Please read and send in as full a discussion as possible at earliest date.

# The Canadian Society of Civil Engineers.

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## POWER DEVELOPMENT ON THE KOOTENAY RIVER FOR THE WEST KOOTENAY POWER & LIGHT COMPANY, LIMITED.

By Robert A. Ross and Henry Holgate.
(Members Can. Soc. C. E.)

Read at joint meeting of the Mechanical and Electrical Sections, May 9, 1907.

The Kootenay River rises in the northern part of Windermere, in British Columbia, a short distance east of the head waters of the Columbia River, and flows southerly parallel to the north-flowing waters of the Columbia for fifty miles, thence through Fort Steele and across the International Boundary into United States territory, flowing south and north-west for a distance of about 120 miles. It then enters Canadian territory again, and soon expands into what is known as Kootenay Lake, which receives a number of small streams in its northern arm. The lake discharges by way of the west arm, at the western end of which is the town of Nelson; the river keeps a south-westerly course to its junction with the Columbia River at Robson. The total length of the river is about 350 miles, and the area drained by it and its tributaries, above a point ten miles below Nelson, is some 9,800 square miles, of which 2,500 square miles are United States territory.

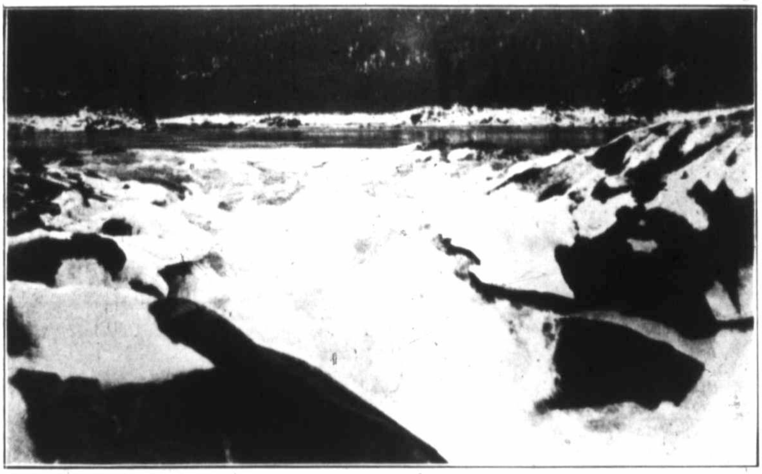
The minimum flow of the river, at a point about nine miles below Nelson, was found to be 5,850 cubic feet per second. These measurements were taken in January, 1905, when the water in the river was lower than at any season previously observed. The variations in flow of the river are very great, but no measurement of maximum flow has been made as far as is known. The periods of high and low water differ from those of rivers not situated in mountainous country, and, in the case of the Kootenay River, which largely depends for its supply from the masses of melting snow on mountains of great altitude, the high water period is comparatively late in the season, highest water being in June and July, as shown on the diagram No. 1.

The power development herein described was built at the Upper Bonnington Falls, the lower falls having been partially developed some years ago by the same Company. The site for the development of the upper falls was chosen on the north bank of the river, and is generally shown on accompanying diagram No. 2.

The channel between the Rocky Island and the north bank was made use of for approach and tail race; the power house was built in the river, and a cofferdam was built from the bank to the island, thus unwatering the whole site and diverting the water to the south of the island. Although the natural channel assisted materially in the development work, yet about 40,000 cubic yards of rock had to be removed to provide power house foundations and tail race. The removal of this rock was somewhat difficult, owing to the confined area in which the work had to be done, the difficulty of disposing of it, the nature of the rock (Nelson Granite) and the irregularity in direction of the seams in the rock, some of which had to be excavated under water. As a large part of the concrete work admitted of the use of large stones, those most suitable for the work were piled up in convenient places for this purpose, and a large quantity was passed through crushers and used in the concrete.

By referring to diagram No. 1, it will be observed that the variations between high and low water above and below the falls do not correspond. The reason for this is, that at present the flow of the river below the falls is restricted by a number of rocky islands. These hold back the flow of the stream, but it is the intention to improve this channel, so as to afford more channel area and more nearly equalize the rise and fall below the falls with the rise and fall above them.

Owing to these variations, which can never be entirely eliminated (except at a cost beyond commercial practicability), the vertical type of wheel setting was adopted, using all the head available at all stages of water, instead of adopting a head which would be nearly constant and which would involve the sacrifice of a large amount of power for periods when low water prevailed.



Site of Power Plant.

Cofferdam.


Power House during Construction.

Of course, when the natural head is least, the volume of water used is not important, as the quantity available is more than ample, but at periods of low water the head is greatest, and the vertical setting is an advantage since it permits the use of the higher head. Had a horizontal wheel setting been adopted, the power house floor would have had to be set above highest water, and, allowing the use of a draft tube of 24 feet at this altitude, the tail water would have had to be maintained at a level above low water, which would involve the loss of head for a considerable period of every year when water was low and, consequently, when head was most valuable.

It is the intention to increase the natural head by building a timber dam across the river to a height that will drown the rapids above the fall, thus affording an increase of head of ten feet, and the machinery and works are designed to meet this condition. This work will be done during the current year. There are no troubles from ice on this river.

It is possible to construct works at the outlet of the Kootenay Lake to maintain the lake level more nearly uniform, and thus to assist materially in reducing maximum discharge and increasing minimum discharge of the river below this point. This will render working conditions much better and increase the potentiality of the river considerably. However, the matter has not yet been considered by the Government, though it would afford advantages of public benefit in the navigation of the lake, which is now, and will perhaps always be, a part of the transportation system of this district, owing to the great difficulty of constructing a railway from Kootenay Landing to Proctor, located 17 miles above Nelson.

The power house construction and arrangement are shown on the accompanying sketches, Nos. 4, 5, and 6. The building is entirely of monolithic concrete construction, reinforced wherever necessary; the reinforcement consisting of round steel rods, and in some places of steel rails, which were used in parts of the structure under severe strain.

The general scheme can readily be seen by referring to plan No. 6. The water enters the flume through the submerged openings between the piers, and can be shut off by gates or by stop logs, the latter being provided for, so as to render the gates accessible in case of emergency. Behind the gates are the screens, which are thus rendered accessible for repairs or cleaning if necessary. The water flows down the tube formed in the concrete to the wheels, of which there are three on each shaft, two discharging into the upper draft tube and one into the lower tube, uniting in a common discharge, which is placed below low water. The draft tubes are moulded in concrete and have no steel lining, being built up with the structure, cored openings in the monolith. Care was taken to secure a very smooth surface on the inside of all passages for water, and their curves and cross sections were designed to offer as little resistance as practicable.

The exciter turbines are similarly arranged, but are made to operate under a constant head by having the discharge at a higher level, which level is maintained by a weir.

The pressure pumps, governors, and low tension cables are all located in the chamber below the power house floor, the only machinery on the floor being the generators, controlling board and the low tension switches. The crane travels the length of the power house and over the railway track, so that all machinery can be handled from the car to place by the crane. Any leakage through the up-stream wall is taken care of in the air space and drained off.

The tail race openings are also provided with gates and stop logs, which can be closed, and any chamber can be emptied of its water by a system of drains and valves, leading the water from any one chamber to a well at the south end of the building, where a centrifugal pump throws it out into the tail race. The head water is admitted through a by-pass, as shown on plan No. 4. The whole scheme provides the greatest facility for inspection and making of repairs when necessity arises.

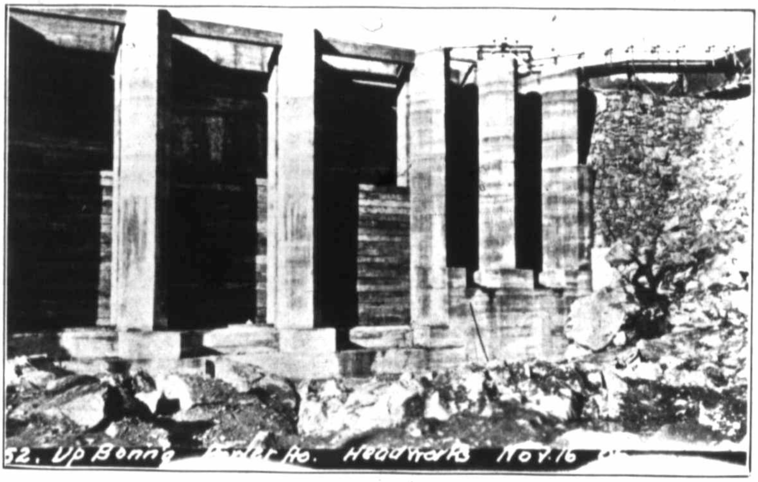
The transformer house and switch room are clearly shown on plans No. 7 and No. 8. The floor of the transformer room is at such a level as to permit of the transformers being wheeled on their own trucks from a flat car on the railway siding into place. The transformers are entirely separated from the switch room by a concrete wall, and the whole building is of concrete, including the partitions and barriers.

Owing to the peculiar location necessary for the transformer and switch building in relation to the power house, it was necessary to throw arches over a gap in the rock to provide foundation for the building, this will be seen on plan No. 8.

