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WATER POWERS ON THE WINNIPEG RIVER

POSSIBLE COMMERCIAL OUTPUT OF RIVER CONSIDERABLY EXCEEDS HALF MILLION HORSE-POWER—MINIMUM FLOW OF TWENTY THOUSAND SECOND-FEET OBTAINABLE AT ALL SEASONS—REVIEW OF REPORT BY DOMINION WATER POWER BRANCH.

WHILE Canada is endowed with a great natural resource in its water powers, a very small percentage of the total power available has been so far developed and used. But in the development that has taken place, Canadian financiers by their foresight; Canadian engineers by their skill; and Canadian government officials by their co-operation, have blazed a trail that can be equalled by few other countries, and surpassed by none.

It has only been in recent years that Canadians have wakened to the knowledge of the tremendous natural advantages that Canada has in her extensive and fortunately located water powers. In most provinces of the Dominion, this awakening has resulted in a sincere and successful endeavor to become fully informed of all aspects of the water power situation, in order that proper provision should be made for investigation, administration and ultimate development.

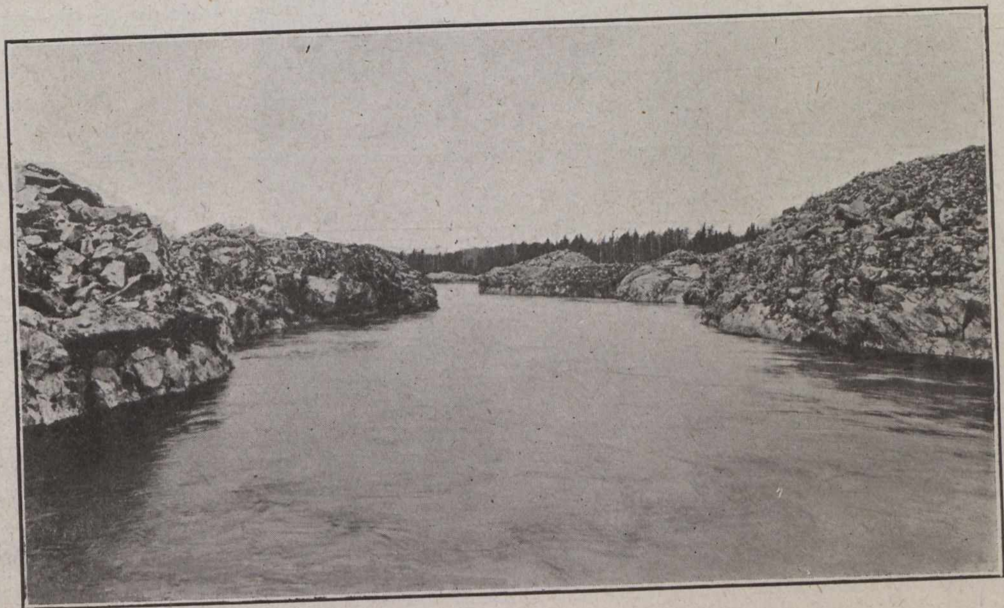


Fig. 1.—Pinawa Channel, Winnipeg River.

Sixteen miles below Slave Falls the river is broken into two channels. The main flow is through the Seven Sisters reach. The lesser flow is through the Pinawa Channel, operating the Winnipeg Electric Railway Company's plant. This was formerly a high water by-pass of the main river. The illustration shows some of the rock cutting that was necessary to straighten and deepen this channel.

There is no part of the Dominion where the advantages and opportunities of water power are more appreciated than in the provinces of Manitoba, Saskatchewan and Alberta. In this territory the water powers are administered by the Department of the Interior through the Dominion Water Power Branch, which branch has, since its organization eight years ago, made thorough reconnaissance investigations of all the water powers in the present settled portions of the prairie provinces, and most of the water powers on the more important rivers in the hinterland. On some of the rivers close to existing commercial centres, such as the Bow River in the province of Alberta,* and the Winnipeg River in the province of Manitoba, it was early found necessary to have a thoroughly complete investigation made of the topographic and hydraulic features of the whole power situation.

The most elaborate and extensive investigations that the Water Power Branch has carried on, have been continuously under way for over four years, under the immediate direction of J. T. Johnston, chief hydraulic engineer of the branch. A complete report of these investigations has just been issued, under the title of "Water Resources Paper No. 3." The results of the investigations are of great interest from engineering, industrial and economic standpoints.

The investigations show that it is possible to develop on the Winnipeg River, at 9 power sites, 420,000 continuous 24-hour horse-power. This is sufficient power to meet the ultimate requirements of the city of Winnipeg for many years to come.

The report on the Winnipeg River powers is unique in scope and arrangement. Every possible aspect of the power situation has been gone into carefully, and the results are tabulated in convenient form.

*Reference was made in *The Canadian Engineer*, issues of November 26th and December 3rd, 1914, to the investigations along the Bow River, which show conclusively that it is possible to develop at five sites on the Bow River, a total of 55,000 continuous 24-hour horse-power, and all within a very short distance (about sixty miles) of the city of Calgary.

Apart, however, from the report itself, the comprehensive scheme of development of the whole river, realizing the best possible use of the natural advantages of the river for power purposes, is so feasible, and of such importance to the West, that a liberal review of the power studies will undoubtedly be of general interest.

Winnipeg River Basin.—The basin of the Winnipeg River forms a portion of the Nelson River drainage system. The watershed is 53,500 square miles in area, of which 37,900 square miles lie in the province of Ontario, 4,600 square miles in the province of Manitoba and 11,000 square miles in the State of Minnesota. The basin is, therefore, international as well as interprovincial, and conflicting problems arise in connection with storage regulation in the upper reaches.

The upper waters are divided between two drainage systems, the English River draining the northerly 21,600 square miles, and the upper reaches of the Winnipeg draining the southerly 27,000 square miles. The entire watershed is very sparsely settled, and a large proportion offers little opportunity for agricultural settlement. The larger part of the basin consists of a forest-covered laurentian formation with much granite outcropping, and is interspersed with lakes and muskegs and occasional stretches of agricultural land. Practically the entire basin is seamed and dotted with lakes of every size, from mere ponds to the 1,500 square mile spread of the Lake of the Woods.

Situation at Beginning of Survey.—At the time when the power and storage investigations along the Winnipeg River were instituted by J. B. Challies, superintendent of the Dominion Water Power Branch, the hydro-electric plant of the Winnipeg Electric Railway Co. was in operation on the river, and the initial installation of the Winnipeg municipal plant was approaching completion.

The Winnipeg Electric Railway Co.'s plant is located on the Pinawa channel of the Winnipeg River, about 58 miles from Winnipeg, and has installed a total turbine capacity of 34,000 h.p. This, in conjunction with the 22,000-h.p. steam turbine plant in the city, supplies power for distribution in Winnipeg.

The city of Winnipeg in 1908 began the construction of a municipally owned power plant at Point du Bois, on the Winnipeg River, distant 75 miles from the city, and at the time of the commencement of the survey, was completing the first turbine installation. Eight units with a total turbine capacity of 47,000 h.p. are installed to date, and additional bays are partially constructed to accommodate eight further units when the market demands. The power is transmitted to Winnipeg for general lighting, industrial and domestic use.

With the power from these two sites either developed or in course of development, the department was in receipt of numerous applications covering other sites along the river. It was, no doubt, realized that further hydro-electric development on the river was a matter of the im-

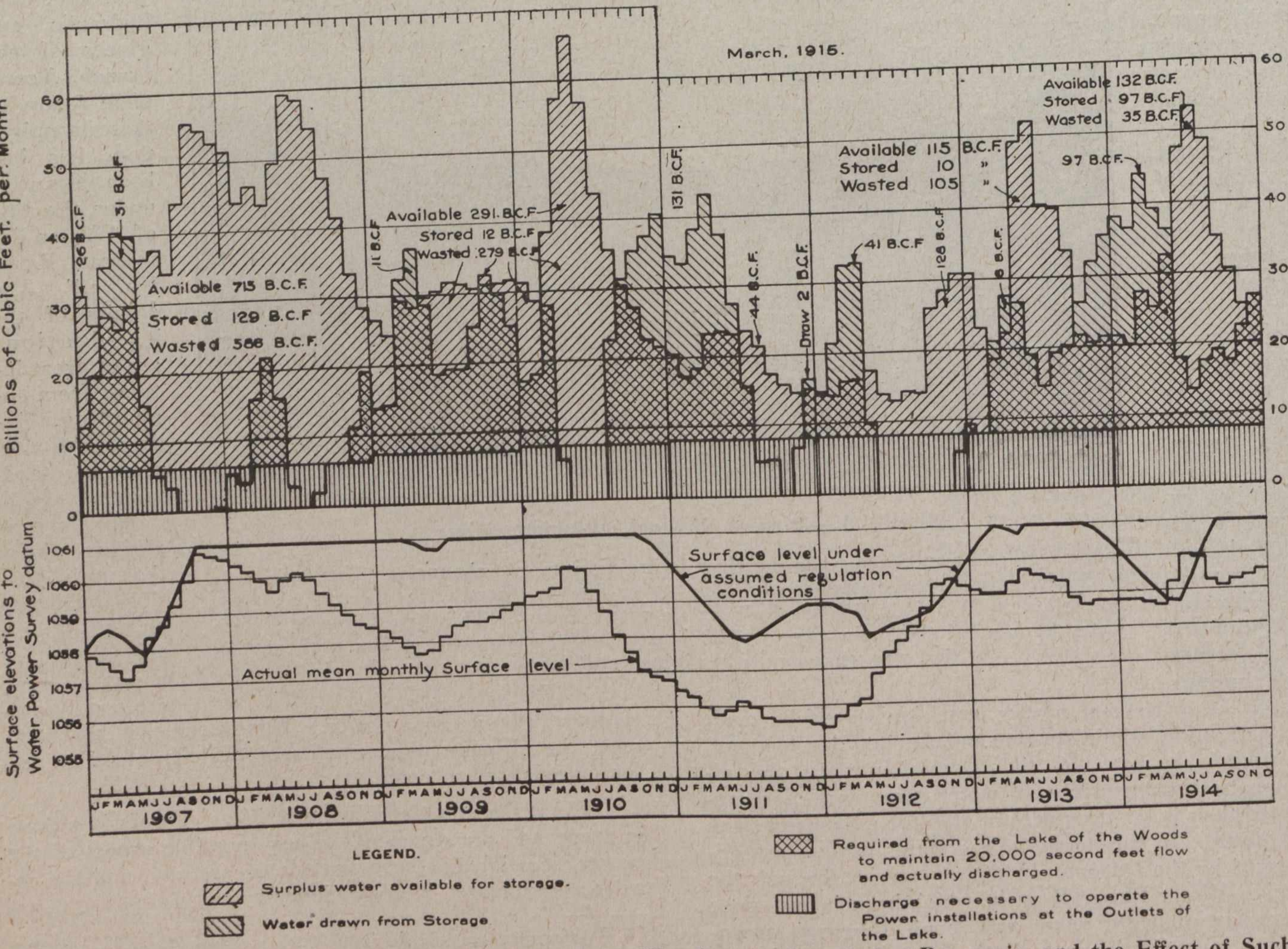


Fig. 2.—Mass Curve Study—Use of Lake of the Woods as a Regulating Reservoir, and the Effect of Such Regulation on the Surface Levels.

[NOTE:—In this analysis it has been assumed that a minimum flow of 20,000 second feet is maintained throughout the power reach of the Winnipeg River in Manitoba, by means of regulations in the Lake of the Woods reservoir alone. At the same time sufficient water has been discharged at all times to operate properly the power installations at the lake outlets.]

mediate future, and that if a comprehensive policy were to be mapped out into which new developments could be incorporated as component units, there could be no delay in commencing the investigations. So, early in 1911 a survey party was placed in the field.

Scope of the Investigation.—It was intended that the investigation should be sufficiently extensive in scope to furnish the department with all information and data necessary to design a power scheme suitable for the development of the entire water resources of the river in the province of Manitoba. This necessitated extensive investigation into the storage resources of the upper watershed. The scope of the investigation was therefore outlined to include the following:—

A preliminary reconnaissance of the power reach; a continuous base profile; detailed contour surveys with soundings of all falls or rapids at which power concentration was possible; contour surveys of the river banks throughout the entire power reach; determination of the best points of concentration; design of power layouts for such locations; estimates of capital and operating costs of proposed plants; establishment of metering stations at strategic points; establishment of evaporation stations; study of existing rainfall and temperature records; investigation into the question of storage in the upper watershed; study of prior water rights and relative value and effect of same; comprehensive provision for future navigation; close study of all existing power plants and interests; study of present market conditions and future prospects; investigation into cost of power from coal, gas and oil; recommendations for the carrying out of an aggressive policy of development; and recommendations insuring government supervision over regulation, both in connection with individual power plants and of the storage conditions as a whole.

River Discharge.—Owing to the extensive forest cover and to the innumerable lakes throughout the watershed, the Winnipeg River is naturally one of the best-regulated rivers on the continent. In a normal year the flood flow seldom exceeds four times the minimum. Continuous discharge records are available at Slave Falls in Manitoba, at the outlets of the Lake of the Woods, and at Fort Frances, from the beginning of 1907 to date. Actual records over this period show a minimum flow of 11,700 and a maximum of 53,440 cubic feet per second in the power reach in Manitoba. Well-defined water marks along the shores would indicate that a flood of possibly 100,000 second-feet has taken place in the past.

While the natural regulation of the run-off is excellent, there are fine facilities for aiding nature by utilizing reservoir opportunities in the upper basin. Among these natural reservoirs might be listed: Lake of the Woods, 1,500 square miles in area; Rainy Lake, 330 square miles in area; Namakan Lake, 100 square miles in area, and Lac Seul, 340 square miles in area.

A review of the run-off records and a study of the storage opportunities warrants the conclusion that a systematically controlled regulation of the reservoirs in the upper watershed will increase the minimum dependable flow in the power reach to 20,000 cubic feet per second.

The splendid facilities of the Lake of the Woods as a storage reservoir are best illustrated by the mass curve, Fig. 2, in which an assumption is made that the lake had been so operated since 1907 (from which date discharge records are available) as to maintain a dependable flow of 20,000 second-feet in the power reach of the Winnipeg River in Manitoba, and at the same time maintain an outflow from the lake, at all times amply sufficient to meet the needs of the existing power developments at the lake outlets. The mass curve indicates that with systematic supervision, these ends could have been attained with a maximum change in the surface level of some 3.1 feet during the period, against a change of 5½ feet which has actually been experienced with the unsupervised regulation which has been maintained. It might also be noted that the cycle considered covers a prolonged period of exceptionally low run-off.

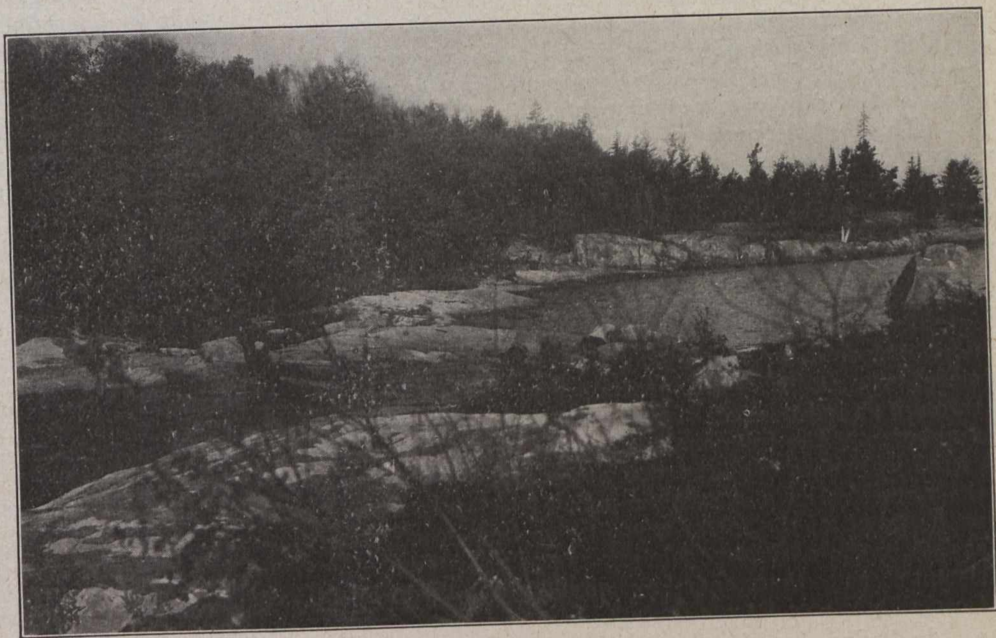


Fig. 3.—Pine Falls, Site of Proposed Power Station.

