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GOVERNMENT WHARF AT WINDSOR, ONT.

LANDING WHARF SIX HUNDRED AND FIFTY-FIVE FEET LONG RECENTLY COMPLETED FOR THE DEPARTMENT OF PUBLIC WORKS OF CANADA—GENERAL FEATURES OF ITS DESIGN.

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DURING the years 1913 and 1914 a landing wharf was constructed at Windsor, Ont., by Mr. A. E. Ponsford, of St. Thomas, Ont., under a contract with the Department of Public Works of Canada. This wharf is 655 ft. long, 20 ft. wide, stands 6 ft. 10 ins. above low-water level, and is situated on the channel bank of the Detroit River, a short distance downstream from the Detroit and Windsor ferry landing.

On account of the very soft and unstable foundation which was found to obtain at this site, it was decided, after considering various designs, to construct the wharf on a foundation of piles. The superstructure consists of reinforced concrete in the form of a slab supported by T-beams extending between the two walls, which form the front and rear of wharf. The slab is 6 ins. thick and is reinforced laterally and longitudinally with round steel. The cross-beams are 24 ins. deep below the slab, 14 ins. wide and are spaced at 4-ft. centres throughout the length of dock. These beams are reinforced with Kahn bars. The front wall is 20 ins. thick, the rear wall 15 ins. thick and both walls are reinforced vertically and longitudinally with round steel. The lower part of each wall for a height of 1 ft. consists of footing blocks that were cast on the site of the works in convenient lengths and after proper seasoning were placed on the pile foundation. The use of such footing blocks enabled the placing of forms and the pouring of concrete in walls entirely above water level.

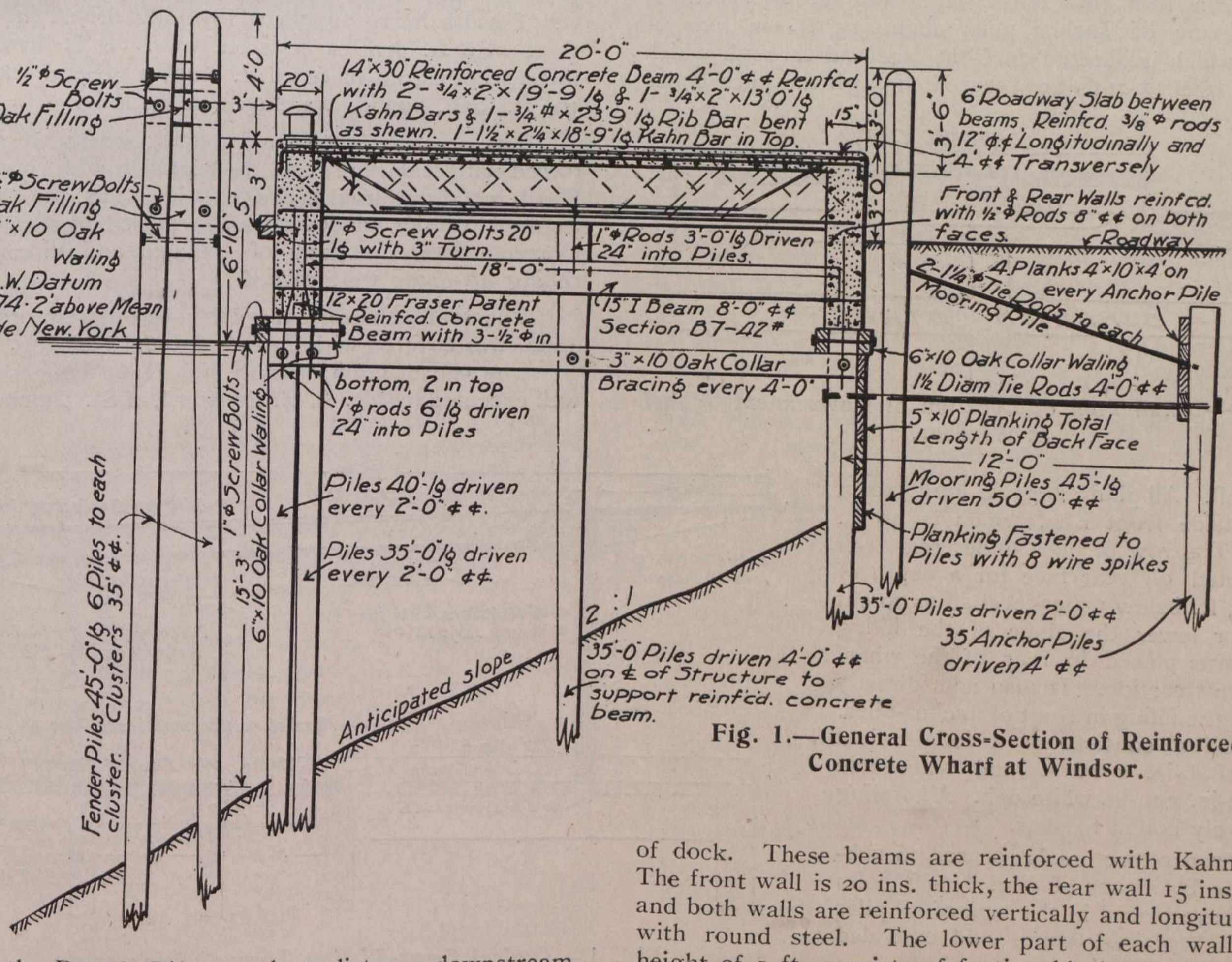


Fig. 1.—General Cross-Section of Reinforced Concrete Wharf at Windsor.

The substructure consists of white oak piles cut off at low-water level and is secured together both longitudinally and transversely with oak waling. The piling is in five rows, there being two rows close together under the front wall at 2-ft. centres, a centre row at 4-ft. centres, a rear row under rear wall at 2-ft. centres and a row of anchor piles about 15 ft. in rear of wharf which is sheeted on front face and through which 1½-in. steel tie-rods are secured through the piles under rear wall. All piling is 35 ft. long except the outside front row, which is 40 ft. long. The row of piles under rear wall is sheeted on rear face for a depth of about 5 ft. below water-level so as to cut down or lower the slope of the filling which was placed in rear of the wharf after construction. It also acts directly against the filling in front of anchor-piles. The waling consists of 4 longitudinal rows of 6-in. x 10-in. and transverse wales 3-in. x 10-in. white oak. All waling is securely bolted to piles.

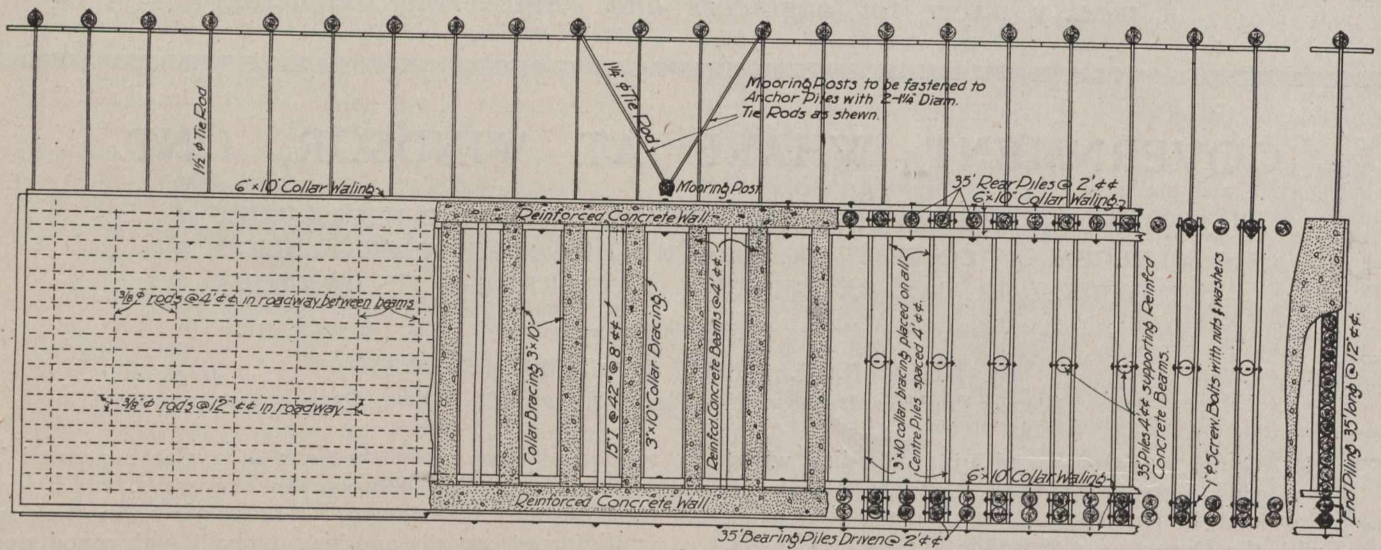


Fig. 2.—Plan of Roadway Reinforcing, Beams, Piling, Collar Waling and Bracing.

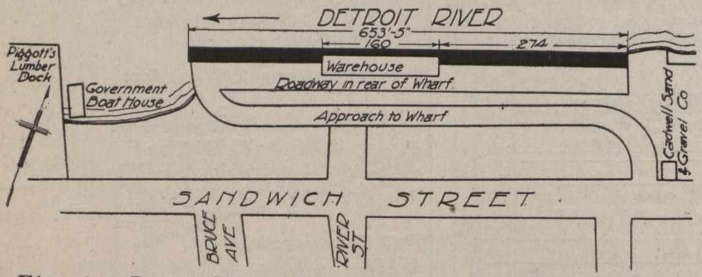


Fig. 3.—Detail Plan of Location of Government Wharf at Windsor.

The superstructure is secured to substructure by means of 1-in. φ drift bolts which were placed in the tops of all piles in holes bored for same and extended through into the concrete.

All concrete consisted of 1 part Portland cement to 6 parts of sand and gravel, reinforced as above stated and as shown on plans.

Fender pile clusters of six piles, 55 ft. long, of white oak, were driven and framed with white oak separators, secured together with bolts, the clusters being placed at 35 ft. centres along the front of the wharf.

A reinforced concrete warehouse 160 ft. long, 30 ft. wide, and about 11 ft. high inside was built along the rear side and opposite to centre of wharf. This building projects 12 ft. over the rear face of wharf, the remaining 18 ft. of width being supported by piles driven in rows of three at 8 ft. centres between rows. It is divided into three sections, an office 20 ft. long, a general warehouse 100 ft. long, bonded warehouse 40 ft. long.

The columns, roof beams and girders are all reinforced with Kahn bars and the roof-slab with round steel. Hyrib metal was used in the partition walls, the steel sash as used for the windows was furnished by the Trussed Concrete Steel Company of Canada, and nine Kinnear rolling lift-doors were placed.

The roof-slab consisting of 3 ins. of reinforced concrete, was covered with Carey's standard roofing.

The construction of both wharf and warehouse was well executed by Mr. A. E. Ponsford, of St. Thomas, Ont., and the total cost of the works, including inspection, was slightly over $75,000, which was approximately $1,000 less than the estimated cost. Of this amount the cost of warehouse alone was $7,931.

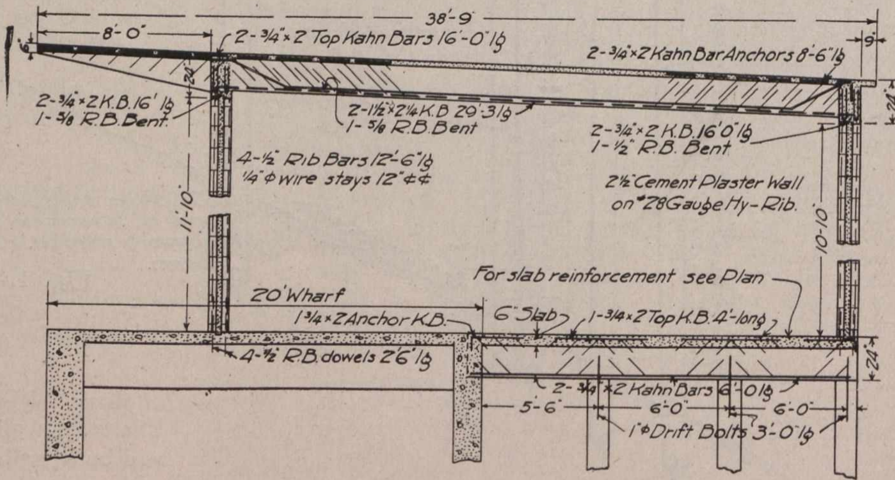


Fig. 4.—Typical Cross-Section Through Warehouse.

The work was designed and constructed by the writer under the supervision of Lieut.-Col. H. J. Lamb, district engineer, who is now on the general staff of the 1st Canadian Expeditionary Forces. The safe load for floor of wharf and warehouse is approximately 500 pounds per square foot.

All grading in rear of the structure was performed by the corporation of the City of Windsor under their city engineer, Mr. M. E. Brian, B.A.Sc.

VANCOUVER POWER OFFERS.

A FEW months ago the City of Vancouver began to look about for some source of hydraulic power wherewith it might fulfil its own requirements in the matter of light and power. The British Columbia Electric Railway Company has been supplying the city for a number of years and has ample supply, but the question of rates had evidently created a desire to investigate the feasibility of a municipal scheme.

The following seven propositions have been advanced for the city council's consideration:

A scheme three and a half miles north of Port Haney, 28 miles from the city, was submitted by F. J. Hart. Three hundred feet of head is stated to be available in a canyon on North Lillooet River. The price was $10,000.

W. T. Hoyse offered a potential water scheme on the West River, flowing into Loughboro Inlet, 180 miles from Vancouver, no price being stated.

E. F. McLennan and Frank Kelley submitted a scheme for developing 50,000 to 75,000 horse-power on Glacier Lake, 16 miles north of Harrison Lake, for $10,000.

The Cheakamus proposition of the B. C. Power & Electric Co. was submitted by Messrs. Ducane and Dutcher, the price being $1 a horse-power on the normal development at the dynamo. The estimated development was 100,000 horse-power. The site is 55 miles from the city by a transmission line.

The Nairn Falls Power Company, through Gerald A. Kent, engineer, submitted its sites on the Pacific Great Eastern Railway, 60 and 66 miles from the city. Two power houses are possible, with a total development of 50,000 horse-power. The price quoted was $250,000.

The water-power sites of J. F. Deeks on Howe Sound, and of the Coast Quarries Company at Granite Falls, on the North Arm of Burrard Inlet, were also offered. The price of the former, which included gravel bunkers, was $250,000. The Coast Quarries Company wanted a price equivalent to the value reckoned on the earnings of the last six years, as being five per cent. of the capitalization. The amount invested had been $100,000. There was from 3,000 to 4,000 horse-power available. In the Deeks offer there was 8,000 to 10,000 horse-power mentioned.

Another scheme offered at a previous meeting was that of the Bridge River Company, near Lillooet, where between 300,000 and 400,000 horse-power is said to be available.

Montana have recently enacted an amendment to their state highway law, providing that all bridge contracts shall be let in accordance with plans and specifications standardized and prepared by the state highway engineering department; the plans to be placed on file with the county clerk for 30 days prior to letting contracts. Under these conditions, Montana will be able to obtain not only cheaper but better results than were possible by the former method. In California, it has been proposed to consolidate all highway engineering within the state under the jurisdiction of the state.

VALUE OF MECHANICAL FILTERS IN WATER PURIFICATION.*

THE efficiency of the mechanical filter must be gauged to a very large extent by the character of the water to be treated—for example, if it has an excess of suspended matter; if it contains an unusual amount of peaty matter, causing a dark color, or giving it a plumbo-solvent action; if it contains an excessive amount of iron in solution; if there is evidence of excess of bacteria; or if there are special difficulties in securing a suitable supply, as in the tropics or on military expeditions. The quality of the water is, of course, determined by its origin, be it an upland lake, natural or artificial, or a deep well, free from pollution, or be it a shallow well or a river, polluted or liable to pollution. For convenience, the subject of the efficiency of these filters may be dealt with under five headings: (1) Suspended matter; (2) presence of iron in solution; (3) coloring matter; (4) plumbo-solvent action; (5) bacterial content.

Before considering these separate headings it may be appropriate to notice the change in the general chemical composition of the water brought about by the mechanical filter. The chemical changes resulting from mechanical filtration have been put forward as percentages of purification; but those who put forward chemical results in this way miss altogether the significance of chemical analysis. Chemical analysis of water had originally as its object, before bacteriology was placed in such a secure position, the detection of sewage pollution; in other words, the detection of matter which is dangerous by reason of its perhaps containing pathogenic organisms such as Bacillus typhosus. If the extent of the chemical change in filtration gave any indication of the presence or absence of pathogenic organisms, then it would be of the greatest value; but the results of chemical analysis give no such indication. From the hygienic point of view the writer is, therefore, not interested in the reduction of free or albuminoid ammonia in filtered water. What he is concerned about is the improvement from the æsthetic and the physiological standpoint; whether the suspended or coloring matter, or plumbo-solvent action is removed, or whether injurious bacilli have been eliminated. Beyond this, chemical results are of secondary concern. However, as a matter of general interest it may be stated that the greatest change in the water on being passed through the filter is that the albuminoid ammonia and the amount of oxygen absorbed are decreased.

The following table gives the analyses of water from three supplies, before and after filtration, through mechanical filters of different types:—

	Swineshaw Reservoir.		Shrewsbury.		Reading	
	Mather & Platt's Delépine.		Bell's Blunt.		Candy's—Smith	
	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
Oxygen absorbed...	0.1156	0.0522	0.090	0.044	0.150	0.090
Free ammonia......	0.0138	0.0128	0.0050	0.0045	0.002	0.001
Albuminoid ammonia........	0.0080	0.0032	0.021	0.007	0.023	0.008
Nitrous nitrogen.....	0.0	0.0	0.0	0.0	slight trace	0.0
Nitric nitrogen.....	0.120	0.118	0.145	0.150	0.30	0.30
Chlorides..........	1.17	1.18	1.1	1.1	1.40	1.40
Hardness—temp.....	0.06	0.6	0.2	0.2	14.30	14.30
Hardness—perm....	3.3	3.8	4.3	4.3	4.70	4.70
Nature of source....	Moorland		River		River	

Taking the results into consideration one is led to conclude that the general effect of filtration through each

* Extracts from paper read before the Royal Sanitary Institute of Great Britain, May 28, 1915.

of these three representative filters is practically the same.

