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Volume 27. Toronto, October 15, 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

TRANSMISSION LINE CHARACTERISTICS

MECHANICAL CHARACTERISTICS OF COPPER AND ALUMINUM WIRES FOR ELECTRICAL TRANSMISSION LINES—SOME USEFUL TABLES, FORMULAS AND CHARTS.

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VARIOUS tables and charts pertaining to electric transmission line wires have been compiled by different authors from time to time. These tables and charts enable the engineer in the field, when stringing the wire, to allow a certain tension at the prevailing temperature in order that the tension may not become excessive at some lower temperature and maximum loading; and on the other hand, to prevent the sag from becoming too great at some high temperature, which might reduce the clearance from ground to lowest point of wire beyond the specified limit.

In order to obtain a clear picture of how different temperatures and various loadings affect the tension and

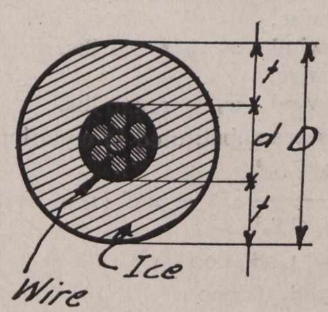

Fig. 1.

sag in the wire, Charts I. and II. have been constructed, the former for copper wire and the latter for aluminum.

These diagrams are easily constructed and the values are read off directly, eliminating all shifting about on the paper with straight-edges, as would be the case with parallel-scale types and others. The following diagrams are based on the parabolic law, as no appreciable error is introduced by doing so, providing the span is within reasonable limits.

The loading on the wire depends, of course, on the climatic conditions. However, in temperate zones an ice loading of ½ inch in thickness at 0° F. in conjunction with a wind pressure of 8 lbs. per square foot of projected area of the wire, corresponding to a 70-mile indicated wind velocity, or 55.2 actual, is usually recommended as maximum loading.

To obtain the weight of ice per foot of wire, the author has derived the following formula, which will undoubtedly be of some value.

Taking the ice as 57.3 lbs. per cu. ft., we have for W, the weight of ice per foot of wire:

$$W = \frac{\frac{D^2\pi}{4} - \frac{d^2\pi}{4}}{144} \cdot 57 \cdot 3 = \frac{57 \cdot 3 \cdot \pi}{4 \cdot 144} (D^2 - d^2)$$

Substituting $d + 2t = D$, we have:

$$W = \frac{57 \cdot 3 \cdot \pi}{144} \cdot (dt + t^2) = \frac{5}{4}\, t\, (d + t) \qquad (1)$$

where t denotes the thickness of the ice coating, and d the diameter of the wire; all values being in inches.

Combining the weight of the wire plus the ice with the wind, the resultant force acting on the wire is thus obtained, which forms the basis to all further calculation.

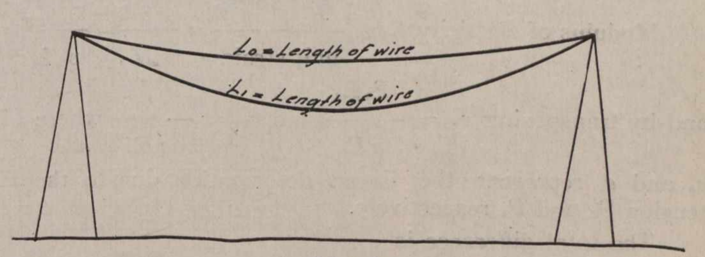

Fig. 2.

Development of Equations.

Let a denote the area of the wire in square inches.
- w_0 " the resultant force per foot of wire under maximum loading at 0° F., in lbs.
- $w_1 w_2 w_3$ " the resultant force per foot of wire under different loading, in lbs.
- l " the span in feet.
- S_0 " the sag at midspan under maximum loading at 0° F., in feet.
- S_1 " the sag at midspan under different loading, in feet.
- P_0 " the pull or tension in the wire under maximum loading at 0° F., in lbs.
- P_1 " the pull or tension in the wire under any loading or at any temperature, in lbs.
- L_0 " length of wire at maximum loading at 0° F., in feet.
- L_1 " length of wire at any other loading and other temperature.
- α " coefficient of linear expansion.
- t " temperature in degrees of Fahrenheit.
- E " Modulus of elasticity in lbs. per sq. in.

Fig. 2 shows two rigid supports and a wire suspended between these supports. Let L_0 represent the length of the wire under maximum loading; *i.e.*, under a loading equal to the resultant of the dead load of the wire plus the weight of ½ inch of ice and a wind pressure of 8 lbs. per square foot of projected area of ice-covered wire at a temperature of 0° F.

Evidently this wire is undergoing a change in length at some other temperature and different loading. A simultaneous change of temperature and loading is more complicated, but by letting the loading remain constant for the time being, calculating the change in length due to the temperature only and finally combining this with the change due to the different loading, the total change in the length is easily found.

Let L_1 (Fig. 2) be this changed length of the wire. The effect of the temperature is always partly counterbalanced by the effect of the change in tension. A higher temperature will stretch the wire and increase the sag. This increased sag in turn will diminish the tension and cause a shortening in the length. The algebraic sum of these changes will be the actual change in the length. The author has seen several charts which do not take account of this change due to the tension, caused by the change of temperature. This factor is quite an appreciable one, even with moderate spans.

Let $L_0 \alpha t$ be the linear expansion due to the rise in temperature t, then $L_0 (1 + \alpha t)$ would be the total length of the wire, providing the tension would remain the same. Since, however, the tension becomes less with the increase in length, the shortening has to be added algebraically to the above value $L (1 + \alpha t)$, and the actual length is thus found. In order to derive an expression for this shortening in the length, we have to employ following fundamental formula:

$$\text{Modulus of elasticity } E = \frac{\text{unit stress}}{\text{unit strain}} = \frac{P_0/a}{e_0/L_0} = \frac{P_1/a}{e_1/L}$$

and by transposing $e_0 = \frac{P_0 L_0}{aE}$ and $e_1 = \frac{P_1 L_1}{aE}$ where e_0 and e_1 represent the linear deformation due to the tension P_0 and P_1 respectively.

The total difference is

$$L_1 - L_0 = L_0 \alpha t + e_1 - e_0; \text{ or,}$$

$$L_1 - L_0 = L_0 \alpha t + \frac{P_1 L_1 - P_0 L_0}{aE} \qquad (2)$$

Transposing: $P_1 L_1 = L_1 aE - L_0 aE - L_0 \alpha t a E + P_0 L_0$

Dividing by L_1; $P_1 = aE - \frac{L_0}{L_1} aE - \frac{L_0}{L_1} \alpha t a E + \frac{L_0}{L_1} P_0$;

$$\text{or, } P_1 = \frac{L_0}{L_1} [P_0 - aE (1 + \alpha t)] + aE$$

The general expression for the length of the wire in terms of the sag is $L = l + \frac{8 S^2}{3 l} = \frac{3 l^2 + 8 S^2}{3 l}$, and substituting for L_0 and L_1 we have

$$P_1 = \frac{3 l^2 + 8 S_0^2}{3 l^2 + 8 S_1^2} [P_0 - aE (1 + \alpha t)] + aE \qquad (3)$$

which is the formula used for compiling Table II. Here we notice that three variables are involved in this equation, P_1, S_1 and t. By giving t a certain value and assume different values for S_1, we obtain corresponding values for P_1 which can be plotted. The P_1 values are plotted on the vertical axis and the S_1 values on the horizontal axis. By repeating this operation and assigning another certain value for t, we obtain a family of curves. This operation renders t a variable parameter.

Since we have two variables now and only one equation, we have to establish some other relation between P_1 and S_1. This is accomplished by using the well-known formula

$$P_1 = \frac{w l^2}{8 S_1} \qquad (4)$$

The value w represents the variable parameter.

Table I. has been worked out for a copper wire of 250,000 C.M. and a span of 600 feet. The values are taken from the reports of the National Electric Light Association, 36th convention:

Table I.—Stranded Hard-drawn Copper Wire of 250,000 C.M.

Area in circular mills	250,000 or a = .19635 sq. ins.
Elastic limit	35,000 lbs. per square inch.
Elastic limit	6,870 lbs. per wire.
Allowable tension...	30,000 lbs. per square inch.
Allowable tension...	P_0 = 5,900 lbs. per wire.
Ultimate strength ..	60,000 lbs. per square inch.
Ultimate strength ..	11,790 lbs. per wire.
Modulus of elasticity	$E = 16 \times 10^6$ lbs. per sq. in.
Coefficient of linear expansion	$\alpha = 96 \times 10^{-7}$
Weight per ft. of wire plus ½ in. ice and 8 lbs. wind.........	w_0 = 1.788 lbs.
Weight per ft. of wire, no ice, no wind....	w_1 = .762 lbs.
Weight per ft. of wire, no ice, 15 lbs. wind	w_2 = 1.061 lbs.
Weight per ft. of wire, ½ in. ice, no wind	w_3 = 1.440 lbs.

Above values are substituted in equation (3).

$$P_1 = \frac{3 l^2 + 8 S_0^2}{3 l^2 + 8 S_1^2} [P_0 - aE (1 + \alpha t)] + aE$$

$l = 600$; $3 l^2 = 1{,}080{,}000$

$$S_0 = \frac{w_0 l^2}{8 P_0} = \frac{1.788 . 360000}{8 . 5900} = 13.637; \quad 8 S_0^2 = 1{,}487.75$$

$$3 l^2 + 8 S_0^2 = 1{,}080{,}000 + 1{,}487.75 = 1{,}081{,}488$$

$$aE = .19635 \times 16{,}000{,}000 = 3{,}141{,}600$$

Table II. gives values for P_1 and S_1 which can be plotted now.

In order to plot equation 4, which furnishes points of intersections with above curves, Table III. has been compiled.

Having plotted all these values for P_1 and S_1, we obtain an exact picture of the behavior of the wire at various temperatures and under different loadings. It will be noticed that equation (3) is rather lengthy and cumbersome. By making a slight change in this equation the whole computation is materially shortened without affecting the results appreciably. This is accomplished by substituting L_0 for L_1 in equation (2) on the right side only, as shown $L_1 - L_0 = L_0 \alpha t + \frac{P_1 - P_0}{aE} L_0$

Solving for P_1 we get $P_1 = P_0 + aE \left[\frac{L_1}{L_0} - 1 - \alpha t\right]$

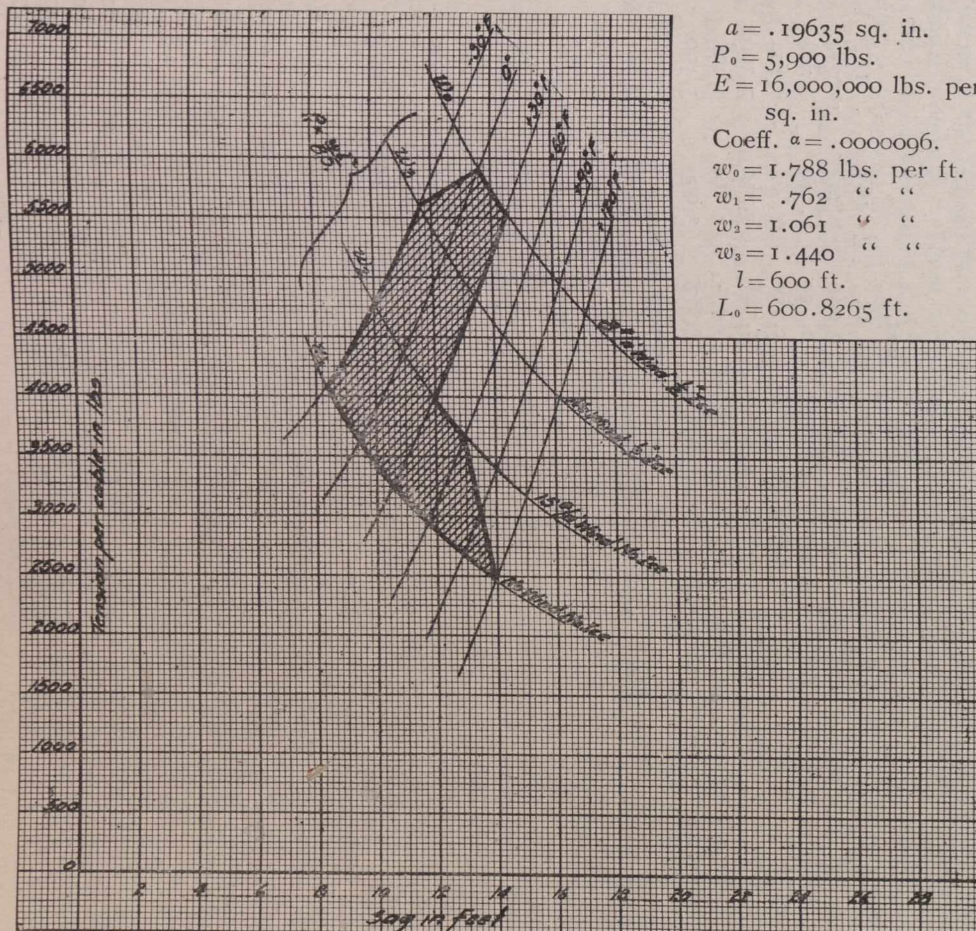

Chart I.—Showing Tension and Sag of 250,000 C.M. Hard-drawn Copper Cable at Various Temperatures and Under Different Loading; 600-ft. Span.

$$P_1 = P_0 + a E \left[\frac{8 S_1^2}{3 l L_0} + \frac{l}{L_0} - 1 - \alpha t^\circ\right]$$

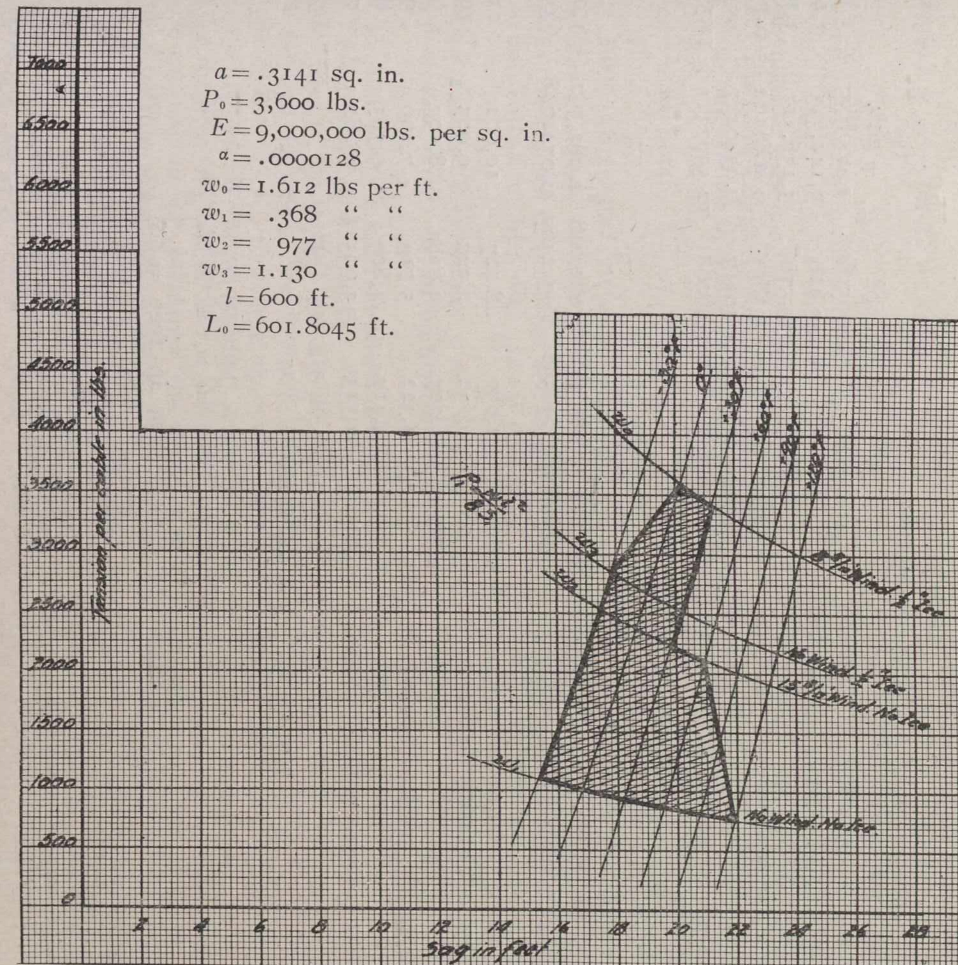

Chart II.—Showing Tension and Sag of 400,000 C.M. Aluminum Cable at Various Temperatures and Under Different Loading; 600-ft. Span.

$$P_1 = P_0 + a E \left[\frac{8 S_1^2}{3 l L_0} + \frac{l}{L_0} - 1 - \alpha t^\circ\right]$$

Table II.

