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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Chippawa-Queenston Power Development

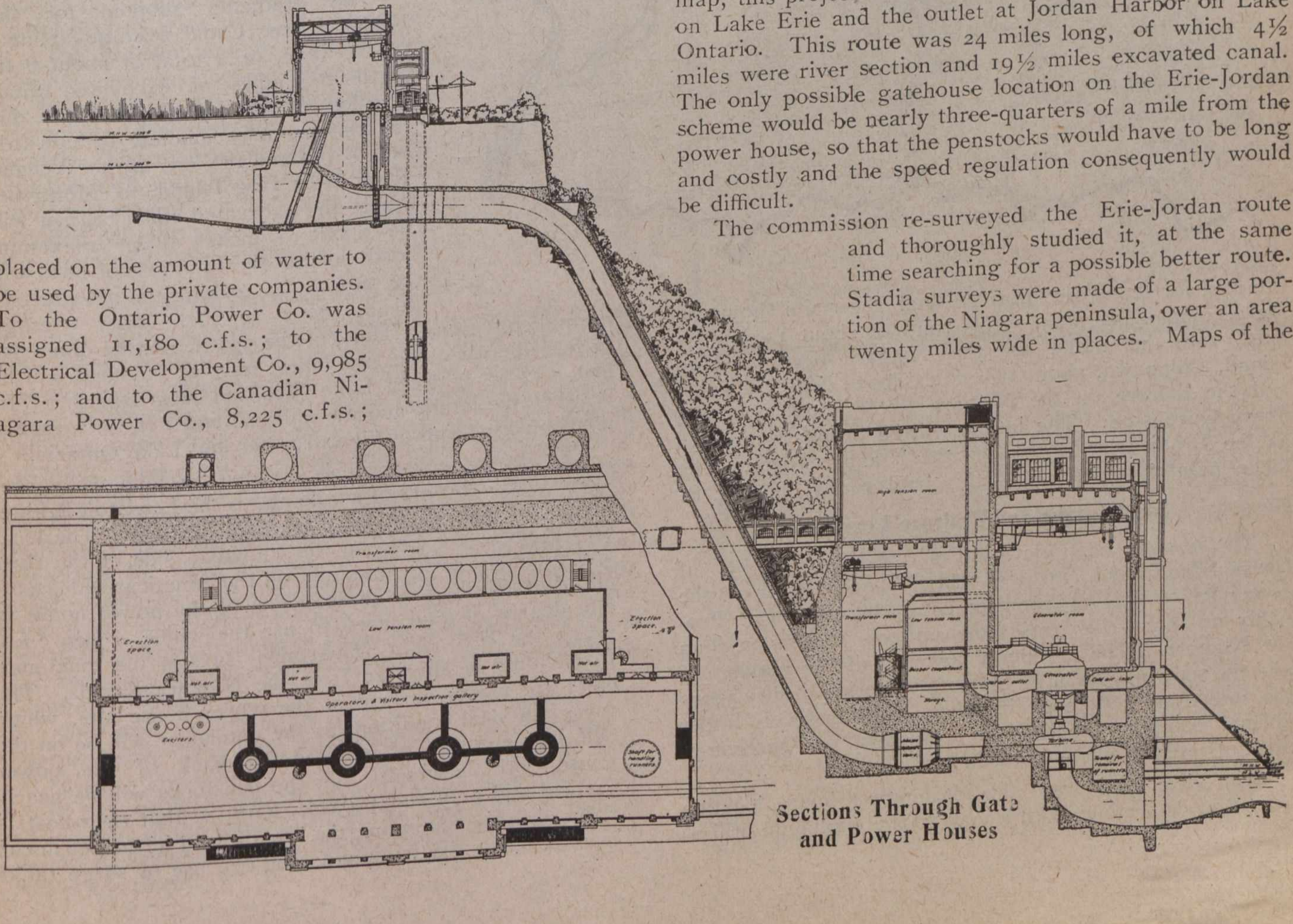
Hydro-Electric Power Commission of Ontario Will Develop 300,000 H.P. Under 305 Ft. Net Head, Using 10,000 C.F.S. from the Niagara River—Largest Hydro-Electric Power Scheme Ever Undertaken—Units Will Be of 50,000 H.P. Capacity—15,000,000 Cu. Yards of Excavation—Plant Could Be Extended to Million Horsepower

BETWEEN Lake Erie and Lake Ontario, the difference in level is 330 feet; but to date the maximum net head utilized by any Canadian hydro-electric power development on the waterway joining those lakes, is about 160 feet. On account of the shortage of hydro-electric power in Ontario, and because of the comparative inaccessibility to manufacturing centres of the other undeveloped water powers, the Hydro-Electric Power Commission of Ontario realized many years ago that more economic development at Niagara would be necessary.

The treaty which was enacted by Great Britain and the United States in 1910, limits to 56,000 c.f.s. the amount of water which can be diverted for power purposes from Niagara's 220,000 c.f.s. mean flow. Of this amount, Canada is entitled to 36,000 c.f.s. By an Ontario order-in-council passed in 1915, a limit was placed on the amount of water to be used by the private companies. To the Ontario Power Co. was assigned 11,180 c.f.s.; to the Electrical Development Co., 9,985 c.f.s.; and to the Canadian Niagara Power Co., 8,225 c.f.s.; leaving only 6,610 c.f.s at the disposal of the commission. The Ontario Power Co. has since been purchased by the commission, however, so that the commission now has within its control a total of 17,790 c.f.s.; and, of course, alterations in the treaty may possibly be made from time to time to meet new conditions, or the commission may purchase one or both of the remaining two private concerns.

Two of the existing Canadian plants are said to be working under net effective heads of less than 135 ft. The commission determined to use more of the 330-ft. head between the two lakes. For the past twenty years various schemes, more or less practical, had been suggested. One of the best of these was a route that had been surveyed many years previously by the consulting engineering firm of Smith, Kerry & Chace, of Toronto. This route, called the Erie-Jordan Canal, cut across the Niagara peninsula. As shown by the accompanying map, this project located the intake near Morgan's Point on Lake Erie and the outlet at Jordan Harbor on Lake Ontario. This route was 24 miles long, of which 4½ miles were river section and 19½ miles excavated canal. The only possible gatehouse location on the Erie-Jordan scheme would be nearly three-quarters of a mile from the power house, so that the penstocks would have to be long and costly and the speed regulation consequently would be difficult.

The commission re-surveyed the Erie-Jordan route and thoroughly studied it, at the same time searching for a possible better route. Stadia surveys were made of a large portion of the Niagara peninsula, over an area twenty miles wide in places. Maps of the



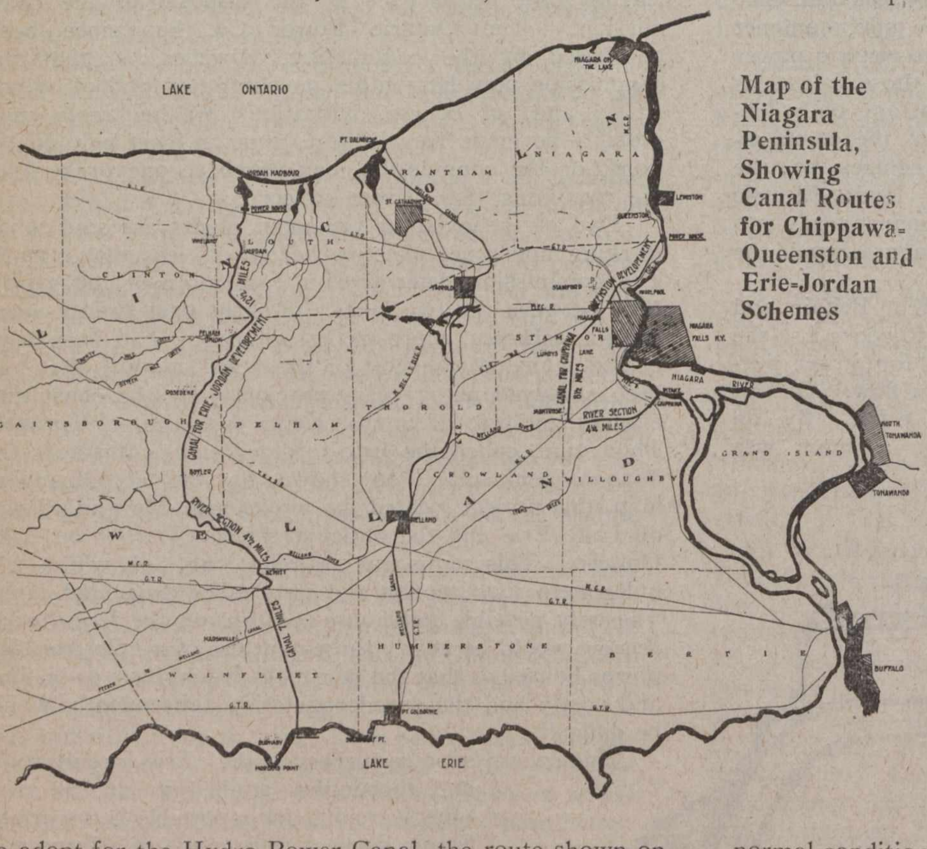
Sections Through Gate and Power Houses

district were drawn and 2-ft. contours plotted. Test borings were taken every 500 ft. with an Ingersoll-Rand Calyx core drill, the cores still being stored for reference.

New Route Located

When the route was discovered which was tentatively decided upon, wash borings, or well-drill borings, were made every 500 feet on the centre line of the proposed canal, to provide an accurate sub-surface profile. A large number of photographs of the district were taken, and also photographs of ice conditions at the proposed intake. The Welland River was sounded, stream measurements were made on the Welland and Niagara Rivers, and the history of the levels of the Niagara River and Lake Erie for the past sixty years was closely studied. The directions of the lines of flow at the proposed intake were noted, and there were obtained all the data necessary for the construction of hydraulic similarity models.

As a result of the surveys and studies, it was decided to adopt for the Hydro Power Canal, the route shown on the accompanying map. This route is about 12¾ miles long, with the intake on the Niagara River at Hog Island, Chippawa, about two miles above Niagara Falls, and the tailrace on the Niagara River about one mile above Queenston. The intake will be in what is known as the Grass Island pool of the Niagara River. The mean monthly elevation of this pool varies about 1 ft.



Map of the Niagara Peninsula, Showing Canal Routes for Chippawa-Queenston and Erie-Jordan Schemes

Ideal Intake and Tailrace Location

The normal mean elevation of Lake Erie is 573; of Grass Island Pool, 561; of the Niagara River at the power house site, 245; and of Lake Ontario, 243. Probably no other river has more uniform regulation than the Niagara. The minimum flow is half the maximum, and the section is so large that over a period of fifty years the maximum difference in mean monthly levels under normal conditions, either at Chippawa or Queenston, amounts only to about six feet.

The ideal intake and the ideal power house location were first determined with a view to the maximum utilization of the available head, and contours and borings were then studied to decide by what route a canal could connect those two points to the best hydraulic and economic advantage. The intake was located at Hog Island partly on account of that point being just above the critical section at which the water begins to speed up for its passage over the falls. Location further up the river would have meant a larger canal; further downstream, a loss in head. Another reason quite equally important for locating the intake at Chippawa was the use which could be made of the natural channel of the Welland River—often called Chippawa Creek—which provides about 4¼ miles of the Hydro Power Canal, leaving only about 8½ miles to be excavated, although the Welland River will have to be somewhat deepened and widened. The flow of the Welland River, which is a sluggish stream with a very flat bed, will be reversed.

The Hydro Power Canal's 8½ miles of excavated section compares with 19½ miles for the Erie-Jordan scheme, and the gross head is 316 ft. compared with 299 ft. for the Erie-Jordan.

The ice troubles that would be experienced in the Erie-Jordan scheme will also be more readily obviated. Ice would have caused immense expense in the Erie-Jordan intake, particularly during east gales, but no such trouble is anticipated at Hog Island. There will be elaborate methods of ice protection at the intake and also at the forebay, to eliminate the troubles experienced at the existing plants.

Only 11 Ft. Loss of Head

The gradients adopted for the Hydro Power Canal average about 1 ft. per mile, or a total of about 8 ft. in the 8½ miles of excavated canal. The loss of head in the penstocks, due to friction, may amount to upwards of 2½ ft., and the loss in the Welland River from Hog Island to Montrose, where the excavated canal begins, will be about 6 inches under maximum load, so that the total loss of head will be only 11 ft., making the net effective head about 305 ft. under average normal conditions. Thus, of the 330 ft. normal difference in level between the two lakes, only 25 ft. head will be lost,—12 ft. between Lake Erie and Hog Island, 11 ft. between the intake and the tailrace, and 2 ft. between the point of discharge of the tail water and Lake Ontario.

The power house will be located down in the gorge, about three-quarters of a mile above the Lewiston Bridge, just at the end of the last rapids in the river. The location is ideal, the best on the Canadian side of the river and probably better than any on the American side, as it affords facilities for the extension of the power house to any degree desired, even to use the whole 40,000 c.f.s. which the U.S. War Department says is the maximum that should be diverted from the Niagara Rapids. The cliffs are nearly vertical at the power house site, which gives the ideal condition, as the gatehouse will be on the cliff just a couple of hundred feet back of the power house, with the results that the penstocks will be nearly vertical and only about 450 ft. long, so that their cost is reduced to the minimum, the loss of head in the penstocks is reduced to the minimum, and the use of surge tanks is avoided. The penstocks are so short that they can be designed to withstand the stresses due to pressure surge. Valves may not be required on the penstocks; regulation will be effected by the gates at the gatehouse and by the wicket gates on the turbines.

About 30 h.p. will be obtained from each second-foot of water, compared with about 14 h.p. obtained by the existing plants. With 36,000 c.f.s., over 1,000,000 h.p. could be developed at this plant, compared with less than half that amount at the heads under which the present plants are operating.

Most of the excavated section of the canal will be in rock, but at the Whirlpool there is a stretch which is in earth; and the initial portion of the excavated section, adjacent to the Welland River, will also be in earth.

Canal Mostly in Rock

Starting at the point of diversion from the Welland River, near Montrose, as station 0, the earth section extends to station 80, a distance of 8,000 ft. Then the canal is in rock all the way to the gatehouse excepting at the Whirlpool, where it is in earth from station 332 to station 351. At station 351 it is in the full rock section again, but the sub-base of rock crops up gradually far ahead of station 351, with the result that only about 1,000 feet, or from station 332 to about station 342, is entirely in earth at this part of the canal. The station at the gatehouse site is 462, a distance of 46,200 ft. from the diversion at Montrose.

The stations on the Welland River section are separately numbered, beginning at Hog Island as station 36, allowing 3,600 ft. for future allotment to plans for the intake works that will be constructed in the Niagara River. The diversion at Montrose is at station 222+40, a distance of 18,640 ft. from Hog Island. The total length of the Hydro Power Canal from Hog Island to the gatehouse location is 64,840 ft., or 12.28 miles.

The gradient and the section adopted for the canal are the most economical for the amount of water which it is desired to pass through the canal. The canal is nominally designed for 10,000 c.f.s. at minimum low water. The rock is mostly very good limestone, and as all the rock will be channelled, and may be lined with concrete where it is too poor to channel smoothly, the friction will not be great. Ten Sullivan channellers, each having a 20-ft. cut, will be used on each side of the canal.

Earth Sections Will Be Lined

The earth sections will be lined in some manner not yet finally decided. The sides of the wetted section will be sloped 1½ to 1 and they will either be "gunited" over light reinforcing, by the Cement-Gun method, or else a heavier reinforcing will be used and the walls will be poured. This detail of design and many other details of the scheme are in a state of flux and will be decided only from time to time as the work progresses. As the commission is both the buyer and the contractor, there is no necessity for rigid decision in advance in regard to details of this sort, the commission being able to leave them for disposal as circumstances may dictate. The entire construction programme is liable to change in any detail at any time should conditions, as the work progresses, suggest changes.

The rock section is 48 ft. wide at the bottom, with perpendicular sides, the average wetted section being 35 ft. deep. The velocity in the rock section will be about 6 ft. per second when the plant is under maximum load. The banks of the overburden will be sloped 1½ to 1 unless local conditions in certain places require a flatter slope or other treatment.

The earth section will be 34.6 ft. wide at the bottom and 162 ft. at the top, the sides having a 1½ to 1 slope, the average wetted section being about 26 ft. deep. The width at the mean water line will be about 84 ft.

