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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Overland Pipe System, Ottawa Waterworks

New Pumping Plant at Lemieux Island Has Normal Rating of 40,000,000 Gallons a Day—Water Carried Overland through Two Lock-Bar Steel Pipes to City's Distributing System—Bridge Built to Carry the Pipes from Lemieux Island to Mainland

By L. McLAREN HUNTER, C.E.
City Engineer's Department, Ottawa

THE scheme for bringing Ottawa's water supply through a system of overland pipes from the Lemieux Island intake to the city, instead of through a tunnel as formerly, was necessitated by the fact that the fire insurance underwriters had placed a very heavy premium rate on risks in the city of Ottawa, and also by the typhoid epidemic which swept Ottawa during 1911. The overland system is free from any possible contamination by sewage, and is a surer supply for fire-fighting purposes, the pipe line being readily accessible, throughout its entire length, both for inspection and for repair in case of accident.

The new intake is in the same location as the old intake, at Lemieux Island. This was found to be the most preferable location, having been tried out for years and found free from ice troubles.

The entrance to the suction tunnel under the pump house at Lemieux Island is protected by a heavy rack. The stop-log checks and screens are located inside the pump house and are operated by a travelling crane. Fig. No. 1 shows plan and Figs. Nos. 2, 3 and 4 show sections of the Lemieux Island pumping station, which contains two high-lift pumping units and provision for extensions as required. The centrifugal pumps now installed are each rated to deliver 20,000,000 Imperial gallons per twenty-four hours, against a total head of 280 ft. These pumps are driven by induction motors of 1,600 horse-power each.

Fig. No. 5 shows pump house nearing completion.

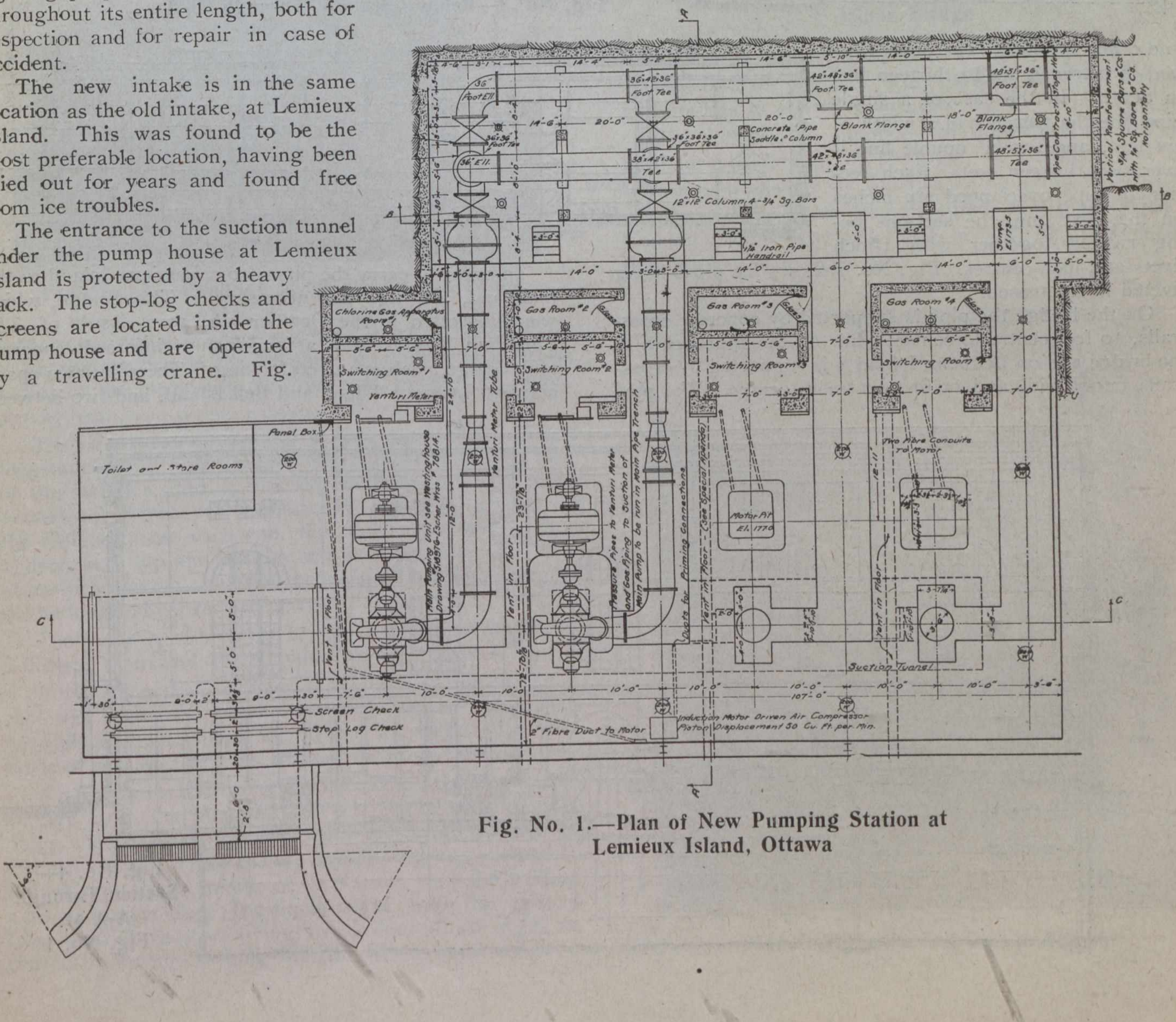


Fig. No. 1.—Plan of New Pumping Station at Lemieux Island, Ottawa

The transformers and heating plant are housed in the sub-station, to meet the requirements of the Canadian Fire Underwriters' Association.

The twin pipe line crossing Lemieux Island Bridge, shown in Fig. No. 6, consists of fifteen thousand lineal feet of steel pipe of the Lock-Bar type, 7/16 inch thick and 51 inches diameter. This pipe was made in 30-ft. lengths, with the exception of bends and other specials. The pipes were laid in a trench six to thirteen feet in depth. In the case of a single pipe line the trench had a width of six feet, and for a double line it averaged thirteen feet. Each section of pipe overlapped six inches on the next one, the sections being riveted together with 1-inch rivets at 3-inch centres. Fig. No. 7 shows the pipes being riveted in the trench.

On the bridge the pipe is supported by concrete cross-walls, 10 feet centre to centre, while on the approaches to the bridge and on Lemieux Island it is supported by cross-walls 1 foot wide and 15 feet centre to centre. The pipe is covered with asphaltum paint and wrapped in burlap. On all the highest points in the pipe line there are 4-inch automatic air valves. Twin 51-inch pipes are laid between Lemieux Island and the intersection of Champagne and Wellington Streets, a distance of 9,247 lin. ft., and a single pipe line from there to Bronson Avenue, a distance of 3,260 lin. ft.

Fig. No. 8 shows the connection between the overland pipe system and the distribution system feeding the city. There are five valves at this point controlling the flow of water.

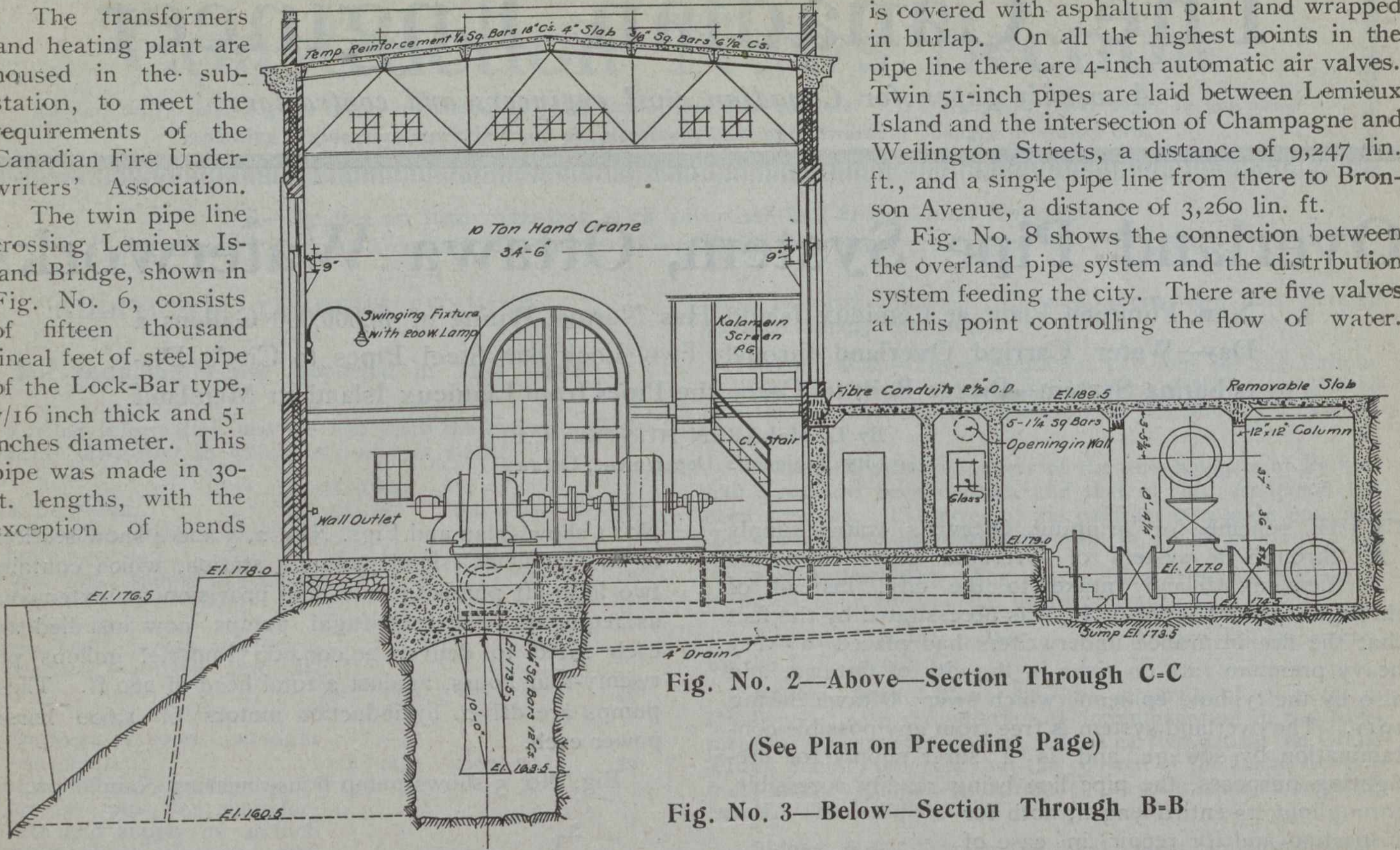
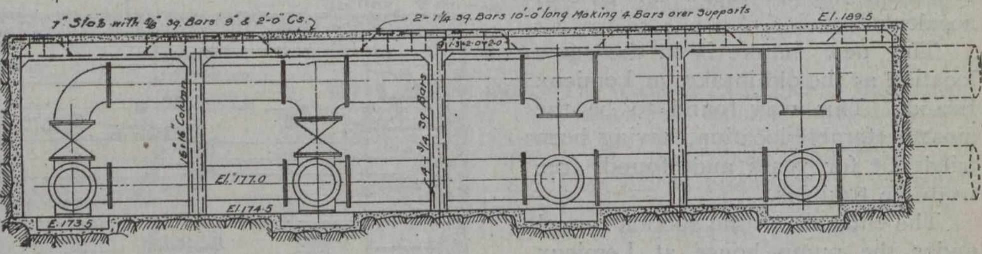


Fig. No. 2—Above—Section Through C-C

(See Plan on Preceding Page)

Fig. No. 3—Below—Section Through B-B



In order to carry the pipes from Lemieux Island to the mainland, a bridge was necessary. This bridge, which was illustrated in the October 4th, 1912, issue of *The Canadian Engineer*, is a four-span reinforced concrete arch bridge, each span 106 ft. long. There are two spans between Lemieux Island and Bell Island, and two between