Initial development proposed, 60,000 h.p.; final development, 100,000 h.p. Capital cost per h.p.—$50.95 for initial installation, $44.07 for complete installation.

Field and Office Investigations.—In June, 1911, active field work was commenced by running a continuous line of base levels, to sea level datum, from Lake Winnipeg to the Lake of the Woods. While this was under way a preliminary reconnaissance was made of the entire power reach and the necessary steps taken to continue systematic field studies. Actual contouring was commenced in September at Du Bonnet Falls and was thereafter continued systematically until the entire power reach was covered.

Detailed attention was given to all falls and rapids and possible points of power concentration. The survey work was plotted in the field to a scale of 400 feet to the inch, on standard sized sheets 30 by 37 inches, fifty-five sheets being necessary to cover the power reach from Lake Winnipeg to and including the pond of the Point du Bois plant. Detailed plans to a large scale were made of all important locations.

This immediate plotting on the ground was greatly aided by the loose-leaf field note books adopted throughout the work. Standard sized leather covers with 5 x 8-inch fillers suitably printed and ruled for transit, stadia and level work were provided. The loose leaves lent themselves readily to a simple filing system on which the records of the survey were properly grouped and were at all times available for instant reference.

The finished tracings were forwarded to Ottawa as completed, where immediate study was given to the design of a comprehensive power system utilizing the river's possibilities to maximum advantage.

Upon the completion of the tentative study of the layouts, a further reconnaissance was made of the actual sites selected, and additional details as to rock surface, etc., were secured.

General Conclusions.—The general conclusions reached as a result of the entire investigation are that full realization of the power resources of the Winnipeg River in Manitoba is possible only through an exhaustive measure of run-off control, and feasible only through the establishment of storage reservoirs in the upper watershed. Due to the conflicting requirements of the lumber, fishing, navigation and power interests represented in the watershed, a proper run-off control satisfactory to all can best be insured by some central governmental authority possessing the full confidence of all interests affected, and having entire authority over all questions affecting lake, reservoir and pond levels, and over all questions of river flow and of discharge requirements.

This authority can only be properly exercised through government-owned or operated storage reservoirs. In conjunction with this control, full realization of the power resources of the Winnipeg River in Manitoba is only attainable by a power system in which each developed site forms a component link in a comprehensive scheme looking to the development of the entire river reach. Due to the interdependence of a series of hydro-electric plants, such as is proposed, and to the conflict of head and tailwater elevations, satisfactory operation can only be realized through an independent supervised control over local pond regulation. The full conservation of the power resources of the watershed requires also the institution throughout the watershed of a systematic policy looking to a proper preservation of the forest cover which now so effectively assists in the natural regulation of the river flow. Consistent steps to these ends have already been taken by the Dominion Water Power Branch.

In laying down a complete system of hydro-electric development for the power reach, two outstanding features compel first consideration, *i.e.*, the existence of the two hydro-electric undertakings of the Winnipeg Electric Railway Co., and of the city of Winnipeg, respectively. With these two plants already in existence, and after fully protecting their interests in all respects, it has been possible to divide the remainder of the river drop into seven concentrations for power development, having a total possible output of 175,000 continuous 24-hour horse-power available at 75 per cent. efficiency under the present unregulated minimum flow, and 313,000 continuous 24-hour horse-power available from the proposed 20,000 second-foot dependable minimum flow under regulated conditions.

Including the two existing developments, the total resources of the power reach at nine sites are 249,000 and 418,000 continuous 24-hour horse-power under the above respective conditions of flow.

As these totals are given in terms of 24-hour power, they give a rather limited estimate of the river's resources, particularly in view of the fact that each proposed plant has ample pondage facilities to handle any peak load which may be anticipated. What may be called commercial output might, therefore, be considered as very greatly in excess of the above figures.

[NOTE.—The reader's attention is called to the brief advance review of this report that was published in the June 1st, 1916, issue of *The Canadian Engineer*, containing some data to which the above is supplementary; also to the seven-page article in the February 12th, 1914, issue of *The Canadian Engineer*, in which was included a plan of the existing sites and possible sites on the Winnipeg river, a profile of the river, and views of the following falls: Seven Sisters, Second McArthur, Pine, Silver, and Grand du Bonnet.—EDITOR.]

TESTS OF FLAT SLAB CONSTRUCTION.

W. W. Pearse, city architect and superintendent of building of the city of Toronto, will co-operate with Prof. Peter Gillespie, of the University of Toronto, in conducting a test of the flat slab construction at the new Simpson warehouse, Toronto. The test will be quite extensive and will cost approximately $1,000. An endeavor will be made to determine accurately the stresses in the concrete and in the reinforcing steel.

The Simpson building is designed according to the Chicago by-law. The test will be completed in August, 1916, and later in the year a similar test will be conducted in connection with the new factory building for the T. Eaton Co., Toronto, which has been designed in accordance with the Philadelphia by-law. These two tests should give a most interesting series of comparable results.

SHIPBUILDING IN BRITISH COLUMBIA.

The British Columbia Legislature is considering a bill to aid the development of the shipbuilding and shipping industries in the province. Two schemes are embodied, one providing for assistance in the building of wooden ships, and the other a bonusing of cargoes taken from British Columbia ports for ten years after the conclusion of the war. A commission of three is to be appointed for the administration of the act, one of whom is to be the Minister of Finance, who will be unpaid, the other two being salaried. The scheme for providing financial assistance for shipbuilding covers advances to the extent of 55 per cent. of the value of the plant and of whatever ships may be built, and will be for a period to be determined by the commissioners, who will exercise considerable control over the construction and subsequent operations of vessels so built, which will remain under the commissioners' control in the same manner until the loans are repaid in full. The second form of assistance is designed to keep the vessels under the commissioners' control returning to British Columbia, to ensure an outlet for British Columbia products. It is proposed to grant a bonus of $5 a ton for ten years on all cargoes, based on the dead weight, taken from British Columbia ports. The administration of the act, when it becomes effective, will be almost solely under the Government control, as practically every act of the commissioners is subject to an order-in-council.

An immense amount of construction work is going on behind the French lines. All old highways are kept in perfect repair and thousands of miles of new roads are constructed. In the region called the Champagne Pouilleuse the road question was a particularly difficult one. Loads of stones were swallowed up without much effect. So logs are laid side by side and corduroy roads built. There are hundreds of miles of these corduroy roads and over them pass heavy artillery, motor trucks filled with shells and other large vehicles. In this district the military engineers have had to bore hundreds of wells, for good water is a rarity. To do this, gangs of professional well sinkers were selected from the mobilized soldiers, and the country is now covered with their cases.

SEWAGE TREATMENT STUDY FOR NIAGARA FALLS, ONTARIO.

By H. S. Philips, A.M.Can.Soc.C.E.,
Formerly Assistant Engineer, Sewer Dept., City of Toronto.

DURING the summer of 1915, the writer was loaned by the city of Toronto Works Department to the engineering staff of the International Joint Commission, for the purpose of assisting in sewage treatment and interceptor studies. The following notes regarding Niagara Falls, Ont., which are condensed from my report to the consulting sanitary engineer of the Commission, may be of interest to readers of *The Canadian Engineer*:—

The 1950 densities, as computed from present-day drainage areas, are greater than are warranted by the present characteristics of this city, but are intended to include provisions either for annexation of city area or for inland extensions of sewerage districts.

Water consumption records are available from the year 1896 to the present date, but until November, 1913, were based upon plunger displacement, and owing to breaks in counters and in other parts, the data are incomplete and unreliable. Detailed studies were, therefore, confined to records since November, 1913, when a Venturi meter was installed. These records show a total pumpage of 1,287 million U.S. gallons during 1914, which is equivalent to a daily average of 3.53 million gallons, and to a per capita consumption of 307 gallons per day.

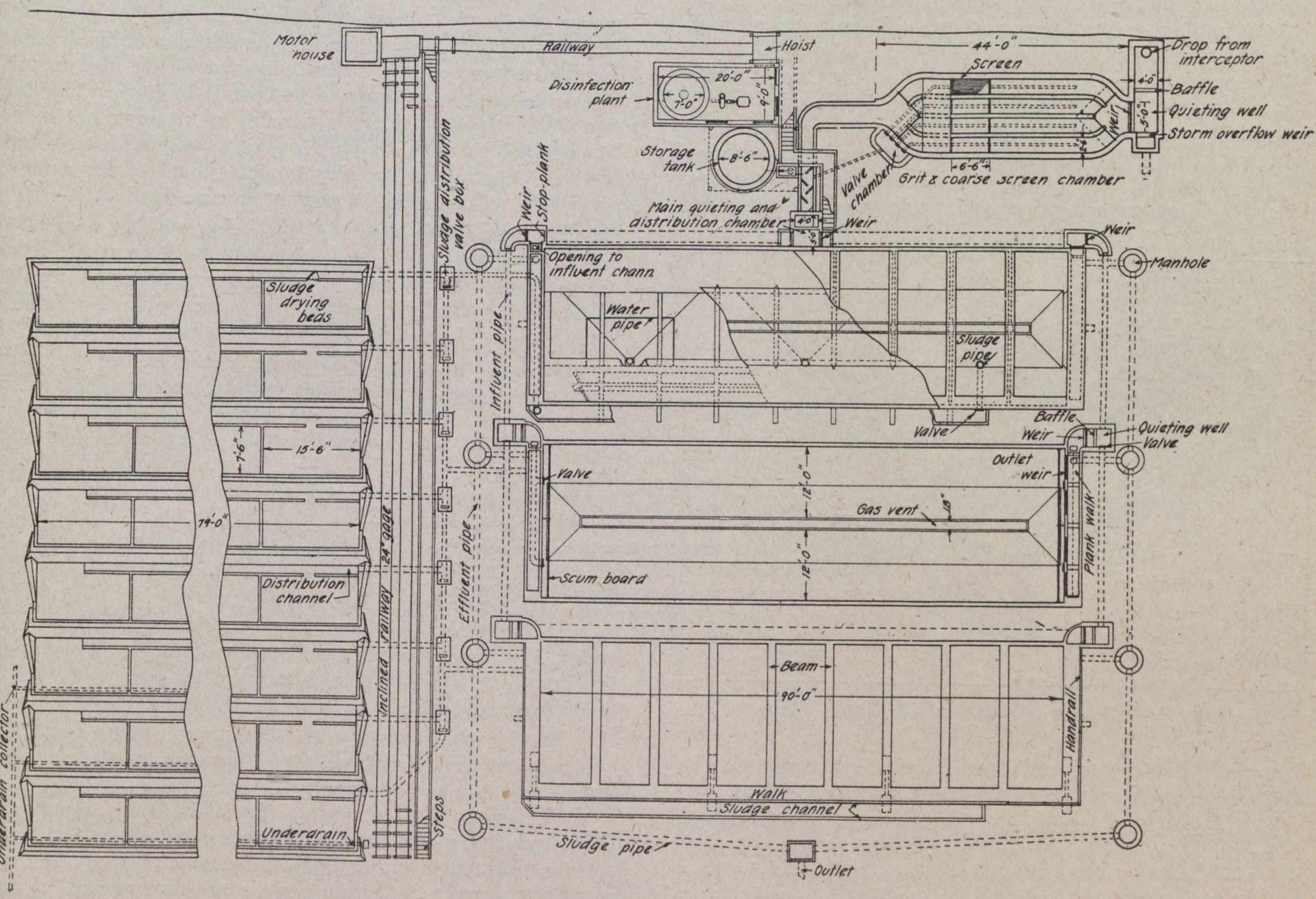


Fig. 1.—Niagara Falls, North End Imhoff Tank Plant.

The city of Niagara Falls, Ont., is located on the Niagara River, about one-fourth mile below the Horseshoe Falls. In addition to its character as a stopping point for tourists, the city is chiefly a hydro-electric power generating centre, though containing a few important industries.

The corporate limits include about 1,630 acres and extend 2.7 miles along the river. The river frontage is well built up with residences, but the major development of the city is centered in the northwesterly section.

Forecast of population has proceeded along two lines, including for collector design an increase paralleling that of the American city and adjacent territory. For treatment works figures the past performance of this city, together with percentage increases of Berlin, Guelph, and Brantford during corresponding periods of growth, have led to a population for 1930 of 18,000.

The figure of 307 gallons per capita daily may be expected to yield an average run-off of 95 per cent. of this figure, or 292 gallons per capita per day, the balance being an estimate of that portion of the total supply lost in lawn and street sprinkling and in processes of manufacture. The particular expression of the ratio has been obtained from studies made in Buffalo as modified to meet local conditions.

The application of the maximum rate of flow of 160 per cent. to the average rate of water consumption sewer discharge of 295 (292) gallons per capita daily gives a run-off of 467 gallons, or, as rounded off, 470 gallons per head per day, which is the figure that has been used for collector design.

For drainage purposes the city is at present divided into four districts, which are fairly well sewered. There being four existing outlets, it is feasible to treat the sewage at four different sites, or else to collect from two or more outlets and carry to one or more disposal plants. From the administrative and operative point of view a single central plant is the preferable, but in the present instance the relatively low elevation of the Bender Street outlet would make very costly any collector to combine the sewage of this district with that from the balance of the city. Accordingly, it has been planned to treat the Bender Street sewage locally at works on the cliff side close to the present outlet.

The remaining outlets can be readily combined by means of an intercepting sewer, which would cost in the vicinity of $35,000. In other words, the expenditure of $35,000 would permit of the construction of one treatment works instead of three, and in addition to the consequent material saving in plant-construction costs would secure a lessening of labor charges due to the concentration and localization of the work. Also, the construction of an interceptor would harmonize with future sewerage development without additional construction, except for plant enlargement, whereas the subdivision scheme would necessitate either a new plant for each new outlet or else the construction of part of the collector proposed under the present plan.

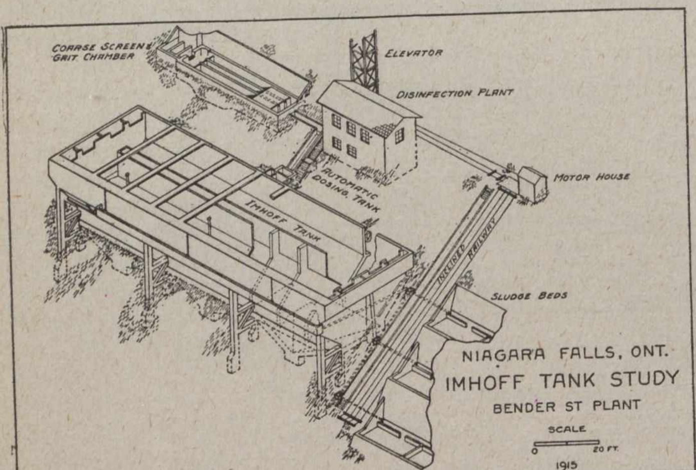


Fig. 2.—Bender Street Imhoff Tank Plant.

For these reasons treatment at one site is favored save in the case of the Bender Street sewage, as before noted.