The commission has purchased a wide tract of land as a right-of-way, and has enough acreage to be able to build two more canals should they be required in the future. These canals would be located a few hundred feet to the west of the first canal and would be almost parallel to it. They would draw water from the Welland River just as the first canal will do. The capacity of these additional canals would, of course, depend upon the section and the gradient assumed, but could be built readily and economically to handle all of the water which both Canada and the United States are now diverting from Niagara Falls, should the people of the United States ever desire to merge their water allotment with Canada's, in one big plant, for the sake of higher efficiency. The cost of all this property is being charged against the present scheme. About $1,000,000 worth of land will have been acquired when the expropriations are complete. This includes the vast disposal area at St. David's, which can accommodate about 20,000,000 cubic yards of dumped material.

The canal's designed capacity of 10,000 c.f.s. at minimum low water refers to the absolute minimum during a period of about sixty years. The records for the Niagara River had been kept for fourteen years, and the records for Lake Erie had been kept for about sixty years, and from the Lake Erie levels the Niagara River levels were estimated for the period prior to the fourteen years for which direct records were kept for the Niagara River. This minimum low water has occurred only about once in fourteen years; the average monthly minimum is much higher; so, in assuming the absolute minimum, the

CHIPPAWA-QUEENSTON SCHEME IN TABLOID

Horse-Power Developed	300,000
Capacity of Units	50,000 H.P.
Number of Units	6
Diameter of Main Penstocks	13 ft. 6 ins.
Gross Head	316 ft.
Net Effective Head	305 ft.
Water Required	10,000 c.f.s.
Length of Canal	12¾ Miles
River Section	4¼ Miles
Excavated Canal	8½ Miles
Gradient in Ex. Canal, per mile	1 ft.
Width of Rock Section	48 ft.
Width of Earth Section	162 ft.
Earth Excavation	11,000,000 Cu. Yds.
Rock Excavation	4,000,000 Cu. Yds.
Deepest Cut	145 ft.
Surveys Started	1914
Construction Commenced	1917
Completion of Work	1921
Estimated Cost, about	$25,000,000

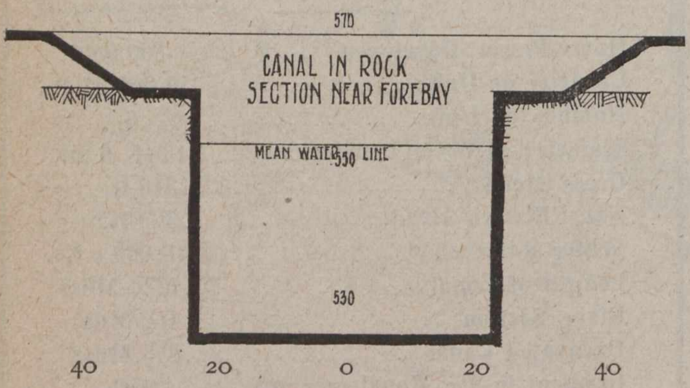
commission allowed a factor of safety which will provide against possible future contingencies.

The scheme as now laid out, using 10,000 c.f.s., will have a capacity of 300,000 h.p., and the canal, forebay, gatehouse substructure and power house substructure are designed for that capacity. The power house and gatehouse superstructures will be designed initially for 200,000 horse-power.

50,000 E.H.P. Units

There will be control works at the head of the excavated canal near Montrose, but from there the canal will be unobstructed until the forebay location is reached, which is at Smeaton's Ravine. At station 438+33, 2,367 ft. from the gatehouse, the canal widens into the forebay, the forebay gradually increasing in width to 300 ft., which will be the approximate overall dimensions of the gatehouse. The last 1,000 ft. of the forebay will be 300 ft. wide. The initial development contemplates four steel penstocks each about 13 ft. 6 ins. diameter, 450 ft. long, and one exciter penstock, about 5 ft. diameter.

There will be four units, each 50,000 h.p. capacity. Two more penstocks will be installed when it is desired to



bring the capacity of the plant up to 300,000 h.p. Both the gatehouse and the power house are designed so that they may be extended whenever conditions warrant and practically to any extent desired.

Single Runner Turbines, 187½ R.P.M.

The turbines will be of the single runner type, probably with cast steel scroll cases. The specifications call for 187½ r.p.m., which is the maximum safe speed giving satisfactory hydraulic characteristics. The specifications for the turbines have been prepared by the commission and prices will be secured in the near future. Although these turbines will have the greatest capacity of any water turbines yet designed, they will not be so large in overall dimensions as some others that have been built which operate at lower heads. The Keokuk and the Cedars Rapids turbines, for instance, are bigger than the commission's turbines will be, but the latter will be more powerful on account of the higher head. Steam turbines have been built of equally large capacity; in fact, the Westinghouse Co. are now said to be constructing for the Chicago Edison Co. a 75,000-h.p. steam turbine, with generator direct connected; but the units at the commission's power plant will be the biggest capacity hydro-electric units ever installed.

The commission has designs for a 100,000-h.p. turbine installation, and when the plant is increased from 200,000 to 300,000 h.p. it may be done by installing just one 100,000-h.p. unit instead of two 50,000-h.p. units. It was decided to install the smaller units for the initial development on account of the proportion of the plant which would be tied up should one of only two big units have to be shut down for any reason.

The power will be taken off the generators at 12,000 volts and will be stepped up, probably to 100,000 volts, for long-distance transmission. Elaborate arrangements will be made not only for leading cool air to the generators, but, what is more unusual, for taking the heated air out of the power house. Large ducts will lead cold air to below the rotors, and after the air has gone through the generators, it will be carried away in flues. There is also a scheme for removing the runners from the turbines without dismantling the turbines and generators, which will weigh about 1,000 tons, the moving parts weighing about 500 tons. Each draft tube will be so arranged that the runner can be dropped into the draft tube, loaded onto a car, pulled through a tunnel and lifted through a shaft by a crane, so that repairs can be effected without dismantling the unit.

The power house will be served by two 300-ton electric cranes. Over the power house will be a large suite of executive offices.

Maximum Cut at Lundy's Lane

Chief Engineer Gaby says that the plant will be turning over in the spring of 1921. Meanwhile temporary extensions are being made at the Ontario Power Company's plant to provide needed power. A large amount of construction plant is necessary in order to complete the tremendous amount of excavation within the time required. While the wetted section of the canal is mostly in rock, there is a considerable amount of overburden to be stripped. The maximum cut is at Lundy's Lane, where the ground elevation is 664 and the elevation of the bottom of the canal is 519, making a cut of 145 ft., of which about 70 ft. is overburden. The average cut over the four miles of the canal adjacent to the Welland River is about 80 ft., of which about half is overburden, while the average cut of the four miles adjacent to the forebay is about 50 ft., mostly rock.

In the concrete-lined sections the soil is a sandy clay and very firm, but some of the overburden is quicksand. The excavation will proceed from the forebay toward the Welland River, so that the quicksand will be given every opportunity to drain through the canal itself. It is expected that pumping will have to be resorted to at times, and occasional slides may be expected, but no undue difficulty is anticipated.

The borings show a considerable number of pockets of water in the sub-base. As all of these are under pressure, it is thought that a number of springs will flow into the canal and that these will slightly augment the flow of water in the canal. During excavation these springs will be allowed to drain down the centre line of the canal, the excavation proceeding upgrade.

Two Huge Bucyrus Shovels

The surveys for the work were begun in 1914 and continued for nearly two years. During the year 1917 the construction plant was brought onto the job and assembled, and during the first part of this year the camps were nearly completed. At the present time the only rock that is being taken out is at the forebay and the only earth that is being moved on the excavated section is at the Whirlpool, but a start will be made in a few days on excavation at other points. Eight hundred men are now at work.

The main equipment for the earth and rock excavation consists of two very large electrically driven, revolving, Bucyrus shovels, fitted with an eight-cubic-yard bucket for excavation in dirt, and of capacity to handle a five-cubic-yard bucket in rock. The boom on No. 1 shovel is 90 ft. long, and the dipper stick 58 ft. The boom on No. 2 shovel is 80 ft. long and the dipper stick 54 ft. Either shovel can load dump-cars which stand on a track the level of which is 62 ft. above the level of the tracks on which the shovel stands. The shovel rests on two tracks (four rails) and is mounted on sixteen wheels. The tracks are 30 ft. centre to centre. The nominal horse-power of each of the two shovels is 715 h.p. upon a half-hour intermittent rating. Each shovel weighs over 400 tons, contains 75 tons of ballast, and has a capacity of 3,000 cubic yards a day when handling earth. At the present time No. 1 shovel is working at the Whirlpool against a face 100 ft. high. It is said to be the largest electrically driven shovel in the world, working against the highest face excavated on work of this character.

There are also five other electrically driven shovels at work, each having a ⅞-yard bucket.

Powerful Construction Equipment

At the Welland River section of the canal, a Lidgerwood cable excavator is at work, fitted with a three-cubic-yard Andreson-Evans clam. The cableway has an 80-ft. head tower and a 60-ft. tail tower, and has a span of 800 ft. The excavated material is being disposed of along the north banks of the river. The width of the Welland River at the water line averages about 300 ft.

The commission has purchased one hundred and fifty 20-yard Western air dump cars, each of 80,000 pounds capacity, six 40-ton steam locomotives and twelve 50-ton electric locomotives. The steam locomotives are switchers purchased from the Pennsylvania Railroad. The electric locomotives were built by the National Steel Car Co., Limited, of Hamilton, Ont., six of them being constructed with General Electric equipment and six with Westinghouse equipment. Two pile-drivers are at work on the river section. There are three 40-ton and two 15-ton Bay City locomotive cranes for general utility work. Drag-line excavators may be purchased at a later date to clean the sloped banks of the overburden which cannot be reached or smoothed down so advantageously by the shovels, or the locomotive cranes may be rigged up for the purpose.

It is estimated in round figures that 9,000,000 cubic yards of earth and 4,000,000 cubic yards of rock must be removed from the excavated section; and from the river section, 2,000,000 cubic yards of material, mostly earth.

Disposal Area at St. David's

At the present time the material which is being excavated from the Whirlpool section is being used to fill the old Whirlpool gulley, but the main dump will be at St. David's. A double-track railway line has been built for the full length of the canal from Montrose to the forebay, and a branch extends to the St. David's dump, two miles away. There will be various other branches of the railroad constructed from time to time as needed. A railway will probably be built from the power house to connect with the Michigan Central at Queenston to bring in the machinery and to take out the material excavated from the power house substructure.

The dump cars drop the material alongside the track and two Jordan spreaders are used to shove it back over the embankment.

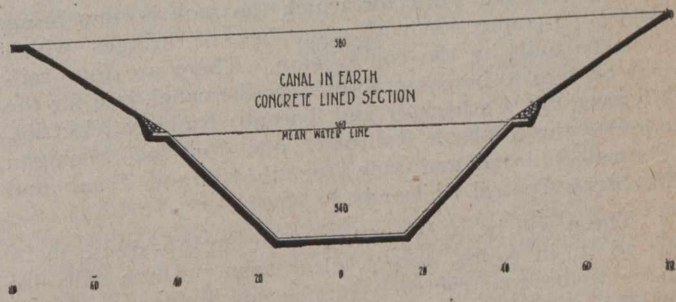
The railroad lines are all electrified, the trolley wires being offset on one side of the track, and carried in clamps devised by the commission's line construction department. These clamps and the hangers which suspend them from the poles, are all made up of standard material, and are so arranged that the temporary use of the material does not injure it. A number of timber trestles are set alongside the temporary tracks and carry the trolley wire for those tracks. These trestles are mounted on four wheels and can be hauled right onto the track and pulled away readily by a steam locomotive when the track is to be moved.

The commission has its own telephone water and electric light systems, and has private, direct telephone communication from the Whirlpool to the head office on University Avenue, Toronto.

Splendidly Equipped Sub-Station

No. 1 sub-station is located at the Whirlpool. The power comes into the station from the Ontario Power Company's plant at 12,000 volts and is stepped down to 4,000 volts by three Canadian General Electric transformers, each of 1,500 k.v.a. capacity. The power is distributed up and down the canal at 4,000 volts. Westinghouse and Maloney transformers step some of the power down from 4,000 to 440 volts for use by the shovels. Three rotary converters, each of 500 kw. capacity, convert some of the power to 600 volts d.c. The station is equipped with most modern appliances in the way of switches and other apparatus, the electrical equipment costing about $110,000.

At this sub-station there are now erected, ready for operation, four Sullivan belt-driven air compressors, each



of 1,000 cubic feet per minute capacity against 125 pounds pressure. They are belt driven from Canadian General Electric 550-volt motors, 180 amperes, 750 r.p.m. As the work progresses, eight or ten more compressors will be installed at this station. All the rock drills, channellers and forges, and much of the other equipment, will be driven by compressed air. The air is piped up and down the canal for three miles in each direction, the mains leading from the sub-station being 10 inches in diameter, reducing to 8 inches and 6 inches. Another sub-station will be built near Montrose and more compressors will likely be installed there.

In the Whirlpool yards is located a large machine shop containing drills, shapers, planers, lathes, forges, trip-hammers and wood-working machines. The commission has built about eighty buildings, including bunk-houses, freight-house, offices, machine shop, store-houses, sub-station, etc. Also a number of buildings are used which were on various parcels of purchased property.

Buildings are Being Gunited

Most of the buildings are of frame construction, but are being gunited on the outside over tar paper and wire mesh, using 1 to 3 mix of cement and sand. Sharp concrete sand is being used and the gunite applied by cement-guns. The sub-station, machine shop and all of the more important buildings have already been fire-proofed and weather-proofed in this manner, and it is the intention to gunite most of the other buildings. The bunk-houses are comfortably arranged upon the cottage plan. Each house has its own garden plot, which the men take care of during the evenings.

The crushing plant is located on the forebay. At the present time there have been erected three gyratory crushers, two No. 7's and one No. 7½, but in the Montrose yard are now the parts for a great 84-inch Traylor jaw crusher which will be erected this summer, and which will have a capacity of 20,000 cubic yards of crushed stone per day. Whether much of the rock will be dumped at St. David's, or whether it will all be crushed for sale to the general public, is a matter of policy that will be determined by the commission.

Building Four Concrete Bridges

The rock will all be drilled with Ingersoll-Rand and Sullivan rock drills and blasted with dynamite. C.X.L. brand, 40% and 60% has been used to date. The rock will be loaded onto the dump cars by steam shovels. At the present time the rock excavation at the forebay is on a very small scale, the stone being quarried merely to provide aggregate for concrete work and to supply ballast for the railways. The rock is loaded into skips which are picked up by a locomotive crane and which dump into a bin. A belt conveyer carries the stone from the bin to the crushers, and there is another conveyer from the crushers to the cars.

The concrete work for which the rock is now being used is in connection with a number of bridges which must be built by the commission. There are four railway bridges to be constructed over the canal, one for the Niagara, St. Catharines and Toronto Railway (electric), one for the Wabash Railroad, one for the Michigan Central Railroad and one for the Grand Trunk and Michigan Central Railroads.

These will be reinforced concrete arch bridges, 36 ft. to 38 ft. in width, 100 ft. clear span. There will also have to be constructed a number of highway and foot bridges to carry the various roads across the canal. In the concrete work to date, both Canada and St. Mary's cement have been used.

Hydraulic Similarity Models

Under the direction of Prof. R. W. Angus, of the University of Toronto, several hydraulic similarity models are being prepared at Dufferin Islands, near the Ontario Power Company's intake in the Niagara River. These models are based on designs prepared by the commission and are for the purpose of studying the conditions at the intake. The design of the intake works will be based upon the results of these studies. The models are being made to a 1/20th scale.

Personnel

Hon. Sir Adam Beck is chairman of the Hydro-Electric Power Commission of Ontario, the other commissioners being Hon. I. B. Lucas and W. K. McNaught, C.M.G. W. W. Pope is secretary, and Frederick A. Gaby, under whose direction the entire work was planned and is being constructed, is chief engineer.

The design and construction of the project are under the direction of the Hydraulic Department of the commission, as were also the studies and surveys for the scheme. Henry G. Acres is hydraulic engineer; Thomas H. Hogg, assistant hydraulic engineer; and Max V. Sauer, the department's designing engineer. E. T. Brandon is electrical engineer.

