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THE HURONIAN COMPANY'S POWER DEVELOPMENT.

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(Read at joint meeting of the Mechanical and Electrical Sections, April 25, 1907.)

The Canadian Copper Company operates numerous nickel and copper mines in what is known as the Sudbury District, the principal mines being at Copper Cliff, Creighton, and Crean Hill. The smelter at which these ores are treated is located at Copper Cliff. To develop and transmit power for their requirements and for other purposes the Huronian Company was incorporated.

The cost of coal for operating the smelting plant and machinery at the mines induced the Huronian Company to acquire the property known as High Falls, on the Spanish River, in the Township of Hyman, and in the spring of 1904 work was begun upon the development of this water power.

High Falls lies about four miles north of the "Soo Branch" of the Canadian Pacific Railway, at a point about 28⅓ miles west of Sudbury. A line of railway was built from the C. P. R. to the site of the works, and all necessary buildings were erected for housing the workmen and storing material. This preliminary work was ready about September 1st, when work on the actual development was commenced.

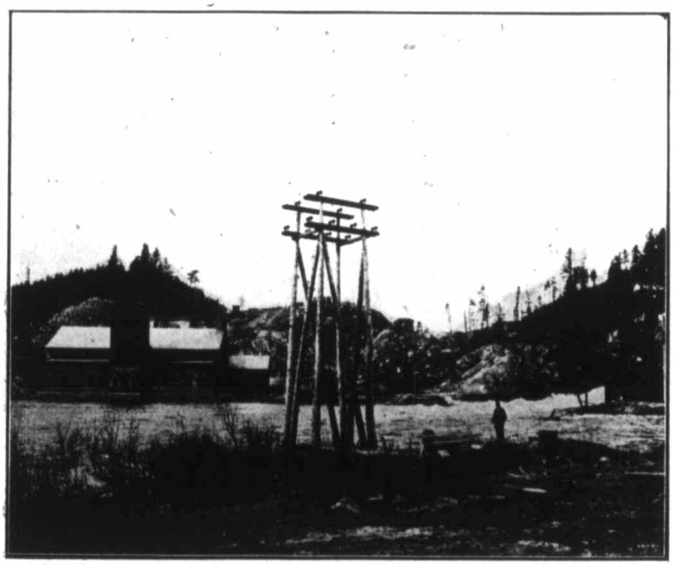
The Spanish River, when it reaches High Falls, drains an area of 2,150 square miles. The average rainfall in this area is not in excess of 30 inches, and during one season, when the rainfall did not exceed 24 inches, the minimum discharge of the river was 1,600 cubic feet per second. The best description of the character of this watershed is found in Dr. Robert Bell's report in the Geological Survey of Canada for 1888-1890. It is owing to the nature of the covering of this watershed and to the numerous lakes in the upper reaches that the minimum flow is high, being .71 cubic foot per second per square mile. The minimum flow of the stream was reached in September, 1904, and also in February, 1905.

Above High Falls, for a distance of six miles, the river is a succession of rapids, and it was considered necessary that these should be drowned so as to prevent the formation of frazil, and to form as much of a reservoir as possible. For these reasons the river level above the falls was raised 18 feet, drowning all troublesome rapids, providing a storage basin about six miles long, and increasing the head from 67 to 85 feet.

The river above the falls flows between rocks and hills. Immediately at the head of the falls are rocky islands, which break the stream into several channels, finally dividing the river into the east and west channels, the two branches uniting a short distance below and thus forming High Falls Island.

The system of dams necessary to control the water was somewhat complicated, and work on concrete dams 1, 2, and 4 was begun first and carried on continuously to completion, notwithstanding the severe winter of 1904-5. At the same time the concrete foundations of the power house were built to above high water so as to avoid any delay in the following spring. A log slide and two temporary openings were left in dams 1 and 2 so as to pass water when it became necessary to stop the water on the east side of the river. The channel on the east side was then closed up by a crib cofferdam against a head of 32 feet of water. This cofferdam was built in the form of the letter "V" in plan, each leg abutting on the rock projecting outwards and up stream at an angle and finished square, leaving a key shape space between the two legs. Accurate measurements were made of this space, and a crib of these dimensions was built up stream a short distance, loaded, and then lowered with heavy tackle to within a short distance of its proposed location, and was then built up and loaded until it was within a few inches of the bottom. When this was completed the position of the key crib was adjusted; then it was lowered as far as possible under control of the ropes, and

General Site, High Falls.



Power Station, High Falls.

when the proper direction of its course was assured, the tackle was quickly slacked and the crib under the action of the current went into its position. The face of the cofferdam was then double sheeted and made as tight as the bottom formation would allow, so that the water was thus diverted to the openings in dams 1 and 2.

As will be seen on plan No. 2, the water for the power plant was taken across the Island, and to do this it was necessary to construct a series of dams, 5, 6, and 7, connecting with the bulkhead, and to close the west channel by dam 3, after which the openings in dams 1 and 2 were closed and the forebay allowed to fill. All of the structures, including the power house, are built on rock, and the forebay to elevation 170 is cut through rock. In dams No. 3 and No. 5 are sluices at level 159, which, with the aid of the logslide and penstock, allow (if ever it should be necessary), the water to be lowered to below 170 and render the racks and bulkhead accessible for repairs. These sluices are also intended to be used to relieve the overflow at high water, and are accessible by bridges from the shore ends of the dam.

As the river is used for lumbering purposes, and as large numbers of logs come down every year, the provision for their passage was made in No. 2 dam, a system of booms being anchored above to guide the logs to the slide, which carries them to the west channel. In order to ensure water in the west channel, the crest of dam No. 3 was made 18 inches higher than dam No. 5, so that a continual flow is assured in the west channel for logging purposes.

From the photographs and general plan will be plainly seen the whole scheme of dams and works, which is of somewhat unusual design, but which was considered the best possible arrangement to secure the full flow of the river, to meet the lumbermen's demand, and also to make advantageous use of the physical peculiarities of the site.

Dams.—All of the dams are founded on solid rock, ample key trenches being cut in the rock for anchorages, both in the foundation and end walls. The foundation rock was made absolutely clean, not a particle of dust or dirt was allowed to remain, the bottom was then dusted over with neat cement, and over this a layer of mortar 1 to 3 was laid to a minimum depth of 4 inches, when regular concreting was begun. The concrete mixture was all 1 cement, 3 sand, and 5 of broken stone, well mixed, and deposited in a very wet mixture. Larger stones were freely used, some measuring over two cubic yards, none being allowed nearer the face of the work than 9 inches, nor nearer each other than

12 inches. All being carefully washed and scrubbed before placing, carefully bedded, and so disposed as to form as effective a bond in the work as possible, the wet condition of the concrete mass facilitating this bedding.

Though a large part of the concrete work in dams, and also in power house foundations was done in winter, with the temperature varying from a few degrees of frost to 15 degrees below zero (and on several occasions much lower), no difficulty was found in securing good concrete work, the only precautions taken being to heat the mixing water by turning a ¾" steam pipe into the water barrel supplying the mixer, and, during the process of mixing, to use a jet of live steam in the mixer, keeping the cylinder closed by wooden coverings during the process of mixing. No attempt was made to head sand or stone, nor was such at all necessary.

In all the winter work care was taken to use only cement which would attain its initial set in not more than 65 minutes, and the results obtained have been absolutely satisfactory.

Except in very thin walls there need be no hesitation in placing concrete in low temperature if the above precautions are taken. Even in thin walls (10 inches or over), it can be safely done, as was done in the case of the sub-station and blowing engine house constructed in connection with this plant at Copper Cliff, which was built during the winter of 1905-6, and which, except for the additional cost, does not differ from work done above the freezing point.

The sections of dams used are shown on the accompanying diagrams, Plan No. 5.

Bulkhead Wall.—This was constructed generally in the same manner as the other dams, the steel structure for racks and the cones for penstocks being built in the work, all steel work being carefully bedded in and covered with wet mortar. The general arrangement of the bulkhead and penstock inlets are as shown on the diagram. The gates are of steel of split pattern, and are operated by a direct current motor driven from the exciters, or by hand, as required. The exciter inlet is separate from the power wheel inlets, so as to permit of a smaller screen spacing being used in the racks. This necessity at the inlet, and the advisability of having the exciters placed in the middle of the power house floor, required the bending of the exciter penstock from the end of the bulkhead wall to a position in the centre of the power house as the drawings indicate. The bulkhead was housed, so as to protect the operators in severe winter weather.