Suspended Matter.—In the removal of suspended matter from the water there can be no question of the efficiency of mechanical filters of whatever make they may be. That they render the water clear, as tested by the 2-ft. tube, is testified by many observers throughout the country. The effect of filtration is most markedly seen in dealing with very turbid water—for example, from a river in flood. No severer test could be applied than in dealing with the water from the Severn, which is liable to heavy flooding, and which at times contains a very large quantity of insoluble solids. During spring and summer the flow of the river remains fairly constant as regards suspended solids, and at those times alumina is added to the extent of 1¼ grains per gallon; but during the autumn and winter when the river is high and floods are common, the amount of alumina added may be raised to 2½ grains per gallon. The clearer the water the less alumina is required. In the summer months the filters are cleansed every twelve hours, but on some occasions during the winter, and fortunately these are few, it may be necessary to wash out the filters every six hours and even every four hours.

The chief difficulty in clarifying the water is the presence of the argillaceous or clayey matter. This fine material sediments slowly. The writer has several times allowed the 2-ft. tube to remain upright for twelve hours, and found that the fine particles had not sedimented even in that time. In dealing with such a water, sedimentation after adding the coagulant, but before passing through the filters, would relieve the work of the filters, and so bring about a better filtrate. Another factor to be considered is that the river may rise quickly, and those in attendance may be taken by surprise before the requisite proportion of alumina is added.

This flood water is very difficult to deal with by any kind of filter without preliminary sedimentation, and perhaps the mechanical filter is preferable to the slow sand filter, which would soon become clogged by the sedimentary material.

Presence of Iron in Solution.—Iron may be found in solution in water from deep wells. It exists in solution in the ferrous state by reason of the presence of carbonic acid, and in the presence of air becomes oxidized, and is precipitated, after which simple filtration will remove nearly all the iron present. If the water is free from pollution, which is probable in the case of a deep well, treatment is only required for the removal of iron. Here the installation of mechanical filters may be all that is necessary.

In the process of removing iron in solution the water must be aërated to cause oxidation and precipitation. Provided aëration is sufficient for complete oxidation, simple filtration through the mechanical filter is all that is necessary for the removal of practically all the iron present.

Coloring Matter.—There appears to be no doubt that mechanical filters act more efficiently than slow sand filters in removing peaty coloring matter. The alumina used in most of the types of mechanical filters seems to form a film which effectively arrests most of the coloring matter, perhaps by a specific mordant action.

Plumbo-Solvent Action.—Plumbo-solvent action is commonly found in moorland waters, the property being due to the presence of peaty acids, which impart an acid reaction to the water. To counteract the action of peaty acids, neutralization may be carried out, as is done in the process of mechanical filtration, by the addition of lime or sodium carbonate, which is added in sufficient quantity to neutralize the acidity and at the same time re-act on the alumina added to force the coagulant; or, in the case of the filter not using coagulant, by the addition to the filter-bed of magnesium oxide, which is slowly dissolved out.

Very careful investigations have been conducted by several observers, especially with regard to two types of mechanical filter in which coagulant is used. Frankland, in making observations on the Stockport water before and after filtration through Bell's filters, found that the plumbo-solvent was reduced by 76.3 per cent., taking the average of a year's weekly samples. Delépine ascertained that the action of moorland water on lead, after chemical treatment and passage through Bell's filters, was considerably reduced and rendered negligible. Ross and Race, studying both Mather & Platt's and Bell's filters, obtained somewhat similar results, the plumbo-solvent action being reduced to a very small amount or completely abolished, and the water giving a definite alkaline reaction.

Although the methods of determination adopted by these observers were different, their scientific accuracy may be taken for granted. These results, coming from men of a high reputation, give expression to the remarkable efficiency of this method of treating water possessed of a plumbo-solvent action which is dangerous to consumers.

Bacterial Content.—The bacterial content of the water need only be considered in relation to the filtration of water which is polluted, or suspected of being polluted, by excremental matter. Upland or deep well waters are likely to be beyond reproach, and the effect on the bacterial content is only of secondary importance.

In the first place it is necessary to allude to the fact that until a sufficient film of hydrate of alumina forms on the surface of the filtering material, the maximum efficiency of the filtration process cannot be expected. This film, however, quickly forms, and Ross & Race found that, under ordinary circumstances, after washing the percentage of purification obtained at the end of ten minutes' working of the filters was 91.9 in the one and 94.7 in the other.

In experiments carried out in November, 1910, the writer found that Bell's filters, two minutes after washing, gave a percentage purification of 91.9 and 87.0 respectively, in two experiments; and fifteen minutes after washing a percentage purification of 95.9 and 92.4 respectively. The time between washing and efficient action of the filters is thus so small that it may be neglected.

As to the bacterial efficiency of mechanical filters, Frankland showed that, working with Bell's type, an average of 95.7 per cent. purification could be obtained. This average deals with a year's weekly samples of the unfiltered and filtered waters, the unfiltered water containing from 45 to 793 bacteria per c.c., and the filtered water from none to 45 per c.c. This water was obtained from an upland source not exposed to pollution. At York, where mechanical filters are used for preliminary treatment instead of storage before filtration through slow sand filters, the average reduction in the bacterial content of the water, which is obtained from the Ouse, was found to be 86.2 per cent. without the use of a coagulant; but with the addition of 1 grain per gallon of sulphate of alumina, in an experiment lasting six days, an average reduction of 93.37 per cent. was obtained. At Bolton, where Mather & Platt's filters are in use, Ratcliffe (quoted by Ross and Race) found in a series of weekly examinations extending over fifteen months that the average reduction of bacteria was 95.6 per cent. Here the untreated water contained from 52 to 793 organisms per c.c. Delépine points out that, if the number of bacteria in the untreated water is very small, little reduction in the number is made by filtration; when the number of bacteria in untreated water does not exceed 5, 10 or 20 per c.c., very little improvement can be expected from treatment. The results of Ross and Race bear out these observations. Bell's and Mather & Platt's filters were kept under supervision by these observers, and 74.7 and 75.9 per cent. purification respectively were found in dealing with water containing from 40 to 95 bacteria per c.c. in the original condition. Both Delépine's and Ross and Race's results were obtained from water which did not require filtration for the reduction of bacteria, but which was being filtered mechanically for other reasons.

During the first year of operation of Bell's filters in Shrewsbury analyses gave an average purification of only 73.3 per cent.; but after the treatment was adjusted, and certain defective valves in the chemical apparatus were corrected, the bacterial purification was found towards the end of 1910 to be from 95.9 to 96.6 per cent. Recent samples taken a few weeks ago gave successively 96.1, 94.1 and 95.6 per cent. purification. At Edinburgh, with the same class of filter, a similar result was obtained—a percentage reduction of from 67 to 81 in the earlier periods of testing, but a greater reduction when the chemicals were adjusted, the washing regulated and the filters kept under careful supervision. These experiences point to the necessity of careful and intelligent supervision of the filters checked by bacteriological examination, so as to determine the amount of coagulant to be used and the periods of washing. The Mather & Platt and Bell filters have been found to act in an equally efficient manner when compared under the same conditions, and it is probable that the Paterson filter, acting, as it does, on the same principles, has the same efficiency. With regard to the Candy filter, no extended bacteriological results appear to be available, and one is inclined to be sceptical as to its equal efficiency when no coagulant is used. Extended observations are required to improve our knowledge of the comparative value of all these types of mechanical filters.

There is a serious source of fallacy in speaking of the bacteria in the filtered water as so much per cent. purification, for the ultimate bacterial content may be large, although the percentage would indicate a large amount of purification. For example, the water of the Severn may contain anything from 143 bacteria per c.c. in the dry-weather flow in summer to 9,920 per c.c. in winter. high-level flow (flood water in all probability will contain more than this); but 94 per cent. purification in the former would result in 8 bacteria per c.c., and in the latter 590 per c.c., the latter the result of an actual analysis. On another occasion, as already noted, when the river water contained 8,000 per c.c., the filtered water gave 290 per c.c.—equal to 96.4 purification. This amount of purification cannot convert a polluted water into a potable one. For total bacteria in potable water the general view is that it should contain more than 100 bacteria per c.c.; but less than this amount does not render a water potable, since the presence of B. coli and its relatives must be considered. Houston, perhaps, expresses the general view of bacteriologists regarding the subject when he states: "Everything depends on the local circumstances, and a standard suitable for one place may be too high or too low for another. . . . Hence it may be said that there seems no convincing reason why, generally speaking, the absence of typical B. coli from 100 c.c. of water in a majority of representative samples should not be taken as a 'working standard.'" Were the water passing through the filters at Shrewsbury intended for potable purposes (which it is not, since another pure supply is available), the extreme limit of absence of B. coli in 100 c.c. would have to be required, since the river is known to be polluted by sewage. Severn water almost invariably contains B. coli in 1 c.c., and sometimes in 1/10th c.c., and the filtered water contains usually B. coli in 50 c.c., and sometimes in so small a quantity as 10 c.c. In the samples taken four weeks ago at several days' interval, B. coli were found in 1 c.c. of the river water, and in one out of three 10 c.c. tubes of filtered water. This result cannot be considered satisfactory from a hygienic point of view.

It may appear irrelevant to quote Shrewsbury results, since the water is not used for potable purposes but I have in mind other towns which receive their general water supply from rivers, only mechanical filtration being employed for purification before reaching the consumer.

These filters have no selective action on B. coli, and so not on B. typhosus. Bacillus coli is taken to be an index of danger of pollution by B. typhosus. Should the water be polluted from the discharges of a typhoid patient, the filters, while acting as a medium of dilution of the poison, would not act as an effectual safeguard. On this account mechanical filtration alone cannot be depended upon to render a polluted water; or one suspected of pollution, satisfactory for potable purposes.

Recourse must be had to other methods of rendering the water safe—for example, preliminary storage or sterilization. Preliminary storage for a sufficient length of time, as recommended by Houston, will render the water free from Bacillus typhosus, the number of other bacteria being lessened at the same time. Houston recommends thirty days' storage, although, from the results of his experiments to determine the viability of "uncultivated" typhoid bacillus in water, one would consider a fortnight a sufficient length of time to render the water practically "safe." In his observations on raw Thames water stored for about fifteen days at Chelsea, he found that the organisms were reduced, taking one year's samples, on an average 95.3 per cent., the B. coli content being also reduced proportionately. If the typhoid bacillus is killed by sufficient storage, mechanical filtration, it may be concluded, is all that is necessary for the stored water to reduce the total organisms to an amount which cannot be objected to, and to render it fit for potable purposes. Further, storage accommodation could be the means of excluding flood water, and so equalizing the quality of the raw water, and avoiding undue strain on the filters. If, as stated by Houston, slow sand filters without preliminary storage will remove 98 per cent. of the bacteria, mechanical filtration, which removes well over 90 per cent., should be all that is necessary for water which has been stored for a sufficient length of time. At York, mechanical filters without coagulant are used instead of storage to reduce the number of organisms, the filtered water passing on to slow sand filters before being supplied to the consumer, the total bacterial content being reduced by both processes to 99.1 per cent. I should, however, consider storage with mechanical filtration preferable to mechanical filtration plus slow sand filters as possessing a greater degree of safety.

As to sterilization of water, I shall simply allude to experience of sterilization at Shrewsbury. The river water is not used for potable purposes; but to render it safe, should it be so used, it was decided to treat it with an anti-bacterial agent. On the recommendation of Dr.

Rideal, sodium hypochlorite, with 12 per cent. available chlorine, was employed, and gave striking results. The treatment was commenced in June, 1910, and has been employed ever since with small intervals for experiments. By experiment it was found that 1 part of chlorine to 2,000,000 parts of water rendered the water practically sterile, without a trace of chlorine being evident on testing by means of starch and potassium iodide. When the treated water is examined in quantities of 3 c.c., organisms are usually absent, although at times there may be as many as 12 organisms per c.c. present. But the striking result is in the B. coli content. Repeated examinations have shown B. coli to be absent in 250 c.c. of water, and in a few examinations made of 500 c.c. a negative result has been obtained; the water may therefore be considered a safe water even for drinking purposes. As to the presence of chlorine in the treated water, no complaints have been made since the first few days of the experiments, when 1 part of chlorine in 1,000,000 parts of water was added, and then it was detected by the starch and iodide test; but daily testings for free chlorine, from July 11, 1910, to December 6, 1911, gave consistently negative results.

In this country there is some prejudice against the addition of chemicals to water for the purpose of purification, and it may be appropriate to consider at this point whether any alumina passes through the filters into the general supply. Delépine found no excess of alumina in the treated water over the untreated. Molyneux, at Stockport, found a film on the bottom of the service reservoir, which has a storage capacity of twenty-four hours, and through which 400,000,000 gallons of water had passed in the eighteen months before being inspected.

At Shrewsbury the service reservoir, with a capacity of slightly over 250,000 gallons, was found, after a year, to have a film of brownish flocculent material of a thickness of ½ in. over the bottom. This film was found to be composed chiefly of hydrate of alumina and iron, derived, presumably, from the coagulant added. The capacity of the reservoir allows an average rest of five hours for the treated water before reaching the consumer, and gives sufficient time for sedimentation; but when one considers that over 400,000,000 gallons of water passed through the reservoir in twelve months, the small amount of deposit may be considered negligible. Repeated tests of the filtered water as supplied to the consumer have failed to show the presence of alumina, so that it may be accepted that if alumina does pass through the filter at times, its amount is negligible from the physiological aspect.

Merits of Mechanical Filters and Slow Sand Filters.—There is ample evidence that, under ordinary circumstances and with careful supervision, the slow sand filter is slightly more efficient in reducing the number of bacteria present in the raw water. The reduction, however, varies just as with the mechanical filter in accordance with the amount of care devoted to the management of the filtering process. Even with careful management the results with the sand filter may not come up to one's expectations. Houston states that the slow sand filter removes 98 per cent. of the bacteria, but at Bolton a comparison of the results of slow sand filters and mechanical filters dealing with the same water showed a percentage purification of 88.8 for the former and 95.6 for the latter.

For the removal of suspended particles, coloring matter, iron in solution, or plumbo-solvent action from a water derived from a source free from human pollution, the mechanical filter appears to be the filter of choice. But, given a water polluted, or suspected of being polluted, without sufficient storage of raw water, or without sterilization of the treated water, the slow sand filter gives a slightly greater measure of safety. Mechanical filtration combined with storage, however, can be depended upon to give a water which can be considered satisfactory from a public health standpoint. Whether sterilization of a polluted water can be depended on under all circumstances remains to be proved. So far it has not had a sufficient trial.

In tropical countries, and in active warfare, mechanical filters, combined with a sterilization process, seems the best method of coping with the difficult conditions.

Further advantages of the mechanical process over slow sand filtration are less capital cost, variously estimated at one-third to one-half that of slow sand filters; economy of space; working under cover; ease of management and cleansing; no interference of supply during cleansing; and less cost of maintenance. Ross and Race have estimated the maintenance charges in connection with a slow sand filter, and with mechanical filters of two types dealing with the same water. They found that the cost per 1,000,000 gallons of water treated by sand filtration was 12s. 11d., and by the mechanical filters 9s. 8d. and 9s. 7d. respectively. These observers give the capital cost of the filters per 1,000,000 gallons of water filtered as £7,989 10s. for the sand filters, and £3,623 4s. and £3,458 4s. respectively for the two types of mechanical filters—Bell's and Mather & Platt's—and the yearly cost per 1,000,000 gallons of £1 13s. 3d., £1 3s. 7d. and £1 2s. 10d., calculating on the loan periods allowed by the Local Government Board. Delépine quotes Dixon, who gives the cost of dealing with 1,000,000 gallons of water by means of Mather & Platt's filters as 9s. 5d. for treatment and maintenance, and an annual cost of 14s. for one installation, and 14s. 8½d. per 1,000,000 gallons for a second installation, taking the annual charges on capital on a forty years' loan basis.

Mechanical filtration, therefore, possesses considerable advantages over slow sand filtration, the chief being the lower capital outlay and the lower maintenance cost. Taking into account the efficiency of these filters, along with the economy in their installation and management, I believe that slow sand filters will be superseded in many cases where formerly they were considered absolutely essential.

SCOTTISH ROAD TESTS.

Road tests are being made in Scotland with eight forms of construction, of a nature which might apply to a very large area of the Scottish roads—covering practically all the county roads. They are:—

(1) Ordinary water-bound macadam.

(2) Ordinary water-bound macadam, surface-sealed with distilled tar.

(3) Macadam, 3 in. thick, grouted with a mixture of pitch and sand.

(4) Macadam, 3 in. thick, grouted with pitch alone.

(5) Macadam, 3 in. thick, grouted with a mixture of Trinidad asphalt and distilled tar.

(6) Ordinary tar-macadam—i.e., tarred whinstone metal surface-sealed with distilled tar.

(7) Tar-macadam—i.e., whinstone metal with a binding mixture of asphalt and distilled tar.

(8) Ordinary tar-macadam, surface-sealed with a prepared bituminous mixture.

The roads selected are what may be termed "main" or "through" county roads. They average about 18 ft. in width.

The Intercolonial Railway is asking for tenders for 1,000 steel box cars and 20 locomotives. Part of the rolling stock of the road has had to be loaned to the Transcontinental.

FOUNDATIONS FOR TRANSMISSION TOWERS.

THERE is a broad field open for engineers in the design and construction of transmission towers and foundations. A series of papers presented last week at the 32nd annual convention of the American Institute of Electrical Engineers brought forth some good descriptions and explanations of various types of towers, foundations, and methods of construction. One of these relates to the towers of the two 60,000-volt lines of the Toronto Power Company, extending between Niagara Falls and Toronto. This paper, by Mr. F. C. Connery, presents some very interesting details of field practice, and alternatives adopted to dispense with massive concrete tower foundations. We are indebted to the paper for the following information.

Fig. 1 shows foundations used in connection with one type of tower. About 100 sets of these footings have been dug up after being in use seven years, and in no instance has the galvanizing deteriorated, and the 3 by 6 by 24-in. impregnated wooden blocks, with a few exceptions, were in a fair state of preservation. These foundations were located in various kinds of soil.

In connection with another type of tower impregnated blocks were not used, nor were any precautions taken, other than the hot-galvanizing, to prevent corrosion of the steel. Six of these towers were erected in low marshy black-muck, no resistance being encountered with borings at 40 ft.