There is a large staff of engineers and construction superintendents and foremen at Niagara Falls under the direction of J. B. Goodwin as works engineer and of George Angell as general superintendent. A. C. D. Blanchard is field engineer; F. W. Clark, assistant field engineer; R. T. Gent, plant engineer; William Snaith, office engineer; W. S. Orr, resident engineer on Division No. 1 (Welland River section); and George Lowry, resident engineer on Division No. 3 (station 235 to station 438+33, where the forebay begins). No construction work has been done yet on Division No. 2 (from the Welland River to station 235). To date, Mr. Orr has been acting as resident engineer on any work done on Division No. 4 (power house, gatehouse and forebay).

F. W. Scriven is division superintendent on Division No. 3, and C. Anderson acting superintendent on Division No. 1. Nos. 2 and 4 division superintendents have not yet been appointed. Harold L. Bucke is superintendent of railway construction; E. M. McGivern, mechanical superintendent; F. F. Cooper, chief clerk in charge of the accounting, cost-keeping and time-keeping systems.

LESSONS OF THE WAR AS APPLIED TO ROADS AND BRIDGES*

By Walton Maughan

ONE of the revelations of the war is the way in which bituminous-bound or tarred or even ordinary macadam—especially when laid over good foundation layers of Telford pitching—"stands up to its work." More than this need not be said to the able macadam enthusiasts in charge of the rural roads of this country.

On *pavé* roads through or near numerous towns in Northern France and Belgium there may be differences of opinion as to its merits as a lasting surface, but motor and horse transport drivers and hapless pedestrians agree that these merits are more than counterbalanced by its unevenness of contour, its irregularity in wear, causing excessive vibration and noise, and its treacherous slipperiness in dirty weather as compared with good macadam. It is surprisingly common—often in short strips—in lanes and by-roads of minor importance as well as on sections of the great routes nationales.

Footpaths

Regarding footpaths for rural main roads the writer will only state that while he was district road surveyor—(pardon, "inspector")—for the Coventry district of Warwickshire there was added to those roads bearing the heaviest motor traffic an aggregate length of footpaths which in a few years amounted to about 15 miles. For over half of this distance all that was necessary was an opening out of overgrown old-time tracks, and a covering of clinker ashes and screenings. The cost was negligible, for much of the cartage of turf and soil was done free by the farmers of the adjoining land to which this compost was applied during the winter months.

Classification of Road Materials

Such systematic study of the effects of road traffic as I have ventured to plead for naturally brings into prominence the classification of road materials, and particularly road stones, and the urgent necessity for stand-

*Abstracted from a paper read at a meeting of the Institution of Municipal Engineers.

ardizing other elements or substances used in road construction. This is the special province of trained geologists and chemists who ought to be put in charge of a department constantly engaged on this vital work of investigation and research.

At the present day we have very little practical experimental data to go on, and even the far-seeing pioneers —such as Mr. Lovegrove and others—who have undertaken such work on a necessarily limited scale have been handicapped by the absence of actual tests on roads bearing different classes of traffic as shown by a scientifically planned traffic census.

This last method is, the writer suggests, the only sure test of a road stone; but the help of such experts as are suggested will become increasingly necessary as the work of road construction becomes more complex and bituminous and other products play a larger part in our work than hitherto. But even our present-day knowledge would—were it only applied—prevent firms advertising as "granite" numerous classes of road stone as distinct from granite as well-defined classes of rocks can be, both from a geological and a business or commonsense point of view.

Such "annexationists'" material is generally vastly inferior to the best-known granites used on our roads. One instance the writer can give, for he condemned some hundreds of tons of defective material from certain particular quarries, which at the best turn out a second-rate road stone (a quartzite) quite suitable for local district roads, but which lasted less than one-third the life of a good granite stone from quarries in an adjoining county, but equally near at hand. And yet to-day we have millions of tons of stone sold as granite and described as such on their letter paper and literature by firms who do not hesitate to try any means to "down" any surveyor who has the temerity to point out that they cannot produce one single ton of granite from their quarries, or to crush between fingers and thumb quantities of "top-stuff" sold as granite with a crushing strain of —— thousands of lbs. pressure per square inch!

Verily our institution has a future, if only in battling against such real corruption—a work which, coupled with our defence fund, is worthy of our best efforts—another battle in which the writer is determined to again "do his d—ndst." And he would venture to pass on to his colleagues in the defence of our rights that time-worn maxim of war, "The best defence lies in attack."

Wanted—"Business Methods"—and an Organizer

And as constructive, rather than carping criticism is the *motif* for these remarks, I venture to throw out the suggestion that a really able and tactful inspector of contracts (annual and other) should, with the assistance of a small expert staff, be able to save the country possibly £100,000 yearly on that half of the total road expenditure (say, £10,000,000) which is expended on material, etc., and which could thus be brought under review for the purpose of a "business" or "quality" audit, as distinct from that mere checking of figures usually subject to those really infantile "deductions" of the Local Government Board. How? (1) By backing up every surveyor, especially at those meetings of his authority when the large annual contracts are let; (2) by inspecting materials on the roads—before, during, and after use thereon—by organizing and checking transport and haulage, and generally by applying those business principles and that wholesome supervision upon which every really successful business organization is built up, extended, or modified as is necessary to meet the complex difficulties every worthy contractor, no less than each surveyor, has to battle against almost every day.

One result of such appointments would be to increase the output of practically every single class of usable road material, and, though insisting upon uniformity and excellence of material would naturally result in increased business to the firms producing such materials, the only people who would be "ousted" would be those retailers of local dumps of materials which experience proves to be worthless for use even on adjoining roads. On the other hand, a good local material should "oust" material from a distance which is no better for the required purpose. Again, the organization of methods of delivery and of transport should result in enormous economies being effected; and in this connection why not prepare to use some thousands of our war-time motor vehicles—in helping to balance "supply" and "demand" in this public service after the war? All this—and more—should be the task allotted to a really "live" man trained in the severe school of experience to distinguish real organization from its shadow.

Road Rollers

Having regard to the necessity for true downward pressing together of present-day bituminous road materials rather than the uneven tangential stresses of wheeled rollers, the writer has designed both steam and motor-engined road rollers on the "Tank" principle, but as he does not consider he has yet fully mastered all these lessons, the less teaching of half-truths the better.

Bridges

As regards new points *re* bridges and bridge construction brought out by the war, many pages could be written from the military point of view, but were it permissible to publish even a résumé of all the facts interesting to us as road engineers, this phase of our common interests would alone provide the subject-matter for several papers more technical than this "summary of lessons" is intended to be.

The first essential of a bridge which has to carry modern traffic is width, and this point has been already emphasized to the best of my ability. And whether for extending lengthwise those countless culverts and small-span arches, or for filling up behind the haunches of those "hog-back" bridges, which alike seriously detract from the utility of our highways, there is, I consider, no one material to compare with ferro-concrete. In fact, the one outstanding lesson as to materials of construction taught by the war is, in my opinion, the all-round excellence from all points of view of concrete, and more especially ferro-concrete construction.

Ferro-concrete bridges are practically indestructible, as the war has well proved. Not only do they bear the downward stresses they were built for, but they stand the lateral and upward stresses from explosions and floods better than bridges of masonry, etc. Even in England we have had the parapet walls of narrow bridges pushed off by ordinary traffic, whereas ferro-concrete will stand up against almost anything.

In the forthcoming directory of the American Association of Engineers, there will be an innovation in the way of a classified list separated into the several branches and specialties of engineers. For instance, under the electrical engineering division will be sub-heads of members who have had experience in the design, inspection, test or sale of batteries. In the base or main list, which will be alphabetical regardless of grade, the full service record will be given, so that the directory becomes a guide to the employer of engineers and a silent salesman for the individual.

ROAD DRAG COMPETITION

RULES for the road drag competition for the year 1918 have been announced by the Saskatchewan Roadways Department. One important innovation will be noticed. The automobile clubs and good roads associations of the province, which have already done so much for the promotion of good roads, are now, at their own request, being invited to take a practical part in the work of maintenance by entering the competition on the same terms as the rural municipalities.

Rules Governing the Road Drag Competition, 1918

1. The competition is open only to the councils of organized rural municipalities, duly affiliated automobile clubs and duly organized good roads associations. Entrants will be grouped together in such manner as to form districts with from ten to twelve competitors each.

Dragging started officially on June 1st and will end September 30th.

2. Only one entry will be allowed from each municipality, automobile club and good roads association. The entry of automobile club or good roads association must be accompanied by the approval of the municipality in which they are located.

3. The road to be entered must be at least two and no more than six miles long.

4. Any road which was entered in one of the former competitions will not be accepted for entry this year.

5. Roads entered in the competition must be a continuous grade. New roads to be built this year will not be accepted for entry. Roads graded in former years may be regraded and will then be eligible for entry, but such regrading must be finished prior to June 1st.

6. Every competitor is to put a sign on each end of the road bearing the following legend: "This road is entered in this year's road drag competition."

(The Department of Highways will supply, free of charge, to such competitors as apply for same, the necessary signs printed on heavy cotton.)

7. The competing roads must be kept clear of weeds and all manner of growth from ditch to ditch, very short grass between grade and ditch excepted.

Must Make Monthly Returns

8. Returns on forms to be furnished by the Department of Highways must be made regularly every month, and not later than on the date printed at the bottom of the form. They must be filled in complete by both operator and secretary. If the returns are withheld until the end of the competition and then sent in a bunch, or if no returns at all are sent, the competitor who in such manner disregards this rule will be disqualified thereby.

9. The prizes to be awarded in each district will be as follows: First prize, $150; second prize, $125; third prize, $100; fourth prize, $75; fifth prize, $50.

10. The roads of the first prize winners in all districts will be inspected again after the regular prizes have been awarded, and of these roads the one that is adjudged best will receive a grand prize of $250, the second best will receive a grand prize of $150, and the third best a grand prize of $100.

11. All the above prizes will be paid in the following proportion: 75 per cent. to the competitor winning a prize and the remaining 25 per cent. to the winning operator. This applies to both regular and grand prizes.

12. The competitive roads will be inspected from time to time during the season, and the condition of the road at the time of entering, the character of the soil, the amount of traffic and other general conditions affecting it, and the state of the road during the season and when the competitions close, will be taken into consideration in awarding the prizes.

13. The judging will be done by points and the awards of the prizes will be made by disinterested judges appointed by the department, the decision of the judges being final.

14. Roads will be judged along the following lines: 1, Condition of road before dragging starts; 2, nature and formation of soil; 3, length of road. During season: 4, improvement of road in (*a*) crown, (*b*) hardness, (*c*) smoothness; 5, condition of ditches; 6, freedom from weeds; 7, general appearance. End of season: 8, value of returns.

15. No withdrawal of a road will be accepted after June 1st, 1918.

GOOD ROADS ASSOCIATION FOR OTTAWA

ANNOUNCEMENT has been made that in the very near future an Ottawa and District Good Roads Association will be launched. In view of the increase in motor traffic and the success which has attended the Ottawa Motor Club, it is thought that the time has arrived for the organization of a district association whose main object will be the promotion of good roads in that section. So far, most of the responsibility in this connection has fallen on the shoulders of the Ottawa Motor Club officials. In Western Ontario and other parts of the country there have been formed, in addition to the automobile clubs themselves, associations which must link up with autoists in encouraging the work of road construction and maintenance. Ottawa has determined to follow the example of her western friends and the suggestion was discussed last week by President Ahearn, Vice-President Jarman and other officers of the Ottawa Motor Club.

Farmers from the surrounding district will be invited to take part as they, too, will share in the benefits accruing from the policies of road improvement to which the Ontario and Quebec governments are committed.

What is said to be one of the largest hydraulic turbines yet built, is to be installed by the Hydraulic Power Co., of Niagara Falls, N.Y. The normal operating conditions for which the turbine has been designed are as follows: Heads from 213 to 214 ft.; speed, 150 r.p.m.; discharge, 1,500 cu. ft. per second; capacity, 37,500 h.p. The turbines which will be built for the Chippawa development on the Canadian side of Niagara, will have a capacity of 50,000 h.p., but will operate under higher head.

There is urgent need for a definite stocktaking of the commercial timber and pulpwood now available. Mathematical accuracy is not essential, but sufficient cruising and gathering of data should be completed to permit of reliable estimates being made. Such work has already been done by the Commission of Conservation in British Columbia. Similar work will be done in Ontario as soon as the funds are available and the necessary organization has been completed. Then, too, the provincial government of New Brunswick is engaged in making such a survey. As yet, however, only a partial methodical stocktaking has been made of the available pulpwood supplies of Quebec. Quebec has, however, the most important pulpwood area in Canada. The transportation facilities of the province, both natural and artificial, are excellent for the delivery of pulpwood and pulpwood products on the important markets in America and England.

Reconstruction of Devastated Halifax

Under the Leadership of Canadian Engineers and Contractors, Splendid Maritime Port Recovers Rapidly From the Terrible Effects of the Mont-Blanc Explosion—Description of Relief Organization and Methods

WHEN the Belgian Relief boat, "Imo," collided with the French munition ship, "Mont Blanc," in Halifax Harbor at 9 a.m., December 6th, 1917, setting on fire the Mont Blanc's deck load of benzine and resulting in the explosion of her cargo of 4,000 tons of trinitrotoluol, about 2,000 residents of Halifax were killed and 5,000 injured; 3,164 houses and factories were totally destroyed and over 6,000 houses were damaged, the total property loss being $25,000,000.

That such enormous havoc could be wrought without creating vast engineering problems, seemed inconceivable; so after allowing plenty of time to elapse, in order not to interfere in the slightest degree with the all-important work of rehabilitation, Halifax Relief Commission officials were asked to co-operate in the preparation of an article covering the engineering features of the work of reconstruction.

"There is no engineering of any magnitude in this work," said Col. Robert S. Low, the manager of reconstruction. "It's merely a mess of details,—broken windows, fallen chimneys, tottering houses, debris to be carted away, temporary houses to be provided and a hundred and one other detailed jobs of that sort; but nothing of special engineering or contracting interest."

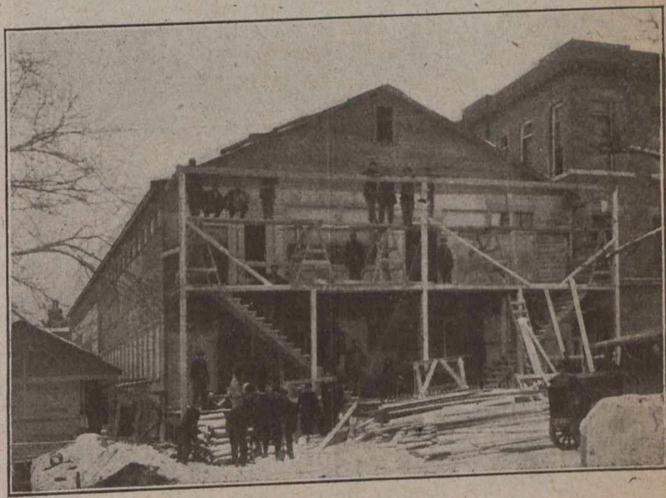
A thorough inspection of the city and surrounding district substantiated Col. Low's summing up of the situation in all but one particular: the splendidly organized system of handling this "mess of details" would interest any engineer or contractor whose average labor consists

The Foreground was Covered with Houses and Stores Before the Explosion, which Occurred at Almost the Exact Centre of this Photo. Beached Across the Narrows can be Seen the Belgian Ship "Imo"

not in the carrying out of extraordinary and unique jobs but in the successful and efficient organization of just such routine details.

Powers of Relief Commission

In view of the magnitude of the relief needed after the accident, and the rapidity with which it had to be afforded on account of the severity of the weather, there was organized a Relief Commission which later was permanently incorporated by the provincial House of Assembly. Should any member of the commission die or resign, the Governor-General is to appoint the successor. The act gives the commission power to expend as it sees fit all money donated for Halifax relief, and to "repair, rebuild



Model Labor Camp

or restore buildings or property damaged, destroyed or lost in the explosion; or compensate the owner to such an extent as the commission thinks fit." Portions of the money subscribed may be set aside for the maintenance, support and education of victims of the disaster, and for the aid of institutions or associations interested in the work of relief.

Regarding reconstruction, the act provides that the commission shall exclusively have such powers as has any city, town or municipality by virtue of the Town Planning Act of 1912. The commission is authorized to lay out and open any new street in the devastated area; to widen, straighten, alter or extend any existing street; to remove the whole or portion of any building, wall or fence; and to raise or lower the level of any street. No action may be maintained against the commission or its officers for any injury occasioned to any property. The commission is empowered to open the soil of any street in the devastated area for any purpose, notwithstanding anything contained in the Halifax City Charter. Any new street opened by the commission shall be considered a public street or road. This also applies to streets widened or otherwise improved.