Penstocks.—The entrance cones, built in the concrete wall, are 10 feet in diameter at the upper end, and 9 feet in diameter at the outside of the wall; the penstocks are 9 feet in diameter from this point to the wheel cases, and are of steel plate, resting on concrete saddles, spaced at two diameters of the penstock centre. The penstocks are four in number and are anchored in the centre of their length, an expansion joint being provided near the bulkhead wall, and also one near the power house in each. To prevent the formation of ice in the penstocks, they are covered with a wooden structure, made as nearly air tight as possible, and this arrangement is quite effective and necessary in a plant operating in this locality, where the temperature sometimes reaches 45 degrees below zero. The maximum speed of water in the penstocks is at full overload 7.2 feet per second. Air pipes of ample capacity, protected from freezing, are provided at the upper end of the penstocks.

Power House.—The foundations of the building are carried down to rock, which dipped to the north and east at a depth of about 30 feet below the floor level. The overlying material was soft blue clay and quicksand, which gave a good deal of trouble in excavating, though the low temperature at which most of the work was done tended to facilitate rather than retard progress, as every opportunity was given the frost to penetrate the earth beyond the limits of the excavation, rendering the standing walls secure and enabling the excavation to be carried down on about plumb. The sub-floor work consisted of concrete walls, piers, and arches, as shown.

The floor arrangement of the power house provides for two exciters in the middle of the room, each capable of serving four generators, both being furnished with water from one penstock, and each provided with an hydraulically operated gate valve. The power units are arranged with two on each side of the exciters. In the centre of the building is the switch tower, and on each side of it are the transformer compartments separated from the main room by steel doors. A railway track leads into the power house, and an overhead crane commands all the machinery, the transformers being all mounted on trucks, which can be pushed forward so as to bring them under the crane.

The base of the operating platform is faced with enamelled brick, the platform itself being reached by a removable iron stairway at each side.

The roof of the transformer rooms and of the switch tower is of concrete, and the roof of the main building is of pine, 2" × 4", laid on edge on steel trusses, and covered with 26 gauge galvanized iron. The building is heated from a boiler placed in a room on the east end of the building, the Sturtevant system of warm air being used. A room is also provided for stores and small repair work, furnished with a complete lavatory. The tail race was excavated to ample size, and some necessary retaining walls and cribs were built for its protection.

The walls of the power house were built of red brick, laid in a mortar consisting of Portland cement and lime; the inside well finished and the walls painted for six feet above the floor, while the remainder of the walls were tinted a buff color.

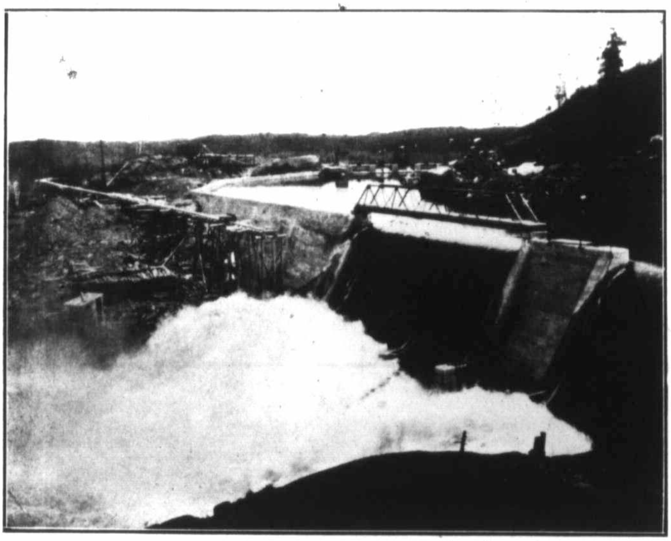
Turbines, etc.—The main turbine wheels were designed for a maximum of 3,550 H.P. each. Each turbine operated a 2,000 Kw. generator, so that the wheels have a capacity sufficient for operating the generators at 33% overload. The effective head is 85 feet, and the speed is 375 R.P.M. The wheels are enclosed in steel cases, with case and head split horizontally so as to give quick access to the moving parts in case of repairs being necessary. One pair of wheels is used in each unit, the diameter being 34 inches, the runner being of bronze. The thrust bearing is of the marine type, located between the wheel case and the generator. The case head bearing is in effect merely a stuffing box and really takes no weight. The gates are of bronze of wicket design, being as nearly as possible balanced, and are operated by a governor of the Sturgess type. The exciter turbines are similar in design, and are also controlled by Sturgess governors; all governors are electrically controlled, being handled from the controlling desk by the operator on duty, who can start up any or all machines from this point. The total full load capacity of the station is 8,000 Kw.

Tachometers are attached to each main unit.

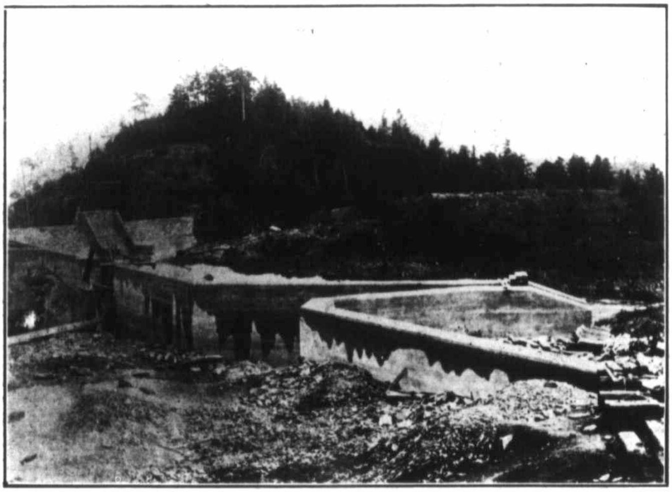
Generators.—The electrical plant was designed for the eventual installation of four generators, two of which are at present operating, and a third has been contracted for. These generators are each of 2,000 Kw. capacity at 80% power factor, 3 phase, 25 cycles, operating at 2,400 volts. The revolving field is mounted on a steel shaft with the coupling forged out of the solid and directly connected to the water wheels.

Exciters.—The exciters, two in number, are of 200 Kw. capacity each, operated at 550 R.P.M., each being of a capacity sufficient to furnish excitation for the four generators. These exciters are also directly connected to their own wheels.

In connection with the testing of the generators, it may be interesting to note that loads were obtained by connecting one generator up as a motor reversed in direction of rotation and operating it from the other machine running as a generator. Both machines, for the purpose of the tests, were brought up to



Dam and Forebay.



Dam on West Side of River.

full excitation and switched together before being started up. The gates on the generator wheel being opened up gradually, both machines came up to speed, the motor, of course, driving its wheel in the opposite direction to normal rotation. When both machines were at speed, the gates on the wheel connected to the motor were gradually opened, thus obtaining practically a water brake load. It was possible by this means to get any load required, and also to reach any power factor by over or under exciting the synchronous motor, thus determining the regulation of the generator at any power factor. This scheme is decidedly superior to a water rheostat load, which, in addition to troubles of its own, gives only a fixed power factor.

Switchboard.—The switching arrangement was laid out so that any generator, set of transformers, or line might be operated together or operated singly in any combination.

The marble bench board from which the operation of the station is controlled in every particular, including the speeding of the water wheels, was placed on a gallery to give the operator a clear view of the power station and the switching apparatus in the tower. The switches, being distantly controlled, are placed on two floors of the switching and line tower, the 35,000 volt outgoing line switches, together with the lightning arresters, being placed at the top of the tower, and the 2,200 volt apparatus in the base, so that on the benchboard the only voltages are those from the exciter and the operating voltages from the switch controls. In other words, nothing higher than 125 volts is admitted to the main power station, except within the generators themselves, which have no exposed parts, and the current from which is carried by cables in ducts to the low voltage chamber in the switch tower.

All of the bus bars, switches, etc., in the tower, are properly barriered by concrete slab construction.