A two-inch plank sheathing was driven around each tower-leg location, the muck dug out and a floating foundation built six feet below the ground surface; this consisted of impregnated two-inch planking, the footings being set in concrete, approximately one yard of cement being placed around and under each stub, the excavations being 30 in. by 30 in. by 6 ft. These towers have been erected for one year and have neither settled nor gotten out of alignment.

Great care was taken in connection with the locating of towers, so as to avoid, where possible, soft marshy soil

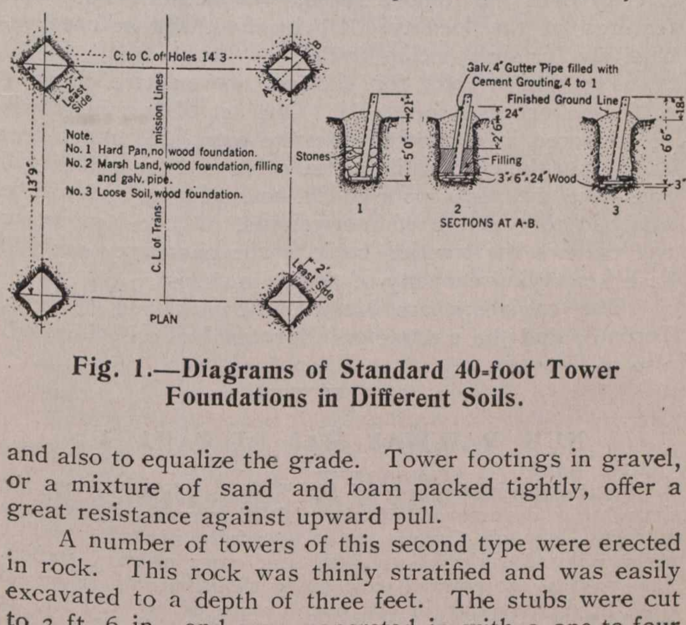


Fig. 1.—Diagrams of Standard 40-foot Tower Foundations in Different Soils.

and also to equalize the grade. Tower footings in gravel, or a mixture of sand and loam packed tightly, offer a great resistance against upward pull.

A number of towers of this second type were erected in rock. This rock was thinly stratified and was easily excavated to a depth of three feet. The stubs were cut to 3 ft. 6 in., and were concreted in with a one-to-four mixture. This construction has proved satisfactory.

In a type of narrow-base latticed tower, the foundations were built in two ways.

(*a*) A foundation 6 ft. by 6 ft. by 6 ft. with twelve 1¼-in. anchor bolts 5 ft. 6 in. long. This was a one-three-five concrete mixture.

(*b*) Foundations 6 ft. by 6 ft. and varying in depths were built in the following manner:

Excavation was taken out, copper grounding-ribbon placed, and 12 inches of one-three-five concrete placed and tamped. No anchor bolts were used, but the tower was erected on this 12-in. base, and then the excavation filled with one-three-five concrete. This method being used on account of the variation in the dimension of the bases of these towers. Minimum depth, 6 ft.

Construction of Footing.—Eleven of these footings were constructed in the waters of Lake Ontario at Burlington Beach, Ont., the mean depth of water being about three feet.

A double coffer-dam was built of 2 by 8-in. tongued and grooved spruce, driven to a depth of 10 feet below the

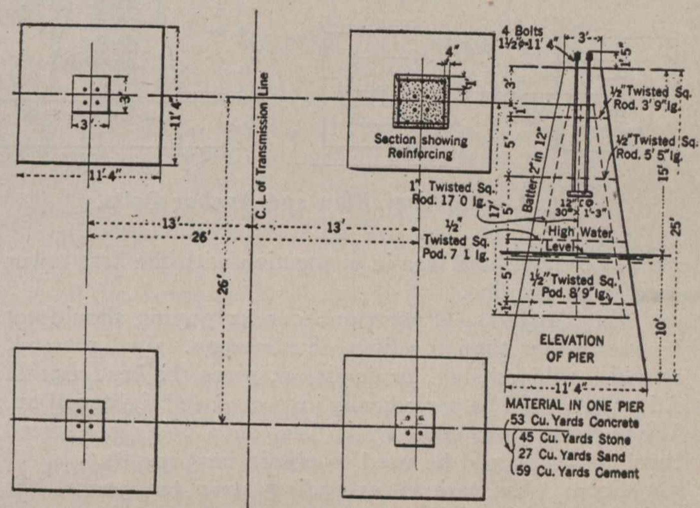


Fig. 2.—Foundation Plan for Lake Towers.

lake bottom by a small steam hammer. The water was pumped out, and sand and gravel excavated to a depth of six feet below the lake bottom, where very coarse gravel was encountered.

The foundations were then constructed as shown, the spruce sheeting being left in to protect against scouring. After the foundations were complete, a tallis of 10-inch rock, each piece weighing from 500 to 1,500 lb., was built around the two outer footings of each foundation for extra protection, the location of these towers being on a shore where storms from the east are very prevalent.

Method of Setting Stubs.—A template was used with success in the setting of stubs. This template was carried by the setting-gang, lined up on the centre line stakes and levelled by the gang foreman by means of a carpenter's level, and then blocked up and checked.

The stubs were bolted to the template and the filling in of holes proceeded with. One man back-filled while two men tamped. Special attention on the part of the foreman should be given to the tamping, as workmen are apt to do this in a careless manner. Where water was available it was used to settle the back-filling.

The towers were assembled at the locations where they were to be erected, and were erected with a shear-leg outfit. From eight to twelve towers of the second type mentioned were erected in one day by eight men and one team.

Mr. Connery used portable derricks, gin-poles, etc., for erecting towers, and believes the shear-leg method to be the most efficient, except where cramped for room, when the gin-pole should be used.

The shear-legs used, were constructed in the following manner: Two pieces of 6-in. by 8-in. clear Georgia pine, 34 ft. long were bolted together with a 1-in. by 14-in. through bolt, 14 inches from the top. This, along with a set of 12-in. triple blocks, hand-lines, anchor-pins, etc., makes a cheap and serviceable erecting outfit. The above outfit was used in the erection of a line of 928 towers averaging 2¼ tons each, and only one mishap occurred, this being caused by negligence on the part of the foreman in charge, and was in connection with the first tower erected on the line.

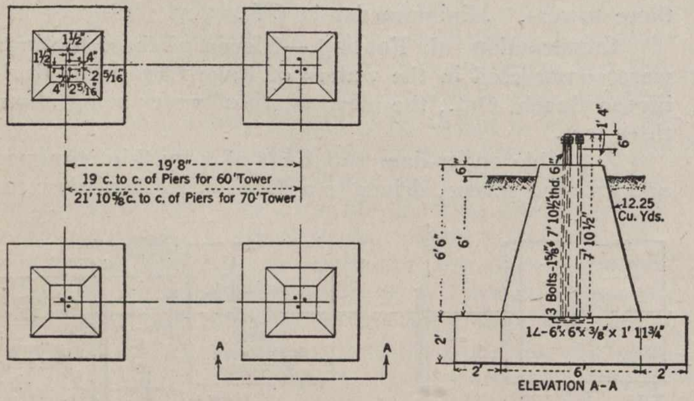


Fig. 3.—Masonry Plan and Anchor Bolts.

Guy Anchors.—Patent anchors for guying should not be used other than for light construction. In light soil, an old-fashioned slug, or deadman, gives the best results. All guys should be periodically inspected and tightened up. When more than one guy is used on a pole, galvanized turnbuckles should be used to obtain best results.

From observations extending over ten years, the writer states that fully 40 per cent. of the guys in use are inefficient, this condition being due to lack of inspection. To obtain the best results in guying, the anchor should be placed at a distance from the base of the pole equal to one-third the height.

In using rock-bolts for anchoring, care should be taken, if the rock is covered with a layer of earth, to place the anchor so that the ring is just above the surface of the rock; then fasten a long link to the ring, and guy to this. This method will give much better results than if the ring had been left above the surface of the ground and guy attached to it, as the anchor rod will bend in the latter case. These rock-bolts should be grouted in with hot brimstone.

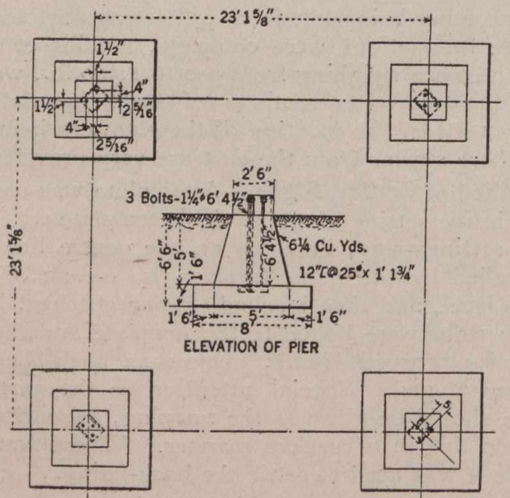


Fig. 4.—Foundation Plan for 75-foot Heavy Strain Towers.

The company is now designing tower footings which include the following points:—

(1) A modification of an ordinary screw-type guy anchor, similar to the Matthews or Stombaugh anchor, with the top of the anchor rod shaped to take the tower leg; this for towers of light wind-mill type.

(2) For heavy anchor, long-span, towers, etc. A large foot-plate supported on a shallow concrete footing sufficient to give a good bearing, and an anchor similar to those mentioned above, with the exception that the end of the bolt will be threaded to take a nut and locknut.

(3) For extra heavy, or four-circuit towers. A large section screw-pile with top plate to which the tower foot plate can be bolted.

The question of threading an ordinary wooden pile is also offered for consideration. There are locations on almost every line where marshy land or muskeg is encountered, and it is usually a very expensive operation to use a pile-driving outfit in these locations.

In connection with this method, it has been found that it is not necessary to drive a pile to refusal to obtain a good footing for a standard tower, as there is sufficient skin friction developed by the pile in the upper layers of the ground to give satisfactory results. Twenty-five-foot piles have been found satisfactory in very swampy ground, where borings had been taken to a depth of forty feet without striking firm soil.

AERIAL PASSENGER TRAMWAY OVER NIAGARA RIVER.

The Niagara-Spanish Aero-Car Company, representing the Estudios Y Obras de Ingenieria, of Bilbao, Spain, are proceeding to build an aerial tramway across the Niagara Whirlpool, from a location near Colts' Point to Thompson's Point, both terminals being on the Canadian side, in Stamford township of Welland county. The cableway will have a span of about 1,800 feet, and, in crossing directly over the famous rapid, will add to the scenic features of the locality. Obviously it will be used exclusively for sight-seeing traffic.

The design calls for six-inch woven wire carrying cables on one traction cable. One set of terminals will be anchored in reinforced concrete piers, set a few feet back from the cliff, while at the other end the cables will pass over sheaves supported on steel columns and will be attached to concrete counterweights. A 200-h.p. motor will operate the traction cable. The passenger car will have a carrying capacity of about 30 people.

The engineers are Messrs. Howard and Wright, Toronto, and the contractors Norman McLeod, Limited, also of Toronto.

NEW RAILWAY MAP OF CANADA.

At the special request of Sir Thomas Shaughnessy, the draughting department of the C.P.R. recently prepared a splendid map of Canada, most carefully plotted, showing every railroad right up to date, and every railroad station. The original map, which cost many thousands of dollars to prepare, is hanging in the board room of the C.P.R., at Montreal. Permission has been given by the C.P.R. to Ewing, Lovelace and Tremblay, consulting engineers, Montreal, to reproduce the map, as Mr. James Ewing, of that firm, was in charge of the preparation of the original. Splendid reproductions, only slightly reduced in size, have been printed, and are being sold, either hand colored or uncolored, by Mr. Ewing, Birks Building, Montreal, at very reasonable prices.

MONTREAL'S FILTER PROBLEM.

THE Board of Control and City Council in Montreal evidently do not see alike as to the necessity of extending the filtration plant at present under construction. A few weeks ago a press dispatch had it that an additional $900,000 filter would be necessary to provide for the insufficiency of capacity of the present plant, when the latter would be ready for use. The aldermen will not hear of it, however.

It was in 1909 that the Montreal City Council first took up the problem of filtered water, but it was in July, 1911, that tenders were finally called. As a preliminary, however, sterilization of the water by chloride of lime was begun in 1910.

Two years ago there was a serious set-back to the completion of the plant, owing to its huge foundation walls being injured by frost. The contractors put up a plea that the city was responsible for the mishap, as the site selected was not good, and law suits against the corporation were threatened. Experts were called in, an examination of the site was made and the verdict given that there were no ground for the charge of the contractors. At this juncture the civic authorities threatened to take over the work and have it completed under civic management. Matters were patched up, however.

The original plans called for a filtering capacity of 50,000,000 gallons; it was held that this would be sufficient for many years to come. Now comes the report of the controllers that the consumption of water is such that, if the plant is to be efficient the capacity for filtering must be 100,000,000 gallons—just double.

The site of the plant is mostly in the town of Verdun, and occupies about eighty-five acres. The system is that of double filtration. After being conveyed to the filtration pumping station, the water from the aqueduct will be lifted to the prefilters, then will flow by gravity to another set of filters, and then to the filtered water reservoir; it will then be forced, by electric power, to the reservoirs in Mount Royal and distributed throughout the city.

The filtration pumping station will be equipped with motor-driven centrifugal pumps, to lift the raw water to the prefilters, and the filtered water to the wash tower. The filtered water reservoir will be 230 feet wide, and 426 feet long.

Seven gate houses and numerous conduits complete the main structure of the filtration works. The superstructure of the pumping station, prefilter gallery, wash tower and gate houses, will be of reinforced concrete.

The filtered water reservoir, and the final filters, are to be partly above and partly below the present surface of the ground. It is the intention to beautify the entire surroundings by planting shrubbery. The vicinity will also be made attractive for park purposes. The original wheel house will be entirely removed and in its place a new hydro-electric power building approximately 600 feet long and 50 feet wide will be erected.

The controllers are proposing to spend about $4,500,000 on improvements to the water supply system, to be distributed as follows: Land, $225,000; fencing, $35,000; draining ditches, $25,000; culverts, $15,000; entrance to aqueduct, $475,000; entrance gates, $100,000; bridges, $560,000; retaining walls, including $110,000 for additional plain concrete, $675,000 ($2,110,000 in all); hydro-electric power house, $1,500,000; $900,000 for the second filter, giving a total of $4,500,000.

Messrs. Hering, Fuller and Gregory, consulting engineers, New York, recommended the construction of the new filter, and the strengthening of the retaining walls for supporting the banks of the aqueduct excavation. The Board of Control was advised that as the proposed capacity of the filter, not yet completed, has already been surpassed by the quantity of water consumed, the time had come to double the capacity of the filters, or in other words, to provide for a daily consumption of 100,000,000 gallons of water instead of 50,000,000.

Respecting the additional filter recommended, Mr. Fuller advised that the mechanical type be used, as it would give satisfactory results and would be more economical than the present double filtration system.

The estimates supplied to the Board for the additional 50-million-gallon filter were: Double filtration (present type), $1,750,000; slow sand filtration, $2,100,000; mechanical filtration, $900,000.

CANAL TUNNELS.

The first modern tunnel constructed for commercial transportation was the Malpas tunnel on the Langguedoc Canal in France. It was 515 ft. long, 22 ft. wide, and 27 ft. high, and was built between 1679 and 1681 by Riquet. No more canal tunnels were driven in France until nearly 100 years later, the Rive de Gier tunnel (1,656 ft. long) being constructed on the Givors Canal in 1770, and the Torcy tunnel (3,970 ft. long) on the Centre Canal in 1787. The Tronquoy and the Riqueval tunnels on the St. Quentin Canal were started in 1803, and the Noireu tunnel (approximately 39,400 ft. in length) on the same canal, was begun in 1822. On the Bourgoyne Canal, the St. Aignan tunnel was started in 1824, so that by the middle of the 19th century nearly 20 canal tunnels, with a total length of nearly 93,500 ft., had been constructed in France.

The earliest transportation tunnel in England was the Harecastle, on the Grand Trunk Canal, which was begun in 1766, and opened for traffic in 1777. This tunnel was 8,640 ft. in length, 9 ft. wide, and 12 ft. high. There were originally four other shorter tunnels on this canal. The Harecastle tunnel was replaced in 1824 by a parallel tunnel which was 16 ft. high and 14 ft. wide, 4 ft. 9 in. of the width being used for a towpath. The Sapperton tunnel on the Thames-Medway Canal was started in 1783. It was approximately 12,500 ft. long, and its construction took six years. The next large canal tunnel in England was the Blisworth (9,250 ft. long), on the Grand Junction Canal. It was started in 1798, and required seven years for its completion. In 1856 there were over 45 tunnels on the various English canals, aggregating some 220,000 ft. in length.

The first canal in the United States was the Auburn tunnel at the Orwisburg on the Schuylkill Navigation Canal. The tunnel (which was 450 ft. long, 20 ft. wide, and 18 ft. high) was begun in 1818, and opened for traffic in 1821. The tunnel was made an open cut in 1855-56. The Summit Level, or Lebanon tunnel, on the Union Canal, was begun in 1824, and finished in 1826. It was originally 720 ft. long, 18 ft. wide, and 15 ft. high. It was followed by the Conemaugh and Grant's Hill tunnels on the western division of the Pennsylvania Canal (1827-30); the Pawpaw tunnel, on the Chesapeake and Ohio Canal (1836); and two tunnels on the Sandy and Beaver Canal, Ohio (1836-38).

A new plant is in operation in the Maritime Provinces, manufacturing trinitro-toluol, a new high explosive. About 800,000 lbs. per month of the explosive will be turned out. Other plants are under construction.

NOTES ON PLANE TABLE WORK.*

By C. R. Westland.

In choosing points for determining elevations, choose points at any general change of grade, and in general take enough points to fix the contours closely, or to be able to closely determine them by interpilation. Contours crossing streams almost always run well up the stream when near the water line, and do not cross abruptly.

Prominent topographical features too far distant to get rod readings on, may often be cut in by intersections from two stations, a cut from a third station being taken as a rule, as a check. The elevation of the point can be determined by reading the angle of elevation or depression from one of the stations, noting it down along the cut when taken at the first station, where it will be convenient for use when the distance to the point is found.

Readings should, as a rule, be taken on more than one corner of a building in order to locate it properly, as, otherwise, when the rodmen bring in their sketch of it, the orientation of it would be incorrect when plotted. Often, when a second point can not be conveniently obtained, the orientation of the building may be determined by pacing the offset to the produced side of the building, the second point being thus unnecessary.

