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Results of Test on Robert Simpson Building

Comparison Made With Flat Slab Codes—Simplicity of Construction, Economy in Story Heights, Unbroken Ceilings, Make Flat Slab Construction Popular

By

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At the time the tests referred to in this article were made, Professor Gillespie kindly consented to help the Architects' Department in conducting a test which would prove whether the building was strong enough to carry the loads for which it was designed, and it was also thought that the tests would give additional information to the department so that it might be in a position to draft an up-to-date by-law covering flat slab type of construction.

Due to the cracks around the column capital, it was necessary, as shown in Fig. 6, to break the panel into strips, finding the moment of inertia of each strip and then adding them together. This, of course, would only give at best a very rough approximation, and, therefore, in considering these tests, due consideration must be given to this. I might also direct attention to the stresses given on Fig. 3-4, where it will be noticed, in a great many cases, that when the load is removed entirely, there still seems to be a larger stress in the steel and concrete than what was given by the first load of 135 pounds. This is shown in tables of stresses under columns 1 and 4. One explanation for this is that concrete has not the elastic nature that steel has but is more plastic, and, therefore, when the load is applied to the concrete, the concrete in compression is crushed and does not spring back to its original position. Another reason, no doubt, is due to the fact that, when the second load of 270 pounds was applied, bad cracks developed around the column capital head, thereby weakening the resisting value of the concrete in tension, so that even when all the loads were removed the original dead load would cause considerable stress in the steel and concrete due to the damaged condition of the concrete, therefore, when the final extensometer readings are taken the set of the concrete will be read by the instrument.

The deep cracks around the column heads are due to the steel work being set too low below the top of concrete. It will be noted by referring to Fig. 3, Col. 23, that the average distance below the top of the concrete to the steel is about 3½ inches. It is evident, therefore, that as soon as there is any tensile stress in the steel that there must be considerable tensile stress in the outside fibres of the concrete, and as this is only good for about 350 pounds to the square inch it would soon crack. From this test it would seem to the writer that either Chicago or Philadelphia codes, or the Report of the Joint Committee would give very safe and satisfactory results.

Professor Gillespie was assisted by Mr. R. J. Fuller and Mr. T. D. Mylrea, who were in the employ of this department at the time the tests were made, and Mr. W. A. McM. Cook, of this department, assisted in compiling the results as given herewith.

W. W. PEARSE, City Architect and Superintendent of Buildings.

THE method of construction used in the Robt. Simpson Building, Toronto, is the four-way flat-slab drop-head reinforced concrete system known as "the four-way system."

Fig. 1 is a general plan of the building showing the area tested.

Figs. 2, 3 and 4 show the arrangement of the reinforcement, and the location of the points where the readings were taken and the stresses obtained.

The readings for a live load of 135 lbs. per square foot will be considered.

In comparing the stresses found by extensometer tests and those computed in accordance with the various building regulations the following notation will be used:—

L = distance c. to c. of column, in feet.
w = total live and dead load per square foot = 135 + 113 = 248 lbs.
W = total panel load in lbs. = wL^2.
s = tensile stress per square inch in steel.
c_t = extreme fibre tensile stress per sq. in. in concrete.
c = extreme fibre compressive stress per square inch in concrete.
I = moment of inertia.
Q_t = section modulus for side in tension.
Q_c = section modulus for side in compression.
E_s = modulus of elasticity of steel = 30,000,000.
E_c = modulus of elasticity of concrete in compression = 3,500,000.
E_t = modulus of elasticity of concrete in tension = 2,800,000 (assumed as $\frac{8}{10}E_c$ same as used for Wm. Davies Co. Building, Toronto).

Fig. 5 shows the strips into which the slab is considered to be divided for purposes of calculation.

Strip A at Edge of Capital

The stresses in strip A at the edge of the column capital will be considered first. The width of strip A will be taken as $\frac{L}{2}$, as assumed in the Chicago Code and Joint Committee Report.

In Fig. 6 the neutral axis, as obtained from deformations, has been plotted for readings Nos. 710, 713, 717, 601, 607 and 614, and its average position was found to be 9¼ ins. from the top of the slab, as indicated

In order to arrive at a rational method for determining the section moduli of the section, making due allowance for tension in the concrete, it was assumed that the tensile strength of concrete is 1/12th of its compressive strength (see "Materials of Construction," 4th edition, by J. B. Johnson, p. 604d) and thence was found the maximum deformation which could occur in the concrete without the formation of cracks.

The ultimate compressive strength of the concrete was found by test to be 3,900 pounds per square inch. Hence the ultimate tensile strength would be $\frac{3{,}900}{12}$ pounds per square inch = 325 pounds per square inch, and the corresponding deformation reading for live load, $325 \times \frac{40{,}000}{2{,}800{,}000} \times \frac{135}{248} = 2.5$ (see note at foot of Table 4), taking $E_t = \frac{8}{10}$, E_c = 2,800,000 for the concrete used.

The points in the cross-section at which this deformation occurred have been plotted in Fig. 6 and the concrete below the same was considered as effective cross-section in computing the moment of inertia and section moduli of the section. The upper inclined line in the figure marks the upper limit of this effective cross-section and the lower inclined line is drawn through the points obtained for the neutral axis for the three sets of readings mentioned above.

The effective section of concrete was divided into five rectangles, a, b, c, d and e. Figs. 6A, 6B, 6C, 6D and 6E show these rectangles with the positions of their respective neutral axes as obtained from Fig. 6.

The steel has been considered as replaced by its equivalent area of concrete assuming the moduli of elasticity of steel and concrete in tension to be 30,000,000 and 2,800,000 respectively. The moment of inertia of each rectangle and its proportionate area of steel was obtained and the results added to obtain the total moment of inertia for the section; using the average position of the neutral axis as 9¼ ins. from the top of slab the section moduli were then determined.

The results are as follows:—

$$I = 14{,}906$$
$$Q_c = 3{,}140$$
$$Q_t = 1{,}612$$

According to Chicago Code,

$$Mr = \frac{WL}{30} = \frac{125{,}000 \times 22.43 \times 12}{30} = 1{,}120{,}000 \text{ inch-pounds.}$$

$$\therefore \quad c = \frac{Mr}{Q_c} = -\frac{1{,}120{,}000}{3{,}140} = -357 \text{ pounds per sq. in.}$$

$$\text{and } c_t = \frac{Mr}{Q_t} = \frac{1{,}120{,}000}{1{,}012} = 695 \text{ pounds per sq. in.}$$

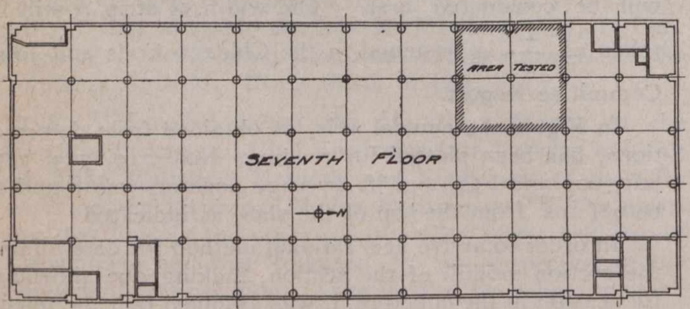

Fig. 1—Key Plan

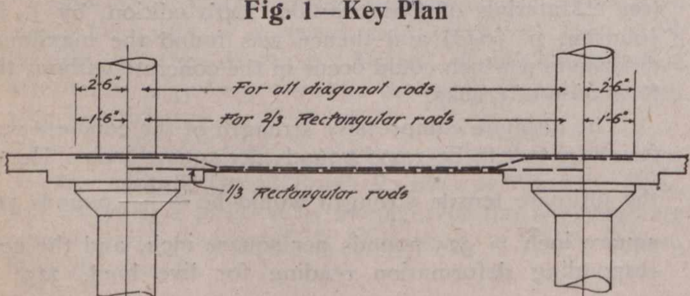

Fig. 2

The average of readings 601, 607 and 614 is —257 for live load only, which corresponds to a stress of —257 ×

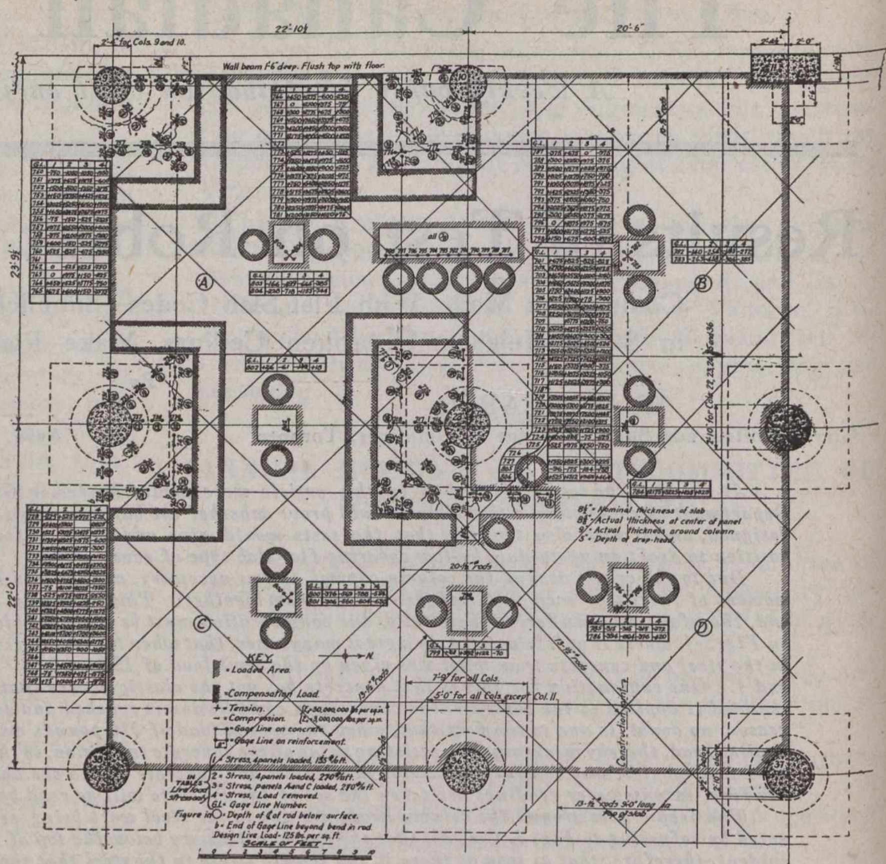

Fig. 3—Plan of Seventh Floor

$\frac{248}{135} = -476$ pounds per sq. in. for live and dead load combined. This is somewhat greater than the value for c computed above.

Using the extreme fibre stress $c_t = 695$ pounds per square inch in the concrete as found above, the computed stress in the steel is found to be 5,020 pounds per sq. in.

The average of readings 710, 713 and 717 is 2,300 for live load only, which corresponds to a stress of 2,300 × $\frac{248}{135} = 4{,}230$ for live and dead load combined, which agrees very well with that computed.

The Philadelphia Code gives the bending moment as $\frac{WL}{28.4}$ ($\frac{WL}{47}$ for the steel in the straight band, and $\frac{WL}{72}$ for the steel in the diagonal band).

The Joint Committee Report gives the moment as $\frac{WL}{25}$.

The stresses computed by these moments for the readings mentioned above are given in Table 3. It will be noted that the distribution of steel at the column capital in the straight and diagonal bands differs considerably from that required by the Philadelphia Code, so that the table shows a high stress for the steel in the straight band and a comparatively low stress for the steel in the diagonal band at this point in the computation by the Philadelphia Code.

To find the moment coefficient which corresponds to the stresses computed from deformations given by test we may equate the bending moment to the resisting moment thus: $\frac{WL}{x} = Q_t\, c_t$ and $\frac{WL}{x'} = Q_c c$ where x and x' are the coefficients to be determined.

The average unit stress in the steel for total load as found above from readings 710, 713 and 717 was 4,230 pounds per square inch.

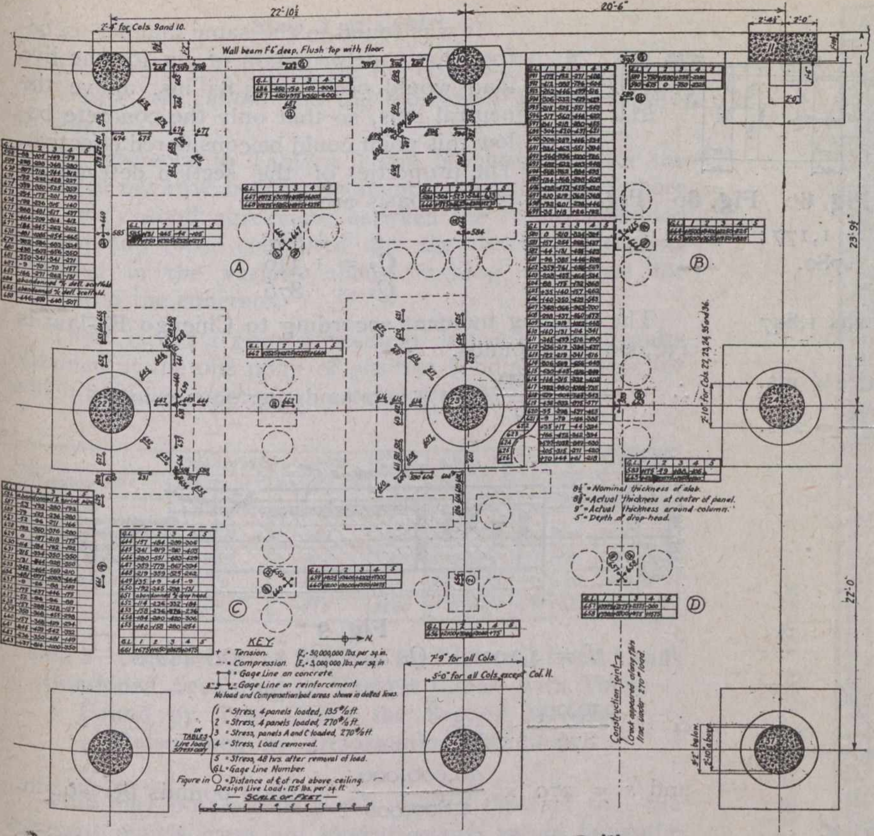

Fig. 4—Plan of Sixth Floor Ceiling

This corresponds to an extreme fibre stress in the concrete of $4,230 \times \frac{2,800,000}{30,000,000} \times \frac{9\frac{1}{4}}{6\frac{1}{4}} = 584$ pounds per square inch.

$$\therefore \frac{125,000 \times 22.43 \times 12}{x} = 1,612 \times 584$$

whence $x = 36$.

The average extreme fibre stress in the concrete for total load as found above was — 476.

$$\therefore \frac{125,000 \times 22.43 \times 12}{x'} = 3,140 \times 476$$

whence $x' = 22.6$.

The average of x and $x' = 29.3$ or, roughly, 30.

$\therefore$ the moment as found from test is $\frac{WL}{30}$, which agrees with the Chicago By-law and also very closely with the Philadelphia By-law.

Strip B at Centre of Panel

In Fig. 8 the position of the neutral axis has been determined as before from deformation readings 800, 801, 659 and 660, the average of readings 800 and 801 being 3.9 and the average of readings 659 and 660 being 1.35.

The width of strip B has been taken as $\frac{L}{2}$ and the area of steel assumed according to the Chicago By-law.

Using the greater of the deformations found for the reinforcement, *viz.*, 1.6, it is found that the concrete below a point about ⅝ in. from the lower surface is overstrained in tension. Therefore, only the concrete above this point has been considered as effective cross-section in computing the moment of inertia and section moduli of the section which follow:—

$$I = 7,195$$
$$Q_t = 2,620$$
$$Q_c = 1,410$$

According to Chicago By-law, $M_c = \frac{WL}{120}$

$= 280,000$ inch-pounds.

$$\therefore c_t = \frac{280,000}{2,620} = 106$$

$$\text{and } c = \frac{280,000}{1,410} = 200$$

Using the extreme fibre stress of 106 pounds per square inch in the concrete, the computed stress in the steel is $106 \times \frac{1^{13}/_{16}}{2\frac{3}{4}} \times \frac{30,000,000}{2,800,000} = 750$ pounds per square inch.

The average live load stress found from readings 659 and 660 is 1,012 pounds per square inch, which corresponds to a total stress of $1,012 \times \frac{246}{135} = 1,847$ pounds per square inch or more than twice that found by using the Chicago Code, taking into consideration tension in the concrete.

The average live load stress found from readings 800 and 801 is 341 pounds per square inch, which corresponds to a total stress of $341 \times \frac{246}{135} = 622$ pounds per square inch compression in extreme fibre of concrete, or more than three times that found by Chicago Code, taking into consideration the tension in the concrete.

The stresses computed by the other by-laws are given in Table 3.