The bench board is low, and instead of using marble panels for the instruments, which would have obstructed the view of the station, ornamental pillars, carrying all instruments, were installed along the face of the controlling platform.

All switching and other operations are governed by small control switches, with indicating lamps on the board; and on the wall, opposite the bench board, is set a large synchroscope and the visual and bell signal system for each power unit. A synchronizer is also located on one of the instrument pillars.

In the compartment below the bench-board platform is located the motor-driven air compressor, used to supply air for cleaning purposes. This air is piped to a number of accessible places throughout the main floor, transformer rooms, and also to the tower for cleaning lightning arresters, etc.

The exciter and generator field rheostats are also located in this compartment.

Transformers.—Two groups of three transformers each were installed with the first equipment, and the third set has been contracted for. These are placed in a transformer room extending along the entire length of the power house and sub-divided into four compartments, thus isolating each group of three transformers from the rest.

The specifications for these transformers required that the cases were to be constructed entirely of boiler iron, designed to withstand an explosive pressure of 150 lbs. per square inch, and so arranged as to be full of oil at all times, being kept in this condition by means of a system of piping extending to an expansion tank on the wall, which was carefully covered. With the precautions taken, no space in the cases is allowed for gas to accumulate and, therefore, no explosions will be possible under proper supervision. If, however, through carelessness, the oil were to be allowed to sink below the level of the tops of the transformers and an explosion should take place, no harm would be done outside the case, as the pressure generated by an oil gas explosion is never over 100 pounds per square inch.

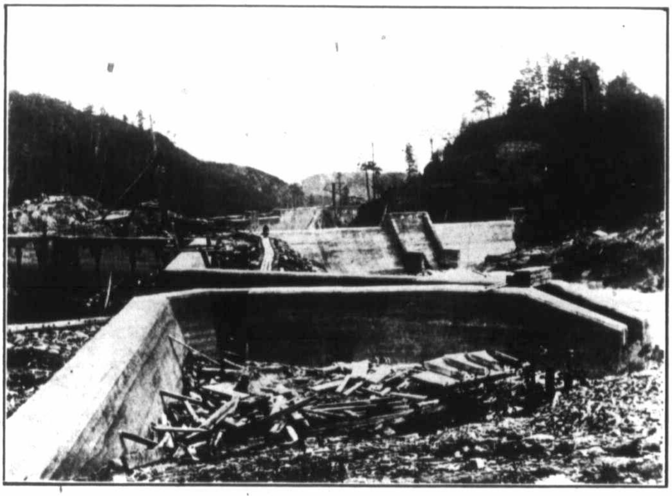
In case of a short circuit in the coils, the heat generated expands the coil and throws it into the tank, which also provides for the inevitable expansion and contraction of the oil in the transformer case as the apparatus heats up or cools off.

This is the first time the engineers have used this scheme in their practice, and owing to its success in this plant will continue to use it for all future work.

For handling the oil, a piping system is provided, with an underground tank at one end of the building, divided into two parts; one for spare clean oil, and the other for dirty oil, the latter running from the transformer to the tank by gravity, while the clean oil is forced into the cases as required, by compressed air, which is obtained from the air tank and compressor used for blowing dust out of the generators and switches.

Some strenuous criticisms were offered to this method by the transformer builders, who took the ground that moisture from the air, under compression, would be sure to be forced into the oil, thus rendering it unfit for use. To demonstrate the fallacy of this, a quantity of oil was forced by air backwards and forwards a number of times into and out of two interconnected vessels, and after this test absolutely no moisture could be detected. It

No. 3 Dam and Forebay.



Log Chute in Foreground.

may be stated, however, that no air is taken directly from the air pump, but from the air pump tank in which all the moisture due to compression is deposited. As the air compressor for blowing out purposes is essential in any modern plant, this scheme affords a means of handling the oil safely and economically.

Fire Protection.—For fire protection of the wooden penstock covering, bulkhead structure, and other buildings, a 500 gallon, 2-stage turbine pump, directly connected to a 50 H.P. direct current motor and supplied with current from the exciter circuit, has been located between units Nos. 1 and 2, with water connection to both penstocks, so as to ensure at all times a supply of water to the pump. From the pump a dry pipe line has been run

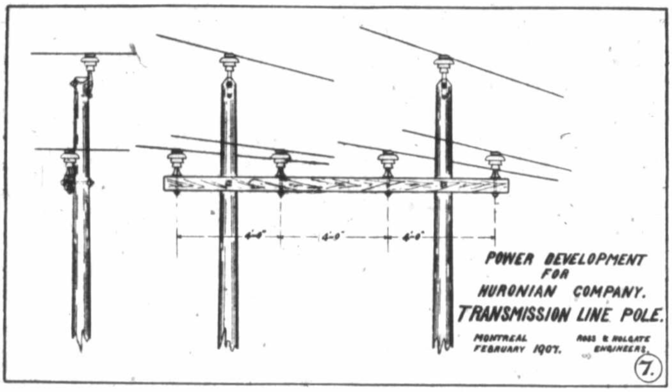


Fig. No. 7.

with outlets at various points along the penstock, and a line has also been carried over to protect the houses of the employees.

Transmission Line.—The transmission line from High Falls to Copper Cliff, operating at 35,000 volts, is about 29 miles long, and runs for the most part upon a right of way acquired immediately outside that of the Soo Branch of the Canadian Pacific Railway, thus affording ready access from the railway at all points. The line consists of two 3-phase circuits of No. 1 wire, one line being transposed three times, and the other running straight through.

The telephone line was placed on the Canadian Pacific Railway Company's telegraph poles on the opposite side of the track, at a distance of about 80 feet, to avoid the possibility of induction.

The pole line construction is shown in figure No. 7, and it will be noted that specially designed malleable iron pins are used, with a double pole construction throughout. Owing to the wide spacing of wires, it would be impossible to carry the two circuits on one pole, so that in the interest of structural stability it was advisable, instead of installing a second pole line, to combine the two with a common cross arm; these cross arms being made of long leaf Southern pine. This gives a very solid structure, and eliminates a lot of guying and strutting, which is always objectionable.

The insulators were tested at the works of the makers by a representative of the engineers for a period of 15 minutes at a voltage of 70,000, and the result of this very rigid test, especially as regards time, was that the lines were energized without a single breakdown. Since that time they have given absolutely no trouble, except where insulators have been shattered by bullets or other missiles.

The high tension exits of the lines from the power station and entrances to the sub-stations have been made through 18" tiles with plate glass screens, and have given no trouble, except at the sub-station at Copper Cliff, where sulphur fumes and metallic dust from the smelter have deposited from time to time, forming a scum, over which leakage has taken place. This has been remedied.

Aerial switches for isolating the branches to Crean Hill and Creighton Mines, as shown on photographs, have been located at Victoria Mine and the Quartz Quarry. These switches were not designed to open the circuit with any load on at the sub-stations, but simply to open the branch lines in case any repairs were necessary while the main line was alive. These aerial switches are both connected to the same line, the other main line running straight through to Copper Cliff sub-station.

Sub-Station, Copper Cliff.—The main sub-station is at Copper Cliff, and contains, in addition to electrical apparatus, some very interesting machinery for the operation of the smelter, etc., as follows:

Electrical Equipment.—

6 667 Kw. Transformers, 35,000 to 2,400 volts.

3 175 Kw. Transformers, 2,400 to 575 volts.

1 40 Kw. Motor Generator Set, 575 A.C. to 250 D.C., for operating furnace charging locomotives.

1 75 Kw. Frequency Changer Set, 25 to 60 cycles, for operating the A.C. series arc circuits used for lighting the streets.

13 Feeder and Control Panels for transformers, motors, lighting, etc.

1 Storage Battery for operating distant control switches.

75 Light capacity in constant current A.C. arc regulators.

3 600 H.P. Induction Motors, each connected to a blowing engine having a capacity of 35,000 cubic feet of air at 40 oz. pressure. These blowing engines are driven by the motor with 18 1½" Manilla ropes on the English system.

The motors are fitted with a special speed-changing controller, arranged for controlling speed by changing the number of poles in stator, with electric locking device to prevent the operation of controller when motor is in operation.

These motors are mounted on base rails, and are fitted with the regular starting compensators and circuit breakers.