In cutting in hilltops, etc., a prominent tree, boulder, or something which can be seen from the various stations should be used if possible. Otherwise a third cut will not pass through point as determined by the first two cuts. If the tree tops were sighted on for elevation, a quantity, to allow for the height of the trees will have to be deducted from the computed elevation, to obtain the approximate elevation of the hill top.

The buildings are sketched by a rodman on a small pad which he carries, the sides being paced and entered on the sketch in feet or metres, according to the scale being used. On this sketch he should also mark the position of the points rodded, as well as the approximate direction of the table.

If a station off the main traverse is desired, the rodman can choose a point from which a good view of the country to be reached can be obtained, and after rodding it, mark the point with a hub. The instrument man can best orient the table at this new station if, when plotting the previous station, he draws two fine cuts, one at each end of the straight-edge, marking them similarly so they will be easily recognizable at the next station, where it will be used. These two cuts give an accurate long line along which to lay the straight-edge when preparing to orient the table at the new station. Several stations are often chosen from one set-up, and unless the various pairs of cuts are marked, mistakes will possibly occur in orienting the table, by using the wrong ones. This would, of course, ruin any work at this station or continued from it. It thus follows that the correct orienting of the table is of primary importance.

In setting up at a station, do not set the centre of the table over the point, but, with the table roughly oriented and levelled, set the point itself, as plotted, over the point on the ground. When the table is levelled and oriented the centreing can be checked by plumb-bob, and if out, can be adjusted, the relevelling and reorienting necessary, not affecting the centreing to any extent. The table should be carefully levelled up, so that, the alidade being in adjustment, the bubble will remain in centre when the vernier reads zero, for all positions of the alidade.

*From paper presented at the annual meeting in January last of the Dominion Land Surveyors' Association.

To orient the table at any station, lay the straight-edge along the cuts, but in the reverse direction to what it was when the cuts were made, and, with the clamp on the instrument head loose, so the table can move freely, bring the cross-hair onto the picket at the station where this station was established from. The tangent screw can be used to set accurately. The table must be very firmly clamped as any error in orientation should be prevented.

A striding level is provided with the alidade. This can be adjusted by the end-for-end adjustment so that the bubble is parallel to the telescope to which it can be attached. For station sights or for any long sights, or for any important points the level should be used, in order to get the index error to apply to the vertical angle.

The collimation of the central wire, and also of the vertical wire, can be corrected by the regular method of turning the telescope about its own axis 180 degrees and bringing half way back by the small screws at the sides of the reticule. The vertical cross-hair must also be made truly vertical. This can be done by setting the upper end of the cross-hair on a point and then elevating the telescope until the point appears at the other end of the cross-hair. If the point is off the wire correct by the adjusting screws on either side, under the telescope on the shoulders which prevent the telescope from turning through more than 180 degrees.

The vernier should read zero when the bubble of the striding level, after adjusting, is in centre. If it does not, make it read zero by the adjusting screw on the vernier, the bubble, of course, being kept in centre.

If the table is warped or of uneven surface in any way, the alidade will not lie firmly, but will rock slightly. If this be the case, the table should either be exchanged or planed down. Until this is done, the index error must be determined with the striding level for all readings.

When inconvenient to read the whole interval, on the outside wires a half interval or a quarter interval may be read and the quantity multiplied by the correct amount, although doing so usually means some loss of accuracy. In many cases the reading of fractional intervals is unavoidable, either on account of obstructions hiding the rod for the most part, or on account of the distance. In some cases even eighth intervals are useful, though not suitable for important sights. In taking readings through trees, etc., many sights could not be taken except by using any two wires that can be made to read on the rod.

For computing elevations, Stadia Slide Rules are used, or when not available, the following rule is much used:—

$$\frac{\text{Angle in minutes} \times \text{distance in meters}}{1{,}000} \times \frac{19}{20} = \text{change in elevation in feet.}$$

This rule is very accurate for all ordinary angles and distances, but above 10° the error begins to be noticeable, and for larger angles a correction should be applied to the result obtained.

Distance.	Angle.	Error in feet.
100″	10°	0.0
100″	15°	0.6
100″	20°	1.8

To obtain the proper elevation angle after reading the stadia distance, the middle wire must be set on the rod at the height of instrument, or if this can not be seen, then at some known point on the rod, the distance of which from the height of instrument can be measured, and the correction applied to the computed difference of elevation. For rough contour points, the top of the rod can often be taken as being 5 feet above the height of instrument.

Heat and moisture will change seriously the scale of the paper so should be avoided. In damp or misty weather, or when the dew is falling, the paper will expand, while, in the sun it will contract. An umbrella and holder is provided as a protection against the sun. If celluloid sheets be used instead of paper, the weather will not affect them, and work can be carried on, mists and slight drizzles having no effect. The sheets will require to be shaded from the sun, however, as when paper is used, as the reflection from the table is very hard on the eyes, and also the sighting is very difficult when facing the sun, unless the telescope is shaded. Celluloid sheets, though not so large as the paper, are particularly convenient for lake work, etc., as getting wet does not injure them.

The far shore of a river or pond or small lake can often be plotted from points obtained in an indirect manner. The station must be well above the water in elevation and this elevation known. Points on the far shore can be chosen, as many as required, and the angle of depression to the height of instrument at them, very carefully read and corrected for index error by bubble. Now, the change of elevation being known and the angle of depression being known, the distance can be computed and the point plotted as usual.

When running, roughly speaking, in one direction for a long distance the orientation can sometimes be kept correct by choosing, at one of the first stations, a well-defined point on the horizon, as nearly in line with the general direction of the traverse as possible, and making a long cut on it. The orientation can be checked at any station by setting the straight-edge very carefully along this cut, and then if the cross-hair does not pass through the distant point cut on, make it do so by moving the table with the tangent screw.

All lines should be drawn finely and carefully, close to the edge of the rule of the alidade. With the alidade and table in proper condition, the contact of the rule with the paper will be continuous throughout its entire length, and in drawing a line along the edge care must be taken to keep the pencil at the same inclination, otherwise, the pencil point will deviate from a straight line. The same error will occur if the pencil point is not kept finely sharpened. This will also be the case if the straight-edge should be raised above the paper at any point, unless great care is taken that the point of the pencil does not run under the rule. For cuts, etc., the pencil should be very hard, a chisel edge being often used. For detail work, such as sketching contours, etc., a somewhat softer pencil will be found better, though it will require more attention to keep it sufficiently sharp. A very convenient and useful pencil sharpener is made by pasting a small strip of fine sand paper on a piece of wood of the same size. The pencil points can be readily touched up at any time by rubbing along this strip.

Often the triangulation is being carried on at the same time as the topography, or, if completed, has not been computed and so cannot be plotted. In this case, not only can the work be controlled by tying onto the stations, or occupying them when possible, but cuts can be taken from plane table stations well distributed over the work. Three cuts per station are necessary, and four much preferred. When the triangulation is plotted these stations can be correctly plotted, graphically or as regular three-point problems. Thus the topography can be regularly adjusted to these stations, the stations as plotted in the field being superimposed on the correctly plotted ones, any small discrepancies being distributed proportionately.

In determining the elevation of a new station, it will be found that it will be much more accurate to not only compute the difference of elevation from the angle read at the old station, but to also take a reverse reading for angle and recompute the difference of elevation and take the mean of the two determinations as the true difference. On hot days or other days when the refraction is bad, the difference between the two determinations will often be very large, but by using the means carefully, very little error will result, especially if the two determinations have been made within a short time of each other when the atmospheric conditions were the same. A traverse run in this manner for a great many stations will close very closely on a B.M. at the end of the traverse. The lengths of the courses will also be more accurate if read in both a direct and reverse direction and the mean taken.

In small lake and river work long sights can be read across the water if the conditions are right, especially if the sun is on the instrument man's back, when it will then make the rod very easily read on. The work can often be arranged so that a number of stations shall always be available for occupation, those where the sights will be away from the sun in the morning being used then and the others will then be suitable for the afternoon.

On lake or river work stations can sometimes be best carried on by forming quadrilaterals with them, two being used as a base, to cut in two others from, these two thus cut in, being used in turn as a base from which to establish two other points to form a new quadrilateral. By using this method of intersections, the errors due to using poorly determined distances, and which often accumulate to a considerable quantity, will be eliminated. Occasionally a distance between two points, obtained by intersections from two other stations can be checked by stadia, and then corrected for any error.

If the stadia wires are rules on glass, they sometimes give a great deal of trouble on account of their indistinctness, as the fine material filling the lines comes out. By using great care this may be remedied by applying very lightly, with a piece of soft material such as chamois, etc., a little of the carbon deposited on a saucer, when a candle is burned underneath it. The glass reticule, if wiped gently in a direction at right angles to the lines, will retain in the lines enough of the carbon to make the lines very distinct for stadia purposes. If the lines appear to be too heavy, the reticule can be again gently wiped, until the desired fineness of line is obtained.

A correction for curvature of the earth, when computing elevations from very long sights, will be necessary. This correction is always +ve. That is, a point is always higher above sea-level than it would be computed to be, using distance and vertical angle only. Thus, if an angle of depression be read, the proper correction will be, − computed amount + correction for curvature. And if an angle of elevation has been read, the correction will be, + computed amount + correction for curvature.

The following rule is usually used for curvature:—

Correction for curvature = 8″ × (No. of miles)$_2$

For distances up to ten miles, when curvature would have to be allowed for, no correction for refraction is, as a rule, made. If applied it is always —ve, thus making the curvature correction smaller by a small amount. For distance under ten miles, the refraction correction is so small compared to the error that may be made in reading the vertical angle, as the alidade only reads to minutes, it is usually omitted.

If 7″ be used in the rule in place of 8″, the correction will be very nearly right for both curvature and refraction.

Example 1.—Elevation of station occupied is 100 feet. Angle of elevation read to hilltop 6 miles away is 2 min.

Apparent correction to get hilltop elevation	=	+ 18.3 ft.
Curvature correction $8'' \times 6^2$	=	+ 24.0 ft.
Refrac. corr. (— negligible small quantity)		
True correction to apply to get hilltop	=	+ 42.3 ft.
∴ Elevation to hilltop	=	142.3 ft.

Example 2.—Elevation of station occupied is 100 feet. Angle of depression to a point 6 miles away is 6 minutes.

Apparent corr. to get elevation of point..	=	— 55.3 ft.
Correction for curvature	=	+ 24.0 ft.
True correction to get elevation of point..	=	— 31.3 ft.
∴ True elevation of point	=	68.7 ft.

Example 3.—Elevation of hilltop 6 miles away is 100 ft. Angle of elevation to hilltop is 2 minutes.

Apparent amount hill is higher than station occupied	=	+ 18.4 ft.
Curvature correction	=	+ 24.0 ft.
True amount hill is higher than station occupied	=	+ 42.4 ft.
But elevation of hilltop is 100 ft.		
∴ Elevation of station occupied	=	57.6 ft.

Example 4.—Elevation of point 6 miles away is 100 ft. Angle of depression to point is 6 minutes.

Apparent amount point is lower than station occupied	=	55.3 ft.
Curvature correction	=	+ 24.0 ft.
True amount point is lower than station occupied	=	31.3 ft.
But elevation of distinct point is 100 ft.		
∴ Elevation of station occupied	=	131.3 ft.

In the case of very long sights for head-lines, the distance can often be much more accurately determined by breaking the line up into two or, if necessary, three parts, and reading each part separately. The whole distance can be read as a check, when the rodman is rodding the station. The rodman can then come in towards the table along the line of sight until he is close enough to the table for the distance to be read accurately. This is then done, the rodman marking the spot temporarily. The remainder of the distance, if the line has been divided into two sections, can then be determined, either by setting up temporarily at the intermediate marked point when going to the new station and sending the rodman ahead to the station, or by occupying the new station, and then sending the rodman back to the intermediate point, when the remainder of the distance can be accurately read, the sum of the two sections thus determined giving the plotting distance of the station from the last station. The error caused by setting up the table at the new station without having the station accurately determined can be neglected as a rule, as the true position of the point will be only a very small distance from the point as plotted from the check distance read at first. When more than two sections of a line are used, each section can be read from temporary set-ups at the intermediate points, the sum of them being plotted along the cut made at the first station. The angle for computing the elevation of the new station should also have been read at the time the cut was made at the first station.

The Plane Table Three-point Problem.—By means of this three-point method a station may be established at any desired point, where a good view of the surrounding country can be obtained, and if the position of the point chosen is not known on the sheet, it can now be found by means of the re-section of lines from three fixed points whose positions on the sheet have already been plotted. The great advantages of the plane table for mapping purposes are due to the rapidity with which it obtains results by the use of the graphic method of triangulation, and also by the facility with which the topographer may determine his position in the field, by means of graphically solving the three-point problem. The three-point method is only applicable when the country is fairly open and the signals and points whose positions are plotted on the sheet may easily be seen. Under these circumstances, it is manifestly much superior to ordinary methods, as the topographer is quite free to choose his station without any reference to a previous station. No backsight has limited his choice of position or the necessity for a satisfactory foresight. To secure this commanding view he need not preliminarily set up his table at a point of little value as regards detail, or traverse to the position by lines cut through obstacles of all kinds, such as woods, etc.

The number and position of plane table stations are governed by the extent of the work and by the amount of information desired to be shown on the map. Thus, when the three-point method can be employed a great saving naturally results, in stations occupied, as otherwise many comparatively useless set-ups will probably be found necessary in order to carry the line forward. And as considerable time is used up for each set-up made, the saving totals to a considerable amount.

When the point selected on the sheet as representing the actual point occupied is not correctly chosen, the table thus not being truly oriented, the lines drawn from the three projected points, when sighting on the corresponding actual points, will not intersect at one point—the point incorrectly chosen to represent the point occupied, unless this point lies along the circumference of the circle passing through the three fixed points on the ground, known as the great circle, the triangle formed by the three fixed points on the ground being known as the great triangle. Except for this case, which gives an indeterminate position for the point sought, and which can usually be avoided in choosing the three fixed points to be used, the three resection lines will either form a triangle, known as the triangle of error, or, if not forming a triangle, two of the lines will be parallel, intersected by the third.

To obtain the three resection lines, the edge of the alidade is carefully laid along a line drawn to cut the point chosen to represent the point occupied and one of the plotted fixed points, the eye-piece of the telescope at the same end of the line as the point chosen to represent the point occupied. The table is now turned until the actual point represented by the fixed point cut by the alidade comes onto the vertical cross wire of the telescope. The table is now clamped in this position, and with the edge of the alidade cutting through the plotted position of the second fixed point, the telescope is pointed so that the actual second point is on the wire. A line is now drawn to cut the first line. Now, with the edge of the alidade passing through the plotted position of the third fixed point and the actual third point on the wire, draw a third line. This line will either cut the other two lines or be parallel to one line and cut the remaining one. Of course, if the three lines intersect at one point, no further work is necessary, as the point of intersection is the point sought, and the table will be properly oriented in its present position. However, as the three lines rarely intersect in one point, there is usually the triangle of error, or, when the point chosen on the sheet is in range with two of the fixed points, the two lines cut by the third.

Before proceeding with the solution of the three-point problem, a statement of the importance of the relative position of the three fixed points with reference to the new station being determined, will be of value, since their position governs the strength of the determination made, though, of course, it is not always possible to pick and choose the stations, on account of the limited number available for use.

(a) When the new station is outside the great circle, the strength of the position determined will be weak when the new station is some distance from the circle, as the angles will be small. The determination increases in strength for given angles as the middle point approaches the new station.

When one angle is small or zero (when the points are in range), the determination will be strong, provided the two points making the small angle or in range are not too near each other compared to the distances to the new station or to the third station; also provided that the angle to the third point is not too small.

(b) When the new station is within the great circle, the strength of the determination increases as it approaches the centre of gravity of the great triangle (formed by the three fixed points).

(c) When the new station lies on or near the great circle, its position is indeterminate, since it is obvious that all points on the circle will have the same angles subtended by the fixed points.

The method of solution known as Lehmann's method is the simplest and most direct, and is always applicable. There are a number of other graphic solutions, some of them often unsuited for field application. The directions for Lehmann's method are best expressed in the form of rules, or conditions.

The point sought is understood to mean the true position on the sheet of the station occupied.

The topographer is assumed to be facing the signals in the field and the directions right and left are given accordingly.

Rule 1.—When the triangle of error is inside the great triangle, formed by three fixed points, then the point sought must be within the triangle of error.

Rule 2.—When the triangle of error is outside the great triangle, then the point sought will be outside the triangle of error. In this case, the position of the point must be such that it is to the right of all the lines drawn from the station occupied in the direction of the three fixed points, or to the left of all these lines. Of the six sectors formed by the three lines, it can be seen that only two will fulfil this condition.

Rule 3.—The exact position for the point sought is now determined by the condition that the distances of the point from the lines drawn must be proportional to distances that the actual respective fixed points are from the station occupied.

General Rule.—The point sought is always distant from each of the three lines drawn from the three fixed points in proportion to the distances of the actual corresponding points from the station occupied, and it will always be found on the corresponding side of each of the lines drawn from the fixed points. When the point sought has been estimated and plotted from the foregoing rules, a new orientation should be made, and if the lines now drawn from the three stations intersect at that point, it proves the estimate to have been correct, and the table is now properly oriented for work. If a new triangle of error is formed it indicates that an erroneous estimate has been made, and the operation must be repeated. The smaller the triangle of error, the closer the estimated position of the new station is to the true position sought.

If there has been any distortion of the sheet, due to exposure to atmospheric conditions, since the fixed points nave been plotted on it, the triangle of error obviously cannot be wholly eliminated, as the relative position of the plotted points will not remain the same as the position of the points on the ground.

RAILROAD EARNINGS.

The following are the railway earnings for the first three weeks in June:—

Canadian Pacific Railway.

	1915.	1914.	Decrease.
June 7	$1,585,000	$2,171,000	— $586,000
June 14	1,623,000	2,158,000	— 535,000
June 21	1,619,000	2,185,000	— 566,000

Grand Trunk Railway.

June 7	$ 958,977	$ 996,040	— $ 37,063
June 14	949,313	1,000,639	— 51,326
June 21	989,072	1,042,646	— 53,574

Canadian Northern Railway.