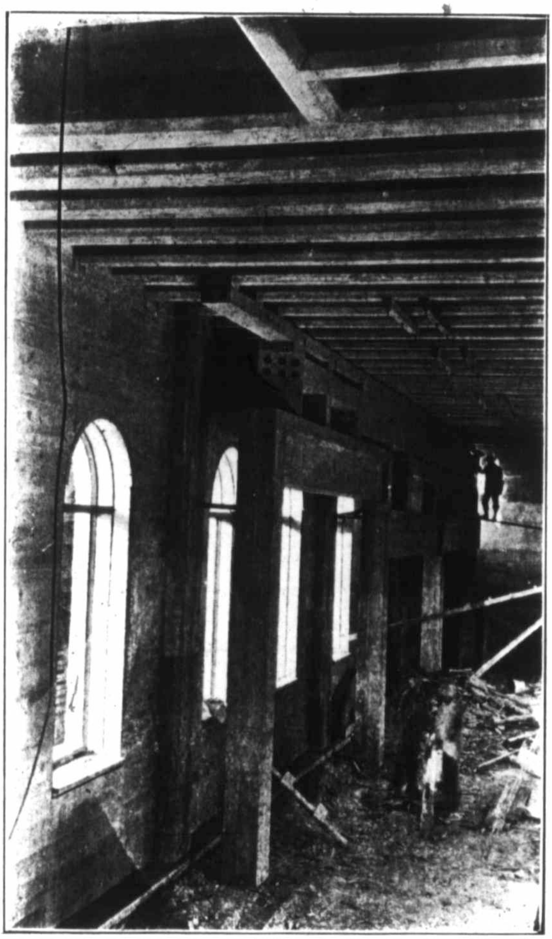
As this work is the largest single piece of concrete construction yet built in the Province, it is satisfactory to be able to say that the whole of the cement used was manufactured in British Columbia, and successfully passed the rigid tests of the Engineers prior to acceptance.

*Hydraulic Machinery.*—Each main unit is capable of delivering to its electrical generator 8,000 mechanical horse power when operating under a head of 70 feet of water and when running at a speed of 180 revolutions per minute. The quantity of water


Downstream View of Power House.




View Showing Upstream Piers.



Pump Chamber and Duct System.

required per unit is 1,260 cubic feet per second, or a volume equal to the flow of a river 100 feet wide, 5 feet deep, and moving with a velocity of 151.2 feet per minute.

Each 8,000 H.P. turbine consists of three inward flow Francis runners mounted on a vertical shaft, each runner being equipped with its own distributor and moveable guide vanes. These distributors are bolted to heavy cast iron base rings secured to the masonry. The runners are thus mounted in concrete pits, which form the turbine wheel casings and the draft tubes for carrying the discharge water to the tail race.

The runners are made of special turbine metal of approximately 88 parts copper, 10 parts tin, and 2 parts zinc. Each is made in one piece, cast in cores and bolted to the hub. The hubs are made by enlarging the shaft at the points where the runners are attached, and heavy flanges are turned on the shaft above the hubs, to which the runners are securely bolted.

The upper and intermediate runners discharge in opposite directions into a common draft tube, the upper one discharging downward. The lower runner, like the upper one, discharges downward also, but into its own individual draft tube. The chamber above the upper runner is by-passed to the draft tube, which relieves the pressure in the chamber, and thus eliminates the hydraulic thrust of this runner. As the other two runners discharge in opposite directions, the total resultant thrust on the shaft is theoretically zero. The thrust bearing, however, has been designed to take care of a generous amount of thrust over and above the dead weight of the revolving parts. The revolving parts consist of the rotor of the generator, the shaft in three sections, three runners weighing 4,000 pounds each, couplings and bolts, making a total of 170,000 pounds. The thrust bearing consists of two specially close grained cast iron disks. The lower disk is supported by a ball seat, while the upper is securely held in place by an adjusting nut on shaft. The disks have raised lips on the outside and inside circumferences, so as to form an annular pressure chamber, into which the oil is forced under a pressure of 250 pounds, which lifts the revolving parts. When these parts are lifted the oil escapes between the surfaces of the disks, by this means supporting the total weight on a film of oil.

The thrust bearing is covered with a cover, fitted with glass peep holes. The oil is supplied to the bearing from a high pressure triplex pump, capable of working under a pressure of 500 pounds per square inch. This pump is directly driven from the main turbine shaft by bevel gearing and counter shaft. Each turbine has its own pump, oil tank, piping, gauges, etc., which, in fact, is a complete system in itself, and independent of the governor system.

An extra motor driven pump, with piping, has been provided, which is arranged to act as a spare for any one of the main units or exciters, but its primary use is to supply oil to the turbines when starting up.

The main turbine shaft is kept in alignment by three guide bearings. The upper guide bearing is built in conjunction with the thrust bearing. It is lined with Parson's White Brass and is lubricated by oil supplied under pressure.

The intermediate and lower guide bearings, the former situated above the upper runner, and the latter between the intermediate and lower runners, are of lignum vitæ, made by driving lignum vitæ into the dovetail spaces in the bronze boxes. As these bearings are submerged, they are well lubricated with water and require little or no attention.

The water is distributed to the runners through malleable iron moveable guide vanes finished smooth, so as to offer little resistance to the water. These vanes are operated by means of links from one side of the vane. The links are connected up to the vane operating ring. The rings are operated by rods and levers from a vertical shaft which leads to the operating deck, where the governor is located.

The revolving balls of the governor control a pilot valve attached to an equalizing lever. This valve operates a relay valve, which in turn controls the main operating piston, which is connected to the vane operating shaft.

An oil pump, a pressure tank, and the necessary piping is furnished with each governor.

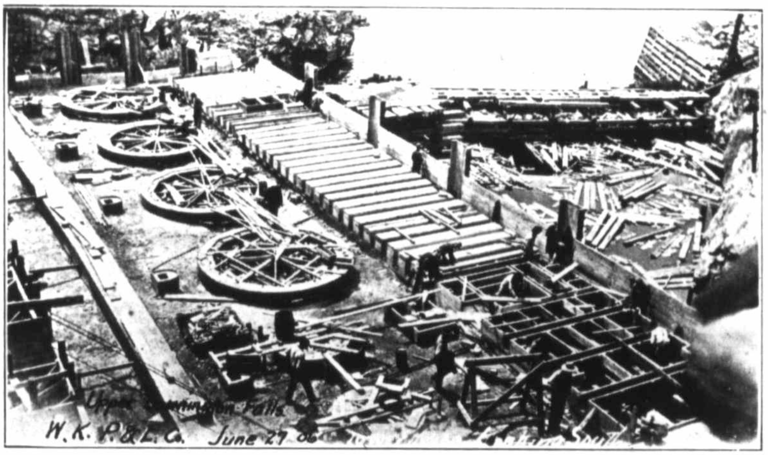
In order to control the speed of the turbines from the switchboard, each governor is furnished with remote electric control.

The two upper sections of the main turbine shafting are joined together by a cast steel coupling four feet in diameter. The brake mechanism is fitted about the coupling, the outer edges forming the brake band. Two brake shoes are applied on the brake band, and a hand mechanism is arranged so that a force of 10,000 lbs. is brought on each brake shoe.

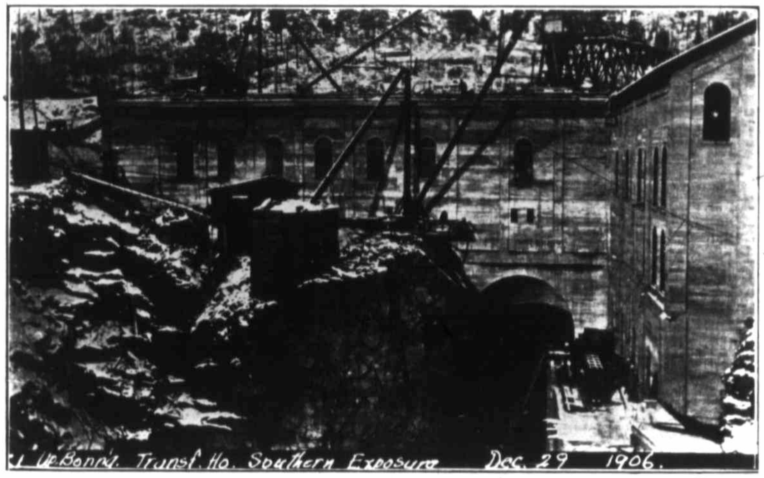
Each turbine is guaranteed to give an efficiency of at least 80% when delivering 8,000 H.P. and operating under a head of 70 feet running at a speed of 180 revolutions per minute.

The hydraulic machinery is all the product of the I. P. Morris Company, whose hydraulic engineer, Mr. W. M. White, designed and carried out the work so successfully.

*Electrical Development.*—The general scheme of electrical distribution is so arranged that power can at present be delivered to




Generator Floor in Construction.




View showing Transformer House.

Phœnix, 79 miles distant, at 60,000 volts; Grand Forks, 69 miles distant, at 60,000 volts; Greenwood, 83 miles distant, at 60,000 volts, and to Rossland, 32 miles distant (in the latter case over the existing lines of the old plant), at 22,000 volts.

It will be seen that owing to the complication involved in tying-in to the old plant two transmission voltages were required, and therefore transformers, switching apparatus, etc., had to be provided for both. Plan No. 9 shows diagramatically the connections of the different plants and sub-stations.