1 300 H.P. Induction Motor directly connected to a compound air compressor operating at 100 lbs. pressure and 120 revolutions per minute. The speed of this motor is constant, the compressor being fitted with an unloading device, which is automatically brought into use when the pressure rises or falls below 100 lbs. This motor is fitted with starting compensator and circuit breaker.

1 500 H.P. Induction Motor, constant speed, operating at 375 R.P.M., connected to a blowing engine having a capacity of 10,400 cubic feet of air at 12 lbs. pressure, and driven by 16 1½" Manilla ropes on the English system.

This motor is mounted on sliding base rails, and is equipped with the regular starting compensator and circuit breakers. Space is provided for a second blowing engine of the same capacity as above engine.

1 4-stage, 6-inch turbine pump directly connected to a 225 H.P. Induction Motor; this outfit being used for fire protection, is connected to a dry fire line, which is piped around yards and buildings. The supply of water to this pump is taken from a 16" water main under 20 lbs. pressure, being obtained from a series of small lakes by gravity.

1 2" Vertical Pump and direct connected motor, with automatic starting switch, operated by a float, is used to pump the water from the sump, which is located in the basement. The transformer cooling water drains into this sump, as well as any seapage.

2 8-inch, single-stage Turbine Pumps directly connected to 80 H.P. Induction Motors, housed in a separate pump house,

which are used to circulate the water supply to the furnace jackets.

1 5-inch, 2-stage turbine pump directly connected to a 50 H.P. Induction Motor is located near the smelter furnace gallery, which pump is held in reserve in case of the molten metal burning its way through between the furnace jackets. This pump is used to supply water to chill same and stop the flow of metal.

1 10 H.P. Induction Motor belted to a Sturtevant blower and located in sub-station, is used in connection with the hot blast heating system of the sub-station.

It will be noted that the motors here installed are very large, and being connected to air compressors of great size, take a very large amount of current on starting up. Owing to these conditions, the lighting is by no means as perfect as if the motor units were smaller, but no serious trouble has been encountered from this cause.

This sub-station is constructed entirely of concrete, with a steel frame and book tile roof, and covers approximately one-half acre of ground.

The apparatus contained in this station, including two 10-ton cranes, together with all the air piping to the smelter, was contracted for and installed by the engineers of the Huronian Company's plant, the whole forming a rather interesting application of electricity for mining and smelter purposes.

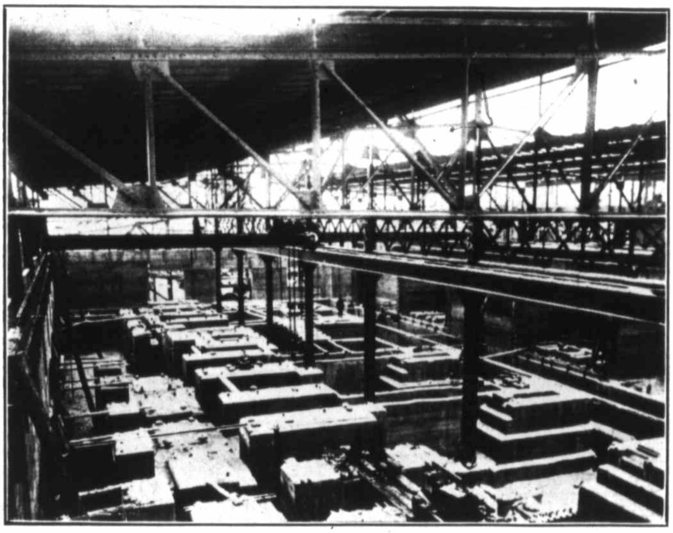
Cranes.—In addition, two 40-ton alternating current cranes, with 5 motors each, have been installed in the smelter for the handling of ladles carrying melted matte, and in spite of predictions to the contrary, these handle perfectly, pouring the metal into the converters as readily as by a hand ladle. These alternating current motors operate under the most adverse conditions, in an atmosphere of tremendous heat and covered with sulphur fumes and metallic dust from the furnaces and converters.

The converters also are tipped by alternating current motors from a controlling stand some distance away.

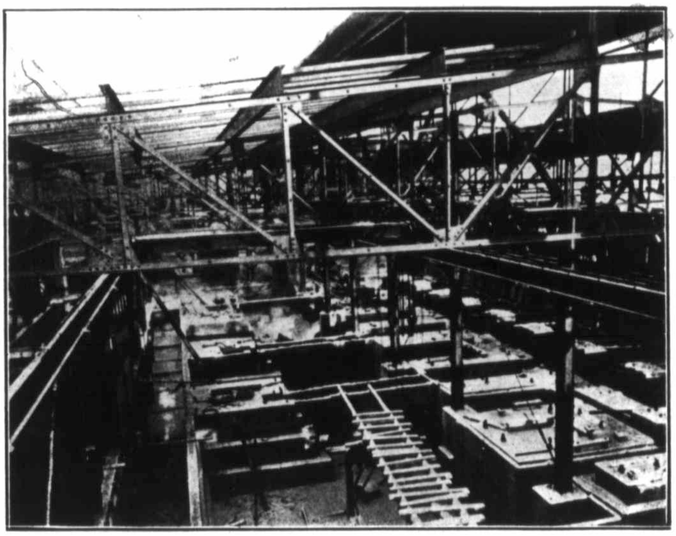
Crean Hill Sub-Station.—This sub-station is connected to the first branch taken off one of the two main transmission lines, which is approximately 3½ miles long and of single pole construction, with special aerial switches located at point of departure from the main line.

The sub-station building is constructed of concrete and brick and provided with a 10-ton hand power travelling crane.

For the housing of lightning arresters, high tension line switch,



Main Sub-Station, Copper Cliff.



Main Sub-Station, Copper Cliff.

choke coils, disconnecting switches, etc., a tower has been provided in one corner of the building.

For the reception of the 3-175 Kw. 35,000 to 550 volt, oil-filled, water-cooled transformers, a special fireproof compartment has been provided with iron doors, so as to completely isolate the transformers from the main building, this being practically the same scheme as followed at the main power house at High Falls.

For the control and distribution of power to the various receivers throughout the mines, the necessary totalling and feeder panels have been provided, the cables to and from same being run in fibre conduit and laid in the concrete floor.

Air Supply.—For supply of air to the mines, a compound, direct driven air compressor has been supplied, operating at 120 R.P.M. and supplying 1,635 cubic feet of free air per minute, with an intercooler of extra large capacity. As the speed is constant, regulation is obtained by automatic Corliss valve step regulation.

For driving the compressor, a 2,300-H.P. 3-phase, 550 volt induction motor has been installed, with the motor mounted on the main shaft of the compressor, operating at 120 R.P.M. and provided with all the necessary starting compensator, circuit breakers, and panel.

Mine Hoist.—In connection with the operation of the mine skips, a special three-drum mine hoist has been installed, the drums of which are arranged for the operation of two drums in counterbalance, also independently, or all three together if necessary. The rope speed is 500 feet per minute, and the capacity of each skip 6,000 lbs.

For the operation of this hoist, a 150 H.P. 3-phase, variable speed induction motor has been provided, complete with reversing controller, resistances, circuit breaker, panel, etc.

Fire Protection.—For the protection of the buildings and plant, a 1,000 gallon 6-inch, four stage fire pump directly connected to a 150 H.P., 3-phase, 550 volt induction motor has been installed; also a dry fire line has been piped to various points throughout the plant.

Cooling Water for Compressor and Transformers.—The water for cooling the compressor and transformers is kept in circulation by the aid of a 250-gallon, 3-inch, single-stage centrifugal pump directly connected to a 5-H.P. 3-phase, 550 volt induction motor, operating at 1,500 R.P.M.

Water Supply.—For storage of water for the fire pump supply, a steel tank holding 60,000 gallons has been erected close to the sub-station, the water for this tank being obtained from a lake

3,000 ft. away, at which point a 250-gallon, 4-inch, two-stage turbine pump, with a 20-H.P., 3-phase, 550 volt induction motor directly connected to same, and operating at 1,500 R.P.M., is located. For the reception of this outfit a concrete and brick building has been erected.