June 7	$ 247,500	$ 383,800	— $109,300
June 14	268,600	353,100	— 84,500
June 21	278,900	406,100	— 127,200

The Canadian Northern Railway's statement of earnings and operating expenses for the month of May is as follows:—

	1915.	1914.	Inc. or dec.
Gross earnings	$1,193,900	$1,641,600	— $447,700
Expenses	871,000	1,160,000	— 289,000
Net earnings	322,900	481,600	— 158,700
Mileage in operation	4,965	4,670	+ 295

The figures from July 1st, 1914, to May 31st, 1915, compare as follows:—

	1915	1914.	Inc. or dec.
Gross earnings	$16,024,300	$21,045,400	— $5,021,100
Expenses	11,530,900	15,157,000	— 3,626,100
Net earnings	4,493,400	5,888,400	— 1,395,000
Mileage in operation.	4,770	4,553	+ 217

The Canadian Pacific Railway's gross and net earnings for May were as follows: Gross earnings, $7,261,496; working expenses, $4,818,494; net profits, $2,443,002.

For eleven months ending May 31st, 1915:—Gross earnings, $91,353,176; working expenses, $50,456,580; net profits, $30,896,596.

In May, 1914, net profits were $2,963,012, and for the eleven months ended May 31st, 1914, $39,090,303. The decrease for May was $520,010, and for the eleven months $8,193,707.

BRITISH PIG IRON AND FERRO-MANGANESE IN 1914.

The British pig iron output in 1914, according to the British Iron Trade Association, was 9,005,898 gross tons, compared with 10,481,917 tons in 1913, a decrease of 1,476,019 tons, or 14.2 per cent. The 1912 output was 8,889,124 tons. The figures for 1914 include 3,430,448 tons of forge and foundry iron, 3,235,403 tons of Bessemer hematite, 2,003,693 tons of basic iron and 336,354 tons of spiegeleisen, ferro-manganese, etc. The production of ferro-manganese and spiegeleisen in 1914 was only 19,035 tons less than in 1913, when it was 355,389 tons. In 1912 it was only 277,240 tons. The 1914 output was the largest since 1905, except that of 1913.

DESIGN OF RECTANGULAR CONCRETE BEAMS.

THE resisting moment of a reinforced concrete beam, in inch-pounds, may be represented by the formula: Resisting moment = $R\ b\ d^2$, where b is the breadth of the beam in inches, d is the effective depth in inches, and R is a numerical co-efficient. The value of R (for a given ratio of the modulus of elasticity of steel to that of concrete) depends upon the percentage of steel reinforcement used and the safe working stresses for steel and concrete. In the case of reinforcement in excess of cross-sections permitted by steel specifications, have prompted the plotting of the equations involved in order to arrive by a direct and speedy method at the result desired. The reader is referred to Mr. D. A. Molitor's article on "Reinforced Concrete Design" in *The Canadian Engineer* for March 11th, 1915, for a very complete set of graphic diagrams for use in the design of various members.

The accompanying diagrams are similar in purpose with respect to rectangular concrete beams, but differ in that the logarithmic method has been employed. They

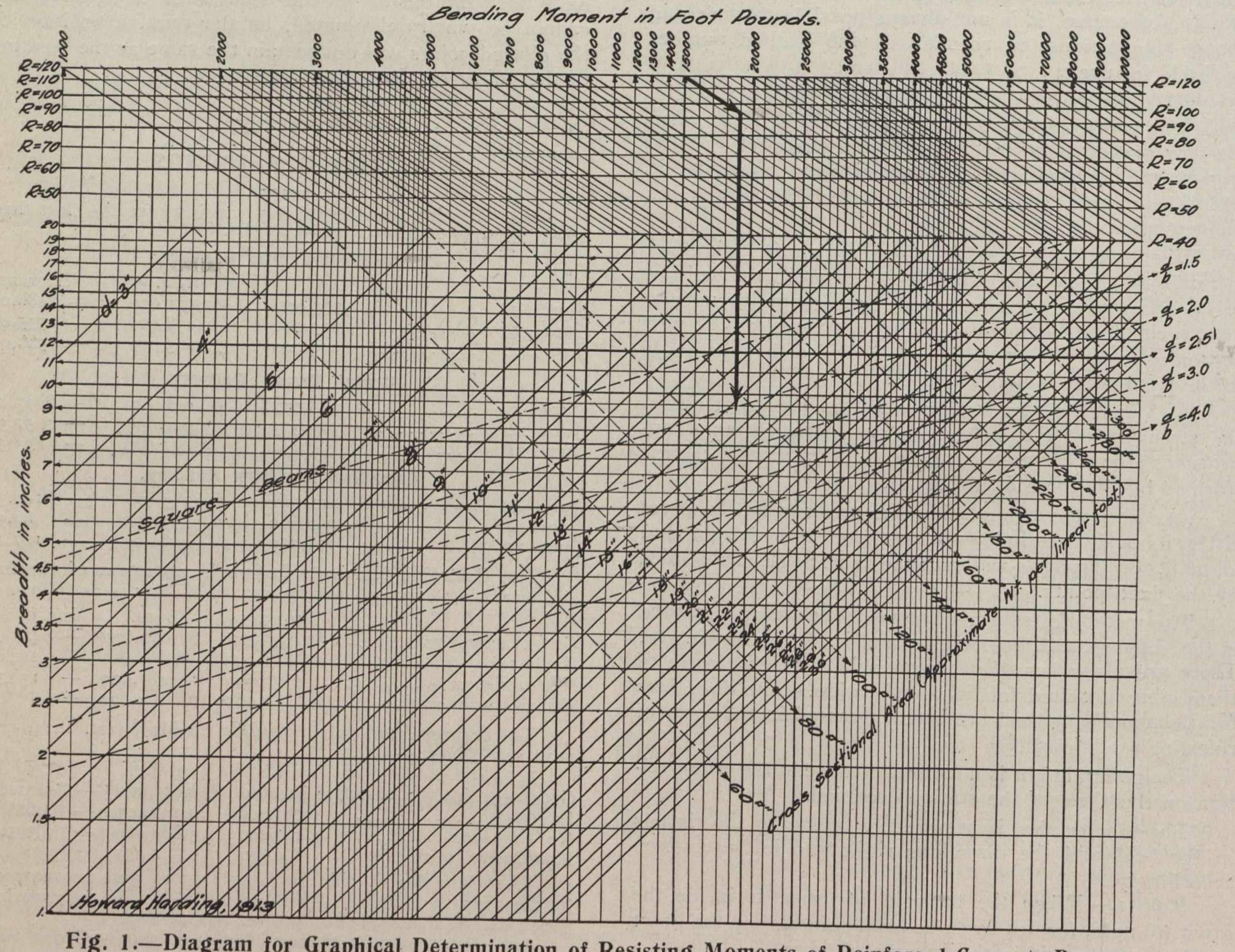


Fig. 1.—Diagram for Graphical Determination of Resisting Moments of Reinforced Concrete Beams.

the amount required to properly divide the working stresses there is a slight gain in strength due to the shifting of the neutral axis toward the steel. When the concrete has reached its working stress the steel will still be under-stressed. In such cases the value of R used must be the one corresponding to the working stress of concrete and the percentage of reinforcement. The ordinary way of using the data thus given is that of "cut and try," but to arrive at the final dimensions some allowance must be made for the dead weight of the beam and such allowance will necessarily depend largely upon the span for which the beam is to be used. The method is, accordingly, very indirect and round-about.

The solution of beam, column, floor slab and like problems in reinforced concrete design depends for extreme accuracy upon such analytical computations. Dissatisfying experience with unwieldy methods, coupled with the percentages of variation in ultimate strength and are from a paper presented at a meeting last month of the American Society of Mechanical Engineers by Mr. Howard Harding, Rochester, N.Y. The paper outlines the development of the two diagrams and the adopted method of facilitating the mechanical worth of solution. Diagram 1 gives the dimensions of beams just strong enough to withstand safely any desired bending moment, while Diagram 2 gives factors by which the dimensions obtained from the first diagram are multiplied in order to correct for the bending moment due to the dead weight of the beam itself.

The method of using the first diagram is described by the author as follows:—

First decide upon the working stresses and determine the corresponding value of R and the percentage of reinforcement. Then compute the bending moment in foot-pounds which it is desired that the beam should withstand. Locate the bending moment thus computed at the top of the diagram, Fig. 1. Thence proceed parallel to the oblique lines until the value of R previously determined is intersected. From this intersection proceed vertically downward into the lower part of the diagram intersecting the horizontal lines representing breadth, and the oblique lines representing depth. At any one of these intersections the required breadth and depth may be read. Any of the corresponding values will satisfy the condition for strength, but the values chosen will depend upon the shape of beam desired. If we wish a certain ratio of depth to breadth we can obtain it by stopping at the dotted line representing that ratio. If a certain depth or a certain

to give the beam enough additional strength to support its own dead weight the diagram (Fig. 2) is used as follows: Starting on the depth scale at a point representing the depth first determined, follow oblique line up or down to intersect value of R that is being used. Thence follow vertically downward to intersect the line representing the span of the beam. If both dimensions are to be increased the value of k may be obtained by proceeding thence horizontally to the left-hand scale. If one dimension only is to be increased (the other being kept at the value first determined) proceed horizontally to the right to intersect the proper scale.

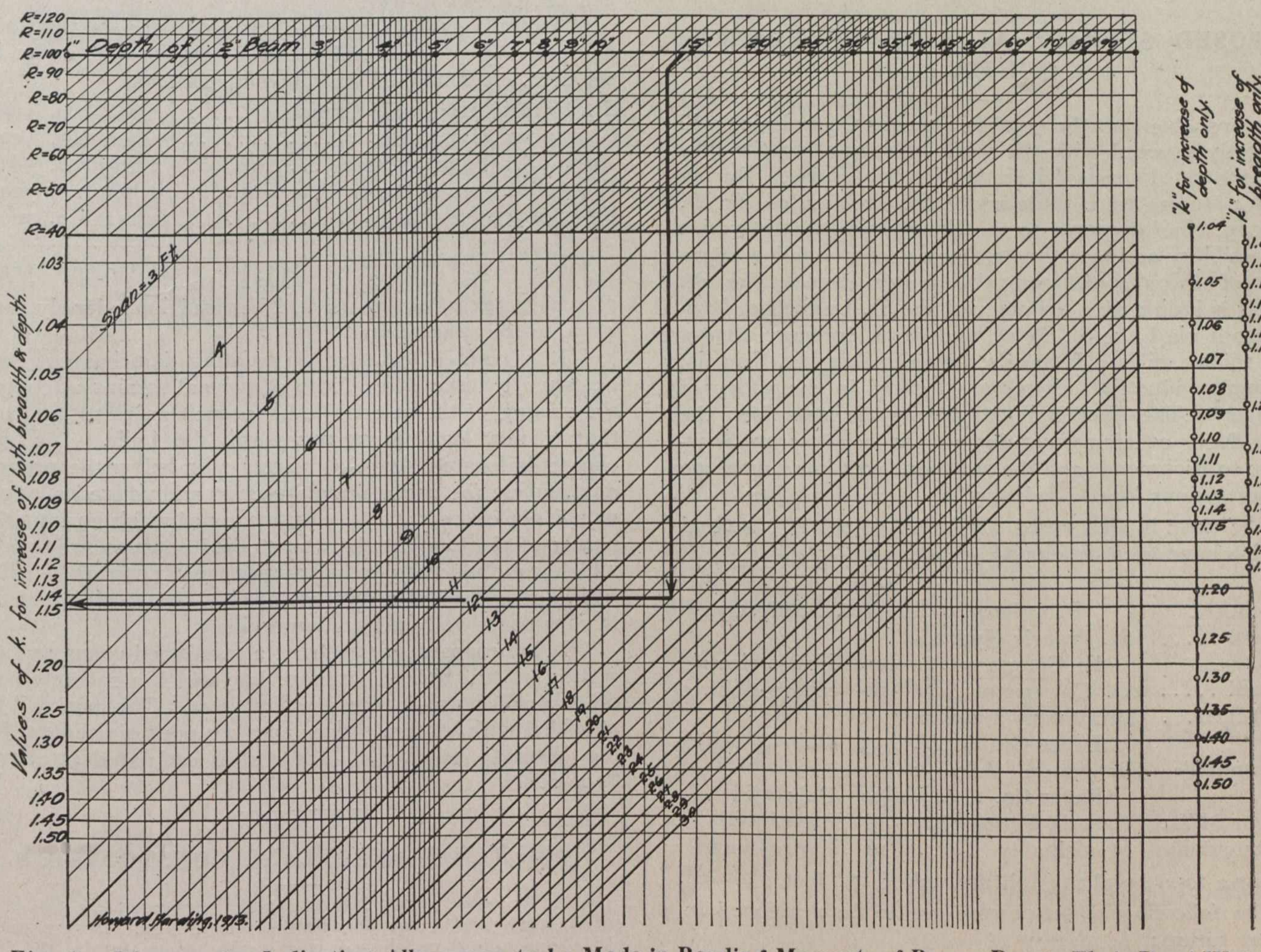


Fig. 2.—Diagram for Indicating Allowances to be Made in Bending Moments of Beams Due to Their Dead Weight.

breadth is desired it is necessary to proceed vertically downward until said depth or breadth is intersected and the point of intersection automatically determines the value of the other dimension.

In a beam of dimensions as determined by the use of the diagram no allowance has been made, as already stated, for the bending moment on the beam due to its own dead weight. To take care of this additional bending moment either one or both of the dimensions must be increased. To determine the amount of increase necessary for different spans and types of beams the second diagram (Fig. 2) has been developed.

The strength of the beam may be increased in three different ways, *viz.*, (*a*) by increasing both breadth and depth, (*b*) by increasing depth only, and (*c*) by increasing breadth only.

In order to find the correction factor by which one or both of the beam dimensions must be multiplied in order

In conclusion, the writer works out the following typical example, presenting, at the same time, a very convenient and useful form of computation.

Span = 18 ft. Load = 370 lb. per linear ft.

$$\text{Bending moment} = \frac{w\,l^2}{8} = \frac{370 \times 18^2}{8} = 15{,}000 \text{ ft.-lb.}$$

Shear = 3,330 lb. + ½ weight of beam

f_s = 16,000 f_c = 600 R = 94% steel = 0.68 sq. steel rods

$b_1 \times d_1$	12.5 × 12.5	9.4 × 14.10	7.5 × 16
Corrector	1.17	1.145	1.136
$b \times d$	14.6 × 14.6	10.8 × 16.1	8.5 × 18.2
b d	213	133	120
Unit shear	25	35	37
Steel	4 ⅝-in. bars, or 3 11/16-in. bars	3 9/16-in. bars, or 2 11/16-in. bars	3 9/16-in. bars, or 2 11/16-in. bars

The above tabulation shows three beams which would be suitable. The one which best suits the rest of the structural design may be used. The correction factor used was the one corresponding to the increase in both dimensions. It should be noted that *d* represents the effective depth, and the distance from the steel reinforcing to the bottom of the beam must be added to get the total depth. This "cover" portion of the beam has been neglected in all of the computations for strength. The determination of the second beam in the tabulated form is plainly indicated on the diagrams so that the method of using them ought to be readily understood.

PROPOSED STORAGE AT LAKE ST. FRANCIS, QUEBEC.

It is probable that the Quebec Streams Commission will shortly proceed with the work of regulating the flow of the St. Francis River and its tributaries. During 1914 studies were made under the direction of Mr. O. Lefebvre, chief engineer to the Commission, to determine the possibility and to estimate the cost of a complete regulation of the run-off from this water shed. The St. Francis is indirectly a tributary of the St. Lawrence, flowing into it via Lake St. Peter, and has a drainage area of 3,931 square miles. It has its source in Lake St. Francis, and many industrial centres are located in the valley of the river. The river is noted for its variable flow, the spring floods causing great damage, especially from Sherbrooke to Richmond, and the summer and winter shortage causing serious loss to industry.

The river is also noted for its water-powers, several of which have been developed, as follows:—

Location.	Proprietor.	Head in feet.	Nature of industry.
D'Israeli	St. Francis Hydraulic Company ...	40	Hydro-electric
D'Israeli	D. Champoux	20	Hydro-electric
East Angus...	Brompton Pulp & Paper Co.	55	Pulp & paper
Bromptonville.	Brompton Pulp & Paper Co.	30	Pulp mill
Windsor Mills.	Canada Paper Co..	16	Paper mill
Drummondville	Municipality	10	Hydro-electric

forming a total height of fall utilized of 171 feet.

The following water-powers are to be developed in the near future:

Two Miles Falls	30 feet
Drummondville	25 "
Hemming Falls	35 "
Spicer Rapids	60 "
forming a total of	150 feet

There is at present at the foot of Lake St. Francis a large wooden dam with rock and earth fill. It is the joint property of the Brompton Pulp and Paper Co. and the St. Francis Hydraulic Co. and is capable of storing water to a height of about 12 ft. above low-water level. It is provided with eight open sluiceways, a sluiceway for logs and a bottom sluice and gate. Water is not allowed to rise above the crest of the dam, the sluiceways being opened in the spring to pass all surplus water from the basin. The storage at elevation 112 is 169 sq.-mile-feet, and is used for power purposes and log driving.

The Commission proposes to construct a dam providing a storage with an average capacity of 438 sq.-mile-feet, the storage level being increased about 15 feet in height.

Owing to the proximity of the hydro-electric plant of the St. Francis Hydraulic Company, which must draw all the water it requires from Lake St. Francis, the flow from the outlet of the lake must be constant during the entire year. This average volume will be 56 square-mile-feet per month, equivalent to 600 second-feet.

The minimum flow of this basin is about 100 second-feet, measured last winter. This leaves an increase of 500 second-feet for complete regulation.

The present storage can supply a constant flow of 300 second-feet. The increase above the present storage will be 300 second-feet.

According to the report of the engineers of the Commission, this storage will create a total power, under 80 per cent. efficiency, of the following amount:

St. Francis Hydraulic Company	1,818 h.p. years
Champoux (D'Israeli)	909 h.p. years
Two Miles Falls (70 feet)	2,386 h.p. years
Brompton Pulp & Paper Company....	1,545 h.p. years
Balance 500 feet head	15,152 h.p. years
	21,810 h.p. years

of which 5,060 h.p. years will be used immediately, and 4,659 in the near future.