The whole of the power so far sold is used for mining work for large motor equipments, for the lighting and power of the mines, and the lighting requirements of the various mining towns above mentioned.

In addition, it is thought that the company will be able, at some time in the not distant future, to sell power to the railways in the vicinity of Rossland for operating, especially on the heavy grades necessary in attaining the elevation of the Rossland Camp. The haulage over those grades at the present time is operated by steam locomotives of special type. In some cases these are geared, and switchbacks are established along the route in order to ease grades and for safety. As the heaviest grade does not exceed 4½%, this is quite within the capacity of a modern electric locomotive of considerably less total weight than the present steam machines, and as the advent of the single phase motor has rendered it possible to operate without the use of rotary converters or dynamo motor sets, the problem is much simplified.

*Generators and Exciters.*—The generators are four in number, each of 4,500 Kw. capacity at 2,200 volts and 80% power factor, at a frequency of 60 cycles, being of the umbrella type and directly connected to vertical water wheels. Two units only are at present installed.

The exciters are two in number, each of a capacity sufficient to excite the entire equipment when finally installed. These are also of the umbrella type and directly connected to vertical wheels.

*Generating Station Switchboard.*—As will be seen from plan No. 4 current is carried at 2,200 volts to the bus bars, in compartments elevated above the station floor, and formed entirely of concrete, all parts being thoroughly barriered with the same material. The top of this bus bar compartment, in which all operating transformers are placed, forms the base of a platform, upon which are mounted 19 2,200 volt oil switches, all being motor operated by distant control from the bench board.

The bench board, which contains the controls for the whole of the station, including the 2,200 volt switches, 20,000 volt switches, 60,000 volt switches, together with the speeders for the water wheels, is situated in front of the instrument panel at the end of the station, all connections thereto being reduced to a pressure of not over 110 volts for safety.

The general switching arrangement has been worked out on the basis of two separate and distinct plants, which may be coupled together or run separately on any transmission line or any bank of transformers.

The cables for connecting to the low voltage bus bars, and from thence to the transformer station adjacent, are all rubber covered and drawn into bituminous fibre ducts, which are embedded in the concrete floors, partitions, etc.

*Transformer Station.*—The transformer station is arranged for four banks of 60,000 volt transformers, each transformer being of 1,875 kilowatts capacity, at 60,000 volts, and one bank of three transformers, each of 1,000 kilowatt capacity, at 20,000 volts, for interconnecting between the station herein described and the old development, which is distant about one mile; of these two banks of 60,000 volt and one bank of 20,000 volt transformers have been installed.

All of the switches throughout the transformer house are motor operated and controlled from the bench board in the same station.

In every case live parts, such as wires, etc., are kept three feet apart and 18 inches from all walls and barriers, and mounted on 60,000 volt insulators. The transformers are oil-filled and water-cooled, and have all the necessary connections for natural circulation of water and for handling of oil into and out of storage tanks by means of oil pumps.

*Sub-Stations; Phoenix, Grand Forks, Greenwood.*—The design of these sub-stations, all of which are alike, is shown on plan No. 10.

Both the transmission lines enter the tower through special entrances, consisting of plate glass and porcelain tubes; from whence the lines pass through the choke coils and disconnecting switches, and from there into the high tension distant control oil switches, and finally into the main transformers, being transformed in pressure from 50,000 to 2,200 or 440 volts, as required by the motor service.

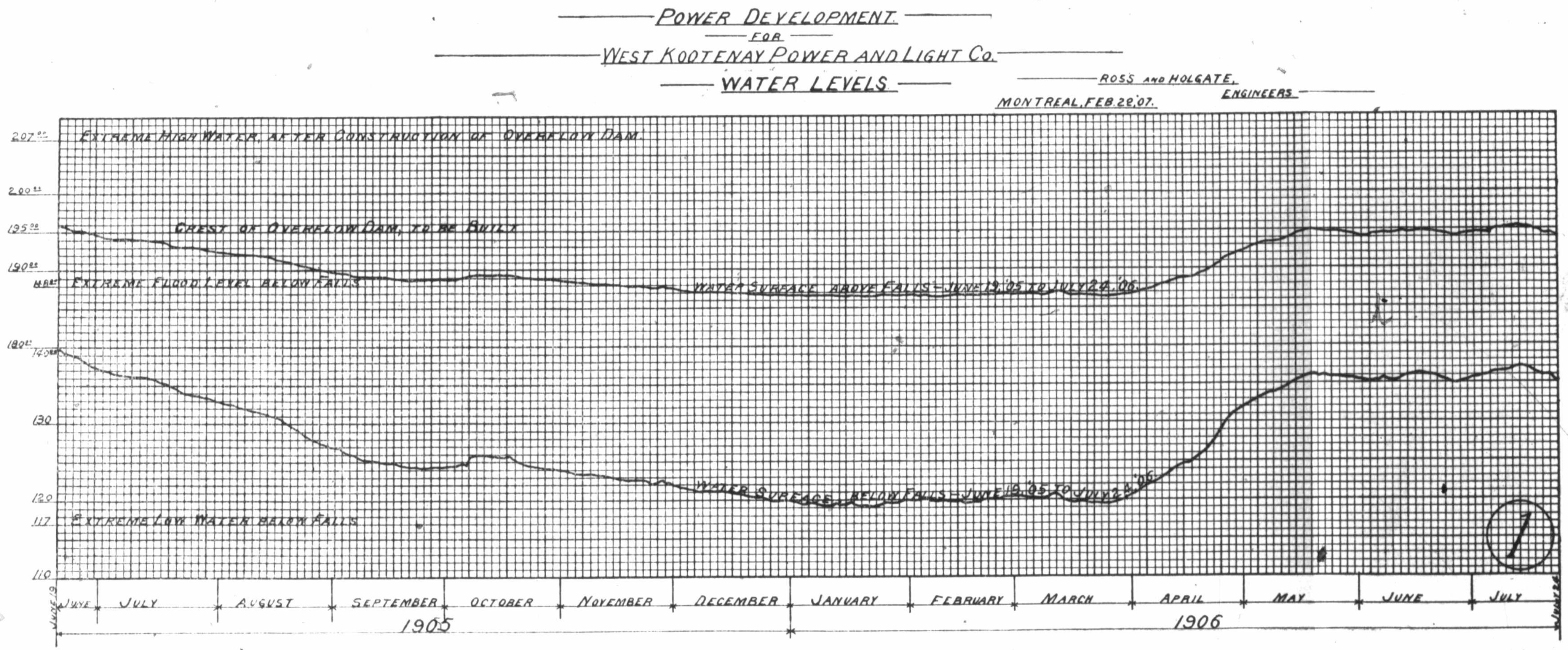
The transformers of 1,000 Kw. each are located in banks of three in separate compartments, the necessary cooling water and oil piping and tanks being supplied. The transformers are mounted on trucks and arranged so that they can readily be run out of the compartments.

*High Tension Switch Room and Tower.*—In this compartment are installed all the high tension apparatus, lightning arresters, switches, etc. The floor of this compartment is raised four feet above the general level, this space thus rendered available being used for carrying the high tension lines connecting between lines and switches. For convenience in inspecting and cleaning the lightning arresters, etc., an elevated walk way has been provided in this compartment. All low tension cables are carried in fibre conduit set in concrete.