	Temperature "t"					
	— 30°	0°	+ 30°	+ 60°	+ 90°	+ 120°
$1 + \alpha t$	.999712	1.000000	1.000288	1.000576	1.000864	1.001152
$aE(1 + \alpha t)$	3,140,695	3,141,600	3,142,505	3,143,410	3,144,315	3,145,220
$P_0 - aE(1 + \alpha t)$ (neg.)	3,134,795	3,135,700	3,136,605	3,137,510	3,138,415	3,139,320
$\log [P_0 - aE(1 + \alpha t)]$	6.4962091	6.4963345	6.4964598	6.4965851	6.4967104	6.7968356
$\log (3l^2 + 8S_0^2)$	6.0340217	6.0340217	6.0340217	6.0340217	6.0340217	6.0340217
$\log [(3l^2+8S_0^2)\{P_0-aE(1+\alpha t)\}]$	12.5302308	12.5303562	12.5304815	12.5306068	12.5307321	12.5308572

		Sag in feet = S_1							
		6	8	10	12	14	16	18	20
$3l^2 + 8S_1^2$		1,080,288	1,080,512	1,080,800	1,081,152	1,081,568	1,082,048	1,082,592	1,083,200
$\log (3l^2 + 8S_1^2)$		6.0335396	6.0336296	6.0337453	6.0338868	6.0340538	6.0342465	6.0344648	6.0347087
	t								
Tension P_1 in lbs.	— 30°	3,324	3,974	4,809	5,820	7,037	8,427	10,002	11,757
	0°	2,417	3,067	3,904	4,920	6,132	7,522	9,097	10,857
	+ 30°	1,511	2,162	3,000	4,021	5,227	6,618	8,193	9,953
	+ 60°	605	1,256	2,093	3,115	4,322	5,714	7,290	9,050
	+ 90°	— 303	350	1,187	2,210	3,417	4,809	6,385	8,140
	+ 120°	— 1,209	— 555	282	1,305	2,513	3,905	5,482	7,243

Table III.—Copper Wire.

$$P_1 = \frac{wl^2}{8S_1}$$

		Sag in feet = S_1							
		6	8	10	12	14	16	18	20
Tension P_1 in lbs.	$w_0 = 1.788$, 8 lb. wind; ½" ice	13,437	10,078	8,046	6,710	5,745	5,028	4,470	4,023
	$w_1 = .762$ No wind; no ice..	5,715	4,286	3,429	2,855	2,450	2,145	1,905	1,715
	$w_2 = 1.061$ 15 lb. wind; no ice	7,958	5,968	4,775	3,980	3,410	2,985	2,656	2,387
	$w_3 = 1.440$ No wind; ½" ice.	10,800	8,100	6,480	5,400	4,625	4,050	3,600	3,240

Table IV.—Copper Wire.

$$P_1 = 23.239\,S_1^2 + 1{,}580 - 30.16\,t$$

		Sag S_1 in feet.							
	Temp. t	6	8	10	12	14	16	18	20
Tension P_1 in lbs.	— 30°	3,322	3,972	4,809	5,831	7,040	8,434	10,014	11,780
	0°	2,417	3,067	3,904	4,926	6,135	7,529	9,109	10,876
	+ 30°	1,512	2,162	3,000	4,021	5,230	6,624	8,204	9,971
	+ 60°	607	1,257	2,095	3,116	4,325	5,719	7,300	9,065
	+ 90°	....	352	1,190	2,211	3,420	4,814	6,395	8,160
	+ 120°	....	....	285	1,306	2,515	3,909	5,490	7,255

Table V.—Aluminum Wire.

$$P_1 = 20.877\,S_1^2 - 4875 - 36.18\,t$$

		Sag in feet = S_1							
	Temp. t	12	14	16	18	20	22	24	26
Tension in lbs. P_1	— 30°	— 784	302	1,555	2,975	4,560	6,315	8,235	10,323
	0°	—1,869	— 783	470	1,890	3,476	5,230	7,150	9,238
	+ 30°	—2,954	—1,868	— 615	805	2,390	4,145	6,065	8,153
	+ 60°	....	—2,936	—1,700	— 280	1,306	3,060	4,980	7,068
	+ 90°	....	....	—2,785	—1,365	220	1,975	3,895	5,983
	+ 120°	....	....	....	....	— 864	890	2,810	4,898

Table VI.—Aluminum Wire.

$$P_1 = \frac{wl^2}{8S_1}$$

		Sag S_1 in feet.							
		12	14	16	18	20	22	24	26
Tension P_1 in lbs.	$w_0 = 1.612$ 8 lb. wind; ½" ice	6,045	5,180	4,540	4,030	3,627	3,300	3,020	2,790
	$w_1 = .368$ No wind; no ice..	1,380	1,182	1,035	920	823	753	690	637
	$w_2 = .977$ 15 lb. wind; no ice	3,664	3,140	2,748	2,440	2,198	1,997	1,830	1,690
	$w_3 = 1.130$ No wind; ½" ice.	4,238	3,632	3,180	2,825	2,543	2,310	2,117	1,955

and substitute $l + \frac{8 S_1^2}{3 l}$ for L_1 we have

$$P_1 = P_0 + a E \left[\frac{8 S_1^2}{3 l L_0} + \frac{l}{L_0} - 1 - \alpha t\right] \qquad (5)$$

which is the equation used for Charts I. and II. Chart I. is for copper wire and Chart II. for aluminum. Substituting the numerical values in above equation and letting $L_0 = l + \frac{8 S_0^2}{3 l}$, we obtain

$$P_1 = 5{,}900 + 23.239 S_1^2 - 4{,}321 - 30.16 t$$

or $$P_1 = 23.239 S_1^2 + 1{,}580 - 30.16 t$$

Chart I. is constructed from Tables III. and IV., and Chart II. from Tables V. and VI., using equations 4 and 5.

Comparing results of equations 3 and 5, it is seen that no appreciable error is introduced by adopting equation 5.

Tables V. and VI. are for aluminum wire. Size, weight, etc., are printed on Chart II.

The boundaries of the shaded area are the limitations to which the sag and the tension are confined. Since max. loading is specified at 0° F., the curve w_0 could not extend further to the left of the temperature curve of 0°, accounting for the edge chipped off in the left-hand upper corner. The ice limit at 32° F. shows the ice loading curves running outside along the 30° curve down to the w_2 loading curve. From there it runs along the latter curve to 60°, where a maximum wind of 15 lbs. is liable to occur. From here the line runs to the intersection of the w_1 curve with the 120° curve, *i.e.*, highest temperature with no ice and wind.

It is to be noticed from Chart I. that the maximum sag does not occur at the highest temperature, but at 30° with a maximum loading. These curves show very plainly what effect the temperature and the loading has upon the tension and the sag of the wire.

In Chart I. it is seen that a change in loading affects the tension more than the sag, while a temperature change has an equal effect on tension and sag. In Chart II. a change in loading is affecting the tension far more than the sag and a change in temperature has a greater effect upon the sag than the tension, especially noticeable with the w_1 curve.

[This article deals with spans of 600 feet only; in a later article Mr. Maerker will extend the information to include spans ranging from 200 to 1,000 feet.—EDITOR.]

NORTHERN WATER-POWERS.

The statement is sometimes made by the uninitiated that the water powers north of the settled parts of our Dominion are of little value. The existence of numerous falls and rapids in these parts is not denied, but the argument is advanced that the temperature and other climatic conditions existing where these falls and rapids are situated will prevent their utilization. As a direct contradiction to the above assertion, we need only turn to Norway, the latitude of which is about the same as that of the Yukon and where climatic conditions are similar to those of northern Canada. In size, Norway is only slightly larger than our Maritime Provinces, and yet we find their water-power plants with a total capacity of over 1,500,000 h.p., either in actual operation or in course of construction. Hydro-electric stations of considerable size have been constructed in different parts of that country. Many of the smaller ones have been erected for municipal use; but the larger ones are for the electro-chemical industry, in which a main factor of success is cheap and plentified electric power.

AMERICAN PIG-IRON, ROLLED IRON AND STEEL.

The official statistics of American pig-iron production in the first half of 1914 make the following comparisons, in tons of 2,240 lbs.:—

	First half.	Second half.	Year.
1911	11,666,996	11,982,551	23,649,547
1912	14,072,274	15,654,623	29,726,937
1913	16,488,602	14,477,550	30,966,152
1914	12,536,094	....	....

Thus there was a decrease of 24 per cent. from the tonnage in the best half-year—the first half of 1913. An interesting feature in the statistics is that while the total production greatly decreased, the production of foundry iron was larger in the first half of this year than in the second half of last year. The explanation probably is that too much foundry iron was made in the first half of last year, while in the second half the stocks were liquidated, with unusually light production, and production this year returned to normal.

The production of rolled iron and steel in 1913 has just been officially reported, and we include in the table below the production of steel ingots, already reported for 1913:—

	Total rolled. Tons.	Rolled iron. Tons.	Rolled steel. Tons.	Steel ingots. Tons.
1911	19,039,171	1,460,615	17,578,556	23,029,479
1912	24,656,841	1,637,582	23,019,259	30,284,682
1913	24,791,243	1,678,257	23,112,986	30,280,130

The rolled material is reported in the form in which it suffered its last hot rolling, the material of course being sheared or cropped thereafter. Thus no billets or sheet bars are included, except those exported, plus rolled forging billets, while rods and skelp are returned as such, and black-plates rather than tinplates are included.

In the past two years the difference between steel ingots and rolled steel has averaged about 7,200,000 tons. A small part of this difference was absolutely lost, but the great bulk of the difference represented new scrap. In addition, there is new scrap produced in fabrication. A small tonnage of sheet mill scrap is used in charcoal forges, but in general there is indicated a supply of about 7,500,000 tons annually, which went to the open-hearth steel works, thus constituting 35 per cent. of the production of 21,599,931 tons of open-hearth steel ingots and castings. The production of basic pig-iron in 1913 was 12,500,000 tons, while there was perhaps 750,000 tons of Bessemer and low-phosphorus iron used in the acid open-hearth steel process. With these figures available, it is evident that the consumption of old scrap in the open-hearth process is really not large.

It is stated by Mr. J. H. Plummer, president of the Dominion Steel Works at Sydney, N.S., that indications point to a speedy resumption of operations of some of the mills of the works. Orders have already been received from England for 2,000 tons of nails and 2,000 tons of wire rods, and negotiations are pending regarding an order for rails.

Although the production of coal in North Dakota in 1913 was only 495,320 short tons, valued at $750,652, some interesting facts regarding the possibilities of the vast deposits which underlie the state are shown in a statement by E. W. Parker just made public by the United States Geological Survey. All the present mineral fuel produced in North Dakota is brown coal, or lignite. Considerable areas of sub-bituminous coal of usable quality and workable thickness are believed to underlie portions of the lignite areas, but no attempt to exploit the sub-bituminous coals has been made. At present the lignite is used chiefly for domestic purposes, but with proper equipment it can be used with satisfaction as a boiler fuel. A convincing example of what may be accomplished with lignite for such use is presented by the irrigation plant of the United States reclamation service at Williston. The lignite used here is taken from the only coal mine owned and operated by the Government. As the gas-producer and internal-combustion engines in large units come into more general use in the West, as they are rapidly doing in the East, the lignites of North Dakota will be recognized as possessing great potentialities in the settlement and economic development of the state. Experiments also show that lignite can be successfully briquetted, after which it stands transportation well and its heat value is increased 50 to 70 per cent.

MODERN FIXED AND INTERLOCKING RAILROAD SIGNALS.

RAILROAD signalling is the art of conveying information as to the occupancy or condition of the track ahead to an engineman or conductor in charge of a train so that he may move his train safely and expeditiously. It is obviously necessary for the train crew to have this information whenever more than one train is operated over the line at the same time. The means of conveying it are numerous, and include the time card, dispatcher's orders, precedence of one class of train over another, hand or lamp signals, and fixed signals.

A discussion of fixed signals, and the interlocking and other devices connected therewith is contained in a paper on railroad signalling read by H. J. Pfeifer, engineer maintenance of way, Terminal Railroad Association of St. Louis, before the Engineers' Club of St. Louis. From it the following notes are taken.

The end sought by all railroads, signal engineers, and the manufacturers of signal appliances is "Safety First." To be successful, however, in these times of dense traffic at high speeds, increased expense and low rates, a signal installation must have other qualities in addition, among which are facility, reliability, and economy.

In the early stages, attempts to secure safety and facility were more or less compromises between the two with sacrifices on the part of each. The advance of the art, however, has been so rapid of late years that less and less sacrifice is necessary. To secure safety and facility the signal mechanism must be reliable in operation; *i.e.*, subject to the minimum of failure.

True economy is not confined to the cost of installation, or even of maintenance and operation, but takes into account the entire conduct of the railroad and that system is the best in each case, which results in the safe movement of the traffic at the least gross expense, and in the shortest time, even though the signalling system is elaborate and costly in itself.

Fixed signals may be divided into two general classes, block and interlocking. The first are for the purpose of maintaining a proper space interval between trains on a given stretch of track, and the second for controlling the movement of trains at crossings, junctions and terminal points.

Block Signals.—Probably the simplest form of block signal is the train order board or simple manual block at a station which is under the control of an operator or agent. Information as to the condition of the line is transmitted to him by telegraph, and in recent years by the telephone. Ordinarily this board gives three indications, "Stop," "Proceed cautiously" because of train in block moving in same direction, (this order is usually given to freight trains only) and "Proceed," block is clear. The manipulation of the signal is entirely in the control of the operator, there being no connection between adjoining stations, except for the transmission of information. You will note that in the use of this system, collision or accident may result, through the unchecked action of at least three men or agencies: First, the operator at the station in advance, having overlooked the train in the block, may give false information; second, the operator may make a mistake and give a clear signal with a train in the block ahead, and third, the engineman may fail to obey a stop signal.

The danger of this lack of control over the operators resulted in the development of the controlled manual block. In this system the signal is locked in the stop position and cannot be cleared until released by the operator at the station in advance. After the passage of the train the signal automatically returns to the stop position. This system increases safety because a clear signal cannot be given, except by the concurrent action of two operators. There is nothing about it, however, reducing the danger resulting from the failure of the engineman to obey a stop signal.

An additional safeguard on single track lines is the electric train staff. In this system there are interlocked receptacles at each station containing staffs for delivery to the engineman. Not more than one staff can be taken out at one time, which is an assurance that there can be only one train in the block, as no train is permitted to enter unless the engineman has a staff. The staff is placed in a frame, adjacent to the track, similar to a mail catcher, out of which the engineman can take it if moving at a reasonably low rate of speed. As the train passes the advance block the staff is thrown off by the engineman and placed in its receptacle by the operator, after which it is again possible to withdraw a staff at either one end or the other. In addition to the main staff, provision is made for permissive staffs, which can be issued to following trains, and grant the right to enter the block under control and with the advice that block is already occupied. This gives great additional safety, because the key for unlocking the system is on the train itself and cannot be used until the train has cleared at either end. In this system also there is no mechanical device to check the engineman in case he fails to obey the signal.

The St. Louis tunnel, as an example, is operated on on an absolute controlled block, with a modified staff system added for eastbound freight trains only. On account of the smoke and darkness it is essential that not more than one train is on each track at one time.

The system consists of an interlocking machine at the west end of the tunnel, known as "X" office, and another at the east end known as "MS" office. They are a little more than a mile apart.