To find the bending moment which corresponds to the stresses ascertained by test, we have as before

$\frac{WL}{x} = Q_t c_t$ and $\frac{WL}{x'} = Q_c c$ where x and x' are the required coefficients.

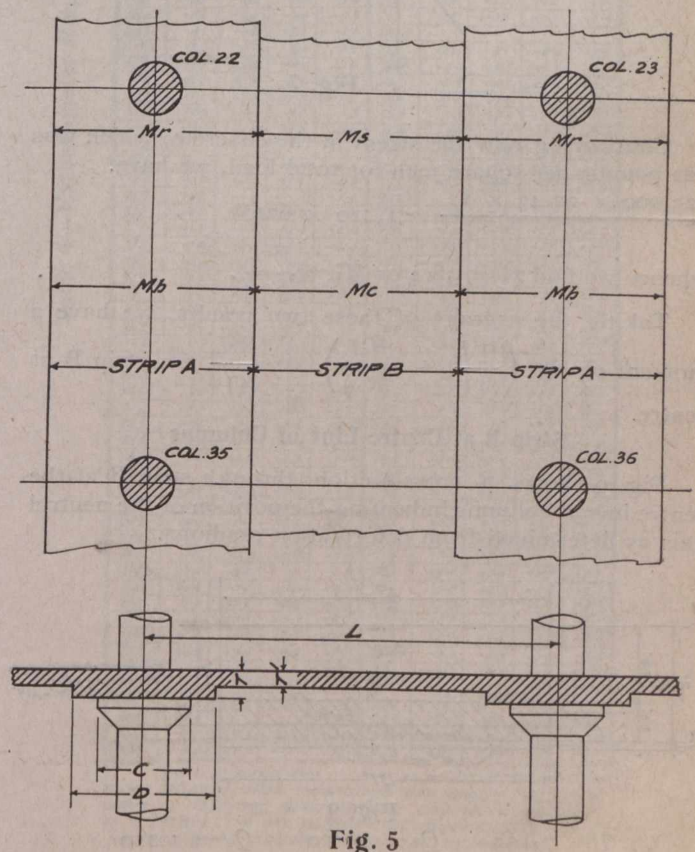

Fig. 5

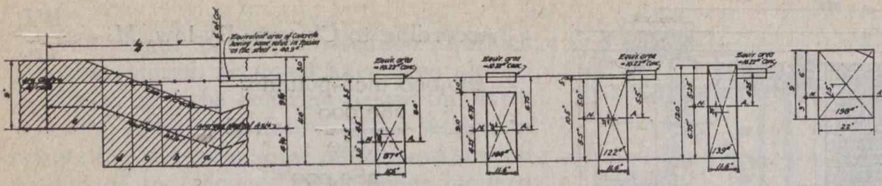

Fig. 6 Fig. 6A Fig. 6B Fig. 6C Fig. 6D Fig. 6E

Summarization of I's: Fig. 6A = 1,111; Fig. 6B = 1,177; Fig. 6C = 1,452; Fig. 6D = 1,933; Fig. 6E = 1,780.

The unit stress in the steel for the total load was 1,847 pounds per square inch, as found above.

This corresponds to a stress in the concrete at 2¾ ins. below the neutral axis of $1{,}847 \times \frac{2{,}800{,}000}{30{,}000{,}000} \times \frac{2\frac{3}{4}}{1\frac{13}{16}} = 262.$

$$\therefore \frac{125{,}000 \times 22.43 \times 12}{x} = 2{,}620 \times 262.$$

whence $x = 49$ or $M_o = \frac{WL}{49}$.

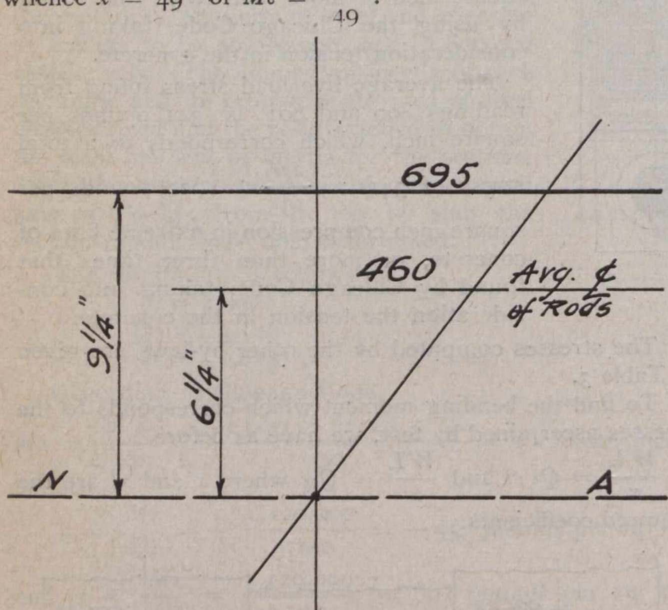

Fig. 7

Considering now the stress in the concrete, which was 622 pounds per square inch for total load, we have.

$$\frac{125{,}000 \times 22.43 \times 12}{x'} = 1{,}410 \times 622$$

whence we find $x' = 38.4$ or $M_o = \frac{WL}{38.4}$.

Taking the average of these two results, we have a moment of $\frac{1}{2}\left(\frac{WL}{49} + \frac{WL}{38.4}\right) = \frac{WL}{44}$ for strip B at centre.

Strip B at Centre Line of Columns

Fig. 9 shows a cross-section through strip B at the centre line of columns indicating the position of the neutral axis as determined from deformation readings.

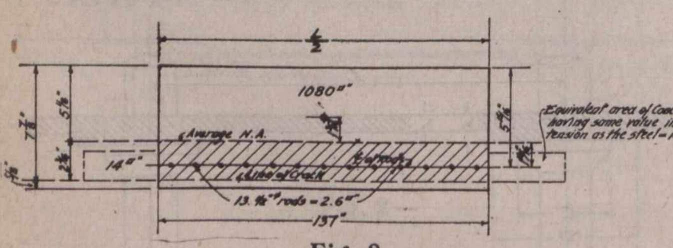

Fig. 8

$I = 7{,}195 \quad Q_t = 2{,}620 \quad Q_c = 1{,}410$

It was found in the same manner as before that a deformation of 2.5 for the live load would occur at 3.82 ins. above the neutral axis, so that only the concrete below this point could be considered effective. The properties of the section determined on this basis are:—

$$I = 4{,}102$$
$$Q_c = 1{,}346$$
$$Q_t = 876$$

The bending moment according to Chicago By-law is 236,000 inch-pounds.

$$\therefore \quad c = \frac{236{,}000}{1{,}346} = 175\tfrac{1}{2} \text{ pounds per square inch.}$$

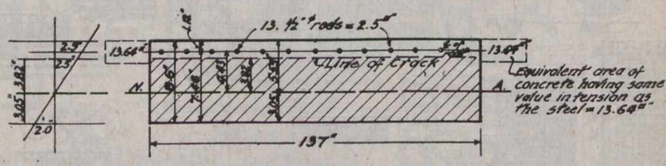

Fig. 9

$I = 4{,}102 \quad Q_c = 1{,}346 \quad Q_t = 876$

$$c_t = \frac{236{,}000}{876} = 270$$

and $s = 270 \times \frac{30{,}000{,}000}{2{,}800{,}000} = 2{,}890$ pounds per sq. in.

Readings 583 and 784 give $c = 319$ and $s = 3{,}960$ as the stresses for total load.

To find the bending moment coefficient corresponding to these readings we have

$$\frac{111{,}000 \times 21\frac{1}{4} \times 12}{x} = 876 \times 3{,}960 \times \frac{2{,}800{,}000}{30{,}000{,}000}$$

whence $x = 88$,

which gives $M_s = \frac{WL}{88}$ computed from stress in steel, also

$$\frac{111{,}000 \times 21\frac{1}{4} \times 12}{x'} = 1{,}346 \times 319$$

whence $x' = 66$

Code	Strip A	Strip B	Mr.*	Mb	Ms	Mc	C†	D†	T†	T'†
Chicago	$\frac{L}{2}$	$\frac{L}{2}$	$-\frac{WL}{30}$	$+\frac{WL}{80}$	$-\frac{WL}{120}$	$+\frac{WL}{120}$	.225L	.33L		6" or $\frac{L}{32}$
Philadelphia	$\frac{45}{100}L$	$\frac{45}{100}L$	$-\frac{WL^*}{28.9}$	$+\frac{WL}{94}$	$-\frac{WL}{155}$	$+\frac{WL}{144}$	.2L	.38L	$1\frac{2}{3}T'$	
Joint Comm'te	$\frac{L}{2}$	$\frac{L}{2}$	$-\frac{WL}{25}$	$+\frac{WL}{55.5}$	$-\frac{WL}{100}$	$+\frac{WL}{133}$	.2L	.4L		6" or $\frac{L}{32}$

*Mr for steel in straight band is $\frac{WL}{47}$ and for steel in diagonal band $\frac{WL}{72}$.
†C, D, T, T', are minimum dimensions allowed by Codes.

Table 1—Comparison of Recommendations of Chicago and Philadelphia and Joint Committee Report

which gives $M_s = \frac{WL}{66}$ computed from stress in concrete, or an average of $M_s = \frac{WL}{77}$ for strip B at the centre line of columns.

	At edge of Capital.						Strip A at Centre			Strip B at Centre								Strip B at ¢ of Cols.	
Reading No.	710	713	717	601	607	614	656	662	663	657	658	659	660	785	786	800	801	784	583
Stress in	Steel	Steel	Steel	Conc.	Conc.	Conc.	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Conc.	Conc.	Conc.	Conc.	Steel	Conc.
Chicago Code	15900	15040	15570	-658	-592	-635	18000	16080	16080	17880	16350	16350	17880	-326	-390	-326	-390	13270	-357
Philadelphia Code	30600 [illegible] 10000 [illegible]	28800 [illegible] 9400 [illegible]	29800 [illegible] 9710 [illegible]	-695	-626	-671	15310	13690	13690	14890	13610	13610	14890	-302	-361	-302	-361	10270	-307
Joint Comm'te Report	19600	18450	19100	-789	-710	-762	25950	23160	23160	11570	10530	10530	11500	-294	-352	-294	-352	15900	-428
Test	5925	4680	2066	-176	-676	-562	3860	6480	7720	7240	7110	1504	2190	-574	-717	-685	-557	3960	-319

Table 2—Comparison of Stresses for Live and Dead Loads Combined According to Various Codes, with Those Found by Test. Stresses are in Pounds Per Square Inch

Strip A at Centre

As there is no reading on the concrete for strip A at the centre, we cannot find the moment of inertia of this section.

By reference to Table 3 it will be noted that for the points of negative bending moment in strips A and B there is a fairly good agreement between the results obtained by test and those computed by the bending moments specified in the various codes, making allowance for tension in the concrete.

There is not a good agreement between the results obtained at the one point of positive bending moment for which readings were given so that *I* could be found.

	Strip A at edge of Capital		Strip A at Center	Strip B at centre				Strip B at ℄ of Cols.	
Reading No.	710, 713, 717	601, 607, 614	656	657-8	659-60	785-6	800-1	784	583
Stress in	Steel	Concrete	Steel	Steel	Steel	Conc.	Conc.	Steel	Conc.
Chicago Code	5020	-357	855	750	750	-200	-200	2890	-176
Philadelphia Code	5300	-377	727	900	900	-185	-185	2240	-151
Joint Comm'te Report	6150	-428	1231	483	483	-180	-180	3460	-210
Test	4230	-476	3860	7175	1847	-645	-622	3960	-319

Table 3—Comparison of Stresses for Live and Dead Loads Combined According to Various Codes, with Those Found by Test Using the Section Modulus Determined by Deformation Readings

This may possibly be partly due to the fact that the adjacent panels were not loaded, which would have the effect of increasing the positive moments in the loaded panels.

Moments which correspond to results found by test:—

$$M_r = -\frac{WL}{29}$$

M_b = (could not be determined).

$$M_c = \frac{WL}{44}$$ A large variation partly due, no doubt, to adjoining panels not being loaded.

$$M_s = \frac{WL}{77}$$

THE QUESTION OF UNBALANCED THRUST

By Peter Gillespie, M.Can.Soc.C.E.

NO other type of reinforced concrete construction has appealed to the building public or has caught the popular fancy as has that commonly described as the flat slab or girderless floor. The resulting economy in story heights, the simplified form construction, the unbroken ceilings and the ease with which auxiliary equipment as, for example, sprinkler systems, can be installed have all contributed to that popularity. But while these advantages have been generally recognized, the difficulties attending the rational design of flat slab structures have also been appreciated because this type does not lend itself to either simple or satisfactory theoretical treatment. Recognizing this, public-spirited firms and organizations have provided facilities whereby tests of full-size buildings have been made with a view to studying the behavior of floors under load and thereby formulating empirical rules for the design of flat slabs which, when constructed, would be safe without being wasteful. These tests have usually consisted in applying to the floor a live load equal to or exceeding that for which the structure was built and then measuring the deflections and the deformations in the steel and concrete at certain selected places in order to determine the intensity of the stress resulting. From the