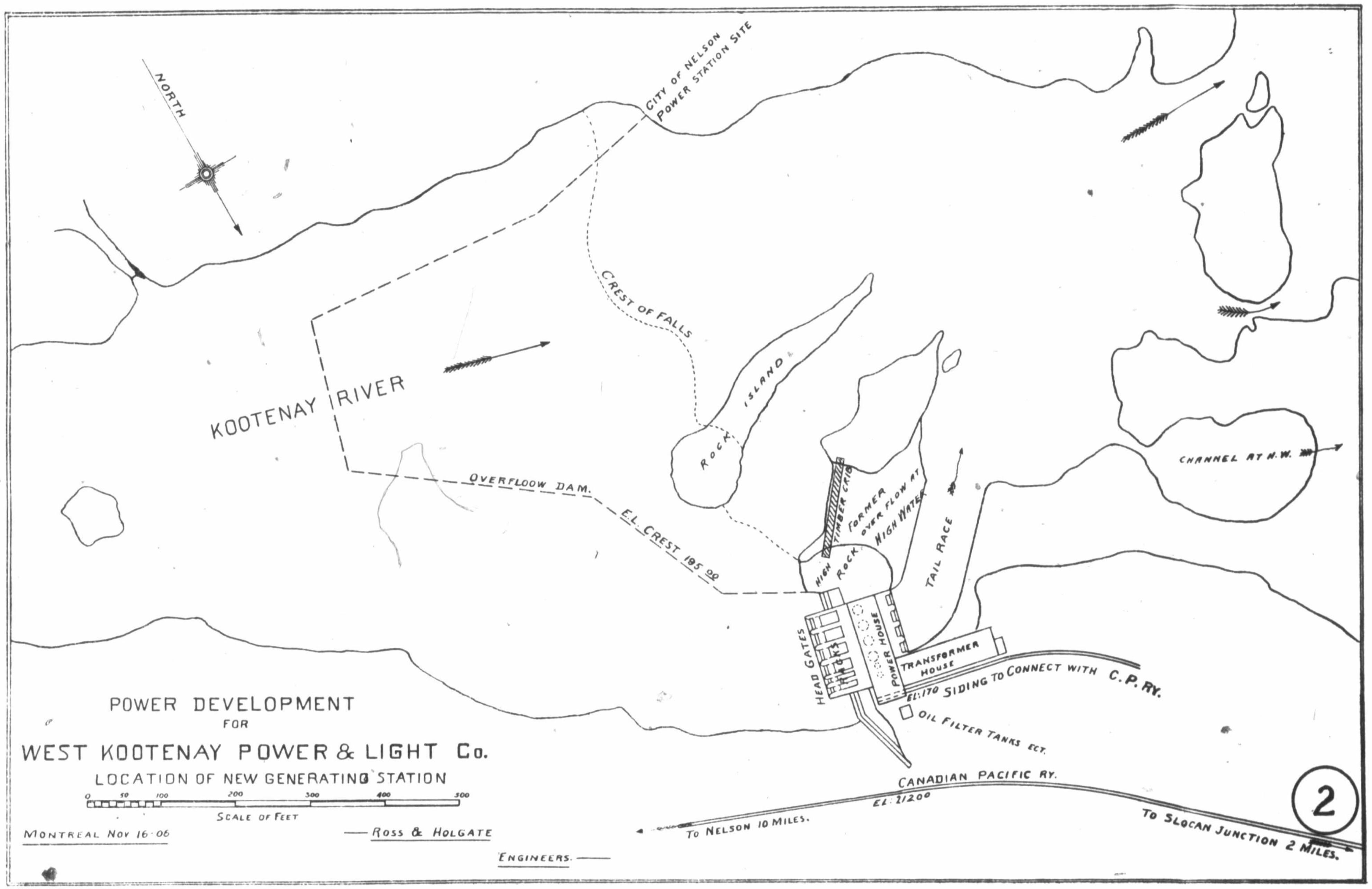
*Low Tension Switchboard Room.*—This room contains all the control apparatus for the high tension switches, etc., as well as feeder panels for low tension lines, also the storage battery for operating the motor operated switches, motor generator set for charging the batteries, etc. One end of this compartment is reserved as a store room for supplies.

The construction of this entire plant was done by day labor under the supervision of the engineers. It was commenced in June, 1905, and water was admitted to the forebay December 24th, 1906. Exciters were operated on December 29th, and one of the power units went into commission on the following day.

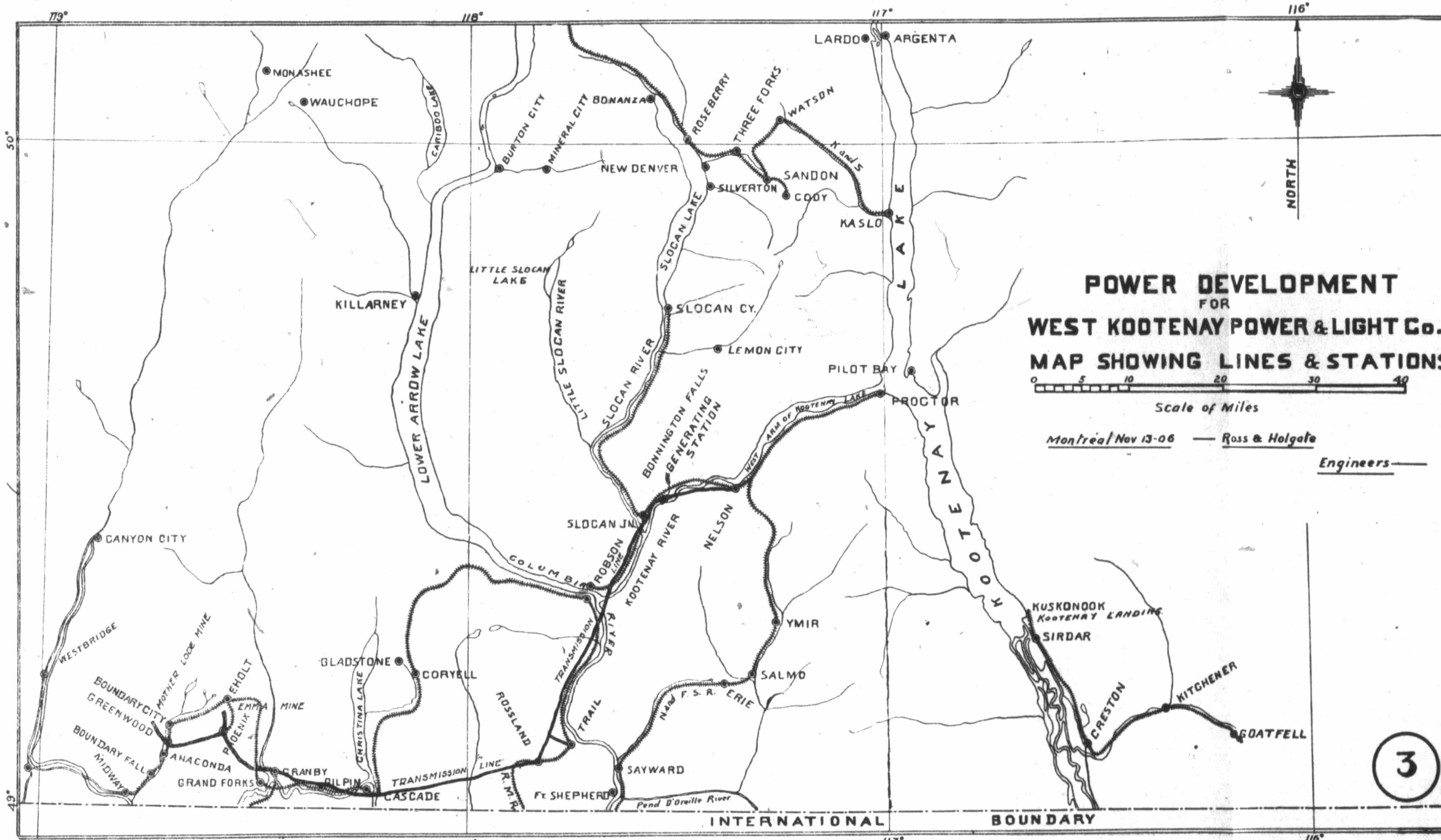
We desire to acknowledge the assistance of Mr. John L. Allison, Member Canadian Society of Civil Engineers, and of Mr. J. N. Smith, for the able assistance given in designing this work, and also the services of Mr. Geo. E. Revell, A.M.C.S.C.E., Mr. Walter J. Francis, M.C.S.C.E., and Mr. A. C. D. Blanchard, A.M.C.S.C.E., who at various stages of the work directed its construction.


POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER AND LIGHT Co.
WATER LEVELS
ROSS AND HOLGATE,
ENGINEERS
MONTREAL, FEB 28, '07.
EXTREME HIGH WATER, AFTER CONSTRUCTION OF OVERFLOW DAM.
CREST OF OVERFLOW DAM, TO BE BUILT
EXTREME FLOOD LEVEL BELOW FALLS
WATER SURFACE ABOVE FALLS - JUNE 19, '05 TO JULY 24, '06.
WATER SURFACE BELOW FALLS - JUNE 19, '05 TO JULY 24, '06
EXTREME LOW WATER BELOW FALLS
207.00
200.00
195.00
190.00
180.00
130
120
117
110
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
1905
1906
1