It is pointed out that the existing dam has not been designed to take care of the additional strains attending the raising of the storage level to such an elevation, and that a new dam must necessarily be built. The site chosen is located about a quarter mile below the present dam, where the banks are quite steep and where its length would not exceed 566 ft. By means of wash borings the nature of the foundations was studied down to solid rock, which was found at depths varying from 14 to 48 ft. The bed is composed of a mixture of clay and small boulders, is very dense and appears impervious.

It is proposed to construct a reinforced concrete dam resting on this bed of hardpan, into which a concrete cut-off wall will be sunk to a depth of 20 ft. The dam will be provided with bottom sluices and two open sluiceways for the passage of logs. The cost is estimated at about $100,000.

TIMBER FOR AEROPLANE CONSTRUCTION.

Pacific coast spruce, known as silver spruce is the only satisfactory timber for aeroplane construction. Large quantities are being purchased continually to maintain the air service of the Allies. The quality demanded is absolutely clear and straight grained, 3 to 6 inches in thickness, 10-14 inches and up in width, 10 feet and up in length, but preferably over 18 feet long. One order for 800,000 feet has been placed, according to the Department of Trade and Commerce, the price in London, where all the stocks are carried, has varied from $170 to $250 per M feet b.m.

This timber is purchased from merchants in the United Kingdom. The merchants buy direct from agents or brokers who represent Pacific coast shippers or exporters. Liner shipments of 50,000 to 100,000 feet b.m. are in demand

Clear Pacific coast spruce in thin stock, one-half inch in thickness, is at times in demand for use in building certain types of naval vessels. Such stock is purchased from the supplies carried by dealers in Great Britain.

The increase in the use of electricity, which is rapidly overtaking steam power in Ontario, is shown by the Factory Inspection Branch of the Department of Agriculture in a statement of the horse-power employed in provincial industries as follows: steam, 386,767 h.p.; electric, 273,357 h.p.; water, 58,896 h.p.; gas or gasoline, 7,042 h.p.

STRENGTH OF CONCRETE-FILLED PIPE COLUMNS.

An investigation of the strength and elastic properties of concrete-filled pipe columns is reported by Messrs. F. W. Swain and A. F. Holmes, in a paper read at the 18th annual meeting of the American Society for Testing Materials, a couple of weeks ago. The object was to determine whether a column, made by filling a steel pipe with concrete, was perfectly elastic under the lower loads, whether it had a definite elastic limit, and if such proved to be the case, to determine the stress in the concrete and in the steel at this load. The columns used in the tests ranged in size from a 4-in. light-weight boiler tube to a 6⅝-in. standard-weight steam pipe, and were all filled with a 1 : 2 : 3 mixture of concrete with ½-in. screened, crushed stone, 8 by 8 by 24-in. test blocks of the concrete being cast at the same time and in the same way.

The methods employed in the making of these test columns were as follows: The pipes were placed on end on the flat table of a specially constructed machine, and were then filled with machine-mixed concrete from an overhead hopper. Air was admitted to a cylinder under the table of this machine, lifting the machine some two inches. A release of the air allowed the table with its load to drop freely, and with a considerable shock, upon the heavy base of the machine. This jarring process was

TABLE I.—Results of Tests on Concrete-Filled Pipe Columns.

Column No.	Outside Diameter, in., and Kind.	Nominal Thickness, in.	Length, ft.	Ratio of Length to Diameter.	Weight, lb.		Ultimate Load, lb.	Average of Three Tests, lb.	Elastic Limit, lb.	Elastic Limit / Ultimate Load.
					Unfilled.	Filled.				
1	4—Light	9/64	8	24.0	44.5	137	85,400			
2	4— "	5/32	8	24.0	47.0	139	92,600	88,700		
3	4— "	9/64	8	24.0	46.0	139	88,200		20,000 (No. 3)	0.227
4	4— "	9/64	10	30.0	55.0	169	67,900			
5	4— "	9/64	10	30.0	61.0	168	78,400	74,900		
6	4— "	9/64	10	30.0	57.0	165	78,300			
7	5— "	5/32	10	24.0	80.0	263	165,100			
8	5— "	11/64	10	24.0	82.0	258	148,000	160,100		
9	5— "	5/32	10	24.0	80.0	265	167,300		45,000 (No. 9)	0.269
10	5— "	5/32	14	33.6	115.5	370	144,800			
11	5— "	5/32	14	33.6	110.5	364	145,300	143,100		
12	5— "	5/32	14	33.6	105.5	360	139,300			
13	6— "	11/64	10	20.0	101.0	365	210,000			
14	6— "	3/16	10	20.0	104.0	377	261,600	241,200	56,000 (No. 14)	0.214
15	6— "	3/16	10	20.0	105.0	377	251,900		73,500 (No. 15)	0.292
										Aver. = 0.253
16	6— "	3/16	14	28.0	147.0	522	199,900			
17	6— "	11/64	14	28.0	145.0	520	243,700	204,300		
18	6— "	3/16	14	28.0	144.5	512	169,300			
19	4—Heavy	7/32	8	24.0	69.0	155	147,400			
20	4— "	15/64	8	24.0	72.5	159	144,700	144,300	40,000 (No. 20)	0.277
21	4— "	7/32	8	24.0	71.0	156	140,900			
22	4— "	1/4	10	30.0	90.0	194	130,900			
23	4— "	15/64	10	30.0	91.0	194	133,100	129,700		
24	4— "	15/64	10	30.0	92.0	198	122,200			
25	5— "	1/4	10	24.0	124.5	295	200,200		60,000 (No. 25)	0.299
26	5— "	15/64	10	24.0	120.0	295	199,900	200,000		
27	5— "	15/64	10	24.0	121.0	291	199,900			
28	5— "	1/4	12	28.8	144.5	345	180,500			
29	5— "	1/4	12	28.8	151.0	357	199,900	196,500		
30	5— "	1/4	12	28.8	148.5	356	208,900			
31	6⅝— "	9/32	12	21.7	222.0	592	Not tested			
32	6⅝— "	17/64	12	21.7	215.0	592	303,300	304,200		
33	6⅝— "	9/32	12	21.7	221.5	597	305,000[a]		90,000 (No. 33)	0.295
34	6⅝— "	9/32	16	29.0	286.5	790	300,000 (not broken)			
35	6⅝— "	9/32	16	29.0	304.0	767	274,900			
36	6⅝— "	19/64	16	29.0	321.5	801	300,000 (not broken)			

[a] Failed at a load slightly above rated capacity of machine and was assumed to be 305,000 lb.

continued at the rate of about 150 shocks per minute, concrete being added at intervals, until there was no room for more.

After the concrete had become somewhat seasoned the ends of the columns were trued in the following manner: Each column was strapped in V-blocks on the horizontal table of a cup-wheel grinder and the wheel was brought up against the end of the column, then carried across the end, at right angles to the axis of the column. After each trip across, the grinder was set a little ahead before starting the return cut. This gave a perfectly square cut across the full area of the pipe and concrete. The column was then turned end for end and the grinding repeated.

The average metal area in the cross-section was determined from the weight of the pipe before it was filled, and this value was used in making all computations. The results of the tests on the columns are given in Table I.

The results show that the filled columns were perfectly elastic when subjected to the lower loads, no permanent set taking place until after the elastic limit was

Table II.—Elastic Limit of Concrete-Filled Pipe Columns.

Specimen. Con-crete.	Specimen. Col-umn.	Area of Steel, sq. in.	Total Equivalent Area, sq. in.	Stress in Concrete at Elastic Limit, lb. per sq. in.	Stress in Steel at Elastic Limit, lb. per sq. in.
A	..	....	64.0	1,170	....
..	3	1.69	27.10	740	7,100
..	9	2.35	39.85	1,130	10,800
..	14	3.06	54.58	*1,030	11,400
..	15	3.08	54.74	*1,350	
..	20	2.66	35.46	1,130	10,800
..	25	3.66	51.10	1,170	11,200
..	33	5.43	81.16	1,110	10,700

* Average = 1,190 lb. per sq. in.

reached. With the exception of one column the stress-deformation diagram consisted of two straight lines intersecting at the elastic limit.

It was evident that in the filled column the steel tube prevents the permanent set from taking place in the concrete below the elastic limit, and the assumption was therefore made that the stress-deformation diagram for the concrete, restrained by the pipe, was the same as would be obtained for the unrestrained concrete with the sets deducted. On this assumption and the further assumption that the modulus of elasticity of the steel pipe was 30,000,000 lb. per sq. in., we have the following, using the deformations recorded in Fig. 1:

From Diagram With Sets Deducted.—E_c = modulus of elasticity of concrete =

$$\frac{55{,}000 \times 20}{64 \times (0.0074 - 0.0011 - 0.0008)} = 3{,}125{,}000 \text{ lb. per sq. in.}$$

From Diagram With Sets Not Deducted.—E_c = modulus of elasticity of concrete =

$$\frac{55{,}000 \times 20}{64 \times (0.0074 - 0.0008)} = 2{,}605{,}000 \text{ lb. per sq. in.}$$

$$\frac{E_s}{E_c} = \frac{30{,}000{,}000}{3{,}125{,}000} = 9.6$$

Using this ratio of $E_s/E_c = 9.6$, the proportion of the load carried by the concrete and by the steel was determined and it was found that the stress in the concrete at the elastic limit checked almost exactly with the stress in the unrestrained concrete at its elastic limit. Therefore, it is evident that the elastic limit of the column was determined by the elastic limit of the enclosed concrete. The elastic limits of the columns are given in Table II., as well as the computations for column No. 25, which are typical.

An explanation of the low value obtained in the case of column No. 3 was found upon inspection of the deformation readings. The compression was confined almost entirely to one side, but whether this eccentric loading was due to a defective pipe or improper bearing is not known.

Calculations for Column No. 25.

Weight unfilled = 124.5 lb.
Outside diameter = 5 in.
Length = 10 ft.
Load at elastic limit = 60,000 lb.

$$\text{Area of steel in cross-section} = \frac{124.5 \times 144}{490 \times 10} = 3.66 \text{ sq. in.}$$

Area of concrete in cross-section = 19.64 — 3.66 = 15.98 sq. in.

Concrete equivalent of steel = 3.66 × 9.6 = 35.12 sq. in.

Total equivalent area = 15.98 + 35.12 = 51.10 sq. in.

$$\text{Stress in concrete at elastic limit} = \frac{60{,}000}{51.1} = 1{,}170 \text{ lb.}$$

per sq. in.

An investigation of the ratio in each case of the elastic limit to the ultimate load (see Table I.) would indicate that a load of at least 25 per cent. of the ultimate would

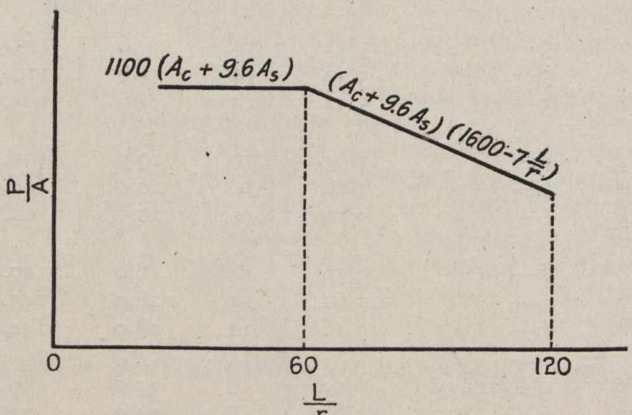


Fig. 1.—Formulas for Concrete-Filled Pipe Columns.

be a safe working load, and that an even higher value might be used in certain cases.

As a result of these tests the column formulas given in Fig. 1 were devised to take into account the stiffness of the column, and they were used in compiling a table of safe working loads to which concrete-filled columns of this

A_c = Area of concrete in cross-section.
A_s = Area of steel in cross-section.
E_c = Modulus of elasticity of concrete (sets deducted).
E_s = Modulus of elasticity of steel.
E_s/E_c = 9.6.
L = Length of column.
r = Radius of gyration (solid section).
P/A = Safe working load (lb. per sq. in.).

type could be subjected, when the values of L/r varied between 30 and 120. The formulas as given apply only to columns made of the same 1 : 2 : 3 mix of concrete as was used in filling the columns tested, but the constants could easily be modified to adapt them to any other mix.

COMPARISON OF BRIDGE COSTS.

In a paper before the Western Society of Engineers, Mr. C. N. Brainbridge goes into the subject of elimination of grade crossings. One feature of his discussion that bears considerable mention is a comparison of the costs of bridges of various types for use under or over the railway tracks, together with the advantages and disadvantages of the various types. The structures considered were those for 60, 66 and 80-foot streets. Table I. gives the general dimensions and features of the types selected for consideration.

All track-elevation bridges are two-track structures designed for Cooper's E-50 loading, with centre girders, and track and girders 13 ft. on centres. The floor depths are 3 ft. 6 in. for the steel bridges and 3 ft. 10 in. for the concrete. The steel bridges are figured with I-beam and concrete-slab floors. The abutments and pier footings are figured on the basis that the foundation is good for from 2 to 2½ tons per square foot. The overhead bridges are designed for a 24-ton concentrated load on two axles of 5-ft. gauge, 10 ft. on centres, and two 40-ton street cars, together with 150 lb. per square foot on the remainder of the bridge. The clearances are 20 ft. above top of rail. The floor depths are given in Table IV.

Table II. gives the estimated costs for the track-elevation bridges. No account is taken of the additional cost chargeable to the concrete structure due to the difference in thickness of floors, nor on the other hand to the additional cost of maintenance of the steel bridges. These amounts vary and tend to offset each other. Paving and sidewalks are figured for an assumed right-of-way of 100 ft. Rails, ties, ballast and drainage of subways are excluded, as common to all.

Table III. gives the estimated costs for the street bridges, where the streets are carried over the railroad. The quantities in each structure were given by Mr. Bainbridge, but space does not permit their publication here. The unit prices assumed for the estimate in Tables II. and III. are given in Table V.

Considering the different types of track-elevation bridges, the author pointed out that it is desirable to (1) keep the floor of the bridge as thin as possible; (2) avoid any projections above the top of rail which might be a menace to safety, and (3) select a type which can be readily

Table II.—Estimated Costs of Railroad Bridges Over Streets.

Type	Material	60-Foot Street		66-Foot Street		80-Foot Street	
		Two tracks	Each additional track	Two tracks	Each additional track	Two tracks	Each additional track
		$	$	$	$	$	$
A	Steel	16,400	6,000	18,000	6,700	21,700	8,000
B	Steel	15,000	5,400	16,500	5,800	19,200	6,900
C	Steel	15,500	5,500	17,100	6,000	18,000	6,800
D	Steel	14,900	5,100	16,000	5,500	17,800	6,300
D	Concrete	12,500	4,200	13,400	4,500	15,000	5,300

Table III.—Estimated Costs of Street Bridges Over the Railroad.

Type	60-Foot Street		66-Foot Street	
	Steel	Concrete	Steel	Concrete
E2	$12,900	$11,400	$15,100	$13,200
E3	14,700	13,200	17,100	14,700
E4	*17,800	......	*21,700	......
	†16,400	......	†19,600	......
	*24,200	......	*29,800	......
E6	†22,000	......	†26,500	......
F2	17,500	14,200	23,700	17,200
F4	20,500	17,100	27,000	20,400
F6	21,600	18,200	28,200	21,600

*Without centre girder. †With centre girder.

Table IV.—Floor Depths in Feet for Street Bridges.

Type	60-Foot Street		66-Foot Street	
	Steel	Concrete	Steel	Concrete
E2	3	3½	3	3½
E3	4½	5	4½	5
	*4	...	*4½	...
E4	†3	...	†3¼	...
	*4	...	*4½	...
E6	†3	...	†3¼	...
F2	3	3½	3½	3½
F4	3	3½	3½	3½
F6	3	3½	3½	3½

*Without centre girder. †With centre girder.

Table I.—Different Types of Bridges Available for Grade-Crossing Elimination.

Type.	General features.	Remarks.
		Railroad over 60, 66 or 80-foot street.
A	Single span	
B	Two spans, bent in centre of street	
C	Three spans, bents at curbs	Centres of curb bents 10½, 9½ and 16½ ft. respectively, from face of abutment for 60, 66 and 80-ft. street; 36-ft. roadways for the 60-ft. streets and 44-ft. for the others.
D	Four spans, curb and centre bents	
		60 or 66-foot over railroad.
E2	Single 29-ft. span over two tracks	All 60-ft. bridges designed for 12-ft. sidewalks and 36-ft. roadway; all 66-ft. bridges designed for 11-ft. sidewalks and 44-ft. roadway, including double-track car line.
E3	Single 42-ft. span over three tracks	
E4	Single 55-ft. span over four tracks	
E6	Single 81-ft. span over six tracks	
F2	Three spans over two tracks	Bents alongside tracks, 29 ft. face to face; natural slopes beyond bents, with low abutments at tops of slopes. All clear spans 29 ft.
F4	Three spans over four tracks	Same location for bents and abutments; abutments and slopes carried down part way to allow one track outside each bent, on 18-ft. centres with interior tracks.
F6	Three spans over six tracks	Same arrangement, with abutments carried down full depth to allow two tracks under each span.

altered to provide for additional tracks. All of the types lend themselves to the first qualification. Bridges of types A, B and C fail in part as to both the second and the third, but D, on account of the short spans, meets them more fully. Types B and D have the objectionable feature of obstructing the centre of the roadway.

Table V.—Unit Prices Used in Foregoing Estimates.

Item.	Unit.	Price.
Excavation for masonry	cubic yard	$ 1.00
Backfill—		
Types A-D	" "	0.25
Types E-F	" "	0.60
Concrete—		
Abutments, plain	" "	7.00
Abutments, reinforced	" "	10.00
Pier and column footings	" "	8.00
Columns, type D, concrete	" "	21.00
Columns, types F, concrete	" "	23.00
Floors, steel railroad bridges	" "	18.00
Slabs, type D, concrete	" "	14.00
Slabs, types E, steel	" "	20.00
Floors, types E2 and E3, concrete, and types F	" "	22.00
Waterproofing	square foot	0.20
Structural steel—		
Types A-D	pound	0.03
Types E-F	"	0.03¼
Falsework	linear foot	8.00
Paving, not on bridges	square yard	3.25
Paving, on bridges	" "	2.25
Concrete sidewalk, not on bridges	square foot	0.15
Concrete sidewalk on bridges	" "	0.40
Hand-rail, steel bridges	linear foot	1.50
Hand-rail, concrete bridges	" "	2.25
Engineering and contingencies	per cent.	20.0

For street bridges, with the tracks depressed, it is desirable to (1) keep the floors as thin as possible, (2) avoid any obstructions between tracks, and (3) select a type which can be readily altered to provide for additional tracks. Type E lends itself to the first condition, but usually not as well as type F. It fulfils the second but fails in the third. Type F, on the other hand, fulfils the third while failing to some extent in the second.