Gage Line	135# on 4 panels	270# on 4 panels	270# on 2 panels	Load Removed	Gage Line	135# on 4 panels	270# on 4 panels	270# on 2 panels	Load Removed
580	±0.0	-2.4	-3.7	-3.7	650	-2.2	-2.8	-3.4	-1.5
581	-1.8	-2.9	-3.0	-5.0	651				
582	-0.5	-1.5	-5.2	-4.6	652	-1.3	-2.7	-3.8	-2.1
583	+2.0	-0.9	+1.0	-1.2	653	-1.8	-2.7	-4.3	-2.7
584	-3.5	-6.0	-6.1	-7.0	654	-2.1	-3.2	-4.8	-3.5
585	-1.5	-2.8	-4.7	-1.2	655	-1.6	-1.8	-3.2	-2.9
586	Cancelled	— —		— —	656	+2.8	+5.2	+4.0	+0.1
587	-0.6	-2.2	-3.2	-2.2	657	+5.3	+9.7	+15.1	-0.4
588	-0.9	-1.4	-2.7	-3.2	658	+5.2	+11.6	+1.3	+2.1
589	-1.0	+2.0	+0.3	-3.0	659	+1.1	+4.8	+5.6	+4.4
590	-0.9	0.0	-1.0	-3.1	660	+1.6	+4.8	+6.6	+3.3
591	-2.0	-2.2	-3.1	-4.6	661	+0.9	+2.2	+3.3	+3.3
592	-4.7	-10.4	-9.1	-6.9	662	+4.7	+13.5	+16.5	+8.8
593	-3.0	-5.1	-5.7	-5.9	663	+5.6	+18.1	+1.8	+1.6
594	-3.5	-3.8	-4.9	-4.9	664	+2.0	+11.2	+3.0	-1.5
595	-3.6	-6.0	-6.3	-6.2	665	+2.0	+10.2	+2.6	+1.1
596	-5.9	-6.4	-5.1	-7.1	666	+1.3	+7.5	+5.6	+1.7
597	-3.9	-2.5	-3.2	-5.2	667	+1.3	+12.1	+13.8	+8.0
598	-1.0	-1.2	-1.7	-0.9	668	+1.7	+7.8	+9.3	+5.7
599	-3.4	-3.4	-4.2	-3.2	669	+1.0	+3.1	+3.1	+1.7
600					670	-3.8	-8.2	-8.5	-7.0
601	-1.1	-4.4	-5.1	-5.8	671	-2.2	-3.4	-4.9	-2.6
602	-4.1	-8.7	-7.5	-6.5	672	-4.1	-4.0	-6.0	-4.1
603	-2.6	-5.2	-5.3	-6.1	673	-2.9	-2.0	-2.3	-2.2
604	-1.0	-2.0	-2.2	-4.2	674	-2.2	-2.7	-3.6	-1.6
605	+0.4	-1.6	-1.8	-3.0	675	-4.2	-5.5	-5.9	-5.0
606	-1.6	-4.0	-4.9	-6.2	676	-5.3	-8.1	-9.3	-4.7
607	-4.2	-8.9	-11.0	-8.0	677	-2.1	-2.8	-3.0	-3.0
608	-3.4	-5.0	-6.4	-5.4	678	-5.5	-12.4	-13.2	-7.6
609	-5.4	-10.5	-11.7	-7.4	679	-3.8	-6.7	-7.8	-3.7
610	-1.6	-1.5	-1.3	-3.9	680	-3.0	-6.9	-7.5	-4.0
611	-2.8	-5.7	-5.9	-5.6	681	-4.0	-3.9	-3.9	-3.1
612	-2.7	-2.5	-3.7	-5.0	682	-0.1	-0.8	-0.8	-1.8
613	-1.4	-2.5	-3.9	-5.9	683	-1.9	-3.1	-3.0	-1.5
614	-3.5	-6.5	-7.5	-7.4	684				
615	-7.2	-13.1	-13.9	-9.7	685				
616	-1.3	-3.6	-3.8	-4.6	686	-0.6	-0.2	-0.2	-1.2
617	-3.8	-11.2	-12.2	-8.4	687	-0.6	+1.3	+1.0	-0.8
618	-2.5	-6.9	-8.5	-6.2	688	-5.1	-5.7	-7.4	-5.8
619	-5.2	-9.5	-14.0	-6.6	689	-3.5	-4.8	-5.0	-7.1
620	-0.4	-3.4	-5.0	-5.2	690	-3.5	-4.1	-5.1	-6.1
621	-0.1	-0.9	-1.9	-4.4	691	-3.7	-5.3	-6.3	-4.5
622	+0.4	+0.2	-0.5	-3.7	692	-6.4	-10.7	-11.4	-8.3
623	-1.9	-5.4	-3.9	-4.5	693	-5.5	-7.1	-7.8	-7.4
624	-6.8	-11.8	-9.7	-7.2	694	-6.5	-8.7	-10.1	-6.8
625	-1.2	-3.6	-3.1	-4.8	695	-2.1	-1.9	-3.4	-5.8
626	+0.8	+0.5	+0.7	-2.5	696	-4.9	-5.4	-5.2	-4.8
627	-0.6	-1.1	-3.1	-1.9	697	-2.4	-2.5	-4.2	-4.2
628	-2.2	-4.0	-4.3	-3.2	698	-2.2	-2.3	-2.7	-5.1
629	0.0	-1.8	-2.5	-2.0	699	-0.4	+0.2	+0.3	-2.2
630	-1.5	-2.1	-2.2	-2.2	701	+0.9	+1.1	-1.1	-1.1
631	-3.6	-4.5	-4.0	-4.0	702	+3.6	+6.2	+3.0	+1.5
632	-1.5	-0.5	-10.6	-4.0	703	+2.2	+3.4	+1.6	-1.4
633	-3.9	-5.3	-6.5	-2.4	704	+2.2	+4.9	+4.4	+2.5
634	-5.5	-11.4	-12.5	-5.3	705	+1.0	+3.2	+1.5	+1.2
635	-0.1	-0.3	-1.0	-1.7	706	+0.3	+2.0	+0.1	-1.2
636	-2.0	-5.0	-5.1	-2.0	707	+3.0	+4.7	+3.9	+2.1
637	-0.6	-1.1	-1.1	-1.0	708	+3.0	+4.1	+2.0	+0.5
638	-1.8	-3.3	-2.6	-1.8	709		+7.7	+1.6	-1.0
639	-4.0	-4.2	-5.2	-3.4	710	+4.3	+5.7	+3.1	+1.8
640	-1.8	-4.2	-4.9	-3.4	711	+1.4	+3.2	+1.2	+0.4
641	-2.8	-4.9	-6.2	-3.8	712	+2.9	+6.7	+6.0	+0.7
642	-2.7	-4.0	-5.5	-1.7	713	+3.4	+7.0	+7.1	+1.6
643	-3.0	-9.3	-11.4	-4.0	714	+6.3	+10.3	+9.9	+3.9
644	[illegible]	-2.1	-3.3	-3.5	715	+0.2	+4.5	+1.2	-0.5
645	-3.9	-10.5	-10.4	-4.6	716	+3.8	+2.5	+4.5	-1.4
646	-3.2	-6.3	-7.8	-4.9	717	+1.5	+3.5	+5.3	+0.4
647	-4.1	-8.9	-9.9	-4.5	718				
648	-2.5	-4.1	-6.0	-3.0	719	+5.1	+9.1	+8.6	+3.6
721	+5.3	+9.3	+10.0	+1.9	764	+0.6	+8.7	+7.7	-1.0
722	+1.0	+5.0	+2.8	+0.5	765	+0.9	+0.8	+0.2	-4.5
723	+1.1	+3.4	+2.3	+1.2	766	+0.6	+1.7	-0.8	-3.1
724	+0.8	+1.5	-0.1	-1.5	767	0.0	+2.8	+0.5	-0.1
725	+0.7	+1.3	+1.0	-1.0	768	+0.4	+3.7	+0.9	+0.4
726					769	+2.0	+4.6	+4.5	+0.9
727	+1.8	+1.1	+0.4	+0.3	770	+5.6	+12.6	+12.4	+4.8
728	-0.3	+0.7	+1.3	-0.7	771	+2.9	+6.4	+6.0	+2.5
729	+3.2	+5.2		+5.1	772				
730	+0.7	+4.1	+3.3	+1.7	773	+0.7	+1.7	+0.6	-1.5
731	+1.8	+3.9	+2.1	-0.8	774	+1.8	+3.3	+1.3	-2.2
732	+1.4	+2.6	+2.9	-0.4	775	+2.2	+2.6	+1.2	+0.3
733	+4.6	+10.8	+11.0	+4.2	776	+1.7	+0.5	+2.7	-1.3
734	+5.2	+10.9	+11.3	+3.6	777	+1.0	+7.2	+3.8	+1.7
735	+5.1	+8.9	+9.0	+4.7	778	+6.9	+12.9	+7.9	+4.0
736	+2.0	+6.3	+6.0	-1.6	779	+2.0	+5.3	+4.0	+2.6
737	-0.1	+2.8	+2.7	-1.8	780	+3.0	+5.3	+3.3	+3.5
738	-0.7	+2.1	+2.5	-3.4	781	+1.6	+4.2	+2.2	+0.1
739	+3.1	+7.9	+8.3	-1.0	782	-1.6	-2.9	-2.2	-3.1
740	+3.1	+6.4	+7.7	+1.7	783	-3.0	-5.0	-3.5	-4.4
741	+5.0	+9.0	+9.4	+2.6	784	+2.9	+4.3	+1.9	+1.1
742	+3.9	+8.4	+8.3	+1.8	785	-3.6	-3.6	-3.6	-3.1
743	+5.6	+7.6	+7.6	+4.8	786	-4.5	-6.9	-4.3	-4.8
744	+3.4	+5.4	+8.4	+2.9	787	-0.5	+0.9	0.0	-1.3
745	-1.4	+1.8	-1.2	-1.4	788	+0.4	+3.0	+1.3	-0.5
746					789	+2.0	+2.1	+1.5	+1.3
747	-0.2	+6.1	+5.6	+4.9	790	+1.1	+1.7	+1.0	-1.0
748	-0.1	+1.8	+0.9	-2.1	791	+1.4	+4.1	+2.5	+0.7
749	+0.1	+1.6	+0.1	-2.1	792	+1.9	+3.9	+1.8	-0.5
750	-1.0	-1.4	-1.4	-2.6	793	+0.5	+3.8	+1.4	-1.0
751	+0.5	+0.9	+1.7	-0.8	794	+2.7	+4.9	+2.5	+1.3
752	-2.0	-2.0	-1.8	-2.9	795	-0.4	+3.0	+0.5	-2.9
753	+0.2	+5.0	+5.9	+0.3	796	0.0	+2.5	+1.3	-2.1
754	+2.7	+7.0	+8.2	+2.6	797	+2.4	+2.9	+1.7	-0.7
755	+2.2	+3.3	+4.9	+0.5	798	+0.2	+0.9	-0.8	-2.5
756	-0.1	-0.2	-0.7	-3.1	799	+0.7	+3.8	+1.4	-0.8
757	+1.3	+3.4	+4.0	+0.8	800	-4.3	-6.5	-9.0	-6.1
758	-0.5	+1.6	+1.3	-1.6	801	-3.5	-6.4	-6.9	-7.2
759	+0.8	-0.2	-0.7	-3.7	802	+0.3	-0.7	-1.7	+0.2
760	+0.7	-1.1	-0.9	-1.8	803	-1.9	-5.7	-7.6	-4.4
761					804	-2.6	-8.2	-13.2	-8.5
762	0.0	-0.7	+0.3	-1.0	805	-1.1	-2.0	-2.1	-1.8
763	0.0	+1.3	+0.2	-1.5	806	+6.0	+15.0	+11.0	+5.3

+ = TENSION — = COMPRESSION

Note - Deformation readings are multiplied 5000 times. Also, the deformations are for a distance of 8 inches, so for actual unit deformations figures given should be divided by 40,000.

Table 4—Extensometer Readings of Deformation Caused by Live Loads

nature of the work some form of portable extensometer was necessary and for this, that known as the Berry strain gauge or some modification of it, has generally been used.

Any type of extensometer which has to be attached to a specimen and removed again between readings cannot possess the accuracy of measurement usually obtained from the stationary forms. Then, again, concrete is a material for which the ratio of stress to deformation is much more variable than it is for the metals. Moreover, for any given concrete and for all stresses above moderate working values, Hooke's law of proportionality between stress and strain does not obtain. Further, it is usually quite impossible to know at just what stage of the operation of loading, the concrete in tension will crack and throw upon the reinforcement the bulk if not all of the tension which it had been carrying. In consequence of these limitations it will be conceded that the figures obtained from the use of the portable extensometer, especially on concrete structures, must be interpreted in a broad and liberal manner and that they must not be considered as reflecting the last refinement of physical measurement. It should be noted, too, that the inevitable errors are probably relatively greater for small deformations than for large since the ratio of a probable error to a large deformation is less than to a small one.

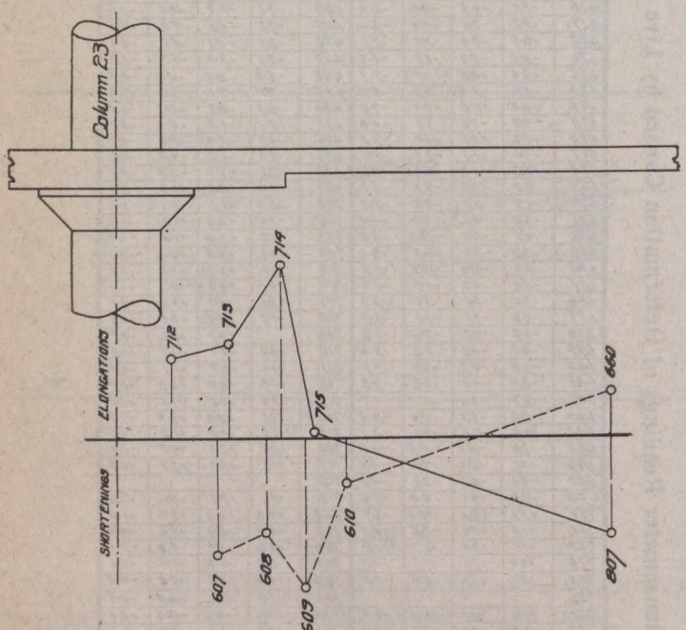

Fig. 10—Deformations in Steel and Concrete Graphically Shown

Top of slab shown thus ——————

Bottom of slab shown thus — — — — — —

With respect to the Simpson Building test, there is one point to which attention might be called because it relates to a phenomenon which has been observed in several previous tests and is one which concerns the values to be assigned for the working stresses in both materials. To illustrate, Fig. 10 has been prepared from the test data. It will be seen that the various values of the observed deformations for the several gauge lines lying diagonally in one direction from column 23 have been plotted with respect to a horizontal axis, elongations upward and shortenings downward. Whether these relate to steel or concrete does not concern us, since it is to only one position on this radial line that attention is invited. Generally speaking, when either line crosses the horizontal axis, it denotes a point of zero deformation and therefore a point of zero flexural stress and of zero bending moment. If both lines cross the zero axis at the same point, it denotes a true point of contraflexure at which the stresses are mainly shears. In Fig. 10, however, this is not the case and for some distance outward from gauge line 715, the slab appears to be altogether in compression, and at gauge line 610; this, according to the records, is equal to an average stress of 70 pounds per square inch with a resultant acting much nearer the lower face than the upper. Moreover, in this particular region, the situation is not complicated by the presence of three or four superimposed layers of metal such as are found in some other places. This phenomenon is probably due to the partial behavior of the slab as an arch, an hypothesis, indeed, for which there is considerable warrant, since the peculiarity has been observed and reported on several occasions.

The city architect of Toronto, Mr. Pearse, is to be commended on the way in which he has planned these investigations and on the amount of profitable study which he has devoted to this problem of construction. All of the doubtful points have not been cleared up as yet, although much light has been thrown on many of them. As a result of careful and patient work by many investigators, the design of flat slab structures is to-day on a much more intelligent basis than it was five years ago.

WATERWORKS DEPT., CITY OF EDMONTON

A report just issued by City Commissioner A. G. Harrison, of the city of Edmonton, covering 1917, says that the waterworks department for the city enjoyed a surplus of $38,189.75. The total mileage of mains under pressure in the system at present is 164.8 miles. The total cost of water maintenance for the year amounted to $6,346.95, making an average cost of maintenance per mile, $38.70. During the year, 168 new water services were installed and 132 house sewer services. The total number of house services to date is 9,602 and the total number of water services 10,839. The average cost of maintenance per water service is 73 cents.

The growth of the system has been remarkable during the past ten years. In 1908, the city had 2,520 water services, 200 hydrants and 48.8 miles of water mains. In 1917, the number of water services had increased to 10,829 with 787 fire hydrants.

The number of water meters in use in the city is 7,700 and the average cost of maintenance per meter is 96½ cents.

The service given has been constant througrout the whole period and by regular daily tests the water supply is shown to be free from all contamination. One pound of liquid chlorine per million gallons was all that was found necessary, and proved to be far more economical than the old hypochloride of lime system.

The report of the Department of Public Works for the Province of British Columbia show an expenditure in 1916-17 of $48,754 in construction of roads and trails in the districts of Fernie, Greenwood, Kamloops, Kaslo, Revelstoke, Richmond, Similkameen, Skeena, Slocan, Yale and Ymir.

The iron work on the six new vessels to be built by the Lyall Shipbuilding Co., Vancouver, B.C., for their own use, will be manufactured in the shipbuilding yards by the company. Manager Cook is having installed under the superintendence of Supt. F. Davey, a large blacksmith shop, equipped with two steam hammers, furnaces and modern machinery for the carrying out of part of the ship construction.

THE GAS INDUSTRY AND CANADA'S FUEL PROBLEM*

By Arthur Hewitt
General Manager, Consumers' Gas Company, Toronto.

THE condition which prevails in Canada to-day, with regard to the supply of fuel necessary for the maintenance of the industrial activity of the country, and for the domestic requirements of its population, demands a careful survey on the part of governmental authorities, and that every possible economy be exercised in order that the total requirements of fuel may be reduced to a minimum.

The fuels available for use in Canada may be generally stated as: coal, wood, petroleum, gas and water power electrically distributed. Each of these fuels has certain inherent advantages and their economic value is largely determined by the service to which they may be applied, and the localities in which they may be required.

In considering the economic value of various fuels on which Canada may rely to meet its domestic and industrial requirements, manufactured gas, or what is sometimes called "city" gas, must be given an important place. Originally used only as an illuminant, gas has become one of the vital necessities of the domestic and industrial life of urban communities throughout the civilized world.

In using the term "city" gas, I mean gas as ordinarily manufactured by gas companies, and distributed through pipe line systems laid beneath highways of cities and towns. In the early days of the industry, this commodity was called "coal" gas, for the reason that it was produced entirely from bituminous coal. The qualifying word "city" may be appropriately prefixed to the commodity as now supplied in recognition of the fact that economic considerations have caused different localities to combine with the coal gas, what is known as carburetted water gas. Indeed, in many cities on this continent carburetted water gas now forms the whole of the supply.

For practical purposes, however, there has been very little difference in the general character and useful properties of city gas during more than one hundred years.

The tremendous development and growth of the gas industry, particularly during the past ten years, furnishes abundant evidence of appreciation by the public, of the merits of the commodity supplied, and of the economy in the use of gas for the thousand and one purposes for which it is now so well adapted.

Its success in holding the market against all rivals of the same order of utility is due, largely, to its possession of certain valuable and unique physical properties, *viz.*:

(1) It is a permanent gas, suitable for consumption in or out of doors, either as an illuminant or as a smokeless fuel of high or low intensity, or as a source of motive power—all from the same supply system.

(2) It is susceptible of perfect sub-division without loss of efficiency for use in either required application for lighting or the production of heat or power. The cost to the consumer is always in direct proportion to the quantity consumed.

(3) It is a readily available fuel, cleanly and inoffensive, to be obtained by the turning of a tap, which will grill a chop, boil a kettle, or heat a flat iron, and there is no metallurgical or smith's work for which its heat is not adequate; no household warming for which it is not suitable. As a means of domestic cooking and heating, it is incidentally the practical cure for the smoke nuisance of towns.

*Abstracted from paper read before the first general professional meeting of the Canadian Society of Civil Engineers, held at Toronto March 26th and 27th, 1918.

City gas, as supplied in Toronto, is made by the distillation of Youghiogheny and Westmoreland coal, obtained in the Pittsburgh district, with the addition of about 40 per cent. of carburetted water gas.

At this point it might be interesting to see what a gas company can secure from a ton of bituminous coal.