While the act provides that the commission shall have power in the devastated area to divert any public or private sewers and to connect with the sewer system of any city and not be liable in any action therefor, the provision is made that in doing so the commission shall do the work in conformity with the sewerage system of the city. Power is given to the commission similarly with regard to water supply and hydrants.

Any land which the commission may think fit for its requirements, whether this land is in the devastated area or not, may be expropriated, and provision is made for the appointment of arbitrators.

The commission may from time to time describe, delimit and define any part of the city of Halifax, the town of Dartmouth or the county of Halifax as the "devastated area." The commission may also from time to time alter,

These Temporary Relief Apartment Houses Were Completed at the Rate of One Apartment an Hour

enlarge, restrict or in any way change the area so defined by giving proper published notice to the public.

Organization of the Relief Commission

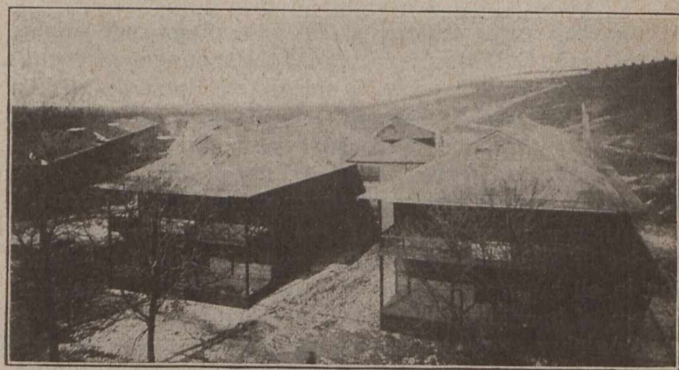
T. S. Rogers, K.C., is chairman of the Halifax Relief Commission, the other members being Judge W. B. Wallace and F. L. Fowke. The work of the commission is divided into two distinct divisions, rehabilitation and reconstruction, the former department dealing with the physical and financial welfare of the victims of the disaster, while the latter department attends to all matters involving buildings or property. Col. R. S. Low was manager of the reconstruction department until June 1st, 1918, when he resigned, having told the commission last January that he would be able to stay only until May. He was succeeded by Geo. Archibald, of Toronto. Ralph Bell is the secretary of the commission, and H. W. Johnston, acting city engineer of Halifax, is consulting engineer. Col. Low attributes a very large share of the credit of the work accomplished to Mr. Johnston, who was an indefatigable worker.

Offices of Relief Commission

Immediately after the disaster, Col. Low opened reconstruction offices at the Halifax Hotel. After the more immediate needs of the situation had been met, and when there had arrived sufficient materials to spare some for the purpose, he built two temporary frame and beaverboard office buildings for the use of the Relief Commission. While classed as temporary structures, these buildings—which were erected and furnished complete in seventeen working days, by the way—are very substantially constructed and will no doubt serve the purposes of the commission for several years. These buildings, and also the mess kitchen and staff quarters were built for the commission gratuitously by the firm of Bate, McMahon & Company.

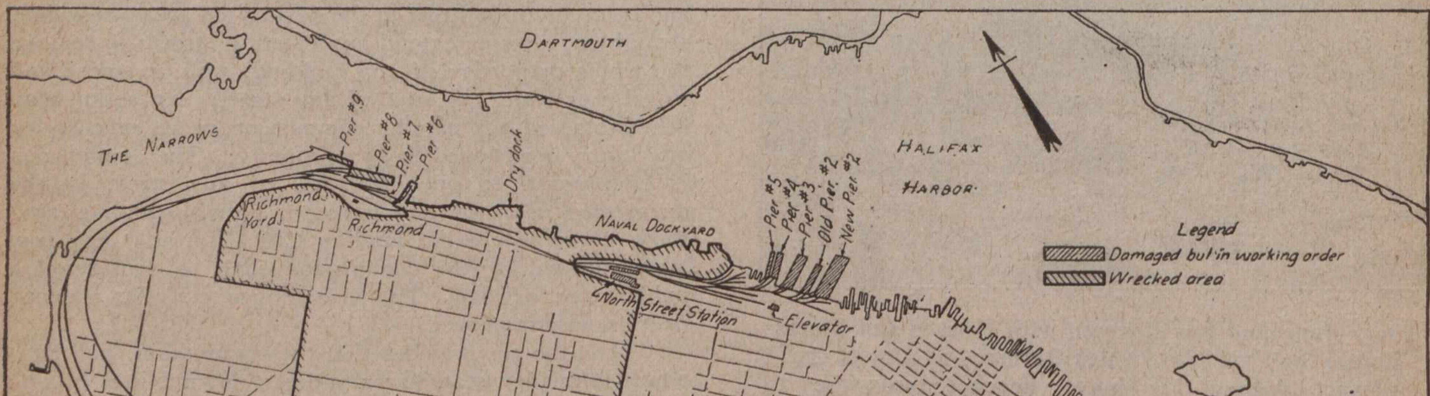
The two buildings are exactly alike and are connected by a hallway. One is occupied by the reconstruction department and the other by the rehabilitation division. The buildings are each 41 ft. x 96 ft., placed 30 ft. apart. They are two stories in height.

The Reconstruction Building provides offices on the ground floor for the purchasing agent, invoice clerk, general superintendent, district superintendents, manager



Halifax Relief Commission's Offices

of reconstruction, acting city engineer, statistical clerks, stenographers, time-keepers, accountants, employment agents and transport clerks; and on the upper floor for the chairman of the commission, Secretary Bell, Commissioner



Map of Part of the City of Halifax, Indicating the Destroyed Area. The "Mont Blanc" was Between Piers 6 and 8 When Her Cargo Exploded

Fowke, engineers and draftsmen, office staff, telephone and telegraph operators, post office employees and appraisal board and staff. In this building is also the general board room.

The Rehabilitation Building houses the medical, social service, food, records, finance, military housing and stationery departments, and Commissioner Wallace. Also in this building is the court room where evidence is heard regarding claims, and where claims for small amounts are promptly disposed of if properly presented and proven.

System in Reconstruction Office

All requests for repairs or reconstruction go first to the general office in the reconstruction building, and are usually handled primarily by the reconstruction manager. Unless there is apparent attempt to defraud by claiming repairs to which the applicant is not entitled, or other reason for special treatment, a memorandum of the application is passed on to the inspection department for report. There are specially qualified inspectors for the various kinds of work required; that is, chimney inspectors, sanitary inspectors who work under the direction of the city's board of health, etc. An inspector promptly visits the given address and reports on the nature and actual extent of the damage, its cause, probable cost of repair, probable time required for repair, and exact amount and size of materials needed. This report in triplicate goes back to the general reconstruction office, and if approved, one copy is fyled, another copy goes to the records office, and the third is sent to the district superintendent in whose territory the work happens to be.

Halifax and its surrounding territory are divided into ten districts, each in charge of a superintendent who has a staff of plasterers, carpenters, masons, etc. Each district has its own headquarters centrally located within the district, also its own carpenter shop, storehouse and toolroom. There is also a general warehouse from which materials are requisitioned by the districts, and to which all materials are originally delivered.

After the final repairs on, say, John Smith's house, 411 Main Street, have been completed, the district superintendent reports the time and materials used, and this information is compared for checking purposes with the

Typical View of Streets Bordering the Devastated Area

estimate previously made by the inspector, and if reasonably O.K. it is entered on a card as illustrated below.

The third column of the card below indicates where further details about each item may be found. "R.R. 1203," for instance, refers to account No. 1203 in the temporary repair records card index. P.R. is the code for permanent repair records; C.R., chimney repairs; W.R., wiring and roofing; S.R., sanitary repairs; G.R., gas repairs; X, special records. These more detailed records are entered on cards in the manner indicated on the following page.

These, of course, are merely the cost and material records and are, in turn, supported in further detail by receipts, requisitions, etc., the whole system being as thoroughly detailed, cross-indexed and "fool-proof" as is possible without involving red tape which would delay the

PERMANENT REPAIRS

Main St. *No.* 411 — John Smith *Owner.*

WORK	DATE	NO.	COST	REMARKS	Total Cost
Temp. Repairs		RR1203	$104.50	Mat. del. by Relief Com. #1217—$32.40	$136.90
Shoreing	3-2-18	RR1505	37.90	Jacking in side of house	37.90
Mason	10-3	PR302	18.00	Foundation	18.00
Chimney	6-1	CR201	25.53		25.53
Glazing	15-1	161	50.50		50.50
Carpenter					
Roofing	14-3	WR300	20.70		20.70
Plumbing	7-1	SR35	10.72	Mch. 10-18 Brown's final bill $30.20	40.92
Heating	15-3	X91	21.70	Jones Ltd. Bill	21.70
Electric	14-3	WR300	17.50		17.50
Gas	4-3	GR25	7.40		7.40
Plastering	23-3	PR340	51.50		51.50
Painting	30-3	PR400	30.20		30.20
Papering	1-4	PR450	15.75		15.75
Barn	11-2			Owner to repair	
				TOTAL	$474.50

work; in this connection, bearing in mind that a large number of these repair orders were of very urgent character.

All systems in the general office are reduced to the simplest form consistent with affording a complete analysis of every expenditure and the rapid finding of any item of expenditure under any heading—type of work, name of owner, or street address. The book-keeping in regard to labor, and the preparation of pay-rolls, etc., are mostly done automatically by specially devised adding and listing machines of large size.

Daily Material Inventory

The vacant plant of the Nova Scotia Car Works was seized by the commission as the general warehouse. Each day the warehouse superintendent makes a report to the general office of the incoming material, outgoing material and stock on hand. The incoming material reports for several months were each made up of from fifty to two hundred or more items such as the following:—

Ex. car No. 152708	10 Wasp ranges
	90 bags cement
	14 wooden benches
The Barrett Co.	190 rolls 2 ply roofing
	2 casks green stain
Brandram-Henderson	2 bbls. green stain
	2 bbls. brown stain
	20 gals. varnish remover
Imperial Oil Co.	4 bbls. gasoline
	5 bbls. coal oil
Stairs, Son & Morrow	6 kegs 4" wire nails
Etc., etc.	

The daily stock sheet is arranged alphabetically and generally contains about 350 items such as the following:

Bath tubs	139
Beaver-board, sq. ft.	152,920
Benches, wooden	20
Brick, cars	1½
Cement, bags	750
Coal, cars	2
Hammers, claw	64
Kitchen sinks	350
Lumber, 1" rough spruce boards	57,436
Lumber, 2" rough planks	11,526
Lumber, 3" rough deal	47,442
Etc., etc.	

These stock lists include all manner of building materials, either bought or contributed. For instance, the stock list of March 10th, 1918, included various sizes and kinds (the quantity of each and kind being separately reported) of axes, bath tubs, beaver-board, benches, blocks, bolts, boilers, Bon Ami, bowls, braces, brick, brooms, brushes, carbide, cement, church bells, clay, closet bolts, clothes lines, coal, copper, cord, crowbars, dampers, disinfectant, doors, dry cells, extinguishers, files, gasoline, glazier points, globes, glue, grease, hammers, handles, hasps, heaters, hinges, hooks, hooks and eyes, jars, keys, kitchen sinks, knives, knobs, ladders, lanterns, latches, laths, lead pipe, levels, lifts, lime, locks, lumber, nails, oil, pails, paint, picks, pins, pipe, plaster, pliers, powder, pulleys, roofing, rope, sand, sand paper, sash weights, saws, scrap lead, scrapers, screw drivers, screws, sets, sheathing, shellac, shingles, shovels, snips, soda, stain, staples, stove pipe, strainers, tape measures, tar, tarpaulins, tins, turpentine, twine, valves, waste bales, wheels, whitening, wicks, wrenches and zinc.

Separate Glass Warehouse

The greatest demand for weeks after the explosion was for plate glass and ordinary window glass, as practically every pane in Halifax and Dartmouth was broken, and most of them were blown out entirely. The explosion was followed by a severe blizzard and very cold weather, and there was acute suffering until the windows were replaced or boarded up. A separate glass warehouse was established where the various sized panes were kept in racks and were cut to exact measurements before being sent to the different jobs, so as to avoid all waste. Glass was purchased twenty carloads at a time. The local dealers were cleaned out in a day, and soon so was every dealer in St. John, Sydney, New Glasgow and other cities in the Maritime provinces. One of the earliest relief shipments from Boston, Mass., was half a shipload of glass. Most of the glass came from West Virginia, Ohio and Pennsylvania, from a score of manufacturers.

1203RR **TEMP. REPAIRS**

Main St. 411		#6 Dist.	John Smith
#432	20-12-17	Inspect and repair house - -	$ 8.90
	24-12-17	RR340 Gl. B.B. &c.	21.40
	26-12-17	RR569 carp. -	28.60
#690	3-1-18	Repair Roof and Plumbing	
#732	30-1-18	Shore up house and further repairs needed	
	5-3-18	Carpenter and Glazing RR900 -	45.60
			$104.50

302PR **FOUNDATION**

Main St. 411	#6 Dist.	John Smith
6-3-18	13 h., 50c. $6.50	
	13 h., 30c. 3.90—10.40	
	8 Bags Cement 6.00	
	16 " Sand 1.60— 7.60—$18.00	

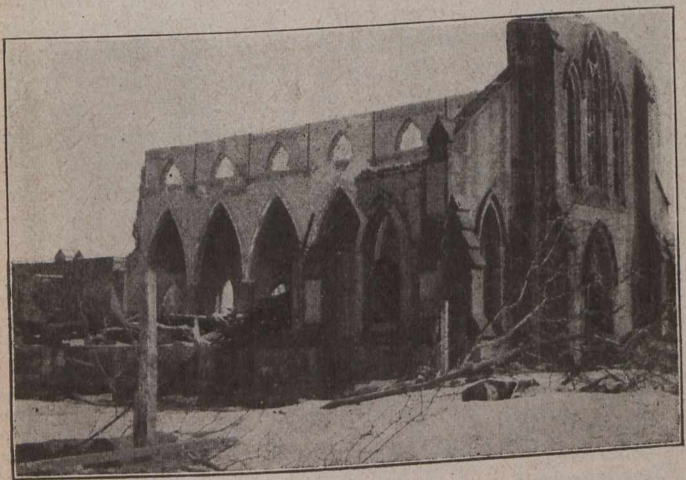
201CR **CHIMNEY**

Main St. 411	#6 Dist.	John Smith
6-1-18	Masons 20 h., 50c.—10.00	
	Lab'rs 20 h., 30c.— 6.00—$16.00	
	375 Bricks $5.63	
	2 Bags Cement 1.50	
	6 " Sand 1.20	
	2 " Lime 1.20 —	9.53
		$25.53

Model Labor Camps

In answer to the call for help that went broadcast at the time of the accident, workmen were sent to Halifax from many parts of Canada and the United States. For several months the number of men employed was very large, totalling at times about four thousand. Most of the large buildings which were situated advantageously for use as camps, had been wrecked, so one of the first things that Col. Low had to do was to erect camp buildings. Two camps were built of the type shown in the accompanying illustration, and other camps were established at the curling rink and at the new Alex. McKay school. These camps are all very sanitary and clean; with large, comfortable mess halls, shower baths, porches and fire-escapes. The bunk rooms are well ventilated and kept remarkably well deodorized.

Each camp superintendent reports each evening on the number of workmen in camp that morning, the number received and discharged during the day, the number in camp that evening, the number of unoccupied bunks, the check numbers of the men received or discharged, the number and occupation of the camp employees, the check numbers of the men who are sick or lying in, and the number of meals served at breakfast, dinner and supper time. The report of the Alex. McKay school camp for March 10th, for instance, showed 1,609 in camp in the morning, 16 received, 12 discharged, 195 unoccupied bunks, 89 employed on camp duties, 4 sick, 1 lying in, 1,330 breakfasts, 1,448 dinners and 1,558 suppers.



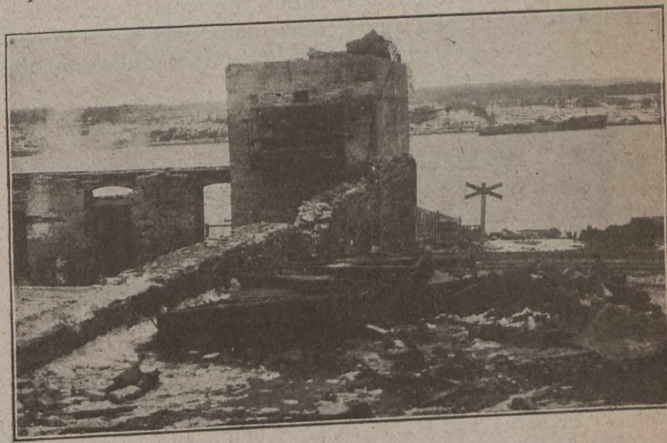
Not Rheims nor Lille,—Just Halifax, After the Explosion. Ruins of St. Joseph's Church

The camps have a medical inspector, Dr. V. A. Miller, who reports daily on the number of men sick and not working, the number examined and treated, and the number in hospital.