The two machines are connected by a system of electric locking which compels the co-operation of the operators at both ends before signals can be given which will permit a train to enter the tunnel. These signals, by means of track circuits, are automatically returned to the stop position behind the train accepting the proceed signal and entering the tunnel. The track circuit is in two sections of about 240 feet, one at each end of the tunnel. The signal automatically restored to the stop position and the signal governing in the opposite direction cannot again be cleared until the train has passed out of the tunnel. As an additional precaution there must be a red light on the rear end of each train. The operator at the outlet station must see this light and then record on his train sheet the hour and minute during which the train passed his station. There is a heavy grade eastward through the tunnel and it is possible that an eastbound freight train may break in two, and leave cars standing between the track circuits, without being noticed by either the engineman or the operator. As the forward part of the train would release the track circuit control, it is within the bounds of possibility for the operator to make a mistake, say, that he saw the red light on the rear end of the train, when he actually did not, and release the tunnel entrance signal at the west end for another train. The disastrous possibilities of the resulting collision with the cars in the tunnel led to the adoption, a few years ago, of the following device:

Before entering the tunnel the rear switchman on every freight train, who is compelled under the rules to ride on the rear end of the last car, is given a numbered leather disk by the yardmaster. This number is communicated to the dispatcher or operator at the west end of the tunnel. As the train passes "MS" office at the east end the rear switchman delivers this disk to the operator, who reports its number to the dispatcher at "X" office. Unless the number reported by the yardmaster and operator agree, no train is permitted to enter the tunnel until it has been found clear by a light engine feeling its way through.

Another form of block signal is the automatic, which is defined as follows in the Signal Dictionary:

"A block signal, worked by electric or pneumatic agency, which is controlled by the passage of a train into, through and out of the block section to which the signal is connected. The entrance of a train sets the home signal at stop, and the clearing of the block section by the passage of the train out of it sets that signal clear. The apparatus is so arranged that the misplacement of a switch or the accidental entrance of a car from a side track will set the signal at stop."

This result is accomplished by the use of the track circuit defined as follows in the same volume:

"An electric current flowing through the rails of a railroad track. In a typical track circuit, the current flows from the battery to the nearest rail of the track, thence to the other end of the track circuit section; thence by wire to the track relay (controlling a signal) back by a wire to the farther rail, and by that rail back to the battery. Each rail is made electrically continuous from one end of the track-circuit section to the other by metallic bonds at the joints, and at the ends of the section insulated joints are used."

Automatic signals have been in use in this country since 1871 with "track instruments" and since 1879 with "track circuits."

The first form of automatic signal was the enclosed disk or banjo type which is still used on some of the largest railroads. The day indications are given by the color or position of circular disks, and the night indications by the usual colored lenses.

Of late years the disk signal has been almost entirely superseded by the semaphore; defined as follows:

"A type of signal introduced on railroads in England about 1841 and now in almost universal use for both block and interlocking signals. It consists of an arm about 4 ft. long and 10 in. wide, mounted on a post usually 24 to 30 ft. high at one side of the tracks; or on a shorter post supported by a bridge or other structure above the track. Day indications are given by the position of the arm horizontal, inclined or vertical, and night indications by a light. The pivot of the arm is combined with a spectacle casting holding colored glass disks, which, as the position of the arm is changed, move in front of a lamp mounted on the post."

By far the largest portion of all automatic semaphore block signals are electric, although there are some electro-pneumatic and electro-gas signals.

In some of the earlier automatic installations, the signal indicated the condition of the track for one block section only. It was found particularly in mountainous regions, where the view of the track ahead is obscured, that this was not sufficient, if a reasonable speed was to be maintained. Three general methods have been used to supply the engineman with additional information.

(1) By the overlap, which is an extension of the track circuit one or two thousand feet beyond the advance signal. The effect of this is to encourage an engineman to pass a signal at danger, by giving him the assurance that the track for a considerable distance beyond it is clear. As there is a large element of danger in this, the use of the overlap as outlined is not considered good practice.

(2) By the use of the distant signal which, when clear, indicates that the home or main signal is clear, and when blocked tells the engineman that he must be prepared to stop at the home signal. The distant signal is frequently placed on the same mast with the preceding home signal, and by this means the condition of the track for the two blocks ahead is indicated.

(3) By the use of the three-position signal, which indicates the condition of the track for two blocks ahead as follows:

Blade horizontal, first block occupied.

Blade inclined at an angle of forty-five degrees, first block clear, second block occupied.

Blade vertical, both blocks clear.

Automatic block signals are usually operated on the permissive system as follows: If a signal is in the stop position, the train must come to a full stop for one minute, after which it may enter the block under control prepared to stop in case of danger without any additional signal or warning.

The number and location of automatic block signals varies with the nature of the service. On lines of heavy traffic they must be placed as close together as possible, so as to get the maximum operating capacity out of the line. In no event should they be placed any closer than the distance required by the fastest and heaviest train to come to a full stop.

The automatic block signal is superior as a safety device to any of the manual block systems, because in addition to making known the presence of a train in the block, it also gives an indication of track obstructions, such as cars on sidings fouling the main line, broken rails or other defects destroying the continuity of the track.

The automatic block, like the manual, does not and cannot guard against the failure of the engineman to obey signals. The only manner in which the engineman can be controlled is by some system of automatic speed control or train stop, which would shut off the steam supply and set the brakes on the locomotive. There has been considerable talk about these devices but so far nothing practical for general use has been developed, and we must therefore depend on the care and watchfulness of the man at the throttle. After all, in spite of the multiplicity of automatic devices, we must always in the last analysis depend on a man or men for our safety.

One of the latest developments in automatic block signals is the use of alternating current signals. An installation of this kind was recently completed on the Southern Railroad between Denim, N.C., and Charlotte, N.C., a stretch of 100 miles. The line had been previously operated under the manual block system with 19 stations. When the new system was installed 15 of the 19 operators were no longer needed and were sent to other parts of the line. The power-house was installed at about the middle of the system and the current, which was also used for lighting stations and other buildings along the right-of-way, was transmitted at 4,400 volts. There are 118 signals in the system and the total energy required for the signals, track circuits and lights in the signals, is less than 10 kw.

There are at present more than 35,000 miles of automatic block signals in use on American railroads, and the mileage is rapidly increasing. Their installation in many instances is an economy, because aside from the greater safety secured they increase the traffic-carrying capacity of the line to such an extent that the construction of an additional track, entailing a much larger expense, may frequently be indefinitely postponed.

Interlocking.—This has been defined as "An arrangement of switch, lock and signal appliances so interconnected that their movements must succeed each other in a predetermined order." The term includes the cabin, the machine, switches and signals and all the connections and appurtenances.

Patents for manually operated interlocking devices were first granted in England in the year 1856, and in 1873 the system had been so generally adopted in England that the London & Northwestern Railway alone employed 13,000 interlocking levers. The first experimental interlocking installation was made in the United States at Spuyter Duyvil Junction, New York City, in 1874. The first important installation on a commercial basis was made by the Manhattan elevated lines in New York City in 1877-78.

Interlocking resulted from the desire on the part of English railways to save labor by concentrating in a single frame the levers operating a number of widely separated switches and signals. After this it was a short and simple step to so lock these levers one with the other that a clear signal could not be given unless the route was properly set up, and so that signals for conflicting movements could not be given. As the cost of labor is higher in the United States than in England there was a demand in this country for an interlocking that would permit of the operation of switches and signals over greater distances and with fewer operators. This resulted in the development of a hydro-pneumatic interlocking, which was first installed in 1884 at Bound Brook, N.J., at the crossing of the Philadelphia & Reading and Lehigh Valley Railroads. From 1884 to 1891 eighteen of these plants, having 482 levers, were installed on six railways. As the system developed many serious defects were found, and its inventors devised the electro-pneumatic system in 1891, which is still in general use, particularly in large installations.

The first interlocking in the St. Louis territory was installed in 1883-84 to control switches and signals at both ends of the tunnel, and at about the same time the crossings, switches and signals at the east end of the east approach to the Eads bridge were also interlocked. The levers of these machines were made to operate special valves which controlled the hydraulic pressure used to operate the switches and signals. Pipes were laid from the ports of the valves to the switch and signal-operating mechanism in which the pressure was maintained by a system of pumps and accumulators or hydraulic rams.

It is here noted that this was one of the first interlocking plants using other than manual power installed in this or any other country. This type of machine, although it developed many defects, was continued in service with some modifications until 1899, when the present electro-pneumatic plant was installed at the tunnel entrances.

Interlocking development has easily kept pace with that in other fields.

The principal types of machines now in use in this country are the mechanical, the electro-pneumatic, the pneumatic and the all-electric.

Mechanical.—A mechanical interlocking plant consists of a frame of levers in a tower, which are connected by means of pipe and wire-runs to switches and signals which are moved by manual power applied to the levers in the tower. Where the distances are not too great, the switch layout comparatively simple and traffic light, this type of plant is both cheap and efficient. With the present tendency toward the control of trains by the block system, most modern mechanical plants are equipped with a number of electric safeguards, such as power distant signals, track circuits, electric route locking, etc. These trimmings in some instances have cost more than the mechanical interlocking itself.

Electro-Pneumatic.—Electro-pneumatic interlocking was first placed on the market in 1891 by the Union Switch and Signal Company. It was found to be particularly advantageous for use in large, complicated installations. The original St. Louis Union Station interlocker, built in 1891-92, was one of the first large installations of this system. This was followed a year or two later by the South Boston station interlocker, and since that time the system has been installed in some of the largest plants in the country, including the St. Louis Union Station as remodeled in 1903-1904.

Electro-pneumatic interlocking is described as follows: Compressed air at a pressure of about 85 lbs. is stored in a reservoir at or near the signal tower and is conveyed in pipe laid underground to cylinders, one at each switch and signal, in which the pressure by means of a piston, moves the switch or signal. The admission of air to a cylinder is controlled by an electric magnet fixed at its side, and the circuit of this magnet is controlled by a miniature lever in the cabin, the wires being run from the switch or signal to the cabin. These little levers are suitably interlocked the same as the large levers in a manual machine. The movement of a lever to work a switch does not, however, actuate the interlocking which releases the lever to be moved next; for the lever movement does not insure that the switch has actually been moved, it only closes the circuit. The next lever is held locked until by an electric current, the circuit of which is closed by the switch rails themselves, after their movement is completed, the "indication" of such completion is sent back to the cabin permitting the unlocking of the next lever.

Electro-pneumatic, in common with other forms of power interlocking, has many advantages over mechanical or manual, particularly in large complicated installations in which the installation of manual interlocking is practically impossible on account of the size of machine required and the great number of pipe-runs. The same amount of interlocking can be accomplished by power with fewer levers and each lever occupies about one-third as much space in the machine. A manually operated machine to operate the Union Station layout, if it were possible to properly lock it, would be at least two hundred feet long; and the pipe-runs would be so numerous and bulky that it would be difficult, if not impossible, to find space for them and the tracks too.

Pneumatic.—Another form of machine is the pneumatic or low-pressure air which has been used to a limited extent within the past 12 or 14 years. This machine acts more slowly than the electro-pneumatic or all-electric. In this system the pressure in the cylinders, moving switches and signals is 15 lbs., and in the small pipes leading to the diaphragm valves it is only 7 lbs. per square inch. The signalman's work consists in opening and closing these valves. The interlocking is the same as in other machines.

All-Electric.—The all-electric interlocking was developed by J. D. Taylor about 1900. A switch is moved by a one horse-power electric motor fixed to the ties and worked by an electric current conveyed by wires from a dynamo or storage battery in the cabin; and a signal by a motor of 1/6 horse-power, fixed to the signal post. The storage battery is usually charged by a generator run by a gasoline engine; and the amount of electric power used is so small that a small engine need be run but a few hours daily.

The machine in the cabin consists of a frame supporting horizontal sliding bars or levers, each movement closing a circuit to a switch or signal. The levers are interlocked as in other machines, and as in other power machines the interlocking is controlled by an indication sent to the machine from a switch after it has actually completed its movement. This "indication" current is generated by the momentum of the switch motor, which is converted into a generator for a fraction of a second after it has completed its work of moving the switch. The movement of a switch requires a current of only seven amperes.

All-electric interlocking has been manufactured since its development by the General Railway Signal Company.

Among the large all-electric installations may be mentioned the new Grand Central Terminal at New York, and the Chicago & Northwestern Terminal at Chicago. The latter is one of the most recent and up-to-date installations, so that a short description of it may be interesting. The Lake Street or main plant controls the entrance to 16 station tracks, which converge into six main lines. The semaphore signals are all of the three-position upper quadrant types and the dwarf signals are also three-position. The signal blades when horizontal mean stop; when inclined at an angle of 45°, proceed, stop at next signal; and when vertical, proceed.

In place of mechanical detector bars, which are usually installed at all interlocked switches to prevent the throwing of the switch under a train, electric track circuit locking is substituted. Miniature lights are placed on switch levers to indicate the presence or absence of trains on the switches and illuminated track diagrams are employed to give information to levermen as to occupied or unoccupied condition of all tracks.

An elaborate system of route and release locking is installed at this point, which by means of track circuits, controlling lever locks in the interlocking machine, prevent the movement of switches in a given route after a clear signal has been given to and accepted by a train over such route, even though the governing signal has been restored to normal or stop position. An ingenious feature of this "Route and Release" locking system is that while it is impossible to change the position of switches ahead of a train moving over the route, it is possible to move switches immediately after it has passed, thus permitting a new route to be lined up for a following train. In the older methods of track circuit route locking, the train must pass over all the switches in the circuit before any of them can be moved. The former scheme greatly facilitates train movement, while retaining all of the safety features of the latter.

There has been in late years a good deal of discussion as to the proper signal aspects for both day and night. While practice is not uniform the consensus of opinion is that a semaphore signal at the right side of the track or above it, with the semaphore blade to the right of the mast and working through the upper quadrant is the best practice. In this type of signal the blade horizontal means stop; inclined upward at an angle of 45°, proceed cautiously; and inclined upward at an angle of 90°, proceed.

At night the stop signal is a red light, the caution a yellow and the proceed a green light. Formerly, a white light or an ordinary flame seen through an uncolored lens was the clear indication, but on account of the danger of confusing this light with others in the vicinity, and the fact that the breaking of a red lens might cause a light to appear white when it should be red, the green light was adopted for the clear indication.

At interlocked railroad crossings it is the general practice, and in most States the law requires the installation of derails and distant signals. The derail on high-speed tracks is placed about 500 feet from the crossing and will throw a train off the track if the stop signal is not obeyed by the engineman.

The distant signal is placed about 2,000 feet ahead of the derail and warns the engineman that he is approaching an interlocking plant. The distant signal gives two indications—one that the home signal is clear and that he may proceed over the crossing without stopping, and the other that he must approach the home signal prepared to stop.

It is customary in modern installations to have a track circuit route locking which will prevent the moving of any switch or signal on the route after a train has accepted and passed a clear distant signal and until it has passed the home signal or through the entire plant.

RAILWAY ELECTRIFICATION IN ENGLAND.

A brief description has recently been published on the electrification by the London and North Western Railway Company of some 80 miles of single track, the first section of which was placed in operation on May 1st, of the present year. In all, about 7½ miles of single track have been equipped to date. High tension cables will, as far as possible be carried on short posts along the railway. The low tension cables will be laid underground. The conductor rails are all of a special low carbon soft steel having a weight of 105 lb. per yard; and the electrical resistance is approximately 6½ times that of copper. The rails are supported on porcelain insulators attached to the sleepers by malleable iron clips.

Trains, such as it is proposed to operate on these lines, will consist each of three cars having a total length of 179 feet. End doors are used with through communication, and both cross and longitudinal seats are provided. The electrical control gear will be supplied by the Siemens companies. Every motor car will be fitted with four motors of 250 h.p. each.

The generating equipment will consist of 5 turbo-generators of 5,000 kw. each, three-phase, 11,000 volts, 25-cycles; and transformers and rotary converters will be used to reduce the current to 600 volts d.c. Storage batteries will also be installed for peak and emergency service.