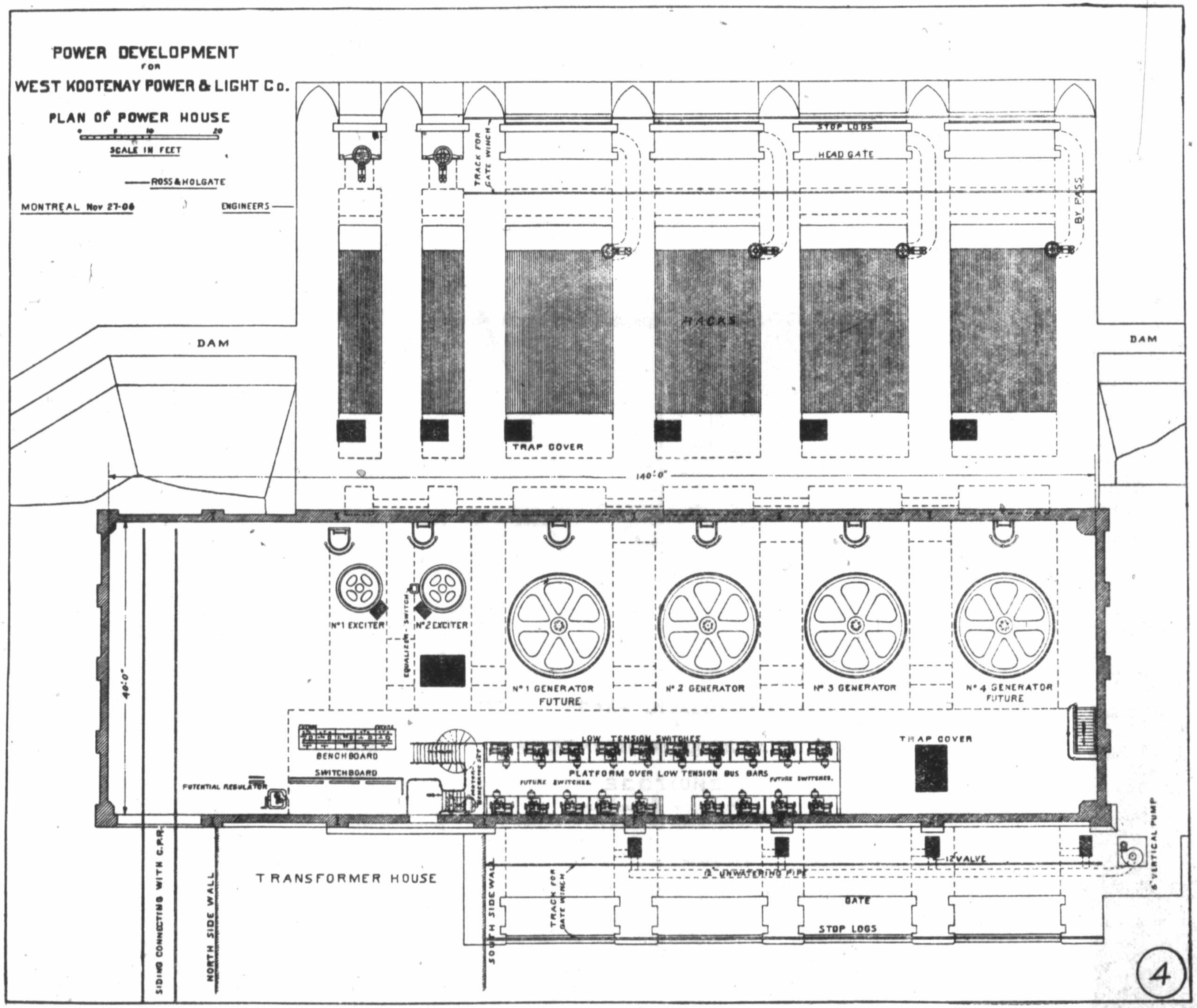
Plan No. 1.


NORTH
CITY OF NELSON POWER STATION SITE
CREST OF FALLS
KOOTENAY RIVER
ROCK ISLAND
OVERFLOOW DAM.
EL CREST 195.00
HIGH TIMBER CRIB
ROCK
FORMER OVER FLOW AT HIGH WATER
TAIL RACE
CHANNEL AT H.W.
HEAD GATES
RACKS
POWER HOUSE
TRANSFORMER HOUSE
EL.170 SIDING TO CONNECT WITH C.P. RY.
OIL FILTER TANKS ECT.
CANADIAN PACIFIC RY.
EL. 2/200
TO NELSON 10 MILES.
TO SLOCAN JUNCTION 2 MILES.
POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co.
LOCATION OF NEW GENERATING STATION
0 50 100 200 300 400 500
SCALE OF FEET
MONTREAL NOV 16-06
ROSS & HOLGATE
ENGINEERS.
2

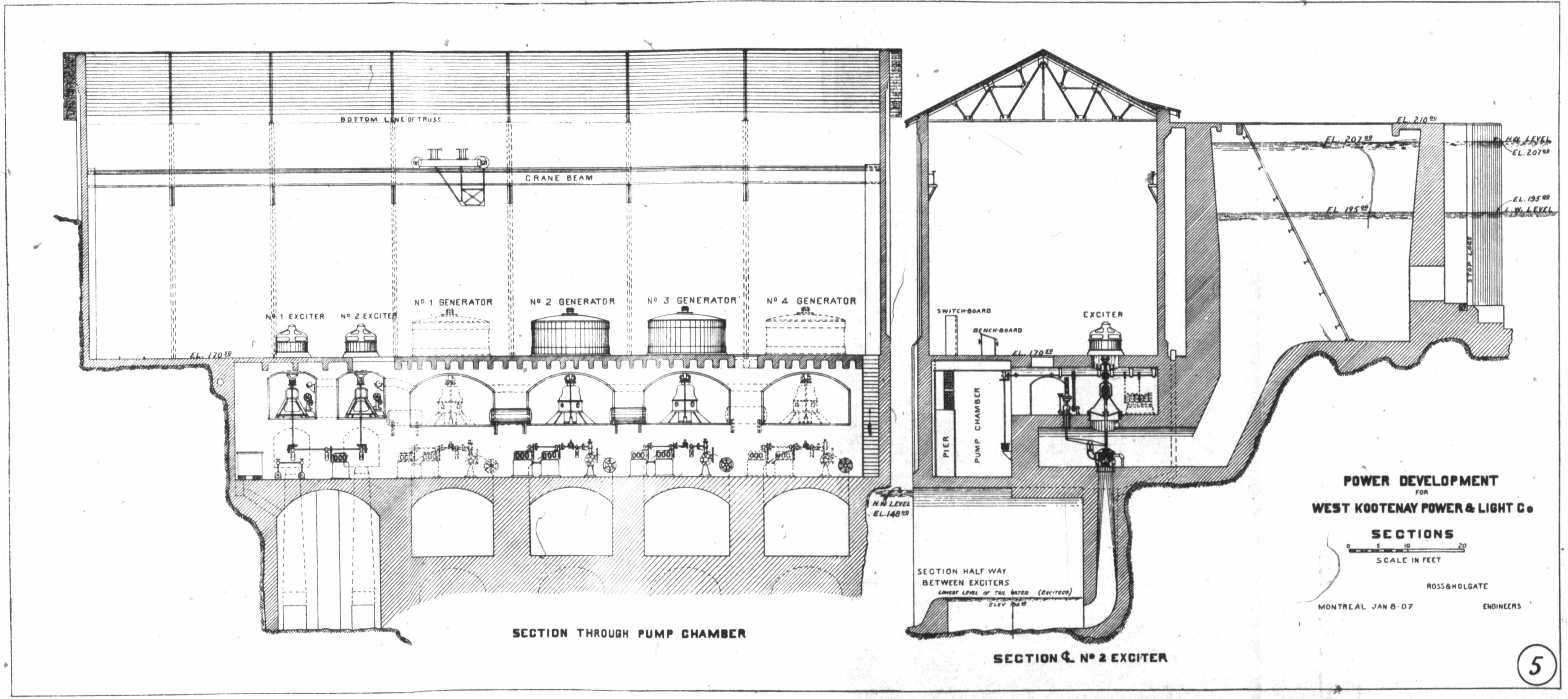
Plan No. 2.


POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co.
MAP SHOWING LINES & STATIONS
0 5 10 20 30 40
Scale of Miles
Montreal Nov 13-06 — Ross & Holgate
Engineers
NORTH
119° 118° 117° 116°
50° 49°
INTERNATIONAL BOUNDARY
MONASHEE
WAUCHOPE
CARIBOO LAKE
BURTON CITY
MINERAL CITY
BONANZA
ROSEBERRY
THREE FORKS
WATSON
LARDO
ARGENTA
NEW DENVER
SILVERTON
SANDON
CODY
KASLO
K and S
LITTLE SLOCAN LAKE
KILLARNEY
SLOCAN LAKE
SLOCAN CY.
LEMON CITY
LITTLE SLOCAN RIVER
SLOCAN RIVER
PILOT BAY
PROCTOR
LOWER ARROW LAKE
BONNINGTON FALLS GENERATING STATION
WEST ARM OF KOOTENAY LAKE
KOOTENAY LAKE
SLOCAN JN.
NELSON
CANYON CITY
COLUMBIA
ROBSON
LINE
KOOTENAY RIVER
TRANSMISSION
RIVER
YMIR
KUSKONOOK
KOOTENAY LANDING
SIRDAR
WESTBRIDGE
MOTHER LODE MINE
BOUNDARY CITY
GREENWOOD
EHOLT
EMMA MINE
PHOENIX
GLADSTONE
CORYELL
ROSSLAND
TRAIL
SALMO
ERIE
N and F.S.R.
CRESTON
KITCHENER
GOATFELL
BOUNDARY FALLS
MIDWAY
ANACONDA
GRAND FORKS
GRANBY
GILPIN
CHRISTINA LAKE
CASCADE
TRANSMISSION LINE
R.M.R.
SAYWARD
Ft. SHEPHERD
Pend D'Oreille River
3

Plan No 3.