In the first place, a ton of gas coal in an efficient carbonizing plant will yield ten thousand cubic feet of gas, from which may be extracted a certain percentage of benzene and toluol. It will produce approximately 1,350 lbs. of coke, from which, after providing the necessary fuel for the producers, there will be left a residue of from 800 to 850 lbs. of coke to be marketed as fuel for steam raising, industrial purposes and for domestic use. It will yield ten Imperial gallons of tar, from which may be recovered toluol, benzene, fuel oil, acids, dyes, etc. Another important by-product is ammonia, useful in the manufacture of fertilizer, and for refrigeration, and other purposes. There is also, as a minor by-product, retort carbon, which is used in the manufacture of carbon electrodes for search-lights, electrical steel furnaces, etc.

It is estimated that the percentage of efficiency obtained from coal, in a gas works, will run from 60 to 70 per cent. Compare this with the efficiency obtained in general practice from a ton of the same kind of coal used in an open fire which has just been fed with coal. Would the efficiency be 20 per cent. or less?

Let us make another comparison, and remember that the object of our discussion is to find the most economical way to use fuel, and especially coal.

The available supply of anthracite coal is admittedly limited, and the need for conservation is probably greater with regard to it, than is the case with any other kind of fuel. From every thousand tons of bituminous coal which a gas company carbonizes it produces and makes available for general consumption, as a substitute for anthracite coal, four hundred tons of gas house coke. The value of coke, as compared with anthracite coal, may be observed from the following analyses:—

	Anthracite coal.	Coke.
Moisture (after air drying)	3.20	1.60
Volatile combustible	6.86	8.27
Fixed carbon	76.61	76.23
Ash	13.33	13.90
Sulphur	.920	.942
Gross B.t.u. per lb.	12,800	12,200

Gas as Fuel for Industrial Purposes

A great deal has been said from time to time as to the unsanitary conditions of the atmosphere in our city, caused by the discharge of black smoke from chimneys. In spite of by-laws and the watchfulness of officials concerned with their enforcement, the evil seems to remain unabated, with every prospect of conditions becoming worse with the further growth of the city.

The problem of furnishing power, without making smoke, is rapidly being solved by the use of water power, distributed by electric lines. The use of coal in manufacturing processes, however, is still to be considered. Here the gas industry offers a means for the displacement of crude heating, which not only disestablishes the chimney as a polluter of the atmosphere, but introduces into the factory itself a controllable and uniform system of heating, producing constancy of result, and adding materially to industrial economy, by the reduction of labor, the promotion of cleanliness, and the speeding-up and improvement of factory output. These aspects of the case require the main part of our consideration, but without going into details we might well consider also the great destruction of value for which the present crude methods of heating in factories are responsible. While gas can supply heat so easily controllable that there is comparatively little waste in obtaining from it effective duty, with coal there is necessarily a large waste of heat. There is a large amount of heat wasted in effecting its combustion, and in driving off those volatile constituents which are useless where high temperature and pure incandescence are required. There is also waste of heat up the chimney and through stand-by requirements. There is waste of heat every time a fire is re-charged until once more favorable working conditions of the fire are obtained. With the gas as fuel, the heat can be directed exactly as needed into the furnace, and heat losses by radiation and otherwise, can be reduced to a minimum.

I do not say that coal can be entirely displaced in factories; but I claim that a large part of it could be. The point I wish to make is, that in addition to air pollution, our industries are largely wasting, by their crude methods of heating, parts of the substance of the country which are necessary—more necessary to-day than they ever have been.

If these statements are correct, it can readily be seen how vast an opportunity there is to benefit the country at large, if we are able in any appreciable extent to do away with this waste. In case of any doubt as to the practicability of accomplishing this result, I believe that when it is seen how much has already been done in developing gas appliances to supplant the crude methods still so largely used, our knowledge of possibilities will lead us to believe that we see only the dawn of a new era in industrial heating.

The manufacturer has his point of view in this matter. It is not sufficient to explain to him how the use of gas will benefit the community; it is necessary to show him that it is to his direct benefit as a manufacturer, to adopt the modern methods of using heat in his processes. Some of these advantages are:—

(1) Economy in space occupied by appliance, and in some cases the necessity and expense of a smoke stack is avoided; a practically unlimited choice of position for the furnace, which enables it to be brought into close proximity to the machine workers.

(2) No space required for storage of fuel, and no removal of ashes.

(3) Increase in output per cubic foot of factory space, owing to economy of space occupied by gas furnaces in comparison with coal furnaces.

(4) The constant and unvarying supply of fuel, of a uniform heat value, at a fixed rate.

(5) Labor saving—absence of stoking, storage and conveyance of fuel.

(6) Rapidity, and improved production, due to ability to precisely control working temperatures.

(7) In many cases a lower capital expenditure for installation.

(8) Cleanliness, which frequently assists in decreasing net labor cost.

(9) No interest to be paid on investment in fuel in storage.

(10) Reduced fire risk.

(11) No loss of material due to inability to check a high temperature instantaneously.

(12) Less repairs on equipment.

(13) Enormously smaller loss from articles or materials being spoiled by irregular heat.

When these points are taken into consideration, it is really astonishing how many instances there are where the total cost of manufacturing is less with gas than with coal.

The Use of Gas in the Manufacture of Munitions

The same causes which make gas valuable for ordinary industrial purposes apply with increased force to the manufacture of munitions. In England it is publicly admitted that the tremendous leap forward in munition manufacturing could not have been made without the use of gas. On this side of the water, while the need for gas was not vital, nevertheless gas has played an increasingly important part in munition making. At times it has been adapted solely because of the speed with which an installation could be made, but once in, it stays in, when the intrinsic merits of the fuel become known.

When munitions are mentioned, we naturally think of shells, and it is in the manufacture of shells that much of the gas used in munition works has been consumed.

In the manufacture of shrapnel, every shell has to be hardened and tempered in a manner similar to the treatment of tool steel. The end of the shell must also be heated in order to forge in the end, or "nose" it. Much gas has been used for this purpose, and also for heating water used for washing grease off the finished shell, and for melting rosin which is poured into the shell after it has been charged with bullets. Even the high explosive shells have required gas. It has been used in ovens for baking varnish on the inside of the shell and in some sizes, notably the six-inch, large quantities have been used in forges for "nosing in."

Comparatively large gas-fired annealing furnaces have been employed for the treatment of various parts of shells, rifles, etc. Many parts are heated in forges for various operations, some of these forges being even 25 or 30 feet high, which shows that gas is being worked into the heavier operations.

Although large quantities of gas have been used for the purposes to which I have referred, it is not contended that other fuels could not be used, but nevertheless for various reasons, gas has been preferred. In the manufacture of small cartridge cases, however, gas is almost a necessity, and to the best of our knowledge is the only fuel used in the intricate machines which turn out millions of small cases, every one of which must be treated with absolute uniformity.

Continuity of Gas Supply in Toronto

Gas was first supplied in Toronto on the 28th of December, 1841, and from careful investigation it would appear that, while there have been local stoppages due to frost, broken mains, etc., there has not been even a momentary interruption to the general gas supply to the city since that date, a period of more than seventy-six years.

Conclusion

I shall have failed in the purpose of this paper if I do not state definitely my conviction that each class of fuel available for consumption in Canada should be selected and appropriated for the purposes for which it is inherently and economically best suited, regard being had to the essential objectives of:—

(1) Limiting the necessity for importing fuel from other countries.

(2) Limiting as far as possible the use of high-grade gas coal, to the purposes for which the largest percentage of its efficiency can be usefully employed.

(3) Avoiding the use of fuel requiring a long haul wherever it is possible to secure a suitable substitute requiring only a short haul.

CONCRETE PAVED BANK REVETMENT*

By G. C. Haydon, M.Am.Soc.C.E.
Assistant Engineer, Missouri River Improvement Scheme.

IMPROVEMENT of the Missouri River by the United States government, by means of works designed for the contraction of channel widths and bank protection, began as early as 1876.

The successful protection of caving banks is the foundation of the improvement of the river, and has been the great study to those engaged on the work. This study, combined with trials and experiments with many types of work, resulted in the evolution of what is known as "Standard Revetment" . . . This consists of a continuous woven willow brush mattress ballasted to cover the bank below the water line and, on the river bed, for protection of the subaqueous bank, the upper sloped bank being covered with a rough pavement of one-man riprap stone. It has generally been found that, from the use of this type fair results have been obtained, due, perhaps, to the fact that it readily adjusts itself to any disturbance of its foundation which may reduce the extent of the disturbance, and because it lends itself to repair which can

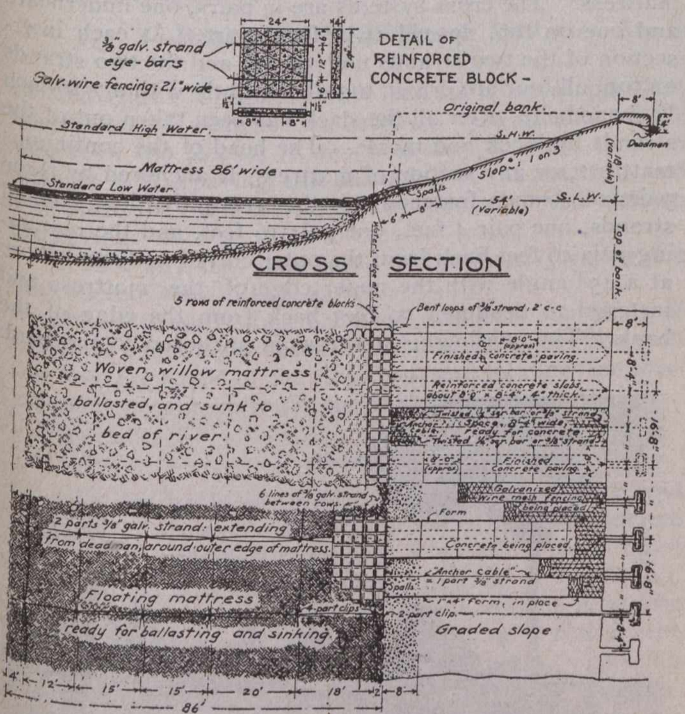

Plate 1—General Plan, Standard Revetment

readily and economically be made in its incipiency. The estimated cost of the standard type is $10 per linear foot for completed work. For general plan, see Plate 1.

Concrete Paved Bank

There seems to be no record of any claim for the first experiment in protecting the slope of a river bank by paving it with concrete, although it was used as early as 1897 in protecting the toe of the slope for the Holland dikes, and in 1900 by the Corps of Engineers, U.S. Army, for the upper bank paving in river improvements.

This type is somewhat like a monolithic structure and tends to lose the advantage of automatic adjustment to slight changes in the foundation, so that there is a constant uncertainty as to its condition and a possibility of a serious collapse in after years.

This revetment is a departure from the standard type used on the Missouri River in that the upper bank is paved with a 4-inch layer of reinforced concrete slabs instead of broken stone, and the subaqueous willow mattress pro-

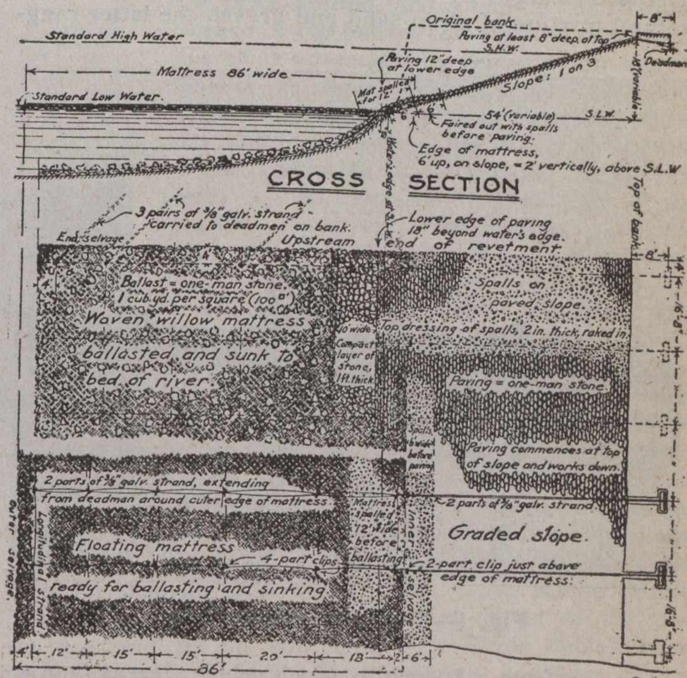

Plate 2—General Plan, Combination Concrete and Willow Mattress Revetment

tected for about 10 feet width from the shore edge, with reinforced concrete blocks connected to the solid upper pavement, and so laced and tied together with wire strand within themselves as to form a flexible covering instead of the compact layer of stone for the same width. For the general plan, see Plate 2.

The concrete paved bank revetment, selected for description, is known as the Bates Island Bend revetment, located on the right bank of the river at mile 98, above the mouth.

It was the first piece, of any magnitude, constructed on the river in which machinery and a system of organization for progress was used, and comprises 14,188 feet of finished work at $7.58 per linear foot. It was begun in March, 1912, and completed September 8th, 1913, by hired labor and government plant.

Plant

The plant used on the work consisted of the following: One double-decked quarterboat with a capacity of housing from 60 to 70 laborers and necessary foremen, 1 hydraulic grader, 1 mattress barge, 1 barge for concrete mixer plant, 6 material barges, and 1 tow boat. The working plant was supplemented by an 8-inch suction pump, installed on a material barge, for procuring gravel. The value of this plant is estimated at $60,000, no charges having been made for depreciation.

Material

The principal material used, which was procured locally and delivered by barge, consisted of willow brush at $1.60 per cord; stone at $0.68 per cubic yard, and sand and gravel at $0.08 per cubic yard; manufactured material delivered by freight consisted of 3/8-inch galvanized strand at $0.71 per linear foot; 50-inch galvanized woven-

*"Professional Memoirs."

fence wire, for the paving, at $0.06 per linear foot; 22-inch fence wire, for blocks, at $0.03 per linear foot; lumber, for forms, at $22 per M. b.m., and Portland cement at $0.75 per bbl. (f.o.b. factory). The gravel for the concrete paving and blocks was procured from the Gasconade River about 2 miles above the mouth, and delivered on barges by an 8-inch suction pump. It is a natural mixture of clean sand and gravel, the latter ranging in size from a ¼-inch to 3-inch pebble; it was impracticable to keep an itemized cost of procuring this gravel as it was in conjunction with other items of construction.

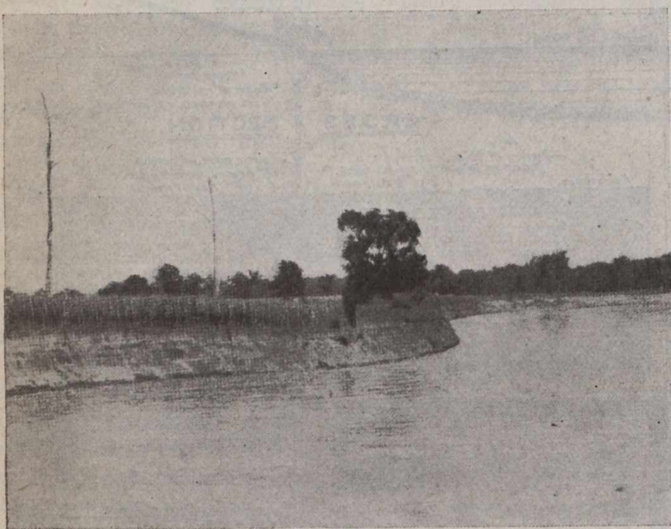

Fig. 1—Typical Concave Bank

The cement used was of the American Portland brand. The finished aggregate is of a 1 : 2 : 4 mixture.

The ⅜-inch diameter galvanized strand is composed of seven No. 11 wires, having a tensile strength of about 5,000 pounds.

The reinforcing for the paving consists of galvanized woven-wire fabric, diamond mesh 50 inches wide, formed of thirteen No. 10-gauge line wires uniformly spaced, with No. 12½-gauge stay wires at 4-inch intervals; elastic limit 75,000 pounds to the square inch. In addition to the woven-wire fabric, and the mattress ⅜-inch anchor strands, similar strands for block fastenings are spaced 16⅔ feet, which gives a ⅜-inch strand reinforcing every 8⅓ feet, in the slab, anchored to a deadman on top bank.

The reinforcing for the concrete blocks consists of 22-inch woven-wire fabric, similar to that used in the paving. In addition to the woven fabric, two ⅜-inch strands are placed with an "eye loop" at each end for joining the blocks. These blocks, 2 ft. x 2 ft. x 4 ins., were made at a central yard at a cost of 28 cents each, and delivered by barge at site of the work.

In the construction of revetment the work is practically divided into three general classes: First, grading; second, mattressing; and third, paving. In the matter of cost accounting, the two latter classes are subdivided into the necessary heads for determining the expenditures of procuring, delivering, and placing the material. As these are usually variable quantities fixed by accessibility and the law of supply and demand, these detailed headings will be omitted. For a typical concave bank, see Fig. 1.

