Canada Rushing Huge Niagara Development As War Conservation Measure

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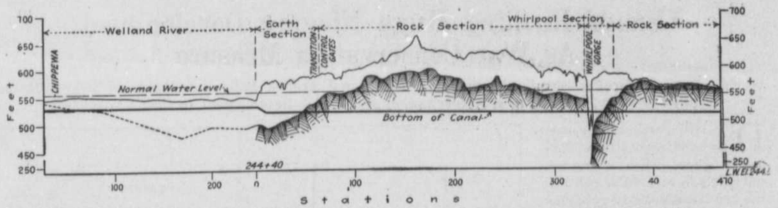
World's Largest Electric Shovels Digging 8½-Mile Canal Around Falls and Rapids to 300,000-Horsepower Power House in Heavy Overburden and Rock—Development to Cost $25,000,000

DIGGING partly in fine, wet clay sand, productive of dangerous slides when undrained, and partly in very stable red clay, the two largest electric revolving shovels in the world are stripping the site of the Queenston-Chippewa Canal, most of the flow section of which will be in rock. The canal, which will take water from the Niagara River above the Falls through the Welland River, locally known as Chippewa Creek, and deliver it to a 300,000-hp. power plant below the last rapids, is part of a project to develop 305 ft. net head of the 327-ft. difference in level between Lakes Erie and Ontario. The work is being pushed during the war by the Hydro-Electric Power Commission of Ontario as a conservation measure, made urgent by the great shortage of power, both steam and electric, in the territory served by power from Niagara Falls, and by the fact that none of the plants now in operation at the falls can be made to develop more than two-thirds of the total available head, while the treaty limit of possible diversion from the falls has been nearly reached, making it necessary to utilize the small surplus of available water under the maximum head which physical conditions will permit.

The construction, which is being carried on by forces of the commission, involves the removal, from the Welland River and the artificial section of the canal, of 13,000,000 yd. of earth, which is being taken out by cableway and dredge on the river section and by the big shovels in the dry cut, and 4,000,000 yd. of rock from the canal and forebay, to be removed by the big shovels and by standard railroad shovels. In addition to the power house and the gatehouse, ten concrete arch bridges, three of them carrying railroads, and a reinforced-concrete intake structure requiring extensive coffer-

CANAL FROM WELLAND RIVER TO NIAGARA GORGE BELOW RAPIDS



PROFILE SHOWING DIFFERENT SECTIONS OF CANAL AND MATERIALS ENCOUNTERED IN EACH

dam work in the Niagara River, are among the structures required.

The dredged river channel, with a gradient of 0.63 ft. to the mile and a mean velocity of 2.0 ft. per second, and the canal, with a gradient of 1.1 ft. to the mile and an estimated velocity of 6 to 7 ft. per second, will pass 10,000 sec.-ft. of water. The power house will contain six 52,500-hp. units, and the site itself, as well as the scheme as a whole, is capable of being expanded, by the provision of additional waterways and power-house space, to take the entire quantity of water that can be diverted under the present treaty on the Canadian side, amounting to slightly more than 1,000,000 hp. capacity.

Drawing water from Grass Island pool after a slight fall from Lake Erie, and delivering it back into the Niagara River below the last rapids at a point where the fall to Lake Ontario is but little more than a foot, the general scheme of development is thought to be by far the most favorable of any yet conceived, and will cost, complete, about $25,000,000. The time of completion is conditioned by the excavation, on account of the heavy yardage involved, and the opening up of the work and the method of attack with large shovels was dictated by the character of the overburden, which could not be depended upon to support heavy, concentrated loads. The nature of the soil, which contains a considerable quantity of ground water and is so fine in places as to have the appearance of clay, made the use of large draglines, operating from the tops of the slopes, out of the question. For the same reason it was desirable to carry the heavy excavating equipment right through on the rock surface, to avoid the continuous trouble with soft ground. This required shovels with a great reach, cars on a track 64 ft. above the rock surface having to be loaded at several points. Very large revolving shovels were therefore selected for the work. One has a 90-ft. boom set at 53 deg., with a 58-ft. dipper stick and a 5-yd. dipper. Another has an 80-ft boom set at 45 deg., a 54-ft. dipper stick and an 8-yd. dipper. A third shovel, similar to the second, will soon be installed. After the earth is stripped and the three shovels are put on the rock excavation, all will be equipped with 5-yd. dippers.

