, Pa. At points exposed to severe lightning the line will be protected by 12 ft. extensions carring galvanized steel cable above the power conductors.

There will be three division houses along the line, dividing it into four sections, any one of which can be cut out for inspection or repair. The length of the line is about 90 miles, and the division houses will therefore be 22½ miles apart. A lineman will control each section daily after the transmission is in operation.

The sub-station in Toronto is designed for fifteen 2,670-k.w. transformers, and is similar to the transformer house at Niagara Falls, except that there will be double low-tension bus bars and a much larger number of feeder cables for distributing power throughout the city of Toronto.

The switchboard is located at one end for controlling the transmission lines, transformers and 12,000 volt circuits. This is equipped with dummy bus bars with all necessary instruments.

In the plans of the Electrical Development Company every effort has been made to avoid any interruptions to the power service. No single accident or any probable combination of accidents is ever likely to shut down the entire plant. The double ice protection, twin tailrace tunnels, the extra 8,000 k.w. water wheel, generator and transformer unit, and the duplication of the transmission lines and of all auxiliary apparatus is with this end in view.

The engineering design of the plant is in charge of Dr. F. S. Pearson as consulting engineer. The water power development was planned by Mr. H. L. Cooper, chief hydraulic engineer, and the writer laid out the electric plant. The construction of the hydraulic work and power house was originally under Mr. Beverly R. Value, and is now in charge of Mr. Walter Pearson as electrical engineer.

The transformer houses and transmission line were built by Mr. Robt. C. Brown, chief electrical engineer of the Toronto and Niagara Power Company.

The general manager and secretary is Mr. H. H. Macrae, and the treasurer, Mr. D. H. McDougall, and the head office of the company is at Rooms 411-420 Traders' Bank Building, Toronto.