Rock House Equipment.—After the skips have delivered their loads, hoisted from the mine to the grizzly, the ore falls by gravity on the spalling floor, and from there is fed into crushers, which are 30" × 18". After passing through the crushers, the crushed ore passes through special revolving screens, the perforated plates of which are constructed of manganese steel. After passing through the screens the ore falls on the picking belts, each of which is 36" wide and approximately 50 feet between pulley centres. All necessary hoppers, chutes, troughing idlers, etc., are supplied for delivery of the ore into the various ore pockets provided for its reception. The cars into which the ore is finally loaded pass below these pockets, into which the ore is fed by gravity.

The power to operate each crusher, with its complement of screens and picking belts, is obtained from a 50-H.P. 3-phase, 550 volt induction motor of the wound rotor type, operating at 500 R.P.M. by means of belting and shafting.

Mine Pumps.—For clearing the mines of water there have been provided special single-acting, vertical, triplex, brass-fitted pumps, each having a capacity of 100 gallons per minute against a head of 250 feet, each pump being connected by gearing to a 15-H.P. 3-phase, 550 volt induction motor, operating at 750 R.P.M.

Creighton Mine Sub-Station.—The sub-station at Creighton Mine is almost exactly similar to that at Crean Hill, and is connected to the second branch line from one of the two main transmission lines, this branch line being about 3½ miles in length. It is of single pole construction, and has special aerial switches located at the point of departure from the main line.

The building itself, the switching and lightning arrester tower, the transformer compartment, and the switchboard arrangements are almost exactly like the corresponding items at Crean Hill, except that the three transformers have a capacity of 275 Kw. each, instead of 175 Kw.

The apparatus for supplying air to the mines is the exact counterpart of the Crean Hill compressor outfit. There are two mine hoists at Creighton for handling the ore, instead of one as at the former mine.

The devices for fire protection, transformer, and compressor cooling water, and the tank and apparatus for water storage for the fire pump supply are also the same as the corresponding apparatus at Crean Hill, and the rock house equipment and the mine pumps will, when completely installed, also carry out the general idea of duplication.

No. 2 Mine Sub-Station.—No. 2 mine, situated in Copper Cliff, has its sub-station situated approximately one mile distant from the main sub-station. The building, as in the other cases, is constructed of concrete and brick, and has a similar ten-ton crane to handle its apparatus. The supply of current for all purposes is obtained directly from the main sub-station at 2,300 volts, 3-phase, 60-cycles. Part of the machinery in this building is operated at the above pressure, and part at 550 volts, the control of which is through totalling and feeder panels. Three 125 Kw. transformers, oil-filled, natural-cooled, reducing from 2,300 to 550 volts, are located in a special fireproof compartment.

The air compressor apparatus is the same as those at Crean Hill and Creighton, except that the driving motor is wound for 2,300 volts.

There is installed for operating the mine skips a special double-drum hoist, arranged for the drums to operate in counterbalance or independently, and, as in the other cases, the rope speed is 500 feet per minute, and the capacity of each skip is 6,000 lbs., a similar motor to the other hoist motors being provided for its operation.

The fire protection apparatus duplicates that installed at the other two mine sub-stations, the supply of water for the pump being obtained by tapping a 16" main, which supplies water to the smelter, while the water for cooling the compressor is circulated by a similar centrifugal pump to those at Crean Hill and Creighton. This applies also to the mine pumps.

For the operation of the machinery in the rock house building, a 50-H.P. 3-phase, 550 volt induction motor of the wound rotor type has been installed, all connections to crusher, etc., being by belting.

The Cobalt Smelter Sub-Station.—This sub-station is located in Copper Cliff, and is approximately 2 miles distant from the main sub-station. The building is constructed of concrete and brick, and contains three 75 Kw. oil-filled, natural-cooled transformers, receiving current at 2,300 volts, 3-phase, 25 cycles direct from the main sub-station and reduced to 550 volts and distributed through control and feeder panels.

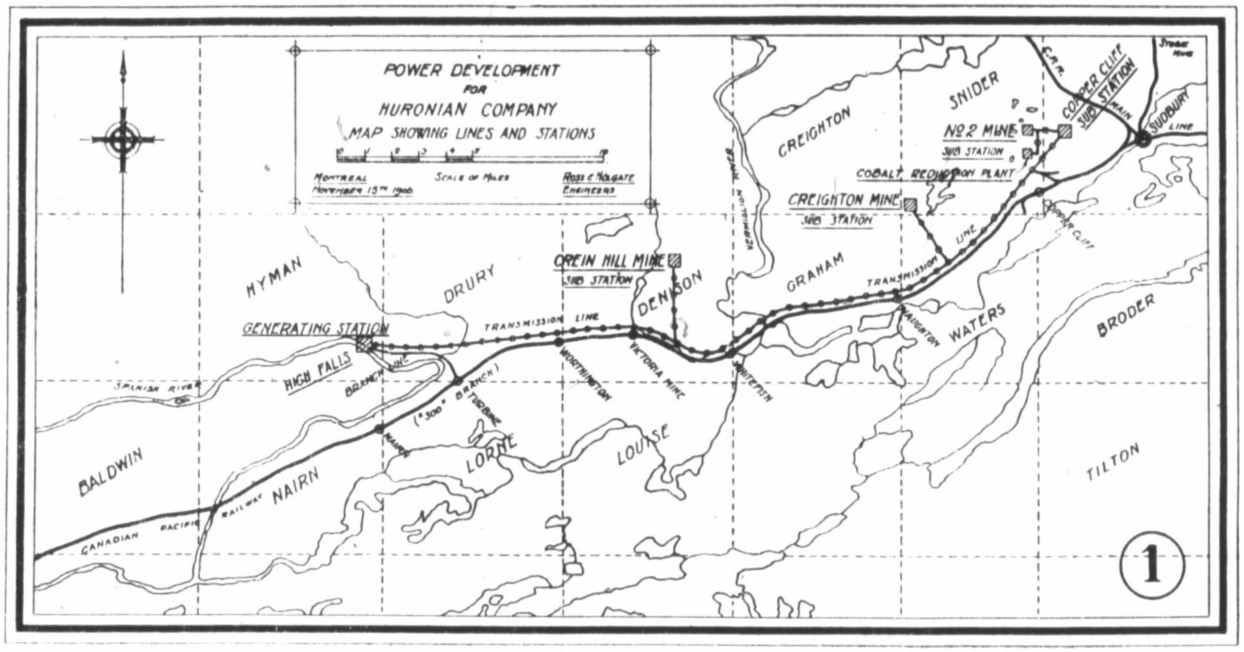
In this building is also located a 1,000-gallon, 6-inch, 4-stage turbine fire pump directly connected to a 150-H.P., 3-phase, 550 volt induction motor, with control panel, also a dry fire line has been piped to various points throughout the plant.

The supply of water to this pump is obtained under 20 lbs. pressure from the domestic service pipes fed from the storage reservoir.