The cut is made by starting a pilot near one side of the canal prism with a railroad shovel, loading cars on the ground surface. In this cut are run the loading tracks for the big shovel, which follows the pilot cut on the rock surface. The loading tracks connect with the main line at both ends, giving the shovels run-around service. With 20-yd. air-dump cars in eight- and ten-car trains, the big shovels have been able to load 4000 yd. in an eight-hour day.

The entire line of the canal is to be paralleled by a double-track standard-gage electric trolley railroad 175 ft. west of its center line. Near the middle of the work is a Y from which a double-track railroad runs two miles to the main dump, which is capable of taking 20,000,000 yd. The hauling equipment consists of one hundred and fifty 20-yd. air-dump cars, twelve 600-volt direct-current 50-ton electric locomotives, and seven steam locomotives. The maximum grade on the construction railroad, which, when complete, will contain 40 miles of single track, is 1%, and the haulage equipment is capable of making 10 miles loaded and 20 miles light with 10-car trains at any point on the line.

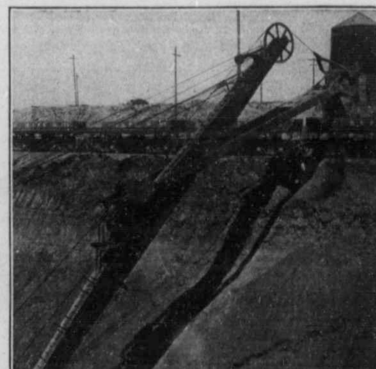
The trolley wires are offset 7 ft. from the center line of the tracks to permit the loading of dump cars, and in order to pass locomotive cranes, of which there are three 40-ton and two 15-ton machines on the work.

THE BRIDGES WERE BELOW THE ORIGINAL GROUND SURFACE

The order in which the work was opened up was dictated both by the length of time required for the excavation and by the location of three existing railroad crossings. Two of these are close together, as may be seen from the map, a short distance south of the Whirlpool Gulch, a deep cut which it is believed was once the bed of the Niagara River. Just south of this gulch occurs the heaviest earth cut on the canal, a face of 100 ft. being encountered here for a short distance. The shovel that started in at the south face of this gulch is the one with the 5-yd. dipper rigged to load cars on tracks 64 ft. above grade. It was possible to dispose of the excavation from this shovel to the extent of 1,500,000 yd. in the Whirlpool Gulch itself, making it unnecessary to cross a main-line railroad in order to get to the central dump. Since the short section between the Grand Trunk Ry. crossing and the next crossing south was the location for the Y leading off to the main dump, and since it could therefore be excavated before the railroad crossings were constructed, this point was selected for starting the other large shovel. With the excavation begun in this way, both shovels could be kept busy while the first bridge was being built. The construction railroad will pass under these railroad bridges, and sufficient clearance is provided for the large shovels by taking down the booms. The southerly shovel will be let out in this way and will proceed south, following the construction railroad and the pilot cut for the loading tracks, until the overburden is completely stripped; being helped, in all probability, by the third shovel when it arrives. The loading tracks will then be lowered to the rock surface, a pilot cut will be made by the railroad shovels, as in the earth section, and the shovel now operating at the Whirlpool Gulch will follow through, taking out the rock cut to grade. The other shovels will, on the completion of the earth excavation, turn north to meet it.

North of the Whirlpool Gulch the cut is almost entirely in rock, and there is a large forebay approximately 300 by 1000 ft. to be excavated. This rock will be removed by the railroad shovels, of which there are two of 3½-yd. and one of 2½-yd. capacity. There are also two ⅞-yd. caterpillar revolving shovels on the work.

The forebay excavation was begun when the two large shovels were started, in order to provide rock for track ballast and for concreting. As the heavy end of the rock excavation is near the forebay, and as little stripping had to be done, the main crusher plant was located here. The rock, which is Niagara limestone, will be used as aggregate for all the concrete. A concrete plant located at the lip of the gorge above the power house will be able to concrete the head house and power house by gravity. As these structures will not take more than 18 months to build, it has not been necessary to start them as yet, and no work beyond the clearing of the building site has been undertaken at this point.