A gorge side situation is at first sight objectionable from the point of expense and of difficulty of construction, but has been selected as more economic than inland sites requiring pumping, or than a northerly location which would require a long interceptor to secure gravity discharge. The gorge side topography consists of a slope of 40 degrees inclination extending from the river edge to a vertical cliff some 60 feet high. The foundation material is limestone, seamy but solid. At Bender Street the slope is covered with 5 or 6 feet of loose rock and boulders, but is bare at the northern site.

The land included within the Canadian gorge limits is under the jurisdiction of the Queen Victoria Park Commission, and inasmuch as the works proposed will in no wise mar the picturesqueness of the locality, it is probable that the use of area sufficient for disposal works can be secured without expense to the city.

The interceptor has been located on the River Road commencing at Seneca Street outlet and continuing to a drop shaft at Park Street, in order to avoid deep cutting; and thence to the outlet near Orchard Street, with a drop pipe to a treatment works located below the cliff.

Flat grades combined with a minimum velocity of 2½ feet per second have been used in the design of the interceptor. The velocity, while not so great as could be desired, is fairly conservative, and allows of the use of shallow cuts.

Treatment-works studies were followed with limitation to sedimentation and to fine screens, each coupled with disinfection by means of a solution of calcium hypochlorite.

In the case of tanks, the dimensions and proportions of the plants have been selected to give a sedimentation of two hours for an amount of sewage equivalent to 120 per cent. of the average flow.

Consideration of fine screens has been restricted to an installation for the North End plant because of the small flow to be treated at the southern plant. At the major works the 1930 average flow has been fixed at 7.7 cubic feet per second with a possible maximum of 23.4 cubic feet per second as the storm capacity of the interceptor. Upon commercial ratings, a 12-foot R-W screen, having one-sixteenth inch slots, is capable of passing 9.3 cubic feet per second with a 2-inch loss of head. With two such screens the available capacity is 18.6 cubic feet per second, or 80 per cent. of the maximum sewage flow.

The details of the two plants being similar, a general description will apply to both. As will appear from reference to Figs. 1 and 2, the features included consist of quieting well, grit and coarse screen chamber, disinfection plant, Imhoff tanks, and sludge-drying beds.

Wells with baffles have been placed at the outlet of the vertical portion of the interceptor to reduce the velocity and turbulence of flow. The baffle is of the underflow type, designed to prevent deposits. The wells are also provided with adjustable weirs at the side to permit of by-passing any desired portion of the storm flow.

The grit chambers have been designed to allow detention of the flow for 45 seconds with a velocity of 0.75 foot per second. The screen is of the usual inclined bar type with a 2-inch spacing.

The disinfection house has two floors, the lower of which contains the mixing well and machinery. The upper is a combined storage and charging floor equipped with a chain hoist and trolley to facilitate the handling of drums.

The bleach solution to the extent of 5 parts available chlorine per million of sewage is applied to the sewage as it leaves the grit chamber.

The sewage, after passing the dosing tank, reaches a central quieting and distribution chamber where the flow can be diverted to either end of the tank units by adjustment of the weirs. Quieting wells are also placed on the lateral influent lines at each tank.

The tanks upon which estimates have been based are of the Imhoff type, as modified by the requirements of the sloping ground at the sites. To meet the condition noted the lower compartment has been formed as half a rectangular pyramid.

Each tank unit as planned consists of two interconnected flow-through channels separated by a gas vent and designed to give a velocity of 0.0125 foot per second for 120 per cent. of the average flow. The sewage will enter through sluice-gate controlled orifices, and discharge over weirs at the farther end, the arrangement being such as to permit of reversal of flow to secure more uniform deposit of solids in the sludge compartment.

Removal of sludge is accomplished by gravity through vertical cast-iron pipes with horizontal valve-controlled connections to a concrete channel supported on brackets along the outer wall of the tank.

The sludge-drying beds are constructed in narrow terraces, partly in excavation and partly in rock fill. The drainage material is sand and gravel 15 inches thick. The beds are divided into stepped compartments by concrete partitions, and are provided with drains at the back of each retaining wall to carry off the effluent and to prevent seepage to the bed below.

The dried sludge will be removed from the beds in handbarrows and raised to the foot of the cliff in dump cars by a narrow-gauge inclined railway, which is double-tracked to allow the use of a counterbalancing car.

The North End fine screen plant, as designed, includes, in addition to the quieting well, grit chamber, and disinfection plant provisions, a screen house and disinfection channels. The common features are similar to those for the tank plant. The relative positions of the different parts are shown in Fig. 3.

The screen house is merely a covered extension of the sewage channel so formed as to receive two disk screens of the R-W type, with appropriate sluice gates, by-passes, and driving machinery. The screenings, as they are swept from the rotating screen plates, will fall through chutes into exterior storage pits, from which they can be removed to hopper cars and carried over a spur track to the elevator.

As shown in Fig. 3, the disinfection process is placed subsequent to the screens, the screen effluent with its charge of chemical flowing to a series of channels arranged in steps upon the hillside. These channels are such length as to secure a detention of 15 minutes at the time of maximum flow, and of such cross-section as to maintain for average flows a velocity of about 0.7 foot per second without regulation of outlet gates.

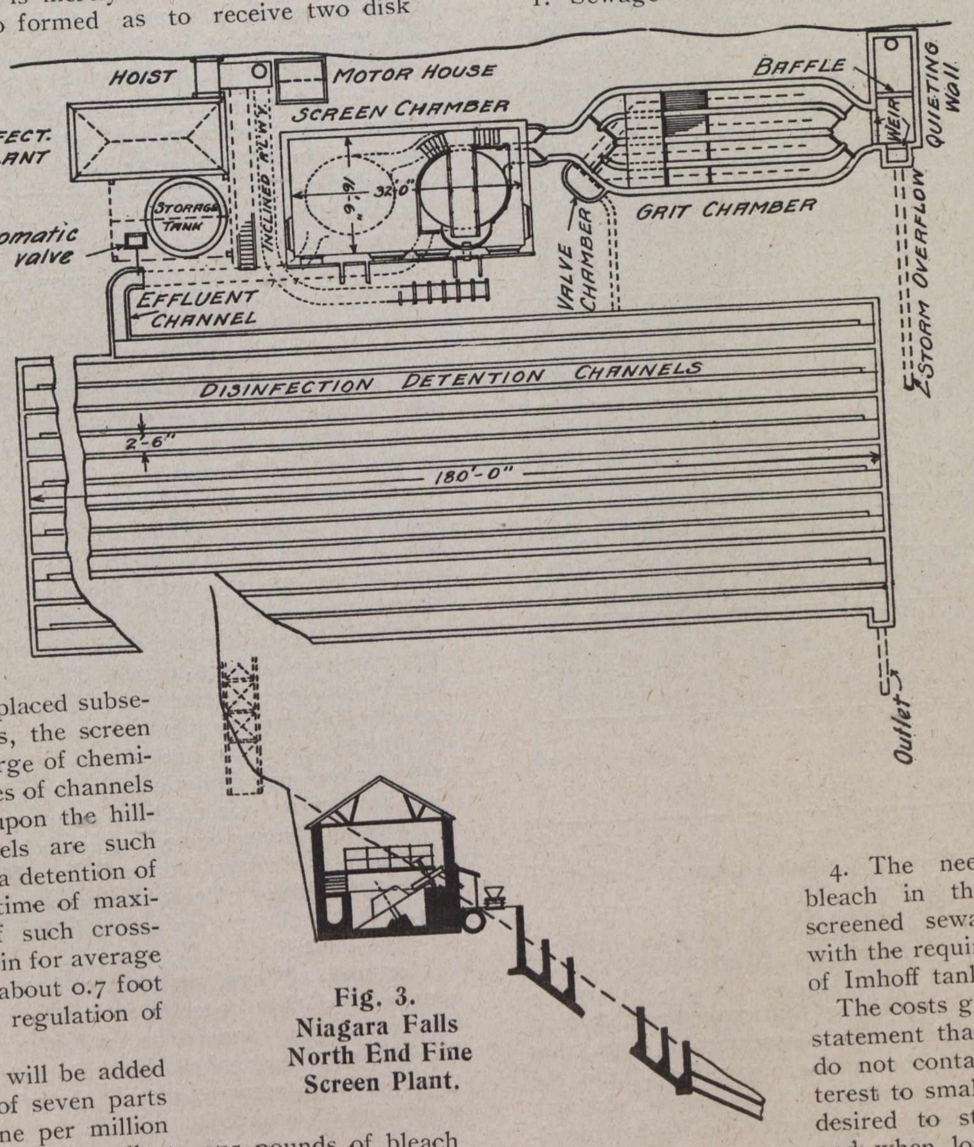


Fig. 3. Niagara Falls North End Fine Screen Plant.

The disinfectant will be added in the proportion of seven parts of available chlorine per million of sewage, equivalent normally to 175 pounds of bleach per million gallons.

The construction and maintenance costs of the different features of treatment were prepared in accordance with contract prices prevailing in Niagara Falls, and were as follows:—

Construction cost of interceptor	$34,600
Construction cost of Imhoff tanks, Bender Street plant	14,853
Construction cost of Imhoff tanks, North End plant	34,184
Cost of fine screens, North End plant	46,950
Annual operation cost Imhoff tanks, Bender Street and North End plants	8,960
Annual operation cost, North End fine screen plant and Bender Street Imhoff tank plant	11,105
*Total annual charges, Imhoff tanks	14,068
*Total annual charges, fine screens	19,297

(In this connection, acknowledgment should be made of the assistance of Lieut. F. J. Anderson, B.A.Sc., formerly city engineer of Niagara Falls, Ont., who supplied the data upon which these studies were based.)

Treatment plants, including Imhoff tanks and disinfection, are thus shown more economic for Niagara Falls, Ontario, than those embodying fine screens. The differences are striking because the conditions are unfavorable to the installation of mechanical screens. The factors prejudical to a fair showing of this type of treatment are:

1. Sewage flows such as to require one fair-sized screen and for dry-weather discharge only one, but which, to sustain the maximum capacity of the interceptor and to provide reserve for the dry-weather unit, necessitates an additional screen, which serves to double this part of the plant cost.

2. The omission of any charges for the purchase of land, in which screens offer an economy.

3. The need for tanks or channels in which the full storm flow can be disinfected.

4. The need for additional bleach in the disinfection of screened sewage, as compared with the requirements in the case of Imhoff tanks.

The costs given strengthen the statement that fine-screen plants do not contain elements of interest to small towns, when it is desired to sterilize the effluent and when long outfalls for the latter purpose are not available. It should further be noted that the costs, as computed, do not make screens comparable with tanks, even in performance, for not only will the screens be overburdened during storm flows, but also at times of dry-weather flow the labor costs include

*Figuring interest at 4½%, eighty-year life for interceptors, fifty-year life for structures and fine screen machinery, and 10% combined amortization and repairs allowance for Imhoff tanks machinery.

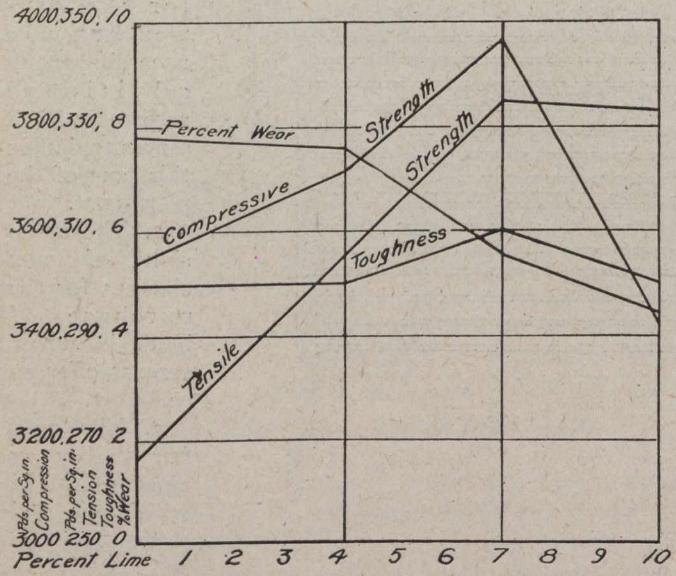
provision for but 16 or 18 hours' operation, upon the questionable hypothesis that the very low night flows can be neglected. In this respect the tank plants possess an advantage in the manner with which they can be left without attendance, though still in operation.

The finding of the report to the International Joint Commission is to the effect that the city of Niagara Falls, Ontario, can meet restriction upon the river discharge of crude sewage by the construction of Imhoff tank and disinfection treatment works at a first cost of $83,600 or less, and with annual labor and material charges of about $9,000.

HYDRATED LIME IN CONCRETE PAVEMENTS.

The use of hydrated lime in the construction of concrete pavements is a subject in which many of *The Canadian Engineer* readers are concerned. In the annual report on highway improvement in Ontario, G. Cameron Parker, B.A.Sc., assistant engineer, Department of Highways, Ontario, presents a report from which the following extracts have been taken:

That the addition of hydrated lime to concrete results in an increase in the waterproofing properties of the material has been recognized for a number of years. The problem of rendering the walls of concrete tanks, reservoirs and foundations has been solved in many cases by the use of this material.



Curves Showing Effect of Hydrated Lime in Portland Cement Mortar. (Mortar 1:2.)

Laboratory tests have shown that concrete containing hydrated lime not only becomes impermeable but that none of the desirable properties are sacrificed. On the contrary, increases in tensile and compressive strength have been recorded along with greater facility in trowelling and surfacing. Ordinary sand mortar does not lend itself to the obtaining of a smooth finished surface. When such is required a coating of neat cement or fine sand mortar, a cement wash, or handrubbing with abrasive blocks is usually resorted to. The lime appears to act after the nature of a flux, rendering the mortar smooth and plastic and making it possible to work up to a fine surface. The formation of surface cracks is lessened by the addition of lime, which indicates that it reduces the coefficient of expansion of the material, due to change in temperature and moisture content, or causes it to be uniform throughout the mass.

While the chemical reactions taking place during the hardening of concrete are not fully understood, it is thought that the lime takes no part in them but acts solely as a void filler, making the concrete more dense and therefore stronger and less permeable. An examination of a piece of concrete mortar will show a certain percentage of fine voids. These are more pronounced where the mortar has been in contact with a piece of the coarse aggregate. By the aid of a microscope of even moderate power smaller voids may be seen throughout the mortar generally. If the material is subjected to the action of water it is to be expected that these voids will become filled. The resulting action on the concrete when the frost reaches these small, water-filled cavities will, to say the least, be deleterious. In warm weather when the danger from frost is not present the water may contain salts or other materials in solution which will have a disintegrating action. Thus, in all seasons the mass is exposed to danger so long as these capillary chambers exist.

It is, therefore, essential that the voids be filled, or reduced to a minimum. It is generally thought sufficient to have the material entering into the concrete so proportioned that the voids in the coarse aggregate are completely filled by the mortar, those in the fine aggregate being filled with cement, with a slight excess of the latter. Concrete so proportioned, properly wetted, mixed and tamped, is considered dense. Simple tests will show that no amount of mixing or tamping, or even the addition of an excess of cement will entirely eliminate the small voids. So long as they exist the mass will be subject to expansion and contraction to a greater degree than if they were filled with material. This is the purpose that is believed to be served by the hydrated lime. The results of tests in actual conditions, as well as those made in the laboratory, show that there is a decrease in the contraction of the material, that it is more impervious to water, and that with certain percentages of lime added there is a resulting increase in strength.