Every foreman and superintendent reports daily the number of men at work and their check numbers, and this is summarized in a report to the general office showing how many men in each trade are at work under each superintendent, and a list of the jobs which each superintendent is handling. The report of March 9th, which is typical, showed 3,299 men at work, comprising the following:—

Blacksmiths, 4; bricklayers, 180; carpenters, 1,017; chauffeurs, 39; checkers, 22; clerks, 29; commissary, 163; engineer's staff, 5; estimators, 2; foremen, 150; glaziers, 160; handymen, 111; helpers, 2; inspectors, 8; laborers, 609; masons, 5; mechanics, 17; mill men, 36; office staff, 43; operators, 3; painters, 275; pipe fitters, 8; plasterers, 132; plumbers, 107; policemen, 18; roofers, 8; shippers, 2; stablemen, 4; storekeepers, 8; superintendents, 24; teamsters, 77; timekeepers, 21; watchmen, 10.

Daily reports are sent to the general office by the inspector of each trade at work. The painting inspector reports on the status of each painting job, the plumbers report their progress, and so do the electricians, carpenters and all other basic trades. In addition to studying these reports, much of the work is personally visited each day by the manager and assistant manager of reconstruction and by the general superintendent, while each district superintendent visits every job in his district.



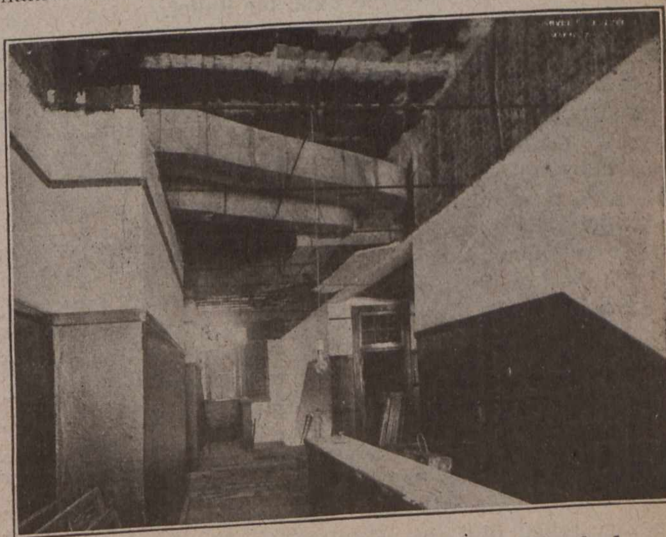
Ruins of a Warehouse—"Imo" Beached Across the Narrows

Daily report is also made of the men who have given notice that they are leaving the employment of the commission. This report takes the following form:—

No.	Name.	Occupation.	Cause.
473	Fisher, Harry	Carpenter	Wife sick
499	Marhian, L.	Bricklayer	Drafted, M.S.A.
672	Aspirat, P.	Glazier	To go on farm
2133	Rawle, C.	Carpenter	Broken ankle
Etc., etc.			

Tab Kept on Teams and Motors

Equally accurate record is also kept of the teams employed. A daily report is made showing who ordered the team, who was the owner of the team, number of hours used, number of loads carried, where loads were obtained, where loads were delivered, character of load, team number (under commission's system of numbering) and name of driver.



Interior of New Alex. McKay School was Wrecked—Walls Bulged and Reinforcing Almost Blown Out of the Concrete in Places

Similar reports are made daily for the motor trucks, and also a garage report showing the number and make of each truck in service and what condition it is in. The garage also reports in this manner on the touring cars in service.

To prevent the use of the touring cars for private purposes, a very detailed touring car report is presented daily, showing just who has used each car and for what purpose it has been used every minute of the day. A summary at the end of the report shows how many total hours each person has used autos, how many cars were in service, the total number of people who used them and the total time for which they were used.

General Summary of Reports

All daily reports of repair work, labor, teams, trucks, etc., are summarized in a daily general report to the manager of reconstruction. The following is a typical example of this general report:—

Report of Repair Work Up To and Including March 17th, 1918

Number of requests made for general repairs	5,397
Number of houses temporarily completed	5,945
Number of repairs completed to soldiers' homes by the Military Housing Committee	152
Number of barns and stable repairs completed	68
Number of houses reported on by city engineer and listed for permanent repairs	3,694
Number of permanent repair jobs in progress	1,527
Number of chimneys inspected by district chimney inspectors and found O.K.	1,268
Number of chimney repairs completed	3,508
Number of sanitary repair requests	2,904
Number of sanitary house inspections by city health board	1,114
Number of sanitary repairs completed	1,598
Total number of men registered: Reconstruction, 6,666; Cavicchi & Pegano, 1,200; Bate, McMahon & Co., 745	8,611
Total number of men working: Reconstruction, 2,973; Cavicchi & Pegano, 464; Bate, McMahon & Co., building temporary dwellings, 250; Eastern Investment Corporation, building temporary dwellings, 12; Falconer & McDonald, building temporary dwellings, 81; Dartmouth relief, 53; Fairview and Bedford relief, 17	3,850
Total number of teams working: Double, 33; single, 16	49
Total number of motor trucks	19
Total number of passenger cars	22

$20,000,000 Cash for Relief

The cash contributions to the Halifax Relief Commission total about $20,000,000, of which $5,000,000 (£1,000,000 sterling, to be exact) was voted by the British government, $12,000,000 by the Dominion government, and about $3,000,000 ($2,835,400 up to February 28th, 1918) by individuals, corporations, associations, municipalities, provincial governments and others.

The private and public donations of $50,000 or over were as follows: British Red Cross, $125,000; Bank of Nova Scotia, $100,000; Chicago Committee, $130,000; Mayor's Fund, London, Eng., $600,000; Province of Ontario, $100,000; Australia, $250,000; Province of British Columbia, $50,000; Dominion Iron & Steel Co., Limited, $50,000; Hero Land Bazaar, New York City, $75,000; Newfoundland, $50,000; Royal Bank of Canada, $50,000; St. John's, Newfoundland, $50,000; Greater Vancouver, $56,180; Winnipeg Free Press Fund, $85,011.

The amounts expended for rehabilitation and temporary relief, plus the amounts so required for the remainder of this year, total about $4,000,000, but this does not include permanent repairs to damaged property nor the restoration of buildings nor compensation for their destruction. An amount of $732,166 was expended by the various voluntary committees before the Relief Commission assumed control. This included transportation to or from Halifax given to 2,308 persons.

There are some special funds not administered by the Relief Commission, but none of these are of very large amounts excepting the $500,000 fund contributed by the people of Massachusetts for the specific purpose of refurnishing homes the contents of which were destroyed. This fund is governed by a Massachusetts committee working in co-operation with a Halifax sub-committee.

Amount of the Damage

The Relief Commission appraises the property damage as follows:—

Dwellings	$ 6,476,000
Contents	3,330,000
Schools	342,000
Public Institutions	222,000
Business Properties and Merchandise	1,041,000
Municipal and Public Buildings	105,000
Churches, Manufacturing Plants and Specials	3,484,000
Total	$15,000,000

These figures do not take into account the destruction of public property belonging to the Canadian Government Railways and the Naval Service Department of the Dominion Government, nor do they include the loss to shipping in the harbor of Halifax. The commissioners have been unable to obtain an accurate account of these losses, but they are of opinion that they may be safely estimated as not exceeding $10,000,000. The shipping losses will be substantially met by marine and war risk insurance, and the restoration of public property has been taken care of by the Dominion government. The extent of the whole loss (excluding any sums to provide for indemnification for loss of life or personal injury, or for trust funds for the education or support of victims or their dependents, or for loss of taxes to the city of Halifax) is placed at the sum of $25,000,000.

The above-mentioned damage to the property of the Canadian Government Railways is estimated as follows by the railway staff:—

Piers, Buildings, Tracks, Machinery, Power and Telegraph Lines, and Signals in Halifax	$ 751,600
Similar Structures in Dartmouth	52,700
Rolling Stock	178,000
Commissary Stores	17,700
Steamer	70,000
Miscellaneous Expenses in Cleaning up and Relief Work	155,000
Total	$ 1,225,000

Damage to Canadian Government Railways

The explosion occurred in the vicinity of Piers 6 and 8, where were located the principal sidings of the Canadian Government Railways. For a time it put the railway completely out of commission. Laymen who viewed the wreckage predicted that trains would not run into Halifax for a month, and even W. A. Duff, assistant chief engineer of the Canadian Government Railways, said it would take a week. However, Mr. Duff and C. A. Hayes, the general manager of the railway, and their staffs, set energetically to work; within two days they had cleared the main line and had trains running into the city.

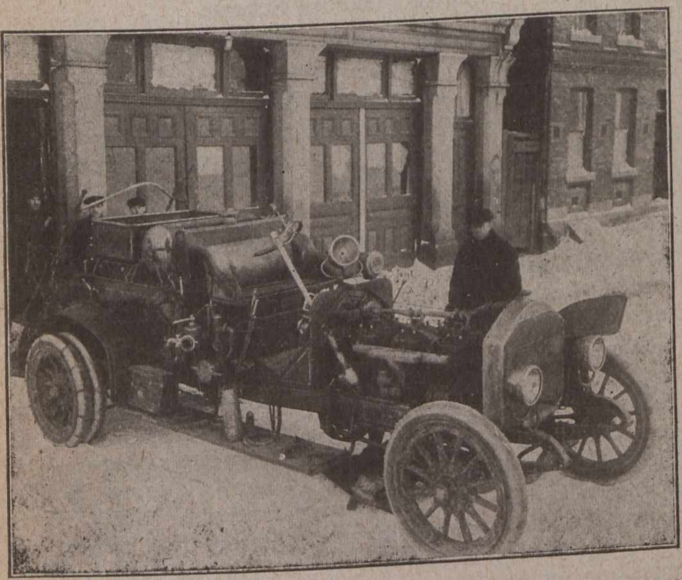
The North Street station, which is the chief passenger terminal of Halifax, was practically in ruins, and the main tracks leading to the terminals for a distance of three miles had been blocked with debris. All telephone, telegraph and despatch lines were down, adding to the difficulties of operation.

Fortunately the line from Rockingham to the new Ocean Terminals, and the terminals themselves, lay beyond the area of destruction, and although the rails had only been used for construction trains and the terminals were entirely without any proper means for the unloading or loading of freight, and lacked passenger accommodation, yet with such limited facilities as could be temporarily improvised, it was possible to rush relief trains and supplies to the heart of the city and carry refugees therefrom. On the evening of the day following the disaster, the first regular train for Montreal also left from the new terminals and the latter were continued in use until the regular station was available.

Heavy cranes were put to work clearing away the wreckage, and by the second day after the disaster, trains were able to leave the regular passenger station at North Street.

Gangs of men were also put on the reconstruction work at Piers No. 2 and 3, North Street station, Willow Park and Richmond, and the work of repair was pushed to the utmost. Arrangements were made to erect additional freight sheds on the completed docks at the Ocean Terminals, to replace those lost at Richmond.

At the same time, order had to be restored in other branches of the railway service. The importance of the terminals called for a large and varied body of skilled



This Fire Department Auto was Travelling a Street Half a Mile from the Waterfront When the Explosion Occurred. The Driver was Blown Out of His Seat and the Machine Wrecked

labor. Hundreds of the employes had had their homes in the immediate vicinity of the catastrophe. They were naturally concerned about their families. The explosion had demoralized the local staff. Fifty-eight employees were killed, over forty seriously injured and over one thousand were incapacitated from their regular duties. Hundreds of employees were called upon from various parts of the line to fill the gap; a whole new staff had to be organized.

As soon as possible a survey was made of the railway properties. At Pier 9, the most northerly railway pier along the waterfront, the force of the explosion was such that the wooden shed had totally collapsed. Pier 8 was destroyed from the water level up, and Pier 6, the reconstruction of which had been completed just a few weeks previously, was completely blown away. No trace of it remained.

Richmond yard station, car repair buildings and cattle pens were blown to atoms; the water tank was rendered useless and the switchmen's shanties were so badly wrecked as to be unfit for repair.

The North Street passenger station sustained very heavy damage. A large portion of the train shed roof was blown up, the remainder practically collapsed and fell down inside the brick walls and what did remain was pulled down later on for safety. The glass was blown out of all the side windows and the doors blown out of their casings. In the solid brick station structure, all the doors, windows and fixtures were blown off, as also happened in the power plants adjoining the station.

On Pier 4 the shed was completely wrecked. Pier 3 had all the trusses on the north half of the shed broken and all the doors and windows blown out. Pier 2 had the doors all blown off on the north side, both upstairs and down. On the south side eight of the large steel doors were blown off and a number damaged.

The roof over the bins of the 500,000-bushel grain elevator was badly damaged.

Damage at Willow Park

At Willow Park, where engine cleaning and housing facilities are located, the doors and windows in the car shop, stores building, planing mill, oil house and engine house were blown out. The roof of the engine house was badly damaged and the greater portion of it collapsed. The power plant was put out of commission, and the power transmission line to North Street and Deepwater, which follows along the city streets, was also wrecked.

The telephone despatching line between North Street station and Rockingham was rendered useless by the explosion. All automatic signals between North Street station and Willow Park were badly wrecked.

With the early operation of the new terminals in view, temporary repairs were made on the old sites and North Street station was made habitable only temporarily.

Notwithstanding all this disorganization, eight days after the catastrophe all the branches of the service were working.

Special Railway Construction Organization

A special railway construction organization was made up to handle the work of repairing and rebuilding the railway structures, and the repairs to the naval dockyard were later also put into the hands of this organization, which consisted of a manager of construction, an architect and a naval man, assisted by two contracting superintendents who acted in a consulting capacity. Under this board there were assembled office and field engineers, draughtsman, auditors, purchasing agent, storekeeper, material men and commissary men. The office of manager of construction was held by C. B. Brown, assistant general manager of the Canadian Government Railways, and the execution of the work was under the direct charge of W. A. Duff, assistant chief engineer.

The Civic Reconstruction Situation

The railway organization normally included a large number of engineers and contractors; and on account of the Ocean Terminals work which was in progress, there was considerable construction equipment available. The city staff was in no such fortunate position, so on the morning of the disaster the emergency committee telegraphed to Ottawa to Col. Low, requesting his services. Col. Low's genius for rapid organization was well-known in Halifax and the committee decided that he was the man to handle the emergency. Col. Low consented to take charge of reconstruction for five or six months, but stipulated that his services and those of his staff be accepted without remuneration. He and his staff even insisted upon paying for their meals at the boarding camp, and it is understood from the Commission that Col. Low and Bate, McMahon & Co.'s staff did not get so much as a postage stamp from the Halifax relief work.

Shelter was the crying need of the hour after the explosion. The temperature dropped to 12° below zero and snow fell the night of the disaster and kept on falling most of the time until nearly April. It was the worst winter that Halifax had experienced in twenty years, and enormous efforts had to be made to house temporarily the afflicted thousands. Owing to the storms, even the work of merely repairing semi-shattered houses was difficult; but it progressed rapidly. Glass and glaziers poured into Halifax from every direction.

Eighty-four Temporary Apartment Houses

"We need food and glass, especially glass," Col. Low telegraphed broadcast. Chimneys were the next consideration, for fire-places and furnaces in thousands of houses could not be lit owing to damaged chimneys. Next, a type of temporary dwelling for the homeless had to be devised, and a city of frame and beaver-board structures sprang up at the rate of an apartment an hour. These dwellings were standardized in the form of two-story apartment houses, each house containing eight four-room-and-bath apartments.

Forty-four of these apartment houses were erected on South Commons by contractors, forty in the Exhibition Grounds by the commission, ten on Garrison Commons by Bate, McMahon & Co. (the firm doing this work free of charge), and eight in Dartmouth by the commission, a total of 102 houses, or 816 apartments.

In addition to the construction of the ten apartments and the two office buildings, and the services of Col. Low and his staff, the firm of Bate, McMahon & Co. also furnished the commission with about $25,000 worth of needed machinery for reconstruction plant. The firm had been asked by Chairman Rogers to help with the construction of the temporary buildings by assuming contracts, but they agreed to help only upon the understanding that their services would be accepted without remuneration.