ONE OF THE SHOVELS WAS RIGGED TO LOAD CARS ON TRACKS 64 FEET ABOVE GRADE

The remaining portion of the work, the dredging of the Welland River, is being carried on simultaneously by a 3-yd. dipper dredge and a large cableway operating a clamshell bucket. On account of bridges, houses and rough ground the cableway was not able to start within 4400 ft. of the intake, and the work between that point and the Niagara River will be done by the dredge, the material being scowed into the Niagara River. The cableway has an 80-ft. head tower and a 60-ft. tail tower, both traveling on railroad trucks on parallel double tracks. The span is 800 ft., and the rig handles a 3-yd. clam. The head tower on the north bank of the river is set far enough back so that all the excavated material can be disposed of by dumping it on that bank. The total cut in the Welland River is to a depth of 30 ft. below the surface, but at 24 ft. below the surface a limited deposit of quicksand has been struck, which cannot be dug with any type of grab bucket yet tried on the cableway. It will probably be necessary to remove this quicksand with a dipper dredge.

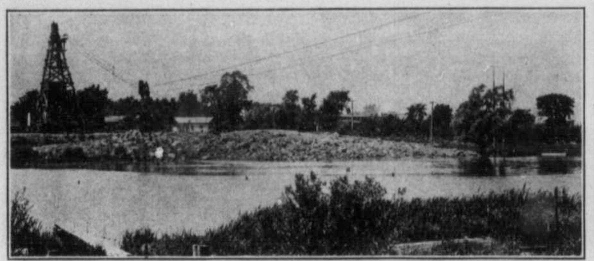
As might be expected, the early construction of the railroad bridges is essential to the prosecution of the excavation. The first started is the center one, as shown on the drawing. This bridge will let the southern shovel out, and by the time it is finished there will still be sufficient time to construct the Grand Trunk crossing before the second shovel will be ready to come through with the rock cut.

To build these bridges, holes had to be dug in the ground, and steel sheet piling used for cofferdams. As shown in one of the photographs, the crown of the arch in the first bridge built is below the ground surface. This bridge is for an electric railway road from Niagara Falls to St. Catharines, but the loading specified by the electric railway company was as heavy as that for either of the steam railroad bridges.

The railroad bridges each contain about 3500 yd. of concrete, each being a single arch. This excludes the wing walls, which will not be placed until the canal excavation has been completed. Because the bridges are built below the original ground surface, the concreting proved easy. It was only necessary to set up a mixer with a loading hopper on the edge of the excavation and spout the concrete directly to place in the forms. The mixer at the first of these bridges was served by a locomotive crane, material being received on a spur from the Grand Trunk Ry. The excavation was carried out with two derricks, the material being dumped around the cofferdam.

As will be seen from the profile, the first rock excavation available was at the lower end. The forebay excavation was begun by shooting out a 10-ft. lift over the entire area, about 1100 holes being fired at once. About one pound of dynamite to the yard, including that used for springing the holes, was used. Each hole was sprung with five or six sticks and loaded with 15 or 20 sticks, the spacing being 7 ft. each way. Several experiments with blasting caps wired up in various ways were tried in an adjacent open field, to make sure that the loaded holes would be fired simultaneously. The firing was done with a high-amperage but low-voltage current thrown with a single switch. As a result of this blast, about 60,000 yd. was broken fine enough to be handled by the railroad shovels.

The crusher plant near the forebay receives material by rail in the 20-yd. dump cars. These discharge direct into a large hopper lined with $2\frac{1}{2}$ x 6-in. steel bars laid flat, and feed a 60 x 84-in. jaw crusher operated by a 250-hp. motor. This crusher reduces the stone to 8-in. size and delivers it to a belt which takes it to the top of the secondary crusher house, where it is fed into three gyratory crushers that reduce it to 2-in. size. From these crushers the material passes through a screen which removes dust and oversize aggregate, and is then carried on a suspended belt conveyor over the storage pile. At the end of the storage pile is the bin structure for the receipt of 1-in. stone to be used for reinforced-concrete work. The 1-in. material is obtained by bypassing the oversize aggregate, after it leaves the screen, into a small auxiliary gyratory crusher, which delivers its product directly into the bin mentioned above.