With these facts determined it was natural that favorable results should be expected from the use of hydrated lime in concrete pavements. When laid in this form, concrete is subjected to what is perhaps its most severe test. In addition to being under static and live loads, it is exposed to extreme climatic conditions. The temperature in the southern portion of Ontario commonly ranges from 95 degrees in summer to 20 degrees below zero during short periods in the winter months. In addition, the snow lies on the ground for at least three months of the year, attaining a depth of from 12 to 24 inches on the level. The average frost line is about three feet below the surface of the ground. When, together with these conditions, it is remembered that concrete in a pavement has a greater area of surface exposed, per cubic yard of material, than in any other class of work, the necessity of obtaining a thoroughly dense material with the minimum coefficient of expansion, is realized.

In the summer of 1913 a section of concrete road containing hydrated lime was laid by the Office of Public Roads and Highways near Sarnia, Ont. The road is 5,946 feet long, 16 feet wide and 7 inches thick, one-course construction being used. Gravel shoulders 4 feet wide, bound with limestone screenings, were laid on the sides. Expansion joints filled with paving pitch were placed at 30-foot intervals. The gravel used, was supplied from the St. Clair River at Point Edward.

The hydrated lime, which replaced 10 per cent. of the cement by volume, was mixed with the cement in a small gasoline-driven mixer and rebagged. The cost of this was $0.084 per square yard of pavement laid. One carload of cement was thus handled per working day. At the present time this pavement is in first-class condition, showing but a few cracks, in spite of the fact that tons of heavy machinery were hauled over it in connection with building operations on adjoining property.

The writer conducted a preliminary set of laboratory investigations with a view to determining, if possible, the factors affecting the use of hydrated lime in Portland cement mortars.

Tests were made to determine the following properties: Tensile strength, compressive strength, rigidity, toughness and resistance to wear.

A fine, clean, pit sand was chosen, the fineness being considered advisable, tending towards consistent results. The Granulometric analysis gave the following:

Screen	No. 10	No. 20	No. 30	No. 40	No. 50	No. 100	No. 200
Per cent. passing	98.9	92.3	46.9	21.7	21.7	2.0	.4

Silt present, 0.2 per cent.

The Portland cement was of average grade and had the following properties: Specific gravity, 3.15. Per cent. retained, No. 100 screen, 5.3; No. 200 screen, 19.2. Initial set, 1 hour 30 minutes. Final set, between 4 and 5 hours. Acceleration test showed no checking or cracking. Strength of neat cement at 24 hours, 240 lbs. per square inch. Strength of neat cement at 7 days, 525 lbs. per square inch. Strength of 1:3 mortar of standard Ottawa sand at 7 days, 200 lbs. per square inch.

The hydrated lime used was obtained from the Provincial Prison Farm at Guelph, Ont., and has the following analysis: Magnesia (MgO) 33.1 per cent.; calcium oxide (CaO) 43.5 per cent.; silica, alumina, etc., 23.4 per cent.; class of lime, Dolomitic.

The mortars used, with the proportions of lime added, were:

Series.	Mortar.	Per cent. lime.	Series.	Mortar.	Per cent. lime.
A-1	1-2	0	B-1	1-4	0
A-2	1-2	4	B-2	1-4	8
A-3	1-2	7	B-3	1-4	15
A-4	1-2	10	B-4	1-4	25

The weight of lime is based on the weight of cement, both dry, and is added to it, not replacing it.

The dry cement and lime were screened together twice and turned over three times. The water was then added and the mass turned six times with the shovel. The consistency in each case was standard throughout the tests, the mixture being on the wet side, although not sloppy.

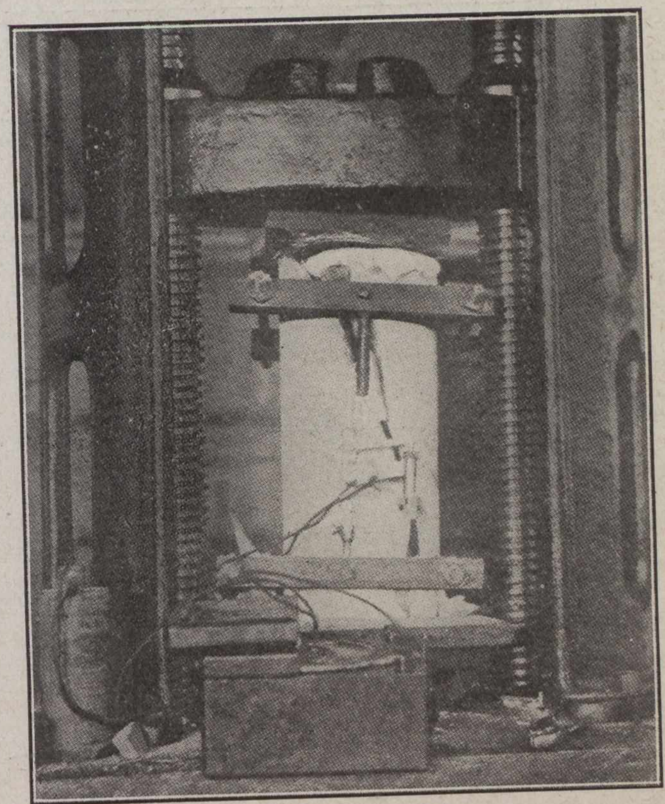
In placing in the moulds care was taken that each specimen received the same amount of tamping and packing. The chances for error due to variations in this operation were reduced to a minimum.

At the end of twenty-four hours the moulds were removed and the material dried in air for thirty-six hours, when it was immersed in water, being completely covered. Any loss due to evaporation of the water was made up from time to time.

The tests for tensile strength were made on standard cement briquettes, with a Reihlé shot machine. Twelve briquettes were tested and the average of those giving the most consistent results recorded.

The tests for compressive strength and rigidity, or modulus of elasticity in compression, were made at the same time. The cylinders, measuring 8 x 18 inches, first being capped with plaster of paris, were placed on an adjustable block on the testing machine. A metal plate was set on the top and the head lowered slowly. The adjustable blocks were set so that the top plate was parallel with the head in order that the pressure would be evenly distributed over the surfaces.

The reduction in length was determined by means of a compressometer with 12-inch centres. The micrometer screws read to .00001 inch and were fitted with electric contacts, providing a very accurate adjustment. The reading for no load being taken, the load was applied and the compressometer readings taken. Sufficient readings were taken to give from 12 to 15 points on the stress-strain curve. The type of clamps used with the compressometer were such that it was possible to leave the instrument on the cylinder throughout the test for compressive strength; that is, until the cylinder failed.



Compression Test Specimens in Testing Machine, Showing Methods of Attaching Compressometer.

The testing machines used were the Riehlé 100-ton, vertical machine, and the Riehlé 50-ton, vertical machine. The cylinders from series "A" were tested on the former as their strength exceeded the capacity of the smaller machine. Series "B" were all tested on the 50-ton machine. Both machines were adjusted before the commencement of each test.

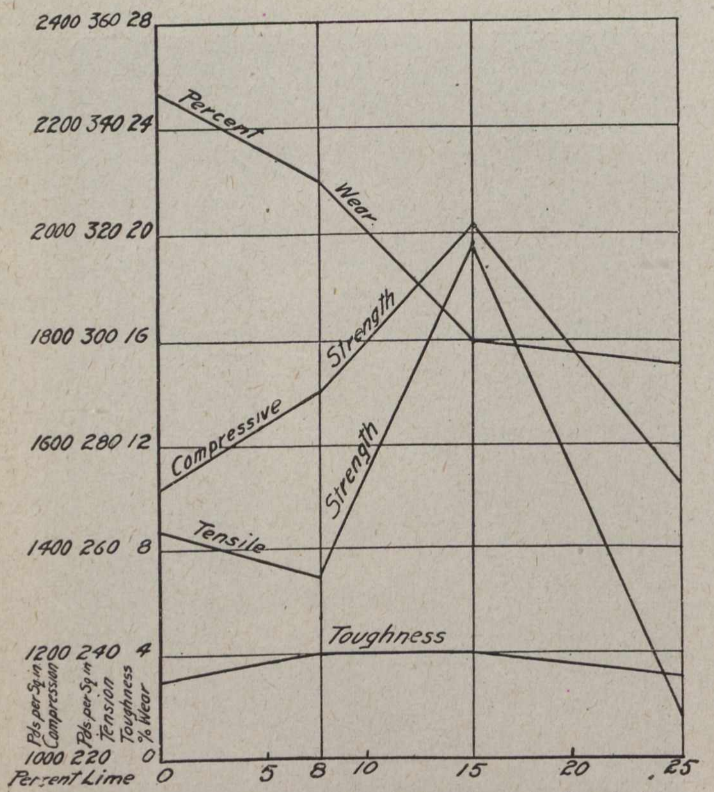
The methods of attaching the compressometer and applying the load are shown in the accompanying photograph. All the cylinders of series "A" failed suddenly with a loud report, while those of series "B" failed slowly with a "crunch," usually after the load had been constant for some seconds. In several cases it was impossible to get a definite reading at the point of failure on series "B" as the fatiguing of the material caused a continuous change of length until failure took place. In series "A" the point of failure came in every case with an increase in load, indicating that the 1:2 mortar withstood fatigue longer than the 1:4 mortar.

The tendency to produce cones was shown, in every case with series "A" and in several cases with series "B," these latter not being so well formed. The forms that the cones took together, with one cone still in position, is shown.

The compressive strength was calculated by dividing a load in pounds on the cylinder at failure by the area in square inches. This gives the compressive strength (ultimate) in pounds per square inch.

The points on stress-strain curves were calculated and plotted in the following manner:

For a given load in pounds per square inch, the average difference in the compressometer readings was



Curves Showing Effect of Hydrated Lime in Portland Cement Mortar. (Mortar 1 : 4.)

reduced to strain (change of length in inches, per inch of length). With strain as ordinate and stress as abscissa the curves were plotted. As the modulus of elasticity in compression (Ec) depends on the inclination of the curve with the axis of stress, a constant "Ec" is indicated by a straight line curve. Hence from the origin to the point where the curve ceases to be straight the Ec remains constant, and is determined by dividing the stress by the strain. Thus

$Ec = C/S$, where Ec is the modulus of elasticity for concrete.

C is the stress, and

S is the strain.

The quotient gives what might be called the average modulus of elasticity, covering a range of stresses from zero to the point calculated. As stated before, where the curve has a constant inclination to the axis of stress a calculation for any point on the curve will give the same value.

The stress-strain curves were calculated for the test from which it was possible to get the greater number of readings near the upper portion of the curve. Two cylinders were tested for each mortar in order that a check might be had. In practically every case the test readings checked closely; consequently in order that the curves might be easily read, the one giving the most points was recorded.

The test for toughness was made on 1-inch cubes. These were tested on the impact machine for testing the toughness of rocks. The test consisted of repeated blows of the hammer, starting with a fall of 1 cm. and increasing by 1 cm. for each succeeding blow. The number of blows required to cause failure represents the toughness of the material. The average of two tests was recorded.

The test for resistance to abrasion was made in the Deval abrasion machine. The pieces from the briquettes broken in the test for tensile strength were placed in the cylinder, after weighing, and given 6,000 revolutions at a rate of 33 per minute. They were then removed, carefully cleaned and weighed, the loss of weight by abrasion being expressed as a percentage of the original weight.

Series "A," Mortar 1 : 2.

Lab. No.	Per cent. Lime.	Tensile Strength.	Compressive Strength.	Per cent. Wear.	Toughness.
A-1	0	267.2	2,540	7.88	5
A-2	4	305.5	3,715	7.625	5
A-3	7	335.5	3,970	5.600	6
A-4	10	328.0	3,425	5.000	5

Series "B," Mortar 1 : 4.

Lab. No.	Per cent. Lime.	Tensile Strength.	Compressive Strength.	Per cent. Wear.	Toughness.
B-1	0	264	1,520	25.40	3
B-2	8	255	1,700	22.00	3
B-3	15	318	2,015	16.00	4
B-4	25	227	1,520	15.00	3

Series "A" Values of "Ec" up to 1,200 lbs. per sq. in.

A-1	3,337,500 lbs.
A-2	3,080,000 lbs.
A-3	3,337,500 lbs.
A-4	2,925,000 lbs.

Series "B" Average values of "Ec" up to 800 lbs. per sq. in.

B-1	2,650,000 lbs.
B-2	2,500,000 lbs.
B-3	2,350,000 lbs.
B-4	2,425,000 lbs.

Observations.—With the addition of hydrated lime to the 1 : 2 mortars an increase of tensile strength was observed, reaching the maximum in a mortar containing 7 per cent. lime. Beyond this point the tensile strength decreased. In the 1 : 4 mortars the maximum tensile strength was developed by that containing 15 per cent. of lime, a falling off taking place when this was exceeded.

The same variation was noted in the compressive strength, a 7 per cent. lime content giving the highest values with a 1 : 2 mortar and a 15 per cent. lime content with the 1 : 4 mortars.

The observations and calculations for the modulus of elasticity for the 1 : 2 mortars did not give as definite variations as in the other tests. There was little variation in the mortars containing from 0 to 7 per cent. lime, a very slight decrease being recorded for the 4 per cent. lime content, the same value being obtained with 7 per cent. as with 0 per cent. lime. With the 1 : 4 mixtures a smaller variation was found but a slight decrease in the values, as the percentage of lime was increased. The decrease between 0 and 15 per cent. lime contents was slight.

An increase in toughness was found in the 1 : 2 mortars, reaching a maximum with that containing 7 per cent. lime and an increase, to maximum at 15 per cent., with the 1 : 4 mortars.

(Continued on page 646.)

WATERWORKS RESERVOIRS.*

By Dabney H. Maury, Mem.Am.Soc.C.E.

[The purpose of Mr. Maury's paper is to discuss governing considerations in reservoir design, show a few typical designs, describe difficulties encountered in actual construction, and to make suggestions which may assist engineers to overcome some of these difficulties.—EDITOR.]

IN any waterworks system there are usually a number of steps which lie between the taking of water from its original sources and the actual delivery of it to the consumer. These steps include some or all of the following: (*a*) The collection and storage of the water of a stream in an impounding reservoir. (*b*) The pumping of water from a stream or lake or from wells to a suction reservoir, or to a settling basin, or to filters, or directly into the distribution system. (*c*) The purification of the water either by sedimentation, or by filtration, or by both. (*d*) The pumping of the water from the surface reservoir, or from the sedimentation basin, or from the clear water reservoir of the filters, into the distribution system. (*e*) The actual delivery of the water from the distribution system to the various consumers.

Field of Usefulness.—The usefulness of any reservoir depends upon, and is limited by, the position which it occupies in the order or procession of the steps just enumerated.

For example, if it be an impounding reservoir it can do no more than store the waters of the stream above it, and is of no value in conserving or helping out the capacity of the low-lift pumps which take their supply from it; or of any suction reservoir, or filter plant, or clear water reservoir, which may follow it; or of the high-lift pumps; or of the distribution system. If it be a suction reservoir or clear water well, then it will help out the capacity of everything back of it, which may be a stream, an impounding reservoir, wells, or low-lift pumps taking water from any of these sources and delivering it into the reservoir under consideration, or a water purification plant which may discharge into it. Such a reservoir does not, of course, conserve the capacity of the high-lift pumps which draw from it, or of the distribution system into which its waters are discharged.

A distributing reservoir, located on the discharge side of the pump and connected to the distribution mains, has more of these steps back of it than any of the other reservoirs just enumerated, and its usefulness may include the conservation of the capacity of stream, or of impounding reservoir, or of wells, or of sedimentation basins, or of filter plant, or of low-lift pumps, or of high-lift pumps, or of all of these together.

A distributing reservoir properly located will, in addition to all of the foregoing, help out the capacity of the distribution mains themselves, and this last and very important function has in the past been frequently overlooked.

It follows from what has just been said that the nearer a reservoir is to the beginning of the order or procession of the successive steps in water supply, the less will be its value, other things being equal; and that the further along in this procession of steps, the greater will be the value of the reservoir.