Grading

The bank is graded by the hydraulic method to 1 on 3, which gives a length of slope from 42 to 54 feet according to height above standard low water, which also determines the length of a slab. (Fig. 2.)

Mattress

After the bank is graded the continuous mattress, 86 feet wide, is woven of bar-growth willows, from ½ to 2 inches in diameter at the butt end and 10 to 25 feet long. The header, about 12 inches in diameter, is formed by lapped bundles of willows bound together to the desired width of mattress, by ⅜-inch strand. The stitch is then started by inserting single willows into the bundle at an angle of about 45 degrees, from one end of the header to the other; then the willows are inserted at the same angle in the reverse direction, the last willow inserted being on top (Fig. 3). This makes the weaving a continuous over process, the stitch having an over and under appearance. The willows are placed in such numbers and closeness of weave as to make a mattress 12 inches thick. As the weaving progresses a selvage is made along each side of the mattress by turning in the tops of the outer willows, or an equally good selvage (known as the "sidewalk") is made by platting willows, longitudinally along the edges.

The mattress is strengthened by a longitudinal and cross system of ⅜-inch in diameter galvanized strand. The longitudinal system for an 86-foot mattress consists of 6 pairs of strands, spaced as required, each pair consisting of 1 strand underneath and 1 strand on top of the mattress. The cross systems are in pairs, one underneath and one on top, spaced 16⅔ feet apart. At each intersection of the two strands underneath and the two strands on top, all four are drawn together tightly with a 7/16-inch U-shaped clip, after all the slack has been taken out of the strands by block and tackle. The head of the continuous mattress, or any section of mattress, is anchored by three pairs of strands fastened to the respective longitudinal strands, one pair 4 feet, one pair 16 feet, and the remaining pair 46 feet back from the outer corner and run ashore at a 45° angle with the upper edge of the mattress and fastened to deadmen 50 feet back from the edge of the bank. The continuous mattress is anchored to the bank by each pair of cross strands carried up the slope and fastened to a deadman placed 8 feet back, and 4 feet below the top of slope.

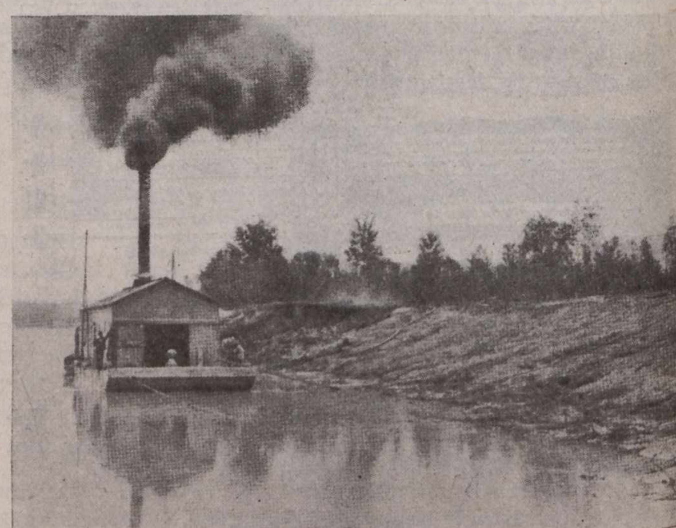

Fig. 2—Hydraulic Grading of Bank; Slope 1 on 3

It was planned to string the concrete blocks, forming the 10-foot width inshore mattress flexible protection, on six longitudinal ⅜-inch strands passed through the eye loops, but this method was found difficult and slow. A change was made for connection of the inside blocks by using short pieces of ⅜-inch strand passed through the eye loops and twisted into a clip. The changed plan required only four longitudinal strands; the two outside ones passed through the eye loops, the upper one serving to anchor the blocks to the paving, and the lower one to lock the system or hold the blocks *en masse*; the two inside strands laid along alternate joints are held in place by the twisted clips. The blocks are laid as close as possible, longitudinally, with no ties between. On account of the weight of the blocks, it was necessary to place them in advance of the paving and ballasting of the mattress and well up to the mattress barge and later anchored them to the paving.

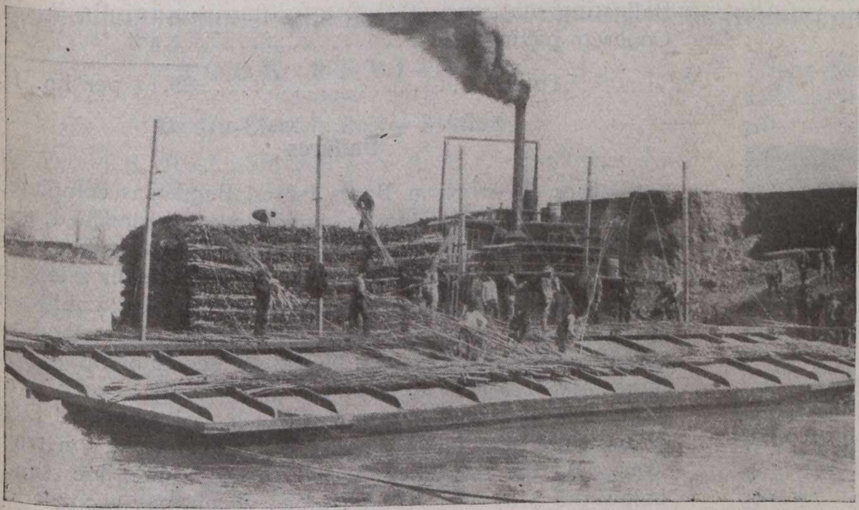

Fig. 3—Header for Willow Brush Mattress; Starting Stitch

In this way they also serve as the lower forming for the concrete slab. (Fig. 4.)

The mattress is then ballasted with one-man stone of sufficient quantity to cause it to be in good contact with and take the shape of the river bed, and to allow the mixing plant to come near the toe of slope.

Paving

After the bank is graded, and mattress woven and ballasted in place, the slope is prepared for the concrete paving. It is divided into panels 8 feet wide, from top of bank to water surface, by placing a forming of 1-in. x 4-in. plank on edge, held in place by small wooden pegs, the inside pegs being removed as the aggregate is placed; the panel is then divided into 8-foot sections by placing ordinary plastering laths across the panel, or longitudinally with the bank under the mattress and block anchor strands; this forming makes the joints of the slabs. At the foot of the paving additional short pieces of 3/8-inch strand are so placed as to provide the required number of fastenings for the 2-foot blocks. The reinforcing wire mesh is then laid in place by unrolling the bundle from top to bottom of slope and held in place by pegs (which are removed as the aggregate is placed), two widths to the panel, each overlapping about 3 inches along the middle line and cut off at the bottom to the required length.

The concrete mixer and delivery plant were installed on a barge, 30 ft. x 80 ft. x 4 ft. (mattress barge). The mixer was a standard make on skids; the delivery plant or cableway, consisted of a regulation 3-drum hoisting machine and stiff-leg braced mast, with top sheave for the hoisting cable carrying the mortar bucket. For convenience in moving and to procure the proper land height the carrying end of the cable was passed over a wooden horse about 8 feet high. The mast and mixer were so placed that the bucket could easily pass to and from the discharge spout.

After the bucket was filled it was raised to proper height and travelled ashore by gravity; a reverse operation returned the bucket to the mixer. A movable stop block on the cable, held by dogs, marked the place desired, and a trip on the running sheave of the bucket coming in contact with the block automatically deposited the aggregate of the slope. (Fig. 5.) The method of depositing the aggregate as described above was later changed to the use of governing cables connected to the bail of the bucket, with a trip, worked by hand, to tilt the bucket. After experimenting for cable anchorage the following was evolved and proved very satisfactory: The carrying cable, after passing over the horse, was connected with a sheave and shackle so as to run in the bight of a double cable, about 350 feet long, running parallel to the bank and anchored to deadmen at each end. Two of these cables were provided, and when placed, were laid with the ends overlapping about 50 feet, so that the arrangement carrying the sheave could be run from the end of one cable direct to the other without delaying the work. The cable behind would then be carried forward and placed ahead of the one in use and so on continuously. These cables were found to carry the strain without danger and were especially advantageous for allowing ready movement forward or backward from one slab to the next. The deposit of the aggregate on the slope began at the top, which always gave a downward movement of the material. No attempt was made to give a finished surface other than that produced by a 2-in. x 4-in. scantling in evening up the aggregate to the required thickness after the necessary spade spreading. Before the final set occurs the top of the longitudinal joint is made, by a roller cutter, through the concrete down to the top of the lath (the lath being left in place).

The slope is paved in alternate panels; that is, if the panels should be numbered 1, 2, 3, 4, 5, 6, 7, etc., panels

Fig. 4—Placing Concrete Blocks

1, 3, 5, 7, etc., would be completed and after sufficient set of the odd numbered panels the forms are removed and placed ahead for a new section, leaving the finished panels to become the forming of the unfinished even numbered panels. The mixing plant is then moved back and panels

2, 4, 6, etc., are completed, and so on until the completion of the work. (Fig. 5.)

About one-half of the work at Bates Island Bend was completed during the season of 1912, at which time it was not thought necessary to make provision for expansion joints, but during the hot weather of 1913, the necessity of expansion joints became evident when several of the

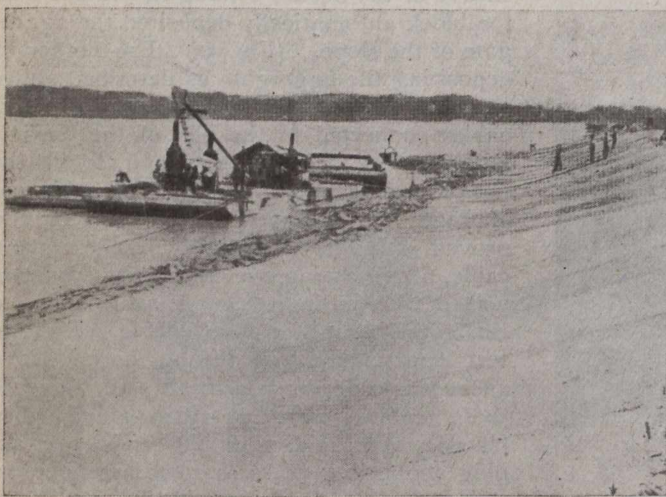

Fig. 5—Concrete Mixer and Delivery Plant; Also Completed Section of Paving

slabs buckled up at the joints. In all cases where the slabs had buckled, which occurred at about 1,000-foot intervals, the joints were cut to let the slabs resume their natural position; because of this defect the remainder of the revetment was provided with ½-inch expansion joints every 50 feet to allow the slabs to expand or contract lengthwise of the revetment.

Cost

As stated above no charge for plant depreciation has been entered into the cost of the revetment, but from the field cost as shown, a liberal percentage of cost of plant depreciation can be added and the total for this type will be under that of the standard type. The statement given below contains only field expenditures with the cost divided as follows:—

Grading bank	$0.55 per lin. ft.
Weaving mattress	1.98 " " "
Concrete blocks in place	1.16 " " "
Ballasting mattress	1.13 " " "
Concrete paving	2.76 " " "
Total	$7.58 per lin. ft.

As two other pieces of this type of revetment have since been completed under similar conditions, their costs are given here for general comparison, and, to a certain extent, permit the establishment of a proper basis for estimates.

Marthasville Bend: 11,960 feet at $8.05 per linear foot, completed November 25th, 1914.

The cost is divided as follows:—

Grading bank	$0.84 per lin. ft.
Weaving mattress	1.85 " " "
Concrete blocks in place	1.56 " " "
Ballasting mattress	.83 " " "
Concrete paving	2.97 " " "
Total	$8.05 per lin. ft.

Dewey Bend: 7,215 feet at $88.13 per linear foot, completed December 17th, 1915.

The cost is divided as follows:—

Grading bank	$0.67 per lin. ft.
Weaving mattress	2.31 " " "
Concrete blocks in place	1.45 " " "
Ballasting mattress	1.22 " " "
Concrete paving	2.48 " " "
Total	$8.13 per lin. ft.

Failures

Before the work at Bates Island Bend was completed one break occurred where the paving was undermined, and the slabs broken in a diagonal line, down stream from the water surface to about 15 feet up the slope, over a length of about 100 feet. The exact cause of the break could not be determined, for, as nearly as could be ascertained by soundings the mattress and blocks seemed to be intact and later investigations confirm this fact. The break was located in a strong eddy (produced by a submerged false point which was not known to exist at time of construction), and the nature of the soil in the bank, fine sand, below the eddy was very unstable, which may account for the bank sliding or being sucked out between the interstices of the mattress. This break was successfully repaired with a brush and stone fill to fair out the bight and break up the eddy.

The revetment withstood the high stage of 1914, only to be battered and damaged during the continued high stages of 1915. This failure was described in the Annual Report of the Chief of Engineers, 1916, as follows: "This revetment (Bates Island Bend) was badly damaged at intervals, for a distance of about 6,000 feet from the lower end; so far, a satisfactory reason for this damage has not been determined, as much of the paved bank with mattress and concrete blocks is intact at toe of slope, the breaks being mostly in the paving, 8 feet above the low-water line, where the slabs, with reinforcing strand and wire are broken in every conceivable manner and shape, the strand and wire being sheared off as though with a knife. At low water, about 1,000 feet of this revetment from the lower end, shows up with the bottom row of 8-foot paving slab intact, with a pocket of water 6 to 8 feet deep behind the line. The breaks in this revetment, except the 1,000 feet at lower end, were repaired with brush and stone fills to fair out the slope line, in all 2,956 linear feet."

Sufficient time has not elapsed to pass on the positive merits of the monolithic type, nor do the failures noted seem of such seriousness as to warrant its discontinuance, but from the many methods of slope paving and subaqueous bank protection still in the experimental stage, the problem seems to remain unsolved, and because of this, there will be no attempt made to forecast the values of any type of bank protection, as the number of unknown forces constantly in operation toward deterioration precludes any prediction of permanency.

Grant Hall, vice-president and general manager of the Canadian Pacific Railway's western lines, was waited upon at Regina recently by the Hon. Charles Dunning, provincial treasurer and director of food productions, Alberta; J. A. Maharg, M.P., president of the Saskatchewan Grain Growers' Association, and George Spence, M.L.A., for Notukeu, representing a provisional railroad organization in the southwestern part of the province with reference to the construction of branch lines in the south western parts of the province.

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BOOK REVIEWS

Hydro-Electric Power Stations

By David B. Rushmore and Eric A. Lof. Published by John Wiley & Sons., Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. First edition, 1917. 822 pages, 408 illustrations, 6 x 9 ins., cloth. Price, $6 net.

This treatise deals with the problems of design and operation of hydro-electric power stations. The chapters in their order are entitled: General Introduction, Hydrology, Classification of Development, Dams and Headworks, Water Conductors and Accessories; Storage Reservoirs, Power House Design, Hydraulic Equipment, Electrical Equipment, Economical Aspects, Organization and Operation, Three Appendices.

In such a book it is impossible to do more than direct the reader's attention to the essentials of proper and adequate design of power stations. The authors in this case have succeeded in indicating with clearness and conciseness, yet with sufficient detail, the primary requisites of modern, well-balanced design, and by means of references to current technical literature have shown where detailed information on special points may be found.

A glance over this book may lead the reader to infer that certain parts, particularly the hydraulic features, are treated in a cursory manner. This impression, however, is not sustained after a careful reading, as all the works appurtenant to any development are treated in sufficient detail to give correct methods. With the references mentioned above, the student should have no difficulty in advancing his knowledge of the subject.

The part of the book covering the electrical equipment describes modern practice and devotes considerable space to the application of current limiting reactors and to the rupturing capacities of oil switches.

Considerable space is devoted to a discussion of the economical aspects of developments, also to the operation and maintenance of plants.

The three appendices give a fairly complete list of references to articles in the engineering press describing large power developments in America, and a table gives the principal data on transmission systems operating at 70,000 volts and above.

This volume should prove valuable both to the student of hydro-electric engineering and to the operating engineer.

Estate Economics

By Andrew Slater, late land agent to the War Department in the Southern, Northern and Scottish Commands. Published by Constable & Co., Limited, London. 264 pages, 87 illustrations, 5½ x 8¾ ins., cloth. Price, $2.50 net. (Reviewed by H. L. Seymour, B.A.Sc., A.M.Can.Soc.C.E., Ottawa.)

As applied to towns and cities the term "town planning" is now well known if not always well understood. The equally important problem of rural planning is also beginning to receive some share of attention. In general, it may be stated that the number of Canadian engineers who are interested in the scientific laying-out and development of land is on the increase. To such engineers Mr. Slater's work may make an appeal, though it treats entirely of estate or farm development in Great Britain.