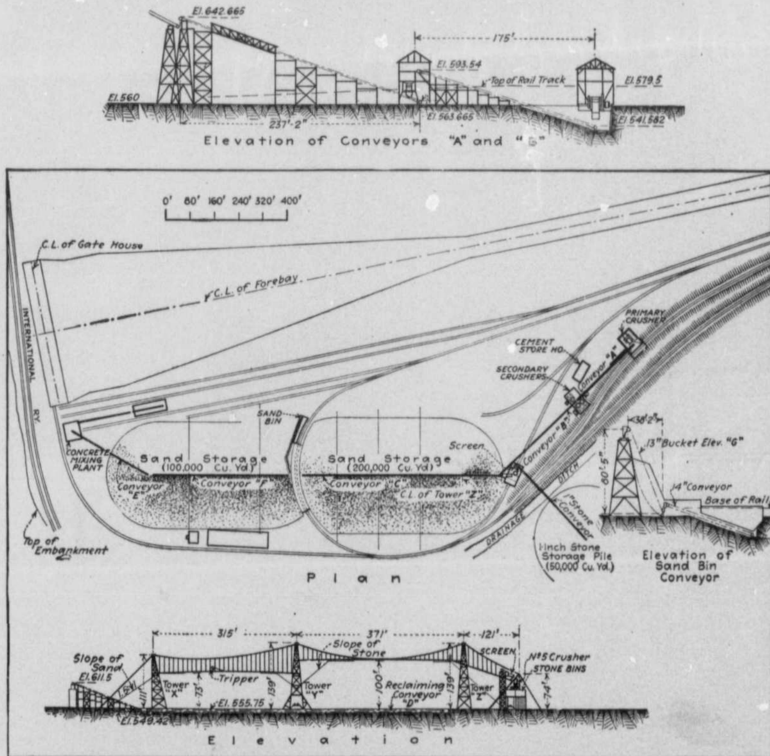


CABLEWAY EXCAVATOR AND NEAR VIEW OF GRAB BUCKET ON WELLAND RIVER SECTION

Under the storage pile is a gallery containing another conveyor for delivering stone to the concrete plant, which it is planned to build as shown in the layout drawing.

The rock-excavation work on the canal itself is carried out in such a way as to produce smooth sides and secure the maximum flow. It is the intention to channel the rock down to the water line in advance of blasting, and to break the rock back below this face so as to allow for a 6-in. lining of concrete throughout the entire flow section. There are 15 duplex channelers cutting to a depth of 20 ft. at one operation on the work, most of them being at present employed around the forebay. The channelers and the tripod drills are operated by compressed air delivered by a 10-in. pipe.

There will be 12 motor-driven compressor units, having a total capacity of 12,000 ft. per minute, on the work. A capacity of 8000 ft. is concentrated at the Whirlpool station in the center of the work now in progress, and the other 4000 ft. is located at Montrose station at the southern end of the line. Six of these machines are now in operation at the first-mentioned station, where one of the main transformer substations for the work is also situated. After-coolers are used on the compressors, and it has not been necessary to employ reheaters, although these may be resorted to in cold weather. At present the loss of pressure in delivery from the central station to the drills in the forebay is about 3 lb. per square inch, the drills taking air at a little more than 100 pounds.



LAYOUT OF CRUSHING, CONVEYING AND CONCRETE MIXING PLANT AT POWER HOUSE

Because plenty of electric power was available, and because shipments of coal are becoming more and more difficult to obtain promptly, electric power was used wherever possible on the work. As stated, the haulage equipment uses 600-volt direct current, transformed by rotary converters at the central stations. The other equipment uses 440-volt alternating current, the lines to the two large electric shovels carrying current at 4000 volts to transformers on the shovels themselves. For the smaller plant units the current is stepped down before being delivered to the machine.

For organization purposes, the work, which is being done entirely by the forces of the Hydro-Electric Power Commission, has been divided into four sections. The first of these includes the deepening of the Welland River. The second is the portion of the main canal from station 0 to station 235, the third is the other half of the main canal from station 235 to the forebay, and the fourth section includes the power house, gatehouse and the forebay itself. Sir Adam Beck is chairman of the commission, for which Frederick A. Gaby is chief engineer, Henry G. Acres hydraulic engineer, T. H. Hogg assistant hydraulic engineer and M. V. Sauer designing engineer. The work is in charge of J. B. Goodwin, works engineer, under whom G. H. Angell is general superintendent and A. C. D. Blanchard field engineer. F. W. Clark is assistant field engineer, R. T. Gent plant engineer, and William Snaith office engineer. C. F. Whitney is resident engineer on divisions 1 and 2, George Lowry on division 3, and W. S. Orr on division 4.