Value of Proper Location of Distributing Reservoirs.—In order to derive the greatest possible benefit from a distributing reservoir, it should be properly located; and the intrinsic value of the proper location of such reservoirs has not always been appreciated in the design of waterworks systems. Where small waterworks plants have elevated storage, one frequently sees the tank located on the pumping station lot. A tank so located is in most cases a monument to the bad judgment of the man who designed the plant.

To illustrate the point, two cases, out of many that could be mentioned, will be cited:

In the first case the main pumping station was two miles north of the centre of the congested value district in a small city. The elevated storage reservoir, originally built close to the pumping station, had been destroyed, and it was necessary to provide a new one.

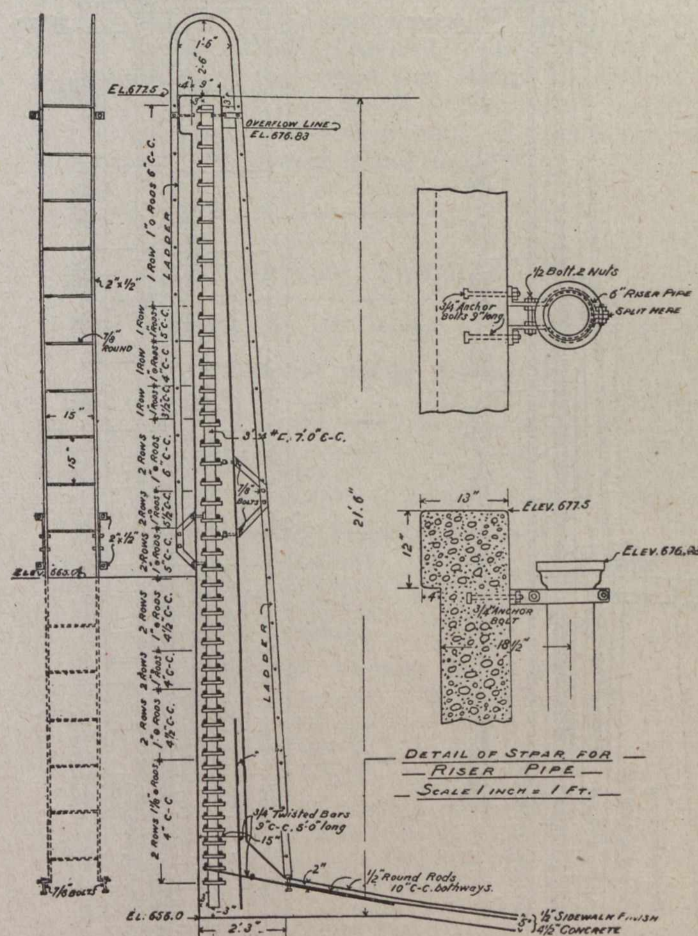


Fig. 1.—Wall of 2,000,000-Gallon Reservoir.

For the purpose of computing the friction losses it was assumed that a fire broke out during sprinkling hours on a hot day in summer and that the plant would be required to furnish water at the rate of 4,000 gallons per minute, distributed throughout the city for domestic consumption, in addition to a supply of 2,000 gallons per minute for fire service, which latter amount would be drawn at or near the centre of the congested value district. It was found that if the tower and tank were located close to the pumps at the northern end of the city the pressure remaining in the mains in the congested value district would be only 25 pounds, whereas with the same elevated tank located near the southern end of the town the pressure remaining in the mains would be more than 53 pounds. To save this difference of 28 pounds by laying additional mains from the pumping station to the congested value district would have involved an expenditure

*Abstract of paper read before the American Water Works Association, June 7th, 1916.

of at least $30,000; so that it may be fairly stated that the advantage obtained in this case by locating the elevated storage near the centre of the congested value district instead of at the pumping station was worth not less than $30,000.

In the second case, which involved a city of larger size than the one just mentioned, a site for an elevated reservoir of a capacity of 7,500,000 gallons has been selected on an eminence opposite the main pumping station. The congested value district in this city was comparatively small, and its centre was more than three miles south of the pumping station. A topographic map had been made of the proposed reservoir site, and test pits had been sunk through the top soil to bedrock, when the writer was called in to pass upon the suitability of the topography and soil conditions for a reservoir of the capacity contemplated. It was at once apparent that the location of the reservoir with regard to the pumping station, to the distribution system of mains and to the territory to be supplied, was far from being a desirable one. An examination was made of high ground opposite the congested value district, with the result that a much more suitable site was discovered, which was later purchased by the city.

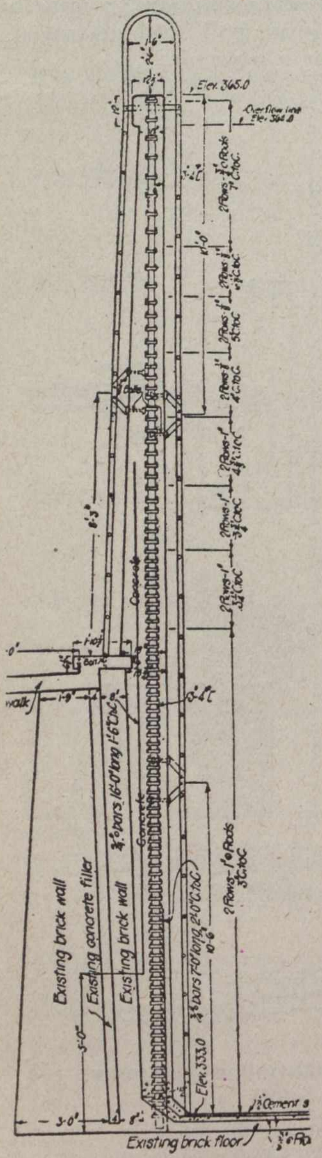


Fig. 2.—Wall Section, Old Reservoir.

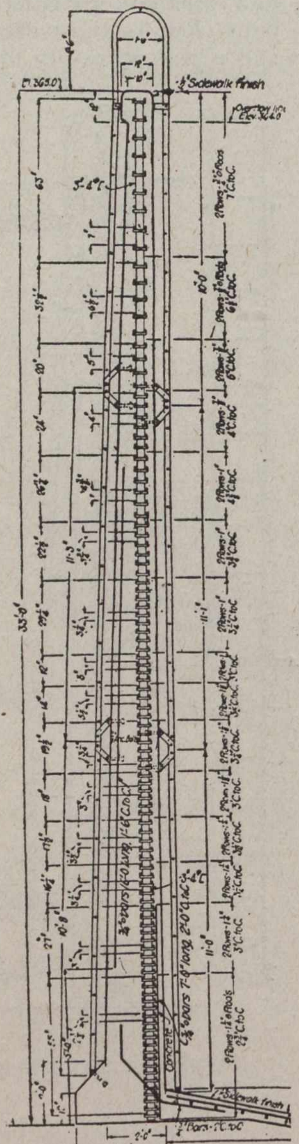


Fig. 3.—Wall Section, New Reservoir.

Among the first points to be determined are the location, capacity and elevation desired. These having been at least approximately determined, the work of designing may be begun.

Some Typical Designs.—Fig. 1 shows in cross-section the wall and part of the bottom of a 2,000,000-gallon reservoir, 120 feet inside diameter, 19 feet 10 inches deep at the wall, and 24 feet 10 inches deep at the centre. This reservoir was built partly in excavation and partly in embankment on clay soil. Its bottom, which was 5 inches thick, was reinforced throughout with steel sufficient only to resist temperature stresses. The reinforcement in the wall was continuous around the circumference, and was designed to resist the internal pressures just as the hoops on a barrel resist the internal pressures in the barrel.

Fig. 2 shows in cross-section the wall of another reservoir in which the steel reinforcement was stressed as are the hoops in a barrel. This wall was built to enlarge the capacity of an existing reservoir by increasing its depth from 14 to 32 feet. The inside diameter of the reservoir, as enlarged, was 142 feet, and its capacity about 4,000,000 gallons. Right alongside of this old reservoir was constructed a new one which was so designed that the part of it which showed above the finished grade should be an exact duplicate of the enlarged old reservoir, and Fig. 3 is a section through the wall of the new reservoir. Here again the reinforcing steel is subjected to hoop stresses.

Fig. 4 shows an entirely different type of reservoir, with beam and slab roof, slab walls and slab bottom for the bay next to the walls on each side, the remainder of the bottom being of the inverted groined arch type. This is not a distributing reservoir, but is intended to serve for the present as a storage reservoir for water pumped into it from distant wells. The reservoir is, however, so designed that later on its columns may serve as supports for an iron removal plant to be built on top of it, and it will then serve as a clear water reservoir. At times of very high water, the ground water, if it were unaffected by the pumping operations at the adjacent pumping station, would rise as high as the top of the reservoir, and if the reservoir were empty as such a time, the total upthrust would be greater than the weight of the reservoir and of its covering.

While it is not likely that there will ever be a time when the pumping operations at the station will cease for any long period, coincident with the pumping out of the reservoir itself, provision was nevertheless made to guard against any such contingency by sinking in each corner of the reservoir a 10-inch well equipped with a strainer of liberal area, having openings so large that they cannot become clogged by rust, and with a check valve opening into the reservoir. Should the ground water outside of the reservoir at any time rise higher than the water inside, these four wells will admit water to the reservoir with sufficient rapidity to prevent any danger from the unbalanced pressure of the ground water.

These wells were sunk before the construction of the reservoir was begun, and by pumping from them, the ground water, which would otherwise have stood several feet above the bottom of the reservoir, was held down below the bottom during the entire construction period, so that the whole structure was built in the dry.

Some Construction Difficulties and Some Suggestions.—The first thing naturally demanded of a waterworks reservoir is that it shall hold water, and as a rule the most difficult part of the construction of a reservoir is making it watertight.

A small amount of leakage really does no great damage; but so long as any leakage can be detected, it is an eyesore, and it remains as a reproach to all of those in any way connected with the design or construction of the reservoir, whether contractor, engineer or owner. For these reasons, leaks so small that they could do no harm whatever are not, as a rule, permitted in the finished structure, even though the cost of stopping them is out of all proportion to the value of the water lost.

It is not an easy matter to build a reservoir which shall be absolutely watertight from the time the forms are removed. Fortunately, however, very small leaks will usually become less or "take up" in a short time, especially when the stored water contains iron or sediment, and in most cases it is not very difficult to stop large leaks or at least to reduce them to so small an amount that they will ultimately stop of themselves.

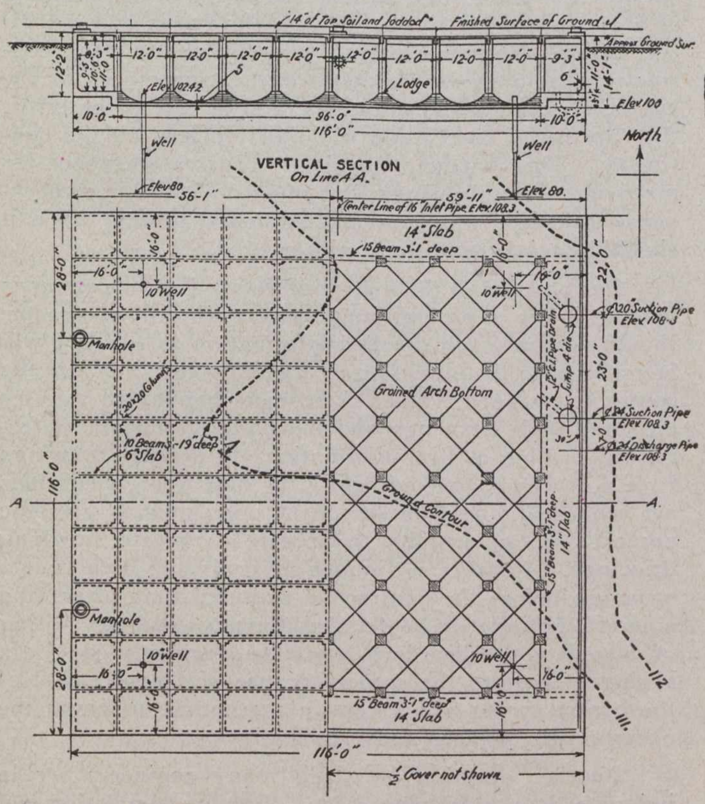


Fig. 4.—Plan and Section of 1,200,000-Gallon Covered Reservoir.

As a result of his experience with these and with a number of other concrete reservoirs, the writer would draw the following conclusions:

1. It is entirely possible with proper materials, mixture and workmanship to prevent moisture from passing through a concrete wall a foot thick, even under fairly heavy pressures.

2. It is not to be expected, however, that the perfection of workmanship required to produce these results will always be obtained at every single point over an area of thousands of square feet of wall.

3. Such leaks as may show in spite of conscientious efforts to do good work can almost invariably be stopped entirely or be reduced to such a point that they will stop themselves in the course of time, especially if the water carries iron or sediment.

4. Leaks are most likely to occur at construction joints. The use of steel dams will reduce the danger of such leaks, but these dams cannot always be relied upon to prevent the leakage, and their presence should not be allowed to diminish in any way the precautions which should always be taken to prevent leakage at the joints.

5. The surface of concrete which has begun to set should be scratched and roughened, and all dust, rubbish and laitance should be carefully removed with a vacuum cleaner before the next batch of concrete is poured. This will not always prevent leakage, but it will go far towards doing so.

6. In reservoir construction the use of chutes for conveying concrete to its place in the wall should not be permitted unless the concrete is thoroughly remixed just before it reaches its final place in the wall.

7. While good results can be obtained by very careful spading of the concrete adjacent to the forms, so as to keep the stone away from the inner surface of the wall, it is believed that far better results would be secured by the plan devised by the contractor for the 10,000,000-gallon reservoir already described; namely, the use of a portable sheet of thin metal with means for holding it about ¾ inch away from the inner form, the concrete to be poured back of this sheet of metal, and cement mortar in front of it and between it and the form

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RAILWAY EARNINGS.

The following are the weekly railway earnings for May:—

Canadian Pacific Railway.

	1916.	1915.	Increase.
May 7	$2,763,000	$1,594,000	+ $1,169,000
May 14	2,592,000	1,604,000	+ 988,000
May 21	2,610,000	1,575,000	+ 1,035,000
May 31	4,222,000	2,223,000	+ 1,999,000

Grand Trunk Railway.

May 7	$1,030,768	$ 863,195	+ $ 167,573
May 14	1,076,436	922,106	+ 154,330
May 21	1,088,679	938,386	+ 150,293
May 31	1,482,053	1,291,615	+ 190,438

Canadian Northern Railway.

May 7	$ 677,400	$ 419,600	+ $ 257,800
May 14	748,300	364,800	+ 383,500
May 21	693,100	387,500	+ 305,600
May 31	970,100	549,500	+ 420,600

The Canadian Pacific Railway net earnings for April totalled $3,733,736 as compared with $2,687,753 during the corresponding period in 1915. Gross earnings for the month were $10,881,306, and working expenses $7,147,590.

The figures for the ten months of the current fiscal year show gross earnings totalling $105,117,108, working expenses $63,953,104, and net profits of $41,164,004. For ten months ended April 30th, 1915, net profits were $28,458,594.

The gross earnings of the Grand Trunk Railway System for April were $3,584,828, while expenses amounted to $2,344,104, making the net revenue for the month $1,240,724, as compared with $1,167,492 for the same period of 1915, an increase of $73,232, or 6.2 per cent.

The earnings and operating expenses of the Canadian Northern system for April were as follow:—

	1916.	1915.	
Gross earnings	$2,824,300	$1,948,900	+ $875,400
Expenses	2,274,400	1,404,500	+ 869,900
Net earnings	549,900	544,400	+ 5,500
Mileage in operation.	8,270	7,248	+ 1,022

The New York State Public Service Commission, First District, reports that on a typical day the number of persons passing over the four bridges across the East River, between Manhattan and Brooklyn, in a period of 24 hours, was 804,146, an increase of 41,064 over the total on the day when the count was made in the preceding year.