To any engineer a consideration of the subject matter of the various chapters must indicate how useful a wide engineering knowledge may prove in rural development. In what might appear to many an elementary way, the author treats of many subjects with which engineers are more or less familiar; of the geology of soils, their origin and drainage; of the protection of the banks of water courses; of road construction and maintenance; of water supply ad sewage; of motive power produced by natural and artificial means; of motor traction; of forestry; of farm buildings, fences, etc.

From the standpoint of greater production, which the author urges in his introduction, probably the most important chapter in the book is that entitled "The Utilization of Land." This chapter might seem to apply most particularly to those classes of British land owners, land agents and factors for whom the author hopes to provide a practical guide, but even here will be found several matters more or less of interest to engineers.

A Treatise on Concrete, Plain and Reinforced

By F. W. Taylor and S. E. Thompson. Published by John Wiley & Sons, Inc., New York; Canadian selling agents, Renouf Publishing Co., Montreal. Third edition, 1916. 885 pages, 262 figures, 6 x 9 ins., cloth. Price, $5 net. (Reviewed by E. Brydone-Jack, superintending engineer, Manitoba, Saskatchewan and Alberta, Department of Public Works, Canada.)

The third edition of this standard work has been brought up to date by its authors. Much new material on design and tests of reinforced concrete and on beam bridges has been added and the old edition has been largely rewritten and revised, to bring the subject up to date, while the most recent and accepted standard specifications for cement and reinforced concrete are given.

The main features dealt with in this edition may be classified as follows:—

Materials: Classification of cement, Chap. 4; chemistry of cement, Chap. 5; specifications and tests of cement, Chap. 6; tests of aggregates, Chap. 7; voids and other characteristics of concrete aggregates, Chap. 8; cement manufacture, Chap. 31; specifications for reinforced concrete, Chap. 3.

Proportioning of Materials and Strength: Strength and composition of cement mortars, Chap. 9; proportioning concrete, Chap. 10; tables of quantities of materials for concrete and mortar, Chap. 11; strength of plain concrete, Chap. 19.

Workmanship: Elementary outline of the process of concreting, Chap. 2; preparation of materials for concrete, Chap. 12; mixing concrete, Chap. 13; depositing concrete, Chap. 14; laying concrete in freezing weather, Chap. 16.

Destructive Agencies: Effect of sea water upon con-concrete and mortar, Chap. 15; destructive agencies, Chap. 17.

Theory, Design and Tests of Reinforced Concrete: Theory, Chap. 20; design, Chap. 22; tests, Chap. 21.

Construction: Foundations and piers, Chap. 24; dams and retaining walls, Chap. 27; conduits and tunnels, Chap. 28; reservoirs and tanks, Chap. 29; pavements and side-walks, Chap. 30; beam bridges, Chap. 25; arches, Chap. 26; buildings, Chap. 23; miscellaneous structures, Chap. 32.

A special chapter is devoted to the subject of water-tightness and the laws and tests of permeability.

Chap. 1 is devoted to a summary of the most essential elements in concrete construction. The essential elements are clearly stated and emphasized in heavy type and form an extremely valuable guide for the main principles required to ensure good workmanship and proper design.

The principal conclusions of the effect of sea water upon concrete and mortar, as reached by the author of Chap. 15, are given at the beginning of this chapter and form a valuable summary

The effect of alkalies and oils upon concrete receives only passing mention.

The importance of this subject in the West especially would warrant a much more extended treatment giving the latest developments and investigations, indicating the dangers where alkalies are present and the necessity of proper materials (including water), proportioning and workmanship for protection.

The subjects of theory and design are treated in two separate chapters, and there is considerable repetition that could have been avoided; for instance, some of the sections under "theory" being repeated verbatim in the chapter on "design."

Chap. 10 deals with the proportioning of aggregates and contains a summary in heavy type of the laws relating especially to the grading of aggregates, and also the application of mechanical analysis to proportioning.

This, together with Appendix 1, on the method of combining mechanical analysis curves, should be of great assistance in obtaining the best kind of concrete.

The salient features of many of the chapters are brought into prominence by the use of summaries and heavy type, while, where several different formulæ are given under different assumptions, the authors state the formulæ recommended by themselves.

The great value of the book lies in the fact that it is practical in its treatment and applications, as well as giving the theoretical principles involved.

The authors are to be commended on the whole for the clearness of presentation and arrangement of the work, as well as on the matter contained.

The book is indispensible for engineers dealing with concrete work and design.

Railroad Engineering

By William G. Raymond, Dean of the College of Applied Science, State University of Iowa. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Limited, London; Canadian selling agents, Renouf Publishing Co., Montreal. Third edition, revised, 1917. 453 pages, 5¾ x 8½ ins., 18 plates, 113 figures, cloth. Price, $4 net. (Reviewed by G. A. McCarthy, chief engineer, railway and bridge section, City Hall, Toronto.)

It seldom falls to the lot of a student to get within so few pages so many sound principles, so clearly set forth, on railroad inception, location, financing and valuation, as he finds in the introduction. The work consists of three parts.

Part I. In ten chapters, deals with rails and fastenings, ties, track, roadbed and structures, including signals which go to make up the permanent way.

Part II. In seven chapters, treats of the locomotive and its work, train resistance, grade and curve resistance, velocity grades, operating expense, and gives in a fair amount of detail, examples of problems met with by the railroad engineer when called upon to estimate the allowable expenditure to effect certain improvements in grade or alignment, or both. This chapter also contains twelve plates showing the different classes of locomotives, with particulars of size, weight, etc.

Part III. In six chapters, describes reconnaissance, preliminary, and location surveys, together with the estimate of cost of a railroad from such surveys. One chapter is devoted to construction surveys, methods of staking out work, overhaul, etc. One chapter of twenty-three pages is devoted to valuation. An appendix contains almost complete reprint from the Transactions, American Society of Civil Engineers, Vol. lii., of the paper by W. D. Taylor, M.Am.Soc.C.E., on "The Location of the Knoxville, La Follette and Jellico Railroad, of the Louisville and Nashville System." Most of the discussion of this paper is also included.

The author has treated of railroad engineering in a most practical manner, realizing that many of the problems are not subject to exact solution.

In dealing with matters which may be more or less controversial, the author, while expressing his preference, gives the student the opinions held by others. Many references are made to works of other well-known authors and to the Manual and Proceedings of the A.R.E.A.

The book is of convenient size, well arranged, clearly printed and practically free from errors.

One has only to go carefully through a volume of this nature to realize how great is the field covered by railroad engineering. The author has successfully covered this field in a general way, referring the reader to reliable sources of information, if greater detail is desired.

Every student of railroad engineering can make no mistake in adding this book to his library.

Gas Chemists' Handbook

Compiled by Technical Committee, sub-Committee on Chemical Tests, 1916; A. F. Kunberger, editor. Published by the American Gas Institute, New York City. 354 pages, 6 x 9 ins., illustrated, cloth. Price, $3.50. (Reviewed by J. Watson Bain, B.A.Sc., past-chairman, Society of Chemical Industry, (Canadian Section), Washington, D.C.)

As in so many other branches of chemical industry, the methods of control in the manufacture of gas have been wonderfully developed in recent years. The modern purchasing agent buys on specification and desires to know whether or not he is obtaining what he pays for, while the operating engineer judges the successful operation of the plant largely by the chemical analyses which are furnished to him. The older gas chemists contented themselves with determining the sulphur, ammonia and candle power of their product, and this volume of 354 pages, devoted to methods of analysis, shows very strikingly the progress which has been made. Until the appearance of this volume, there was no publication which dealt in a comprehensive manner with the various problems which fall to the lot of the gas chemist, and in many cases recourse had to be made to the technical journals, some of which are not readily available. The publication of this compilation is, therefore, a great service not only to the chemist at the gas works, but to all chemists who have to deal with the problems of the related industries.

The subjects discussed comprise: Coal and coke, gas oil, purification material, gas analysis, heating value, tar, ammonium sulphate, lime, cyanogen, impurities in gas, tar products and light oils, miscellaneous, Portland cement, steel, alloy steels, etc. There are some excellent tables and a good index. The newest developments in the gas industry, such as the recovery of cyanogen and the recovery of benzol and toluol, are well covered and the descriptions are clearly written.

It would be difficult to conceive of a gas chemist to-day who would not desire to have this book on his shelf for reference, if not for daily use.

PUBLICATIONS RECEIVED

Berger Transit Bulletins Nos. 2 and 4.—Published by C. L. Berger and Sons, Boston, Mass.

New Brunswick Power Company.—Annual report for 1917. H. M. Hooper, secretary, St. John, N.B.

The Resources of Tennessee.—Quarterly, January issue, published by the State Geological Survey, Nashville, Tenn.

Back Pressure Valve.—Pamphlet describing and illustrating the Cochrane Multiport valve, issued by Canadian Allis-Chalmers, Limited, Toronto.

Street Flushing.—Catalogue of Tiffin 2-motor-system flushing and sprinkling machines. Sent on request by the Tiffin Wagon Co., Tiffin, Ohio.

American Railway Engineering Association.—Bulletin, nineteenth annual convention. Published by the association at 910 Michigan Avenue, Chicago, Ill.

Mineral Production of Canada.—Preliminary report for 1917. Prepared by John McLeish, B.A. Published by Mines Branch, Department of Mines, Ottawa.

Belts.—A monthly, containing information for users of pulley belts. Published and distributed free by the Federal Engineering Co., Limited, 172 John Street, Toronto.

Industrial Storage Battery Locomotives.—Catalogue No. 231. Interested persons can obtain free copies by writing to The Jeffrey Manufacturing Company, Power Building, Montreal, P.Q.

Tests of Small Telescopes at the Laboratory of the Dominion Land Surveys.—By E. Deville, LL.D., Surveyor-General of Dominion Lands. Bulletin 41, Topographical Surveys Branch, Department of Interior, Canada.

Block Survey Reiterating Transit Theodolite.—Six-inch micrometer, 1912 pattern. Description, adjustments and methods of use. By W. H. Herbert, B.Sc. Bulletin 34, Topographical Surveys Branch, Department of the Interior, Ottawa.

Combustion of Coal and Design of Furnaces.—Report of experimental investigations to determine the most efficient designs and operation of furnaces. Bulletin 135, published by the Bureau of Mines, Department of Interior, Washington, D.C.

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Rare and Standard Books on Exact and Applied Science.—A catalogue of (including the scientific portion) the library of the late Rt. Hon. Sir James Stirling, F.R.S., etc. Issued by Henry Sotheran and Co., 140 Strand, W.C. 2, near Waterloo Bridge, London, Eng.

Sulphur—An Example of Industrial Independence.—Bulletin 102, Part 3, the Mineral Industries of the United States. By Joseph E. Pogue, of the Division of Mineral Technology, U.S. National Museum. Published by the Smithsonian Institute, U.S. National Museum, Washington, D.C.

Coal Products; An Object Lesson in Resource Administration.—Bulletin 102, Part I., the Mineral Industries of the United States. By Chester G. Gilbert, curator of Mineral Technology, United States National Museum. Published by the Smithsonian Institute, U.S. National Museum, Washington, D.C.

Percentage of Extraction of Bituminous Coal.—With special reference to Illinois conditions. By C. M. Young, Illinois Coal Mining Investigations Co-operative Agreement. Prepared under a co-operative agreement between the Engineering Experiment Station of the University of Illinois, the Illinois State Geological Survey and the United States Bureau of Mines. Issued by University of Illinois, Urbana, Ill.

The Canada & Newfoundland Development Company, North Sydney, N.S., are having plans prepared for six reinforced concrete scows. Architects, Booker & McKechnie, Davidson Bldg., Halifax.

E. D. Creer, engineer of the Vancouver and District Joint Sewerage and Drainage Board, is asking for the establishment of a permanent maintenance gang. The sewerage system of the municipalities is worth over $2,000,000, and consists of over 20 miles of trunk sewers. For financial matters, the sewerage board makes the allotments, and the municipalities acting as collecting agencies. The allotments are divided so that 30 per cent. of the amount is borne by the whole sewerage district affected, and 70 per cent. by the immediate district benefited.

Railways and canals votes in the estimates tabled in the Commons at Ottawa include, in addition to the I.C.R. and Hudson Bay Railway votes: $700,000 for the Quebec bridge, $1,860,000 for the Welland ship canal, $500,000 for the Trent Canal and $250,000 for the National Transcontinental Railway. Public works votes include an additional $1,500,000 to cover the cost of construction of the new Parliament buildings at Ottawa, and $1,000,000 for the new departmental building at Ottawa. Harbor and river votes under this head include $350,000 for improvements at Port Arthur and Fort William, $150,000 for improvements at Vancouver, and a similar expenditure of $166,000 on Victoria Harbor, B.C. The total vote for public buildings is $2,620,000, as compared with $2,125,000 for the current fiscal year. On the other hand, harbor and river votes will decrease from $5,931,000 to $1,836,000. Estimates for public works in the Province of Ontario total $607,800, of which revotes amount to $180,300. Every item is in connection with the completion of buildings already under construction. For harbors and rivers in Ontario the total vote is $252,315, the main items being: $77,000 further for Port Stanley harbor improvements; $40,000 for repairs to Langevin pier; $14,000 for repairs to piers at Port Burwell, and $7,400 for repairs to breakwaters at Port Colborne.

THE EFFECT OF COVERING A SERVICE RESERVOIR*

By John Gaub

It is hardly necessary to say that no one at the present time expects to hear of such highly developed animals as fish or eels in a municipal water supply, especially after it has been filtered, yet in many communities where filtration has been adopted the water is served to the consumer from an open reservoir, thus permitting all manner of dust, droppings from birds, insects, microscopic growths and many other influences tending toward deterioration, to cause much trouble and anxiety. Although it may be possible to account for these various troubles and it may be shown that the water has been filtered properly, yet the layman will be of the opinion that the supply is not cared for in the proper manner and hence the usual complaint, whereas if the reservoir had been covered or protected in some way, everything would have been satisfactory.

The open surfaces of water, whether in service reservoirs, clear-water tanks or basins or channels, lend themselves primarily to the introduction and development of

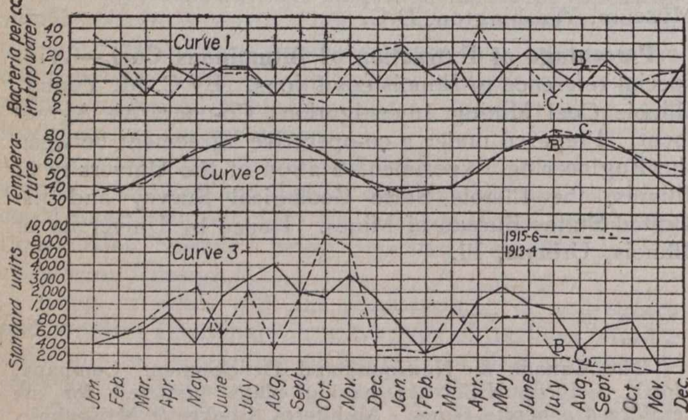

Fig. 1—Temperature and Bacteria Variations

algae and insects. The latter lay their eggs on the borders of the open bodies of water, in which when hatched the larvae spend one part of their existence as free-swimming animals before reaching a further stage in their development, thus permitting, sometimes, the consumer to obtain some of the larvae from the spigot in his home. Fortunately, many of these larvae and algae do not make the water-mains their permanent abode, and hence may be regarded as occasional passengers on an unknown journey. Especially is this so with algae, since they thrive best in the sunlight, and yet it should not be forgotten that such forms as Sponge and Crenothrix are met primarily in iron pipes.

As a result of the presence of algae in water basins, the water becomes subject to disagreeable tastes and odors resulting from the growth and decay of the organisms. Again, small organisms visible to the naked eye, such as Daphnia and Cyclops cause much worry on the part of the consumer when seen in the glass of water as drawn from the spigot. In most reservoirs the appearance of algae and the larger forms of life tend to act as scavengers, living on the organic matter, bacteria and other ingredients which the water might have picked up in its flow. Especially is this so in the case of surface waters. However, when these forms of life die the bacteria increase in numbers, and though they be only water forms and have no significance still they do not improve the water in any way; this is easily seen when curves 1 and 3 in Fig. 1 are compared, especially for the spring, summer and fall months. From these curves it will be seen that where there was an abrupt change in the algae growths (curve 3) the bacterial content was not affected, in some instances increasing; whereas when the algae were permitted to grow the bacteria were kept down.