For an examination of the estimates, it can be seen that for a two-track or three-track proposition there is little to choose between the cost of bridges for track elevation and those for track depression. Concrete bridges of types D and E are respectively the cheapest types. As the number of tracks increases, however, type F gains the advantage over type E. If the distance between bridges is great this may be more than offset by the extra width of cut due to the wide track centres. In bridges of type E from $20 to $30 per linear foot, aside from the reduced grading, concrete, paving, etc., due to decreasing the floor depth 1 ft., can be saved by using the centre girder.

BIG ORDER FOR CARS.

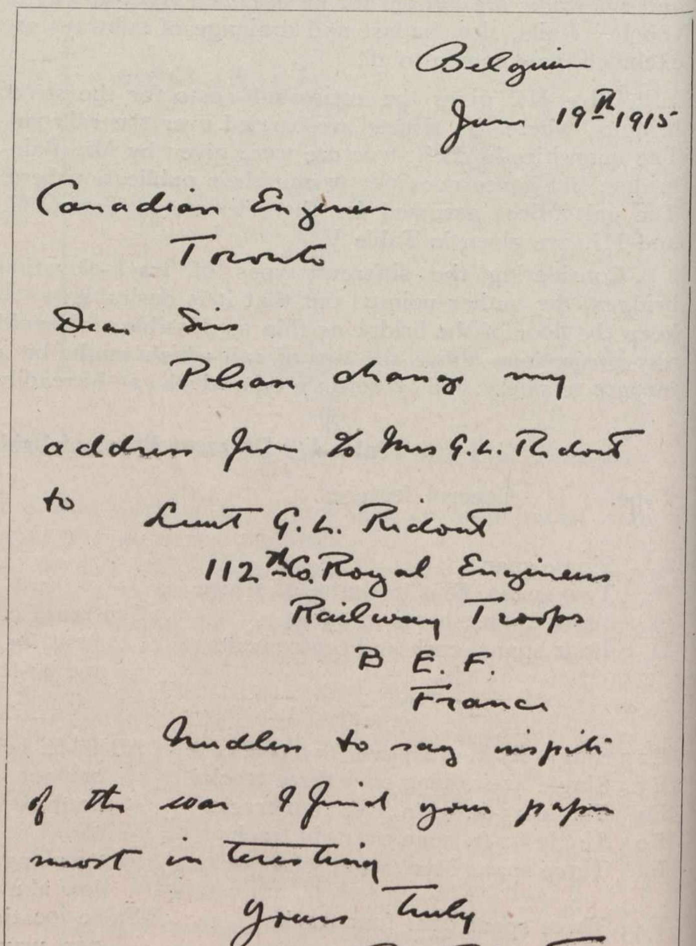
Orders for rolling stock aggregating $1,250,000, have been placed by the railway department for the government railways. The Canadian Locomotive Works is to supply 15 locomotives, while an order for 1,000 box cars is divided between the Canada Steel Car and Foundry Company, Montreal; the National Car Company, Hamilton; and the Eastern Car Company, Halifax. Delivery is to be ready by the crop moving period.

CANADIAN PULP PRODUCTION INCREASING.

Some economists have termed this the "paper age" from the increasing use of paper in all walks of life. This being the case it is gratifying to know that Canada is one of the great paper countries of the world and is destined to become still greater in this respect. All interested in paper and the materials from which it is produced, (pulp and pulpwood), look forward to the issue of the annual bulletin on "Pulpwood" by the forestry branch of the department of the interior. This has now been sent to the printer and a few of the leading facts from it may be given. In spite of the war the consumption of pulpwood in Canadian mills was over 10 per cent. greater in 1914 than in 1913.

Since 1910 the pulpwood consumed in Canadian mills has a little more than doubled. The consumption in 1910 was 598,487 cords and in 1914, 1,224,376 cords. The commonest and cheapest kind of pulp, made by the grinding process and known as ground-wood pulp, increased by 9 per cent. over 1913, but that made by chemical processes increased by over 14 per cent. This increasing use of chemical processes helps the country greatly as the product is worth nearly three times as much as the ground-wood pulp.

Quebec is still the leading province in pulp production, having 31 active mills out of a total of 66 mills for all Canada. Quebec produced 55 per cent. of all Canadian pulp in 1914. Ontario came second with nearly 37 per cent. of the total production and the other producing provinces in order were British Columbia, New Brunswick and Nova Scotia. The total value of pulpwood consumed in Canadian mills in 1914 was $8,089,868 and of that exported to foreign countries in a raw state $6,680,490, making a grand total of $14,770,358 for the value of the pulpwood produced last year. It is interesting to know that the proportion of pulpwood manufactured into pulp in Canada is increasing over that exported in the raw state.


Belgium
Jan 19th 1915

Canadian Engineer
Toronto

Dear Sir
Please change my address from c/o Mrs G. L. Ridout to Lieut G. L. Ridout
112th Co. Royal Engineers
Railway Troops
B. E. F.
France

Needless to say inspite of the war I find your paper most interesting

Yours truly
G. L. Ridout.

Editorial

FILTRATION OF WATER.

A natural filter possesses the defect that the manner of its operations is in some doubt, and although the filtration rate is not uniform over the entire surface at any particular place, the filtration rate at a given position is possibly as uniform as that of any artificial filter. Owing to the distance traversed by such waters the results of the process are doubtless less subject to quick change than those of any system of artificial filtration; and in this there is a distinct advantage, as uniformity of results is one of the most important matters in water purification.

It has been proved that not only will sand, in mass, hold back bacteria, but that surface soil, consisting of a mixture of earth and decaying vegetation, is an extremely valuable filter. Where artificial filtration is resorted to it is curious to note that the greater the water pressure the less active becomes the bacteria. Further, those which pass through the filters are almost invariably of a large size, the smaller microbes being apparently retained by adhesion. Properly devised sand filters will safely remove the bacteria of typhoid and other similar harmful organisms, provided there be but little nutriment in the water. In designing artificial filters, therefore, the engineer must work in co-operation with the chemist. In some localities double filtration may have to be resorted to as a safeguard. The engineer must therefore be well on his guard when advising the installation of sand filters for municipal, village, or country-house supply, and still more so when advising on filters for the purification of sewage, as they may receive a large amount of bacterial nutriment which may cause the bacteria present to be nourished and propagated therein. A point which the engineer must bear in mind in devising filtration systems for domestic water supply is that bulk storage must be arranged for whenever possible, as it has been found that not only does this reduce the hardness and improve the color of the water, but that storage reduces the number of harmful bacteria present to a much greater degree than it does those of other types.

ROAD ENGINEERING—MAKING EVERY DOLLAR COUNT.

Writing in the Montreal press relative to the condition of roads in the Province of Quebec, Mr. J. Stadler, of Shawinigan Falls, refers to the interesting report of certain Swiss engineers concerning North American highways, which concludes with the following statements:—

(1) The mileage of roads of macadam or similar construction is a very small percentage, compared with Switzerland, both as to area and population.

(2) The macadam roads of better class, built in the United States, differ very little from old Roman roads, but the general construction of their roads is on much lighter base with the consequent frequent deformation of the road surface under heavy traffic.

(3) The methods and implements employed in the construction of roads and the preparation of material are far superior to those in Switzerland. The large amount of special machinery employed is due to high rate of wages, which justifies their application.

(4) The machinery for preparation of road surface is very efficient, but the results obtained are very irregular, due to improper workings of successive layers, and neglect to take the subsoil into consideration.

(5) For surface treatment, special compounds and mixtures are employed in large quantities of different compositions, and by these surface materials are made to appear very efficient; but our observation shows that only bituminous surface treatments would be suitable for our roads, especially in the higher altitudes where temperatures go lower than in the section of the United States reported on.

(6) Insufficient cost-data is available to compare the maintenance of the surface-treated macadam of the United States with our ordinary macadam roads, but we believe that in most instances the poor base of the road does not justify any special surface treatment; a heavier base and in many instances a harder surface material would have reduced the upkeep considerably. Therefore our methods of applying surface treatment only after a few years is more economical, as any irregularities or settlement can easily be levelled in and the costly surfacing material applied economically on a settled base.

(7) The new roads in general are good, but the maintenance is insufficiently taken care of, no permanent organization being yet worked out. It also appears that politics have a large influence on the construction and this undoubtedly accounts for the high cost of routes in a good many instances.

No special appropriation seems to be set aside for the maintenance of roads built, which accounts for some state and municipal roads of recent construction being in a deplorable condition at some short sections.

(8) Canada has only very few miles of roads and considering the short time these roads have been built we cannot consider the routes as a factor for our report. Our general observation, however, is that for such climatic conditions, the roads are built rather for appearance than for durability; the drainage, such an important factor in cold climates, is grossly neglected; the depth of the porous material in a good many instances insufficient and for the amount of traffic; in a good many instances the width of macadam road is too large to present an economical investment.

Mr. Stadler states he noticed these defects in a number of newly constructed Quebec roads—poor base and insufficient drainage. Instead of using large stones or boulders in the base of certain roads, he has seen sand and stone dust employed, and scant provision made for withstanding heavy traffic. It is pointed out that there should be no difficulty in obtaining properly screened gravel or stone along the roadway, or large boulders for foundation, either. He calls attention to various other sections, built only last year and already badly in need of repairs and full of holes owing, not to surface wear, but to displacement and sinking of the foundation.

Mr. Stadler lays the trouble to one of two things, either incomplete specifications or insufficient supervision. He inclines toward the latter as various sections along the route between Quebec and Montreal are better built than others, and it looks as if some contractor is endeavoring to do the right thing while others seem to try and work around the specification whenever possible.

These are times when a little money must go a long way in Canadian road-building; when roads are more badly needed than ever before; when money is tighter than we hope it will ever be again; when road-contractors are looking for something to keep their plant from rusting, and when many well qualified engineers would not askance their eye from an inspector's job. No matter what types of roads we build, they must be well built. Otherwise, our handiwork will be no recommendation to the public to solve the great transportation problem of the Dominion —the problem of good roads—in the speediest, most direct and most economical way.

FUTURE TRADE WITH RUSSIA

There are signs that Canada will compete keenly for a share of Russia's import business after the war. The representatives of several Canadian companies already have visited Russia, chiefly in connection with war orders but also with a view to doing business in that country when the conflict has ended. These companies include the Canadian Car and Foundry Company, the Eastern Car Company and the Canadian Locomotive Company, who have received between them orders for shrapnel shell, railroad cars, and locomotives. The Dominion government has appointed a trade commissioner to Petrograd. Mr. Just, the commissioner, is an able linguist and an energetic and capable officer. He was formerly Canadian trade commissioner at Hamburg.

In an article on business with Russia, in the Export World, of London, it is pointed out that any British firm which is not prepared to meet its customers in granting credit, had much better give up all idea of doing business in Russia. With the exception of a few articles in which British firms have a practical monopoly and can, therefore, dictate their own terms, they will meet keen competition on the part of firms who have long ago built up a large business in that country, and are always ready to give credit when necessary. On the other hand, British goods have a reputation for superior quality, and terms of payment being acceptable will always find a ready sale.

There is an alternative to working with agents, and that is to send out travellers and get into direct touch with the larger shopkeepers and merchants, but few British firms are equipped with employees capable of handling business of this description in the proper manner. What should be avoided if possible is dealing direct with small local commission agents in the provincial towns of Russia. Russia will revise its tariff at the conclusion of the war and there is some hope that Canada will be given favorable tariff treatment.

MUNICIPAL IMPROVEMENTS IN TORONTO.

THE City of Toronto, with a land area of about 32 square miles, has 529.69 miles of streets and about 140 miles of lanes. The mileages of various types of roads and pavements as they existed at the close of the years 1913 and 1914 respectively, are as follows:—

	Jan. 1st, 1914.	Jan. 1st, 1915.
Asphalt	182.82	201.16
Asphalt block	6.28	6.28
Cedar block	4.29	2.97
Brick	27.45	29.22
Macadam	38.83	31.32
Wood on concrete	.72	.99
Stone and scoria block	1.56	1.56
Gravel	18.54	18.14
Concrete (other than lanes)	2.69	3.56
Asphaltic concrete and asphaltic macadam	5.05	7.86
Bitulithic	42.56	45.56
Paved lanes, mostly concrete	9.21	11.53
Unimproved roadways	191.99	178.56

The sidewalk mileage is as follows:—

Stone flag	1.73	1.73
Concrete	630.81	689.95
Brick	3.66	3.74
Wood	34.49	28.68

The city had 506.54 miles of sewers, at the beginning of the year, about 72.5 miles of which were added in 1914. The sewage, which averages 42,000,000 gallons daily, is all treated before it is discharged into the lake.

Other important mileages are:—

	Jan. 1st, 1914.	Jan. 1st, 1915.
Water mains	526.03	555.03
Gas mains	506.80	573.66
Street railways (single track)	114.78	119.45

The following table, prepared by the Department of Works, and published in the Municipal Handbook for 1915, issued recently by the city clerk, shows the approximate annual cost of different classes of pavements in Toronto:—

Pavements.

(Roadway 28 feet wide with concrete curbs.)

Description of Pavement	Cost per square yard (Estimated)	Cost per foot frontage	No. of Annual Payments	Cost per foot frontage per annum
Asphalt on 5-in. concrete	$2.26	$4.69	10	64.3c.
Asphalt on 6-in. concrete	2.44	4.98	10	68.3
Asphaltic concrete on 5-in. concrete	2.42	4.94	10	67.8
Asphaltic concrete on 6-in. concrete	2.60	5.23	10	71.7
Bitulithic on 5-in. concrete	2.53	5.10	10	70.0
Bitulithic on 6-in. concrete	2.71	5.40	10	74.1
Brick bl'k on 5-in. concrete	3.24	6.16	10	84.5
Brick bl'k on 6-in. concrete	3.42	6.48	10	88.9
Treated wood block on 5-in. concrete	4.61	8.05	10	110.4
Treated wood block on 6-in. concrete	4.79	8.58	10	116.9
Macadam	1.75	3.52	5	83.9
Macadam, with brick gutters	1.75	3.81	5	90.8
Rocmac macadam	1.95	3.86	5	92.0
Rocmac macadam, with brick gutters	1.95	4.13	5	98.4

The asphalt, bitulithic, brick block and treated wood block pavements are guaranteed by the contractors for ten years, the Rocmac macadam for three years and the macadam for one year.

COAST TO COAST

Peterborough, Ont.—A reorganization of the city engineering department is under contemplation.

Redcliff, Alta.—A number of factories were demolished, or partly so, during the cyclone of June 25th.

Lochearn, Alta.—The Clearwater bridge was swept away by the floods which followed the heavy storm on June 28th.

Chatham, Ont.—Hon. Sir Adam Beck officiated at the turning on of hydro-electric power on Wednesday of this week.

London, Ont.—The electrification of the London and Port Stanley Railway has been completed and the line was opened for traffic on July 1st.

Calgary, Alta.—The new $500,000 customs house was opened last week. It is 100 ft. x 120 ft. and has been under construction for about two years.

Hamilton, Ont.—The city and Barton township have come to terms whereby the latter will have water and sewer connection with the city main throughout a part of its area. There will be a number of sewer and water main extensions as a result.

Victoria, B.C.—The city council has awarded contracts for the surveying of the Sooke Lake water-shed, in connection with the new waterworks system, to C. H. Topp and Company. The greater part of the area is the property of the E. & N. Railway, but the city will buy it at $12 per acre.

Woburn, Ont.—The new bridge being constructed over the Rouge River by the Scarboro Township Council is progressing favorably. Most of the concrete work is now in position and work will start shortly on the superstructure. The new bridge will cost about $2,200 to complete.

Banff, Alta.—Some preliminary work was commenced this year on the new bridge that it was understood the Dominion Government would complete before fall. Test pits were sunk along the river banks and soundings taken, but the work has apparently been dropped for the present season, owing to more needful expenditures.

Brantford, Ont.—The offer by the city of the sale of the Grand Valley Railway line from Paris to Galt for $30,000 and electrification of the L. E. & N. Railway from Port Dover to Brantford has not been accepted by M. H. Todd, general manager of the Lake Erie. He offered $26,000, the city to retain the Galt power house.

Montreal, Que.—The Southern Counties Railway have prepared plans for a sub-station and car barns to be located at Granby. It is likely that the sub-station will be constructed without delay. The immediate purpose in view is to equip the line for operation between Granby and Montreal, giving the company 16 additional miles of line in the southern counties.

Sarnia, Ont.—As a result of a report submitted by the Ontario Hydro-Electric Commission, Sarnia city council will offer the Sarnia Gas and Electric Company $155,000 for its plant and equipment, with the installation of Niagara power the object in view. If the company accepts the offer, as is expected, a hydro-electric by-law will probably be submitted to the ratepayers shortly.

Port Mann, B.C.—There are approximately seventy-five miles of roadbed on the Canadian Northern Pacific Railway yet to be ballasted before the line is completed between Port Mann and Albreda Summit, according to Mr. S. H. Sykes, assistant chief engineer for the company, who has returned from a trip over the line. This work is being carried forward and will soon be finished.

Regina, Sask.—A contract to lay sewer mains on a number of streets, let last year to R. J. Lecky at a price approximating $24,000, will probably be relinquished by him in order that the city may do the work by day labor, thereby relieving, to a certain extent, the unemployment situation. Mr. Lecky has signified his willingness to rescind the agreement and the city commissioners are likely to accept.

Dunvegan, B.C.—Mr. George H. Webster, who has a sub-contract for grading on the Grand Prairie Branch of the Edmonton, Dunvegan & British Columbia Railway, has 600 men at work grading from Spirit River to Grand Prairie City, a distance of about 60 miles. There is considerable heavy work where the line cuts through the Saddle Mountain, but the grading is expected to be completed before fall.

Ottawa, Ont.—An agreement has been reached by the Department of Railways and Canals with the Grand Trunk Pacific Railway for the leasing of the Lake Superior section of the National Transcontinental Railway which runs from Graham, Ont., to Fort William. When the N.T.R. was being built the G.T.P. was allowed to build the branch from the main line to Fort William, the outlet to the Great Lakes. The result was that when the N.T.R. came back on the hands of the Government, the latter found itself without an outlet to the lakes and negotiations accordingly followed relative to the Lake Superior section.