Of the 44 apartments erected under contract, the Eastern Investment Corporation built twenty, and Falconer & MacDonald built twenty-four. The lump sum contract price was $6,600 per house, exclusive of water and sewerage works.

Early Resumption of Business

Speedy rehabilitation, so as to permit of early resumption of business, was the aim in determining what reconstruction should first be given attention. The principle of enabling the citizens to "carry on" again independently of charitable relief was the one adopted by the commission. The population of Halifax city and county at the time of the 1911 census was 74,662, and was estimated at over 80,000 at the time of the disaster; but more people than that number were affected, owing to the interruption to shipping. The exports from the port of Halifax for the year 1917 totalled $142,000,000; imports, $10,000,000. The customs receipts totalled $2,500,000; building permits, $900,000; value of manufactured products, $22,000,000; post-office receipts, $1,800,000; bank clearings, $152,000,000; civic assessment, $38,000,000; shipping, 17,100,000 tons; freight handled, 1,700,000 tons. The business that was interrupted by the explosion was, therefore, of no mean proportions, and the Relief Commission wanted the same sort of rapid construction work that had built Valcartier and Borden military camps in world's record time. It is true that there were some who preferred to assume the rôle of obstructionists rather than reconstructionists, but in the main the people bent to the task eagerly and helped Col. Low in every possible way to carry out the decisions of the Relief Commission.

Sanitary Precautions

The commission decided that a separate organization should be effected for clearing the devastated area, and awarded a contract to Cavicchi & Pegano, contractors, of Halifax, to carry out that part of the work. They were paid a lump sum price per load of debris carried away and also a certain sum for the remains of each body found, and the work was done very carefully so as to find every victim.

Dr. J. W. S. McCullough, head of the Ontario Provincial Board of Health, went to Halifax as consulting sanitary specialist, and upon his advice the devastated area was quickly and most thoroughly cleared of every particle of debris, to prevent unsanitary conditions arising, and possible epidemics, with the coming of warmer weather. Every drain was removed down to the sewer connections. The water mains and sewers were not injured, so far as could be ascertained upon inspection by the city engineer.

Town Planning Scheme

The devastated areas will be rebuilt under the direction of the commission. In this work a definite "town plan" will be followed. The scheme is being prepared by the town planning boards of the city and county under the advice of Thos. Adams, of the Commission of Conservation, who has been appointed consultant to both boards. In co-operation with the city engineering department, these boards are preparing draft schemes for five areas.

H. L. Seymour, D.L.S., of the surveyor-general's staff, Ottawa, has been loaned to the Commission of Conservation to assist with this work.

One scheme is being prepared for the city of Halifax for an area of about 3,285 acres and four schemes are being drafted for adjacent parts of the county of Halifax, comprising an aggregate area of about 20,000 acres. R. M. Hattie is secretary to the Town Planning Board. Public notice has been published under the Nova Scotia Town Planning Act of 1915, of the intention to proceed with this work under authority of the provincial commissioner of works and mines.

Greatest Explosion in History

At the official investigation into the cause and responsibility for the disaster, an American engineer in the employ of one of the largest manufacturers of explosives in the United States, and who had been selected by them to give expert testimony at the enquiry, said that the explosion at Halifax was the greatest that had ever occurred in the history of the world.

Explosives, he testified, are of two classes: (1) Gunpowder, the explosion of which is comparatively slow, as the material is a mechanical mixture and the flame has to spread from layer to layer. Such a material requires only flame to set it off, and its properties as an explosive are not improved by the action of a detonator, although that means of firing it can be employed. Gunpowder cannot be exploded by shock alone. (2) High explosives, such as T.N.T., picric acid, nitro-glycerine, and dynamite. These substances can be exploded by means of flame, but the best results are obtained by means of a detonator, such as a mercury fulminate blasting cap. This results in an instantaneous release of the explosive into a gaseous form. The gas expands at the rate of 7,600 metres a second, that is to say, about 8,300 yards, or over 4½ miles a second. This applies to T.N.T. Ordinary blasting charges expand at the rate of three to four thousand yards a second. Of course, the effect of the explosion varies, picric acid or T.N.T. causing the greatest results when detonated in a confined space, at high density.

The rapid expansion of this gas in all directions, declared the witness, drives the air away from the area over which the explosion extends. But the gases cool rapidly, and as they cool they again contract, creating a partial vacuum and allowing the air to rush in again over the affected area. It was this sudden withdrawal and return of the air over Halifax which caused houses to collapse like cardboard boxes and smashed the windows and doors of more substantial structures. The witness said that although it would be too light to be seen in daylight, the explosion would be accompanied by a flame which would spread over the whole area of the explosion, and he had no doubt that this flame was responsible for houses being set instantaneously on fire, although possibly in many cases fire would have occurred anyway from the upsetting of stoves.

The greatest previous explosion, said the expert, was that of 500,000 pounds of dynamite which blew up the steamer "Alum Chine" in Baltimore harbor. The "Black Tom" Island explosions of last year were caused by about 350,000 pounds of explosives similar to those which blew up at Halifax, distributed on freight cars and lighters. Even then, there were several different explosions. The island is about one and a half miles from the Battery, New York, where much damage was done, and glass was broken in some parts of Brooklyn, four miles away. There is no doubt, testified the witness, that the wreckage at Halifax was the worst ever created by any explosion in the history of the world.

ONTARIO'S METALLIFEROUS PRODUCTION

Returns received by the Ontario Bureau of Mines for the three months ended March 31st, 1918, are tabulated below. For purposes of comparison the quantities and values are given for the corresponding period in 1917:—

Summary of Metalliferous Production—First Quarter of 1918.

Product.	Quantity. 1917.	Quantity. 1918.	Value. 1917.	Value. 1918.
Gold (ounces)	127,692	113,387	$2,601,760	$2,265,521
Silver (ounces) ...	3,945,957	4,114,856	2,831,873	3,740,843
Cobalt (metallic) (lbs.)	84,710	37,545	78,668	75,625
Cobalt oxide (lbs.)	83,014	81,760	66,798	130,486
Nickel oxide (lbs.)	5,495	......	550	......
Nickel (metallic) (lbs.)	......	44,154	......	17,662
Other Cobalt & nickel compounds (lbs.)	118,292	143,381	13,695	18,386
*Nickel in matte (tons)	10,141	9,677	5,070,410	5,806,200
*Copper in matte (tons)	5,063	4,727	2,025,227	1,748,990
Copper ore (tons) ..	1,507	......	44,097	......
Iron ore (tons)	23,035	32,530	58,205	127,916
Pig iron (tons)	163,020	148,752	2,743,441	3,948,209
Molybdenite, concentrates (lbs.)	25,073	17,410	32,202	24,548
Lead, pig (lbs.) ...	263,046	60,283	27,290	5,066

*Copper in matte was valued at 20 cents and nickel at 25 cents per pound in 1917. For 1918 the values have been placed at 18½ and 30 cents per pound, respectively.

Molybdenite ore, to the extent of 1,295 tons, was treated by the Mines Branch, Ottawa, and by the Renfrew Molybdenum Mines, Limited, at Mount St. Patrick. The output of the last-mentioned company is shipped direct to France. There are works at both Orillia and Belleville for the production of ferro-molybdenum.

MUNICIPAL ELECTRICAL ASSOCIATION

It was very fitting, said President E. V. Buchanan, of London, Ont., in opening the meeting of the Association of Municipal Electrical Engineers of Ontario in the Refectory in Queen Victoria Niagara Falls Park last Friday afternoon, that the first annual convention of the association should be held at Niagara Falls, where several million horse-power await harnessing.

About 160 engineers, representing municipal electrical plants throughout Ontario, three-quarters of which are Hydro plants, attended the convention, which lasted two days. The association was formed three months ago. A hundred and eighty-four municipalities were asked to join, said Secretary R. A. Clement, of Toronto, and eighty-three of these had already become members. There is a bank balance of over eight hundred dollars to the association's credit.

Just before the convention opened, the delegates watched a blast made for the Hydro's 13-ft. 6-in. pipe line which is nearing completion, and which will make possible the development of about 50,000 more horse-power at the Ontario Power plant.

The papers read at the convention were as follows:—

"Factory Lighting," by M. H. Madgsick, of the engineering department of the National Lamp Works of the General Electric Co., Cleveland, Ohio.

"The Evolution of Electrical Inspection in Ontario," by H. F. Strickland, chief electrical inspector, Hydro-Electric Power Commission of Ontario.

"Thirty Years as an Electrical Salesman," by Geo. Rough, vice-president, Packard Electric Co., St. Catharines.

"Overseas Trade," by Fred. W. Field, H.M. Trade Commissioner, Toronto.

"Application of Synchronous Motors to Industrial Uses," by M. J. McHenry, manager, Hydro-Electric System, Walkerville, Ont.

"Sales Service," by J. F. S. Madden, sales engineer, Hydro-Electric Power Commission, Toronto.

Wills MacLachlan, of Toronto, gave a valuable demonstration of a new and successful method of resuscitation.

H. G. Acres, hydraulic engineer of the Hydro-Electric Power Commission, gave a ten-minute talk on the Chippawa-Queenston development, after which the members were motored to the Whirlpool yards and from there were taken on a construction train to the power house site near Queenston; the machine shops, the sub-station and the big Bucyrus shovels being inspected en route.

The following officers were elected for the ensuing year: President, E. V. Buchanan, manager of the London Public Utilities Commission; vice-president, E. I. Sifton, Hydro manager at Hamilton; secretary, S. A. Clement, assistant engineer, municipal department, Hydro-Electric Power Commission; treasurer, R. C. McCollum, municipal auditor of the Hydro-Electric Power Commission.

The by-laws were amended to reimburse the members for their railway expenses in attending the convention; to add five district vice-presidents to the list of officers; and to admit non-voting and non-office-holding commercial members at a fee of $10 per annum. This class of membership will include manufacturers, contractors and dealers in electrical equipment and supplies dealing directly with the municipalities.

The Class A members are the municipalities, each of which can be represented at the meetings only by the chief operating executive of the municipality's utility.

IMPROVING ARCH ACTION IN ARCH DAMS*

By L. R. Jorgensen, M.Am.Soc.C.E.

THE fact that arch dams, and mainly those of heavy sectional area, do not develop arch action before considerable load has been applied to them, is generally known, but, to a great extent, has not been especially considered in their design.

At present, working stresses of about 25 tons per square foot, as used in ordinary dam practice, are sufficiently low to produce a safe structure, even in spite of the fact that the formulas used for the design do not consider everything.

It is obvious, however, that if the practical arch could be constructed in such a way as to coincide more nearly with the ideal arch—that is, one which acts as an arch from the very start, and in which the load is mainly carried by pure arch action—a still safer structure would result. Higher unit stresses than are now common could be used with safety, if arch action could be made more definite from the start. The factor of safety to be used would depend on the importance of the particular structure in each case.

The two main reasons for the phenomenon that an arch dam does not act as an arch before considerable load has been thrown on it are, as is well known: First, the shortening of the arch rib due to shrinkage; and, second, because the arch is fastened to the foundation.

The shortening of the arch rib is caused by the natural shrinkage of the concrete as it sets, the dissipation of the chemical heat, the permanent set after the reservoir has filled once, and the fact that dams are of necessity almost always built during the season of highest temperature.

This shortening of the arch rib is plainly visible on dams provided with contraction joints. With an empty reservoir, during cold weather, these joints will have opened up from ¼ in. to perhaps as much as ⅜ in., where spaced, say, 60 ft. apart. If not provided with contraction joints, a dam of heavy cross-sectional area will undoubtedly show cracks at more or less regular intervals from 40 to 80 ft. apart. A dam of slim cross-sectional area may not always crack, as it is somewhat flexible, and the crown can often be pulled in a down-stream direction without developing excessive tension in the arch.

In cases where the contraction joints have opened up, the water level in the reservoir will have to rise a certain distance in order to throw sufficient load on the structure to force the dam, acting as a cantilever, to deflect in a down-stream direction, before the voussoirs—that is, the bodies between the contraction joints—come into contact with one another. Only from that moment does the remainder of the water load divide up between the arch, the curved beam, and the cantilever.

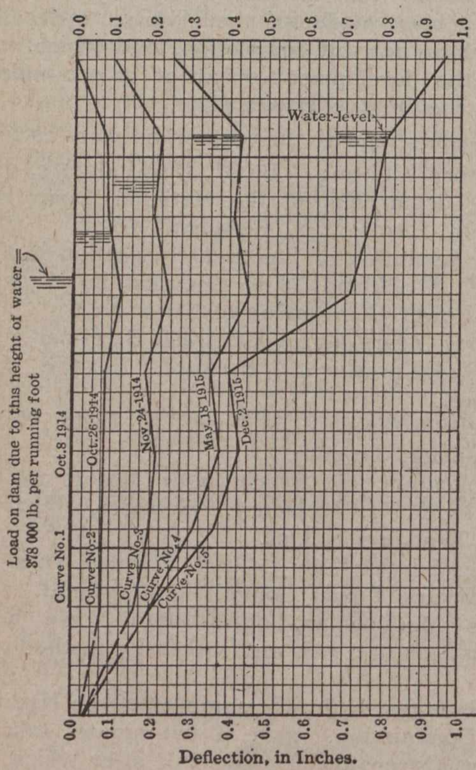


Fig. 1

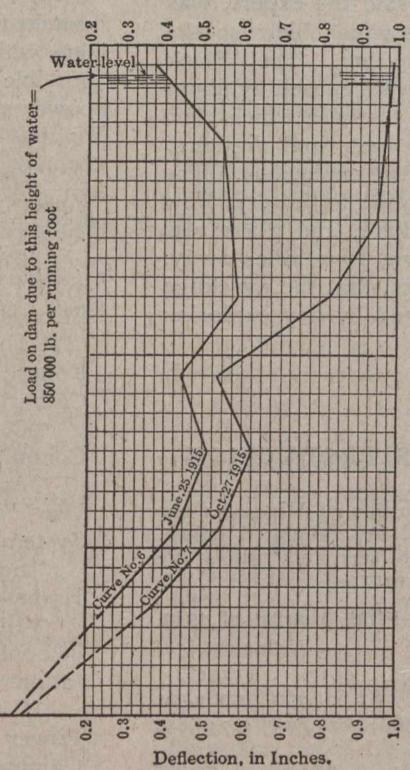


Fig. 2

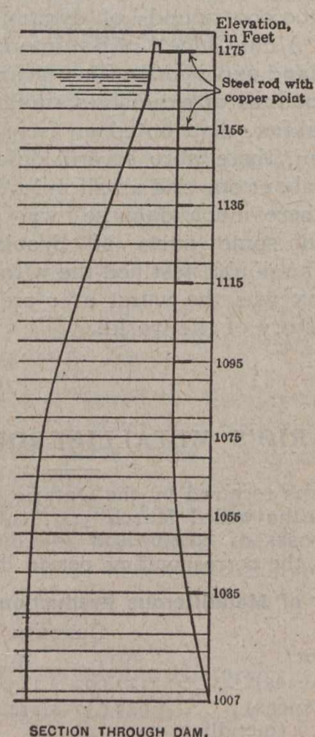


Fig. 3

In the case where the arch has not cracked, although under the influence of tensile stresses, the water level in the reservoir will have to rise until this tension has been compensated for by pressing back the cantilever. The remainder of the water load is then divided up between the arch, the curved beam, and the cantilever, according to their relative capacities for sustaining load.

The fact that the arch is fastened to the foundation prevents any considerable arch action from taking place at or near the latter; this, however, is not detrimental to the safety of the structure, such as would be the shortening of the arch due to shrinkage. The load on the lower portion of the arch causes shearing stresses in the concrete next to the rock and for some distance above and below. These shearing stresses, in turn, cause an elastic deformation, of both the dam and the rock foundation, to take place in a down-stream direction, especially at the crown of the arch, where the movement in that direction is the greatest. Ordinarily, the rock bottom has a higher modulus of elasticity than the concrete; it is well supported laterally from all sides, and therefore offers

*Abstract of paper presented before the American Society of Civil Engineers, June 5th, 1918.

greater resistance to this movement (perhaps three times) than the concrete, but there is nothing to warrant the assumption that the rock bottom is immovable, and measurements also seem to indicate that it is not although measurements of such movements are very difficult to make correctly, as they are so small in this region.

A trial calculation will ordinarily indicate very low unit shearing stresses at the foundation, even assuming that shear alone carried all the load on, say, the lower fifth of the dam.