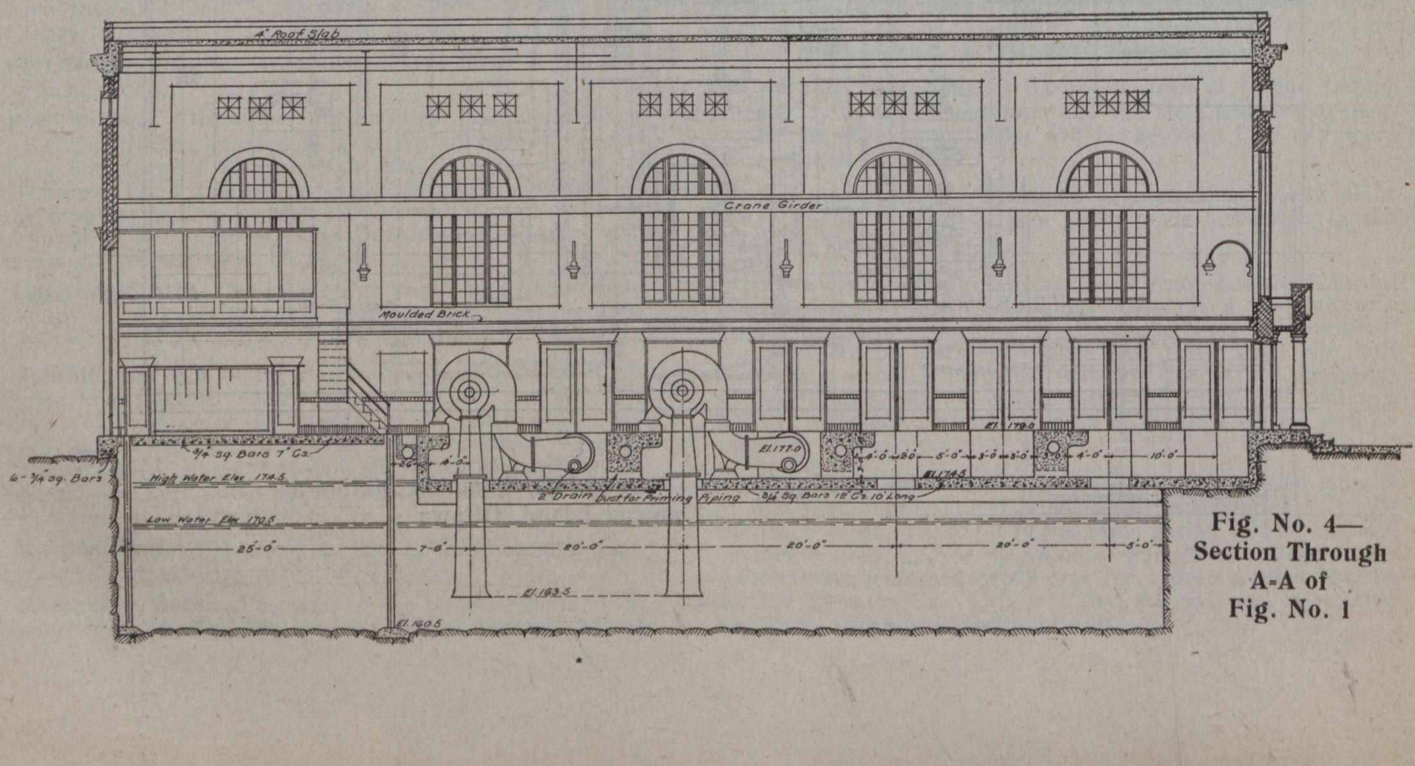


Fig. No. 4—Section Through A-A of Fig. No. 1

Bell Island and the mainland. As Bell Island is at low elevation, the bridge had necessarily to be continued over it. The two piers are each 16 ft. wide, each located in 19 feet of water, on rock bottom. In building these piers, two temporary wooden cribs were loaded with stone and sunk, their upstream ends being connected with framing in the shape of a V. This produced still water within the caisson area and also reduced the span needed to be bridged for carrying the arch centering, as ordinary methods could not be used on account of the impossibility of driving temporary piling. Between these temporary piers and the abutments, two more temporary piers were sunk, one in the centre of each span. This reduced the clear span of 106 feet to two spans of about 40 feet each, allowing for the length of the temporary piers.

The pier caissons were made of 10-in. x 10-in. timber, bound by steel rods. They were sunk into position and sheeted by divers. The concrete for the piers was deposited through still water by means of a 15-inch pipe. This pipe was kept partly filled so that its mouth was always in freshly laid concrete, there being practically no water action.

The arches are of the solid slab type, three feet thick at the crown and five feet thick at the haunches. The

Fig. No. 5.—Pumping Plant at Lemieux Island

arches are circular in shape and have a rise of 12 feet from the springing line to the intrados at the crown. The radius of the intrados is 123 feet and of the extrados, 171.25 feet.

The reinforcing consists of ⅞-inch square bars placed longitudinally at 6-inch centres and 3 inches from the face of the intrados, and ¼-inch square bars placed transversely at 18-inch centres, intrados only, for a third of the distance from each end, the remaining third having ¾-inch bars top and bottom at 6-inch centres. Stirrups at 12-inch centres are used throughout the whole length of the longitudinal reinforcement.

The roadway slab on the bridge is carried by means of a central beam and short column to the transverse wall.

For placing the concrete on all parts of the bridge a cableway system was constructed, the towers of which were placed on Lemieux Island and the mainland, a distance of 700 lin. ft. This worked very satisfactorily.

A septic tank has been constructed to take care of the sewage from the pumping station. It is fitted with a pump which operates automatically when the tank fills to a certain level. From the tank, the sewage is pumped to a flush tank at the middle of the Island, each flush filling a set of porous tile. The liquid soaks into the ground from the tile, thus removing any danger which might be caused by sewage seeping into the intake basin.

Fig. No. 6.—Twin Pipes Laid Across Lemieux Island Bridge

The bridge contract was carried out by Thomas McLaughlin at a cost of $59,500.

The contract for supplying the pipes was carried out by Laurin & Leitch, of Montreal, at $208,800 and the trenching was done by Thomas McLaughlin at $63,514.

The pumps were manufactured by Escher Wyss & Company, of Switzerland, and are of the three-stage, double-suction turbine type.

Fig. No. 7.—Riveting Pipe in Trench

The valves were supplied by the General Supply Co., Ottawa, and the castings by the Victoria Foundry Company, Ottawa.

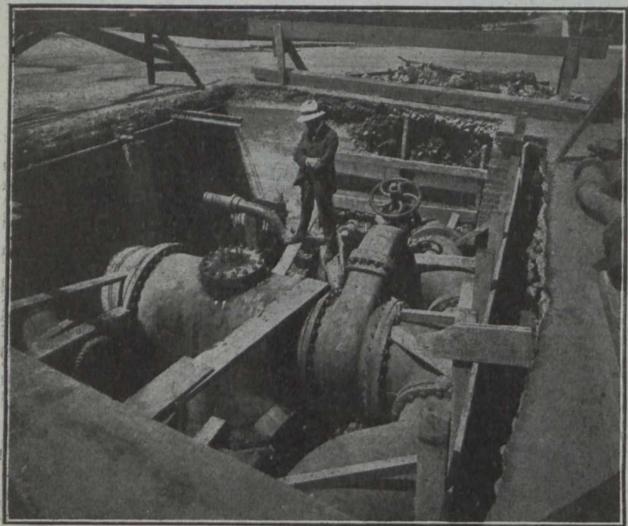


Fig. No. 8.—Junction of Overland Pipe System with City Distribution System. Five Valves are Installed Here

The overland pipe system and its various structures were designed by and constructed under the direction of John B. McRae, B.Sc., consulting engineer, Ottawa, and also latterly under the supervision of A. F. Macallum, B.Sc., commissioner of works, Ottawa.

A.I.E.E. TORONTO SECTION

Major Chas. H. Riches, late of the Canadian Expeditionary Force, will address the Toronto section of the American Institute of Electrical Engineers at 8 o'clock to-morrow evening, Friday, December 21st, at the Engineers' Club, Toronto, on the history and development of patents. Major Riches is a patent attorney-at-law.

MANITOBA BRANCH, CAN. SOC. C.E.

A meeting of the Manitoba Branch of the Canadian Society of Civil Engineers was called for 8.15 p.m. Monday, December 17th, at the Engineering Building of the University of Manitoba, Winnipeg. T. L. Roberts delivered a paper on lignite coal as applied to modern steam plants. Mr. Roberts dealt with the application of lignite coal to high pressure boilers with stoker and hand feeding and forced draft. His paper was well illustrated with drawings and charts.

OTTAWA BRANCH, CAN. SOC. C.E.

Lieut.-Col. C. N. Monsarrat, M.Can.Soc.C.E., chief engineer and chairman of the Quebec Bridge Commission, will address the Ottawa Branch of the Canadian Society of Civil Engineers this evening at the Normal School, Ottawa. on the Quebec Bridge, describing the construction of caissons, piers and superstructure, and the lifting of the central span. His lecture will be illustrated by slides and moving pictures.

NOTES ON THE USES OF CONCRETE

By A. E. Eastman, A.M.Can.Soc.C.E.

MUCH valuable information on the subject of concrete and its uses is being given to the engineering profession in book form, and also in the published reports of experiments and investigations from time to time. In view of this, to make any attempt to bring forward any new or advanced ideas on the subject would be assuming a good deal on the part of one who has not made this subject a particular study, but has only made observations and deductions from what has come under his notice in his work.

It has been remarked that, from an engineer's viewpoint at least, we are living in the "concrete age," and facts seem to bear this out. Many notable engineering works, once laughed at as the dream of some crank, or even worse, but now established facts, were made possible to a great extent by the use of concrete. To mention but a few within the borders of our own Dominion, the new Welland Ship Canal with its immense lock walls; in bridges, the Quebec Bridge, soon to be in use, which while classed as a steel bridge, has upwards of 75,000 cubic yards of concrete in its piers; the C.P.R. bridge at Outlook, Sask., whose piers are concrete monoliths 110 feet high; the huge grain elevators on the Great Lakes ports and elsewhere; in fact to attempt to make a list even approximately complete would require much time and work.

The reasons for the widespread use of concrete are numerous, and will not be discussed here. The old idea that concrete is made by mixing cement, sand and either broken stone or gravel, whichever might be more convenient, with water, hit or miss, any way at all, is fast disappearing, if not entirely gone. Recent experiments have shown the value of grading the sand upon the resulting mixture. "Clean, sharp sand" does not cover the requirements sufficiently to give the best results. The amount of water is also shown to affect the concrete. Former specifications called for the concrete to be "well mixed" or "thoroughly mixed"; now the minimum time for each batch to remain in the mixer after the water is added is commonly given. All these, once considered as minor points, are now shown to be important.

The value of "plums" in a mass of concrete, such as a wall, may be debatable. The writer was with one engineer of considerable experience who would allow no "plums" under any circumstance; while another case came under his observation where the "plums" used were so large as to require a derrick to place them. Here are instances entirely opposite and in both cases the results were entirely satisfactory. Clean, sound "plums" should not diminish the strength of a wall.

In highway and street construction there is no doubt that concrete has at least one place where it will be hard to find a substitute for it, even if one were needed; that is, as a base for the surfacing material, whatever that may be. In fact, in a large proportion of cases concrete itself as a surfacing material is found satisfactory. As a surfacing, however, there are times and places when its disadvantages practically prohibit its use; for instance, on steep grades, as it does not give good foothold for horses, particularly in cold weather. As a material for permanent sidewalks, its use is fast becoming universal.

Mention has been made of the Welland Ship Canal and the use of concrete in the lock walls, etc., and it may be a question whether the same design would have been used had it been necessary to build with masonry instead of concrete. But works of such magnitude as this are not common, and it is in retaining walls, piers, docks and such structures that most engineers are familiar with and interested in.

One of the greatest sources of damage to dock and approach walls to canal locks is from blows from vessels, due either to poor handling by the crews or to winds and currents. Protection must in some way be provided, as concrete walls, even when well reinforced, will not long withstand these blows unless adequate protection is given. The writer knows of one instance where, as a protection, the face of the wall was six inches back from the face of the cribs on which it was built. This did not prove sufficient, as the curved sides of the boats was more than the setback for the same height, and chips were frequently broken from the wall. A 1-foot set back would have been better.

A good waling should be provided above water and also one below would be an advantage. Objection may be made to the difficulty of renewing this waling as it is damaged or worn, as it will be in course of time, often a short time. Fig. 1 is suggested as one way of fastening the waling so as to allow of renewal. Another method of protecting a wall would be a series of rolling wooden fenders loosely suspended over the edge, as shown in Fig. 2. These would often be torn loose but would be easily replaced, and the cost smaller than replacing broken walings.

In the Lachine Canal, part, if not all, of the approach walls to the locks are concrete, and as a protection to the coping of these walls steel plates about three-eighths of an inch thick, about a foot wide and any convenient length are bent longitudinally to fit the arris of the wall and fastened to the wall with bolts with countersunk heads. It apparently answers the end in view. As a further protection to the walls in places, a timber float from four to six feet wide is fastened to the wall. This is not in all places permissible owing to the space taken up.

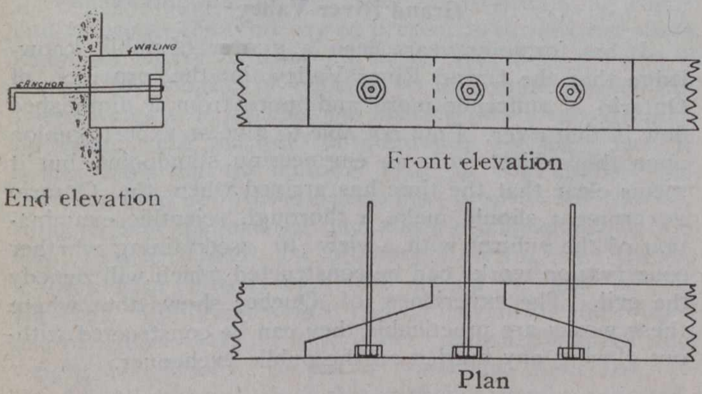


Fig. 1.—Suggested Method of Fastening Waling to a Wall

But the writer has often thought that for such walls as approaches to canal locks or small docks of some kinds, it would be an advantage to have the top foot of the wall a course of good quality cut stone, instead of concrete. The first cost would be somewhat greater than concrete but there would be advantages to offset this. The stone would withstand as heavy, if not heavier, blows than concrete without damage, and if by repeated blows one stone should be damaged enough to need replacing, a new stone of the same size would make the work as good as new, whereas, patched concrete is never as good, either in appearance or strength, as the original wall. Patching concrete is neither easy nor satisfactory.