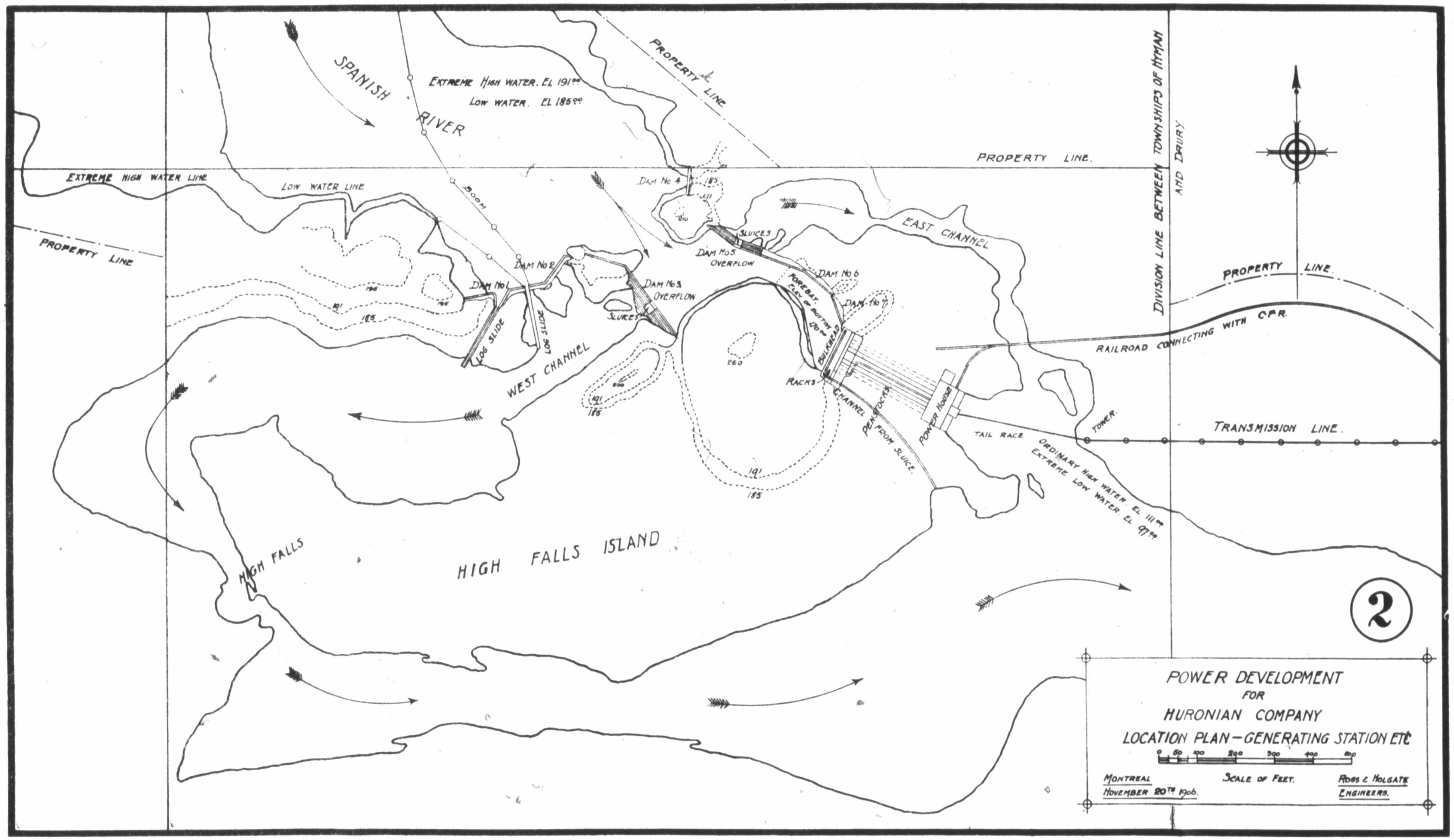
Throughout the smelter the following three-phase, 550 volt induction motors are installed:

3 50 H.P. running at 500 R.P.M.
1 35 H.P. running at 750 R.P.M.

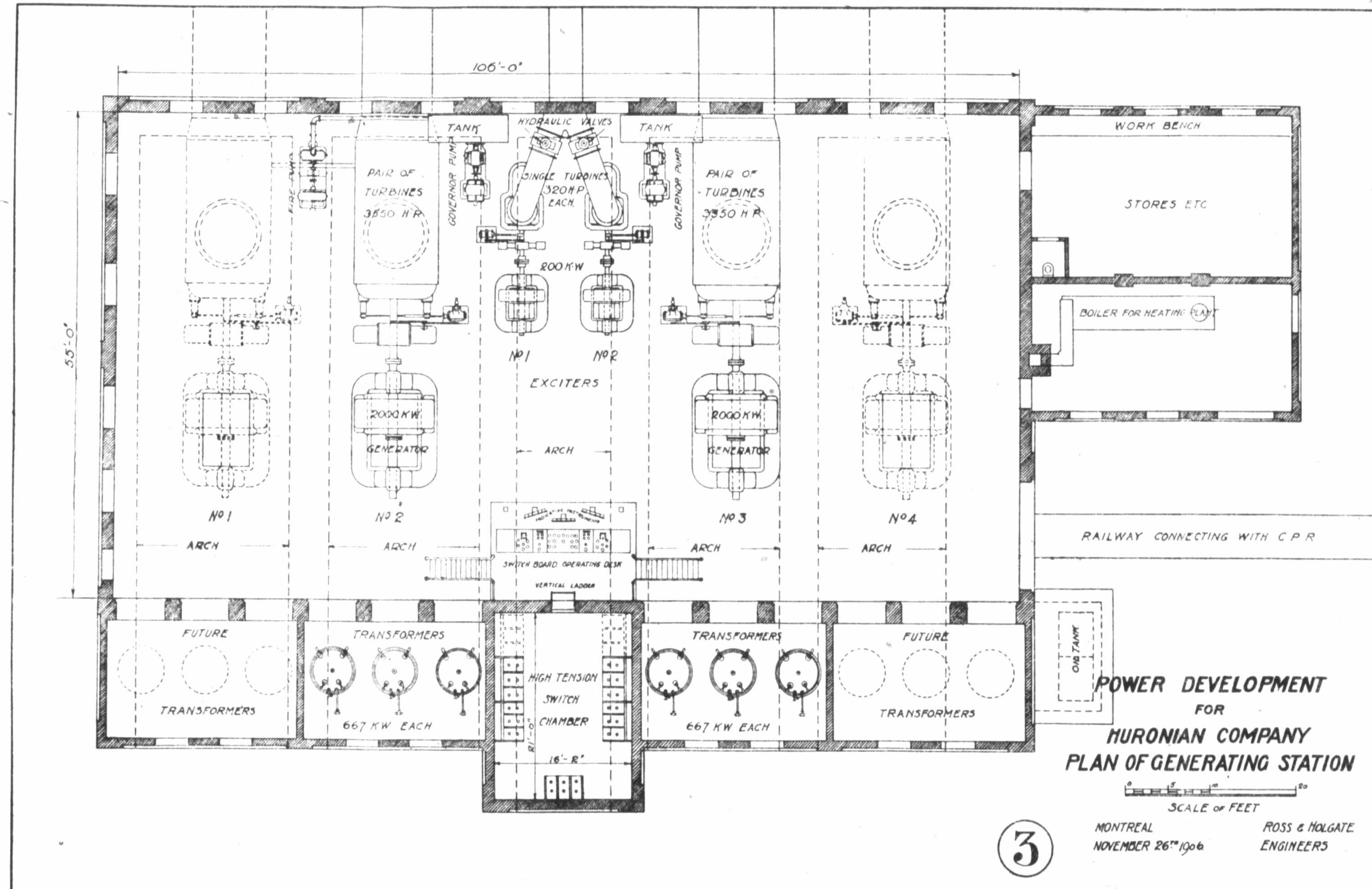
The plant was put into operation in February, 1906.


POWER DEVELOPMENT
FOR
HURONIAN COMPANY
MAP SHOWING LINES AND STATIONS
SCALE OF MILES
MONTREAL
NOVEMBER 15TH 1906
ROSS & HOLGATE
ENGINEERS
HYMAN
DRURY
GENERATING STATION
HIGH FALLS
BRANCH LINE
SPANISH RIVER
TRANSMISSION LINE
OREIN HILL MINE
SUB STATION
DENISON
WORTHINGTON
VICTORIA MINE
WHITEFISH
("300" BRANCH)
TURBINE
NAIRN
LORNE
LOUISE
BALDWIN
CANADIAN PACIFIC RAILWAY
VERMILION RIVER
CREIGHTON
SNIDER
GRAHAM
WATERS
BRODER
TILTON
NO 2 MINE
SUB STATION
COBALT REDUCTION PLANT
CREIGHTON MINE
SUB STATION
COPPER CLIFF
SUB STATION
C.P.R.
MAIN
SUDBURY
LINE
COPPER CLIFF
1