The unit shearing stresses, in most cases (perhaps in all cases), will be less than the unit weight multiplied by the coefficient of friction; but, in any case, the weight of the structure will exert considerable unit compression perpendicular to the horizontal plane of shear, and thereby improve the ability of the concrete to withstand shearing stresses along horizontal planes.

Deflection Curves

The curves shown on Figs. 1 and 2 are typical for the deflection of the crown of an arch dam due to different water loads and different temperatures of the dam body.

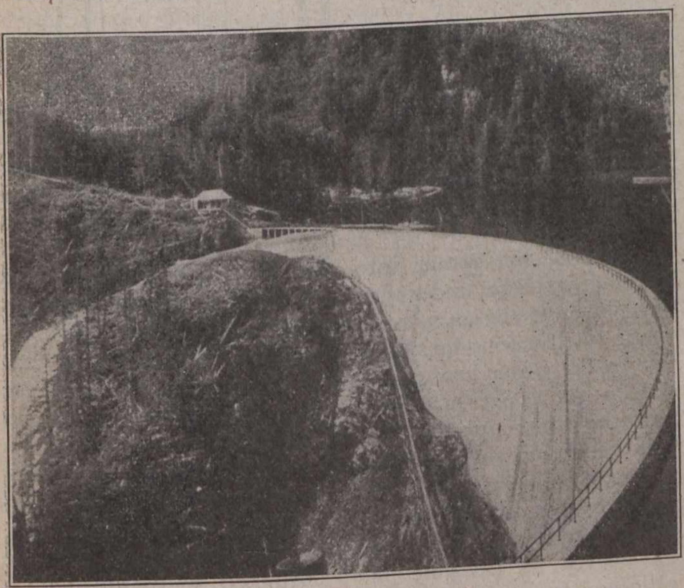


Fig. 4—Salmon Creek Dam, Near Juneau, Alaska. 168 Feet High

The curves are plotted from measurements taken on the Salmon Creek dam, near Juneau, Alaska. This dam (Fig. 4) is of the constant-angle arch type, 168 ft. high, with a crest span of 550 ft.

Fig. 3 shows the maximum cross-section at the crown. On this cross-section is indicated a number of horizontal steel rods embedded in the masonry, 20 ft. apart. These steel rods are provided with copper points on the down-stream end for weather-proofing purposes. The different readings were obtained by sighting these points through a transit and determining their position in regard to fixed bench-marks.

It is very difficult to measure the deformation close to, or at, the foundation. It is so small that a transit reading would not be accurate enough, and if a stationary measuring apparatus was arranged on the ground, down stream from the dam, it would have to be at least 50 ft. distant in order to be on ground which does not take part in any movement caused by the load on the dam. The measuring tape or rod then becomes so long that all measurements taken must be compensated for temperature changes, and even a small error in such calculations or estimates will be sufficient to make this method of doubtful value. The best thing to do seems to be to extend downward, in a uniform direction, the curve obtained from observations at higher elevations.

The measurements on the Salmon Creek dam were commenced on October 8th, 1914, when the reservoir was filling for the first time, and the position of all the copper points on that date is taken as zero for all curves shown on Figs. 1 and 2. The actual zero will lie a little to the left; it may be some time before the water will be low enough to determine it by measurements.

The load due to the water level shown for Curve No. 1 was sufficient to keep the contraction joints (only two) closed.

Construction Features Cause Peculiarity

There is not much that need be explained about the results of the first and second deflection measurements—those taken on October 26th, and November 24th, 1914. The water kept rising, deflecting the crown in a down-stream direction, about as might have been expected. The fourth measurement, Curve No. 4, taken on May 18th, 1915, begins to show some peculiarity about this dam, that is, the knee in the deflection curve at Elevation 1,095, which is still more apparent on the three following curves. This peculiarity is caused by construction features which must be known to be appreciated.

As it was necessary to stop construction work late in the fall of 1913 at about this elevation, the zone of the dam in this vicinity was built during the coldest portion of the fall and the coldest portion of the following spring. The total shrinkage of the concrete in this zone, there-fore, has been less than the average, and the arch, there-fore, takes a greater proportion of the total load than it does either above or below; in fact, some load is trans-ferred through the vertical beam (the cantilever) to this zone from both above and below. Such transference of load also takes place through the vertical beam at the crest, as shown by Curve No. 4, but this would be ex-pected in any case.

Curve No. 5 shows considerably more excess deforma-tion of the dam than Curve No. 4, although the water load is only slightly higher, but Curve No. 5 was plotted from measurements taken on December 2nd, 1915, at a time when the days had been short and cold for some time, compared with the long, warm days around May 18th (Curve No. 4). Curve No. 5 also indicates that the outside temperature has been lower than that of the water and the dam body below the water level for some time, as the portion of the dam above the water level is forced downstream to a greater extent than the lower loaded por-tion as a result of the greater shortening of the arch (rib) in the upper region, produced by a lower temperature in the upper exposed portion of the dam.

Deformation Due to Temperature Changes

Curves Nos. 6 and 7 give an idea of the magnitude of the deformation due to temperature changes alone. The water load is the same in both cases—that due to reser-voir full—but the average temperature of the dam body was high when the measurements for Curve No. 6 were taken, on June 25th, 1915, and low when the measure-ments for Curve No. 7 were taken, on October 27th, 1917. The days, of course, are still shorter and colder in January (Juneau, Alaska) than in the latter part of October, but October 27th was the last day the reservoir was full to the spillway crest.

Both curves are of the shape expected, except for the knee at Elevation 1,095, but low temperatures at the time of construction were responsible for that, as already explained.

That the upper end of Curve No. 6 turns in an up-stream direction, the same as on Curves Nos. 2, 3 and 4, is only logical. All dams—and this is no exception—are provided with an excess of material at the crest, and therefore the stresses and the resulting deformation must be less in this than in lower zones; besides, for Curves Nos. 4 and 6, the outside temperature, and therefore, also, the temperature of the dam body, especially at the crest, was higher than that of the water on May 18th and on June 25th.

This higher temperature of the crest portion tends to accentuate the pointing of the upper portion of Curves Nos. 4 and 6 in an up-stream direction. Curve No. 7 (October 27th, 1915) indicates the effect of lower temperatures of the crest portion, than that of the water and of lower portions of the dam body.

The horizontal scale of these curves is exaggerated 1,200 times, in order to show the results more plainly. In reality, the curves are smooth, although the irregularities, as shown, are present.

In the foregoing description, some of the actions and behaviors of arch dams have been explained in detail. In the following the method of eliminating some of the undesirable features and making the structure act more like a theoretical arch, than otherwise possible, will be outlined.

By a simple system of iron pipes (shown in Figs. 5 to 8), distributed on the face of the contraction joints, and provided with slots at certain intervals, it is possible to deliver cement grout under pressure into the space (from ¼ to ⅜ in. wide) between adjacent walls of the contraction joints, and put initial axial compression into the whole structure, thereby making it act like a solid arch.

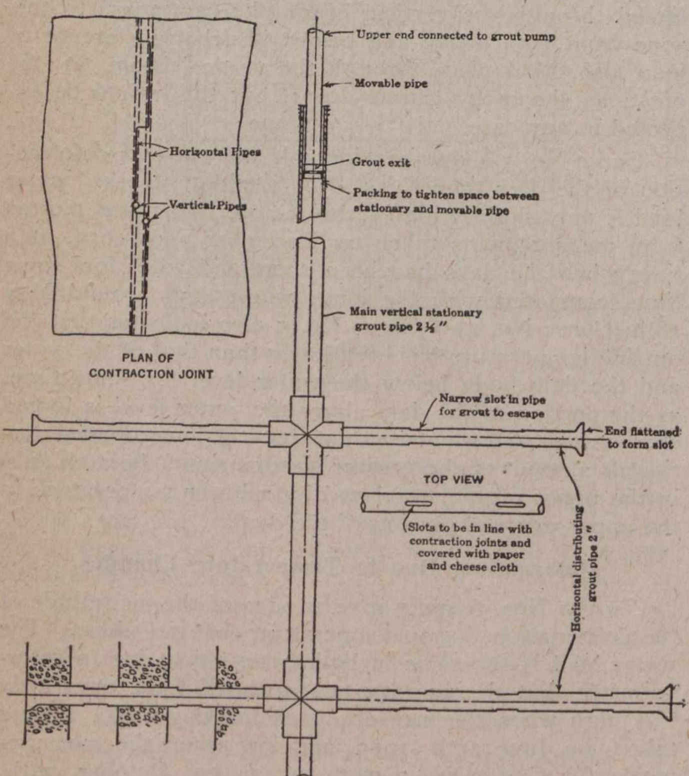


Fig. 5—Arrangement of Pipes for Grouting

At the same time, this grouting will greatly improve the watertightness of the dam.

It is well known that contraction joints, even of the most efficient design, cannot be expected to be entirely watertight. The leakage through such joints on large structures may easily amount to from 10,000 to 20,000 gallons daily, and has amounted to as much as 450,000 gallons daily. This can be eliminated by grouting the joints under pressure; still, the main purpose of this grouting is to compel the arch dam to act as an arch from the very moment the water begins to fill the reservoir.

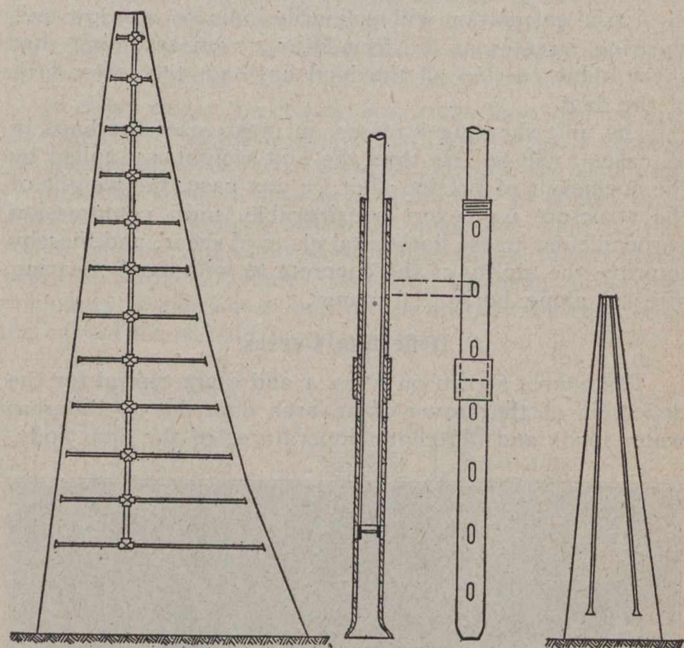


Fig. 6 **Fig. 7** **Fig. 8**

Forcing the grout into the contraction joints, and keeping it there under pressure until it has set, presses the crown of the arch in an up-stream direction, and puts shear on the foundation in the opposite direction to that due to the water load. It seems logical, therefore, to use such a grout pressure as will force the crown up stream half the total amount of the deflection resulting from a full reservoir. In this way the maximum shearing stresses are reduced by one-half (reservoir full), the maximum cantilever stresses are reduced by one-half, and, when fully loaded, the arch compression should then be as nearly as possible in accordance with the values obtained from the simple formula:

$$\text{Unit compression} = \frac{\text{Unit water pressure} \times \text{upstream radius}}{\text{Thickness of section}}$$

A check on the necessary grout pressure can be obtained by sighting across the crown of the arch with a transit, after first establishing the necessary bench-marks.

Great refinement in choice of final grout pressure, however, cannot be counted on, and is not essential. Considering the great influence of the temperature on the total deflection of the arch structure, as can be seen from the curves, especially Curves Nos. 6 and 7, it is necessary to use some judgment as to what the grout pressure should be in each case.

As a general rule, it can be stated that the grouting ought to be accomplished at a time when the structure is cold, and when the joints, therefore, have opened to their maximum extent, permitting easy access for the flow of all parts of thin grout (1 cement to 7 water to start with and thicker to finish). A large dam will generally have the least volume during March, and, therefore, the contraction joints will have opened up a maximum during this time, if the reservoir is empty.

When applying the grout pressure at such a time, it should be kept in mind that the dam body is larger at any other time, due to an increase in temperature, and that, with the cracks closed, the compression per square inch of contact surface will be increased as the temperature of the dam body increases.

Thus far only arch dams have been mentioned, but it would not require much explanation to show the advantage of tight grouted contraction joints on straight gravity dams also.

Grouting the contraction joints under pressure on straight dams throws longitudinal compression on the structure, and enables it to act as a beam held at both ends, at least until the initial compression has been overcome by the beam tension. A trial calculation will prove that the factor of safety has been greatly improved, especially at the lower levels, unless the dam is very long.

Grouting Worth Its Cost

The grouting of the joints naturally improves the watertightness of the dam, and, for this benefit alone, it is worth its cost. Judging from the results of analysis of leakage water through concrete dams, there are good reasons for assuming that a tight dam is going to remain safe for a longer time than a leaky one, although the writer is not attempting to predict the probable natural life of any dam.

A straight dam which has its contraction joints grouted under pressure during the cold season, will automatically have this pressure increased during the warm season, at the site of about 11 lbs. per square inch for each degree of rise of temperature of the concrete of 1° Fahr., as this material tries to expand and cannot. This, of course, should be allowed for, when selecting the grouting pressure for a straight dam. There could be no objection, however, to having a longitudinal compression of, say, from 200 to 300 lbs. per square inch, or even more, on the concrete during the warm season.

A typical grout piping arrangement for a rather large dam section is shown by Figs. 5 and 6.

Feed Pipes Remain in Dam

On the plan of the contraction joint on Fig. 5 there are two vertical feed pipes which are desirable on a joint of the kind shown. Each vertical pipe feeds a system of horizontal pipes arranged at different levels. These horizontal pipes are provided with slots wherever they cross the open space of a joint (Fig. 5). When the pipes are put in place, these slots are covered with paper and cheesecloth to prevent the concrete from entering the pipes from the outside and blocking them. Later, when the contraction joints open, this covering will either adhere to the concrete, or the grout pressure will burst it open.

The pipes cannot be recovered, but will remain forever buried in the dam. They are necessary, however, in order to keep the grout in a liquid condition from the time it leaves the pump until it passes through a slot very close to the desired point of deposit. The iron walls of the pipes do not absorb any of the water in the grout; the absorption, however, commences as soon as the grout leaves the exit slot in the pipe and comes in contact with the concrete walls of the joint. Therefore, his outside grout sets first and shrinks, to a large extent. The grout in the pipe system, being fluid for a long time, is able to follow up the shrinkage and fill out the cavities and keep the joint under pressure until the filler has solidified, in from ½ to 1 hour or more.

Avoiding Air Pockets

To avoid air pockets as much as possible, and otherwise to insure uniform work, the grouting should proceed from the bottom up; therefore a second, and movable, pipe is inserted in the stationary vertical pipe at the time grouting is to be done, as indicated in Fig. 5.

When starting to grout, one end of this movable pipe is to be at the bottom of the vertical pipe, the upper end being connected to the grout pump by a flexible connection. Grout is forced through the movable pipe and flows through the lower Tee, the lower horizontal pipes, and the slots in them; out into the space between the walls of the contraction joints, and rises vertically.

Before grouting commences the down-stream end of the contraction joints should be caulked (with lead wool) except for small stretches left open for exploration purposes. These are closed when the grout starts to flow out of them. The up-stream end of the contraction joints are generally provided with copper plates or other kinds of effective stops.

When the grout has reached the second story of horizontal pipes, or nearly to it, the movable pipe is raised so that the lower end is just above the Tee connection leading to those pipes. Grout is then forced into them, and, proceeding in the same manner as previously described, the crest is eventually reached. Then, finally, the pressure is kept on until the filler has thoroughly set. It is the grout pressure used on the last, or preferably on the last two joints, spaced one-third of the arch length apart, that determines the initial arch compression, and therefore on these the greatest care should be exercised.

Grouting During Cold Weather

If a dam is so large and high that it takes two or three seasons to build it, it is advisable to grout the lower third of the height at the end of the cold season, before the construction of the dam is continued; otherwise, the lateral expansion (Poisson's ratio), due to the weight of material on top, will tend to close the contraction joints. These spaces will always be narrower close to the foundation than higher up, due to shearing stresses, developed by shrinkage in the concrete close to the rock bottom, tending to prevent complete contraction.