Another disadvantage to the use of concrete, especially for docks and piers for bridges in our climate, is the effect that ice has upon it. This effect is particularly shown in at least two forms. In many places there is little or no current and the ice once formed remains practically stationary till it thaws in the spring. Here the danger is from the filling of cracks in the concrete with water, the freezing of the water with its resulting expansion, and the slow but sure disintegration of the concrete. Careful

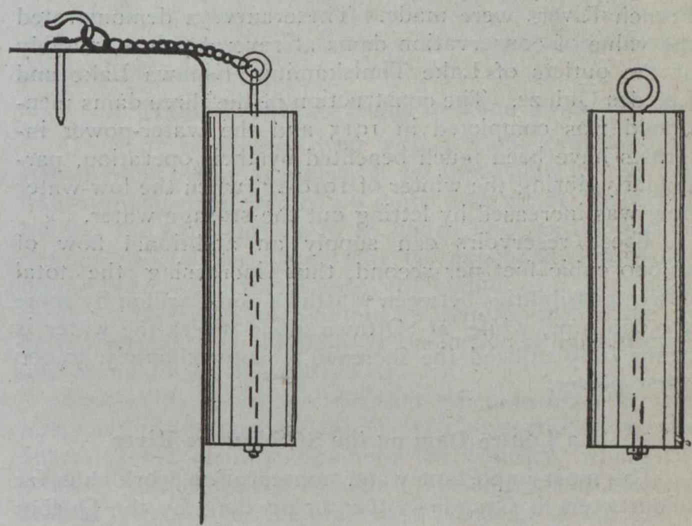


Fig. 2.—Rolling Fender for Wall Protection

construction will, in a large measure, do away with this danger to walls.

But it is in rivers and harbors where there is more or less current that the effect of ice is more marked, in the wearing away of the concrete by rubbing and grinding of the ice cakes. In such cases the best protection is a timber sheathing which is comparatively easy to renew. The writer recalls an instance on a river flowing into the Bay of Fundy where at low tide there was but a foot or so of water in the river, but at high tide upward of thirty feet. Here ice formed in huge masses, and while there was very little movement of ice up or down river, yet the rising and falling with consequent grinding twice a day, wore away masonry bridge piers to such an extent that completely encasing them in timber was the only thing that could be done to save them from complete destruction. Piers of concrete in such circumstances would be no better than—if as good as—the masonry.

While all admit the great advantages and adaptability of concrete, yet it cannot be claimed that its use is a cure-all for every engineering problem. There are many occasions where something else may be substituted to advantage.

One use to which concrete could be put more generally, and to advantage, than at present is in shore protection, or rip-rap to river banks, or where currents are cutting away valuable lands. On the St. Lawrence canals some ten or eleven years ago concrete was laid as rip-rap in place of the usual hand-laid stone. It was partly an experiment and partly to finish a certain piece of work that season. It was a stiff mix of ordinary proportions, laid on a 1½ to 1 slope with an expansion joint every forty feet or so. It is in good condition to-day; in fact the only

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GOVERNMENT WATER CONSERVATION

THE following notes concerning government water conservation are taken from the address of the chairman of the Commission of Conservation, Sir Clifford Sifton, before the recent annual meeting held in Ottawa:—

Ottawa River Storage

Over half a century ago it was urged that the construction of dams on the Upper Ottawa would be of great benefit to power users at the Chaudiere Falls, Ottawa. Between 1904 and 1908, detailed surveys of the proposed Georgian Bay Ship Canal via Ottawa, Mattawa and French Rivers were made. These surveys demonstrated the value of conservation dams at several points, notably at the outlets of Lake Timiskaming, Kipawa Lake and Lac des Quinze. The construction of the three dams mentioned was completed in 1915 and the water-power interests have been much benefited by their operation, particularly during the winter of 1916-17, when the low-water flow was increased by letting out the storage water.

These reservoirs can supply an additional flow of 10,000 cubic feet per second, thus increasing the total power possibilities between Mattawa and Carillon by some 400,000 h.p., while at Ottawa alone where the water is being fully utilized the increase is approximately 30,000 horse-power.

La Loutre Dam on the St. Maurice River

The most important water conservation work thus far undertaken in Canada is that being done by the Quebec government and now nearing completion at La Loutre, on the St. Maurice River. It will store up the waters of the St. Maurice for the benefit of its many water powers and will double the low-water flow.

This work had been projected for many years as the regulation of the river is of the greatest value to the important developed water powers at La Tuque, Grand Mere and Shawinigan Falls, but no construction work was undertaken. After full investigation of the project, both from the physical and financial viewpoint, the Quebec Streams Commission let the contract for construction in the summer of 1915.

The work has progressed steadily since, in spite of the great difficulties in transportation. It is now 80 per cent. completed and will cost about $1,500,000. When finished, it will create a reservoir of 160,000 million cubic feet, forming the third largest artificial reservoir in the world, being exceeded only by the Assouan reservoir on the Nile and the Gatun Lake on the Panama Canal. From the owners of the power sites already developed, the commission will receive a revenue of upwards of $130,000 per annum.

Between the reservoir and the mouth of the St. Maurice there are 17 power sites with heads of from 10 feet to 150 feet. The aggregate descent at these sites totals 800 feet but the dams erected in developing the various sites will increase this total head to 900 feet. Under present conditions, these sites have a total capacity of approximately 350,000 theoretical h.p., but it is estimated that some 900,000 h.p. will be available when the flow is regulated from the reservoir. At Shawinigan, Grand Mere and La Tuque alone, the three sites at present utilized on the St. Maurice, the potentiality will be raised from an aggregate of some 190,000 theoretical horse-power to over 400,000 horse-power.

Another water storage undertaking of the Quebec Streams Commission, now nearing completion, is the St. Francis River dam at the outlet of Lake St. Francis, the lake being used as a reservoir.

St. Francis River Storage

Contracts for the construction of the work were awarded in September, 1915. As the majority of the power sites on the St. Francis are actually developed and as the power owners have suffered from insufficient water for a number of years, this work will afford much-needed relief. It is estimated that revenue from the use of the conserved water will cover all overhead charges and maintenance costs.

By raising the level of the lake 15 feet, the reservoir will have a capacity of 12,200 million cubic feet, and will increase the flow at the outlet from the natural minimum of 100 cubic feet per second to 600 cubic feet per second. The corresponding total power increase on the river will be 21,810 h.p., of which 6,000 h.p. will immediately be absorbed by the present users, while the development of the remaining sites will be greatly facilitated.

Trent River Conservation

An extensive system of small conservation reservoirs has been established in connection with the canalization of the Trent River. These serve the double purpose of supplying the canal system and supplementing the minimum flow in the river for power purposes. There are four hydro-electric plants on this river, supplying the Central Ontario system of the Ontario Hydro-Electric Power Commission and these are benefited by the regulated flow in the river, some of these plants having a capacity as high as 8,000 h.p.

Dams have been built at the outlet of many lakes on tributary streams and the water is stored until required in the dry summer and autumn for navigation and power purposes. The control of the flow is being constantly improved by the further utilization to the fullest extent of the natural storage basins of the Trent Valley.

Grand River Valley

It has for some years been a matter of public knowledge that the Grand River Valley in the province of Ontario is suffering more and more from a diminished flow in that river. I am not able to give an expert opinion upon the subject from an engineering standpoint, but it seems clear that the time has arrived when the Ontario government should make a thorough scientific examination of the subject with a view to ascertaining whether conservation works can be constructed which will remedy the evil. The experience of Quebec shows that where these works are practicable they can be constructed without placing any burden on the public exchequer.

During the few years preceding the war the chemical industry of France made considerable headway, the proportion between imports and exports showing a marked alteration in favor of the home industry. The French chemical industry was particularly wanting in coal-tar products, especially dyestuffs and pharmaceutical preparations, also potash, saltpetre, sulphuric acid, etc. On the other hand, France has always been able to export glycerin, substances for tanning, super-phosphates and soda products. At the commencement of the war there was a shortage of several chemicals particularly wanted for military purposes, such as benzol, phenol, etc., but during the war a number of coal tar products works have been erected, and it is considered quite likely that they will be able to maintain their position after the war.

HARD-SURFACE PAVEMENTS FOR STATE HIGHWAYS*

By Charles J. Bennett
State Highway Commissioner of Connecticut.

IT is the intention of the following discussion to suggest some thoughts on the development of state highway systems for heavy traffic. There is no intention to lay down any fixed rules or to draw any rigid conclusions, because our experience has not extended over a sufficient length of time to determine what is the exact and best solution of the problem of highway surfaces. Nevertheless, it is increasingly evident to all engineers that there are certain needs of traffic which are not generally met by the highway systems constructed at present. The first of these needs is for a road surface which is usable continuously during twelve months of the year for moderately heavy loads, and the second is the need for co-ordinating the design of the road and the design of the vehicle.

Considering the first, heavy loads should be able to use the road continuously, since heavy loads are carried for business purposes and on this account demand uniform service during the entire year. Pleasure traffic which, of course, constitutes the major portion of the traffic using the roads at the present time, adjusts itself to weather conditions and is virtually nothing during extremely cold weather. Motor-truck traffic and business traffic, on the contrary, demand continuous service, and the highway surface and foundation must be designed to give this desired result.

At the present time the highways are used for long-haul freight under abnormal conditions, and our problem is not concerned particularly with these conditions, since it is thought that eventually the highway system will find its proper place in the scheme of transportation and the adjustment between railroad use and highway use will be made so that each will carry its proper share of traffic.

Co-ordinating Roads and Vehicles

Considering the second need, for co-ordinating roads and vehicles—the tendency at present is toward excessive loads on motor trucks. It seems that there must be a limit to the weights of vehicles, so that some relation between weights of vehicles and bearing power of road may be found. For purposes of discussion and argument, it is suggested that the limiting load on four rubber-tired wheels should not exceed 25,000 lbs., properly distributed, so as to limit the load per inch width of rubber tire to 700 lbs. In other words, for ordinary state highway traffic, a truck with capacity of 5 tons should be the largest allowed. Additional weight can be carried by the proper use of rubber-tired trailers under reasonable speed and weight restrictions. Given a reasonable limit for the weight and speed at which these vehicles may be operated, it will be increasingly easy, as experience extends, to design a suitable road surface for traffic needs.

In general, this discussion may be confined to those sections of country which are thickly settled manufacturing communities or to those areas where property values are high, due to concentrated agriculture or development of natural resources. It is evident that in these sections the highway traffic will be greater, yet the land and property will stand a sufficient amount of taxation to justify the expenditure necessary to secure the best highway surface.

*Abstract of article in Engineering News-Record.

With our present knowledge, it is impossible to figure accurately the advantage of one type of road construction over another, since no charge per mile of use is or can be made. The only criterion is the cost of annual maintenance plus the annual capital charge, and in the experience of the writer it has been found that all types of road are virtually in the same financial class, when the annual cost of maintenance plus the annual cost of financing first cost is taken into consideration. Consequently, the only method of determining what is the best type of road surface is the amount of travel and the duration and requirements of service. For this reason, a traffic census, both present and estimated future, is of value as an indication of the possible use of a road. This census should pay particular attention to classifying traffic and should take into consideration also the possible development of industry.

Traffic Census as Guide to Road Type

It occurs often that even with a traffic census, other information being available, it is impossible in the first improvement of a road to do more than grade and drain, leaving the hard surface to be added later as the surface develops and more money may be expended reasonably on the road. For this reason, the budget of a state highway department should contain an item for reconstruction or replacements in addition to the ordinary construction and maintenance appropriations.

Another factor in the selection of pavement is that many highways connect thickly settled sections, yet run beyond these communities into the country, where the property values are not so high. Through traffic between centres forms by far the greatest percentage of the whole, and there is consequently a need of a uniform hard surface for the entire length between centres to meet the traffic needs. In such a section, it should be demonstrated easily that hard pavements are needed, not so much on account of the reduction in annual cost of maintenance, as on account of the need for safe, usable surfaces during the entire year. This makes it necessary, in the opinion of the writer, for the highway engineers to build rural or suburban roads in the same manner and with the same care as in the case of cities. Furthermore, a hard, clean pavement is always a delight to the motorist and certainly reduces the cost of maintenance and operation of the motor car. While the annual charge for capital invested is high, the cost of surface maintenance is low and the general result in service is far ahead of that on the cheaper types of road which under heavy traffic in bad weather become difficult and dangerous to travel. With hard surface pavements, a uniformly good condition of surface may be obtained more easily.