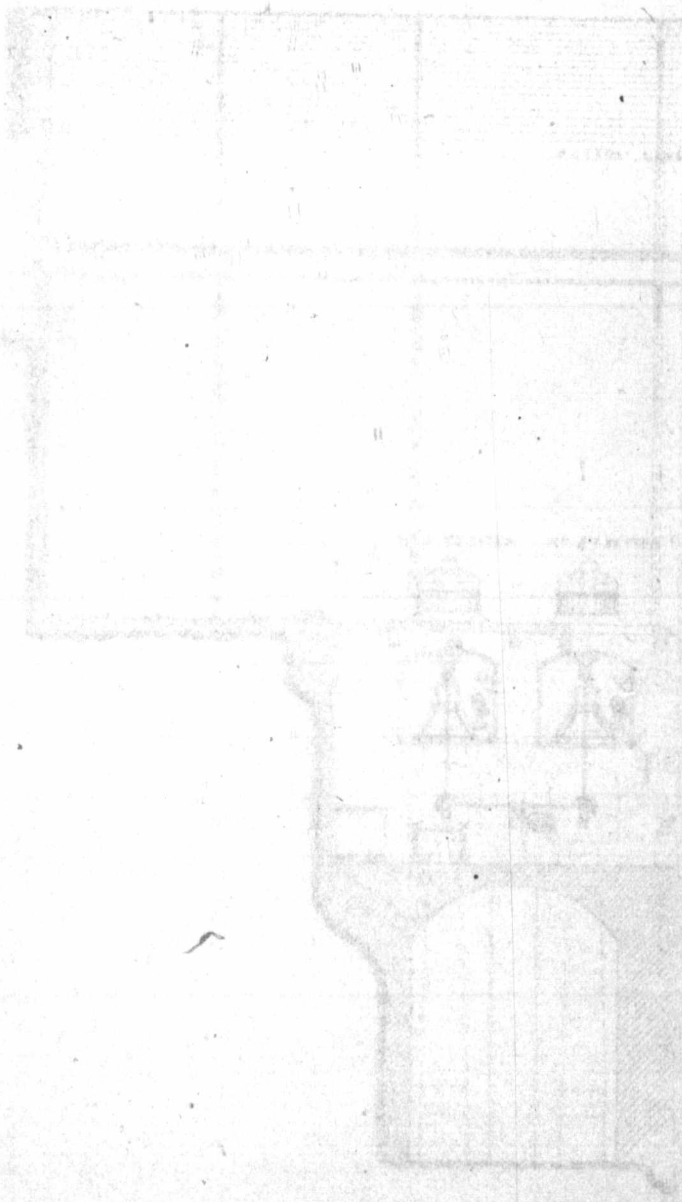

POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co.
PLAN OF POWER HOUSE
SCALE IN FEET
ROSS & HOLGATE
ENGINEERS
MONTREAL Nov 27-06
DAM
RACKS
TRAP COVER
STOP LOGS
HEAD GATE
BY PASS
TRACK FOR GATE WINCH
140'-0"
40'-0"
No 1 EXCITER
No 2 EXCITER
No 1 GENERATOR FUTURE
No 2 GENERATOR
No 3 GENERATOR
No 4 GENERATOR FUTURE
BENCH BOARD
SWITCHBOARD
LOW TENSION SWITCHES
PLATFORM OVER LOW TENSION BUS BARS
FUTURE SWITCHES
POTENTIAL REGULATOR
TRAP COVER
VERTICAL PUMP
VALVE
UNWATERING PIPE
GATE
STOP LOGS
TRANSFORMER HOUSE
SIDING CONNECTING WITH C.P.R.
NORTH SIDE WALL
SOUTH SIDE WALL
4

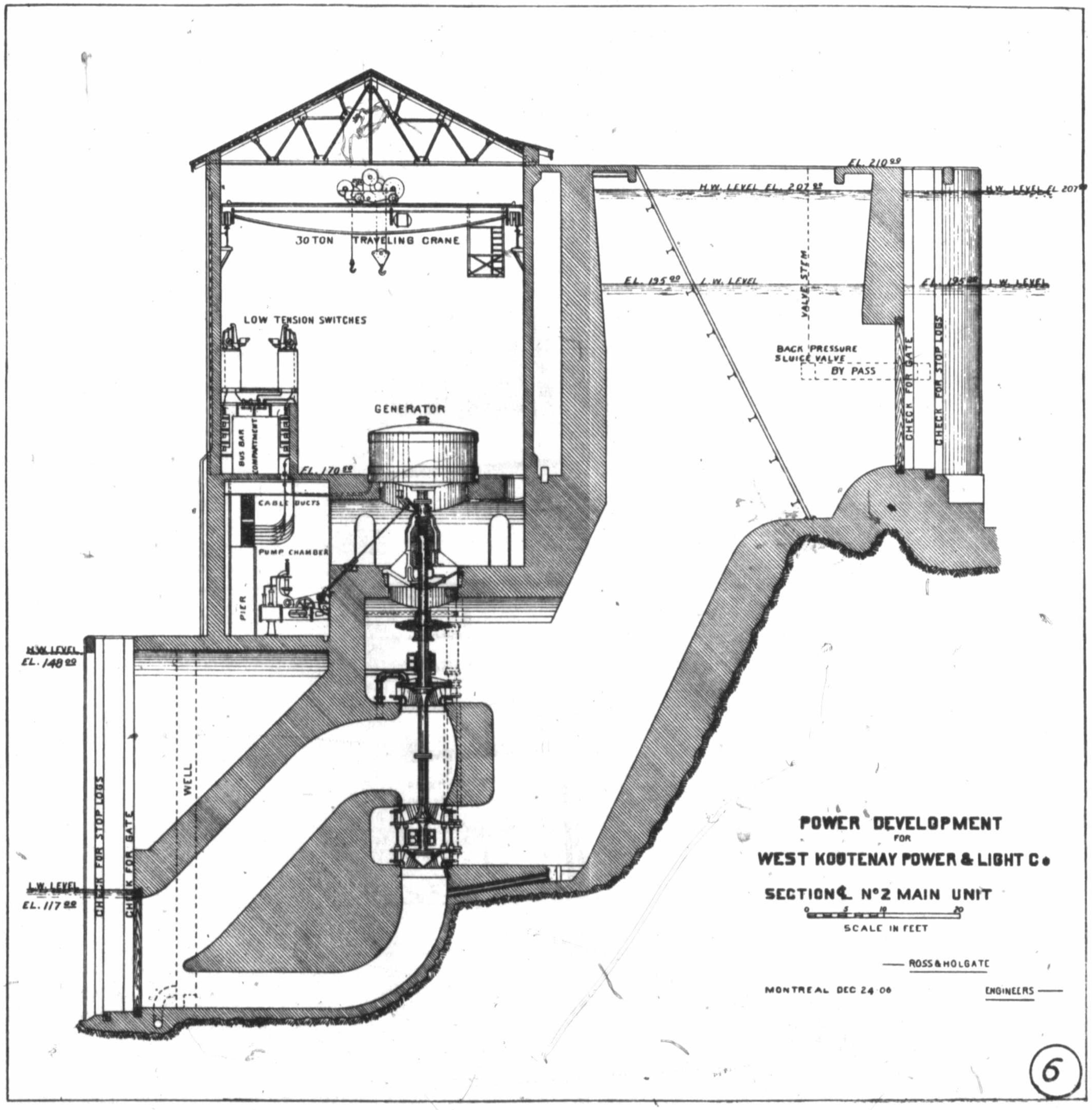
Plan No. 4.



BOTTOM LINE OF TRUSS
CRANE BEAM
No 1 EXCITER
No 2 EXCITER
No 1 GENERATOR
No 2 GENERATOR
No 3 GENERATOR
No 4 GENERATOR
EL. 170.00
H.W. LEVEL
EL. 148.00
SECTION THROUGH PUMP CHAMBER
SWITCH-BOARD
BENCH-BOARD
EXCITER
EL. 170.00
PIER
PUMP CHAMBER
EL. 210.00
EL. 207.00
H.W. LEVEL
EL. 207.00
EL. 195.00
EL. 195.00
L.W. LEVEL
STOP LOGS
SECTION HALF WAY
BETWEEN EXCITERS
LOWEST LEVEL OF TAIL WATER (EXCITERS)
ELEV 130.00
SECTION ℄ No 2 EXCITER
POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co
SECTIONS
0 5 10 20
SCALE IN FEET
ROSS & HOLGATE
ENGINEERS
MONTREAL JAN 8-07
5