EQUITABLE SPECIFICATIONS AND CONTRACTS.*

By Hillis F. Hackedorn.

THE American Society of Engineering Contractors, ever since its organization in 1909, has had a number of ideals to which it has clung tenaciously. One of these is the idea of equitable specifications and contracts; specifications that are written fully and completely describing the work down to the minutest detail, eliminating all guesswork and conveying to the contractor completely the ideas of the engineer; describing fully what work he expects to do, how he expects to do it, sequence of the performance and the results he expects to obtain, leaving nothing for future argument, nothing for guesswork.

One of the greatest impositions that is ever placed on the contractor is by the engineer whose specifications fairly teem with the expression "to the satisfaction of the engineer." This very-much-abused, never-understood, and impossible-to-forecast expression is about as serious a handicap as can be hung onto a contractor who is making up an estimate of cost on any type of construction. It leaves such a wide field for guesswork, it opens up such a broad avenue of opportunity for the engineer or inspector to "get even" with the contractor for some fancied or real grievance. It is something against which a contractor has no opportunity whatever to protect himself.

This phrase impresses the contractor as an evidence of either lack of knowledge on the part of the engineer or laziness in preparation of the specifications, and in many instances the contractor views these clauses in the light of a club to be held over his head during the construction of the work. They impress him with the belief that the engineer *thinks* he wants certain things done but if the contractor learns during construction that the engineer wants something else done, the contractor must pay for the change. The engineer should be sufficiently advised and have sufficient knowledge of all conditions surrounding the work to enable him to make up a correct detailed guaranteed design and estimate. He should have the nerve to stand pat on his estimate and likewise should not expect the contractor to make good the cost of any mistake he may make in the preparation of plans and specifications; neither should the contractor be put to the expense of thoroughly checking the engineer's estimates, and all engineering and contractors' organizations should join in an effort to educate specification writers to a proper conception of what is fair and equitable to owners, engineers and contractors alike.

In Great Britain carefully prepared schedules as to quantities are submitted to the contractor. These quantities are guaranteed, and in case of error, the contractor has a ground of action against the quantity surveyor if his bill of quantities is wrong. This method enables the contractor to estimate much more closely as to the cost of the work than under customs in this country, where all estimates of quantities are *frankly* labeled as guesses, and the engineer dodges all responsibility by stating that the contractor must assume all the hazard as to errors in such estimates. Of course, the contractor, under these conditions, must charge for an element of chance which should not enter into the proposition. The engineer should make his estimates carefully and thoroughly and be ready to stand behind them in case of error. I know of but one bridge engineer who guarantees his quantity estimates and as a result bidders can make much closer estimates, knowing as they do, that he will stand responsible for any errors in his quantity statements.

An unfair engineering practice frequently resorted to in the writing of specifications is to require the contractor to prepare the detailed working drawings for the job, including, for reinforced concrete, bending diagrams and special details as to connections of reinforcement, thereby making it necessary for the contractor to maintain a much more extensive engineering and drafting department than would be otherwise required if the engineer did his full duty, preparing all detail plans and working drawings so that there would be no question in the contractor's mind, when he bid on the work, exactly how the work was to be executed to the most minute detail. In addition to this, some specifications require that the contractor "having checked the plans shall be responsible for the correctness of all drawings, as to dimensions, elevations and mutual correlation of various parts," thereby making the contractor absolutely responsible for the correctness of the engineer's design and drawings, and in case of an error, the expense of correlation is unfairly placed on the contractor. The contractor is given no extra allowance for preparing these drawings, but must do it at his own expense and deduct it from his estimated profits, when it should be taken from the engineer's fee.

Our position in the matter of detailed specifications is that we know of no legitimate reason why the contractor should not have full detailed information as to what will be required in the execution of a given contract *before* the contract is signed, rather than make haphazard guesses on small scale drawings and indefinite specifications frequently lacking in vital information. If detailed drawings have not been completed before the date upon which bids are requested, the date should be postponed to give the engineer an opportunity to prepare complete working drawings. It takes no longer to study the details of a structure before the contract is executed than after, and a careful preparation of detailed drawings and the writing of complete specifications, would frequently result in saving of cost to the owner because of the necessity of the contractor to add a certain percentage to cover the uncertainties of plans and specifications.

Another question in which many engineers err in judgment is in specifying a short time for completion and requiring the starting of work immediately upon the awarding of contract. A short limit reduces competition because it admits only the contractor who is fully equipped and ready to begin immediate work, and where a short time limit is provided, the engineer should include a certain compensation to cover the cost of night work necessary on the part of the contractor in order to complete the work within the time set. It has been our experience that where the engineer co-operates with the contractor, the quality of work is very much improved, resulting in a great benefit to the owner.

One manifestly unfair condition in many specifications is that of giving the engineers the right to make minor changes in the plans, without extra compensation to the contractor, unless "in the opinion of the engineer" he is entitled to such extra compensation, the amount of any such extra compensation to be determined solely by the engineer. This condition leaves a very large opening and opportunity for the engineer to abuse his authority over a contractor whom he does not like, or seriously cripple him, when the wrong man, in the opinion of the engineer, has landed the job.

*Abstract from paper read before a joint meeting of the American Society of Engineering Contractors and St. Louis Section of the American Society of Mechanical Engineers.

In my mind, one of the greatest injustices which enter into nearly all specifications, is the clause requiring the contractor to "indemnify, keep and save harmless the owner and engineer from all liabilities, judgments or costs and expenses which may in any wise come against the owner or engineer on account of any infringement of any patent on the use of any design, material, machinery, device or apparatus used in the performance of the contract." In other words, the engineer goes along, prepares his design, specifies his materials and method of construction and puts the responsibility on the contractor for ascertaining whether or not there are any patents on the type of design, or material used, or on the method of construction. It seems to me that this is part of the duty of the engineer, and that in making his design he should ascertain beyond the possibility of a doubt whether or not his design infringes any of the many patents which have been granted by the Patent Office at Washington, and in case he cannot make a design without infringing a patent, he should either notify all bidders of the existence of such patent, and the fact that his design infringes, or he should obtain from the owner of the patent the right to use it for a specific price on the work. It is entirely unfair to shoulder this responsibility and liability on the contractor, in addition to the many other troubles which he has to guard against in executing the contract.

Another inequity is that of giving the engineer the right to direct the sequence of the work and issue orders as to the manner and time in which the various parts of the work shall be done, and the force required to complete it within the time specified. I believe I can state, without fear of contradiction, that no two contractors would handle the same job in the same manner and sequence. It is customary in making up estimates, to carefully plan the manner and sequence of the construction, and if the contractor is not permitted to follow his own methods, it frequently results in turning a contract, that would otherwise be profitable, into one that results in a loss to the contractor.

The business relations between the contractor and the engineer are little understood by the public at large. We, as contractors, realize that one of the most difficult problems confronting an engineer is the preparation of his specifications, in making them rigid enough to control the bad contractor and at the same time work no hardship on the contractor who is honest and sincere in his work.

The wise engineer knows that many contract conditions can be ignored without any harm being done, and that many facilities can be given the contractor to help expedite the work. We believe that the contractors as a body will not take unfair advantage of these concessions, but in their turn, will go out of their way, even at extra expense, to meet some special request of the engineer, playing the game of "give and take" in a reasonable way without expecting extra pay for every trifling piece of work, thus bringing about a great improvement in the relations between engineer and contractor and eliminating many of the disputes which at present are too frequent.

Signal horns, similar to automobile horns, are attached to lighting-poles along many of the busy thoroughfares of Washington, Baltimore, Binghamton, Bridgeport and a few other United States cities. When a fire alarm is rung the route to be travelled by the apparatus is quickly determined, and by electrical control at fire headquarters the alarm gongs are sounded all along the route. Traffic stops at once; the streets are cleared well in advance, and the fire apparatus has a safe right-of-way.

CITY OF KAMLOOPS HYDRO-ELECTRIC PLANT.*

By H. K. Dutcher, M.Can.Soc.C.E.

It is the purpose of this paper to refer to some of the engineering and economic features in connection with the design and construction of the municipal power plant and pumping systems of the city of Kamloops, which have been recently completed and placed in service.

These systems include a steam turbine power plant and pumping system, a new reservoir and a hydro-electric power plant and sub-station.

The steam power plant and pumping system, together with the sub-station of the hydro-electric plant are included in the one building, and located near the eastern limits of the city, while the generating station of the hydro-electric plant is located on the Barriere River, which flows into the North Thompson, the distance of this plant from Kamloops being about forty miles almost due north.

To properly appreciate the relation of these systems one to the other and their importance in the general scheme upon which the plans of development were based, it is necessary to refer to some of the economic conditions affecting the growth of the city and the development of the surrounding districts.

The city of Kamloops is located on the main line of the Canadian Pacific Railway at the junction of the North and South Thompson Rivers, and for some years it has maintained the normal growth of a railway divisional point, and centre of a considerable ranching district. Very little attention has been paid to mixed farming in this district, due partly to the fact that most of the settlers were cattle ranchers, and also to the limited supply of water available from the streams for gravity irrigation systems.

When the richness of the lands in the "Dry Belt" had been more thoroughly appreciated, greater efforts were then made towards intensive cultivation, and many of the lands were divided into small areas for fruit trees, but as the precipitation on the district varies from ten to fifteen inches per year, the dependence upon limited sources for gravity irrigation systems, imparted a certain feeling of timidity with respect to the planting of crops and intensive farming. Consequently Kamloops has been obliged to import butter, eggs and other farming products which should have been supplied locally.

This condition would tend to affect the cost of living and the discouragement of much desired local industries, but when the plans of the Canadian Northern Railway included a route from Vancouver to Edmonton by way of Kamloops and the North Thompson River, the location of the city as a centre of some importance for future growth was more fully realized. Therefore, when the increasing demand for power, both for the municipal electric light and power service and for the pumping plant, was rapidly passing beyond the capacity of the old steam plant, it was decided to investigate the possibilities for an ample supply of cheaper power, with particular regard to hydro-electric development, in order that, if possible, electric power might be available to irrigate by pumping, the rich lands along the North and South Thompson Rivers.

During the course of examination of the several streams available for power within practical range of the city, there appeared to be some prospect that a company holding the power rights on the Adams River might de-

*From a paper read before the Vancouver Branch of the Canadian Society of Civil Engineers.

velop power from this source, in which case the lands along the South Thompson River would be looked after.

Attention was directed, therefore, mainly to an examination of the streams flowing into the North Thompson River, and of these the Barriere River appeared to answer the requirements for power development most satisfactorily, especially in view of the two large lakes available for storage, the heavy grade of the stream and the convenience of the transmission line passing down the valley of the North Thompson through comparatively open country with a prospect of a power market along the entire route.

It was estimated, however, that winter conditions of the Barriere River would affect the operation of the hydro-electric plant for probably an average of six weeks per year, and in view of the importance of the prospective power loads it was considered advisable to plan the auxiliary steam plant system with a capacity equal to the hydro-electric plant, and to estimate the period of operation of the steam plant both as an auxiliary and reserve system for an average of six hours per day throughout the year, and the estimated cost of the combined system was, therefore, based on this condition.

The capacity of the old plant was about 500 h.p. and included three 150-h.p. return tubular boilers, two tandem compound steam engines, one belt-connected and the other direct connected to generators, and for the waterworks service there were two steam-driven plunger pumps, one with capacity of 1,000 gallons per minute and the other 700 gallons per minute. Both pumps, however, were in poor condition and were continually breaking down.

Moreover, it was impossible to keep a reserve supply of water in the reservoir for fire protection, as the capacity of this reservoir was only 150,000 gallons, and during the summer months the demand for water in the city exceeded ten times this amount.

The water for the city system was pumped in from a well located under the power house which was fed by two intake pipe lines carried out into the river about 100 feet, and the rapid growth of the city along the river above the location of the intake created a danger to the sanitary conditions of the water supply which required immediate attention.

After some study of these different factors affecting the immediate and future requirements, the city finally decided to proceed upon the following scheme of construction:—

(*a*) The development of a hydro-electric power plant on the Barriere River with a capacity of at least 5,000 h.p., of which the first installation would provide for 2,000 h.p.

(*b*) The construction of a new steam plant and pumping station in the city, the steam plant to provide for either oil or coal fuel, and to have the first installation up to 2,000 h.p. capacity. The pumping plant to include two motor-driven centrifugal pumps to deliver 1,200 Imperial gallons per minute each, and one steam turbine pump of equal capacity.

(*c*) The construction of a covered concrete reservoir of 1,500,000-gallon capacity but designed for an extension to 3,000,000 gallons by the construction of a second section.

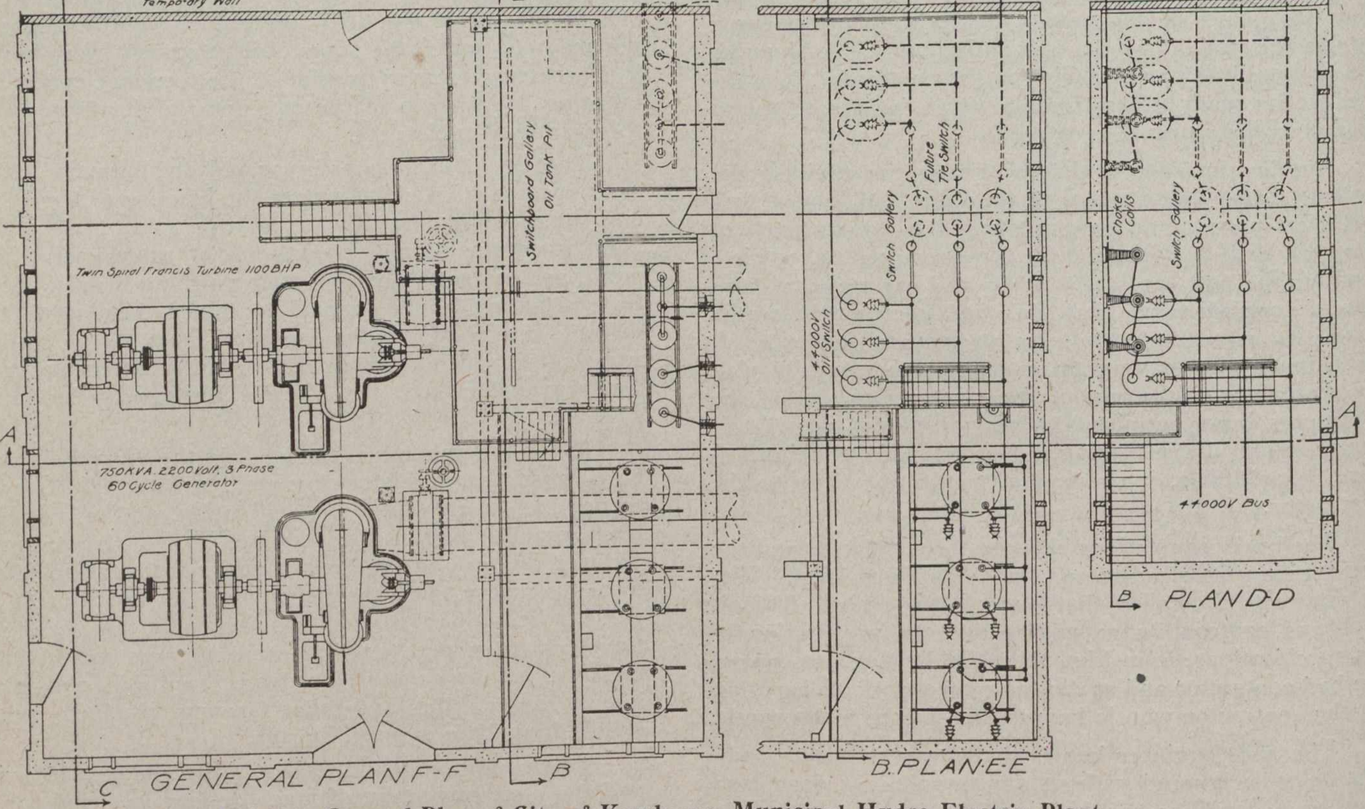

Fig. 1.—General Plan of City of Kamloops Municipal Hydro-Electric Plant.