In the selection of road types for state highways there are certain requisites which should be secured:

First: Proper foundation and drainage must be provided. This topic has been discussed exhaustively and can be left with the comment that in the case of hard surface pavements it would seem necessary to provide a foundation of Portland cement concrete or of bituminous concrete, with the preference given to the former on account of the more definite knowledge of the action of the material under certain conditions.

Second: The pavement should be smooth and hard, so as to give easy traction to vehicles passing over it.

Third: The pavement surface should be reasonably safe for operation of rubber-tired vehicles. Consequently, it should have a flat cross slope and be of sufficiently rough texture to give a grip for rubber-tired vehicles. It is safe to say that all hard pavements at present constructed are slippery under certain conditions, and here again is need for co-operation between road engineers and vehicle builders in securing a material for road surface or a material for tire construction which will do away with most of the difficulty which exists. Experience shows that by far the greater number of accidents to motor vehicles are caused during slippery weather by the failure of chains or non-skid devices to control the motion of the car, and, in passing, it may be said that the highway engineers are in duty bound to find a proper road surface, even at some additional cost, that the risk to the public will be reduced materially.

Fourth: The road must be of reasonable cost, which should be determined, not so much by the yearly financial cost of maintenance (although this is a prime requisite) as by a co-ordination between the needs of traffic as best judged by the engineer and the amount of money which can be put reasonably into the construction of the pavement.

In general, the width of these hard surface roads should be sufficient to carry at least two lines of vehicles, say, not less than 18 ft., except through the centres, where there should be extra widths to accommodate necessary standing vehicles used locally. The shoulders or berms should be hard and reasonably safe to travel at moderate speeds when turning out to pass safely. Much has been said of the necessity of increasing widths of road to accommodate four lines of vehicles, but it would seem reasonable that before the expenditure for highway systems are doubled, there should be proper restrictions to the traffic using the road so as to make it unnecessary to spend this extra amount of money. In general, the tendency of automobile traffic has been toward unreasonable speed without regard to the results, but a proper regulation would make a two-line width of road satisfactory for the operation of four thousand vehicles per day, even with the inevitable congestion at certain hours.

An endeavor has been made to prove the need for hard-surface city-type pavements on state highway systems outside of cities, and the chief problem which then comes to the engineer, as indicated above, is the selection of the best type of pavement. There is nothing so difficult at present for the engineer as to select the proper type of pavement even if he is left unhampered by outside influence. Virtually no data are available which would aid in determining mathematically the type of pavement to be chosen. The choice of pavement is generally a local engineering problem which can be worked out at the present time only by the use of judgment, opinion and data from a moderately small amount of experience, since the construction of these highway systems has been carried on only through a comparatively short time. It is evident that even with the best of intentions and the use of proper judgment, mistakes will be made, but the following general ideas would seem to be of value in the selection of type of pavement. These are in addition to the general requirements stated previously.

In the first place, the road surface and material should be chosen so as to give the best service to the traffic using the road, with a reasonable first cost. On this account, so far as possible for Portland cement concrete bases or surfaces or for bituminous foundations or surfaces, the local material should be used for aggregate so long as it gives a suitable result. Other types of surface, such as blocks, either brick, wood or stone, should be selected with a view to using the nearest source of supply, not only on account of the reduction of cost, but because of the need of conserving supplies of material and using everything which is available.

REPORT OF COMMITTEE ON SERVICE PIPES

FOLLOWING is an abstract of the report of the committee appointed by the New England Water Works Association to investigate waterworks service pipes:—

The requisites for a good service pipe are, in order of their importance, (1) that it should not affect the water passing through it in such a manner as to make it injurious to the health of those using the water; (2) that it should not have a deleterious effect on the appearance, taste, or odor of the water even though not injurious to the health; (3) that it should have a sufficient capacity to give adequate service at all times; (4) that it should be strong and durable; (5) that it should be easily laid; (6) that it should be inexpensive.

To meet the first condition, that portion of the service pipe which comes in contact with the water should be of some material which is either not acted upon by the water standing in contact with it, or, if acted upon, produces no compounds which would affect the health of those using the water.

To meet the second condition, the material of which the inside of the service pipe is composed should not be acted upon by the water to produce rust or other substances which may come away with the water; it should not be composed of any material which will disintegrate; it must not be coated with any substance which will impart a taste or odor to the water.

These first two conditions should be considered absolutely essential in any system, for, as Mr. FitzGerald so well expresses it in his discussion, "of what use is it to spend millions and millions on the quality of your water and yet allow services which affect that quality materially?"

To carry a sufficient quantity of water for good service, the pipe should be of suitable size, dependent, to some extent, on the available pressure, and should not become coated on the inside with rust or other material so as to diminish the flow to such an extent as to make the service unsatisfactory. The requirements of the water takers as to the rate of use of water are ever increasing, and these requirements should be met.

Strength and durability should be assured chiefly as a matter of economy. Where services are laid in streets having expensive paving, the digging up of a service pipe is a serious matter. The service should, therefore, be constructed of material that will stand the pressure which may be put upon it, and will not be corroded by the action of the water on the inside or the action of the atmosphere, or of substances which may be contained in the soil on the outside.

It is desirable to have a flexible pipe which may be bent around any obstructions which are likely to be encountered in the street and one which is not liable to break with any settlement which may take place.

The first cost of the service pipe is the last point which should be considered, for it is a very small item as compared with the cost of maintenance and the cost of renewals. In fact, it may be said that the service pipes cost the least to install of any portion of the waterworks system and are capable of giving the greatest amount of trouble.

The service pipe which perfectly meets all of the above conditions has not been put on the market, and after many years' experience waterworks men are not yet agreed as to the materials which most nearly meet them. The committee has, however, secured as much information as possible both from men of practical experience and those who have approached the subject from a scientific standpoint.

Many towns continue to use for service pipes the material which has always been used since the works were installed, although in many cases much trouble has been experienced. There are, however, about one hundred places where changes are reported to have been made for various reasons. A study of these changes and the reasons given therefor is very interesting.

The table below gives the changes which have been made and materials used before and after the change.

Changes Made in Material Used

From	To: Wrought Iron or Steel	Enameled	Galvanized	Lead	Lead Lined	Cement Lined	Totals
Wrought iron or steel	..	..	11	4	3	4	22
Enameled iron	..	..	10	1	1	1	13
Galvanized	..	1	..	7	7	2	17
Lead	..	..	4	..	..	2	6
Lead-lined	1	..	5	..	..	2	8
Cement-lined	..	..	16	6	5	..	27
Totals	1	1	46	18	16	11	93

The disfavor with which plain iron and steel are regarded is shown by the fact that 22 places have changed from those materials to some other, while only one place has reported as having taken up their use. Galvanized pipe, on the other hand, has lost only 17 while gaining 46. Lead and lead-lined pipes have gained 18 and 16 places respectively and lost 6 and 8. Changes to cement-lined pipes have occurred in 11 places, and changes from cement-lined pipes to some other material have occurred in 27 places.

A comparison of the number of places now using the different materials with the number of places where this material has been abandoned shows that 63 per cent. of those formerly using plain iron or steel pipes have changed to some other material. Eight per cent. have changed from galvanized iron; 19 per cent. from lead or lead-lined; and 42 per cent. from cement-lined.

Of those places where changes have been made from galvanized pipe to some other material, 13 are supplied from surface sources, 1 with ground water, and 3 with filtered water. Of the places changing from lead or lead-lined pipe to some other material, 5 are supplied from surface sources, 13 from ground water sources, and 4 from filtered sources. Of the places abandoning cement-lined pipes for other material, 18 are supplied with surface water, 7 with ground water, and 1 with filtered water.

A large proportion of the places where the works have been in operation for a sufficient time report trouble with service pipes no matter what the material used, except in the case of cement-lined pipes. With cement-lined pipes, 54 per cent. of the places reporting report little or no trouble. With galvanized pipe, 36 per cent. of the places report little or no trouble, and with lead pipe 10 per cent. so report.

The trouble with iron and steel pipes, both plain and galvanized, appear to be through the entire length of the pipe. The trouble with lead pipes appears largely at the corporation cock. The trouble with cement-lined pipes is very largely corrosion of the outside of the pipe just inside the cellar walls, with some trouble at the lead gooseneck.

Life of Service Pipe

The data in regard to length of life of a service pipe and the period that elapses before it begins to give trouble are very unsatisfactory. The averages of the figures given in the returns are as follow:

	Years before Trouble Begins	Life of Pipe (Years
Plain iron or steel	12	16
Galvanized	15	20
Lead	10	35
Lead-lined	10	23
Cement-lined	14	28

The main sources of trouble from corrosion are largely inside the pipes, due to the action of the water. In certain soils, however, there is a rapid corrosion of the pipes on the outside, and, if the inside is protected, as in the case of cement-lined pipes, this is the main source of trouble. Pipes laid in salt marsh or in cinder-fill are certain to be acted upon rapidly. Pipes in clay are much more subject to corrosion on the outside than those in sand or gravel. One of the common places where trouble occurs is at the corporation cock, or, where a gooseneck is used, at the junction of the gooseneck with the service pipe. Some of the troubles at the corporation cock are due to the tuberculation of the inside of the main pipe, which tends to cover the end of the corporation cock. This can be overcome in a large measure by inserting the corporation cock well beyond the inside of the main.

The following table gives the location of the principal troubles with different kinds of services as reported to the committee:

Where Trouble Occurs

	Plain Iron or Steel	Galvanized	Lead	Lead Lined	Cement Lined
Throughout entire length	10	49	17	8	2
Couplings and fittings	4	24	7	6	10
Cellar wall	3	8	5	6	13
Corporation or gooseneck	7	20	14	6	14
Curb cock	3	8	6	2	4

Conclusions

Service connections may, and frequently do, give more trouble than any other part of a waterworks system, causing the deterioration of an otherwise good water and constituting an unduly large proportion of the maintenance expense. The preservation of the purity of the water is obviously the most important requisite, and only those materials should be used which will not impair in any way the quality of the water.

The cost of the installation of services is so small in comparison with the total cost of the system, and the expenses for repairs and renewals are so large, that only the most durable materials should be used.

There are very few, if any, places where it is advisable to use uncoated wrought iron or steel in service-pipe construction. The metal will corrode more or less rapidly, according to the character of the water, clogging the pipes, giving trouble in the houses from rusty water, and eventually requiring renewal of the service.

The use of galvanized pipe decreases very materially, in most cases, the troubles experienced from the use of plain wrought iron or steel. With some waters, galvanized pipes will give little or no trouble and will last many years. With other waters, the zinc will be rapidly dissolved and the pipe will then become no better than an uncoated pipe. Better methods of galvanizing will undoubtedly produce better results in service, and the process now being adopted of removing scale from the inside of the pipe before galvanizing gives promise of good results.

Lead pipe is mechanically an almost ideal pipe for services, on account of its flexibility and the ease of laying in streets where are obstructions. With waters which do not attack the lead, this material is almost indestructible unless subjected to the action of electrolysis. The lead does not corrode and the pipe remains smooth and clean. The serious objection to the use of this material is the possibility that it may affect the health of those using the water. It is certain that lead services have been in use in many places for a great number of years without any known serious results, and it is equally certain that in other places where they have been used, very serious results have ensued, involving loss of life and the payment of heavy damages therefor.

Many waters act on lead to produce insoluble carbonates on the inner surface of the pipes.

The action of the water on the lead depends on the character of the water and the addition of a new source of supply, or the filtration of the water may produce conditions entirely different from those which now obtain. One case of this kind is referred to in the discussion.

It seems to be practically impossible to determine in advance by laboratory tests whether or not the use of lead will be safe. The only sure test is one of several years' duration in actual service.

In view of the serious consequences which may result from the use of lead, the committee believes that in new works, at least, it is advisable to use some other material for services. In those places where lead has always been used and it is known that the water does not dissolve the lead, its use may be continued until something occurs to change the character of the water, when the effect of this change should be carefully watched.

Lead-lined iron or steel pipe, like lead pipe, will retain a smooth and clean interior, and, as far as the action of the water is concerned, will last for a long period. It has the merit of being stronger and cheaper than lead pipe. The outside of the pipe is subjected to the action of the soil and of the atmosphere, and, unless protected in some way, will rust out as in the case of other material.

Lead-lined pipe carries with it all the possibilities of danger to health that attend the use of lead pipe.

Cement-lined pipes are the most satisfactory, so far as the action of the water is concerned, of any which are now used for services. The difficulties which arise from the use of this material are solely mechanical. Water has no appreciable action on cement, and the cement lining, if properly constructed, will last for an indefinite time.

The troubles which have occurred appear to be due entirely to imperfect work either in lining the pipes or in making the joints. Unless the outside of the pipe is protected, corrosion will take place, the same as in the case of plain and lead-lined pipe.

The waters which will attack metals most actively are, in general, the soft, clear waters. Ground waters are more apt to attack metals than surface waters, and hot water has more effect than cold. Filtered waters are much more active than unfiltered waters.