When grouted during cold weather, an arch dam will always be under the influence of compressive stresses, and any knee in the deflection curve, due to inequalities in temperature during the construction period, will be flattened out. All told, the arch dam will act more nearly as intended, carry the load as calculated, and be more water-tight than without the grouting of the contraction joints. A straight dam will have its factor of safety increased, due to the positive beam action, and also be more water-tight.

Figs. 7 and 8 illustrate a simple arrangement of grout piping for the contraction joints of a small dam.

The public utilities of the city of Edmonton are all on a satisfactory basis, with the exception of the street railway system, and new rates have been adopted with a view to wiping out the deficit on this account. The statement of revenue and expenditure of the different departments for the month of March, 1918, shows a net surplus of $5,403 for all utilities. The surplus for the first three months of this year is $37,543, compared with $20,122 for the corresponding period in 1917.

A company, known as the Beaver Cove Lumber Company, Limited, has commenced the construction of a large pulp and lumber mill at Beaver Cove, B.C., 165 miles north of Vancouver. It is understood about $3,000,000 or $4,000,000 will be invested, and the daily capacity of the plant will be 40 tons of pulp and 100,000 feet of lumber. The company has timber resources totalling five billion feet. and the cost has been over $2,000,000. The property includes some fine spruce, which it is the intention to cut as soon as possible for use in aeroplane construction.

SUPERELEVATION OF HIGHWAY CURVES*

By J. W. Lowell

MANY people look upon superelevation as a convenience to automobile traffic and especially the speed fan. Some take into consideration the factor of safety, but few have given serious thought to the question of maintenance which is equally important.

Any observing person who uses the road knows that curves are generally in worse condition than the straight road. This condition appeared simultaneously with the motor vehicle and has likewise grown with it. One need only to be in an automobile and feel the thrust against the side of the car when rounding a curve to appreciate why pavements ravel, rut and wear out fast. It is hard to realize the severity of the thrust given to the pavement surface and to the wheels and tires of a car when rounding a curve, but we know it is sometimes great enough to cause heavy cars to tip completely over. A curve on a road race-course just after a race is a good example of accelerated disintegration of roads on curves.

Safety to traffic is a problem which must be given serious consideration, for fatalities are increasing at an enormous rate. Superelevating curves will not be a panacea for all road troubles, but it should lessen the fatalities on curves, which is one of the places where many occur. The strain on automobile wheels sometimes breaks them, causing serious accident. This can be eliminated by superelevation which does away with thrust. Superelevation makes both road tracks alike and there remains no object to cross over to the wrong side. With the crowned road there is a tendency for drivers to take the inside of the curve to avail themselves of the superelevation formed by the crown.

Superelevation will result in convenience for all motor traffic which constitutes the majority of vehicles. Both driving and riding will be safer, smoother, more economical and more comfortable.

*"Concrete Highway Magazine."

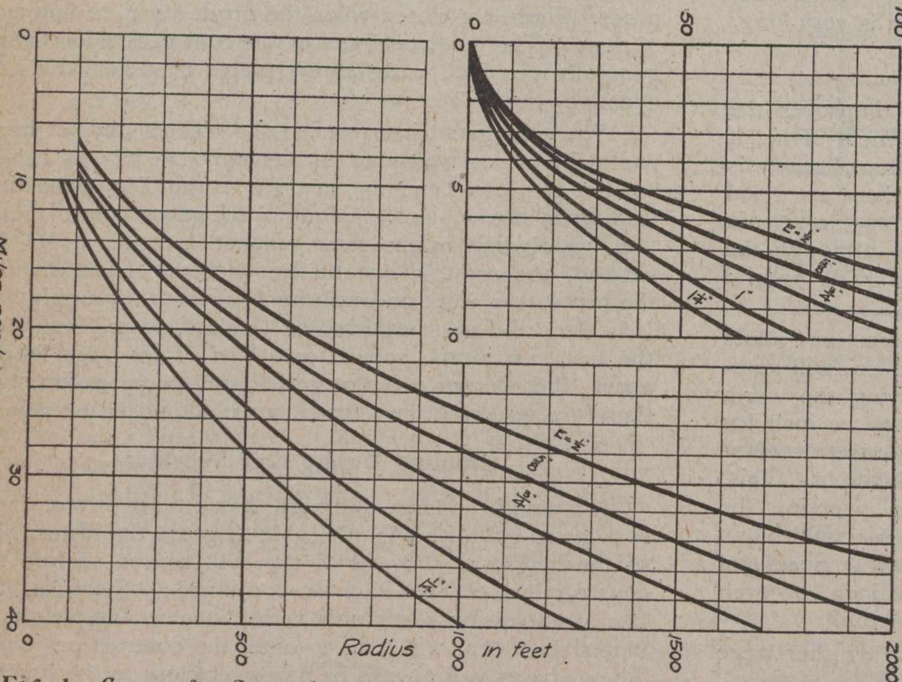


Fig. 1—Curves for Superelevation of 1 in. to 1½ ins. Per Foot for Speeds Up to 40 Miles Per Hour

However, roads are built to accommodate all kinds of traffic and therefore must be designed for the horse as well as the motor. These represent the extremes in speed and stability of footing.

If we superelevate for motors at high speed the horse cannot keep his footing, therefore the maximum superelevation attained should not exceed ¾ in. per foot of width for hard surfaced roads such as concrete and brick and 1¼ ins. per foot of width for stone, gravel or dirt roads. With these slopes horses should pull comfortably, for they are not greater than the ordinary crown.

Just to what extent this small amount of superelevation will be of value is illustrated by Fig. 1, showing the speeds that may be attained on various sized curves for these small superelevations. Analyzing the curves with the thought in mind that the sharpness of curve controls the speed, it is evident that the permissible superelevation compensates for speeds that are likely to occur on most curves from the sharpest to the flattest. Should the speed be excessive and not entirely compensated, we have at least by our superelevation minimized its effect.

Naturally the smoothness and wearing quality of road surface influence the effectiveness of superelevation to a small extent where only part compensation is attained, but after all, we have this condition on roads as now built.

There are probably many ideas as how best to construct a superelevated curve. The problem can be made just as complex as the designer desires. The simplest method is to construct the entire curve at full elevation by raising the outer edge, keeping the inner one to grade and changing from crown the superelevation in a distance of about 30 ft. on the straight road.

NEW INCORPORATIONS

Sandon, B.C.—Silversmith Mines, Ltd., $750,000.

Victoria, B.C.—National Motor Co., Ltd., $10,000.

Kamloops, B.C.—Mountain Sawmills, Ltd., $50,000.

Quebec, Que.—Mile End Milling Co., Ltd., $200,000; E. Turgeon, E. Turgeon.

Toronto, Ont.—Hill Gold Mining Co., Ltd., $3,000,000; W. Gilchrist, J. Stewart, H. J. Stewart.

Stratford, Ont.—McDermid and Kyle, Ltd., $40,000; T. J. Kyle, M. A. McDermid, E. McDermid.

Longueil, Que.—Standard Foundry, Limited, $90,000. Emile Colas, Jules Colas, Miss Emelie Colas.

Three Rivers, Que.—Bellefeuille & Trepanier, Limitée, $49,500. Auguste Bellefeuille, Bruno J. Trepanier.

Admaston, Ont.—North Bonnechere Telephone Association, Ltd., $100,000; J. Barr, J. Payne, R. B. Leich.

Plessisville, Que.—Gregoire Lumber Corporation, Limited, $45,000. M. M. Napoleon Gregoire, J. L. Gosselin.

Montreal, Que.—Union Engine Machine Works, Ltd., $150,000. Griffith Lloyd Williams, Janet Burge, Peter Joseph Kenny.

The Pas, Man.—Herb Lake Gold Mines, Limited. $1,000,000. Clive J. McLeod, Melrose S. Everall, Harley M. Hughes.

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Principal Contents of this Issue

HALIFAX

DESPITE the terrible effects of the "Mont Blanc" explosion, or perhaps partly as a result of it, Halifax is to-day one of the most prosperous cities in Canada. Halifax has recovered courageously and splendidly from the effects of the explosion, and when the devastated area has been rebuilt according to a modern town-plan, Halifax will rise great and glorious from the ashes.

Assuming that the government will give Halifax its due, nothing can prevent that port from becoming one of the most famous in the world. It has all the natural advantages, physical and geographical, for ultimately becoming one of the busiest, if not the busiest, on the American continent.

The recent announcement by the Minister of Marine and Fisheries that the government has awarded contracts enabling the location of a shipbuilding industry at Halifax, is fine news. Halifax needs shipbuilding very much indeed. Without a big shipbuilding plant, the port could never attain its proper place in the world's shipping trade.

The taking over by the government of the Halifax Graving Dock Company's property is also a step in the right direction. A larger dock is needed at Halifax, but competition between the old privately owned dock and a new government dock would be unfortunate. The acquisition of the private dock enables the co-ordination of all terminal facilities at Halifax. The dock was practically public property anyway, being adjacent to the naval dockyard and being devoted, at the present time at least, largely to the repair of vessels directly associated with war work.

The Federal Government's $30,000,000 scheme for the development of Halifax harbor, which was announced some years ago, is still mostly on paper. A relatively small portion of the quay wall has been finished, some temporary sheds have been erected and a contract was recently awarded for a temporary station and car repair facilities; but a photograph of the Halifax terminals at present would not much resemble the architect's drawing of the finished project. It is to be hoped that the Dominion Government will go ahead with the development of this harbor as vigorously as possible. Financing of war needs, of course, must have the first consideration; but it is to be hoped that some way will be found of getting Halifax harbor into such shape that it will not be hopelessly behind in the race for trade after the war.

Notwithstanding the activity of Hun submarines, the tonnage of the principal American and Canadian ports has greatly increased since the war began. In 1913 the tonnage of the port of New York amounted to 28,000,000 tons, whereas for 1917 it rose to 34,000,000; and on account of the value of the shipments it became the leading port of commerce of the world, its exports last year totalling $1,964,000,000, whereas London, which had for years held the foremost place, dropped from $2,004,600,000 in 1913 to $1,867,000,000 in 1917.

This tendency toward increases in the American trade has extended to Canada on a smaller scale. The returns for 1917 make Halifax the third port on the American continent, on the Atlantic coast. In 1913 the Halifax tonnage amounted to 3,182,923 tons; in 1917 it totalled 17,092,911 tons, although part of this was "examination" tonnage. The figures for the year 1918 have greatly exceeded the 1917 figures for the corresponding months, some months showing an increase of over 100 per cent. as compared with the corresponding periods of last year.

Many Canadians do not realize the importance of the port of Halifax. Arguments are brought forth such as the "long rail haul," whereas the same export freight rate exists through all the North Atlantic ports. While there is a published differential of one cent against the port of Halifax, this is practically on paper only. The steamship, as a rule, absorbs it.

In 1913 Halifax bank clearings totalled $105,347,626, whereas in 1917 they had increased to $151,812,752. The figures for 1918 show continued increase.

The set-back which was suffered by the port of Halifax as a result of the explosion on December 6th, 1917, was of a very temporary nature so far as the commercial welfare of the city was concerned.

CONSERVATION AT NIAGARA FALLS

TRUE conservation is being practised at Niagara Falls in the Chippawa-Queenston Power Development. With the tremendous energy shortage in Ontario—neither fuel nor electrical energy being available in sufficient quantities—it would be extremely wasteful not to utilize every second-foot of the 36,000 c.f.s. allotted to Canada as permissible diversion from Niagara Falls, under the treaty between Great Britain and the United States. And so far as possible it should all be used in high head development. Were the whole 36,000 c.f.s. passed through the Queenston power house, it would yield over a million horse-power, compared with less than half that figure if used under existing conditions. Ontario cannot afford to waste that extra half million horse-power. Nor can the United States afford to lose the extra 100 ft. head that the Queenston scheme affords compared with the best conditions now available on that side of the line. The world war has brought Canada and the United States together in closer fashion than many seem to realize. The bond between the two countries is inseparable. Why not merge their interests at Niagara and ultimately develop their whole 56,000 c.f.s.—or as much of it as can be diverted from the rapids wihout causing danger from ice jams—in one big, efficiently-operated, international plant at Queenston, dividing the resulting power in the ratio of 20 to 36, and sharing the total cost in inverse proportion?

PERSONALS

Col. Robert Smith Low, manager of reconstruction at Halifax, was born October 16th, 1874, in East Saginaw, Michigan. His parents were Scotch, and they returned home when "Bob" was an infant. In 1886 the family moved to Halifax, where the son commenced his career as a timekeeper in his father's business, later becoming assistant superintendent. In 1895 he went to the United States and stayed for two years, returning to become superintendent of his father's company. In 1899 he decided to go into business on his own account, and formed a partnership as McManus, Low & McManus, general contractors, in Sydney, N.S. The firm name was changed the following year to Low, McManus & Horne, and again in 1901 to R. S. Low Contracting Co., under which name Col. Low operated until 1912, when he joined the firm of Bate, McMahon & Co., contractors, Ottawa, as partner and manager. He is also a director of several other concerns. At the outbreak of war he was called upon by the Minister of Militia to build Valcartier Camp and completed the work with exceeding rapidity. The record he established there caused both the Militia Department and the Imperial Munitions Board to entrust to him the building of all their camps, eleven in number. At Camp Borden he undoubtedly established a world's record for work of that character. Among the contracts on which he has been engaged are: Dominion Iron & Steel Co., foundations and plant; Intercolonial R'y terminals at Sydney, N.S.; Marconi Station, Table Head, Glace Bay, N.S.; government roads and paving in Maritime Provinces, 1902-1910; paving in Ottawa, 1911; Bate, McMahon & Co., on a wide variety of contracts, since 1912. In August, 1914, he was made an honorary colonel and on February 1st, 1916, was gazetted as Lieutenant-Colonel engaged in military construction work. He has carried out over a million dollars worth of construction work free of charge for the government since war began, including the Halifax fortifications, and has completed several millions more upon a percentage basis. His services at Halifax were offered to the city without remuneration. It may be mentioned that Colonel Low has received no salary or allowance of any kind since undertaking charge of the reconstruction work in Halifax, either before or since the appointment of the Relief Commission. Just recently Col. Low signed two large contracts for his firm, one for the construction of a big plant for the British America Nickel Co., which he agreed to complete in a very few months, and the other for the erection of the new Federal Office Building at Ottawa, a $1,000,960 job.

British and Colonial Press Photo.

E. W. Pattison, of New Westminster, has been appointed municipal engineer of Langley, B.C.

Major Geo. W. Shearer has been awarded the D.S.O. Before joining the forces Major Shearer was an electrical engineer. He is a graduate of McGill University.

J. A. Burnett, electrical engineer, Grand Trunk Railway, has been appointed as technical assistant to the British War Mission at Washington, D.C.

Lieut. Wilmot J. Baird, who has been awarded the Military Cross, took his B.A.Sc. degree at the University of Toronto in 1911, and enlisted in the 1st contingent.

C. R. Polairet, of the Department of Commerce and Industries, of India, last week inspected the hydro-electric plants at Niagara Falls. Mr. Polairet is en route to Great Britain.

Frank C. Christie, an honor graduate in civil engineering at the University of Toronto, has gone overseas with the Royal Engineers and intends to train for a commission in England.

John Perrie, deputy minister of municipal affairs for Alberta, is taking an extended holiday owing to ill-health. J. H. Lamb will be acting deputy minister during Mr. Perrie's absence.

Lawford Grant, general manager of the Eugene F. Phillips Electrical Works, Limited, has been elected a member of the executive council of the Montreal Branch of the Canadian Manufacturers' Association.

Lieut. Lawrence B. Tillson, of Bracebridge, Ont., a graduate in Applied Science and Engineering, class of 1915, University of Toronto, has returned to Canada on leave. Last September Lieut. Tillson was awarded the Military Cross while serving in France.

Lieut. J. W. B. Blackman, who resigned as city engineer of New Westminster, B.C., to go overseas with a railway construction company, is now in France. He was loaned sometime ago to the construction department of the British War Office for the purpose of constructing an aviation camp in England, but he recently completed that work.

OBITUARY

Wilford Phillips, for seventeen years manager of the Winnipeg Street Railway, died last week. In March, 1890, Mr. Phillips accepted a position with the Metropolitan Railway Co., of North Toronto, and remained there until July, 1892, when he accepted the position of engineer and superintendent of North Toronto Waterworks and Electric Light Company. In March, 1893, he became engineer of the Niagara Falls Park and River Railway, and in 1896 was appointed manager of the same company. In June, 1900, he resigned, and in August, 1900, he accepted the position of manager of the Winnipeg Electric Railway Company, which position he occupied until just a few months ago.