Barriere Hydro-Electric Power System, Barriere River.—The Barriere River rises in the mountains near Adams Lake, flows in a westerly direction for a course of about thirty-two miles and empties into the North Thompson River at a point about forty miles north of Kamloops.

On the main branch there is the North Barriere Lake, which is located about nineteen miles from the mouth of the river and receives the flow of numerous streams from the mountains. It has an elevation of over 2,100 feet above sea level, and an area at low water of 1,200 acres with excellent conditions for storage of 30,000 acre-feet of water by the construction of a dam at the outlet.

At the distance of eight miles from the outlet of the North Lake the main branch is joined by the east branch, which empties from the East Barriere Lake, located about four miles from the forks and having almost the same elevation above sea level and an area of about 1,500 acres.

The total drainage area of the Barriere River is about 230 square miles, with an average precipitation of probably about 35 inches. The mean flow during a normal year would be about 550 cubic feet per second with extremes of about 3,600 cubic feet per second as a maximum in the early summer period, and 220 cubic feet per second in the low-water season of the winter months.

Of the total flow, about 80 per cent. comes from the North Barriere Lake, and with the provision of storage for 30,000 acre-feet in the East Lake, there should be no difficulty in maintaining a flow of from 300 to 350 cubic feet per second for power development.

Power Development.—As the elevation of the North Lake is about 2,100 feet above sea level and the elevation at the outlet of the river is about 1,150 feet, there is therefore an average grade of about 50 feet per mile. The plan of power development provided for the location of a generating plant at a point about five miles up from the mouth of the river.

For a distance of about 3½ miles above the site of the generating station the grade of the river averages 65 feet per mile, and a suitable site for an intake dam was located to give an effective head of 192 feet at the generating station by 17,800 feet of flume system.

While the plans provide for the ultimate development of 5,000 h.p. from the present intake, the first installation provides for 2,000 h.p. by two 1,000-h.p. units, which, with the installation of 2,000 h.p. in the auxiliary steam plant, would give the city a maximum of 4,000 h.p. to start with.

The location of the generating station of the Barriere hydro-electric plant was made, however, with the view to the abandonment of the present intake when the demand for power exceeds the economical maximum capacity of the combined Barriere and steam plant systems as developed, and the development of from 15,000 h.p. to 20,000 h.p. by constructing about ten miles of conduit system direct from the North Lake to the generating station to obtain an effective head of 600 feet.

Flume System.—The construction of the flume system, including the intake dam, forebay, and wasteways, was started in February, 1912, the work having been let in one contract, to William Greenlees, of Vancouver.

It was planned to have the entire hydro-electric plant completed, if possible, by the end of the year, and it was therefore important to complete the construction of the intake before the high-water flow of the river in May or June.

A mill was located near the site of the dam and the lumber required for both the dam and the flume was obtained from the timber limits close by the mill, some of the logs being brought down the river and others from the hillside above.

Intake.—The intake dam is a standard rock fill crib type set with a pile foundation to ensure greater stability. The site chosen enabled a suitable intake to be obtained by raising the level of the water ten feet from the normal level of the stream to the crest of the spillway, the grade of the river above this point being such that the flood level extended about 1,600 feet up stream.

The accompanying plan shows the general details of construction, from which it may be noted that the length of the crest is 240 feet, the spillway 110 feet and of sufficient depth to take care of a maximum flow of 7,000 cubic feet per second.

The intake for the flume is located on the north side, and a logway and a fishway are placed on the other side of the spillway, the logway being 12 feet wide and the fishway built in accordance with the requirements of the Provincial Government.

The beds of the stream at the site chosen consisted of a top layer of boulders, underlaid with alternate layers of quicksand and blue clay, but a satisfactory degree of watertightness was secured by carrying the toe sheeting down to a depth of 12 feet, with the filling of mastic and puddled clay, an earth fill being made over this and carried to a height near the spillway by an easy slope.

The foot of the spillway was carried well down stream on piling, to take care of logs and roots which might get past the boom above the dam. The work was completed without difficulty by the middle of April, and passed satisfactorily the severe test of the high-water flow of the following months.

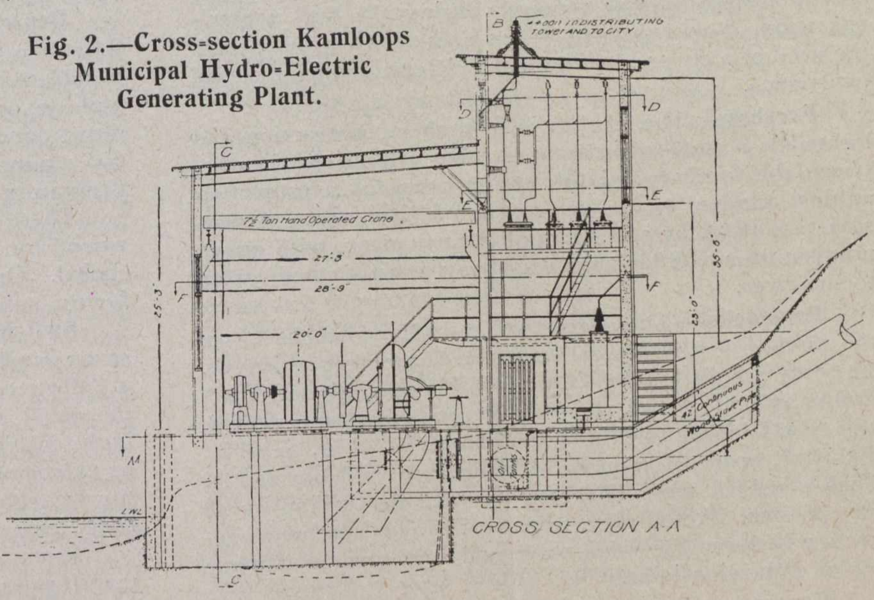

Fig. 2.—Cross-section Kamloops Municipal Hydro-Electric Generating Plant.

Flume.—The flume is designed for an ultimate capacity of 320 cubic feet per second and is 3.4 miles in length from the intake to the forebay. In design it is the standard type of timber flume, 8 ft. wide by 5½ ft. high, built up of 2 x 10-in. fir lumber, supported every four feet, and resting on trestle or cedar sills.

The quality of the lumber available was good, but a better quality of coast fir was used for battens and flooring at those sections where watertightness was especially desirable. Probably the only section which required special attention in this respect was a length of about 1,000 feet, two miles from the intake, where the flume was carried past a steep bank at a horseshoe bend of the river. There appeared some danger of a slide occurring at this section, either from undercutting of the banks of the river or from water running down from the melting snow or leakage of the flume.

It was desirable, however, to continue the flume, if possible, along this section, in view of the necessity of getting timber down from the mill for the construction of the system, and to avoid the heavier expense of carrying a syphon across the river, the cost per foot of the syphon being about four times the cost of the flume for an equal capacity.

The flume system, including wasteways and forebay for penstocks, were completed in the fall, and unfortunately the city was then obliged to shut down on all work on the hydro-electric plant on account of the failure to sell the balance of the hydro-electric bonds due to the financial stringency.

The system as completed was tested out, however, and found to be in satisfactory condition for service, but when the completion of the plant was carried out, two years later, it was found necessary to build the syphon at the section above referred to, on account of a slide occurring which carried away about six hundred feet of the flume. This syphon is built with capacity for half the ultimate capacity of the system. It is wood-stave pipe construction, 66 inches in diameter, 2,100 feet long and designed for varying head to a maximum of 120 feet.

The advisability of covering the flume as a protection against snow was considered, but as the design provided for a velocity varying from 6½ to 7½ feet per second, and careful inspection was required during the first winter's operation, it was decided to leave the system open until the need of a cover could be better determined from actual experience.

Forebay.—The forebay is of timber construction and located in a small depression, so that a hogsback lies between the forebay and the power house as a protection against accident to the water system. Its general dimensions are 18 ft. by 36 ft. long and 12 ft. deep, with ample provision for overflow to a wasteway down a small ravine to the river.

Penstocks.—There are two 42-inch penstocks from the forebay to the power house, each 490 feet in length. They were built by the Vancouver Wood Pipe and Tank Company and are of wood-stave pipe construction with staves 2½ inches thick and steel bands of ½ in. to ¾ in. diameter, spaced for pressure head from 30 ft. to 210 ft. Each penstock was connected up with its turbine by 28 feet of steel riveted pipe, anchored in concrete and connection between the wood-stave and steel pipes was made by an expansion joint.

Generating Station Building.—As already noted, the location of the generating station was governed not only by the plans for the present development, which can be brought up to at least 5,000 h.p., but the prospect of a future development of from 15,000 h.p. to 20,000 h.p. by a conduit system direct from the North Barriere Lake was also considered.

At the site chosen, the sub-surface conditions of alternate layers of gravel, quicksand and blue clay, required that the entire foundations of the building should rest on piles, and these were driven to an average depth of about 30 feet to secure a firm support.

The entire structure was built of reinforced concrete, the details for the tailrace and supporting walls, and beams for the units requiring considerable form work. The sand and gravel for the concrete was obtained close by the plant, and there were no unusual features of construction worthy of special mention.

The accompanying plan and elevation of the building show the general arrangement and some details of construction. The building as completed is intended to form half of the final structure, the construction of the other half will be carried out when other units are required.

The present dimensions are 45 ft. by 48 ft., making the structure, when extended, 45 ft. by 96 ft. It will be noted, on referring to the plans, that the arrangement for the installation of the equipment is fairly compact, although the high-tension equipment is well separated from the other section. The construction of the generating station was carried out by Wm. Greenlees, of Vancouver.

Turbines.—There are installed two horizontal turbine units of 1,100 h.p. each, manufactured by the Platt Iron Works, of Dayton, Ohio, and installed by the C. C. Moore Company. They are the single discharge, inward flow type, mounted in scroll casings divided horizontally, and were designed to operate for 190 feet head at 600 r.p.m.

The runners are of bronze, 28-in. diameter, with a pump-head speed of 66 per cent. of the spouting velocity. The installation of each unit included a cast steel flywheel 5 ft. 6 ins. diameter, a 42-in. butterfly valve hand-operated, and a 10,000 foot-pound direct connected oil pressure type Lombard governor.

The guaranteed efficiency of the turbines was 81 per cent. at full load and 84 per cent. at 80 per cent. full load; regulation 2 per cent. with 250 h.p. thrown off to 10 per cent. by 800 h.p. off, and 20 per cent. by 1,100 h.p. off, under two-second movement of governor.

Generators.—The generators were supplied by the Canadian Westinghouse Company. They are direct connected to the turbines and are designed for 750 kw. at 3-phase, 60-cycle, 2,200 volts. On the same bed plate and direct connected to each generator is a 40-kw., 125-volt, 600 r.p.m. exciter, each exciter capable of exciting both generators when necessary.

There were two banks at three 500 kv.a. transformers wound for 2,200 to 44,000 volts, oil-insulated and water-cooled. One bank for the generating station and the other for the sub-station at Kamloops.

Switchboard.—The switchboard includes at present seven panels of natural black slate. They are mounted on a gallery commanding a full view of the units and have the usual standard switchboard equipment for low and high-tension control. The panels are placed with a view to extension, so that on final completion of the building the switchboard will consist of about twelve panels centrally located.

From the switchboard to the low-tension delta at the transformers 500,000 cm. varnished cambric, lead-covered three-conductor cable in conduit, was used, and 300,000 cm. lead-covered three-conductor, 3,000-volt cable, from the generator to the switchboard. The transformers and switchboard equipment, including lightning arresters, was supplied by the Canadian General Electric Company.

Transportation.—All of the power plant equipment was brought from Kamloops to the Barriere by the C.N.P. Railway, and was hauled in to the plant over a government road a distance of about five miles.

Transmission Line.—The length of the transmission line from the Barriere generating station to the sub-station at Kamloops is 43 miles, and with the exception of two stretches of about eight miles each, the line passes through a comparatively open country parallel to the C.N.P. Railway line with overhead crossings.

It follows as much as possible on the river side of the railway to avoid future crossings when supplying power for irrigation. The poles are of cedar, varying in length from 40 to 50 feet generally, and are fitted with wooden cross-arms designed with the view to a two-circuit line at some future time. These poles were obtained near the line of the C.N.P. Railway, about thirty miles north of the Barriere.

[Note—For description of Kamloops steam turbine stand-by plant, see *The Canadian Engineer*, November 5th, 1914, issue.—Editor.]

LETTER TO THE EDITOR.

The Fetish of Overhead Power Transmission.

Sir,—Why is it that with the constant recurrence of interruptions to their systems, almost mainly due to the adoption of overhead wires, underground cables have not come in for their share of consideration?

With every puff of wind that springs up, heavy surging sets in on the system and very often dislocates one or other of the sub-stations, be it important or otherwise. During the gale which blew on or about the 12th of last month in Toronto and district the writer was informed there were no less than 18 interruptions in 24 hours upon the hydro-electric system of this city, some of quite a lengthy period from a business point of view.

Such a state of things would not be tolerated by any well-managed large industrial concern, where there were a number of employees at work, as these interruptions would upset factory routine and discipline. Now the overhead system has been fairly tried out, and it certainly seems to be found wanting.

There are obviously only two ways to secure continuity of supply—one by having a standby plant at the termination of the main trunk cables. I believe such has been or is being contemplated by the hydro-electric commission, whilst the Toronto Electric Light Co. already have such a plant. It is, however, very questionable whether a scheme of this nature be profitable, for when one considers the enormous capital sunk, and the large standby losses entailed, it would seem to be doomed to failure.

The second method, and one which, I think, merits serious consideration, is by the adoption of underground cables. It may be asked, "Are these any more reliable than overhead wires?" For answer one has only to refer to European practice, where there are thousands of miles of paper insulated cables laid, some working under the most adverse conditions, yet in the large cities, where the laying of the cables has received proper attention, a failure is almost unheard of, and where they have arisen, it has been due to faulty connections, of which a great number naturally must exist in city distribution. There should be none of these on trunk feeder mains, and when once properly laid they should form the strongest link in the chain between the water-wheels and the consumer. It is true that the voltages in use in Europe on these underground cables certainly have not reached the pressures in vogue in this country on overhead systems, but owing to the distances of transmission being much shorter, no demand has arisen for cables to withstand these very high potentials.

The writer, therefore, believes it is now time the cablemakers got busy and showed what they are capable of doing in this direction. This is essentially a country of paper, and as this when suitably impregnated has been found one of the cheapest and at the same time best dielectrics for cables, there is no reason why they could not be constructed to withstand the high voltages now in daily use. The principal factor, therefore, from the cablemakers' point of view, would appear to be one of "cost of cable, plus cost of laying."

Now, if the cost of concrete foundations, steel structure, porcelain insulators, etc., of the present system of overhead constructions be added to that of equipping a modern, up-to-date power station at terminal point, and if the cost of maintenance, together with the running expenses of the power station, be capitalized and also added, I believe it would be found to give a figure so high as to enable the underground cable to compete. Most of the cablemakers' work would be done in factories and by automatic machinery, so that there would only be the necessary trenching and filling to be done on site, and with modern trench excavators this could be done both quickly and cheaply. I trust that the cablemakers will go fully into the matter, and see what they can do.

HARRY F. CLAYTON.

Toronto, June 9th, 1916.

ORDINANCES TO CONTROL THE USE OF SEWERS.*

SECTION 1240 General Code of Ohio requires that plans for proposed sewerage systems shall be submitted to and receive the approval of the State Board of Health prior to their installation. In passing upon such plans it has been the practice of the State Board of Health to attach a condition of approval requiring the council of the municipality to pass a suitable ordinance defining the proper use of sewers for the purpose of preventing the installation of improper connections and misuse of the sewers.