Waters which attack one metal will, in general, attack another, and changing from iron pipe which corrodes badly to lead pipe is likely to produce a dangerous condition. The reason why galvanized pipe is more satisfactory than plain pipe is that the action of the water on the zinc is somewhat slower, and the products of the corrosion of zinc are soluble and innocuous, but the zinc will be eaten through in time and the iron will then be open to attack. The more water which passes through the service, the more rapid will be the action on the metal. Stagnant water will have little effect.

Corrosion of the outside of the pipes is a serious matter, especially in the case of lined pipes, where it generally determines the useful life of the pipe. Outside corrosion is especially serious in clayey soils, in salt-water marshes, ashes or cinders, and near stables. The greatest troubles from this cause, however, occur just inside the cellar wall.

For corrosion in the soil, the best remedy is to use a coated pipe, and in many places where cement-lined pipes are used, the pipes are galvanized. Where the pipe passes through the cellar wall, a pipe encased in cement may be installed, or a short length of brass pipe may be used. In some places a coupling is placed just outside the wall, so that a short section can be readily removed and replaced.

With regard to the relative merits of wrought iron and steel, the great majority of users of these pipes testify strongly in favor of the former. It is undoubtedly a fact that the strong preference for wrought iron is confined chiefly to New England, and that steel is used very generally in other sections of the country.

The experience of superintendents indicates that the steel corrodes more rapidly than wrought iron, and some claim that it is much more difficult to work, although it appears from the testimony of many others that there is no difficulty in cutting and threading the steel pipes if proper tools are used, the tools ordinarily used on wrought iron not being suited to use on steel.

The concensus of opinion among waterworks men in New England is that the water department should lay and maintain all services from the main to the stop and waste in the cellar.

Custom varies as to the method of paying for services, but in New England the general custom is for the department to pay for the services from the main to the curbcock or the property line. Outside of New England, in the majority of cases the customer pays practically all of the cost of the service.

Rigid connections with the mains appear to possess many advantages over the use of a gooseneck, and the experience in many places shows that there is no trouble to be expected where the soil is suitable and there is not much digging up of the streets for sewers and conduits.

Lead flange connections appear to be superior to wiped joints.

The committee believes that in many cases the standard size for services can be made one inch to the advantage both of the consumer and the department. The requirements in the modern house are much greater than in the past, and some plumbing fixtures require a larger flow than can be obtained through a ¾-in. pipe of the average length and with ordinary pressure. The use of meters will control the waste which otherwise might be greater with the larger service. In a pipe which tends to fill up with rust, the larger service will last much longer before cleaning is necessary than the smaller pipe.

EVAPORATION FROM WATER SURFACES AND RIVER-BED MATERIALS*

By R. B. Sleight
Assistant Irrigation Engineer, U.S. Office of Public Roads and Rural Engineering.

THE experiments described below were made at the Irrigation Field Laboratory at Denver, Colorado. The work was commenced in 1915 and continued for over one year.

The first series of experiments was to determine the difference in rates of evaporation from tanks of varying diameters. Thin-metal circular tanks were used, set in the ground so that the top of the tank was 3 ins. or less above the ground-surface. Taking the rate of evaporation from a tank 12 ft. diam. as 100, the rates of evaporation from smaller tanks were found to be as follows: 1-ft. tank, 155; 2-ft. tank, 129; 4-ft. tank, 118; 6-ft. tank, 110; 9-ft. tank, 101.

The second series of experiments dealt with the relative evaporation from square and from circular tanks. The rate of evaporation from square tanks was found to be from 103 to 105 per cent. of that from circular tanks of the same area.

Experiments to determine the effect of depth of water in the tanks upon the rate of evaporation showed greater evaporation in summer from shallow tanks than from deep tanks, and that the reverse was the case in the fall. This difference was relatively small for tanks more than 2 ft. deep.

The relative rates of evaporation from still and from flowing water were studied by keeping the water in one tank flowing by means of a centrifugal pump, another tank of still water being kept under conditions that were similar in other respects. After correcting the results for differences of temperature, the rate of evaporation from the flowing water was found to be about 8 per cent. greater than from the still water. The surface-velocity of the flowing water was from 0.52 to 1.25 ft. per second. No definite relation between rate of evaporation and velocity could be established.

Fig. 1 shows the results of the experiments to determine the effect of temperature upon evaporation. Temperatures are given in degrees Fahrenheit. The temperature given is that of the water-surface, and was taken by means of floating thermometers. In this connection temperature readings of the air and the water at different depths are of interest. On a warm day in March, the air-temperature was 69°, while the water-temperature at the surface was 59°, and at a depth of 2.5 ft., 46.5°. On a cold day in May the air-temperature was 45°, but the temperature of the water had increased to 56° at all depths. During the summer in the daytime the water was considerably cooler than the air, while readings in the latter part of September showed an air-temperature of 56° and

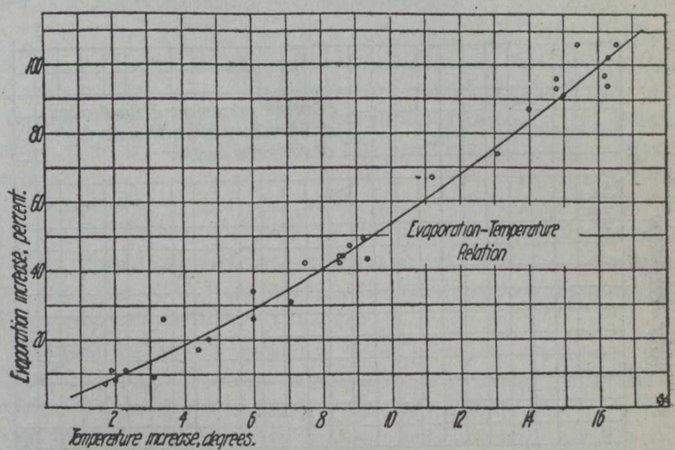

Fig. 1.—Relation Between Temperature and Evaporation

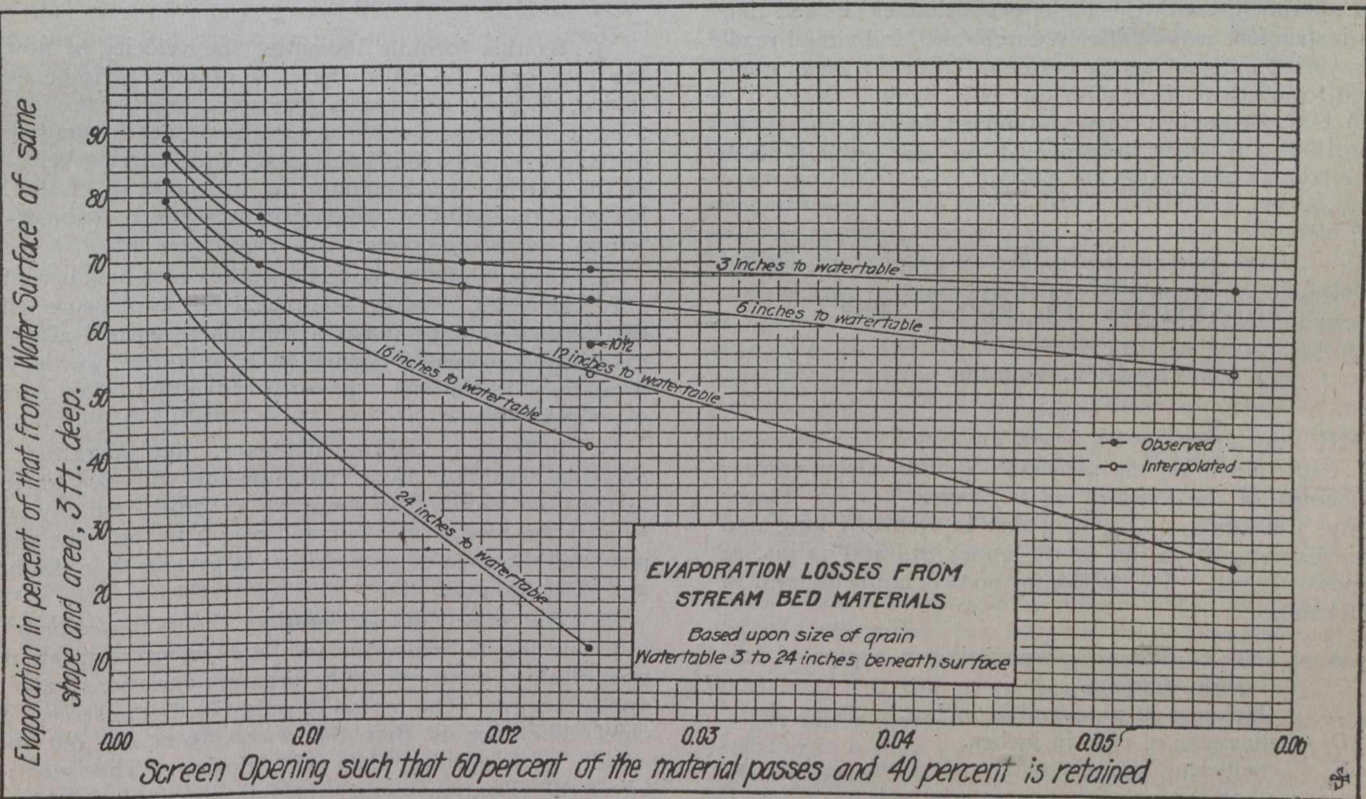

Fig. 2.—Evaporation Losses from Stream Bed Materials

*Abstract from "Journal of Agricultural Research," Vol. X., No. 5, pp. 209-261.

a water-temperature at the surface of 56.5° and at 2.5 ft. of 58°.

Comparisons were made between the U.S. Weather Bureau standard evaporation-pan, which is 4 ft. diam., 10 ins. deep, and is set on a wooden platform resting on a low mound, and the 12-ft. tank set in the ground 2.75 ft., as already described. Readings taken during a period of one year, showed that the rate of evaporation from the

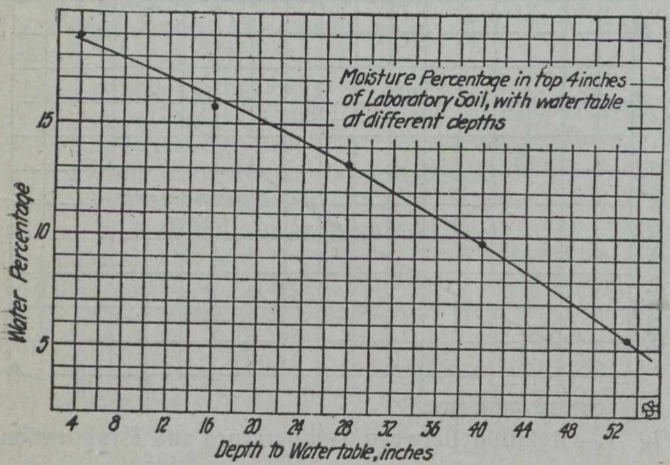

Fig. 3.—Relation Between Depth to Water-Table and Moisture in Top Soil

pan ranged from 131 to 178 per cent. of that from the tank, with an average of 150 per cent.

Experiments with the Piche evaporimeter showed that this instrument was relatively unreliable. Individual readings varied as much as 42 per cent. from the mean computed from comparison with the 12-ft. tank.

A U.S. Geological Survey standard floating-tank, 3 ft. diam. and 3 ft. deep, was placed on an artificial lake

(Concluded on page 522)

PULSATIONS IN PIPE-LINES*

By H. C. Vensano

THE conclusions given below are based on a series of experiments on the penstock at the Drum power house of the Pacific Gas & Electric Co. in Placer county, California. This penstock is 6,282 ft. long and has a diameter of 72 ins. at the upper end and 52 ins. at the power house. The following nomenclature is used in the formulas:

- a = velocity of wave-propagation in a pipe of uniform diameter.
- b = thickness of pipe-wall in inches.
- D = diameter of pipe in inches.
- E = coefficient of elasticity of steel, taken as 30,000,000 lbs. per square inch.
- g = acceleration from gravity in feet per pound.
- h = pressure rise or fall from normal, resulting from pulsations, measured in feet of head at any point.
- K = voluminal modulus of elasticity of water, taken as 294,000 lbs. per square inch.
- L_1, etc. = length, in feet, of sections of pipe of varying diameter, between the point at which the pressure is desired and the reservoir, L being the first section, starting at the point at which the pressure is desired.
- T = time of gate-closure or gate-opening, in seconds.
- V_1, etc. = velocity of flow in feet per second at beginning of gate-motion.
- v_1, etc. = velocity of flow in feet per second at end of gate-motion.
- W = weight of water per cubic foot, taken as 62.4 pounds.

1. The general formula for pressure-variation from normal at any point in a pipe-line, with uniformly varying gate-opening, should be

$$h = \frac{2\,(L_1\,V_1 + L_2\,V_2 + \;.\;.\; L_{x-1}\,V_{x-1} + L_x\,V_x)}{g\,T}$$

This formula applies to a pipe with varying diameter.