The transformers are being manufactured by the British Electric Transformer Company; sub-station plants, by the British Thompson-Houston Company; and the electrical apparatus of the trains, by the Maschinenfabric Oerlikon. Owing to the war, however, it is almost certain that all contracts with the German company have been cancelled.

The state of Texas mined 2,429,144 short tons of coal in 1913, valued at $4,288,920, according to E. W. Parker, of the United States Geological Survey. This production was nearly evenly divided between lignite and bituminous coal, with the balance slightly in favor of the latter. Both classes of coal showed increases in production in 1913, and both made their record output. The total production in 1913 exceeded that of 1912 by 240,532 short tons, or 11 per cent. in quantity, and by $633,176, or 17 per cent., in value.

ECONOMICS OF WATER WASTE IN CITIES.

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A PERUSAL of the technical press and of the papers and discussion at the various conventions of engineers will indicate that the subject of water consumption and waste is one of considerable importance.

That water is being wasted in cities is recognized by engineers, and that it cannot be completely eliminated is admitted by all. But the quantity which is used or wasted in *excess* of allowable or unpreventable waste plus that actually consumed for all legitimate purposes, represents a tangible and potential source of wealth. The means by which such wealth can be conserved is dependent on the method adopted and the manner in which it is organized.

The influences which affect the consumption of water are the nature of the industries, the wealth and habits of the people, the extent to which water is used for fountains or other ornamental objects, watering of lawns, street sprinkling and other public purposes. Climate has also a very considerable influence especially as to the amount used for sprinkling purposes, and that which is wasted in winter to prevent freezing. It is probable, however, that the most important factors in determining the consumption of water is the degree of care taken to detect leakage and other waste, and the fact as to whether the water is sold by measure or otherwise. (1)

It will be assumed that the actual consumption of water on the North American continent is on a more generous scale, and that the climate, as a rule, is less humid and consequently the gardens and streets receive more watering than in Europe. This, however, cannot account for the great difference in the average consumption per capita.

Whilst it is not always a sure method of comparison to consider the consumption in any one city with that of another, owing to the different conditions which obtain, yet when several cities are compared, the above statement loses some of its force.

The following is a list of a few Canadian and American cities selected at random from references in various papers and reports:

City.	U.S. gals. per capita.	Population.	Source of information.
St. John, N.B.	250	42,500	Commission of Conservation
Vancouver, B.C.	164	120,000	Commission of Conservation
Halifax, N.S.	260	46,600	Commission of Conservation
Quebec, Que.	161	78,200	Commission of Conservation
Hamilton, Ont.	148	81,000	Commission of Conservation
Ottawa, Ont.	220	87,000	Special Report
Toronto, Ont.	120	450,000	Commission of Conservation
Montreal, Que.	130	555,000	Hering&Fuller Report, 1910
New York City, N.Y.	111	4,800,000	(2)
Buffalo, N.Y.	321	425,000	(2)
Chicago, Ill.	235	2,200,000	(2)
Philadelphia, Pa.	203	1,600,000	(2)
Milwaukee, Wis.	115	410,000	1913 Report
Kansas City, Mo.	126	300,000	1913 Report
Cincinnati, O.	131	392,000	1913 Sewerage Report
Pittsburgh, Pa.	197	550,000	(2)
St. Louis, Mo.	109	687,000	(2)
Cleveland, O.	102	560,000	Toronto 1912 Report
Detroit, Mich.	173	466,000	(2)
Baltimore, Md.	115	560,000	(2)
St. Paul, Minn.	61	210,000	
New Orleans, La.	53	370,000	1913 Report
Boston, Mass.	108	733,000	1913 Report
Albany, N.Y.	242	101,000	Engr. Record, Aug. 3, 1912
Salt Lake City, Utah	400	......	Engr. Record, July 25, 1913

The following are the statistics of a few European cities:—

City.	U.S. gals. per capita.	Population.	Source of information.
Vienna, Austria	15	1,800,000	(3)
Aachen, Germany	25	....	(4)
Frankfort-on-Maine, Germany	46	400,000	(5)
Wiesbaden, Germany	28	100,000	(3)
Hamburg, Germany	44	757,000	(3)
Munich, Germany	45	524,000	(3)
Berlin, Germany	22	2,100,000	(3)
Basel, Switzerland	42	....	(4)
Copenhagen, Denmark	27	....	(4)
London, England	43	6,721,207	1913-14 Report
Liverpool, England	36	960,000	(6)
Newcastle-on-Tyne, England	36	590,000	(6)
Hull, England	49	250,000	(6)
Manchester, England	42	1,200,000	(6)
Devonport, England	51	75,000	(6)
Glasgow, Scotland	72	1,150,000	(6)
Nuneaton, England	21	37,000	(7)
Stirling, Scotland	64	28,000	(7)
Plymouth, England	47	152,500	(8)
Sydney, Australia	48	668,000	(9)
Riga, Russia	25	....	(4)
Weardale and Consett, England	22	400,000	Letter

Chicago has about the same population as Vienna but the quantity of water consumed is over 15 times as great; Ottawa is about the same size city as Devonport but uses about 4½ times as much water; Montreal and Newcastle-on-Tyne are nearly similar in size but Montreal uses 3½ times the volume of water used in Newcastle; Milwaukee and Frankfort-on-the-Maine have approxi-

(1) Public Water Supplies, Turneaure and Russell, 1903, page 16.
(2) De Varona's paper, American Waterworks Association, 1913.
(3) Lehmann's Hygiene, 1909.
(4) Hütte Engineers' Pocket Book, 1911.
(5) Stadtische Tiefbauwessen, Frankfort, 1903.
(6) American Waterworks Association, proceedings, 1912.
(7) Proceedings, Institution of Municipal and County Engineers, Vol. XXXVIII.
(8) Proceedings, Institution of Municipal and County Engineers, Vol. (XXXVII.)
(9) Proceedings, American Waterworks Association, 1911.

mately the same number of inhabitants, yet the former uses three times the quantity as the latter; Basel in Switzerland and Buffalo in New York State are nearly alike in population, but Basel uses only one-eighth as much water; New York City, the greatest city of the west, requires 2½ times the quantity needed in London, England. The reader who will continue the comparisons will find material for thought and investigation. There are, of course, certain conditions in Europe which tend to keep the consumption low, and these should be studied so as to arrive at a reasonable comparison. Such conditions are the number of faucets fixed on services, types of dwelling, methods of living, density of population in certain quarters and so on, but space will not permit discussing them at present.

In Germany an allowance of 100 litres per capita per day is ordinarily considered as ample for all city uses—this is equal to 27 U.S. gallons. Mr. Edward S. Coles, in a paper read before the American Waterworks Association in 1912, held in Louisville, Kentucky, presented a list of British cities, the average domestic consumption in which was 29.8 U.S. gallons and the average trade consumption was 13.6 gallons, or a total of 43.4 gallons daily per capita.

Even granting that the actual use of water for ablutionary and other purposes is more generous here than in European cities, it is palpable that the excess will not be great.

An American authority (10) estimates that the daily average would be:

For domestic purposes ..	25	gallons per capita
For commercial purposes	20	" " "
For public purposes.....	5	" " "
Loss	20	" " "
Total	75	" " "

There are many cities in the United States and Canada that are thriving on a smaller average. Domestic allowance of 25 gallons daily per capita is more than ample, and when it is borne in mind that a large number of industries, railways, etc., do not use city water, as a perusal of Cincinnati Sewerage and other reports clearly shows, an allowance of 20 gallons per head per day for industrial consumption is high. The loss of 20 gallons is excessive, whilst the preceding allowances evidently include waste also.

The average of the European cities cited is about 40 gallons per head per day. If this figure is increased by 25 per cent. it will represent a reasonable quantity and includes unpreventable waste, which occurs in all cities.

The writer will, for the purposes of this article, assume two hypothetical cities, each of 250,000 inhabitants. One city will consume 50 gallons per capita daily, and the other 150 gallons. Approximate estimates, based on published statements which will be quoted, will be submitted to show the economics of waste. The water is supposed to be filtered, chlorinated and pumped 200 feet high or equivalent in pressure, and distributed. The sewage will be collected on the separate system and treated bacteriologically.

There is ordinarily one ratepaying consumer in every six inhabitants, so that in each city of 250,000 population there will be about 42,000 water consumers.

The daily consumption of water will average: 250,000 × 50 = 12,500,000 gallons; 250,000 × 150 = 37,500,000 gallons, and to these figures must, of course, be added an allowance in capacities of mains, pumps, etc., to meet the fluctuating hourly flows.

The waterworks of the six largest cities in Wisconsin (11) supplying an average of 81 gallons per head daily, cost about $187.25 per consumer, but eliminating one city, where the cost exceeded the average by nearly 100 per cent., the mean of five cities was $151.42 per consumer. Accepting this as the basis of cost, the waterworks system for a city of 250,000 inhabitants or 42,000 consumers will be about $6,360,000. It is therefore reasonable to estimate that for 50 gallons per head daily the cost will be about $6,000,000 and for 150 gallons per head $7,000,000. The extra $1,000,000 will annually cost 5 per cent. for interest and, say, 2½ per cent. for depreciation, a total of $75,000 per annum.

The cost of pumping water will be about six cents per million foot-gallons (12); so that 12.5 million gallons raised 200 feet will cost about $54,750, whereas 37.5 millions raised to the same height will cost $153,250, an extra cost of $109,500 per annum. The average cost in 21 cities in Wisconsin in 1911 was $16.70 per million gallons pumped and on this basis the annual cost would be $76,000 and $228,000 respectively.

Filtration and sterilization will cost about $3.37 per million gallons (13), to which is added the cost of pumping into filters, making a total of $3.50. So that, in the first city, this work will cost about $16,000 and in the second $48,000, a difference of about $32,000 per year.

The distributing mains, sufficient for domestic, industrial and fire purposes, should satisfy the National Board of Fire Underwriters' (1910) standard and also allow for the usual maximum fluctuations in consumption.

The National Board of Fire Underwriters' general requirements may be expressed by the following equation:

$$Y = 1020 \sqrt{X} (1 - 0.01 \sqrt{X})$$

Y = gallons per minute.
X = population in thousands.

The cities under consideration have about 250 thousands population, so that to satisfy the above requirements

$$Y = 1020 \sqrt{250} (1 - 0.01 \sqrt{250}) = 13{,}570 \text{ gals. per min.}$$

The consumption of 12,500,000 gallons per day is equal to an average of 8,700 gallons per minute and 37,500,000 gallons daily represents an average of 26,000 gallons per minute, but the maximum rate will probably be about 150 per cent. of the average. Therefore, the relative requirements of the two cities will be as follows:

	No. 1 City.	No. 2 City.
Fire purposes	13,570	13,570
Domestic and industrial purposes.	8,700	26,000
Add 50% for max. hourly demand	4,350	13,000
Total gallons per minute	26,620	52,570

In other words, the capacity of the mains in the city No. 1 will be only one-half of that in No. 2.

According to published statistics (14), distributing mains absorb about 64 per cent. of the total capita expenditure. There are other published figures which conflict with this percentage, but as the above result was evidently obtained by careful analysis of at least 22 dif-

(10) Water Supplies, Turneaure and Russell, page 22.

(11) Wisconsin Railroad Commission Report, 1911, page 453.

(12) Wisconsin Railroad Commission Report, 1911, page 453.

(13) Fuller, Baltimore Works, Engineering Record, May 9th, 1914.

(14) Proceedings, American Waterworks Association, 1911, page 75.

ferent city waterworks, it may be taken for granted that it is reliable. The cost of the distributing mains in No. 1 city will therefore be about $3,840,000 and in No. 2 about $4,480,000 and additional expenditure of about $640,000. The cost of operating distribution works may be estimated at $2.50 per million gallons pumped (15) which in the first city would amount to about $11,400 and in the second about $34,200, a difference of $22,800 per annum.

After having distributed the water to the people, the city must also provide sewers to drain it away after use or misuse. The lateral sewers are, of course, designed for flows which normally will only partially fill the pipes. The trunk sewers must be calculated so as to be ample to accommodate the districts served.

Supposing that it was necessary to provide one main conduit to the outfall works, that the grade was 1 in 5,000 and that no ground water was admitted, the diameter of such a sewer to convey 12.5 million gallons per day would have to be about 54 inches and for 37.5 million gallons 82 inches, this does not take into account the hourly fluctuations, otherwise the diameter would have in each case to be larger. Accepting Cincinnati prices (16) the cost of these conduits would be:

54-in. Diameter Sewer—

Trenching 8 yds. @ $1.25	$16.00
Concrete, 1.38 yds. @ $15	20.70
Cost per foot run	$30.70

82-in. Diameter Sewer—

Trenching 11.3 yds. @ $1.25	$13.95
Concrete, 2.24 yds. @ $15	33.60
Cost per foot run	$47.55

That is, to convey three times as much sewage as would be required economically, the ratepayer would have to pay about 60 per cent. more in capital expenditure (and of course in annual taxes for interest and maintenance) on such trunk sewers. When the cost of vitrified pipe sewers are analyzed, it will be found that the extra cost for sewers laid to carry, say, 1,200 gallons per minute and 3,600 gallons per minute will be in the following ratio:

15-inch Pipe, Grade 1/600—

Vitrified pipes	$ .75
Trenching 10 feet deep	.70
Total per foot run	$1.45

24-inch Pipe, Grade 1/800—

Vitrified pipes	$2.00
Trenching 10 feet deep	.70
Total per foot run..............	$2.70

Extra cost 86 per cent., so that the additional cost to convey three times a given volume of sewage increases as the diameter of the sewers diminishes. The cost of sewering a city is probably about the same as to provide water mains, perhaps more, because water mains operate under pressure and sewers by gravity; the former are always full, whilst the latter are generally only partially full and consequently larger in diameter or dimensions. Many of the lateral sewers could not be reduced in size even if the water consumed was maintained at 50 gallons per capita, but many of the larger sewers could, and the saving in capital expenditure would be tangible.

(15) Wisconsin Railroad Commission Report, 1911, page 445.

(16) Report on a Plan of Sewerage, Cincinnati, 1913, page 252.

The next item of expenditure is for sewage disposal works. Whilst to some degree it is true that an extravagant use of water does not necessarily entail the construction of works to treat sewage, in proportion to the flow or volume, it nevertheless means works of a greater capacity than would be necessary in the case of economical water consumption, for tanks and pumps must be in some relation to the hourly quantity of sewage. The capacity of the pumps (if any) must be more than equal to the maximum hourly flow of sewage, with reserve pumps and power as well, in case of breakdowns or other contingencies, common to such plant. The velocity of the flow of sewage through the tanks must not for long periods exceed a critical limit. To attain this condition it is evident that tanks capable of treating 37.5 million gallons daily will be much larger than would be necessary for a discharge of one-third that volume.

Mr. George H. Wisner, in his report (17) supplies an interesting table of costs which is copied below:

Type of tank.	Nominal period of settling.	Gallons per capita.	Cost per capita.
Emscher	3 hours	200	$1.44
Dortmund	4 hours	200	.84
Straight flow	8 hours	200	.77
Straight flow	6 hours	200	.58

As Emscher or two-story tanks are now prominently before us, its estimated cost per capita will be provisionally accepted. To maintain the same velocity for 150 gallons per capita daily, the cost will be $\$1.44 \times \frac{150}{200} =$ $1.08 and for 50 gallons per day $\$1.44 \times \frac{50}{200} = \$0.36$.

The writer does not contend that the cost of these tanks will be in strict proportion to the flow of sewage, as there are items of expenditure which are not proportionate; still, taken as an entity, the cost will not seriously exceed the above. Mr. Clark, when discussing a plant in course of construction in Baltimore, stated that the detention period with Emscher tanks would be two hours (18)—which is the ordinary standard detention period—consequently, to maintain this detention period as closely as possible, the number or sizes of the tanks must, in the cases under present discussion, be approximately in the same ratio as to dimension and cost. But to allow for contingencies, assume that the cost would be $1.10 and 40 cents respectively per capita, then, 250,000 × $1.10 = $275,000, and 250,000 × 40 cents = $100,000, a difference of $175,000 which, at 5 per cent. interest and 2 per cent. maintenance, etc., means $12,250 per annum.