In many communities storm water sewers are installed in advance of sanitary sewers and quite frequently the storm sewers are misused to receive sewage. This results in nuisances caused by odors emanating from the sewers and by objectionable conditions at the outlets. Storm water sewers are not designed to serve for sanitary purposes and municipal councils should adopt a suitable ordinance to prevent such misuse.

Sanitary sewers are frequently misused to receive rain water from the surface or from cistern overflows and downspouts. Such sewers are designed for conveying sewage only and the addition of surface water results disastrously in overtaxing the sewers. The excessive flow is also detrimental to sewage treatment works as it exceeds the capacity for which such works have been designed. To secure the greatest benefits from sanitary sewers, care should be exercised by those officials in charge of the maintenance of such improvements to require the proper use of the same.

The appended ordinances properly control the use of sewers and the establishment of connections thereto. In any individual case the ordinance to be adopted may require some modification to meet local conditions, but in the principal features relating to the classes of wastes which may be discharged into sanitary and storm water sewers, the ordinances should not be modified. The State Department of Health will upon request furnish advice in individual cases.

An Ordinance. No. ....

Mr. ....

TO REGULATE THE USE OF STORM WATER SEWERS.

Be it ordained by the council of the village of ...., State of Ohio.

Section 1. That before any connection can be made to any storm water sewer constructed in whole or in part by the village of .... a permit shall be secured by the person or persons by whom the connection is to be made. Application for permits shall be filed with and permits shall be issued by the village clerk.

*Ohio Public Health Journal.

Section 2. Sewage, including wastes from water closets, sinks, bath tubs and laundries, industrial wastes and other wastes objectionable because of appearance, odor or composition, shall in no case be discharged into storm water sewers. Cellar floor drains shall not be connected to storm water sewers. Cesspools or privy vaults shall not discharge into or be connected to a storm water sewer.

Section 3. Surface water, rain water from roofs, subsoil drainage, cistern overflows, clean water from condensers, and any other clean and unobjectionable waste water shall be discharged into storm water sewers.

Section 4. The village clerk shall inquire into and ascertain the purpose of all connections for which permits are requested and the permit issued shall definitely state the permissible use of the connection in accordance with Sections 2 and 3 of this ordinance.

Section 5. All connections in violation of this ordinance shall be abandoned and removed within two months after this ordinance takes effect.

Section 6. Whoever violates any provision of this ordinance shall be fined not less than five or more than fifty dollars and shall pay the costs of prosecution; and any person who shall make an illegal connection to a storm water sewer shall, if ordered by the health officer, remove such connection and if this is not done within five days, the health officer shall cause such connection to be removed and the expense thereby incurred shall be paid by the offending person. In default of such payment for a period of thirty days the said expense shall be certified to the county auditor to be assessed against the property for which the connection was made.

Section 7. All ordinances or parts of ordinances in conflict or inconsistent with the provisions of this ordinance are hereby repealed.

Section 8. This ordinance shall take effect and be in force at the earliest time allowed by law.

Passed .... 19.....

Signed ....
Mayor.

....
Clerk of Council.

An Ordinance. No. ....

Mr. ....

To regulate the use of sanitary and storm water sewers, to provide for the operation and maintenance of sewers, pumping station and sewage treatment works and to provide for the appointment of a superintendent of sewers and sewage treatment works.

Be it ordained by the council of the village of ...., State of Ohio.

Section 1. That before any house sewer can be constructed, or any connection can be made to any sanitary sewer or any storm water sewer constructed in whole or in part by the village of ...., permit shall be secured by the person or persons by whom the sewer is to be constructed, or the connection is to be made. Application for permits shall be filed with and permits shall be issued by the superintendent of sewers hereinafter provided for.

Section 2. A connection to a sanitary sewer or a storm water sewer shall not be made except by licensed plumber or a licensed sewer tapper and no such connection or the trench in which the drain is laid shall be covered or filled until the work has been inspected by the superintendent of sewers.

Section 3. The issuing of permits shall be governed by the following rules:

Sewage, including wastes from water closets, sinks, bath tubs, laundries, and other objectionable wastes shall be discharged into sanitary sewers and in no case into storm water sewers.

Cellar floor drainage shall be discharged into sanitary sewers.

Industrial wastes shall not be discharged into a storm water sewer but may be discharged into a sanitary sewer if the waste is of such character as not to be detrimental to the sewers or to the sewage treatment works. Where such wastes are detrimental to the sewers or sewage treatment works they shall be otherwise disposed of in a satisfactory manner or so improved in character as not to be detrimental to the sewer system or sewage treatment works.

Surface water, rain water from roofs, subsoil drainage, cistern overflows, clean water from condensers, and any other clean and unobjectionable waste water shall be discharged into storm water sewers and in no case into sanitary sewers.

Connections with cesspools or privy vaults shall not be made into sanitary or storm water sewers.

Section 4. All connections in violation of this ordinance shall be abandoned and removed within two months after the completion of the sanitary and storm water sewer system and sewage treatment works.

Section 5. The sewage pumping station and the sewage treatment works shall, from and after completion, be maintained and operated in a satisfactory manner at all times.

Section 6. Prior to the completion of the sewer system and sewage treatment works and before any connections to the sewers are permitted the mayor shall appoint a competent person as superintendent of sewers. The superintendent so appointed shall be charged with the care, maintenance and operation of the entire sewer system, the sewage pumping station and sewage treatment works. He shall issue the permits and make the inspections heretofore provided for and shall perform such duties in relation and pertaining to the provisions of this ordinance as council may direct. He shall give bond in the sum of five hundred dollars, with sureties approved by the mayor for the proper performance of the duties of his office. The superintendent of sewers shall receive a compensation of .... dollars per annum payable from the .... fund.

Section 7. Whoever violates any provision of this ordinance shall be fined not less than five or more than fifty dollars and shall pay the costs of prosecution and any person who shall make an illegal connection to a sewer shall, if ordered by the superintendent of sewers, remove such connection and if this is not done within five days the superintendent shall cause such connection to be removed and the expense thereby incurred shall be paid by the offending person and in default of such payment for a period of thirty days the said expense shall be certified to the county auditor to be assessed against the property for which the connection was made.

Section 8. This ordinance shall take effect and be in force from and after the earliest time allowed by law.

Passed by Council ....

Signed ....
Mayor.

Attest ....
Village Clerk.

Editorial

NON SIBI, SED PATRIAE.

In the last Weekly Bulletin issued by the Department of Trade and Commerce, Sir George E. Foster voices an appeal for the co-operation of various public bodies, including engineering associations, in the practical solution of the problems which will undoubtedly confront us as a people after the war is ended. While it is questionable how soon the war will end, there can be no question as to the wisdom of bringing to bear on this important subject the best intellects that can be found in the country.

Unusual conditions are bound to prevail immediately following the cessation of hostilities, when between fifteen and twenty million men will lay down their arms and flood factory, office and field. In addition, thousands of men who have been strenuously engaged in the production of munitions of war, will be thrown out of employment and will have to look for work in other lines. In view of these facts there is an urgent demand that leaders in all branches of industry, commerce, engineering and finance get together and, in a spirit of service, deal with these problems in a statesmanlike manner.

The engineer, who up to the present has been overmodest so far as his part in the direction of national affairs is concerned, must in the future "find himself" in a far larger degree. By reason of his training and talents he is well able to measure up to what can reasonably be demanded of him in the effort to work out satisfactorily the problems which will follow the war. This war has brought the engineer suddenly to the front—he must stay at the front, even after the war is over. Not only on the firing-line, but in the industrial organization back of the world-struggle the genius of the engineer is seen everywhere.

Surely, in view of the fact that the war has been almost entirely determined by engineering principles, it is not too much to expect that after it is over the engineer should do his part in helping to solve the great reconstruction problems, both abroad and at home.

It is most desirable that the engineering profession should have an important part in the programme outlined in Sir George E. Foster's circular, and it is to be hoped that engineers, individually as well as collectively through the various technical societies to which they may belong, will accept the challenge and contribute their quota,—not for their own personal benefit, but for the good of their country.

UNDERGROUND POWER TRANSMISSION.

On another page of this issue there is a letter from Mr. H. F. Clayton, which he entitles "The Fetish of Overhead Power Transmission."

We assume that Mr. Clayton has in mind the laying of underground cables from Niagara Falls to the various manufacturing centres in Ontario. Theoretically, the idea is good, and Mr. Clayton's letter may stimulate research work in that direction. Practically, however, the suggestion is considerably ahead of the times, and must await the production of a dielectric that will stand up under pressures up to 100,000 volts a.c. before underground construction for high voltages could compete with overhead line construction in either cost or efficiency.

A short length of cable is being operated in Switzerland at 40,000 volts a.c., but with that exception no cable has yet been designed, so far as *The Canadian Engineer* can ascertain, to withstand a working pressure over 33,000 volts a.c.

Several years ago a prominent Canadian hydroelectric engineer considered the possibility of constructing a 44,000-volt, three-phase cable for a comparatively short portion of a transmission system. But, we believe, he could not find a manufacturer who was prepared to submit a price and install the cable under a guarantee.

LETTER TO THE EDITOR.

"Another Water Powers Investigation."

Sir,—I note in your issue of June 1st, an editorial entitled "Another Water Powers Investigation," which, I think, does less than justice to the work of the Commission of Conservation.

In 1910, one of our engineers, Mr. A. V. White, examined all the powers in the province and in Nova Scotia. In New Brunswick, he examined all the powers except on the Restigouche and Upper Miramichi and procured data from other sources respecting the latter.

In Quebec, our hydro-electric engineer, Mr. Leo Denis, examined many powers and procured data respecting others from the engineers of the hydro-electric companies and others.

In Ontario, we utilized the comprehensive reports of the Hydro-Electric Commission and Georgian Bay Canal Survey.

The foregoing were all published in our "Water Powers of Canada," 1911, which also included the available data respecting water powers in Prairie Provinces and British Columbia.

Since 1911, Mr. Denis has examined the rivers to the east of Lake Winnipeg and the Nelson, Hayes, Upper Churchill, Athabaska, Peace and other rivers in Manitoba, Alberta and Saskatchewan. As the Winnipeg and Saskatchewan and their tributaries had already been examined under the direction of Mr. J. B. Challies, he courteously agreed to supply the data re these streams. The foregoing have been incorporated in our report on "Water Powers of the Prairie Provinces," which will be issued to the public at an early date.

In British Columbia, Mr. A. V. White has been engaged in field examinations for three years, and has prepared an exhaustive report, which is now in the hands of our editorial staff. It covers the field in great detail, and, like the two above-mentioned reports, will be authoritative for many years.

JAMES WHITE,
Assistant to Chairman, Commission of Conservation.
Ottawa, Ont., June 2nd, 1916.

PERSONAL.

HENDERSON & TAYLOR were recently appointed municipal engineers at Matsqui, B.C.

DON. E. LESLIE, Sarnia, Ont., has been appointed manager of the Sarnia hydro office.

G. B. RYAN, who has been chairman of the Water Commission at Guelph, Ont., for the past eight years, has resigned

HECTOR SOMERVILLE PHILIPS, A.M.Can.Soc. C.E., of Toronto, has been elected an associate member of the American Society of Civil Engineers.

H. A. BRECKENRIDGE, formerly with the Montreal Locomotive Work, Montreal, has become purchasing agent of the Lima Locomotive Corporation, Lima, Ohio.

ANDREW A. KINGHORN, C.E., Toronto, has been appointed by the Provincial Government to supervise the construction work of the Toronto-Hamilton Highway.

T. C. DUNCAN, E.E., for many years electrical superintendent of the public utilities of the city of Prince Rupert, B.C., has resigned that position to engage in private consulting work in the same city.

R. M. WILSON, chief engineer of the Montreal Light, Heat and Power Company, contributed a paper on "Frazil" at the convention of the National Electric Light Association, recently held at Chicago. P. T. DAVIES, of the power sales department of the same company, was among the Canadian delegates.

SIR WILLIAM PRICE, chairman of the Quebec Harbor Commission, has resigned owing to war obligations. Though not authentic, it is reported that Mr. D. O. L'ESPERANCE will be appointed as Sir William's successor, and that Mr. J. G. SCOTT will represent the English-speaking element on the Commission.

OBITUARY.

Lieut. TRAFFORD JONES, who practised as a civil engineer in and about Toronto for some eight years and enlisted last May with the Canadian Army Service Corps, met his death near Ypres during an aerial battle with German aviators. He was 29 years of age.

Lieut. C. S. D. ROSS, of Calgary, who was recently killed in action at the front, came to Canada from Cheshire, England, and was for some time engaged as civil engineer with the C.P.R. He left with a Calgary engineer battalion early in the war, and had been in the trenches for over a year.

CANADIAN SOCIETY OF CIVIL ENGINEERS, ELECTIONS AND TRANSFERS.

At a meeting of the council of the Canadian Society of Civil Engineers, held on May 23rd, the following elections and transfers took place:—

Members—Francis Blossom, New York City; David Albert Molitor, Toronto.

Associate Members—Hugh Ross Mackenzie, Regina, Sask.; Walter Matheson, Montreal; George Gilbert McEwen, Ottawa.

Juniors—Trevor Eardley-Wilmot, Montreal; Duncan Harold Macdonald, Antigonish, N.S.; John Randall Roberts, Montreal.

Transferred from Associate Member to Member—Samuel Bruce McConnell, North Bay, Ont.

Transferred from Student to Associate Member—Francis Xavier Ahern, Quebec, David Howard Fleming, St. Catharines, Ont.

COMING MEETINGS.

The Western Canada Irrigation Association will hold its convention at Kamloops, B.C., July 25th, 26th and 27th, 1916. The list of speakers already secured for this convention insures a very profitable conference. Among these are the following. Don. H. Bark, chief of the irrigation investigations, Canadian Pacific Railway, Strathmore, Alta.; J. C. Dobson, chairman, Hydro-Electric Co., Kamloops, B.C., who will speak on "The Possibilities of Irrigation by Hydro-Electric in the Thompson Valley"; William Young, comptroller of water rights, British Columbia, Victoria, B.C., on "Irrigation District Acts."

HYDRATED LIME IN CONCRETE PAVEMENTS.

(Continued from page 634.)

The percentage of wear decreased throughout both series with the increase of lime content. Contrary to the results obtained in the other tests, the resistance to wear increases past the points at which the highest values were obtained for tensile strength, compressive strength, and toughness. The increase is, however, not so rapid beyond these points in either series.

Conclusions.—The results of tests described above would indicate a certain marked advantage resulting from the addition of hydrated lime to Portland cement mortars. As well as an increase in the various properties determined there is the additional advantage that the material is more easily handled when the finished surface is developed, trowelling being easier than when the lime is absent.

From a close observation it would appear that there was no decided chemical reaction between the lime and the other contents of the mixture. Apparently the lime acts as a void filler, giving a more dense mixture and increasing the sand carrying capacity of the cement. If a high calcium lime were used there might be a certain limited reaction between it and the silicates of the cement.

From a comparison of the results obtained by other experimenters and those obtained by the writer it would appear that the least percentage of lime that would give the best results will vary with the grading of the fine aggregate.

A study of the accompanying curves will show that the variations in the different properties bear a close relation to each other. This indicates that the material is generally benefited by the addition of the proper proportions of hydrated lime.

The above determinations can only be called of preliminary importance. They indicate the percentage of lime that gives, approximately, the best results. A further series of tests of mortars with lime contents of 6 per cent., 7 per cent. and 8 per cent. for 1:2 mortars, and 14 per cent., 15 per cent., 16 per cent. and 17 per cent. for 1:4 mortars would show within one per cent. where the maximum strengths were developed.