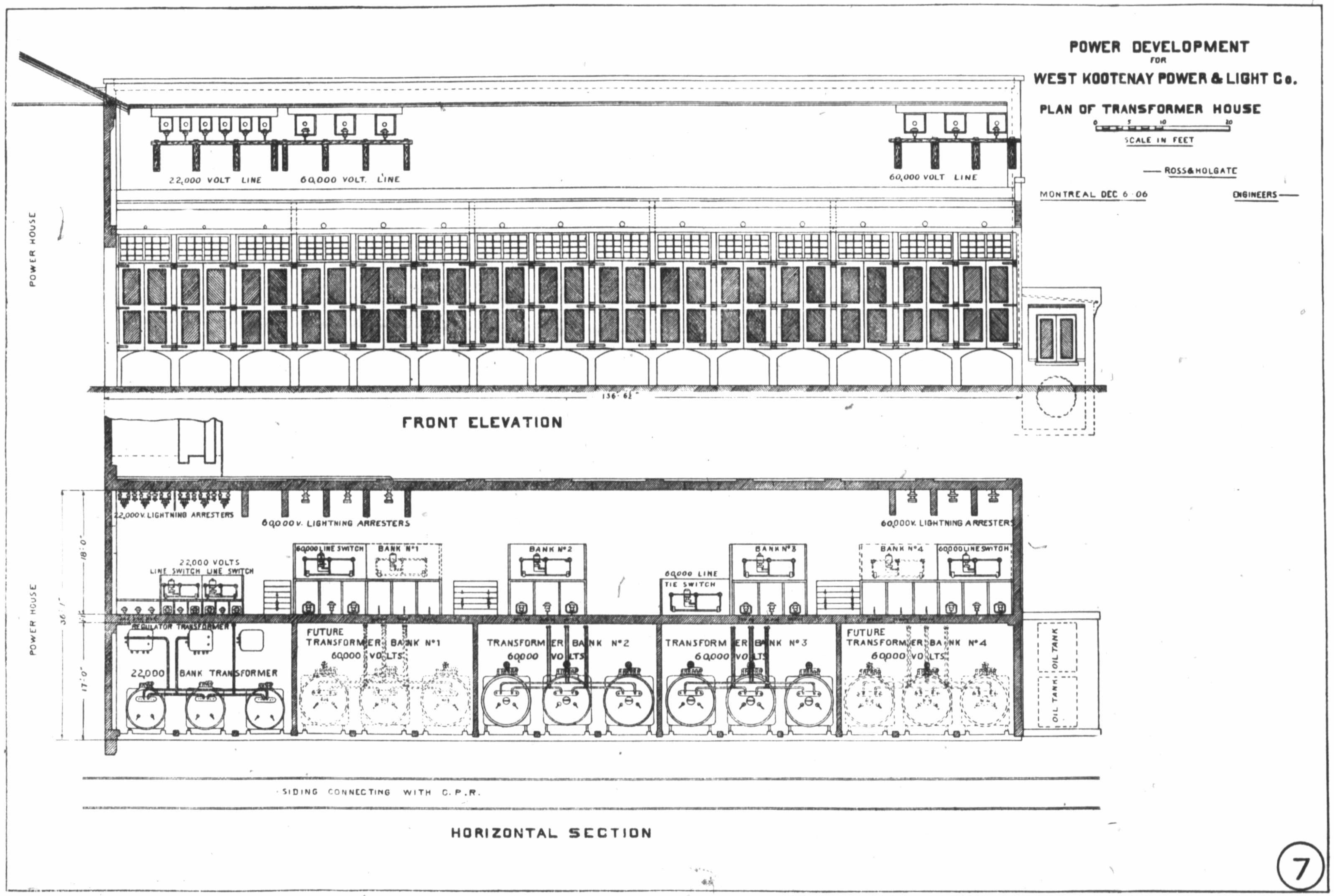

Plan No. 5.



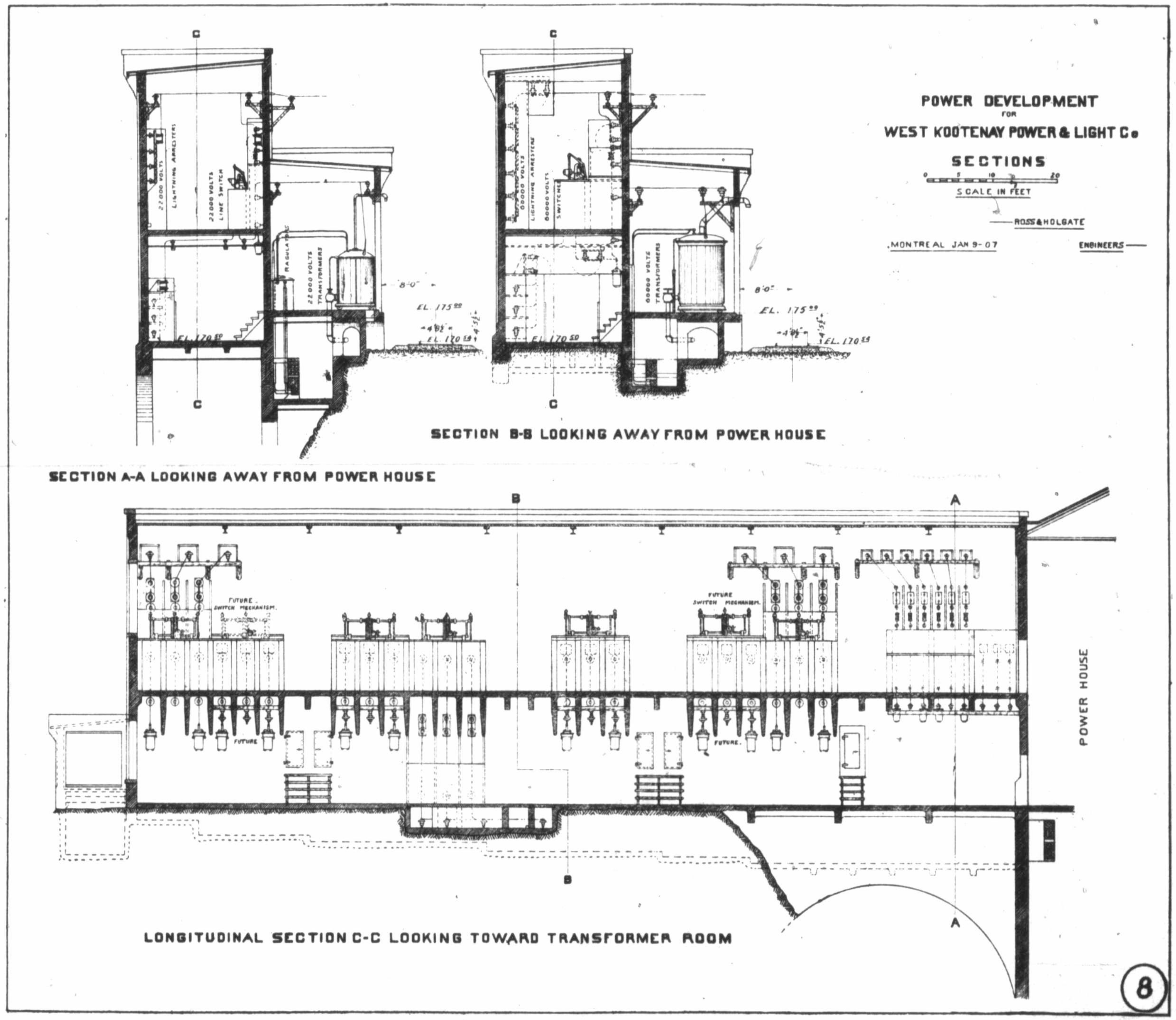


30 TON TRAVELING CRANE
LOW TENSION SWITCHES
BUS BAR COMPARTMENT
GENERATOR
EL. 170.00
CABLE DUCTS
PUMP CHAMBER
PIER
EL. 210.00
H.W. LEVEL EL. 207.00
H.W. LEVEL EL. 207.00
EL. 195.00 L.W. LEVEL
EL. 195.00 L.W. LEVEL
VALVE STEM
BACK PRESSURE SLUICE VALVE
BY PASS
CHECK FOR GATE
CHECK FOR STOP LOGS
H.W. LEVEL EL. 148.00
L.W. LEVEL EL. 117.00
CHECK FOR STOP LOGS
CHECK FOR GATE
WELL
POWER DEVELOPMENT FOR WEST KOOTENAY POWER & LIGHT Co
SECTION ℄ No 2 MAIN UNIT
SCALE IN FEET
ROSS & HOLGATE
ENGINEERS
MONTREAL DEC 24 06
6