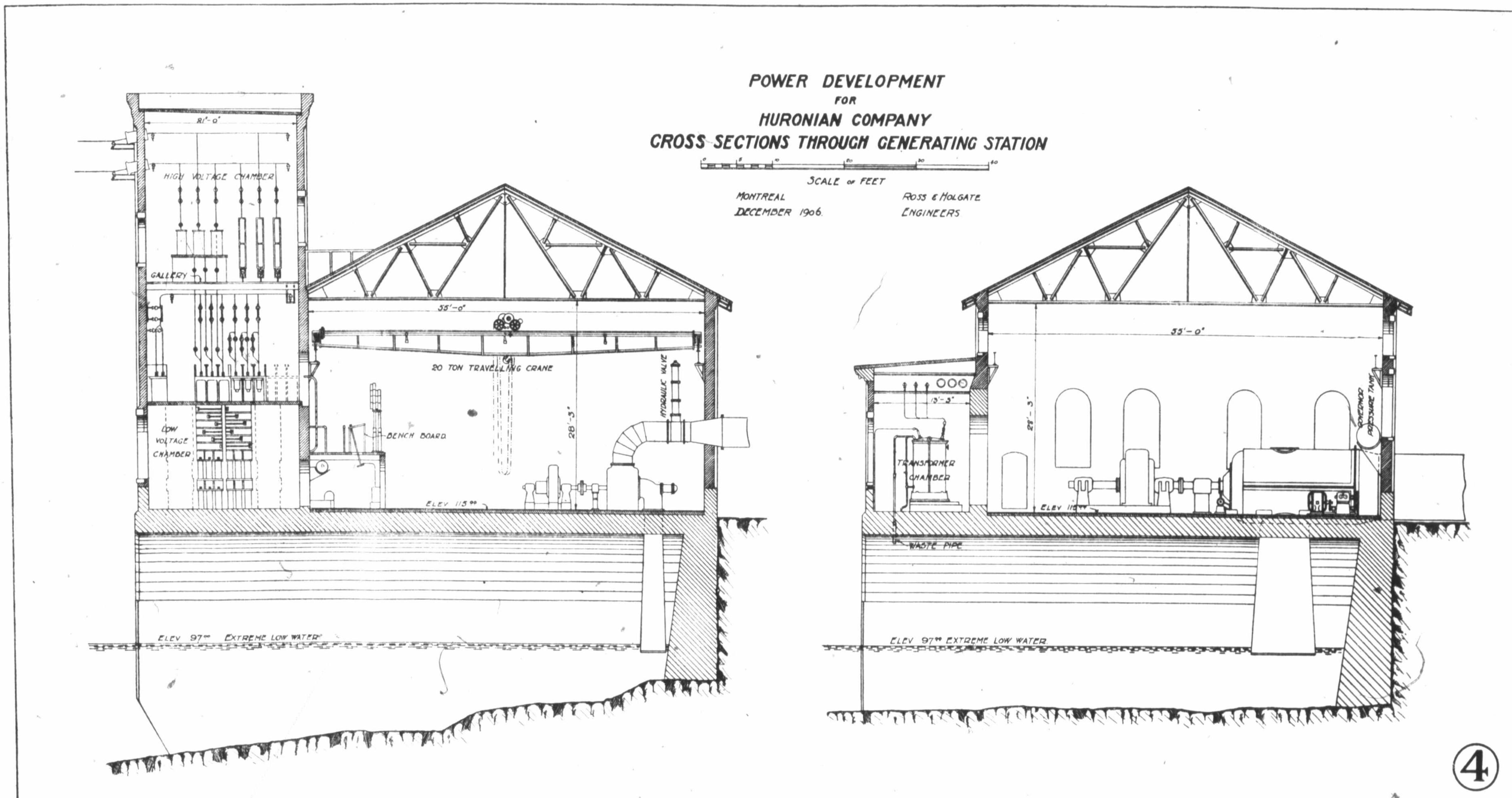
Plan No. 1.


SPANISH RIVER
EXTREME HIGH WATER. EL 191.00
LOW WATER. EL 185.00
PROPERTY LINE
PROPERTY LINE.
EXTREME HIGH WATER LINE
LOW WATER LINE
BOOM
DAM No 1
DAM No 2
DAM No 3 OVERFLOW
DAM No 4
DAM No 5 OVERFLOW
DAM No 6
DAM No 7
SLUICES
LOG SLIDE
WEST CHANNEL
EAST CHANNEL
FOREBAY
BULKHEAD
RACKS
PENSTOCKS
CHANNEL FROM SLUICE
POWER HOUSE
TAIL RACE
TOWER
TRANSMISSION LINE.
RAILROAD CONNECTING WITH C.P.R.
DIVISION LINE BETWEEN TOWNSHIPS OF HYMAN AND DRURY
ORDINARY HIGH WATER EL 111.00
EXTREME LOW WATER EL 97.00
HIGH FALLS
HIGH FALLS ISLAND
2
POWER DEVELOPMENT
FOR
HURONIAN COMPANY
LOCATION PLAN – GENERATING STATION ETC
0 50 100 200 300 400 500
SCALE OF FEET.
MONTREAL
NOVEMBER 20TH 1906.
ROSS & HOLGATE
ENGINEERS.

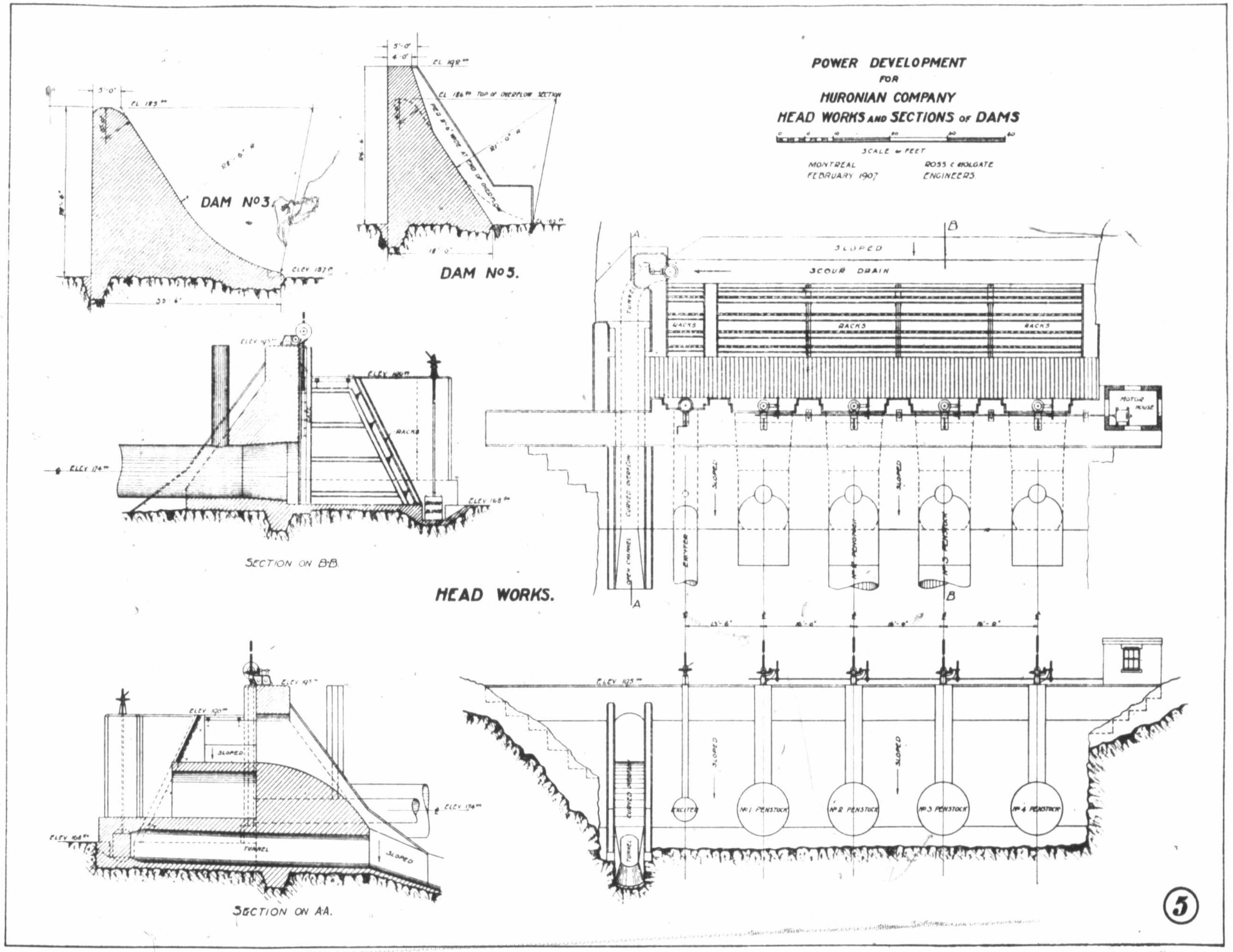
Plan No. 2.