2. For slow gate-closure, this formula reduces to

$$h = \frac{2(L_1 V_1 + L_2 V_2 + L_3 V_3 + \text{, etc., for the full length of pipe})}{g\,T}$$

and, further, reduces to

$$h = \frac{2 L_1\,V_1}{g\,T}.$$

for slow gate-closure with a pipe of uniform diameter. The above formulas are limited to a maximum value of

$$h = \frac{a_1\,v_1}{g}$$

3. As this formula indicates, the velocity of flow at the gate, or at the point where the pressure is to be ascertained, does not necessarily (of itself alone) fix the magnitude of the pressure-wave at such point, but the magnitude of the pressure-wave is influenced by the varying velocities of the moving water-column in all portions of the line between the point at which the pressure is to be ascertained and the reservoir.

4. Under ordinary conditions, the water-hammer effect may, and does, produce as great a fall in pressure below the normal as it produces a rise above normal after the gate has been closed completely. In other words, the pressure vibrates back and forth above and below normal after gate-closure.

5. In pipes of uniform diameter, the magnitude of pressure variation along the pipe-line will vary directly as the time required for the wave to travel from any point in question to the reservoir and return to the same point, provided the time of gate-closure is greater than the half-period of the pipe.

6. The effect of accelerating the water-column by gate-opening is analogous to the effect of retardation in gate-closing, except that the pressure-variations have the opposite sign. The period of pulsation is the same. The chief difference is that the wave-effects die out more rapidly with opening than with closing. This seems to affect the vibration so that the full magnitude is obtained only for a short time.

7. The velocity of wave-propagation in water, for riveted-steel pipe, can be calculated approximately by the recognized formula:

$$a = \frac{12}{\sqrt{\frac{W}{g}\left(\frac{1}{K} + \frac{D}{E\,b}\right)}}$$

if proper allowance is made for the effect of joint-details.

*Abstract from Proceedings of the American Society of Civil Engineers, October, 1917, page 1593.

WATER DEPARTMENTS AND THE PUBLIC HEALTH*

By H. E. Barnard

GOLDEN apples no longer load the public utility apple tree. There was once a time when it was the stockholders' delight to gather in the orchard when the board of directors shook the tree, but those days are gone, and to-day it is the exceptional tree that will yield its expected 6 per cent. The fortunate owners of utilities before the days when commission pests and board of health coddling moths made the crop of golden fruit hard to grow and most difficult to gather, are, like other orchardists, prone to bewail the sad state which has come upon them and deplore the heavy expense to which they are put to make the tree blossom, to say nothing of the continual struggle to mature the crop after the fruit has set. But, coming out of the orchard, where metaphors may please but fail to enlighten, we find the public utility of to-day charged with a double duty. It must render service to those whom it presumes to serve. It should also return a fair profit to its owners. And the first duty is the greater.

I shall confine my analysis to the public utilities known as water companies, and I shall make no distinction between companies owned by stockholders in distant cities or municipal plants owned by the consumers. In each case the duty to the public is the same. If in the fulfilment of that duty the stockholder suffers, he is entitled to sympathy, perhaps commiseration, for the lack of judgment that allowed him to invest his money in a business where the first and last concern is service to the purchaser of the product.

Thirty years ago the water company worked under different conditions. Public opinion was uncrystallized and courts interpreted the law with no idea of what we now call social justice.

Then the consumer drank water at his peril; to-day he drinks with the assurance that if he is injured by his indulgence the water company will compensate him for his illness or his family for his death. There is no question as to the law or the interpretation of the courts. It is an accepted principle that when a man engages in the business of selling food he assumes all the risks. If by his act or by the act of his servant a customer is injured, he must be responsible. And the law is the same for the water company as for the butcher. Both are in the business of selling food, for water is a food and so recognized by all Federal and State food legislation.

In spite of law, court decisions and plain horse sense, there are still in operation water companies that conceive their purpose in life to be pushing water through pipes, and, that accomplished, they claim their reward. Fire protection is a function of a water supply. No doubt many towns would still be using wells if the fire hazard did not compel the laying of water mains and the installation of hydrants. But as soon as the tap is turned on in the kitchen the situation changes, and the primary duty of the water company is not to maintain pressure for fire protection, but to pump food through its line, and, above all, food that is sure to promote health and not to breed disease.

Now, then, where are we? We are up against the incontrovertible fact that a water supply, save in a few unusual instances, is an object of suspicion. There may have been a time when surface waters were pure, when our lakes and ponds were uncontaminated by the wastes of civilization. But that time is long past. No stream is so remote that it may not be polluted, no pond so protected that it is surely safe. The water company must operate a plant to make unsafe waters dependable in addition to the pumps which were once, and unfortunately still are, the superintendent's chief concern.

From the public health standpoint, and the writer maintains that is the all-vital consideration, fire protection is a secondary and minor function. And yet, last July an engineer for a water company in an Indiana city, when confronted by the demand of the fire chief for more water with which to fight a serious fire, turned into his mains the water of a grossly polluted river. After such criminal action, for it was criminal in the same degree as the act of the guard who throws open the city gates at the demand of the assaulting enemy, the officials called upon the state board of health for advice.

What we want, what we must have, is a trained, responsible man in every water company who will seek advice first and act only after the community knows what confronts it. The writer is not sure that the disaster of fire is ever as menacing as the scourge by typhoid, or that there can arise a situation in which a water company will be justified in filling its mains with polluted water, but if such an occasion should confront the water company, its first act should be to protect health by complete warnings.

As water companies have assumed the responsibility of pumping pure water, they have added additional defenses against bacterial contamination. Filter beds, no matter how efficient, are supplemented by chemical treatment. The almost universal use of hypochlorite, or chlorine, protects the consumer and breeds in him a faith that is the greatest asset of the water company. But chemical treatment is only efficacious when it is working. When no chlorine is entering the water, the supply is as dangerous as before the plant was installed; indeed, it is more dangerous, because the faith of the consumer has stopped his practice of boiling his drinking water.

Now, this is an admitted fact. There are no "maybe's" or "perhapses" to the premise. When a water company sells water, it guarantees that water to be pure, it pledges itself to know that it is pure. Why, then, does every political change, petty shifting of civic responsibility from incompetent shoulders to others more or less incompetent, mean a change at the waterworks Why does the job go to some party follower or relative of the mayor, who wouldn't recognize a colon bacillus if it was as big as a toad, and whose only idea of service is the record of the pressure gauge We, the consumers, are asleep; we, the health officers, are bound by precedent or fearful of overstepping our authority; we, the press, are partisan and indifferent; we, the chambers of commerce, are sworn to do nothing that will arouse fear or hurt business.

Consumer, health officer and every civic organization, realizing that pure water is not only a personal right, but a public asset, must work together to put the waterworks into the hands of trained, dependable experts, and, having chosen wisely, to demand full service. Not until then can we count on the public utility in the form of the water company to render dependable service in protecting the public health.

*Abstract of paper read before the Illinois Section, American Water Works Association.

Canada's war expenditure during the month of November totalled $18,714,472, making a grand total of war expenditure to November 30th of $151,969,271.

EXPENSES AND COSTS*

By H. L. Gantt, New York City

IN determining the cost of a manufactured article, should we include all the expense incurred while that article is being manufactured, or should we include only those expenses which contribute to its production?

It does not require any knowledge of cost accounting, book-keeping, or other office art to enable the practical man to say that costs should include only those expenses needed to produce the article in question, and that those people who insist on including in their costs expenses which do not contribute to the production of the article are simply trying to recover from the public through a higher selling price the expenses which they incur through inefficiency and waste.

All cost figures may be divided into three parts:

a Expense for material.

b Expense for labor.

c Overhead expense, or "burden."

There is no great difficulty about getting the expense for material and the expense for labor, and most concerns get these elements quite accurately, but there is a great variety of opinion as to what the "burden" charge on any particular work should be. This overhead or "burden" may be divided into two parts:

a That which is incurred through simple ownership or rental of the plant and keeping it ready for operation;

b That which is incurred by operating the plant, exclusive of direct labor and material.

Analyzing further the meaning of the term "burden," we see that the first part is made up of ownership or rental of a number of machines or work benches, properly housed. The second part consists of the expense of operating the various machines, which consists of such items as power, oil, waste, repairs, etc.

Inasmuch as the rental which we should pay for the plant is made up of the rental of the individual machines and work spaces, we must be able to determine the proper rental for each of these in order to form an intelligent idea of the proper rental for the whole plant. In the same way we can determine the amount of supervision, power, oil, and waste needed to run these machines individually.

Working along these lines, we are able to determine for each machine in the factory both an idle and an operating expense rate.

Any article manufactured on a machine should undoubtedly bear the operating expense rate for the time during which the machine was operated on it.

The expense of maintaining the machine in idleness during the time it was not operated cannot legitimately be charged to the work done while it was operated, and should be put into another account.

We thus see that in every plant there are to be considered two kinds of burden:

a That which produces goods and which can legitimately be charged to the cost of those goods, and

b That which produces nothing, and must be put into some other account.

In the past it has been too much the fashion to put these two kinds into one account and make the product bear both. This has led to so much confusion, and is so evidently wrong, that it is not worth discussion.

On the other hand, a careful consideration of the expense incurred while the plant is idle leads to very fruitful results: first, through an attempt to find out why the plant is idle, and then through an attempt to eliminate the causes of idleness, which are lack of work, lack of help, lack of material, repairs, etc.

Without going into the details of those subjects, it may be readily appreciated what advantages will be derived from a careful study of each of these causes.

This general view of the cost question leads to a further simplification of the problem which is worthy of careful consideration.

First, the expense of owning and maintaining a certain machine in idleness properly equipped for efficient operation should be substantially the same in any part of the country where the machine could be bought at substantially the same price.

Second, the amount of power, oil, waste, and repairs, and even supervision, of a certain machine should be substantially the same in any part of the country, if it were engaged upon substantially the same kind of work.

Following these lines of thought, we readily see that a standardization of cost methods and of costs is possible, which was unsuspected a few years ago.

While the writer and those with whom he has been associated have done quite a good deal of work on these lines, and while the results have been satisfactory to a degree that was entirely unanticipated, he does not yet feel that the matter has been developed to such a degree as to warrant detailed publication. The fact, however, that the Federal Government has placed so many contracts on a "cost plus" basis, leads him to set forth these ideas, which are the only ones which seem to him to give promise of avoiding an almost intolerable situation resulting from a complication of interests which is bound to arise in the near future.

It seems to the writer that much of the confusion on the subject of costs in the past has been due to a misconception of the subject. The intimate relation between production and costs has not been sufficiently recognized, for the accountant has looked upon costs as a bookkeeping proposition, whereas, in truth, costs are much more closely connected with engineering and production than with the subjects of bookkeeping and accounting

If the engineer will recognize this fact and insist that money spent without any corresponding production must be kept separate from that which was productive, either directly or indirectly, many of the apparent contradictions with which we are so frequently faced will be eliminated.

As soon as we establish these methods, the following question is immediately put to us by the accountant and financier: "What are we going to do with this expense of idleness?" they having never before realized that it cost something to be idle.

My frank answer to that is that I do not know. Moreover, I don't care, provided they do not charge it to me in the products which I buy from them. My recommendation, however, would be that they see how they can eliminate such expense by proper managerial methods.

I am perfectly aware that it is extremely difficult to eliminate all of such expense, but I am also aware of the fact that it is extremely easy to eliminate a large proportion of it. The solution of this problem is one of the economic questions which the war will shortly force to our attention, and I insist that it is primarily a question to be solved by engineers rather than by financiers.

*Paper read before the annual meeting of the American Society of Mechanical Engineers.

From reports received, it has been unofficially estimated at the Canadian Fire Underwriters' Association, that the value of property destroyed by the explosion and fire in Halifax was very likely about $5,000,000.

PHELPS JOHNSON ADDRESSES SOCIETY

Phelps Johnson, president of the St. Lawrence Bridge Co., and past president of the Canadian Society of Civil Engineers, will address the Canadian Society of Civil Engineers at Montreal headquarters this evening, December 20th, on the Quebec Bridge. This is the third of a series of illustrated lectures on the bridge, and will deal with the more important phases of the shop work and fabrication of the superstructure. Mr. Johnson will show a number of lantern views of the shop work.

ENGINEER ELECTED AS DIRECTOR

C. B. Thorne, chief engineer of the Riordon Pulp & Paper Co., and manager of that company's Hawkesbury, Ont., mill, has been elected as a member of the firm's board of directors.

ELECTRIC SMELTING IN CANADA

Shortly after Dr. Haanel, the present director of mines, became connected with the public service at Ottawa, he was authorized to make an investigation into the question of electric smelting. The investigation was conducted in a most thorough and scientific manner, and its results were published in a report which has become a standard work in all technical libraries which aim to keep on their shelves up-to-date works upon modern industrial processes. At the time when this investigation was held, the general opinion prevailed that, while the investigation was interesting, the time was distant when electric smelting would be carried into practical operation in Canada. It is, therefore, worthy of special mention that the fruition of the efforts which were made in connection with that investigation has arrived and that electric smelting is now in full operation in Canada. Discussing this matter in an address at the recent annual meeting at the commission of conservation, Sir Clifford Sifton said there are, at the present time, 32 Heroult electric furnaces in Canada and 22 of other eypes—in all 54 furnaces using the electric process. These furnaces have a capacity of 173,000 tons of iron and steel, 50,000 tons of ferro-silicon, and 8,000 tons of other ferro-alloys per annum. The British Forgings plant at Toronto has 10 electric furnaces of the Heroult type and a total capacity of about 72,000 tons per annum, making it the largest electric process steel plant in the world.