Perco filters, again, are designed to deal with about 2,000,000 gallons per acre daily. Columbus filters were designed for this rating. Mr. George W. Fuller states in his book that his practice has been to specify for average conditions a 6-foot filter at an average rate of two million gallons per acre per day (19). This would be for a sewage flow of separate sewers approximately 100 gallons per capita daily. It is contended that perco filters will deal with approximately the same quantity of organic matter per acre per day, regardless of the degree of dilution. In other words, the organic matter from a residential city will, in the aggregate, roughly amount to the same

(17) Report on Sewage Disposal, Sanitary District of Chicago, 1911.

(18) Engineering Record, July 4th, 1914.

(19) Sewage Disposal, George W. Fuller, 1912, page 697.

quantity whether it is contained in a large or small volume of water. The British Government (Local Government Board) ordinarily requires in the case where there is no land for subsequent treatment or a large river for effective dilution, a filter 6 feet deep and one acre in area for each million gallons of sewage (dry weather flow) but when, as is the practice in America, a river is available for the ultimate oxidation of the filtrate, then the area is about one-half. It is, therefore, reasonable to postulate that for a consumption of 50 gallons per capita daily the area of filter will be about one acre per million gallons and for 150 gallons per day an area of one acre for each two million gallons, on which basis the respective areas will be about 12½ and 18¾ acres. A reserve must be added, say, ten per cent., which will increase the areas to 13.75 and 20.625 acres. Mr. Wisner estimates the cost of perco filters at about $28,000, whilst, according to the experience of other cities the average was about $38,000 (20). Basing the cost at $30,000 per acre, then, the first case will require an expenditure of $412,500 and the second $618,750, a difference of $206,250, which, at 5 per cent. interest, is equivalent to an annual burden of $10,312. The cost of operating and maintaining these filters may be placed at $2 per million gallons (21). This will amount to 12.5 × 365 × 2 = $9,125 and 37.5 × 365 × 2 = $27,375.

Sterilization of the filtrate by hypochlorite of lime costs about $1.67 per million gallons treated (22), when 4½ parts of available chlorine per million parts are applied. This for the first case would mean $7,620 and in the second case $22,860.

Summarizing the items already mentioned in the foregoing observations, the following results are obtained:

	No. 1 city. Consumption, 50 gals. per capita daily.	No. 2 city. Consumption, 150 gals. per capita daily.
Interest and depreciation on total capital on waterworks, per annum	$450,000	$525,000
Annual cost of pumping	54,750	153,250
Annual cost of filtration and sterilization	16,000	48,000
Annual cost of distribution works	11,400	34,200
Total on waterworks	$532,150	$760,450
Annual cost of sewers	.....	.....
Annual cost of operating sewage tanks, plus interest	$ 7,000	$ 19,250
Annual cost of operating perco-filters, plus interest	29,750	58,312
Sterilization of filtrate	7,620	22,860
Total	$ 44,370	$100,420

Adding the two expenditures together we arrive at a rough idea of what it means to the ratepayers:

	No. 1 City.	No. 2 City.
Waterworks	$532,150	$760,450
Sewage works	44,370	100,420
Total cost	$576,520	$860,870

The difference of $284,350, capitalized at 5 per cent., will represent a decent sum of $5,687,000.

The writer has advisedly adopted published figures and in doing so has quoted the authorities, but it is manifest that the above estimates serve only as indications, and therefore each city must be considered separately, although the foregoing statistics answer as direction posts to those who will carefully analyze the financial results to be obtained in their own cities. The foregoing will afford sufficiently safe basis to warrant a close scrutiny into the relative cost to the ratepayers of an economical versus an extravagant consumption of water. Furthermore, in those cities where the water supply is controlled by companies, the foregoing observations will suffice to show what waste means to them, and to their customers. The dividend-producing power of any franchise depends on an efficient management and this in its turn means the stoppage of all preventable waste.

(20) and (21) Engineering Record, 22nd August, 1914.
(22) Report on Plan of Sewerage, Cincinnati, 1913, page 567.

CEMENT PRODUCTION IN UNITED STATES, 1913.

A report on the cement output last year in the United States shows an increasing share of the rapidly growing consumption of cement in the United States being supplied by the domestic industry, production having risen from 8,000,000 barrels in 1890 to 93,000,000 in 1913; while imports of cement have fallen from 2,250,000 barrels in 1890 to 95,827 barrels in the fiscal year 1914; which is, with one exception, the lowest total reported in many years. The United States, according to the latest information received by the Bureau of Foreign and Domestic Commerce, Washington, leads the world in the production of cement, its output being approximately four times as much as that of England and nearly three times that of Germany.

The total quantity of Portland, natural, and puzzolan cement produced in the United States last year was the greatest in the history of the cement industry, according to a recent government report. The total amount was 92,949,102 barrels, valued at $93,001,169, compared with 83,351,191 barrels valued at $67,461,513 in 1912.

The total production of Portland cement in 1913, as reported to the Geological Survey, was 92,097,131 barrels, valued at $92,557,617; the production for 1912 was 82,438,096 barrels, valued at $67,016,928.

Of the 113 producing plants in the United States in 1913, 23 were in the State of Pennsylvania, whose output was 28,701,845 barrels of Portland cement, the largest quantity produced by any one state. The second greatest production came from Indiana, with 10,872,574 barrels, and California was third, with 6,159,182 barrels.

The natural cement produced in the United States in 1913 amounted to 744,658 barrels of 265 lbs. each, valued at $345,889, compared with an output of 821,231 barrels, valued at $367,222, in 1912. Puzzolan cement was manufactured in 1913 at three plants in the United States, in Alabama, Ohio, and Pennsylvania. The output of puzzolan and Collos cements in 1913 was 107,313 barrels valued at $97,663, compared with 91,864 barrels, valued at $77,363 in 1912.

The United States has a comparatively small export trade in cement. In 1913 the total quantity exported was only 2,964,358 barrels, most of which was Portland cement, valued at $4,270,666, compared with 4,215,232 barrels, valued at $6,160,341, in 1912.

In 16 years the United States office of public roads constructed 343 object-lesson and experimental roads. The cost has been borne by the localities, and the work of the engineers sent out has proven effective in spreading information. State-aid laws had passed in only 4 states 16 years ago, but 40 states have now adopted the state-aid principle.

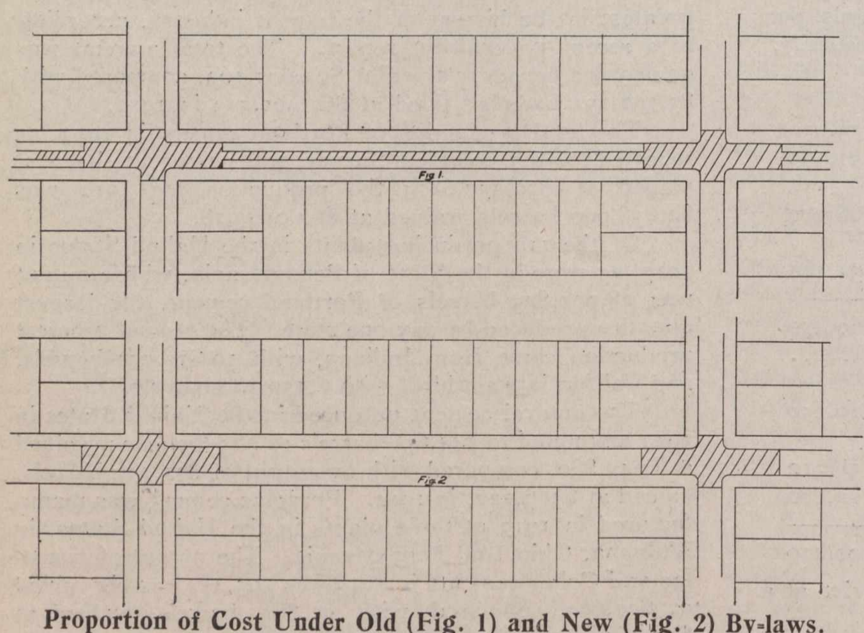
PAVEMENT AND ROADWAY WORK IN OTTAWA, ONTARIO.

By L. McLaren Hunter, A.M.Inst.M.C.E.
City Engineer's Department, Ottawa.

LOCAL Improvement pavements are either petitioned for, by property owners, or initiated under Sec. 9, Chap. 58 of the Municipal Act by the City Council on the advice of the city engineer. If the pavement is petitioned for, the act requires that there must be on the petition the signature of half the property owners representing two-thirds the assessed value of the property—if this is not complied with the petition will be of no use. Supposing, however, the city engineer decides that a pavement on this street is a necessity, then he may advise council to initiate the pavement under Sec. 9. Under these circumstances no petition against the work by the property owners will avail. The work must thereafter be proceeded with.

A Local Improvement report is then prepared by the roadway engineer. This report includes a sketch plan to a scale of 100 ft. = 1 in. showing the location of the work with the lots abutting on it. This L. I. report embraces also the report of the Board of Control and city engineer. The engineer's report contains a detailed statement of the estimated cost of the work.

The cost of the pavements up to July of last year was proportioned as follows: Property owners paid ⅓ the cost of the work opposite their respective lots; the city at large paid the extra third and also all street intersections and the cost of the surface drainage. The city had to pay, also, half the cost of the work opposite any flankage lots, if there were any on the street. It often happened that the city had to pay ¾ the cost of the pavement, so the Council decided to change the by-law and pass another, so that, under the new regulation, the property owners have to pay the cost of all work opposite their property, the city paying the street intersections and half the flankage lots as under the old by-law. Fig. 1 and Fig. 2 show the proportion of costs before and as now regulated. Although pessimists declared at the time the new by-law was passed that it would practically stop all improvements to streets, this happily has not been the case. On the contrary, petitions are now being sent to the city hall in larger numbers than heretofore, and at the time of writing over 200,000 yds. of permanent pavements have been constructed by the council.



Proportion of Cost Under Old (Fig. 1) and New (Fig. 2) By-laws. Shading Denotes Part Payable by City.

When the L.I. report is passed by the board of control and city council, detailed surveys are made and cross-sections taken, by the roadway department. The surveys are plotted to a scale of 40 ft. = 1 in. On the plan a profile of the centre of the road is shown, and also a section of the type of roadway to be constructed. These are the contract plans, and from them the quantities are calculated for the contractors to tender.

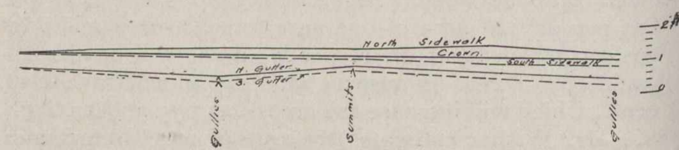


Fig. 3.—Part of Working Profile.

The working profile from which the grades are given is plotted to a horizontal scale of 25 ft. = 1 in. and a vertical scale of 2 ft. = 1 in. The sidewalks on this profile are shown by lines of different colors, and on it are placed the crown of the new roadway in red, and the gutter grades, showing the locations of the various catch-basins and summits. Fig. 3 shows a part of a working profile.

The surface drainage is all done by day labor, and 6 months must elapse after it is completed before the construction of the pavement starts, thus giving time for the loose excavation to become properly consolidated again. At the beginning of the 1913 season the city engineer recommended that all lots not built upon should have sewer services constructed by the city and charged to the owners of the lots along with the first payment on the pavement. The council adopted his recommendation and all the pavements constructed last year had these services put in. In addition to this, all water and gas services are constructed into the building line of the street. This has saved the cutting and disfigurement of the pavements, in more than 50 instances. No more will the city officials have to complain that they are always "digging of it up and putting of it down."

A new system in calling for tenders is being tried this year. Instead of having bulk tenders for each street several streets have been let on the unit principle. A schedule has been added to the specifications upon which the approximate quantities of asphalt, gutter, curb and gutter, etc., etc., have been placed. The contractor fills in his price per sq. yd. or lin. ft., as the case may be, the total charge being placed on a blank form. When the work is finished it is measured by the engineer and charged at the schedule rates. This is the method in practice in Great Britain.

The type of catchbasin and cover used in Ottawa is shown in Fig. 4. It is constructed of concrete with a 6-inch outlet leading to the sewer. The cover is of cast iron and has a very neat appearance on the street.

Asphalt Pavements.—Fig. 5 shows a typical cross-section of an asphalt pavement as it is laid on the residential streets of Ottawa. There is a 6-inch concrete foundation of a 1:3:6 mixture; ¾ inch of binder, and 2-inch layer of asphalt.

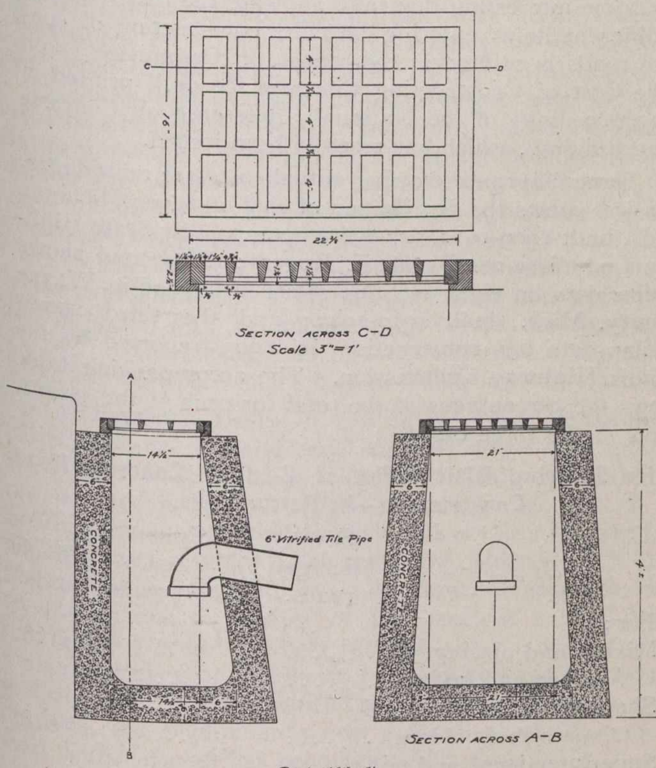


Fig. 4.—Catchbasin Details.