106'-0"
55'-0"
TANK
HYDRAULIC VALVES
TANK
WORK BENCH
PAIR OF
TURBINES
3550 H.P.
GOVERNOR PUMP
SINGLE TURBINES
320 H.P.
EACH
GOVERNOR PUMP
PAIR OF
TURBINES
3550 H.P.
STORES ETC
200 K.W.
BOILER FOR HEATING PLANT
No 1
No 2
EXCITERS
2000 K.W.
GENERATOR
ARCH
2000 K.W.
GENERATOR
No 1
No 2
No 3
No 4
ARCH
ARCH
ARCH
ARCH
RAILWAY CONNECTING WITH C P R
SWITCH BOARD OPERATING DESK
VERTICAL LADDER
FUTURE
TRANSFORMERS
TRANSFORMERS
667 KW EACH
HIGH TENSION
SWITCH
CHAMBER
21'-0"
16'-8"
TRANSFORMERS
667 KW EACH
FUTURE
TRANSFORMERS
OIL TANK
POWER DEVELOPMENT
FOR
HURONIAN COMPANY
PLAN OF GENERATING STATION
SCALE OF FEET
3
MONTREAL
NOVEMBER 26TH 1906
ROSS & HOLGATE
ENGINEERS

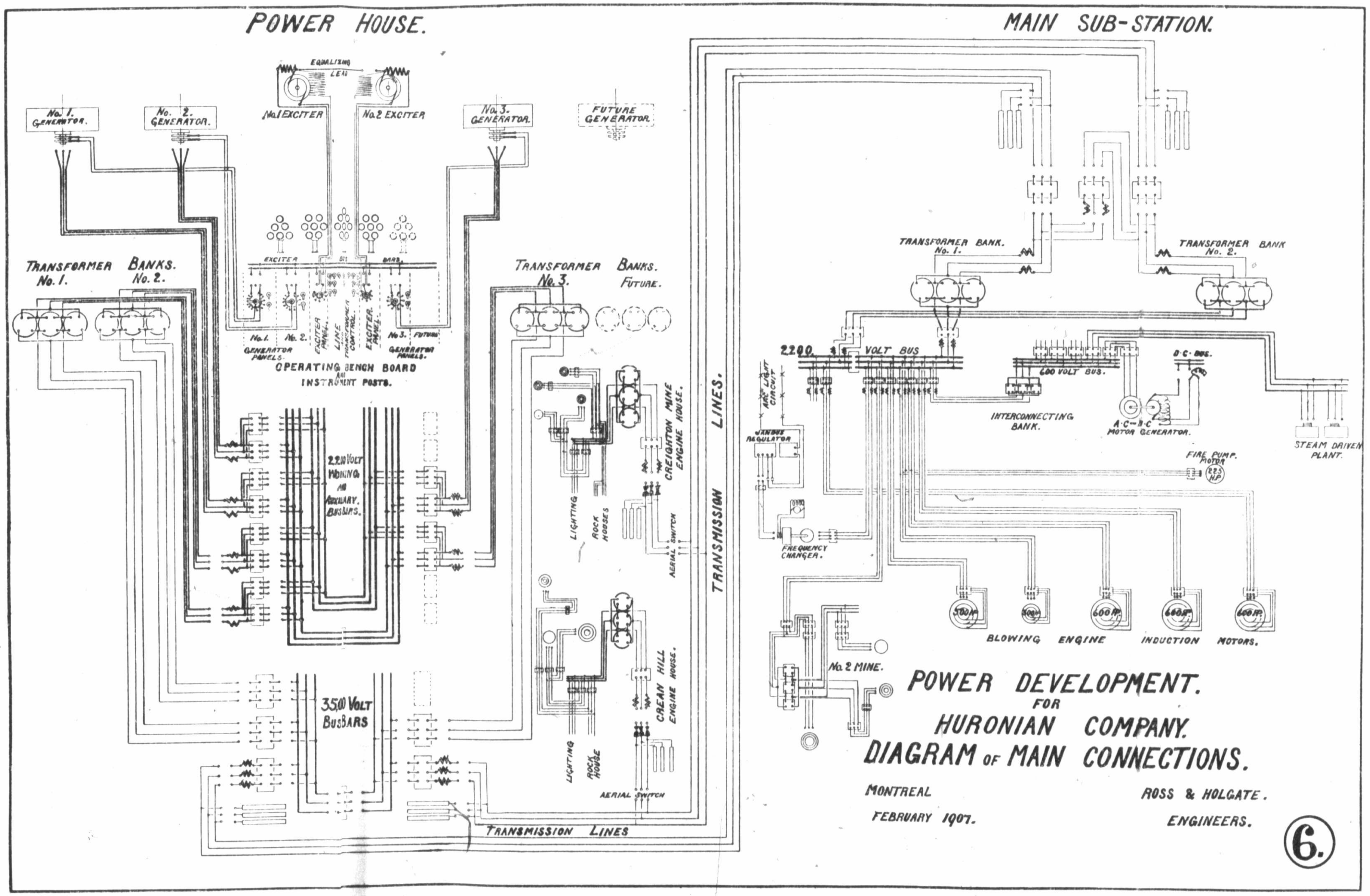
Plan No. 3.


POWER DEVELOPMENT
FOR
HURONIAN COMPANY
CROSS SECTIONS THROUGH GENERATING STATION
SCALE OF FEET
MONTREAL
DECEMBER 1906.
ROSS & HOLGATE
ENGINEERS
HIGH VOLTAGE CHAMBER
GALLERY
LOW VOLTAGE CHAMBER
20 TON TRAVELLING CRANE
BENCH BOARD
HYDRAULIC VALVE
ELEV 115
ELEV 97 EXTREME LOW WATER
TRANSFORMER CHAMBER
WASTE PIPE
PRESSURE TANK
ELEV 97 EXTREME LOW WATER
4

Plan No. 4.


POWER DEVELOPMENT
FOR
HURONIAN COMPANY
HEAD WORKS AND SECTIONS OF DAMS
SCALE OF FEET
MONTREAL
FEBRUARY 1907
ROSS & HOLGATE
ENGINEERS
DAM No3.
DAM No5.
SECTION ON B-B.
HEAD WORKS.
SECTION ON AA.
SLOPED
SCOUR DRAIN
RACKS
MOTOR HOUSE
TUNNEL
EXCITER
No 1 PENSTOCK
No 2 PENSTOCK
No 3 PENSTOCK
No 4 PENSTOCK
5

Plan No. 5.


POWER HOUSE.
MAIN SUB-STATION.
No. 1. GENERATOR.
No. 2. GENERATOR.
No. 1 EXCITER
No. 2 EXCITER
No. 3. GENERATOR.
FUTURE GENERATOR
TRANSFORMER BANKS. No. 1. No. 2.
TRANSFORMER BANKS. No. 3. FUTURE.
OPERATING BENCH BOARD AND INSTRUMENT POSTS.
2200 VOLT WORKING AND AUXILIARY BUSBARS.
3500 VOLT BUSBARS
CREIGHTON MINE ENGINE HOUSE.
LIGHTING
ROCK HOUSES
AERIAL SWITCH
CREAN HILL ENGINE HOUSE.
ROCK HOUSE
TRANSMISSION LINES.
TRANSMISSION LINES
TRANSFORMER BANK. No. 1.
TRANSFORMER BANK No. 2.
2200 VOLT BUS
600 VOLT BUS.
D.C. BUS.
INTERCONNECTING BANK.
A.C.-D.C. MOTOR GENERATOR.
STEAM DRIVEN PLANT.
FIRE PUMP MOTOR
FREQUENCY CHANGER.
BLOWING ENGINE INDUCTION MOTORS.
No. 2 MINE.
POWER DEVELOPMENT.
FOR
HURONIAN COMPANY.
DIAGRAM OF MAIN CONNECTIONS.
MONTREAL
FEBRUARY 1907.
ROSS & HOLGATE.
ENGINEERS.
6.

Plan No. 6.