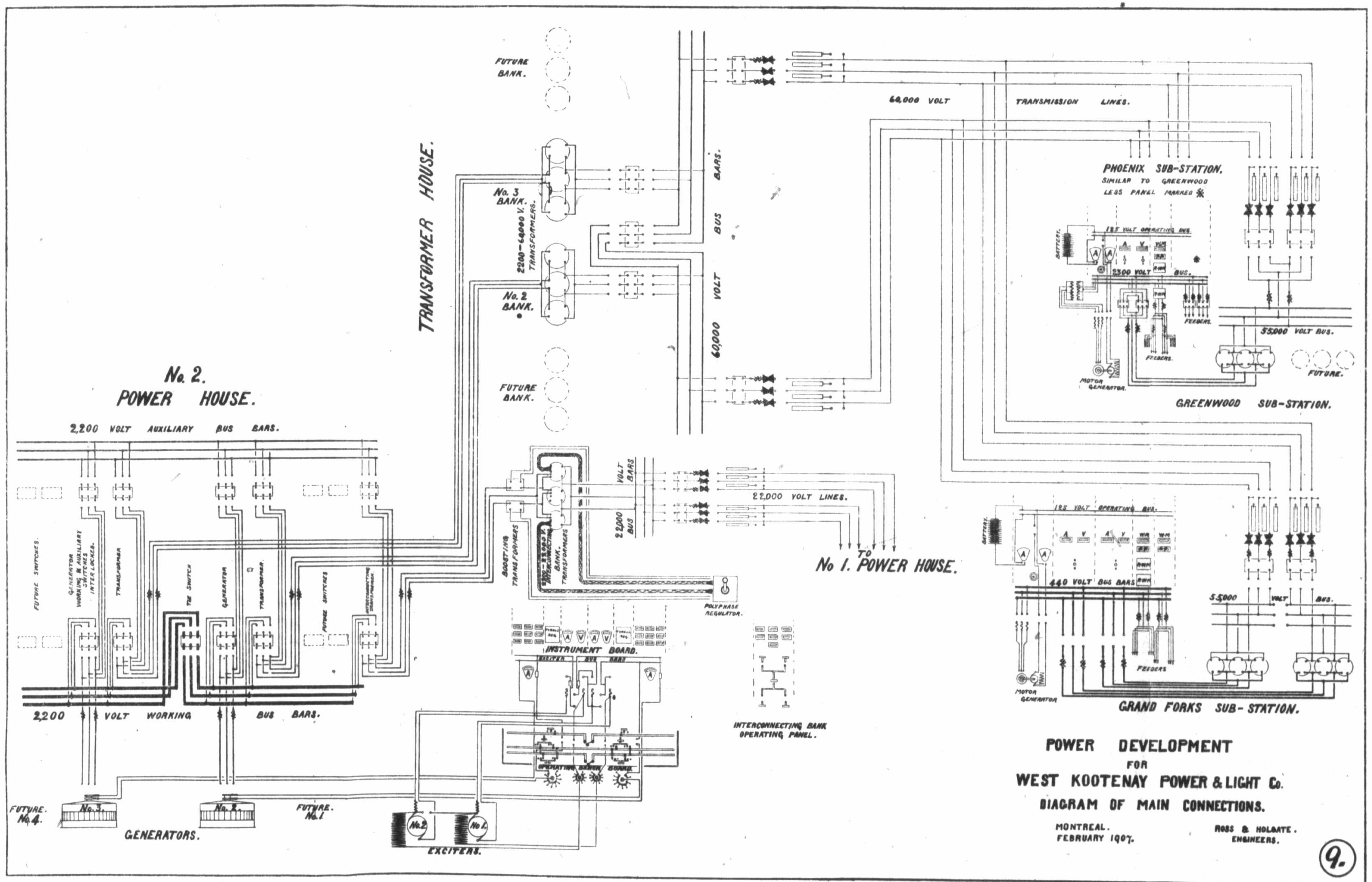

Plan No. 6.


POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co.
PLAN OF TRANSFORMER HOUSE
SCALE IN FEET
ROSS & HOLGATE
MONTREAL DEC 6 06
ENGINEERS
22,000 VOLT LINE
60,000 VOLT LINE
60,000 VOLT LINE
POWER HOUSE
FRONT ELEVATION
22,000 V. LIGHTNING ARRESTERS
60,000 V. LIGHTNING ARRESTERS
60,000 V. LIGHTNING ARRESTERS
22,000 VOLTS
LINE SWITCH LINE SWITCH
60,000 LINE SWITCH
BANK No 1
BANK No 2
60,000 LINE
TIE SWITCH
BANK No 3
BANK No 4
60,000 LINE SWITCH
REGULATOR TRANSFORMER
22,000 BANK TRANSFORMER
FUTURE
TRANSFORMER BANK No 1
60,000 VOLTS
TRANSFORMER BANK No 2
60,000 VOLTS
TRANSFORMER BANK No 3
60,000 VOLTS
FUTURE
TRANSFORMER BANK No 4
60,000 VOLTS
OIL TANK
OIL TANK
SIDING CONNECTING WITH C.P.R.
HORIZONTAL SECTION
7

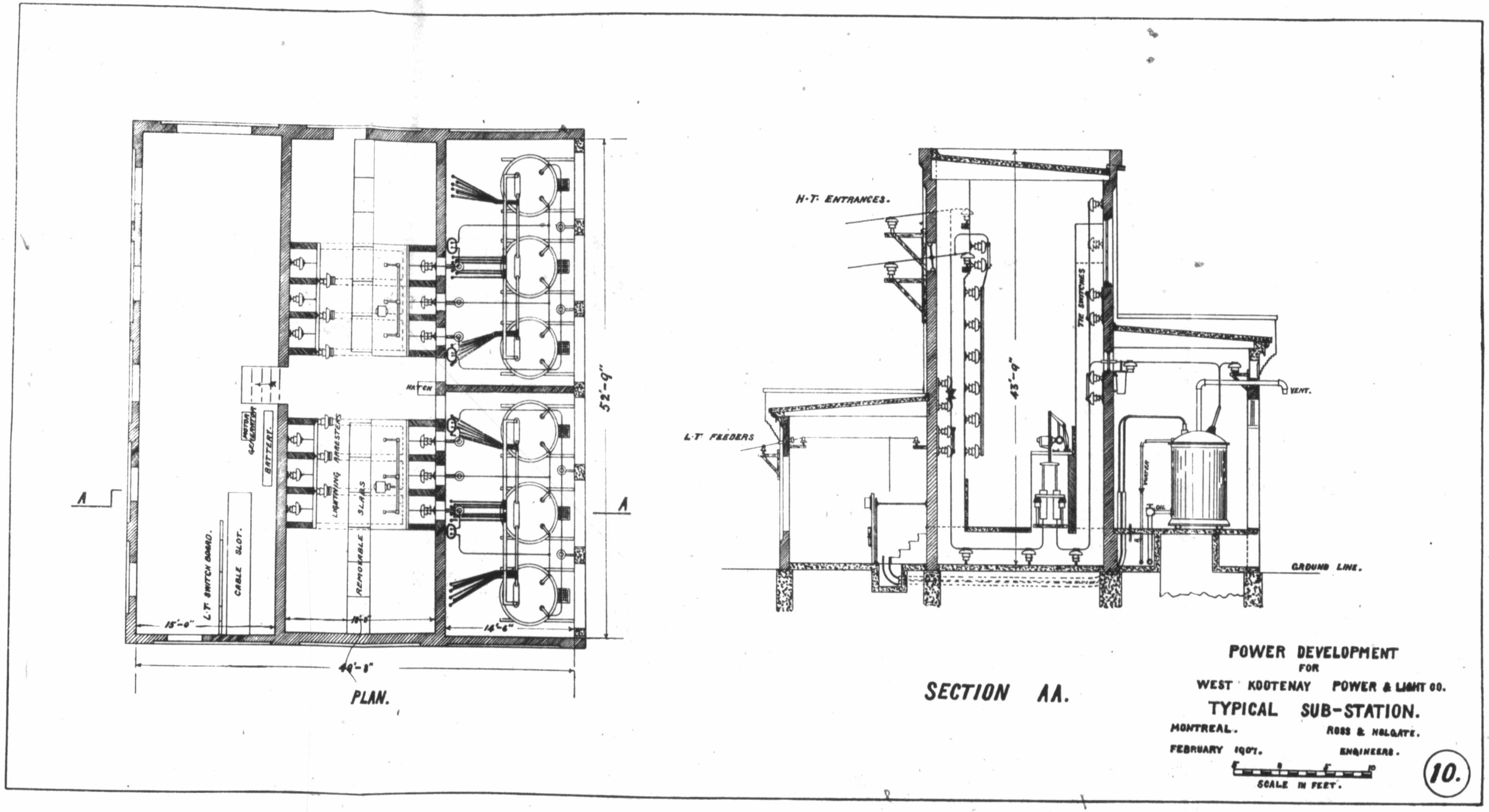
Plan No. 7.


POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co
SECTIONS
SCALE IN FEET
ROSS & HOLGATE
MONTREAL JAN 9-07
ENGINEERS
SECTION B-B LOOKING AWAY FROM POWER HOUSE
SECTION A-A LOOKING AWAY FROM POWER HOUSE
LONGITUDINAL SECTION C-C LOOKING TOWARD TRANSFORMER ROOM
POWER HOUSE
8

Plan No. 8.


FUTURE BANK.
No. 3 BANK.
No. 2 BANK.
2200-60000 V. TRANSFORMERS.
TRANSFORMER HOUSE.
60,000 VOLT BUS BARS.
60,000 VOLT TRANSMISSION LINES.
PHOENIX SUB-STATION.
SIMILAR TO GREENWOOD LESS PANEL MARKED
55,000 VOLT BUS.
FUTURE.
MOTOR GENERATOR.
FEEDERS.
GREENWOOD SUB-STATION.
No. 2.
POWER HOUSE.
2,200 VOLT AUXILIARY BUS BARS.
22,000 VOLT LINES.
22,000 BUS
TO No. 1. POWER HOUSE.
BOOSTING TRANSFORMERS
POLYPHASE REGULATOR.
INSTRUMENT BOARD.
INTERCONNECTING BANK OPERATING PANEL.
2,200 VOLT WORKING BUS BARS.
GENERATORS.
FUTURE. No. 4.
No. 3
No. 2
FUTURE. No. 1
EXCITERS.
No. 2
No. 1
440 VOLT BUS BARS
GRAND FORKS SUB-STATION.
POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT Co.
DIAGRAM OF MAIN CONNECTIONS.
MONTREAL. FEBRUARY 1907.
ROSS & HOLGATE. ENGINEERS.
9.

Plan No. 9.



A
A
52'-9"
15'-0"
14'-6"
40'-8"
L·T· SWITCH BOARD.
CABLE SLOT.
REMOVABLE SLABS
LIGHTNING ARRESTERS
BATTERY.
MOTOR GENERATOR
HATCH
PLAN.
H·T· ENTRANCES.
L·T· FEEDERS
43'-9"
VENT.
GROUND LINE.
SECTION AA.
POWER DEVELOPMENT
FOR
WEST KOOTENAY POWER & LIGHT CO.
TYPICAL SUB-STATION.
MONTREAL.
ROSS & HOLGATE.
FEBRUARY 1907.
ENGINEERS.
SCALE IN FEET.
10.


Plan No. 10.