An interesting development has also taken place with respect to steel for shell making, which has an important bearing on conservation.

"At the beginning of the war," said Sir Clifford, "all shells manufactured in England were made from acid steel. Practically all steel made in Canada was basic steel. The Canadian steel manufacturers had never made shells. It was not absolutely certain that they could meet the requirements of the war office and changing from the manufacture of acid to basic presented many serious difficulties.

"Colonel Cantley, with whom the first shrapnel shell order was placed, made a basic steel shrapnel sheet that met the war office requirements and thus demonstrated its practicability. In December, 1914, Colonel Carnegie, ordnance adviser to the Imperial Munitions Board, took to the war office the first machined shell ever made in Canada.

"Later, he was able to convince the war office that high explosive shells made of basic steel would also meet their requirements. These munition orders have tremendously stimulated the metal and many other industries, notably the recovery of by-products from the coke oven plants. Incidentally also we have derived great benefit from the standardizing of methods and processes and the high degree of skill required to produce a product that is gauged to within one three-thousandth part of an inch and check-gauged to one ten-thousandth part of an inch. Over 250,000 workers have become skilled in such processes and in the use of such tools and gauges."

NOTES ON THE USES OF CONCRETE

(Continued from page 509)

noticeable wear has been that some of the cement from the surface has been washed or worn off, the pebbles in the gravel forming the aggregate now forming the wearing surface. This, however, took place largely in the first two years. It is but fair to state that while this rip-rap was not exposed to violent storms, it was exposed to wave action set up by passing boats and, being at the canal entrance, had to withstand the action of waves from the river caused by heavy winds.

As to the use of concrete as a building material for ships, this is only in its infancy, but should it prove all or even part of what it is claimed by some and hoped by nearly everyone, another great use for concrete is added to the now long list.

Mention has been made to experiments showing the results of grading sands, etc., on the strength of concrete, and while there is no intention to underestimate the value of this and similar experiments, yet it must be kept in mind that laboratory and field conditions are widely different. Furthermore, contractors will not, nor can they be expected to, maintain laboratories for extensive or even fairly extensive, tests on the various requirements for cement, sand, water, stone, etc. Imagine the samples and apparatus required to make one test a day for the various requirements of cement, sand, etc., when a contractor is pouring, say, a thousand or five hundred yards of concrete a day and a test required for each carload of cement, which is the usual minimum. Some may say it should be done, but is it practical without excessive cost which in the end will not be borne by the contractor? Contractors wish to do good work, but as a rule leave such experiments as have been mentioned to others to perform. The results of experiments are of the greatest value and to be more valuable should be made under conditions as much as possible conforming with field conditions.

The writer has not made any claim to having brought out new points or settled disputed ones. The object has been to give expression to some conclusions arrived at from observations during several years' experience on construction work. Whether these conclusions are correct or not may be a matter for argument, and for others to give similar expression of their views would be a benefit to the profession. For instance, two practices have been quoted relating to the use of "plums," and it may be that some reader may have had experience along this line, and while thinking his experience and results noted of no general interest, yet it would help others to know of them. The help to the profession would be greater if coming from older and more experienced men. The use of concrete is almost universal in engineering work and there are few engineers but have had some experience with it with varying results. Its use is an important factor in engineering work and too much information cannot be published about it.

TORONTO BRANCH, CAN. SOC. C.E.

A special meeting of the Toronto Branch of the Canadian Society of Civil Engineers was called for 8 p.m., Tuesday evening, December 18th, at the Engineers' Club, Toronto, for the purpose of discussing new by-laws and for making arrangements for the election of next year's executive committee.

CANADA MUST CONSERVE COAL

The United States fuel administration authorizes the following: "Canada must place herself upon the same basis as the United States with reference to the conservation of coal. This has been made plain to the Dominion government by the United States fuel administration. In an official communication to the Canadian fuel controller, the fuel administration pointed out that Canada would be expected to resort to the same measures to save coal as are being adopted in the United States.

"In the communication to the Canadian authorities the fuel administration calls attention to the fact that an intensive campaign is being carried on in the United States for fuel economy. It is suggested that Canada conduct a similar campaign for the limitation of the uses of coal and the co-operation of the United States government in such a campaign is offered.

"Most of the Canadian coal supply is derived from the United States, and the fuel administration has undertaken to give Canada a pro rata share of the United States' supply on the same basis as the various states of the Union. The fuel administration, however, demands that Canada safeguard this supply by conservation measures in line with those undertaken in the United States."

CRITICIZES ONTARIO'S POWER COMMISSION

It is little more than 22 years ago that the first electro-chemical plant started in Niagara Falls, N.Y., manufacturing aluminum, to be followed in a few weeks by the manufacture of carborundum. A little later we had calcium carbide, caustic soda, chlorine, sodium, phosphorous, potassium chlorate, alundum and numerous other manufactures all attracted by the cheap and convenient power made available by the falls. A full recognition of the immense importance of this development was not reached, however, until after the great war began. Then it was recognized that there was not a centre of industrial activity, the products of which were of more importance to a country at war. These statements were made by Mr. F. A. J. Fitzgerald, B.A., S.B., past president of the American Electro-Chemical Society in an address last month to the Board of Trade, Niagara Falls, Ontario. He outlined the importance in modern warfare of the various products of the factories in that enterprising town and showed how industries in that section are dependent on Niagara power.

"Some years ago," said Mr. Fitzgerald, "an attempt was made to introduce the cyanamid industry into the Southern States, but the policy of the government in relation to water power made the scheme impossible, hence the development of the plant in this city.

"The Canadian government has generally shown a much more rational attitude towards the use of Niagara Falls for power purposes than has the government of the United States. The disastrous policy of the United States government is now demonstrated by the power famine at Niagara Falls, a power famine which seriously handicaps the most important work we have to do at the present, the thorough beating of Germany.

Is Responsible for Shortage

Mr. Fitzgerald stated that he was not interested in any power company and that his work was altogether with people who had to buy power from power companies. He did not believe in the policy of the Ontario Hydro-Electric Commission, although the activities of the commission had been beneficial to him, because the difficulties caused by power shortage at Niagara Falls required his assistance to overcome them. Mr. Fitzgerald dubbed as "nonsense" the assertion that the Hydro-Electric Commission is not responsible for the power shortage.

"Anyone who takes electric power supplied by Niagara Falls is in part responsible for the power shortage," he said. "Anyone who sells power is responsible for the power shortage, so that the commission shares the responsibility for power shortage with the power companies. The real criticism of the commission is that it has sold power which it did not have to deliver and that now factories, like the Canadian Aloxite Company, the Cyanamid Company and the Norton Company, must have their power supply cut down, or cannot get what they need. No doubt, the situation might be relieved to a certain extent by cutting off power from factories in the United States; but then, again, this means cutting down on the production of materials necessary for the successful prosecution of the war.

To Secure Monopoly

"The general impression gained from a view of the Ontario Commission's activities is that its primary object has been to secure a monopoly of the business of supplying electricity for all purposes. With this end in view economic consideration, such as those we have discussed have been forgotten, and no matter whether the people or a private company owns a business if this is run in a wasteful and uneconomical way it injures the people as a whole. The mere fact that the people own the power plants at Niagara Falls will not change the economic laws, hence the tremendous development of the use of Niagara Falls power for municipal purpose is not beneficial. This has been brought home to us most forcibly in the effect it has had on industrial Niagara Falls since the war began.

"It is true that the commission also furnishes much power to munitions plants, but has it done this always with a regard for the best interests of the people? Take the big electric steel plant in Toronto, British Forgings. Is it economical to put a plant like this, using large amounts of power at such a great distance from the source, where it was well known that there was already a power famine? Why could not a plant of this kind have been put near Shawinigan Falls, where there is a large amount of power at a very low price available?

"The fact is that a public owned business will not be a success unless the owners, that is, the people generally, will set themselves the task of studying the business and see that the officers whom they put in charge, run the business in a proper way. Remember, too, that those in charge of a publicly owned business have far more dangerous powers than the officers of the privately owned company. Thus, just as the commission is apt to disregard economic considerations, it will secure legislation which is almost incredible in a country professing to be democratic."

TRINITRO-TOLUOL TO SUPPLANT DYNAMITE?

Many by-product coke plants are already engaged in recovering quantities of trinitro-toluol for manufacturing munitions, and many more plants which will recover this explosive are being built. Its superiority to picric acid was plainly demonstrated early in the war. It is now a question, according to Milton A. Allen, writing in the "Mining and Scientific Press," of November 10th, 1917, whether the trinitro-toluol which is recovered by these plants cannot be put on the market in competition with dynamite as a commercial explosive after the war. On the face of the matter, trinitro-toluol is a much more desirable commercial explosive than nitro-glycerine. It does not freeze, does not melt until a temperature of 81 deg. C. is reached, does not ignite until a temperature of 300 deg. C. is reached, and even then does not explode, does not give off the slightly volatile gases which produce severe headache when dynamite is handled, and does not deteriorate under water. The only serious objection to its use is that the explosion produces a large volume of carbon monoxide gas. However, this is also the case with nitro-glycerine, and dynamites used for tunnel driving are mixed with nitrate as an oxidizer to prevent the formation of this gas. The same thing could, no doubt, be done with trinitro-toluol. Apparently, the chief thing remaining to be worked out is the process of putting the explosive up in convenient form for handling, as is done with nitro-glycerine in dynamite sticks.

BOOKLET ON CONCRETE SHIPS

The Portland Cement Association, 111 West Washington St., Chicago, Ill., have just issued a forty-eight page booklet, 6 in. x 9 in., entitled "Concrete Ships, the Possible Solution to the Shipping Problem." The booklet is well illustrated with photographs and plans of concrete ships. The centre two pages show nine views of the ship recently built by the Atlas Construction Co., Ltd., of Montreal. The booklet includes a bibliography of concrete ship building, a historical summary of progress in this type of construction, and a summary of some recently proposed concrete ship designs. The association would no doubt be glad to send the booklet gratuitously to any engineers who are interested.

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Principal Contents of this Issue

TORONTO BRANCH QUESTIONNAIRE

The special committee appointed by the Toronto Branch of the Canadian Society of Civil Engineers to consider the matter of drafting new by-laws and how best to promote the prestige and influence of the branch, has issued a questionnaire to the members. It is to be hoped that the members will assist the committee by sending in early replies, as it is anticipated that the information to be obtained by means of the questionnaire will materially help the branch executive to formulate a course of action.

Judging from the replies already received, there appears to be a desire—although not a very definitely expressed one—that the Canadian Society of Civil Engineers should do more to enhance the position of its members in the opinion of the public. The members should bear in mind that the Society is exactly what they, themselves, make it. The Society cannot reform itself,—if it needs reformation. The Society is fully representative of the members at large; that is, that its activities, its development, its aggressive attitude in various matters relating to the engineering profession, are simply reflections of what the majority of the members are doing.

A steamship depends upon stokers for its progress and upon its captain for its destination; but navigation officers would be helpless unless the stokers were providing the steam. In a like manner, the Council of the Society, or an Executive Committee of a Branch, must depend upon the body of members to furnish the "steam" without which the Society's "Ship of State" cannot be guided to any harbor of contentment.

If, then, the Toronto members of the Society desire that the prestige and influence of the Toronto Branch should be increased, it must be done by their indicating the methods that they consider advisable for adoption. The prestige and influence of any body of men are inevitably the products of their own personal and collective aspirations and efforts.

OUR SERIOUS COAL PROBLEM

A serious warning as to the necessity for national organization was uttered by Sir George Foster at a Victory Loan meeting in Toronto last week. Just as we are now dependent on our own financial strength, so we may, as the war continues, be thrown upon our own resources in other directions. Sir George mentioned the multiplicity of regulations governing exports, including coal, from the United States to Canada. The time might come, comparatively soon, he said, when the United States, because of the exigencies of war, might have to ask us to depend upon our coal resources. As the neighboring republic assumes a larger share of the conflict, it would require more and more of its resources for carrying on the war. The lesson for Canada is the immediate organization of national resources for application to war conditions.

The statement of Sir George follows closely a similar plea of Sir Clifford Sifton at the recent annual meeting of the Commission of Conservation. War conditions have brought home to the people the critical position in which they stand with regard to fuel and the necessity for applying intelligent study to the whole question. Sir Clifford said that upon the whole question of coal, Canada is woefully behind the times. "Wasteful methods of mining are permitted throughout Western Canada," he said, adding: "No serious attempt has been made to grapple with the problem of preventing the serious and irreparable waste which is constantly going on in the mining of our coal areas. Provisions for inspection to prevent the loss of human life has been made by the provinces; but the permanent waste of very large quantities of valuable coal still goes on. What is required is a competent public service of technically trained men who will undertake the supervision and control of the mining of coal upon Dominion lands and put an end to the waste."