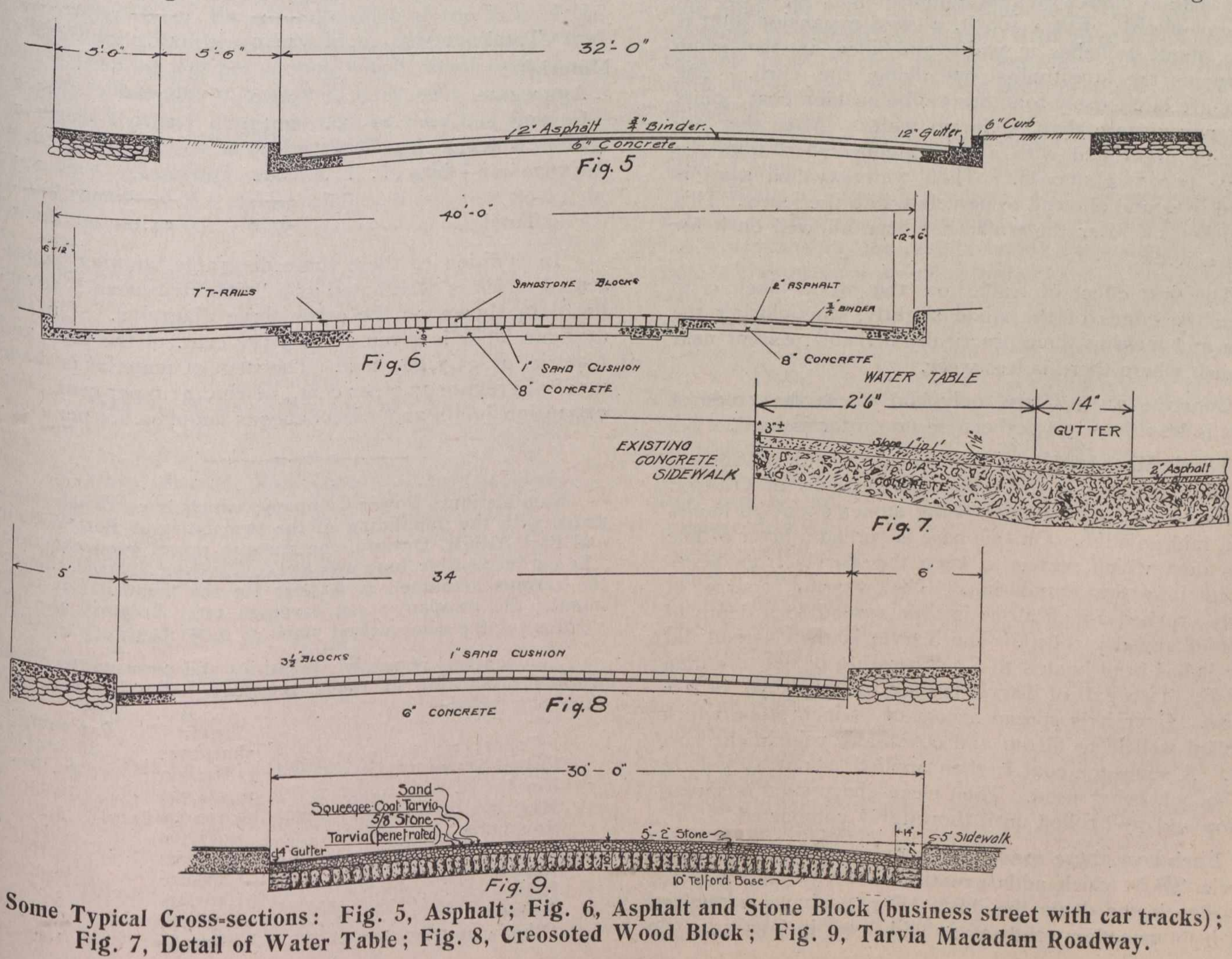
Fig. 6 shows a cross-section of a business thoroughfare, where the street railway operates; 8 inches of concrete is usually laid (especially if there is very heavy traffic) with the same thickness of binder and asphalt. If there happens to be a large number of telegraph poles outside the sidewalk, more so on a business street, a water table is constructed as shown on Fig. 7. This allows an unobstructed run of the water to the catchbasin and also eliminates the necessity for a curb and gutter, which would form a boulevard. In the business section this would be unsightly as the grass between the curb and the sidewalk would be trampled under foot and worn entirely bare.

The asphalts permitted to be used in Ottawa are, Trinidad, Pitch Lake, Bermuda, Mexican, and Californian, and, to show the exact locality from which it comes, the contractors have to furnish the city engineer with proper certificates of shipment.

The matrix or asphaltic cement is made of a mixture of the refined asphalt and flux, proportioned to show the presence of about 22% asphaltine.

The refined asphalt is heated to about 300° F., so that it may be properly agitated by the forced introduction of air. When it is thoroughly melted the flux is introduced and well mixed with the refined asphalt. This is the asphaltic cement that is used for making the binder, and the wearing surface for painting gutters, and, when necessary, for pouring joints.

The wearing surface is formed of the asphaltic cement described above, along with clean gravel and sand or crushed stone. The proportion of each is regulated



Some Typical Cross-sections: Fig. 5, Asphalt; Fig. 6, Asphalt and Stone Block (business street with car tracks); Fig. 7, Detail of Water Table; Fig. 8, Creosoted Wood Block; Fig. 9, Tarvia Macadam Roadway.

according to the kind and shape of the gravel and stone which will pass through a ⅜-inch mesh and be held by a 1-inch mesh. The sand or crushed stone is specified to pass through a ⅛-inch mesh and be held by a 1/50-inch mesh. The stone and sand are heated to about 300° F. by passing through revolving heaters. After all the moisture is driven off and all vegetable matter destroyed, while they are still hot, the asphaltic cement is added.

The proportion of each allowed in Ottawa is as follows (regulated so as to contain from 9% to 11% of bitumen in the wearing surface): Gravel and stone, size ⅜ to ⅛ inch, 25 to 25 parts; sand and stone, size ⅛ to 1/50 inch, 23 to 30 parts; sand, smaller than 1/50 inch, 35 to 35 parts; and asphaltic cement, 17 to 10 parts. These have to be thoroughly mixed and delivered on the work at not less than 250° F.

Two companies operate in the construction of asphalt pavements in Ottawa, namely, The Ottawa Construction Co. (John Foley, managing-director), and the Union Construction Co. (Pat. O'Leary, managing-director).

Creosoted Wood Block Pavements.—About 20,000 yds. of this class of pavement have been laid in Ottawa during the present season, by the Canada Creosoting Co., Toronto. A Norway pine block 3½ inches in depth is being used, laid on a 6-inch concrete foundation, with a 1-inch sand cushion. The blocks are treated with oil to the extent of 16 lbs. to each cu. ft. and are set with the fibre of the wood vertical, in straight parallel courses, at right angles to the curb, except that one row of blocks is placed parallel with the curb, about 1½ to 2 inches therefrom. This is filled with a bituminous filler (two of asphalt to one of pitch). Every 100 ft. a cross expansion joint is made, about 2 inches in width and filled in the same manner as the longitudinal one along the curb. The blocks are laid loosely together on the cushion coat, joints being never more than ⅛ in. in width. After they are laid they are rolled with a light steam roller, until the surface becomes smooth. Then water-washed sand is spread over and allowed to percolate into the joints. This is brushed off after the traffic has been allowed on it for about a week.

The first effect of traffic on the wood block is to broom the edges of the wood slightly, thus closing the joints and making them practically invisible, except near the curb where there is less wear.

Concrete gutters are only laid where the grade of street is less than .5%, otherwise no gutter is used.

Tarvia Macadam Roadways.—This type of roadway is becoming popular in the residential districts of Ottawa. It is laid on a Telford base, being stones about 10 inches thick, laid on edge. On this base is spread a layer of fine stone dust which serves to keep the Tarvia from penetrating into the foundation. The wearing course of evenly crushed 2-inch stone is then spread to a depth of 4 inches and dry rolled. The Tarvia is then spread on, after it has been heated to a temperature of not less than 200° F. Two gal. of Tarvia is used to the sq. yd. in this course. Over it is spread a coat of ⅝-inch stone which is rolled well in to fill up and cover any vein in the surface. A squeegee coat is then applied, about ½ gal. to the sq. yd. being used. Then clean sharp sand is spread on top and well rolled until thoroughly compacted.

Each year these roads are recoated with a coating of Tarvia "B," which adds greatly to the life of the road and also keeps down the dust. Fig. 9 shows a section of Tarvia macadam roadway as laid down in Ottawa.

DISTRIBUTION OF COST OF CONCRETE ROAD CONSTRUCTION.

Some interesting diagrams showing the relative costs of different items entering into the construction of concrete roads is printed in the report of Committee 12 on "The Cost of Constructing Concrete Roads," printed in the proceedings of the National Conference on Concrete Road Building, which has recently been issued.

Three diagrams showing actual costs are reproduced. The first shows the distribution of cost on seven Michigan roads, built 1909-1912, taken from a report by State Highway Commissioner Frank F. Rogers; the second shows similar data on eight sections of concrete road in Wayne County, Mich., built 1912-1913; and the third shows similar data for construction in 1903 reported by the Illinois Highway Commission. The accompanying table shows the percentages of the total for each of the several items in the three cases.

Table Showing Distribution of Cost in Concrete Road Construction—in Percentages.

Item.	Seven Michigan roads.	Eight Wayne Co. (Mich.) roads.	Illinois roads.
Labor:			
Mixing and placing	....	....	11.6
Unloading and laying ..	....	....	13.1
Shaping roadbed and trimming shoulders ..	....	....	6.8
Superintendence and miscellaneous labor	....	....	7.0
Total	43.0	46.0	38.5
Materials:			
Aggregate	29.0	27.0	25.2
Cement	22.7	19.9	31.7
Miscellaneous supplies..	5.3	7.1	2.3
Expansion joints	....	....	2.3
Total	57.0	54.0	61.5

In addition to these three diagrams, another is presented which is designated as a "weighted mean," covering data shown on the other three diagrams. On this diagram labor is given as 44.3 per cent. of the total and material as 55.7 per cent. The item of material is made up of aggregate 27.7 per cent., cement 21.6 per cent., and expansion joints and miscellaneous supplies 6.4 per cent.

Kaministiquia Power Company, which is so closely associated with the upbuilding of the twin cities of Fort William and Port Arthur, Ontario, continues to report good earnings. The net income for June was $22,697. After all fixed charges the surplus amounted to $15,042 for the month. For eight months the company's net earnings total $185,295 and the surplus for the same period amounts to $126,479.

The sources, respective quantities and percentages of the world's production of crude petroleum are shown in the following table:—

Country:	1912, short tons.	Percentage of total.
United States	32,897,060	62.16
Russia	10,174,560	19.23
Mexico	2,910,000	5.50
Roumania	1,987,360	3.76
Dutch East Indies	1,672,000	3.16
Galicia	1,298,620	2.45
India	1,101,450	2.08
Canada	38,750	0.073
Other countries	841,250	1.59

GENERAL CONSIDERATIONS AND COSTS OF REINFORCED CONCRETE DOCKS.

FOLLOWING up the articles that have recently appeared in these columns relating to the application of reinforced concrete in the construction of docks, the available data respecting cost of construction are such that full confidence cannot be placed in them owing to a certain danger of unreliability. Some figures are presented herewith, however, that cover the cost of docks as outlined in articles appearing in *The Canadian Engineer* for August 27th and October 1st, 1914. The data in Table I. have been collected from various publications by Harrison S. Taft and presented in his paper on the subject read before the American Society of Civil Engineers on May 20, 1914. The table gives the cost per square foot of construction.

Maintenance Cost.—A few figures covering the cost of maintenance of reinforced concrete docks in England are noted. In addition to what has already been said on the maintenance question,* the cold storage wharf at Southampton is reported to have cost nothing to date for maintenance. On the other hand, the widened dock and the coal jetties are said to have shown considerable deterioration due to rusting of the steel, it having been improperly placed in these structures. It has been stated authoritatively that "while six to seven years is perhaps a rather short time in which to form any definite conclusions, the maintenance cost (of the above described Port Talbot docks) has been practically nothing"

The annual repair charges on the Purfleet coaling jetty (exclusive of the damage done at the time of the collision) for the first 9 years of its existence are stated to have been but $50 per annum, which, based on its cost, $60,000, is less than one-tenth of 1 per cent.

Table II., from data published by the Chief Engineer of the Mersey Dock and Harbor Board in 1910, gives some very interesting results as respects the cost of annual repairs to six of the reinforced concrete docks at Southampton.

*See *The Canadian Engineer* Aug. 27, 1914.

If the results in Table II. are true, it is no wonder that the English engineers report that their reinforced concrete docks cost nothing for annual repairs.

General Considerations.

Opinions of Foreign Experts.—Although failures have accompanied the use of concrete in sea water and in the construction of reinforced concrete docks, it must be admitted that, if the Engineering Profession did not meet with a failure now and then, it would never acquire anything new, as it is through failures that it gains the most vital knowledge of engineering.

(*a*) In discussing the question of concrete docks, a prominent New York engineer has stated that, of the large number of concrete docks which have come under his observation, the majority have been a success, though here and there he reports a failure due to poor construction and material, and not to defects in the design. It is authentically stated that the reinforced concrete docks at Southampton have shown no deterioration due to salt water action, except at the Southampton coal jetty. The engineers of the Liverpool Docks have been using concrete in connection with their work since 1872, apparently with great success. It has been stated on the best authority that in England the alternation of "dryness and wetness and fluctuations in temperature" does not appear to have affected reinforced concrete sea water structures adversely.

Mr. Henry Hunter, Chief Engineer of the Manchester Canal, England, states that "the concrete in the concrete lock built at Eastham is in better condition at the present date than the day it was deposited," and adds that, covering an experience of more than 30 years of placing concrete in salt water, he has known no failures in such work where the concrete has been properly mixed and deposited.

In discussing the concrete docks of the Port Talbot Dock Company, Mr. William Cleaver has stated that:

"While reinforced concrete requires extreme care, both in the choice of material and in the supervision of the workmanship, the results justify the extensive adoption of the material for dock work."

Table I.—Cost of Concrete Docks.

Location.	Type.	Cost per square foot.
Pier No. 8, Puget Sound Navy Yard	Concrete columns Steel deck-beams. Concrete deck-slab.	$3.11
Naval Station, Philippines	Concrete columns. Steel deck-beams. Concrete deck-slab.	2.60
Balboa, Panama Canal	Concrete columns. Concrete beams. Concrete deck-slab.	3.28
Oakland, Cal.	Concrete piles. Concrete beams. Concrete deck-slab.	3.27
Brunswick, Ga.	Concrete piles. Wooden deck system.	1.40
Charleston Navy Yard, S.C.	Concrete piles. Wooden decking.	2.60
United Fruit Company, Panama	Concrete-protected wooden piles. Concrete deck-beams. Concrete slab.	2.13
Brooklyn, average of two docks	Wooden piles. Wooden caps. Concrete deck-slab.	0.90

The exceptionally experienced dock engineer, Mr. Francis E. Wentworth-Shields, of the London and South-western Railway Company, has stated that "if great care is exercised in making and placing concrete, an impermeable material will be obtained which can withstand the action of salt water." Mr. Shields has also said, "while many engineers were nervous about the life of reinforced concrete (for sea structures), he had observed that maintenance engineers were not so nervous as construction engineers." He is inclined to feel that there is nothing special to be feared respecting the life of reinforced concrete when used in marine work. Although, under certain circumstances, it is likely to deteriorate, he does not think it will do so from simply standing in sea water. He says that though in some cases deterioration has taken place at Southampton above low water, it has not done so below low water; that a 10-year-old reinforced concrete structure standing in sea water at Southampton is in perfect condition at the present date; and that, during the whole experience at Southampton, sea water does not seem to have produced any chemical or other deleterious action on the concrete.

Experiments by Mr. Baldwin-Weisman, in 1907, in England, on the permeability of concrete, show that, if it is well made, it is one of the most water-tight materials known, and that it rapidly becomes less and less porous when water is forced through it.

Mr. V. De Blocq von Keuffeler, in summing up the experience in using concrete for salt water structures in Holland, says:

"A suitable mixture, very carefully manufactured, the use of a good brand of cement with trass, and setting in a moist atmosphere, are the most efficient means of ensuring the preservation of reinforced concrete in sea water."

Mr. I. Ho, one of Japan's expert harbor engineers, who used more than 1,200 mass-concrete blocks in one instance, none of which during a period of 10 years has shown the slightest signs of failure, states, "that whereas a good and proper cement is of consideration, the most important factor is the mode of fabrication."

In reviewing the successful experiences of some of England's leading authorities, the question of the chemical composition of the cement used does not appear to be given. Such information would be of great value, in order that engineers may know whether they use a cement especially manufactured for sea water concrete or simply the ordinary Portland cement, with or without puzzolana, trass, etc.

(*b*) In discussing the deterioration of steel in reinforced concrete, by the action of sea water on ferro-concrete, provided the latter is properly made, Mr. C. S. Meiks, a prominent concrete engineer of England, says that such deterioration "is a negligible quantity." In support of this contention he cites the experience at Southampton, stating "that the exposed steelwork on a pile end that had been in the sea for 8 years was much corroded," whereas the bars in the body of the concrete, on being cut open, were found to be quite free from any rust and as fresh as the day they were put into the pile.

In connection with the building of some of the earlier concrete dock structures at Southampton, it appears that parts or the whole of piles not used were allowed to remain on the beach or shore, exposed to sea water, for some 7 years. At the end of this period the exposed steel had been badly rusted and deteriorated, whereas the part which was embedded in concrete was found to be in fine condition, practically as good as the day it was placed in the concrete. Still, concrete piles lying on the beach are not in the same position as concrete piles subjected to shocks in a dock.

Though the first jetties, built 11 years ago in Southampton water, are in excellent condition at present, the steel in another jetty at the same location has deteriorated, due to electrolytic action.

It is generally accepted by all English authorities that no deterioration takes place in steel when well embedded in the concrete.