Now, with water of this kind, especially after it has been filtered, two things are possible in order to protect it from deterioration, *viz.*, (a) the use of an algicide, (b) the building of a cover for the basin. Copper sulphate is recognized as an algicide everywhere, being used in many cities to prevent and stop the effects of vegetable and animal growths in the water supply. Undoubtedly if used in ample sufficiency and under proper conditions it will destroy everything that affects the aesthetic sense of man in a water supply. However, it has been found that the toxicity of copper salts is low in water containing calcium and magnesium carbonate, in which case the copper is precipitated as basic cupric carbonate, which in turn is slowly dissolved by the carbon dioxide in the water, hence necessitating a larger dose than would be the case with a softer water. Again, when copper sulphate is used at a time when the growths start and before the organisms have developed so as to form a mass, the water becomes full of dead and decaying bodies of the organisms, which due to stagnation cause an effect opposite to that which was intended; after which, in a short time, under favorable conditions, the growths begin again and the same operation must be repeated if some satisfaction is desired. In many cases the effect has been so marked that the reservoir was placed out of service until it was cleaned. In many cities treatment with copper sulphate is begun in the early spring thereby thinking that a good foot-hold will be established by which to check the growths, only to find that in a short time the growth is appearing.

Hence, when everything is considered, labor, material and incidentals, and the number of repetitions in applying the algicide together with the after results, it will be found that the total sum spent equals the interest on the money invested in a good cover for the body of water, especially if the water has been filtered. This, in brief, is what was done in Washington to one of the service reservoirs, thereby eliminating a very troublesome growth of algae, most of which were diatomaceae.

Briefly, the cover was designed as a flat slab concrete floor to carry a live load of 75 pounds per square foot. The reservoir is in two compartments, and one of these was covered while the other was in service, thus causing no delay in the use of the water in that section of the city. The slab is 6 inches thick and is supported on 133 columns 16 inches square. The slab is made of a mix consisting of 1 part (Portland) cement, 2 parts sand and 4 parts gravel, and covers 44,600 square feet. The cost was about 37 cents per square foot.

In studying the effect of an improvement such as this, several facts make themselves known which in a way influence the quality of the water, thereby proving that it was a success. These are: (1) the location of the reservoir, which controls to a degree the physical influences; (2) the effect of such a change on the bacteriological and chemical content of the water; and (3) the all important one, the discontinuance of former microscopic growths.

The temperature of the water, as will be seen from curve 2, Fig. 1, was constant, not having changed in the last four years, and ranging from a minimum of 35° F.

*Journal of the American Water Works Association.

to a maximum of 80° F., thus giving the various organisms their respective optimum temperatures for growth. However, when the cover was applied, as shown between the points B and C on the curve (Fig. 1) the temperature did not fall so readily as when the reservoir was open, thus permitting the bacteria to thrive but to no alarming extent, as is seen from curve 1. Again, the effect of the cover is seen in Table 1, in that the total nitrogen was not as high as it was formerly, due to the lack of organic matter which entered by way of the wind. This is also seen in the amount of amorphous matter which was usually present in the open reservoirs; in this case it followed curve 3, and hence is omitted.

The effect on the chemical constituents will be seen from Table 1, in which it will be noted that the total nitrogen, nitrites and nitrates decreased due to the lack of added organic matter, which in former times was carried in by the wind and birds; again this decrease was due to the decreased number of dying algae, etc. Again, the alkalinity appears to vary in times previous to covering, due no doubt to the varying amount of carbonates and bicarbonates, in which case the carbon dioxide was used by the organic growths; on the other hand, after the cover was added, the alkalinity appears to remain constant. If water plants enter a body of water which is open to the air, as this one was, the mineralized nitrogen and carbon dioxide are used as food, thus causing the plants to excrete substances which to higher life are poisonous. The oxygen consumed, in this case was reduced between 0.2 and 0.3 cubic centimeters per liter, pointing to the fact that something that was at work had now stopped. Hence it is evident that if factors like those above mentioned are controlled the water will not and should not deteriorate.

TABLE 1

Effect of the cover on the chemical constituents, in parts per million

Month	Total Nitrogen				Nitrites				Nitrates				Alkalinity			
	1913	1914	1915	1916	1913	1914	1915	1916	1913	1914	1915	1916	1913	1914	1915	1916
August	0.109	0.040	0.109	0.105	0.004	0.007	0.004	0.003	0.20	0.10	0.20	0.22	76.5	74.0	55.8	64.0
September	0.051	0.19	0.024	0.024	0.002	0.005	0.004	0	0.15	0.25	0.38	0.10	87.2	62.0	67.8	76.0
October	0.054	0.021	0.021	0.020	0.001	0.005	0.004	0.002	0.20	0.24	0.37	0.15	87.2	60.0	71.5	79.6
November	0.031	0.018	0.037	0.017	0.005	0.003	0.003	0.004	0.80	0	0.36	0.10	65.4	71.5	81.2	76.1
December	0.032	0.060	0.032	0.019	0.003	0.002	0.002	0	1.10	0.30	0.30	0	55.4	71.3	64.0	79.6

In curve 3 it will be seen that the microscopic growths have been somewhat excessive, and in those places where a sudden drop is seen either cleaning or copper sulphating or both had been practised, showing an immediate effect but not the permanent one desired. However, when we come to the points B and C an immediate drop is seen, which in comparison with that for former years at the same times appears to be permanent, so that in the future very little microscopic growth may be expected in this reservoir.

Conclusion

Hence for the following reasons every reservoir used for service should be covered.

(1) From an aesthetic sense, in that all matters which have been removed by filtration are kept out.

(2) By keeping out all manner of debris the chemical composition is not changed much, in fact not so much as it would be without the cover.

(3) The temperature will not vary as much, during all seasons of the year, as without the cover.

(4) The expense of treating and cleaning the reservoir, thereby sometimes causing much inconvenience to the consumer, is avoided.

(5) A flat taste may result from the use of the cover, this, however, can be eliminated by constructing the reservoir so that a constant circulation is maintained.

(6) By constructing the cover flat an eye-sore is eliminated in the vicinity, since the cover can be used as a base for a bed of flowers or a garden, thus improving the appearance of things around the reservoir.

TORONTO SECTION, AM. INST. OF E. E.

Nearly fifty per cent. of the members of the Toronto Section of the American Institute of Electrical Engineers attended the meeting held March 15th, when J. J. Frank, of the General Electric Co. of Pittsfield, read a paper on "Modern Transformers." Twenty per cent. of those present took part in the discussion.

The next meeting of the Toronto Section is to be held at the Hydro-Electric Laboratories on Strachan Avenue, Friday, April 5th, when W. P. Dobson is to read a paper on "High Voltage Testing."

CANADIAN RAIL ORDERS IN UNITED STATES

New York dispatches state that the Canadian government railways are in the United States market for 5,000 box cars after placing an order for passenger equipment with the Pullman Company, and ten narrow-gauge engines with the Canadian Locomotive Company.

The Grand Trunk has recently ordered 25 switching engines from the same builders. The Pennsylvania Tank Car Company has taken orders for tank cars from steel companies and from oil refiners. Oil companies continue actively in the market for railroad equipment. Ten companies ask for 600 tank cars, which will require about 9,000 tons of steel.

In the statistical review of the Mineral Industry of Ontario for 1916, the Deputy Minister of Mines notes that the tendency in the mineral industry of Ontario, particularly in the metals, is towards the production of the finished article, as contrasted with the mere mining and selling of the raw ore or material. Molybdenite and lead have not been mined extensively in Ontario so far. The making of war munitions, however, has for the time being, stimulated the demand for both metals. Concentration plants for molybdenite have been followed by the installation of plants at Orillia and Belleville for the manufacture of ferro-molybdenum. Formerly, the English supply of this alloy came entirely from Germany. Another ferro compound, ferro-silicon, is being made on an extensive scale by Electro Metals, Limited, at Welland. A smelter for the production of pig lead has been installed at Galetta on the Ottawa River, to treat the ore raised from the lead mine at that place. About 400 tons of lead were made in 1916. When the plans of the British-America Nickel Corporation are fully carried into effect, there will be two nickel refineries in operation of capacity equal to the demand for the metal from the entire British Empire. A company has also been formed for the manufacture of nickel-copper steel direct from the Sudbury ore, recent investigations and experiments having shown that the prejudice against the presence of a moderate proportion of copper in steel is not justified by the facts. The next logical step in the development of the nickel industry will be the establishment of plants for the making of nickel steel, either from imported or domestic iron ore if the latter can be had in sufficient quantity. Not much has yet been actually accomplished in the treatment of copper ores. The increased demand for fluorspar has come largely from steelmakers. It is used chiefly as a flux, but also in the manufacture of hydro-fluoric acid, and in certain metallurgical operations. A newer use is in the recovery of potash from feldspar and from Portland cement clinker. The last previously reported production of fluorspar was in 1911, when $200 worth was marketed. In 1916 the shipments amounted to 1,283 tons, valued at $10,146, the price averaging nearly $8 per ton.

POSSIBILITIES OF THE RELIEF OF FUEL CONSUMPTION IN CANADIAN INDUSTRY BY THE INCREASED USE OF HYDRO-ELECTRIC ENERGY*

By J. M. Robertson, M.Can.Soc.C.E.

THE growing necessity for some comprehensive plan looking towards the more complete and efficient utilization of our resources has been apparent for many years to those whose duties make them familiar with the tremendous wastage of materials which results from the lack of co-ordination in the use of the various raw materials with which our country is so richly endowed. The public, generally speaking, has little real idea as to what constitutes the real essential of conservation of natural resources. Simple reduction in demand; the restriction of the use of such materials, thereby restricting the output of essential industries is obviously not true conservation. The goal to be aimed at is development, present and future, and in order to secure this end we must make use of such materials as are necessary for the maintenance of our trade and commerce and the growth and development of our national life. Economic utilization of such resources, considering both present and future, would limit the use of irreplacable materials even though they might be more cheaply and readily obtained under given conditions, and promote the use of other materials whose use conserves to a greater extent the assets of the community. The elements of cheapness and availability of raw materials are large factors in determining the success or failure of any industrial enterprise and as such must be given due weight. We have been, however, and we are still, too much inclined to accept these factors as excuses for taking the material nearest at hand which is suitable for our purpose and letting the future take care of itself. A little thought and investigation devoted to the development of possible substitutes will frequently disclose methods by which an industry may utilize materials or processes the use of which does not deplete the resources of the country. The ideal conservation would provide for the maintenance of the industries of the world by the use of basic materials supplied from natural growth so that the stock of raw material which constitutes the capital of the world would not be reduced but would be handed down unimpaired from generation to generation. Such an ideal conservation is obviously beyond reach in our present stage of development but, although we are still using up our capital at an alarming rate, the increasing realization of the need of care and the increasing efficiency of utilization which science is placing in our hands makes the future look more hopeful than might be considered warranted by a consideration of the special and temporary restrictive measures which have been applied to industry as a whole during the past few months. From these experiences it is apparent that the most essential elements in our industrial life at present are transportation and fuel, and to a large extent transportation means fuel since the equipment required for transportation can neither be produced nor operated in the absence of an adequate supply of fuel. It therefore follows that any modification of our past practice which will maintain our industries and at the same time reduce the consumption of fuels will be an application of true conservation principles in more than one way as, first, it will reduce the consumption of a material which once used cannot be replaced, and secondly, it will reduce the demand for transportation for such material as will thereby leave for the use of some other industry a larger supply of raw material for which for its purposes there is no substitute.

The use of raw coal as a basis for the generation of power through the medium of steam is fundamentally uneconomic, as too large an amount of valuable by-product is sacrificed for very little return and the efficiency of the conversion is much too low. When it is considered that under average conditions the amount of coal required to generate a horse-power hour is of the order of five or six pounds, representing an efficiency from coal to power of only 3 or 4 per cent., which, generally speaking, must be again divided by two before the energy is applied to the work, it can be readily realized that our present methods of operation leave much room for improvement. In defence of the steam plant it may be claimed that such figures represent only the practice of the smaller plants and that in the large manufacturing centres power is supplied from steam plants which operate much more efficiently. It is a very good plant which can average a kilowatt hour on 1½ lbs. of coal, including all auxiliaries, so that even under the best conditions we get an efficiency of only about 15 per cent. It is, of course, necessary to remember that such low efficiencies are not due to imperfections in the equipment but rather to the limitations imposed by thermal laws and until a method of conversion radically different from the present has been discovered, such losses cannot be eliminated.

These figures, unsatisfactory as they are, tell only half of the story. In using raw coal we are throwing away in a wasteful manner material which contains many valuable by-products which add but slightly to its value as a fuel but which when extracted have a value greater than the value of the coal itself. Many of these materials are essential elements in our industrial life for which at present there are no substitutes.

Notwithstanding this very unsatisfactory showing, the necessities of the case require that coal should be used for fuel in the absence of better means of providing readily available energy. It would seem, however, more or less elementary that the use of coal for such purposes should be restricted to cases where no substitute is available in order that when science places in our hands improved means of converting fuel into power, we shall not be in the unfortunate position of having squandered our patrimony and left ourselves without the means to take advantage of the improved processes when available.

Climatic conditions in this country, owing to the northern location, impose upon us a heavy burden every winter. Heat must be maintained in our houses and shops. At this stage of progress the only generally available means of heating is by fuel—coal, oil or gas—of which the former is by far the most important. We cannot avoid the use of coal for heating our factories, but we can see to it that as soon as practicable raw coal is not used for this purpose, and that what fuel is used is for heating purposes only wherever adequate substitutes for coal-generated power are available. Too many of our industrial establishments are operated entirely by coal simply because the controlling head likes the idea of "independence" and declines to consider the purchase of public service supply because he would then be "dependent on the power company." In places where hydro-electric service is available the power required by such establishments should be purchased and generally is purchasable at rates and under conditions more favorable than the costs of operation by coal and with much less investment

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*Paper read before the First General Professional Meeting of the Canadian Society of Civil Engineers, Toronto, March 27, 1918.

for plant. In the cases of factories located where such service only is obtainable, sufficient engine plant should be installed to make possible the abstraction of the maximum amount of energy from the steam before it is used for heating, the idea being to operate steam plant only to the extent of the heat requirements utilizing the steam equipment as the reducing valve and increasing or decreasing the purchased power to such extent as may be required to offset the variation in the by-product power recovered from steam required for heating or process work.

As the average manufacturing establishment in most parts of Canada require more steam for heat than for power during the winter months and almost no steam during the summer months, and as the demand for electric energy for lighting purposes is much greater during the winter, such an arrangement works to the advantage of both company and consumer, as the combination makes possible the almost ideal utilization of the energy in the fuel during the winter and the capacity on the power system thus released becomes available to take care of the increased load which must be carried electrically. The diversity thus introduced into the power demand makes possible the fixing of a power rate which is attractive to the consumer and at the same time remunerative to the power company.

In some plants, considerable ingenuity is displayed in so combining equipment for utilizing steam, electricity and compressed air or refrigeration with outside service so that no fuel whatever is burned, except for supplying heat, and every possible unit of energy is abstracted from the steam before it is utilized as heat. Variation in the demand for air and electricity is compensated for by use of machinery driven by two sources of power involving very interesting cross-conversion of energy.

The experience of those who have plants operating under these conditions is quite satisfactory as they have secured the convenience of freedom from unnecessary heat and dirt during the summer, the advantage of a standby plant as protection against shut-down—extremely low cost of power during the winter and a satisfactory power service available at all times when required.

The fact that such economies are usually realized in plants of considerable size is due principally to the fact that the large plants are directed by executives of broad views who realize that elimination of waste is desirable even though in a given case it may not result in a net saving of money.

Instances have arisen this year in which factories which operate by steam power in winter and purchase hydro-electric power during the summer months have anticipated the date for the commencement of this purchased service with the consent of the power company, and are reducing their coal consumption as weather permits to the minimum absolutely necessary for heat and are paying to the power company for service to make up the deficiency in power recovery the net amount they would have paid for additional coal. The power company, having power available, is satisfied to accept this amount for temporary service from month to month without further obligation on the part of either party. Such co-operation shows evidence of broadmindedness on the part of all concerned and leads us to hope that further progress in co-operation would develop many other instances in which very real savings could be made to the advantage of the country as a whole.

An indication of the extent to which an enlightened policy under favorable conditions can carry the substitution of hydro-electric service for steam in an industrial community is given by a comparison of the figures representing the consumption of electrical energy in the more important industrial centres in America. For the year 1916, the figures in kilowatt hours per head of population were as follow: New York, 225; Philadelphia, 250; Boston, 350; Cleveland, 400; Minneapolis, 450; Pittsburg, 500; Buffalo, 585; Toronto, 700; Montreal, 783. The figures for 1917 are not yet available but it is probable that the figures for both Toronto and Montreal would show an increase of about 10 per cent. Montreal would thus be about 800 while the whole province of Quebec was about 700.

The total power utilized in the Montreal district is about 200,000 h.p., of which about 165,000 is supplied from hydro-electric sources and the balance by steam. If the city pumping plant and the plant of the Tramways Co. are excluded the total steam capacity now in regular operation in this territory would be about 10,000 to 12,000 h.p. or about 5 or 6 per cent. of the total power utilized. Even this small part of the demand would be reduced materially were it not for the fact that most of these plants are of a kind which produce large quantities of combustible waste which must be disposed of by burning or are plants in which there is relatively large demand for high temperature steam for process work and a relatively small demand for power.