Edmonton, Alta.—Business firms that were heavy losers owing to the recent flood included the following: Edmonton Lumber Company, Limited, Gallagher Flats, mill a total loss; Walter's mills badly damaged, boom swept out and thousands of dollars of finished lumber lost, as well as scores of piers; Dominion Gravel and Dredging Company, Fraser Flats, almost a total loss of entire plant; Casey Hardstone Company, plant severely damaged; Campbell & Ottewell's flour mills, boiler-house flooded and mill and elevator flooded; Bitulithic Paving Company's outfit, near low-level bridge, completely under water; Huff Grading Company loses scrapers and big shovels and other material.

The smelter production of primary copper in the United States last year was 1,150,137,192 lb., as compared with 1,224,484,098 lb. in 1913, showing a decrease of rather more than 6 per cent. The total value of last year's output, taking an average of 13¼ cents per pound, was $152,968,246, as compared with $189,795,035 in 1913. Refined copper was exported from the United States in 1914 to the extent of 748,902,137 lb.; the corresponding exports in 1913 were 817,911,424 lb.

The "Heating and Ventilating Magazine" is responsible for recording a statement to the effect that the day is coming when the engineer will occupy the position now held by the architect. The remark, which has been voiced by many during recent years had been made by a speaker who said that the public or office building is primarily an engineering problem in which the architect "farms out" 75 per cent. of the work. Moreover, this percentage is constantly increasing. He took the ground that the design of such buildings really belongs to the engineer who should be in charge and, if necessary, "farm out" the architecture. It is easy to see how this proposition will strike the architects, yet its accomplishment is not such a remote possibility as might be imagined. In more than one engineering office at the present time there is maintained a distinct "architectural" department, so that the office which is primarily that of a designing engineer for heating, ventilating, electrical and sanitary equipment, is at the same time fully prepared to handle the other structural features, including the architecture.

PERSONAL

Lance Corporal B. W. HARMON, of Woodstock, N.B., of the 1st Field Company, Canadian Engineers, has been reported wounded.

Lieut. H. O. C. WALKEM, Royal Canadian Engineers, has been gazetted temporary captain in the Royal Engineers of Great Britain.

J. E. SANGER has been appointed acting superintendent of the City of Winnipeg generating station at the Lac du Bonnet power plant.

HARRY F. BARNES, a member of the city engineer's department of London, sails on July 27 to become instructor of railroad engineering in the State University of Tang Shang, South China.

Lieut. A. M. WEST, of the Canadian Engineers Corps, has been granted six weeks' leave of absence from his duties as city engineer of North Vancouver to pursue military studies at Esquimalt, B.C.

GEORGE W. CRAIG, city engineer of Calgary, had a narrow escape from drowning when the Centre Street bridge was carried away by the extraordinary flood conditions on the Bow River last week.

F. H. PETERS, commissioner of irrigation and chief engineer for the Department of the Interior, at Calgary, is captain of the 4th Field Company, Canadian Engineers. Capt. Peters is a graduate of the Royal Military College, Kingston, Ont.

C. E. HASTINGS, a fourth-year student in sanitary engineering at the University of Toronto, and president of the University of Toronto Engineering Society, is taking a course in sanitary engineering at the Harvard Summer School, Cambridge, Mass.

G. R. G. CONWAY, M.Can.Soc.C.E., and for a number of years chief engineer of the British Columbia Electric Railway Company, has resigned to engage in private practice as consulting engineer. Mr. Conway, who proposes to locate in Eastern Canada, will also continue in the service of the B.C. Electric as consulting engineer.

OBITUARY.

The death occurred on June 27th of Mr. Rene P. Lemoy, a prominent architect of Quebec. The deceased was 44 years of age.

CANADIAN SOCIETY OF CIVIL ENGINEERS MEMBERSHIP.

The recently issued statement of membership of the Canadian Society of Civil Engineers, correct to March, 1915, is as follows: Honorary Members, 9; Members, 674; Associate Members, 1,372; Associates, 36; Juniors, 352; Students, 615; making a total of 3,058. The corresponding figure for last year was 2,793.

Decisions are pending at Verdun, Que.; Guelph, Ont., and Transcona, Man., relative to new city engineers.

CANADIAN ELECTRICAL ASSOCIATION.

At a meeting of the member companies of the Canadian Electrical Association, held in Ottawa on June 26th, the following officers were elected: President, Lieut.-Col. D. R. Street, Ottawa Electric Company; first vice-president, D. H. McDougall, Toronto Electric Light Company; second vice-president, W. S. Roberts, Electric Power Company, Toronto; third vice-president, W. G. Matthews, Quebec Railway, Light & Power Company.

Reports presented showed a membership of more than 100 and a total capitalization represented of $230,000,000 in light and power companies from the Atlantic to the Pacific. The association dispensed with its annual convention this year.

ONTARIO MUNICIPAL ELECTRICAL ASSOCIATION.

The engineers' section of the Ontario Municipal Association convened in Brantford on June 30th. The delegates present were: P. B. Yates, of St. Catharines, (chairman); E. I. Sifton, of Hamilton; W. H. Childs, of Hamilton; Mr. Myers, of Stratford; Geo. Grosse, of Waterloo; Mr. McIntyre, of Berlin; Mr. Scott, of Galt; Mr. Elliott, of Galt; Mr. Archibald, of Woodstock; Mr. Haig, of Guelph; Mr. Wilson, of Seaforth; Mr. Buchanan, of London; Mr. Caughell, of St. Thomas; Mr. Tokko, of Tillsonburg; Mr. Chant, of Clinton; L. G. Ireland, of Brantford. The subject of the annual convention, which will probably be held at Toronto during exhibition week, and question of hydro rates, occupied the attention of the delegates.

COMING MEETINGS.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.

A UNIVERSAL STRAINOMETER OF SIMPLE DESIGN.

A new device combining in one instrument all the requirements usually met less satisfactorily by several extensometers and compressometers is described by Mr. S. H. Graf in a paper before the American Society for Testing Materials. It is believed that the strainometer will be especially valuable to commercial and municipal laboratories of limited means, where the outlay of capital for the several instruments usually required is not justified.

Briefly, it possesses the following advantages: (1) Applicability to a wide range of specimen sizes, either for tension or compression; (2) ease of use with a satisfactory degree of accuracy; (3) Simple construction and low cost.

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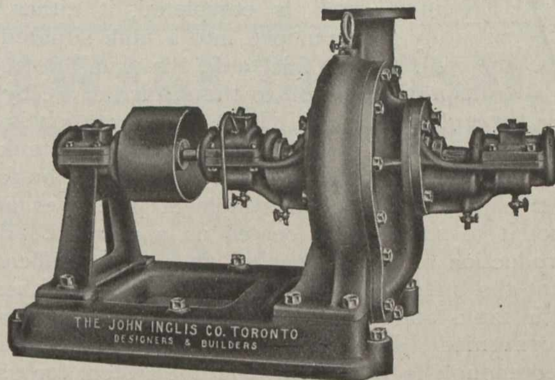

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This advertisement is No. 6 of a series appearing weekly in this paper showing that MIMICO pipe is one of the straightest, most uniform, strongest, soundest, most sanitary makes of sewer pipe in America.

THE TRANSPORTATION OF OIL AND GAS.*

By Forrest M. Towl.

When an oil well is completed, it either flows naturally or is pumped into a tank situated near the well. From this tank, the usual methods of transporting the oil to the refineries are by tank cars or through pipe lines. (Boat transportation is good and cheap if location of wells permits.) When tank cars are used, it is customary to gather the production from a number of wells through a system of pipe lines and to conduct it to some point located on a railroad. Before the production of a field reaches an amount sufficient to warrant the building of a pipe line, the oil is either collected in tanks and allowed to stand, or, if there is a railroad convenient, shipped by cars. After a field is developed enough to warrant a pipe line system for gathering the oil, there is run, from the producers' tanks at each individual well, a pipe line which connects with other similar lines leading to a point of concentration. The oil is either forced through these lines by a pump located at the well, run by gravity, or run into a system of lines having a suction pump at their terminus. The gravity system is to be preferred where it is possible to use it, even though it often requires larger lines. Where the oil is nearly as fluid as water, a pipe about 2-in. in diameter is used, but where the oil is viscous, larger pipes are necessary, the size, of course, depending on the amount of oil to be handled. With the same head, the more liquid oils flow about the same as water, but, when the oil becomes viscous and thick, the flow is very much reduced. The fluidity of the more viscous oils changes with the temperature. In general, the heavier oils are the most viscous, but there are many notable exceptions to this rule. The gravity of the oils is usually obtained by a Baumé hydrometer. The specific gravity of the oil can be obtained by substituting the Baumé gravity in the formula:—

$$\text{Sp. gr.} = \frac{144}{134 + \text{Baumé degrees}}$$

After the oil has been collected by the gathering system into the first concentration tank, it can be pumped through lines to some point of storage, or through a series of pump stations to the places where it is to be refined. There is a great difference in the crude oils, some of them being black, brown, or dark red; while others are amber or straw colored. As these lighter colored oils are often of more value than the darker, it is necessary to keep the different grades separate. This can only be done by pumping through separate lines, or handling the oil in large consignments. The history of the pipe lines dates back nearly to the discovery of oil in large quantities. The first successful pipe line in the United States was built in 1865. This line was only four miles long, but they were able to pump 81 barrels of oil per day using three pumps. Since that time the pumping machinery has improved in line with other machinery being built. At first, high-pressure steam-driven pumps were used, the steam being used but once. This was followed by the introduction of the compound pump, then the triple pump, which later gave place to the high-duty triple expansion condensing fly-wheel type of pumps. The first style of pumps required about 120 lbs. of water, converted into steam, per h.p. per hour. The last type of steam pumps require about 15 lbs. One pound of oil will evaporate about 15 lbs. of water, so that a pound of oil burned under a boiler with a good triple expansion pumping engine will furnish a h.p. for one hour. Recent developments in the oil engine have resulted in producing an oil engine driven pump which will furnish a h.p. per hour on less than 0.5 lb. of oil. In 1902 and 1903 the writer built a pipe line for handling the viscous California oil. The oil was heated by a surface heater using the exhaust steam from the pumping engines. This heating system is now in general use where viscous oils are to be handled.

In the United States, the pipe lines take the oil from the producer's tank, gauging the tank before the oil is run into the pipe line system and after the run has been completed, care being taken to see that all of the water has been drawn from the tank before the run starts, and that the valves and connections are all tight so that no water or oil can come into or leave the tank while the oil is being run into the pipe line. It is customary for the pipe lines to seal or lock their valves when oil is not being run from the producer's tanks. Where the oil is handled by a pipe line company not owning the production, the company furnishes the owner's representative at the well with a statement showing the level of the oil before starting to run, the level at the close of the run, and the number of barrels of oil taken from the tank as shown by the engineer's table. In the United States, the barrel contains 42 U.S. gal. of 231 cu. in. each. This is equivalent to 35 Imp. gal. There is generally some water and sediment in the oil coming from the wells and also considerable gas. For this reason, it is necessary for the oil to stand for some time before it is measured and run into the pipe lines. Even when this precaution is taken, it is found the lighter gravity oils, containing considerable gasoline, lose some in volume; for this reason, it has become a question to allow a certain percentage of difference between the gauge of the producer's tanks and the gauge in other tanks along the lines. With the light gravity oils, this loss amounts to about 2% of the oil run which is the figure used in most of the fields producing light gravity oils. The heavier oils carry more water and sediment and hold them suspended for a long time. In handling the oils through pipe lines, it is necessary to be very careful around the pumping stations and keep fire or lights away from the oil or its fumes. Fires are often caused around the pumping stations and tankage fields by lightning. It has been found that a steel tank with a steel roof is not as liable to be struck by lightning as a steel tank with a wooden roof. Where there is a large tankage field, it is necessary to build banks around the tanks, or place them far enough apart so that when one is on fire it will not endanger others. Lightning rods have been used to prevent lightning striking the tanks, but it is generally considered that their value in preventing the loss by lightning does not warrant the additional expense. Where tanks are located near power plants having steam available, a steam pipe is connected into the top of the shell of the tank, so that, in case the tank is struck by lightning, steam can be turned in above the oil. If the roof of the tank is not blown off by the explosion, it is often possible to put out the fire in this manner. Care is to be taken to see that all of the openings in the tops of the tanks are closed to retain this steam. If water is available, it is the practice to play water on the adjacent tanks and sometimes on the tank which is on fire. This can be done with reasonable safety for a few hours after the tank has been struck. Oil is sometimes drawn off from the tanks by connecting pipe line systems and water forced in at the bottom to keep the burning oil as high as possible. By this means

* From a recent Department of Mines' report on the Petroleum and Natural Gas Resources of Canada.

it is sometimes possible to save the bottom and lower ring of the tank, which is the most expensive part.

For the pipe lines, mild steel or wrought iron screw joint pipe is used. Bessemer steel also is used, but makes a cheaper and inferior grade of pipe.

In the collection of natural gas from the wells, there is often water or oil carried with the gas in such quantities that it will clog the lines. For this reason the wells are connected up with a trap to catch the liquid before it enters the lines. A number of wells are connected into a larger line and these larger lines converge to the trunk lines which carries the gas to a point near to where it is to be consumed. At this point it is usual to reduce the pressure of the lines before distributing. The distribution is carried on in the same manner as when handling manufactured gas. When the pressure at the wells is not sufficient to deliver the gas to the market, compressor stations are put in and the pressure raised to a point sufficient to carry the gas through to the point of consumption. The following formula can be used in computing the amount of gas which will be delivered through a given line:—

$$Q = C \sqrt{\frac{(P_1 + P_2)\ (P_1 - P_2)\ D^5}{L}}$$

Q = cubic feet per hour (15 lbs. absolute).

P_1 = absolute head or initial pressure in pounds per sq. in.

P_2 = absolute delivery or terminal pressure in pounds per square inch.

D = diameter of the pipe in inches.

L = length of the pipe in miles.

C = a constant.

The constant used for air computations is C = 38.28.

The constant for any other gas is inversely in proportion to the square root of the specific gravity of the gas.

For a natural gas having a specific gravity of 0.59 the corresponding constant is C = 50.

These constants have been checked by many tests on pipe lines of various diameters and lengths.

With natural gas, it is seldom necessary to use gas holders to regulate the supply at the point of consumption as the line itself forms a reservoir and can be used to store a large amount of gas by what is known as "packing the line," which consists in permitting the pressure back of the regulator to increase until it approximates the pressure in the field.

Pipe Line Requirements.—The transporting of gas requires a pipe line which shall be air tight. It is much more difficult to make a line to hold gas under pressure than it is to hold a liquid. Trouble has been experienced in almost all lines built for high pressures on account of the leaking of gas at the couplings. The first high pressure lines were laid with bell and spigot joints, caulked with lead. The lines might be tight when they were first laid, but the movement in expanding and contracting soon caused them to leak large amounts. The next lines used were of wrought iron or steel pipe, with screw joints. While these held much better than the bell and spigot pipe, there was still enough leakage to make it desirable to have a more perfect joint. The leakage on some of the earlier screw joint gas lines was such that by putting a rubber bag over the coupling, gas could often be collected at the rate of from 20 to 50 cu. ft. per hour, or enough to run a good sized torch. This was true of lines up to 8 or 10 ins. in diameter. When the lines became larger the leakage increased so much that it was practically impossible to use large size lines and get a large percentage of the product to the market. As the demand for natural gas increased it became necessary to use larger lines, and a rubber packed stuffing box was developed. The first successful joint of this kind in the market was the Dresser coupler, and it is due largely to this and other couplings that the natural gas industry has become so great.

The Dresser coupler consists of a sleeve into which the ends of the pipe are placed. There is a projection in the centre of the sleeve so that the ends of the pipe will be each inserted into the sleeves at the same distance. This sleeve acts as a follower to compress rubber in an annular space into the end rings which are drawn together by bolts. The rubber is surrounded on one side by the pipe, on another by the body of the coupling, and on the remaining sides by the end rings so that there is very little of the surface of the rubber exposed either to the gas on the inside or the air on the outside of the line. It is found that these joints will last for years.

The Hammond coupler is a modification of the Dresser, one of the principal features of which is that the projection at the centre of the sleeve is made by lugs welded on to the sleeve. When it becomes necessary to take apart one of these couplers, the lugs can be broken off and the coupler slipped back so as to allow of the pipe being easily removed.

Lines of pipe can be built in almost any kind of country, but it is necessary in some places to arrange to keep the line from acting as a Bourdon tube and expanding in one direction until the ends of the pipe may be pulled out of the coupling. To avoid this trouble it is customary in such places as river crossings to use screw pipe, and to place over the collar a clamp which is constructed to make a rubber joint between the ends of the collar and the pipe.

For power transmission lines or for temporary gas lines where the distances are short or the service temporary and it is not considered necessary to bury the pipe, it will be found that the screw joint pipe is satisfactory, but for other natural gas or air service, the rubber coupling has many things to recommend it, and when the capacity requires large pipe it is almost absolutely necessary to use this type of coupling. These couplings have been used for manufactured gas, but it is found that the condensation from the gas collects in the coupling and soon causes a leak in the rubber joint. Work is now in progress to perfect a material which will not be acted upon by the condensation in the gas and which will make a gas-tight joint.

CANADIAN SAND IMPORTS.

The following figures relating to imports of sand, etc., into Canada are from the returns of the Department of Customs:—

	1910-1911		1911-1912		1912-1913	
Silex or crystallized quartz ground or unground	cwt. 11,348	$10,634	cwt. 7,445	$ 7,314	cwt. 14,497	$12,898
Flint and ground flint-stones	68,953	32,362	74,061	49.481	72,937	47,956
Gravel and sand	tons 195,149	199,428	tons 263,971	258,438	tons 542,927	465,263

The forest wealth of Quebec province is placed at $600,000,000, of which white and red pine represent $200,000,000, spruce and balsam $250,000,000, other pulpwood $100,000,000, hardwoods $25,000,000, and cedar $25,000,000.

There were 95,116 short tons of fluorspar mined in the United States during 1914, valued at $570,041. This fell short of the 1913 production by 20,464 short tons, but has been exceeded only by the 1912 and 1913 productions.