(*c*) In speaking of reinforced concrete when used in marine work, Mr. Wentworth-Shields says "it will stand a wonderful amount of shock, and bending due to shocks, if a wooden fender is interposed." At a more recent date, Mr. Shields remarked: "On the other hand, reinforced concrete would not bear being knocked about by heavy ships, and where a structure was subjected to severe blows of that sort it was not easy to find anything better than timber, * * * but, when used at the right time and in the right place, reinforced concrete was a valuable material to dock engineers." From the leading position Mr. Shields occupies among the dock engineers of England, it would be of interest to know just what distinction there is between "a wonderful amount of shock" and "subjected to severe blows."

As an axiom: whatever system or design is adopted for a reinforced concrete dock, in no manner whatsoever should a vessel be allowed to rub against the main piling of the dock. The dock should always be protected by a system of fender-piles.

(*d*) As respects the resistance of a concrete pier or dock, when under such treatment as the Purfleet pier was at the time it was rammed, in 1904, Mr. Meiks, engineer in charge of its construction, states that "the vibration

Table II.—Annual Repairs, Southampton Docks.

Dock.	Erected.	Cost.	Cost of repairs to date.	Average per year.	Annual percentage based on original cost.	Remarks.
A	1899-1900	$24,000	$800	$80	0.0033	Deck for Cattle Wharf, Prince's Jetty (wood piles).
B	1904-06	63,500	375	75	0.0012	Floor or deck on Hennebique piles, Prince's Dock, West Quay.
C	1900	13,800	80	8	0.0005	Floor for wharf, Coburg Quay.
D	1901	3,700	25	3	0.0008	Floor for wharf, etc., Brunswick Half Tide Dock.
E	1908	17,500	....	...	......	Floor for wharf, etc., North Quay, Brocklebank Dock.
F	1908	163,500	....	...	......	Treble-story shed, South Quay, Sandon Dock.

Dock *A*. Subject to the effect of moist air arising from water below it.
Dock *B*. Subject to effect of moist air. Piles more or less submerged, according to water level.
Dock *C*. Complete reinforced shed and pile foundation; not sufficient time to form any conclusion.

was so great at the time of the collision that they thought the entire pier would collapse, but that its elasticity was most satisfactory, due no doubt to its horizontal concrete decking." Mr. Meiks also says that the vibration of a concrete pier supported on piles is nearly as great as in a pier made of timber piling; but this has no particular effect on the structure, judging by the experience gained with the Purfleet pier at the time it was rammed.

In speaking of the Port Talbot docks, Mr. A. E. Carey has stated:

"If the structure (reinforced concrete dock) was properly designed and built, its stability and life were assured, the only serious drawback being the difficulty of repairing damage due to collision."

But how often do collisions happen?

The Chief Engineer of the Port of London, Mr. Bryson Cunningham, recently stated that the art of building reinforced concrete docks in England has attained a degree of perfection greatly in advance of early experimental work. If their early experimental docks are still doing good service, will not their more recent docks become structures of an engineering and commercial success, thus justifying the American engineer in recommending concrete docks as long as they are built in a manner to guarantee impermeability and non-deterioration of the concrete?

Concrete Breakwaters.—As the application of reinforced concrete to dock construction has been developed almost entirely since 1900, some of the most conservative engineers may not feel that sufficient time has elapsed to judge correctly as to the merits of using cement and placing concrete structures in sea water, and as to the advisability of adopting reinforced concrete as a coming type of dock structure. As respects the first point, the prolonged and successful use of mass concrete by foreign countries in breakwater, tidal, and graving dock work would in itself appear to be sufficient answer to all such skepticism.

Though an extensive treatise might be written on concrete breakwaters and their construction, including shore protection, those phases of the use of concrete in sea water are supplementary to the principal subject of this paper. There is apparently hardly a leading seaport or a maritime nation outside of the United States that has not made a wide, extensive and successful use of mass and reinforced concrete in the development of harbor and shipping facilities.

Surprising as it may seem, a number of large concrete breakwaters have been in existence in Japan for more than 18 years. As a matter of fact, the use of concrete in the harbor work of Japan is far in advance of American practice, being apparently on the same high level as in England and other European countries.

Mass concrete has been used very extensively in Belgium and Holland for sea water structures for years, and has given the best of results. In fact, some of the concrete sea walls in the latter country, built in 1867-77 and earlier, are so old as to be called ancient, and have as yet shown no signs of being affected by the action of sea water. Perhaps such a statement needs to be qualified, because some of the principal harbors of Holland are some distance from the sea, and are in fresh or brackish water.

Concrete was used by the Romans and Carthagenians in ancient times. Though it fell into disuse for many centuries, it came into use again in 1840-50. To this day, sea walls built of puzzolana and lime cement by the Romans are in existence in Italy.

The Italian engineers report that Portland cement concrete with an addition of one-eighth to one-tenth by volume of puzzolana gave no signs of disintegration in salt water, even after an exposure of 30 years in the harbors of Genoa, Civita Vecchia, Naples, etc.

At several places on the Italian coast concrete-faced breakwaters have been in existence since 1880, in most exposed positions, costing but little for repairs and maintenance, though subject to the high seas and heavy blows of the Mediterranean.

English engineers were using mass concrete in their tide locks and in the construction of massive breakwaters along the coast of England as far back as 1871, if not earlier. The fact that they have continued to use it more extensively each year, even to building vast reinforced concrete structures standing in sea water during the past 15 years, would appear, in spite of some failures, to be sufficient answer to any doubts the American engineer may entertain on the subject.

At Colombo, India, a concrete breakwater, finished in 1885, showed no failures above or below water at the end of 22 years. As stated above, some of the massive concrete breakwaters of the world have a hard stone facing, or are built of concrete blocks, with or without a stone facing.

The reasons that enable the foreign engineers to accomplish such lasting results with concrete is no doubt due to the fact that they, together with the foreign chemists and cement manufacturers, long ago learned the secret and acquired the art of manufacturing and using concrete in sea water structures. Though the American engineer excels the foreign engineer in certain lines of his profession, it must be admitted that, so far as using cement, and hence concrete, in sea water structures, the engineers of the leading European countries and of certain parts of South America are many years in advance. The American cement manufacturer, the chemist, and the harbor development engineer cannot long remain in such a position without reflecting on their ability as experts in their respective lines of work in the minds of their foreign contemporaries.

In view of the marked success obtained by foreign engineers in the use of concrete for sea water structures, when the execution of such undertakings has been placed in the hands of intelligent, skilful, and experienced men, the American engineer who denies the possibility of making a successful use of concrete for structures standing in sea water puts himself in a questionable position. He thereby confesses either his lack of a world-wide knowledge on the subject, or his inability to carry out properly such classes of construction work to the same successful conclusions as his foreign contemporaries have been doing for years past. Such a confession would seem to indicate a lack of foresight and ultra-conservatism as respects the use of cement subject to sea water conditions, on the part of the American cement manufacturer, chemist, and concrete engineer.

The American engineer who assumes a skeptical attitude toward the practicability and commercial success of reinforced concrete docks has standing before him as silent testimony of their worth and practicability such a vast number of foreign reinforced concrete docks—several about 20 years old and yet in excellent condition, with still more massive structures being built each year, some of them costing less than wooden docks, if reports are true, and most of them saving their owners large sums annually on account of their low cost of maintenance and repairs, with no rebuilding, as with our 15-year creosoted wooden pile docks—that the grounds on which he stands become somewhat untenable. It is true that all American cements are not as yet wholly suitable for sea water purposes, and perhaps equally true that each and every American concrete engineer has not hitherto insisted on the proper placing of concrete in salt water structures, not fully realizing the importance of the fundamental principles of the use of concrete in sea water, due to the hitherto limited call for such types of structures in America, lumber having been so plentiful and cheap.

Though reinforced concrete docks have been in existence for more than 15 years, and operated successfully, the same old theorems are still put forth in opposition to them and to the practical experience gained during this period. Possibly these same theories will continue to be advanced against the use of concrete in dock work and other sea structures by the most conservative of our leading engineers, though others, guided and profiting by the experience already gained in such uses of concrete, will continue to expend large sums of money in the further development of such structures.

From a prolonged study of reinforced concrete dock construction, as carried out in foreign countries, it would appear that, in spite of early doubts and skepticism, the success in the use of reinforced concrete in dock work obtained by foreign engineers has swept away all such doubts and skepticism. If these are not facts, why are foreign countries and certain ports in America, including the United States Government, expending vast sums of money in building reinforced concrete docks and in other uses of concrete in harbor development and sea protection work; all "in spite of prejudices which leading engineers (psychologically) have against any new type of construction?"

Although the average American contractor may look upon concrete as just so much cement, sand, and stone, or gravel, to be thrown together and dumped into the forms in the quickest possible time, without any regard for the fundamental principles underlying reinforced concrete construction, a commercial proposition purely, such an application of reinforced concrete to dock work will most certainly spell disaster long before the structure is completed.

In spite of its apparent simplicity on dry land, the use of reinforced concrete in dock work calls for more than mere brawn and muscle. It is a class of construction work especially adapted to the broad knowledge, experience, and deep study of the trained engineer in association with an organization well skilled in the handling of concrete in sea water structures—"a field of engineering in which reinforced concrete will prove to be the most permanent and economical, as it has in the building of bridges, etc."

ST. JOHN VALLEY RAILWAY NEARING COMPLETION.

Before the end of the present month the St. John and Quebec Railway Company expect to have the St. John Valley Railway from Gagetown to Centreville, N.B., ready to be taken over by the Intercolonial. Arrangements are being made for the construction of a connecting link from this line to Fredericton. The proposed route through the city was recently laid before the city council by Mr. S. B. Wass, chief engineer of the St. John and Quebec Railway, and who is in charge of the work. Surveys have been under way for a short time past. The city council has just approved of the contemplated route.

CANADIAN MANUFACTURE OF SHRAPNEL SHELLS.

The Canadian Engineer is informed by Colonel A. Bertram that contracts are being let to various manufacturers in Canada to supply 15 and 18-lb. shrapnel shells and component parts for same. Subsequent inquiries by *The Canadian Engineer* show that these orders are being very widely placed. Among the companies which have received them are the Canadian Locomotive Company, the Canada Foundry Company, the Nova Scotia Steel Company, the Canada Forge Company, and the Canadian Billings and Spencer, Limited. The latter are subsidiaries of the Canada Foundries and Forgings, Limited.

The orders are generally for large quantities and will keep various departments of the companies in full operation during the winter.

Mr. T. J. Dillon, president of the Canada Forge Company, Limited, Welland, states that the shells are forged under their new modern hydraulic forging presses, which are equal in power and efficiency to any on this continent or in Europe.

These two plants are fully equipped to produce any size or class of shells or projectiles which may at any time be required by the government Militia or Navy Department, and it is at the Canadian Billings and Spencer Plant where all the forged steel parts for the Ross rifles are made.

To handle these orders on behalf of the Dominion government, acting for the Imperial government, a shell committee has been appointed with headquarters in Montreal. The members of the committee are: Col. A. Bertram, chairman; Thomas Cantley, George W. Watts, E. Carnegie, Col. T. Benson, Lieut.-Col. F. D. Lafferty, and Lieut.-Col. G. Harston.

INVESTIGATION INTO THE IRON MINING INDUSTRY.

Pursuant to a request made to the Dominion government for the granting of some measure of assistance toward the development of iron ore mining in Canada, and in accordance with the statement of the Hon. Minister of Finance in his budget speech during the 1913-14 session of Parliament, that the iron mining industry would be investigated, a committee has been appointed to enquire into the situation and to report the facts to the government. This committee consists of Messrs. O. E. LeRoy, G. C. Mackenzie, E. Lindeman and John McLeish, secretary.

Every owner or operator of an iron ore property in Canada should be interested in facilitating this enquiry and should communicate with the Deputy Minister of Mines at Ottawa, or the secretary of the committee, who will furnish a schedule of questions covering the information required by the committee.

OUR PUMP IMPORTS.

According to a pamphlet recently issued by the Commercial Intelligence Branch of the Board of Trade of Great Britain, the German trade in hand pumps with Canada, prior to the outbreak of the war, was more than 8 times that of Great Britain. That of the United States with Canada was over 51 times that of Great Britain.

Editorial

USE OF CANADIAN-MADE GOODS.

A recapitulation of Canada's import trade shows that during the fiscal year ended March 31st, 1914, we paid $14,686,069 to Germany, $1,787,473 to Austria, and $601,855,332 to other countries, for their products.

A few weeks ago the Council of the Toronto Board of Trade adopted the following resolution with reference to the use of Canadian-made goods by governments, municipalities, architects and engineers in all works under their control:

"Resolved that, in view of the state of unemployment existing, and of the large importation of goods into Canada, much of which could be supplied by Canadian manufacturers, the Council of the Board of Trade of the City of Toronto make representations to the Ontario Government, the City Council, the University of Toronto, the Board of Education, and the societies of engineers and architects, requesting them, where possible, to use Canadian-made goods for all works under their control."

Copies of the resolution were forwarded to the Boards of Trade throughout Canada asking them also to take similar action with governmental and municipal authorities, architects and engineers in their districts.

Realizing that the Trades and Labor Council's estimate of 20,000 unemployed in Toronto at the present time bespeaks similar conditions of a more or less acute nature in other cities, an effort at the development of every possible Canadian resource would undoubtedly result in the employment of the majority of these unfortunate laborers, the building up of Canada's revenue, and the strengthening of her credit as well.

It must not be forgotten that the incoming flood of foreign-made goods has been checked by the manufacturers themselves owing to lack of assurance of early payment, as much as by the consumers who have been obliged to bear the brunt of the financial stringency. The demands for manufactured goods have fallen off, not from a declining desire on the part of the municipalities, etc., to go ahead with their work but from a necessity owing to the unavailability of foreign capital. Under these circumstances the manufacturers of foreign-made goods should feel it no reflection upon themselves or their products that a widespread movement is under way in the Dominion to bring prosperity out of depression by the advocation of home-made goods for every possible service. There are many important works, small and large, that cannot be delayed for a lengthy period. Among them are certain works that demand goods impossible of adequate and successful manufacture, commercially, in Canada. For these we must look to our close friends and neighbors, the United States and Great Britain, who can supply practically every need of this nature.

The Toronto Board of Trade suggests that every manufacturer and merchant lay down the policy for his purchasing department of demanding Canadian-made products; that architects, builders, and contractors keep thousands of Canadian workmen employed by calling for Canadian-made materials in their building specifications; that government and municipal authorities have it in their hands to create a tremendous volume of business in Canadian factories, and that it would be wise for them, as well as patriotic, to give our own workmen the employment so that they will not become a charge upon the country.

THE CANADIAN MUNICIPALITY AND THE BANK.

A letter comes from a reader of *The Canadian Engineer* stating that a certain municipal contract had not been awarded "owing to concerted actions of the Canadian banks." Our correspondent adds that "towns and cities urgently require public improvements and are willing to pay for them in the only possible way of a new country," and hints that "the bankers are taking advantage of the war to squeeze the municipalities."

This view, we think, is held by many people in Canada, but when the position is closely analyzed it is found to be scarcely the correct one. The Dominion is a heavy borrower and to date has obtained £500,000,000, or about $2,500,000,000 of capital from Great Britain. This has been used largely in constructive work, such as the building of railroads, steam and electric; power developments; water and sewerage systems, and various other improvements of public utility or industrial nature. The country was building not only for the present but also for the future. Looking back now, we realize what a tremendous amount of construction work has been done in the past few years.

Dr. Adam Shortt, discussing the situation in a public address at Toronto the other day, stated that, generally speaking, we have in Canada enough constructive machinery and that what is necessary now is more production from the plant which has been installed. This is largely true. Our development has been very rapid and practically all upon British and foreign capital. The supply of capital is now stopped on account of the war. We cannot ask the Canadian banks to take its place. That is not their function, besides which it would be bad business for national credit. A curtailment of expenditure was due anyway, as the country had come to the end of an unusually active period of construction, and the beginning of a period of what it is hoped will be heavy production. The transition of the one to the other is involving some hardships. It means the transfer of labor to some extent, of economy in expenditures and of efforts to direct capital into some new and productive channel. The municipality to-day is trying to do what the individual and governments must do—economize to a reasonable and necessary extent.