When it is considered that the amount of coal required to replace the electrical energy supplied by these hydro-electric plants would be of the order of 1,750,000 tons per year it is clear that while there still remains much to do, a very considerable amount has been done.

It should be borne in mind that this is no isolated instance. What has been done here is being done to a greater or less extent in many other centres, as is clear from the large and increasing load carried by the hydro-electric system in Ontario. Toronto's use of current is almost equal to that of Montreal and both of them are quite remarkable for very complete utilization of purchased power. Co-operation between the consumer and the company with fair rates and conditions for service rendered and a reasonable willingness on the part of the consumer to adapt himself and his plant to new conditions, even when such adaptation may perhaps entail the sacrifice of a little of his apparent independence, will assist our power companies in improving the already high character of the services they are now rendering by reducing to a minimum the utilization of irreplacable materials and extending and broadening the use of power supplied from inexhaustible natural sources.

The development and utilization of our water power reserves is a measure of our economic advance in the scale of civilization, and the formulating of a broad and liberal policy which will ensure the keeping of such development in advance of the requirements of our industries is something which should engage the attention of our government and our industrial leaders.

It is surely not too much to hope that in a country so richly endowed with natural power sites, distributed almost ideally from an economic standpoint the time will come when practically all of the power required for our industrial life will be supplied from such sources, and we will be free from the reproach that because it is easy and obvious we cheerfully squander our patrimony while we neglect to develop the natural heritage with which a wise Providence has blessed us.

A Seattle syndicate, believed to represent the Pacific Coast Steel Corporation, has bought a manganese mine near Kaslo, B.C., for $160,000. Concentrators are being installed.

READJUSTMENT OF INDUSTRY

How to maintain efficient production with competitive co-operation was the second problem discussed by Colonel David Carnegie, M.I.C.E., F.R.S., Edin., at the recent annual meeting of the Canadian Mining Institute, Montreal. Colonel Carnegie, who is a member and ordnance advisor of the Imperial Munitions Board, Ottawa, had first considered as to how to secure remunerative trade without unrestricted competition.

The problem of the maintenance of efficient production with competitive co-operation affected two classes of labor, said Colonel Carnegie, the employer and the employed. "The intelligent employee to-day not infrequently becomes the prosperous employer to-morrow." He continued. "Such boards of control as we are now considering (outlined in these columns last week), would encourage this tendency.

"While in considering the first problem the curse of unrestricted competition is revealed and condemned, I wish to emphasize just as strongly the true value of maintaining efficient production with competitive co-operation, and, further, that regulated competition in production is a healthy inspiring incentive, producing the best results without having any of the evils attending that unfair competition which secures trade. Competitive co-operation is indeed the life of industry when applied to efficient production. It inspires the best service in the individual worker while producing contentment.

"This condition is not overdrawn, and I am sure that much unrest exists regarding the future relations of capital and labor. Since the war began commissions have been appointed to investigate the far-reaching problems of industry, and recommendations have been made concerning the relationship between capital and labor, the development of industrial research, the employment of the best kind of machinery, the best methods of manufacture, buying and selling products, transportation, facilities, domestic and foreign commercial relationship, together with a host of other subjects of vital importance to the industrial prosperity of the Empire.

"For years past there have been constant conflicts between capital and labor on one or other of the issues I have named. Prior to the war in the United Kingdom strikes were so common and so virulent that they threatened to menace the public safety.

"In March, 1917, the Whitley report of the Joint Standing Industrial Councils was presented to the British parliament. In that report recommendations were made for improving the relations between masters and men and for establishing joint standing industrial councils composed of employers and employees, to obtain harmony and better means of production. Ever since the war began committees and commissions have been at work to solve the problems. It is hoped that the work of these bodies will be of service to the reconstruction committee of the cabinet of the Dominion government.

"These investigations instituted by government indicate the need of changed conditions. It is unnecessary for me to go into details regarding the causes of mutual distrust and suspicion between employers and employed. I would rather, if time permitted, exalt the spirit which is changing daily, the relations of employer and employed, and making possible a speedier union of their efforts in the general harmony of their interests. I believe the way to secure that harmony is by recognizing organized labor and letting them share in a larger manner the responsibility of the output, quality and profits of industry. The following proposals for the formation of production boards are suggested with the hope that they may meet the need.

"1. That production boards be formed for each industry in the same number as the district trade boards, and be incorporated by law to deal with specific duties defined in the articles of association.

"2. The boards to be independent in their control and operation of all matters under their jurisdiction, but to work in direct and harmonious association with the industry trade boards.

"3. Each board to consist of elected representatives of the employers and employees of each industry from the same number of manufacturers and within the same geographical boundaries, as determined by the scope of the industry trade board.

"4. Equal numbers of employers or their representatives, and employees or their representatives, to be elected by the district employers' association, and employees of the industry, whether the masters or men belong or do not belong to employers' associations or trade unions. The idea being to have full representation of each side belonging to the industry of the district in question. The method of election is a detail of organization.

"5. The chairman and vice-chairman to be nominated by the board as a whole. The chairman to be nominated from the elected representatives of the employers and the vice-chairman to be nominated from the elected representatives of the employees. Approval and election of both to be sanctioned by government and for the period of their election their services to be secured by the government.

"1. The acceleration of output by the introduction of the most important processes and plant used in any part of the world in the same industry. The consideration of this phase of the board's work to be placed in the hands of a committee who would investigate all modern improvements, review current scientific journals and reports of investigations relating to the industry. The committee to report periodically to the board, making recommendations for improved production. The board would consider and submit such recommendations to manufacturers associated with the board, and leave it to them to make such improvements as they consider desirable. The board would not accept responsibility for the results.

"2. To consider the provision of suitable industrial, technical and commercial training for boys, girls, men and women, with the object of improving the output and the quality of the product. A small committee of the board to investigate this subject, always with a view to training for the specific industry represented by the trade board. This section of the board's work would cover a very wide but necessary field of operation. It would embody:—

"(a) The vocational training of the child in preparation of his or her entry into the industry; (b) the education of the actual producers (principally manual); (c) the education of the directors of production (both manual and technical); (d) the education of the distributors of production (principally financial and commercial).

"3. To consider the classification, certification and valuation of labor. Another committee of the board could be formed for this definite object, having in view:—

"(a) The classifying of apprenticeship or in drafting boy and girl labor from vocational schools into those sections of industry best suited for their health, aptitude and age.

"(b) The certification of apprenticeship after probationary period in works, or office, to satisfy all concerned that the right employment has been selected for the child.

"(c) The classification of boys and girls after completion of apprenticeship for further training as draughtsmen, foremen, managers, salesmen, accountants, etc., according to the quality of the talent they had developed during their apprenticeship.

"(d) The classification of craftsmen of the same vocation, such as moulders, pattern makers, machinists, gauge makers, etc., into different skilled classes—say, 1st, 2nd and 3rd class moulders. The classification would distinguish between the good and very skilled moulders. Such classification is common in the civil, military, naval and professional services, where each receives a diploma, certificate or badge, indicating his ability, class or rank in the services. Labor unions classified their trades but not the ability of one individual as compared with another, although there are widely marked differences between the skill of moulders for instance. This neglect of classification has been one of the greatest causes of friction between the employer and the employed. The complaint has been that the skilled worker has not done more work than the indifferent worker. To initiate this work by one of the committees of the board with proper means for the certification of all labor by examination (manual or oral), by craftsmen in the art, would be a great service. The board to issue certificates indicating to what trade and class they belong, just as 1st, 2nd and 3rd class certificates are issued to the marine and land stationary engineers, sailors, miners and to others in different vocations. Arrangements to be made for the periodic renewal and O.K.'s of certificates. Such certificates to carry the board's district rate of pay. Should the holder of the certificate wish to leave the district over which the board presides, the certificate to be presented to the board to be O.K'd, so that on presentation to a new employer in a different district his value would be known at once.

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Principal Contents of this Issue

RAILROAD RATES

THE increase of 15 per cent. in railway rates authorized by the Railway Comission has been approved by the Governor-in-Council, and became operative from March 15th until one year after the end of the war. There was no other decision, consistent with the facts, open to the government. While the cost of all factors of railroad operation has rapidly increased, the companies were not allowed to charge any more for the commodity, transportation, they sell. The result has been clearly reflected in earnings in which the government is now vitally interested.

The Canadian Pacific Railway with the other roads, will charge the increased rates but it has to contribute to the public revenue one-half of its net earnings from railway operation in excess of 7 per cent. on its common stock. This is the present rate of dividend paid from this source. Upon the revenue derived other than from railway operations, such as lands, steamships, hotels, and telegraphs, the company must pay income tax, which under the legislation of last session of Parliament amounts to 25 per cent. on incomes over $100,000. The wording of the provisions of the order-in-council apparently means that the payment to be made by the company to the public revenue shall be up to $7,000,000 annually, and a larger sum if the increase in net earnings from the 15 per cent. higher transportation rates exceeds net earnings in 1917 by more than $7,000,000. Thus, whatever additional revenue the Canadian Pacific Railway derives from the new tariff of rates will accrue to the government. The special taxes imposed are obviously aimed at this company, which is tantamount to an admission that in the case of the other railways, such as the Canadian Northern, the Grand Trunk and the Grand Trunk Pacific, the higher rates will not produce net earnings in excess of charges on capital. The Canadian Pacific is actually to be penalized for its prosperity, built chiefly on efficiency and good management. A Montreal dispatch quotes a high official of the company to the effect that the corporation does not regard the new law as confiscatory. The dispatch concluded: "The Canadian Pacific Railway is not complaining." That has always been the spirit of this well-managed Canadian enterprise which has helped in innumerable ways and continues to do so to perfect the war organization of Canada and the British Empire.

Our railroad problem is not yet solved but the exigencies of war have brought a temporary measure. The outstanding features are the willing diversion of a large part of the company's profits to the conduct of the war, the maintenance of the company's and Canadian credit generally by the allowance of 10 per cent. dividends to the shareholders, and the recognition of the inadvisability of the nationalization of the Canadian Pacific Railway.

TRADE AND INDUSTRY AFTER THE WAR

DISCUSSING in a clear and able paper last summer, the industrial situation and outlook, G. Frank Beer, of Toronto, pointed out that Canadian factories were for the most part like young robins with open mouths into which the Munitions Board dropped orders averaging $1,000,000 a day. How can we prepare for the time when these activities cease? That question remains unanswered. There may be unforeseen factors, favorable and adverse, which will affect the situation after the war, but no good reason exists for postponing intelligent preparation for these post-bellum problems. Mr. Beer recalled that an organization of each separate American industry for export trade is the object of a trade commission now sitting permanently at Washington. "The form which such an organization should take," he said, "to meet Canadian requirements can not be decided upon without a most careful and thorough enquiry, and such an enquiry should be engaged in at once by the federal labor department, the department of trade and commerce, or other government authority in co-operation with a carefully selected committee of industrial leaders and labor representatives." He also referred to the important functions which a competent board of industry might exercise in connection with national production, adding: "Service of equal value should be provided for in connection with the problems of marketing. An effort has been made to show that only by the consideration of production and marketing, as constituting one problem, can the problems of each be adequately dealt with. The experience of the past two years has demonstrated the desirability, and indeed the necessity, of enlisting the services of successful and practical business men to control and administer work of this nature. A nucleus for the board of industry proposed lies within the personnel of the present Imperial Munitions Board. To a board of this character might with safety be assigned the task of co-ordinating and strengthening the work of all government departments now having to do with export trade."

Col. Carnegie, a member and ordnance advisor of the Imperial Munitions Board, apparently having read Mr. Beer's exposition of the subject, has now advanced a detailed scheme to solve two problems, namely, how to secure remunerative trade without unrestricted competition and how to maintain efficient production with competitive cooperation. An abstract of his address appears on another page of this issue. His plan to combine the activities of our manufacturers would undoubtedly be opposed both by our industrial captains and by the public. It would probably discourage initiative and investment of capital, and what is most dangerous, it would tend to create large monopolies. Col. Carnegie's ideas with regard to organization for export trade are far more practical and should receive the consideration of the government and manufacturers. His plan, as a whole, however, looks impracticable, even in these days when we are bound to recognize the necessity of drastic changes in our conduct of affairs. That fact, however, does not remove the necessity for consideration of these important problems, and Col. Carnegie is to be commended for his investigation of them.

PERSONALS

M. V. Sauer, chief engineer of design of the Greater Winnipeg Water District, has resigned to accept a position with the Ontario Hydro-Electric Power Commission. He will leave the district's employ April 30th.

Frederick Field, engineer superintendent of the Montreal, P.Q., fiiltration plant, is asking for indefinite leave of absence to take a position under the chief engineer of the Housing Department of the U.S. Shipping Board in Washington.

J. H. Lamb, ex-president of the Alberta Association of Local Improvement Districts and Rural Municipalities, and a member of the Municipal Hail Board, has been appointed municipal commissioner for Alberta, a new office on the staff of the Department of Municipal Affairs.

Lieut.-Col. William G. MacKendrick, D.S.O., Toronto, who has recently returned from the Front, received his decoration for his work as director of roads with the Fifth British Army. In civilian life, he was president of the Warren Bituminous Paving Company of Ontario. Debarred by his age from the combatant branches of the service, he went overseas and offered his services to the British War Office. He was there able to convince the authorities that his knowledge of road-building would be of practical use to the Allies and was given a captaincy in the Royal Engineers. There his ability in rapidly constructing roads fit for the heaviest traffic, quickly brought him into prominence and he was promoted first to the rank of major and then as lieutenant-colonel, made director of roads for the Fifth British Army. In appreciation of the services which he rendered at the Front and which involved the saving of hundreds of thousands of dollars in road construction, the Imperial Government conferred the Distinguished Service Order upon him. His son, Lieut. Gordon King MacKendrick, has found a soldier's grave in France.

OBITUARIES

Hugh O'Donnell, P.L.S., C.E., who has been engaged in engineering work in Quebec city for nearly fifty years, died suddenly at his home there on March 13th. One son, John O'Donnell, C.E., is in the employ of the Imperial Munitions Board, Montreal.

Members of the county roads committee of Peel, Dufferin, Wellington and Grey, which met in Toronto on March 19th, were given official assurance that the Toronto-Sydenham road would be taken over as part of the county provincial roads system.

SIR COLLINGWOOD SCHREIBER

One of the greatest figures in Canadian engineering circles passed away on Saturday morning, March 23rd, shortly before nine o'clock, in the person of Sir Collingwood Schreiber. The death took place at his home, "Elmsleigh," Argyle Avenue, Ottawa, where he had been ailing for some months. The deceased was the son of Rev. Thos. and Mrs. Sarah Schreiber, of Bradwell Lodge, Essex, England, where he was born on December 14th, 1831, and was educated in England. He was twice married. His first wife, Caroline, daughter of the late Lieut.-Col. A. H. MacLean, of Her Majesty's 41st Regiment, died in 1892, and his second wife was Julia Maude, daughter of Hon. Justice Gwynne, of the Supreme Court, Canada, whom he married in 1898.

For sixty years the late Sir Collingwood has been actively associated in the construction and development of both public and privately owned railways in Canada. He had a tremendous share in planning transportation systems, both east and west, and in the latter part of his career, as deputy minister of railways and canals, he helped to wisely administer lines directly under the government and subsequently superintended the construction of the Grand Trunk Pacific.

He came to Canada in the year 1852 and secured a position on the engineering staff of the Toronto and Hamilton Railway. He stayed with this road until 1856. By that time he had become known as an efficient and capable engineer. He was taken into partnership in the engineering firm of Fleming, Ridout and Schreiber, of Toronto, thus becoming associated with Sir Sandford Fleming. From 1860 to 1863 he superintended the construction of the Northern Railway, now a part of the northern division of the Grand Trunk. He was then invited by the Nova Scotia government to assist in the development of railways in that province. He remained there until 1867, and was subsequently connected with the Temiscouata section of the Intercolonial Railway.

He built and became superintending engineer of the eastern extension line, now part of the Intercolonial, and having played such a great part in the development of government railways, he was appointed chief engineer and general manager of all government railways in operation in 1873. Seven years later he succeeded his old partner, Sir Sandford Fleming, as chief engineer of the great transcontinental line, the Canadian Pacific Railway. He retained his position on the government railways, and on the Canadian Pacific Railway until 1892, when he was appointed chief engineer of the department of railways and canals. Later he became deputy minister of this department and for thirteen years administered the railway and canal policy of the country as permanent head of the service.

In 1905 he became general consulting engineer to the Dominion government and chief engineer of the western division of the national transcontinental railway. Since that time his chief work has been the inspection of the construction of the Grand Trunk Pacific. Year by year since the road was begun he has made his annual trips of inspection. Even when he had attained the age of 79 years he covered 500 miles on horseback in connection with the survey of the line. He was a big man physically, and possessed a magnificent constitution. His faculties remained bright until the end.

A concrete interior, estimated at $100,000, is under construction in the process and offices building of the Simcoe Canning Factory.