This waste, in peace time, is bad enough; in war time, it is almost criminal. In national organization, the Dominion government must lead the way. The question of our coal supply is a matter for their immediate attention in co-operation with technically trained men.

ENGINEERS AND CONTRACTORS

One of the most frequent causes of trouble between owners, engineers and contractors is the neglect of some engineers to express themselves clearly. As a result, uncertain specifications are introduced and these in turn are followed by controversy and litigation between the parties concerned.

While it is frequently impossible for the engineer to know in advance of construction exactly what will be required, the contractor very naturally objects to the attempt that is sometimes made to shift the burden upon the contractor by the introduction of ambiguous clauses which, in most cases, are unfair to all concerned and lead to misunderstanding all along the line.

A great deal of trouble of this kind can be attributed to the practice of copying specification provisions from some one else's work or from some older specification, without due regard to whether the class of materials is the present market classification or whether obtainable except at a very much increased price.

Considerable misunderstanding between the engineer and contractor is also caused by over-estimating. Often severe loss may result from quantities over-estimated in the specification, because a decided disparity there affects various overhead charges that must be distributed in order to make up a contract bid on the unit price basis.

Payment for extras is another rock upon which the engineer and contractor very often split. In many cases the contractor will go ahead and put in extra work without proper authority; so that, although performing legitimate service, he is unable to compel payment therefor. The only really fair way to cover this point is a cost plus 10 per cent. proposition for authorized or necessary extra work, including in the cost the overhead expenses, which apply as much to labor and plant on extra work as to any other part of the job.

Over and above all, however, the personal disposition of the engineer in charge is an important consideration. If too arbitrary and disagreeable, it is more than likely that contractors will come to know him and to arrange their bids so as to protect themselves, with the result that the work may cost more than similar work carried out under another engineer. On the other hand, through too great a degree of obliging laxity, an engineer can sometimes cause the owner equally serious losses if the contractor be not thoroughly reputable.

THE HALIFAX DISASTER

To the city of Halifax, in its great disaster, the practical sympathy of the entire Dominion is extended. While the organization and work of national reconstruction is proceeding, the immediate task of relief is well in hand. Halifax will not be allowed to want or to appeal in vain. Every province will do its share in helping to mitigate suffering, to provide the immediate necessities, and to rebuild the devastated portion of that historic city.

To those States, municipalities, and other organizations in the neighboring republic, and to Congress, the Dominion expresses thanks for the assistance which they rendered so quickly. In a manner which typifies the splendid spirit of our neighbors, relief trains and ships were on their way to Halifax before even the advice of their despatch.

The explosion of the munition ship in Halifax harbor may not have been due to German machinations. At the same time, many will believe, after reading the evidence at the Kaltschmidt trial at Detroit, that we cannot afford to allow enemy aliens much freedom of movement in this country. The testimony of one of the witnesses was that Kaltschmidt had conspired to blow up munition ships in New York harbor in 1915. At another German agency trial at Concord, N.C., a witness stated he had told United States Secretary Daniels of a plot to burn the Parliament Buildings at Ottawa four weeks before it occurred, and told him also just how it was to be done. If the Halifax disaster be devoid of Hun devilment, yet it reminds us of the dangers which war brings to a belligerent country even though distant from the battlefields. One of those dangers is the German agency system on this continent, headed by cut-throat ambassadors, criminal diplomats and lawless gangsters.

PERSONALS

Lieut. H. C. MacKendrick, a forestry student of Toronto University, year 1918, has just returned from France suffering from the effects of gas poisoning.

Lieut.-Col. C. H. Mitchell, C.M.G., D.S.O., of Toronto, who has been at the head of the Intelligence Department of the Second British Army in France, has been transferred to a similar position with the British staff in Italy.

Prof. E. A. Stone has received an offer from the new Chinese Government University of Engineering in North China, of the chair in engineering. Prof. Stone holds the chair in structural engineering and bridges at Queen's University, Kingston, Ont.

EVAPORATION FROM WATER SURFACES

(Continued from page 516)

about 3,400 ft. from the laboratory. The same general atmospheric and other conditions existed in both places. The area of the lake was 17 acres. From the data obtained the following rules were deduced:

1. Evaporation data from tanks 2 ft. or greater in depth, preferably circular, set in the ground so that a metal rim not over 3 ins. wide is all that projects above the surface, and in which tanks the water is kept approximately at the ground-level, are most applicable for extension to large open-water surfaces.

2. Data on such tanks may be extended to large open-water surfaces that are under the same conditions of wind, air-temperature, and relative humidity by multiplying the evaporation-depth from a

Tank	2 ft. diam.	by 0.77
Tank	4 ft. diam.	by 0.84
Tank	6 ft. diam.	by 0.90
Tank	9 ft. diam.	by 0.98
Tank	12 ft. diam.	by 0.99

The second part of the investigation related to the rate of evaporation from stream-beds when no water flows on the surface. Samples were taken of sand and gravel from stream-beds in different Western States. These were placed in tanks in which the water-table was kept at a given distance from the surface, and the rate of evaporation determined. The relation between these rates of evaporation and the rate from a water surface under similar conditions is shown in Fig. 2.

Similar experiments were made using the soil at the laboratory site in place of river sand and gravel. The mechanical analysis of this soil was as follows: Fine gravel, diam. 1 to 2 mm., 2.3 per cent.; coarse sand, 0.5 to 1 mm., 6.2 per cent.; medium sand, 0.25 to 0.5 mm., 4.5 per cent.; fine sand, 0.1 to 0.25 mm., 34.8 per cent.; very fine sand, 0.05 to 0.1 mm., 20.5 per cent.; silt, 0.005 to 0.05 mm., 15.8 per cent.; clay, less than 0.005 mm. diam., 15.8 per cent. Taking the rate of evaporation from a tank 2 ft. diam. with the water 2.75 ft. deep as 100, the corresponding rates for the soil for different distances of the water-table from the ground-surfaces was as follows: 4 ins., 88.2; 16 ins., 79.8; 28 ins., 62.4; 38 ins., 33; 43 ins., 7.63; 50.5 ins., 7.24. No explanation is given for the break between the 38-in. and the 43-in. depth. Fig. 3 shows the relation between the depth to the water-table and the proportion of moisture in the top 4 ins. of the laboratory soil.

Coast to Coast

Aroostook, N.B.—The concrete dam, 400 ft. long, constructed for the Maine and Aroostook Power Co., is now completed. Henry Post was the contractor.

Edmonton, Alta.—The big merger of the United Grain Growers has, in one season, extended its area to 40 separate local points, and, in fact, many other locals have been established, at which points it is probable that additional elevators will be constructed in the spring or summer of 1918. The 40 elevators, construction of which commenced in the spring and early summer, have all been practically completed, and most of them have been opened to the grain traffic.

Halifax, N.S.—The nature or extent of damage to engineering structures in the city is still unknown. The scene of the explosion was some distance from the new ocean terminal being constructed by the Canadian Government, which is reported virtually undamaged. As to the effect of the disaster on the two new reinforced concrete piers at the northern end of the business section of the city, very close to the explosion, nothing has been reported. One report that a considerable quantity of fill, trackage and rolling stock at the site of a new railroad yard north of the city was washed away by tidal waves following the explosion is unconfirmed. It is believed that the drydock mentioned in earlier despatches is a small one built a long time ago.

Kingston, Ont.—Last Thursday, by the turning on of 44,000 volts of hydro at the Kingston substation, the city was linked up with hydro-electric power.

Kingston, Ont.—Water power from the Trent is turning the wheels of Kingston industries, and the streets, stores and dwellings of the city are lighted from the same source of electrical energy. The city's turbine and boilers, which produced electrical power from coal, are at present idle. They will be retained, however, so that in case of any accident the city's needs will be taken care of. The turbine will also be used to keep down the peak load.

Montreal, Que.—Since 1911 the following expenditure has been made for sewers, and in each case the interest is calculated at 5 per cent. on December 15th, 1917: 1912, $26,182, interest $6,873; 1913, $469,138, interest $99,692; 1914, $1,097,362, interest $178,321; 1915, $1,510,636; 1916, $978,268, interest $61,141, making a total of $4,081,589, with interest total of $515,974. It was contended that if the rolls had been prepared during the construction of the sewers, allowing a reasonable time for the preparation of the rolls, at least one year's interest, or an amount of $204,079, would have been saved, which would have left the total interest $311,895. Comptroller Pelletier pointed out that the engineers make the valuation of the proprietors 62½ per cent. of the cost of the sewers at the time each credit is voted for any operation. He thought that in future the assessment should be made at a price fixed in advance at so much per lineal yard. The rolls could then be made at the same time as the work of the sewer, and the city would save a considerable amount of interest, as well as simplifying the whole procedure.

Montreal, Que.—That work should be commenced on the Montreal-Sherbrooke highway, was the request of a deputation from the Dominion Good Roads Association and Eastern Townships, who waited on the Hon. J. A. Tessier, Minister of Roads. The Minister promised that this should be done in the spring, provided all the municipalities would get into line. Mr. Tessier also expressed a hope that he will be in a position to make an early start on a road between Sherbrooke and Beauce, forming a connecting link with the Levis-Jackman highway. The Quebec Legislature is to be asked to improve the roads in the Laurentian Mountains.

Montreal, Que.—The Southern Canada Power Company's operations cover an exceptionally wide range of territory, doubtless the largest east of the Niagara power zone. On the south, power is carried across the international boundary into Derby, Vermont. On the west, the transmission lines approach as near to Montreal as St. Johns, Iberville, St. Hilaire and Belloeil. On the north Drummondville and adjacent municipalities are tapped, while on the east the principal points of consumption are Sherbrooke, Lennoxville, Richmond and Compton. These distances are approximately 70 to 75 miles east and west, north and south. It is quietly but gradually developing into an important development, and is extending a network of power wires throughout the southeastern section of the Province of Quebec, and working up the available hydro-electric propositions in that area. The company at present has under construction about 85 miles of transmission lines from Sherbrooke to Granby and Cowansville, from Sherbrooke to Bromptonville and from St. Cyrille to St. Germain through Drummondville, with the necessary substations and distribution systems. The power development at Richmond, Drummondville, Foster and Granby are being considerably improved and enlarged and put into shape for the most economical operation, through the transmission lines, with the other plants of the company.

North Vancouver, B.C.—The Board of Trade executive has been informed by Mr. G. A. Kent that American interests had bonded the Von Rees copper mines, near the forks of Lynn Creek, and the Lynn Creek Gold and Copper Company's claims, near the old Swayne mines, also on Lynn Creek, and that development work would start immediately. A good trail was now opened up to the Cedars, Limited, camp, and this will be continued up to a point near the forks of Lynn Creek. Mr. Kent was not informed as to the particulars of the deal except that machinery was being taken in and development on a very considerable scale was soon to commence.

Prince Edward County, Ont.—The Hydro-Electric Commission propose to serve the towns of Picton, Wellington and Bloomfield, in Prince Edward county, by means of a 44,000-volt line from Trenton. A sub-station will be erected at Wellington for serving Wellington and Bloomfield, and a 4,000-volt line will be built from Wellington to Bloomfield. A sub-station will also be erected at Picton to serve this town.

Puget Sound, B.C.—Puget Sound will be the directing headquarters of the Foundation Company in the United States, according to reports received here from Seattle. The Foundation Company, Limited, which is building ships in the Inner Harbor for the Imperial Munitions Board and Dominion Government, is associated with the parent firm, which has its head offices in New York. A report says that the Foundation Company plans building twenty vessels each at Portland, Tacoma and in British Columbia. The company, in addition to its activities in Victoria and New York, is engaged in building ships at Portland and Tacoma, and the general supervision of those plants will be through the newly-established offices in Seattle, which is an intermediary point between the yards already established.

Sandwich, Ont.—The Hydro-Electric Power Commission of Ontario's work of installing one of the 2,000 K.V.A. rotary converters in the salt company's plant at Sandwich is practically complete, and it is expected that this company will be in a position to use off peak power until after the winter peak on the system.

Vancouver, B.C.—Two routes were proposed this summer to secure a trans-provincial highway across British Columbia, one through the Hope Mountain, from the town of Hope to Princeton, the other along the Fraser River canyon to Kamloops, and thence northward up the Thompson River and through the Rockies to Edmonton. Alfred Driscoll, C.E., of Edmonton, Dominion Government engineer, was recently assigned the task of inspecting the route between Kamloops and Hope. Beginning at Edmonton, Mr. Driscoll made the trip across the mountains and down the Thompson River to Kamloops by pack-horse. At present there is some eighty miles of road along the Thompson River from the interior metropolis north. After completing this work a party left Kamloops and inspected the route along the Thompson and Fraser River as far as Hope, while some attention was also given to the Hope-Princeton route, which was surveyed some years ago by a Vancouver firm of engineers. It is expected that Mr. Driscoll will make his report to the Dominion Government and his opinion regarding the feasibility of the northern route and estimate of the cost of the undertaking is being awaited with interest by the people of Kamloops, who have become deeply interested in the project.

Welland, Ont.—The total expenditure on the construction of the Welland Canal is about $13,000,000 of the estimated cost of $50,000,000. The work has been suspended on account of the war.