The banks' chief duty is to see that they are prepared against all contingencies. Discussing the position of the banks in the present crisis, Dr. Shortt referred to the popular cry in certain quarters for them to come to the rescue just now and provide money to maintain the city and railway construction which had been going on and had been supported by British capital. "That would be perverting the function of the banks," said he, "which was simply the facilitating of exchange. You cannot," he continued, "by adjusting the banking system create one more mouthful of food. The money-lenders abroad must be paid by bills of exchange or counter goods, and not by Dominion notes."

Mr. J. W. Flavelle in a recent public speech said: "Let us bear in mind this is not the banks' trouble. A great number of us seem to have the impression that the only reason that we are unable to borrow all the money we need is because the banks are unreasonable and won't lend it. After all, the amount of resources which we have liquid in this country is comparatively limited. What do our friends the bankers have to do? They are trustees to hold these liquid resources of this country available for the need of this country, distributing them as best they may over the largest surface possible to accomplish the best result."

The same point was made in an interview recently given by Mr. G. B. Schofield, general manager of the Standard Bank of Canada. After stating that the Canadian banks would still stand in most intimate relationship with the manufacturing, agricultural and commercial life of Canada, he added: "Now, the role so long played cannot be cast aside, even if the banks wished to do so; which, as I need not say, they have no desire to do. At the same time, the banks must of necessity be very careful what they do with the people's deposits at this trying time. We must, above all, see to it that we keep our assets liquid. While every aid will be given to legitimate business enterprise, we must be doubly careful to see that such funds as are advanced are not placed in fixed capital forms. Now, as never before, it is necessary to keep our resources in a fluid form."

The Canadian banks have on loan to municipalities throughout Canada at the present time more than $40,000,000. Since 1905, Canadian municipalities have borrowed over $200,000,000, while they have raised also large sums in Canada and the United States. It is not contended that municipal development has ceased in this country, but owing to the economic depression and the advent of the war, much of that development is suspended temporarily.

At the same time *The Canadian Engineer* reiterates its opinion that governments, federal, provincial and municipal in times of extreme trade depression, should spend money on public work so far as proper economy dictates. So long as there is a sound method of financing such works, the banks will probably be found willing to take the necessary action. In a time such as the present, and in view of the fact that the theatre of war is not actually on Canadian soil, the Dominion Government well might employ fairly substantial sums upon certain public works, consistent with economy. Private borrowers will hesitate considerably at present because Canada's chief lender (Great Britain) has a bigger job on hand now than loaning money to its overseas dominions. Indeed, private borrowers, in which are included corporations, are almost helpless, except for funds in hand and for the possibility of borrowing elsewhere than in Great Britain.

It is reported that timber limits extending over 115 square miles along the foreshore of Seymour Inlet and adjacent waters in British Columbia, including 3,000,000,000 feet of high-grade cedar, were recently transferred to a syndicate of capitalists from the United States. It is said to be the intention of the purchasers to begin logging operations on the limits in the near future, and the plans contemplate placing several sawmills on the property. The scarcity of cedar and the increasing price of high-grade timber in the United States have caused American millmen to turn their attention to British Columbia, which has the largest compact area of merchantable timber on the continent. The abolition of the duty on Canadian shingles and other forest products has encouraged and given impetus to the shingle industry, which has made great progress in the province recently.

DEEPENING OF BURNETTE RIVER, B.C.

A very interesting drainage project is being carried out by the Vancouver and Districts Joint Sewerage and Drainage Board. The Burnette River is being deepened between Burnaby Lake and the eastern boundary of the municipality of that name. The new channel will regulate the size of Burnaby Lake. It forms a part of the sewerage scheme reported upon by Mr. R. S. Lee, consulting engineer, Montreal, and adopted by the municipalities. The scheme divides the Burrard Peninsula into several areas according to the bodies of water into which each drains. One of these is the watershed emptying into Burnaby Lake. The report, taking cognizance of the fact that the lake could hold a very limited amount of domestic sewage, but almost unlimited natural drainage, provided that an intercepting sewer be ultimately built around the south shore of the lake; but that for the present, and until the district had become more densely populated (the domestic sewage now being almost negligible), surface water might be allowed to flow into the lake.

The rise in the lake each spring is considerable, owing to the nature of the country surrounding it and also to a ledge of rock at the outlet into Burnette River which prevents more than a certain flow. The lake is thereby rendered more or less stagnant. The Joint Sewerage Commission, therefore, started during the summer on the task of deepening the river. A mile or more at the eastern end of the municipality has been dredged and cleared of boulders and logs which impeded the stream flow. Further up the stream the rock bed has been blasted out to a uniform depth of 6 or 7 ft. lower than the original depth. This cut, about 7 ft. in width and a mile or more in length, conforms to the old bed of the river. A temporary diverting flume is used to deviate the stream from the site of operations.

The Sewerage Board expects to continue the work well into the coming winter. This will necessitate a different method of flow control. It is proposed to dam back the flow a short distance from the outlet of the lake and to curtail it during the 8 hours of each working day, allowing the accumulated water to run off during the intervening 16 hours.

The work will result in a uniform depth, during summer and winter, of Burnaby Lake. It will greatly facilitate the drainage scheme and will permit the reclamation of a considerable area previously subject to floods in the rainy season. Eventually the level of the lake will be lowered several feet and approximately 150 acres more land will be thereby reclaimed. The Provincial Government has been approached with a proposal to convert the lake and its surroundings into a park.

The "Vita" the third of three similar steamers, which are being built at the Neptune Works of Swan, Hunter and Wigham Richardson, Limited, for the British Indian Steam Navigation Co., Limited, for the service of that company between India and the Persian Gulf, was launched on August 24. She is a twin screw steamer, 390 ft. in length by 53 ft. beam by 26½ ft. in depth, and has accommodation for first and second-class passengers, together with space for a large number of native passengers. The propelling machinery is being built by Swan, Hunter and Wigham Richardson, Limited, at their Neptune Works, and consists of two sets of triple expansion engines with six large boilers of sufficient power for a speed of 16 knots. The auxiliary machinery is very complete and includes 8 steam winches, steam warping winch, steam steering gear, steam capstan, steam windlass, electric light and ventilation, wireless telegraphy, refrigerating machinery, etc.

AMERICAN ROAD CONGRESS, ATLANTA, GA.

"Overtopping all other road problems in its importance is that of maintenance," says Logan Waller Page, Director of the United States Office of Public Roads and President of the American Highway Association. "The destructive agencies of traffic and the elements are unceasing in their activities and it is idle to talk of permanent roads any more than to speak of a house, a fence, or a railroad ties as permanent.

"The public roads to-day, by reason of the exceptionally destructive traffic conditions, are more costly in construction and this is continually increasing with the advance in the prices of labor and material. It is criminally wasteful, therefore, to invest large sums of public money in building the highways demanded by traffic, unless the investment is conserved by adequate maintenance. Without such adequate maintenance a road costing anywhere from $5,000 to $15,000 per mile may go to ruin in a year or two, thus involving a permanent loss of considerable magnitude.

"When it is considered that the aggregate expenditure on roads in the United States is well over $200,000,000 annually, the seriousness of the question is apparent. I look to the conference of highway officials which will be held during the Fourth American Road Congress, which meets in Atlanta, Georgia, on November 9, to devote much attention to road maintenance, and that the accumulative moral effect of their findings will go far towards bringing legislatures and county boards to a realization of the necessity for prompt and efficient action. The roads should be classified and suitable maintenance, in organization and money, provided according to the importance of the representative classes of roads."

One of the questions which the Congress will discuss is that relating to the revision of road laws. A complete compilation of the road laws of all the states will be available for the session devoted to legislation and it is expected that in outlining bases for revision, maintenance will be given particular attention.

OPPORTUNITY FOR CANADA IN PAPER INDUSTRY.

A report from the European continent announces a dearth of sulphite pulp. Quotations on wood pulp have advanced from 92 to 145 shillings per ton in England. On the outbreak of the war 30,000 tons of paper consigned to the United States were on the sea. Of this amount, 20,000 tons had been sold, and the remainder not yet disposed of. The United States annually imports 350,000 tons.

France and Great Britain are beginning to suffer, as the greater part of their paper comes from Germany and Scandinavia. With Germany eliminated, Scandinavia is left to supply both countries. As the Baltic sea is normally open to commerce only between May and November, importers customarily lay in sufficient supply in the later part of the summer to last for the year. The present is the season of lowest supply.

With the Baltic blocked on account of the hostile fleets and with little hope of its being opened shortly, the shortage is being felt more and more each day. Some of the English publishers have already cut down the size of their papers. South American publishers are feeling the stress too, as they also procure paper from Europe. This leaves Canada as the only producer that is not affected which has any surplus paper.

Coast to Coast

Winnipeg, Man.—The engineers of the administration board of the Greater Winnipeg Water District have announced that, while the original estimates for the Shoal Lake scheme totalled $13,045,000, the outlay will be $1,200,000 less than that amount. Total disbursements on the entire project up to September 25 were $946,431.82; and the bank overdraft, $340,354.34.

Calgary, Alta.—Good progress is reported upon the work being supervised by Engineer Winter on the new east-end tunnel, which is to convey the Calgary sewerage system under the Bow River at Fifteenth Street East for the accommodation of Tuxedo Park and other parts of the North Hill. Of a total approximately 900 feet, 285 feet of the tunnel have been constructed, and it is stated that it will take until midwinter to complete the work.

Montreal, Que.—Outstanding features of the work which has been accomplished by the C.P.R. during 1914 are a new machine and erecting shop at McAdam Junction, as well as over one mile of new storage tracks to the yard at that centre; at West St. John, a fireproof elevator with a capacity of 1,000,000 bushels together with an up-to-date power house, also extensive improvements to terminal facilities in that city; at Windsor Station, Montreal, improvements to the passenger and freight terminals, the train shed just completed being one of the most modern and one of the largest now known; at Place Viger, Montreal, the completion of the improvements which have been in progress for three years, and which comprise a station, an hotel and trackage, the erection of which has cost nearly $5,000,000; and the commencement of the Union Station at Quebec. Throughout the year, also, there was completed the double track bridge at Lachine costing nearly $3,000,000 and the new Lake Shore line opened for traffic in June. The commencement of the new station and viaduct at Toronto has been authorized, and is being delayed only temporarily. Other works authorized and now assuming various stages of completion are: the extension of the Kippewa branch line 10 miles in a northerly direction; a 30-mile extension from Expanse to a junction with the Weyburn-Sterling branch of the C.P.R., which will be completed this fall; the line between Swift Current and Empress, a distance of 112 miles, which will be completed this year; the main line cut off from Swift Current to Bassano, of which 150 miles are completed; the 78 miles of the C.P.R. branch from Lacombe to Kerrobert, a new extension; the Alberta-Central Railway to Lochern, a distance of 65 miles from Red Deer; the great tunnel at Roger's Pass, of which one mile of the Pioneer tunnel has been completed; the C.P.R. depot and terminal offices at Vancouver; the Kootenay Central which is now open for traffic, from Golden, 60 miles south, and the work on which is being pushed vigorously between Golden and Colvalli; and the Esquimalt and Nanaimo line from Parksville Junction to Courtenay. Further, the C.P.R. is interested in the Kettle Valley Railway, and in connection with the same it is building a line from Midway to Penticton—a distance of 134 miles, 76 of which are already open for traffic. A line from Penticton to Osprey, 41 miles in length, has been completed; and work has been commenced on a new line between Osprey Lake and Princeton. The Kettle Valley Railway is also building a line 54 miles in length between Hope and Otter Summit; and a part of the track has already been laid. In addition to all this, the C.P.R. has continued its policy of double tracking.

PERSONAL.

W. P. HINTON has been appointed Assistant Passenger Agent of the Grand Trunk Railway with head-quarters in Montreal.

W. S. DAVIS, of Oakville, has been appointed to the Toronto-Hamilton Highway Commission, to succeed C. G. Marlatt, resigned.

C. L. CANTLEY, assistant general manager of the Nova Scotia Steel and Coal Company, is with the Canadian contingent as a lieutenant in the 5th Royal Scots, 13th Battalion.

MAURICE KERNOH, chief engineer of the Australian State Railways, is in Canada, investigating the government ownership, construction and management of railways and canals.

THOMAS ADAMS, of the Local Government Board of Great Britain, has been retained by the Commission of Conservation, Ottawa, to act as adviser in the work of encouraging town planning in towns and cities in Canada.

FRANK W. SKINNER, M.Am.Soc.C.E., has opened consulting offices at 45 Broadway, New York, and in the Crabtree Annex, St. George, Staten Island, and is associated with Mr. C. E. Fowler, C.E., Seattle, Wash. Mr. Skinner will continue in the field of bridge and structural steelwork, foundation and general civil engineering field construction methods, operations and plant with which he has long been intimately and extensively identified, and will also specialize in the preparation of engineering cases for litigation, expert witness research and testimony, preparation and mediation of cases in controversy.

EN ROUTE FOR THE FRONT.

A partial list has been compiled of the University of Toronto men who are now in England with the first Canadian expeditionary force. This contains the following names of students and graduates of the Faculty of Applied Science and Engineering:—L. C. M. Baldwin '14, P. G. C. Campbell (4th year), E. S. Foulds '11, G. G. Blackstock (4th year), B. H. Hughes (3rd year), G. H. Marani (3rd year), H. A. M. Grassett (3rd year), H. F. H. Hertzberg '07 (Chief Engineer, Canadian Bridge Co., Walkerville), H. A. Heaton '14, R. W. Hains (2nd year), T. S. Glover (2nd year), F. L. Erdley-Wilmot (2nd year), D. H. Storms (4th year) and C. H. Mitchell, C.E., '92 (Consulting Engineer, Toronto). Major C. H. Mitchell received an appointment to the post of general staff officer on the headquarters staff of the Canadian division.

ONTARIO CANALS UNDER INSPECTION.

Hon. John A. Bensel, New York State engineer, and the Board of Consulting Engineers of the New York State barge canal, consisting of M. G. Barnes, Wm. H. Burr, Geo. S. Greene, Jr., Joseph Ripley and T. Kennard Thomson are on a tour of inspection of the canals of Ontario.

NAME OMITTED.

In *The Canadian Engineer* for September 10th, 1914, omission was inadvertantly made of the name of the manufacturer of the large combined gas and steam engine unit which formed the subject of the article on Page 413. The engine was built and installed for the Ford Motor Company by the Hoover, Owens and Rentschler Co., Hamilton, Ohio.

NEW CANADIAN MEMBERS, AM. SOC. C.E.

Recent elections to the American Society of Civil Engineers include that of W. Chace Thomson, consulting engineer, Montreal. Mr. Kay Alexander, of Grant, Smith and Co., and McDonnell, Limited, Revelstoke, B.C., was transferred from associate member to member.

The list of elections to associate membership includes W. C. Bodycomb, superintendent, Victoria, B.C., branch of Westinghouse, Church, Kerr and Co.; J. B. Challies, superintendent, Water Power Branch, Department of the Interior, Ottawa; H. Osborne, resident engineer, Kettle Valley Ry. Co., Hope, B.C.; and J. C. K. Stuart, first assistant engineer, Mount Royal Tunnel and Terminal Co., Montreal.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Edmonton branch of the Canadian Society of Civil Engineers held its first general meeting since the organization was affected, at its headquarters in the University of Alberta, on October 1st. The meeting was largely attended by local engineers, and a programme was arranged to be carried out during the coming season. The chairman of the branch is Professor W. Muir Edwards, University of Alberta, and the secretary-treasurer is Mr. L. B. Elliot, Box 957, Edmonton.

COMING MEETINGS.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—Annual Convention, Grunewald Hotel, New Orleans, La. October 20th to 23rd. Secretary, Mr. McFall, Roanoke, Va.

ALABAMA GOOD ROADS ASSOCIATION. — Nineteenth Annual Convention will be held from October 21st to 23rd at Montgomery, Ala. Secretary, J. A. Rountree, 1021 Brown Marx Building, Birmingham, Ala.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

EIGHTH CHICAGO CEMENT SHOW.—To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.